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

In the Matter of	)	
	)	
Gogo CA Licenses LLC	)	File No. SES-LIC-____________
	)	
Application for Blanket License to Operate	)	
Ka-Band Transmit/Receive	)	
Earth Stations Aboard Aircraft	)	

APPLICATION

Gogo CA Licenses LLC ("Gogo") hereby seeks a blanket license to operate Ka-band transmit/receive earth stations aboard aircraft ("ESAA") terminals on domestic, international, and foreign flights with geostationary orbit ("GSO"), Fixed-Satellite Service ("FSS") spacecraft pursuant to Section 25.228 of the Commission's rules.[1] Gogo also operates a Ku-band ESAA network,[2] and adding Ka-band authority will enhance Gogo's ability to provide efficient, cost-effective in-flight broadband service. Grant of the requested license is consistent with Commission precedent and will serve the public interest by allowing Gogo to expand its services, promoting competition in this important market.

A completed Form 312 and Schedule B are attached. Gogo seeks action on this application in order to commence Ka-band ESAA operations beginning in January 2021.

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1 47 C.F.R. § 25.228.

2 Call Sign E120106, File No. SES-MFS-20200501-00470, granted July 7, 2020 (the "Ku-band ESAA License"). The Ku-band ESAA License was previously held by Gogo's affiliate, AC BidCo LLC. The Commission granted an application for *pro forma* assignment of the license to Gogo on July 10, 2020, and the assignment was consummated later that month. *See* Call Sign E120106, File No. SES-ASG-20200708-00723, granted July 10, 2020.

In an application pending before the Commission, Intelsat S.A. as debtor-in-possession is seeking authority to acquire control of Gogo. *See Intelsat S.A., as debtor-in-possession*, File No. SES-T/C-20200915-01018. Gogo requests that any Ka-band ESAA authorization issued pursuant to the current application be included in the requested transfer of control.

I. INTRODUCTION

Gogo is a leading provider of in-flight connectivity in the United States and around the world. Gogo is seeking authority to supplement its existing Ku-band ESAA operations by adding a Ka-band terminal designed by ThinKom, which also produces one of the antennas used in the Ku-band network. Complete technical information regarding the antenna is provided in the attachments to this application.[3]

Gogo seeks authority for the Ka-band terminal to communicate with satellites on the Commission's Permitted Space Station List ("Permitted List") in conformance with the Equivalent Isotropically Radiated Power ("EIRP") density limits set forth in Section 25.218, as well as for operations with individual satellites pursuant to coordination with adjacent satellites as described in Section 25.220. The requested authority will allow the Gogo terminal to communicate with any Permitted List spacecraft for operations that comply with the EIRP mask in the conventional Ka-band spectrum and to operate on a satellite-specific basis in additional spectrum and/or at higher power levels as coordinated with adjacent satellites.

The details regarding the proposed ESAA network components are supplied in the attached Technical Description, and the space stations, teleports, and specific frequency assignments to be used with the network are identified below and in Annex 2. Letters confirming that the proposed ESAA operations will conform to coordination agreements with the operators of adjacent satellites are attached as Annex 3. These materials demonstrate that the ESAA network will comply with all substantive requirements for ESAA operations.

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[3] The Commission recently granted a license for the ThinKom Ka-band terminal. *See Thales Avionics, Inc.*, Call Sign E170068, File No. SES-MOD-20200818-00888, granted Oct. 1, 2020.

II. SATELLITES TO BE USED WITH THE GOGO KA-BAND ESAA NETWORK

Gogo will use transponder capacity on commercial Ka-band GSO FSS satellites. As discussed above, Gogo seeks Permitted List authority and also requests that the Commission authorize communications with the following in-orbit satellites:

(1) the U.S.-licensed AMC-15 satellite at 105.05° W.L.;

(2) the U.S.-licensed AMC-16 satellite at 85° W.L.;

(3) the U.S.-licensed Jupiter 1 satellite at 107.1° W.L.;

(4) the U.S.-licensed Jupiter 2 satellite at 97.1° W.L.; and

(5) the Norway-licensed Thor-7 satellite at 0.65° W.L.

Each of these satellites is eligible for authority to communicate with the Gogo ESAA network, as discussed below.

AMC-15: AMC-15 is a U.S.-licensed satellite operating at 105.05° W.L.,[4] and complete technical information regarding the satellite is therefore already on file with the Commission. Gogo seeks authority to use AMC-15 capacity for ESAA operations in the 28.4-28.6 GHz and 29.5-30.0 GHz uplink spectrum and the 18.6-18.8 GHz and 19.7-20.2 GHz downlink spectrum, consistent with the AMC-15 License and as permitted under the Commission's decisions regarding earth stations in motion.[5] AMC-15 will provide coverage of North America, the

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4 *SES Americom, Inc.*, Call Sign S2180, File No. SAT-MOD-20200227-00020, granted June 11, 2020 ("AMC-15 License").

5 *Amendment of Parts 2 and 25 of the Commission's Rules to Facilitate the Use of Earth Stations in Motion Communicating with Geostationary Orbit Space Stations in Frequency Bands Allocated to the Fixed-Satellite Service*, Report and Order and Further Notice of Proposed Rulemaking, 33 FCC Rcd 9327 (2018) ("ESIMs 2018 Order"); *Amendment of Parts 2 and 25 of the Commission's Rules to Facilitate the Use of Earth Stations in Motion Communicating with Geostationary Orbit Space Stations in Frequency Bands Allocated to the Fixed-Satellite Service,* Second Report and Order in IB Docket No. 17-95 and Report and Order in IB Docket No. 18-315 and Further Notice of Proposed Rulemaking, 35 FCC Rcd 5137 (2020) ("ESIMs 2020 Order," and with the ESIMs 2018 Order, the "ESIMs Orders").

Caribbean, and Central America. A letter confirming that operation of the Gogo ESAA terminal is consistent with coordination agreements with satellites operated within six degrees of AMC-15 is included in Annex 3.

AMC-16: AMC-16 is a U.S.-licensed satellite operating at 85° W.L.,[6] and complete technical information regarding the satellite is therefore already on file with the Commission. Gogo seeks authority to use AMC-16 capacity for ESAA operations in the 28.4-28.6 GHz and 29.5-30.0 GHz uplink spectrum and the 18.6-18.8 GHz and 19.7-20.2 GHz downlink spectrum, consistent with the AMC-16 License and as permitted under the ESIMs Orders. AMC-16 will provide coverage of the United States and the Caribbean. A letter confirming that operation of the Gogo ESAA terminal is consistent with coordination agreements with satellites operated within six degrees of AMC-16 is included in Annex 3.

Jupiter 1: Jupiter 1, also known as EchoStar XVII, is a U.S.-licensed satellite operating at 107.1° W.L.,[7] and complete technical information regarding the satellite is therefore already on file with the Commission. Gogo seeks authority to use Jupiter 1 capacity for ESAA operations in the 28.35-29.1 GHz and 29.3-30.0 GHz uplink spectrum and the 18.3-19.3 GHz and 19.7-20.2 GHz downlink spectrum, consistent with the Jupiter 1 License and as permitted under the ESIMs Orders.[8] Jupiter 1 will provide coverage of the United States. A letter confirming that

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6 *SES Americom, Inc.*, Call Sign S2181, File No. SAT-MOD-20191223-00152, granted March 5, 2020 ("AMC-16 License").

7 *Hughes Network Systems, LLC,* Call Sign S2753, File No. SAT-LOA-20120424-00075, granted June 12, 2012 ("Jupiter 1 License").

8 Gogo recognizes that its use of Jupiter 1 capacity in the 18.8-19.3 GHz and 28.6-29.1 GHz bands will be on an unprotected, non-interference basis with respect to non-geostationary orbit satellite systems. *See* ESIMs 2020 Order, 35 FCC Rcd at 5144, ¶ 20.

operation of the Gogo ESAA terminal is consistent with coordination agreements with satellites operated within six degrees of Jupiter 1 is included in Annex 3.

Jupiter 2: Jupiter 2, also known as EchoStar 19, is a U.S.-licensed satellite operating at 97.1° W.L.,[9] and complete technical information regarding the satellite is therefore already on file with the Commission. Gogo seeks authority to use Jupiter 2 capacity for ESAA operations in the 28.35-29.1 GHz and 29.3-30.0 GHz uplink spectrum and the 18.3-19.3 GHz and 19.7-20.2 GHz downlink spectrum, consistent with the Jupiter 2 License and as permitted under the ESIMs Orders.[10] Jupiter 2 will provide coverage of North America, Central America, and the Caribbean. A letter confirming that operation of the Gogo ESAA terminal is consistent with coordination agreements with satellites operated within six degrees of Jupiter 2 is included in Annex 3.

Thor-7: Thor-7 is licensed by Norway and is operating at 0.65° W.L. The satellite is not on the Permitted List, but the spacecraft has been approved for operations with U.S.-licensed ESAA terminals.[11] As a result, technical data relating to the satellite, including orbital debris mitigation materials, are already on file with the Commission. Gogo seeks authority to use Thor-7 capacity for ESAA operations in the 29.5-30.0 GHz uplink spectrum and the 19.7-20.2 GHz

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[9] *Hughes Network Systems, LLC*, Call Sign S2834, File No. SAT-MOD-20171204-00163, granted Jan. 18, 2018 ("Jupiter 2 License").

[10] Gogo recognizes that its use of Jupiter 2 capacity in the 18.8-19.3 GHz and 28.6-29.1 GHz bands will be on an unprotected, non-interference basis with respect to non-geostationary orbit satellite systems. *See* ESIMs 2020 Order, 35 FCC Rcd at 5144, ¶ 20.

[11] *See Thales Avionics, Inc.*, Call Sign E170068, File No. SES-MFS-20190424-00544, granted Aug. 17, 2020 ("Thor-7 Grant"). As part of this authorization, the Commission granted a waiver of the orbital debris mitigation requirements in Section 25.283(c) of the Commission's rules with respect to sealed helium tanks onboard the spacecraft. *See id.* at 5, Special and General Provisions 90580.

downlink spectrum, consistent with the Thor-7 Grant and as permitted under the ESIMs Orders. Thor-7 will provide coverage of Europe, the Middle East, and the North Atlantic.

II. PUBLIC INTEREST SHOWING

Grant of the Gogo Ka-band ESAA blanket license application will promote competition in the market for in-flight broadband services, to the benefit of air travelers in the United States and abroad. ESAA networks enhance the security of air travel and allow passengers to access services that provide entertainment and enable increased productivity. With its history and technological expertise as an ESAA operator, Gogo is well-positioned to deliver high-quality, reliable Ka-band in-flight communications to passengers and crew on flights in U.S. airspace and around the globe. The Commission has reviewed the characteristics of the Ka-band ESAA terminal Gogo proposes to use, and the satellites for which authority is sought are either U.S.-licensed or have been authorized for operations with U.S.-licensed ESAA networks.

Accordingly, grant of the application is consistent with Commission policies and precedent and will serve the public interest.

III. CONCLUSION

For the foregoing reasons, Gogo respectfully requests that the Commission grant Gogo a blanket license to operate Ka-band transmit/receive ESAA terminals on domestic and international flights, consistent with the technical parameters specified herein.

Respectfully submitted,

GOGO CA LICENSES LLC

By: *<u>/s/ Saumil Mehta</u>*

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Dated: October 6, 2020

ANNEX 1: Table of Information Required by Commission Rules

Regulatory Requirement	Citation to Information Provided
25.115(e), 25.115(g), 25.115(n)(1)	Off-axis EIRP density information is provided in Annex 4, Section 2.
25.115(n)(2), 25.220	Target satellite operator certifications pursuant to Section 25.220 are in Annex 3 attached.
25.115(n)(3)(i), 25.228(b) & (c)	A demonstration that the ESAA network is self-monitoring, is controlled by a network control and monitoring center, and will comply with requirements to cease transmissions if applicable limits are exceeded is provided in Annex 4, Section 2. Gogo's certifications are in Annex 6.
25.115(n)(3)(ii)	The 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 ESAA network are described in the table found in Annex 2 attached, and a composite coverage map is provided in Annex 4, Section 2.
25.115(n)(3)(iii), 25.228(g)(1)	The 24/7 point of contact information is the same as for the Gogo Ku-band ESAA network. The phone number is +1 866-943-4662 and the email address is noc@gogoair.com. The street address is: Gogo Network Operations Center, 111 North Canal Street, Chicago, IL, 60606, as specified in Form 312 Schedule B, Items E2-E9.
25.115(n)(3)(iv)	The Radiation Hazard analysis is attached as Annex 5.
25.220(d)(1)(iv)	Gogo's certifications are in Annex 6.

ANNEX 2:
Spacecraft and Teleport Tables

Satellite	Location	Beam Coverage Area	Tx (GHz)	Rx (GHz)	Use in US airspace?	Satellite Operator
AMC-15	105.05W	North America, Central America, and the Caribbean	28.4-28.6; 29.5-30.0	18.6-18.8; 19.7-20.2	Yes	SES
AMC-16	85W	United States, the Caribbean	28.4-28.6; 29.5-30.0	18.6-18.8; 19.7-20.2	Yes	
Jupiter 1 (EchoStar XVII)	107.1W	United States	28.35-29.1; 29.3-30.0	18.3-19.3; 19.7-20.2	Yes	Hughes
Jupiter 2 (EchoStar 19)	97.1W	North America, Central America, and the Caribbean	28.35-29.1; 29.3-30.0	18.3-19.3; 19.7-20.2	Yes	
Thor-7	0.65W	Europe, the Middle East, and the North Atlantic	29.5-30.0	19.7-20.2	No	Telenor

Satellite	Teleport Location	FCC Call Sign
AMC-15	Cedar Hill, TX Laredo, TX Spokane, WA	E170140 E170143 E050372
AMC-16	Duluth, MN Woodbine, MD	E170142 E170141
Jupiter 1	Various (CONUS, AK, HI, PR, USVI)	E110149
Jupiter 2	Gilbert, AZ Cheyenne, WY Duluth, MN Roseburg, OR North Platte, NE Tukwila, WA Bismarck, ND Amarillo, TX Albuquerque, NM Bellevue, NE Lindon, UT Santa Clara, CA San Diego, CA North Las Vegas, NV Boise, ID Missoula, MT Billings, MT	E150076 E150077 E150078 E150079 E150080 E150081 E150082 E150083 E150084 E150085 E150086 E150087 E150088 E150089 E150090 E150091 E150092
Thor-7	Nittedal, Norway	N/A

ANNEX 3: Satellite Company Letters

SES

Frederic Portier
Senior Manager, Spectrum Management & Development, Americas

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

11 September 2020

Subject: Engineering Certification of SES Americom, Inc. for the AMC-15 and AMC-16 Satellites

To whom it may concern,

This letter confirms that SES is aware that Gogo CA Licenses LLC ("Gogo CA Licenses") is preparing to seek a blanket authorization from the Federal Communications Commission ("FCC") to operate technically identical Ka-band Earth Stations Aboard Aircraft ("ESAA") transmit/receive terminals. As part of the application, Gogo CA Licenses will seek authority for the Ka-band ESAA terminals to communicate with the AMC-15 satellite at 105° W.L and the AMC-16 satellite at 85° W.L. pursuant to FCC Rule Section 25.228.

Based upon the representations made to SES by Gogo CA Licenses concerning how it will operate on AMC-15 and AMC-16 according to its letter dated September 4, 2020:

- SES certifies that it has completed coordination as required under the FCC's rules and that the power density levels specified by Gogo CA Licenses are consistent with any existing coordination agreements to which SES is a party with adjacent satellite operators within +/- 6 degrees of orbital separation from AMC-15 and AMC-16.
- If the FCC authorizes the operations proposed by Gogo CA Licenses, SES will include the power density levels specified by Gogo CA Licenses in all future satellite network coordination with other operators of satellites adjacent to AMC-15 and AMC-16.

Yours Sincerely,

Frederic Portier

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Federal Communications Commission
International Bureau
445 12th Street, SW
Washington, DC 20554

September 14, 2020

Re: Coordination Certificate for Gogo CA Licenses LLC Earth Stations Aboard Aircraft Application

To whom it may concern:

This letter certifies that Hughes Network Systems, LLC ("Hughes") is aware that Gogo CA Licenses LLC ("Gogo CA Licenses") is planning to seek authority from the Federal Communications Commission ("FCC") to operate Ka-band transmit/receive Earth Stations Aboard Aircraft ("ESAA") terminals. The Gogo CA Licenses application will seek authority for the ESAA terminal to communicate with the Jupiter 1/ECHOSTAR XVII satellite ("Jupiter 1") at 107.1 W.L. under the current ESAA rules, including Section 25.228.

Based upon the representations made to Hughes by Gogo CA Licenses concerning how it will operate on Jupiter 1 in the Ka band frequencies according to its letter dated September 10, 2020, Hughes certifies that it has completed coordination as required under the FCC's rules and that Gogo CA Licenses' use of the Ka-band ESAA transmit/receive terminal, installed and operated in accordance with the Gogo CA Licenses application and the above conditions, is consistent with existing coordination agreements to which Hughes is a party with all adjacent satellite operators within +/-6 degrees of orbital separation from Jupiter 1.

If the FCC authorizes the operations proposed by Gogo CA Licenses in its application, Hughes will include the power density levels used by Gogo CA Licenses in all future satellite network coordinations.

Yours sincerely,

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Kimberly M. Baum
Vice President, Regulatory Affairs

Federal Communications Commission
International Bureau
445 12th Street, SW
Washington, DC 20554

September 14, 2020

Re: Coordination Certificate for Gogo CA Licenses LLC Earth Stations Aboard Aircraft Application

To whom it may concern:

This letter certifies that Hughes Network Systems, LLC ("Hughes") is aware that Gogo CA Licenses LLC ("Gogo CA Licenses") is planning to seek authority from the Federal Communications Commission ("FCC") to operate Ka-band transmit/receive Earth Stations Aboard Aircraft ("ESAA") terminals. The Gogo CA Licenses application will seek authority for the ESAA terminal to communicate with the Jupiter 2/ECHOSTAR XIX satellite ("Jupiter 2") at 97.1 W.L. under the current ESAA rules, including Section 25.228.

Based upon the representations made to Hughes by Gogo CA Licenses concerning how it will operate on Jupiter 2 in the Ka band frequencies according to its letter dated September 10, 2020, Hughes certifies that it has completed coordination as required under the FCC's rules and that Gogo CA Licenses' use of the Ka-band ESAA transmit/receive terminal, installed and operated in accordance with the Gogo CA Licenses application and the above conditions, is consistent with existing coordination agreements to which Hughes is a party with all adjacent satellite operators within +/-6 degrees of orbital separation from Jupiter 2.

If the FCC authorizes the operations proposed by Gogo CA Licenses in its application, Hughes will include the power density levels used by Gogo CA Licenses in all future satellite network coordinations.

Yours sincerely,

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Kimberly M. Baum
Vice President, Regulatory Affairs

Annex 4 – Technical Annex

This Technical Annex describes the operational characteristics of the Gogo 2Ka Ka-band Earth Stations Aboard Aircraft (ESAA) system and explains how the Gogo 2Ka system will comply with the FCC's rules regarding protection of other systems.

1. Gogo ESAA Terminal Overview

The ThinKom KA2517 antenna subsystem is made up of five major physically separated components, along with the interconnecting RF Cabling: (1) two Fuselage Mounted Antennas, transmit (Tx) and receive (Rx), (2) the radome, (3) the Ka-band Aircraft Networking Data Unit (KANDU), (4) the Modem/Manager (ModMan), and (5) the Ka-band Radio Frequency Unit (KRFU). The antennas and radome are mounted on the top of the aircraft fuselage and constitute the Satellite Antenna Assembly, and the remaining components are mounted within the pressurized airframe, just under and in close proximity to the antennas. The figure below provides a detailed layout of the system showing components and relative placement on the aircraft.

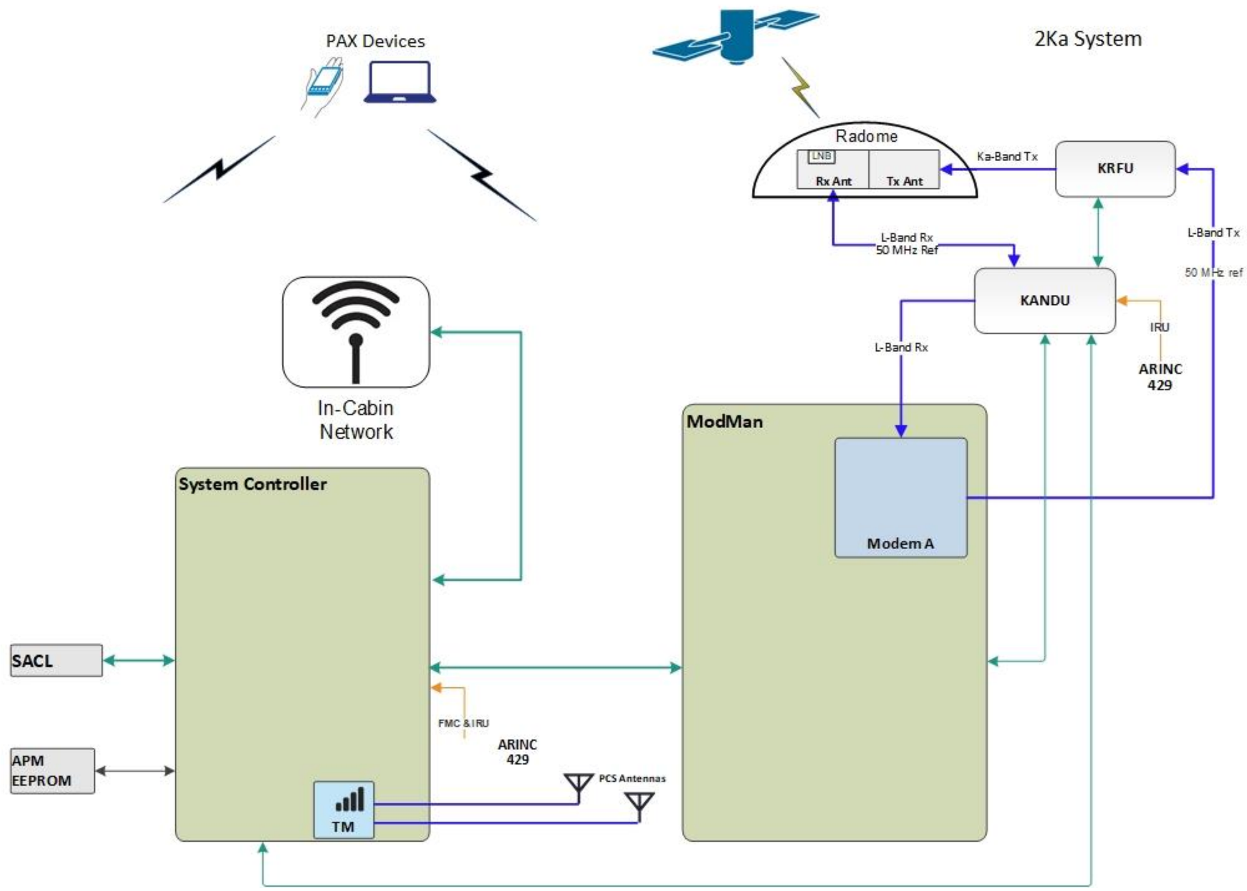


Figure A4-1 – Gogo's Ka-band ESAA system showing components of the 2Ka terminal layout.

1.1. Antenna System

The 2Ka antenna system consists of the radome, the receive antenna, and the transmit antenna. The radome is a frequency specific component of an aeronautical satellite communications system that provides an aerodynamic cover and environmental protection for the antenna assemblies. The receive antenna is a 25" mechanically phased array that is mounted to the exterior of the aircraft underneath the radome. The transmit antenna is a 17" mechanically phased array that is mounted to the exterior of the aircraft and placed in the forward position underneath the radome.

The antenna gain can vary with elevation angle, as shown in the table below:

	Receive Gain (dBi)		Transmit Gain (dBi)	
Elevation Angle	19.3 GHz	20.2 GHz	28.5 GHz	29.75 GHz
15˚	32.8	33.6	30.8	31.6
30˚	36.0	36.7	34.2	34.8
45˚	37.7	38.1	36.2	36.9

1.2. KANDU

The KANDU is the primary controller for the 2Ka connectivity subsystem. The KANDU is responsible for alignment of the antennas with the satellite and ultimately facilitating the closing of the satellite link. The KANDU gets location information from the aircraft's ARINC 429 interface, which it then uses in its pointing of the antennas and selection of satellite directed by the modem. The KANDU controls and manages the KRFU, including the capability to mute or reset the KRFU.

On power up, the KANDU will attempt to establish and close the satellite link with the last commanded satellite. The KANDU initializes the antenna, and if navigational data is available, the pointing position will be updated based on the plane's location and orientation. A tracking cycle is then initiated to fine-tune the antenna pointing position, based on the received signal strength. Once this process has been successfully, the KRFU is commanded to enable transmit, and the modem closes the satellite link.

1.3. ModMan

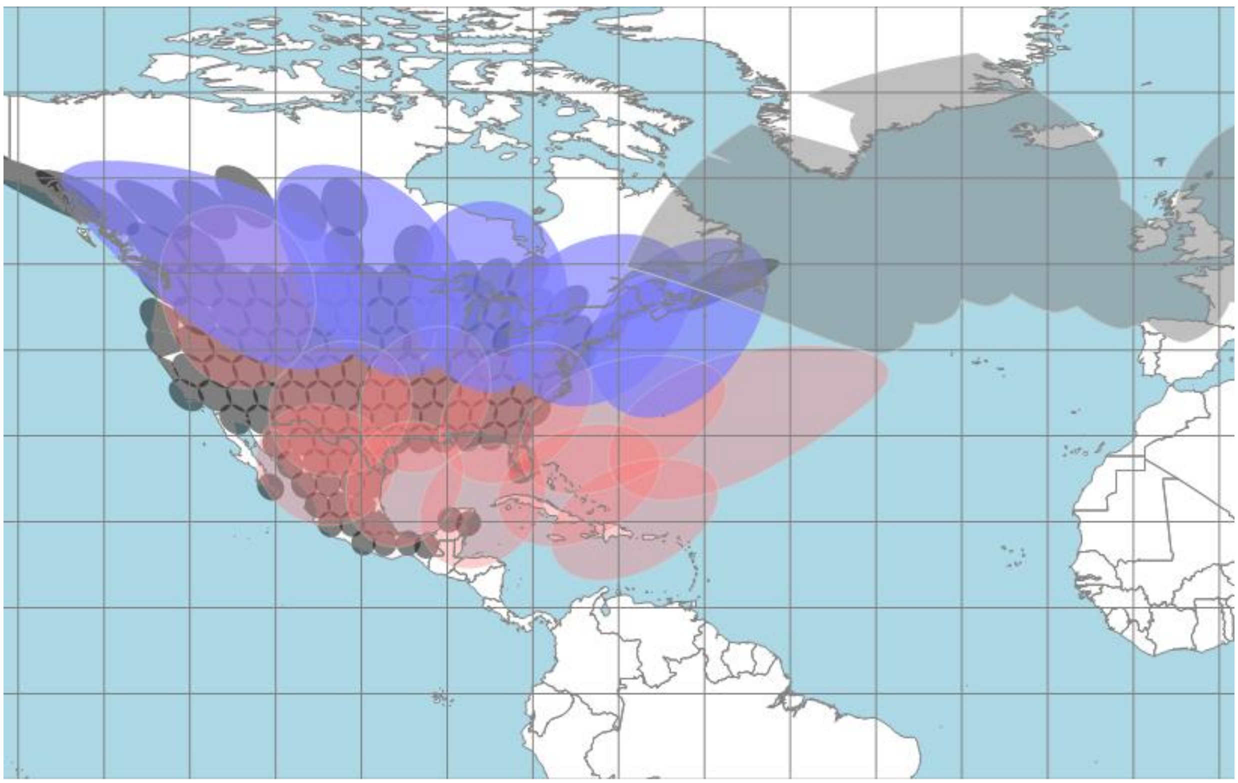
The Modman is responsible for return link power control. The Modman executes a power control algorithm that uses local feedback from the antenna system that provides the real-time maximum EIRP spectral density (ESD) allowable based on the current antenna performance with respect to off-axis emissions as a function of elevation and skew angles. The Modman calculates the required transmit power using this information and adjusts the carrier characteristics to provide the most efficient link budget while not exceeding ESD limits.

1.4. KRFU

The KRFU delivers the transmit data signals to the transmit antenna and provides a software interface to allow the KANDU to monitor and control the KRFU operational state. The KRFU mutes transmissions and reports the condition to the KANDU upon detecting certain operational faults.

2. Compliance with FCC Rules

The 2Ka terminal will comply with applicable FCC rules, as shown in the compliance matrix in Annex 1. Gogo is seeking authority to communicate with satellites on the Permitted List using off-axis EIRP spectral density (ESD) limits that conform to Section 25.218, as well as with individual satellites pursuant to coordination with adjacent spacecraft as described in Section 25.220. A map showing the combined coverage of the satellites specified in this application is provided below.



2.1. Self-Monitoring and Cessation of Emissions

The 2Ka terminal will only transmit when it is in communication with the network hub. Additionally, the system is designed to ensure compliance with Sections 25.228(b) and 25.228(c) of the Commission's rules. Specifically, the terminal is self-monitoring, and the network management system will disable all transmissions within 100 ms if the system exceeds the authorized ESD values and will not resume transmission until the ESD is corrected to authorized levels.

2.2. ESAA Terminal EIRP Spectral Density Characteristics

The following images and charts describe the operational characteristics of the Gogo 2Ka terminal communicating with the five satellites identified in this application. For each satellite the worst and best operational scenario is determined, and the appropriate ESD charts are included. The network management system employed by Gogo will limit the transmit power from the ESAA terminal to maintain compliance with the FCC masks or other coordinated limits at all times. This includes both the GSO mask in §25.218(i)(1) and the non-GSO mask in §25.218(i)(2). Gogo will limit the transmit power as necessary to ensure compliant operation in both planes.

2.2.1. AMC-15

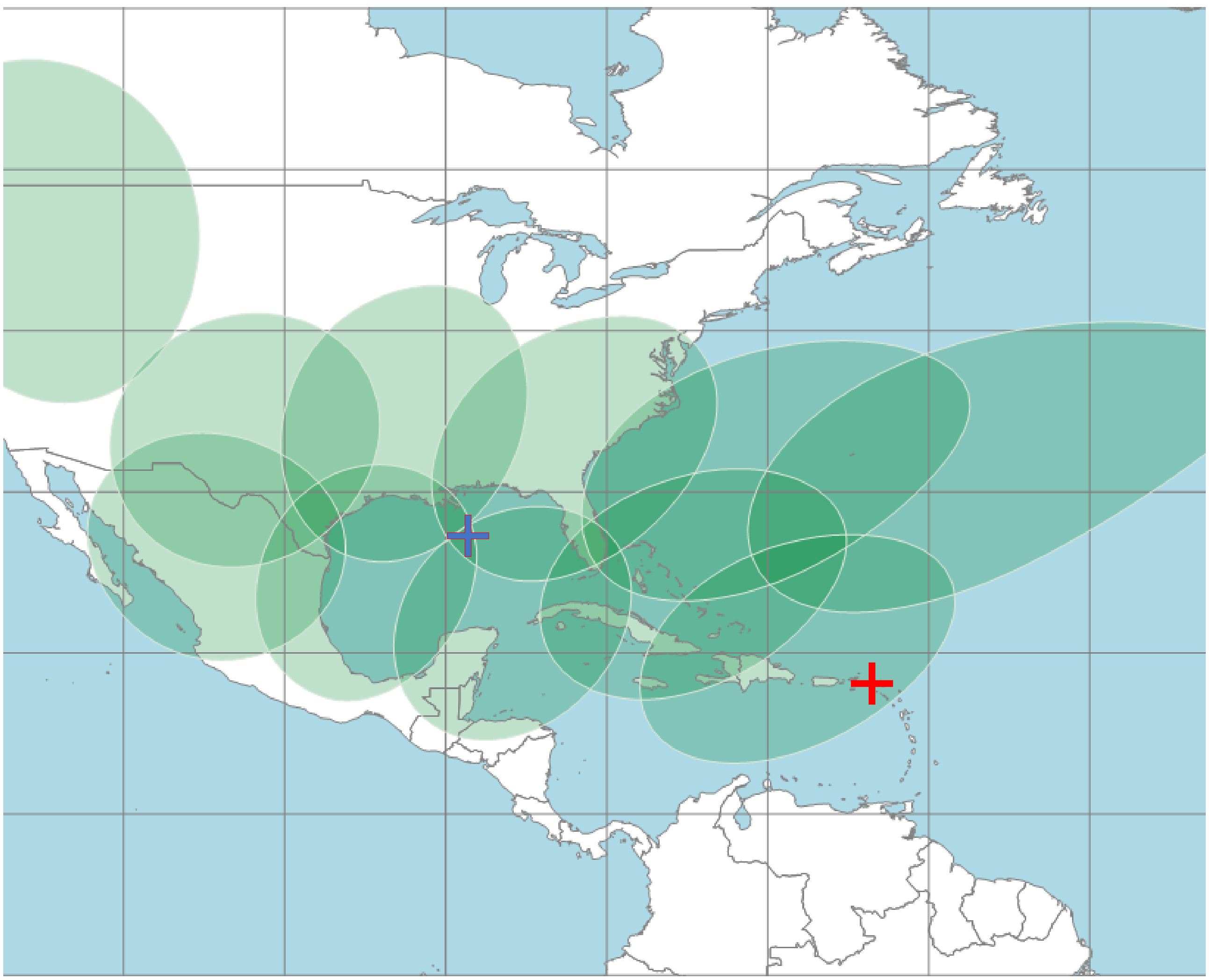


Figure A4-2 – AMC 15 (105˚ W.L.) Ka-band beams. Worst case occurs at skew of 65˚ and elevation of 45˚, as shown on figure (+). Highest ESD can be achieved at skew of 15˚ and elevation of 45˚ (+), see map).

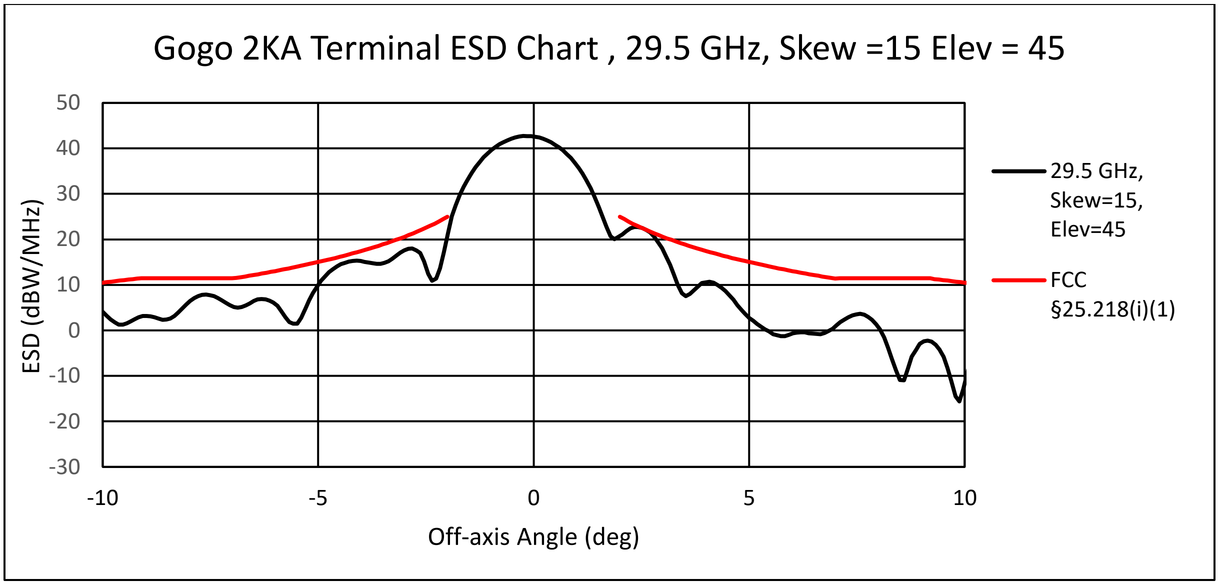


Figure A4-3 – Best-case ESD for operation on AMC-15, skew=15˚ and elevation = 45˚. In this case the maximum ESD can be as high as 42.8 dBW/MHz.

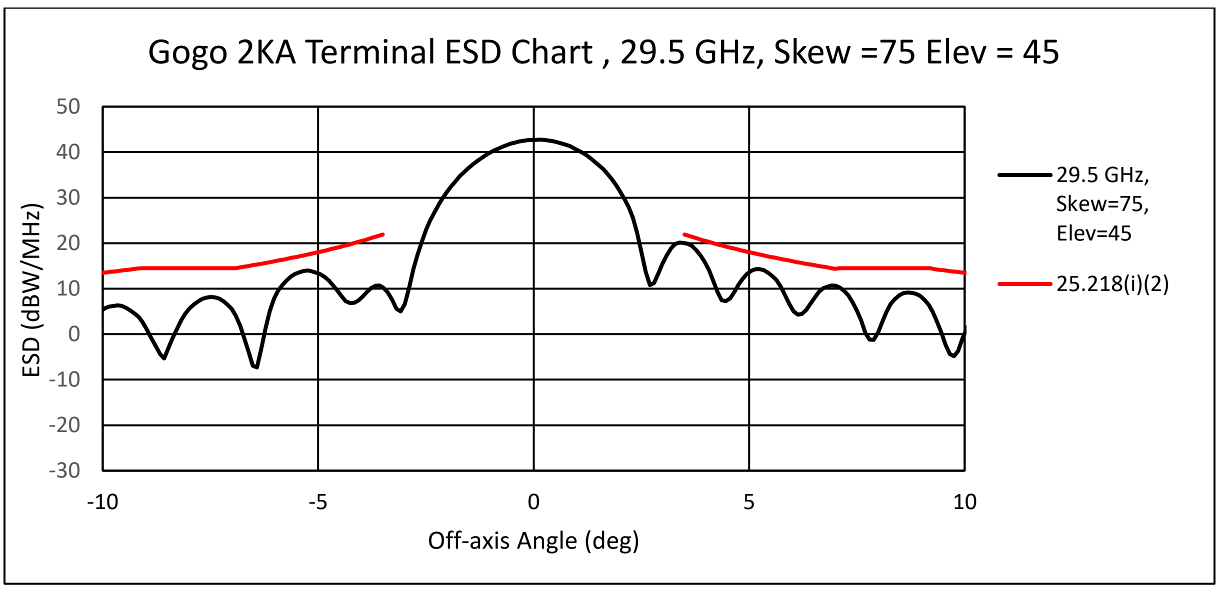


Figure A4-4 – At the highest ESD operation of near 43 dBW/MHz the 2Ka terminal will not cause interference into the non-GSO plane. Operation at maximum ESD will comply with applicable limits for this position.

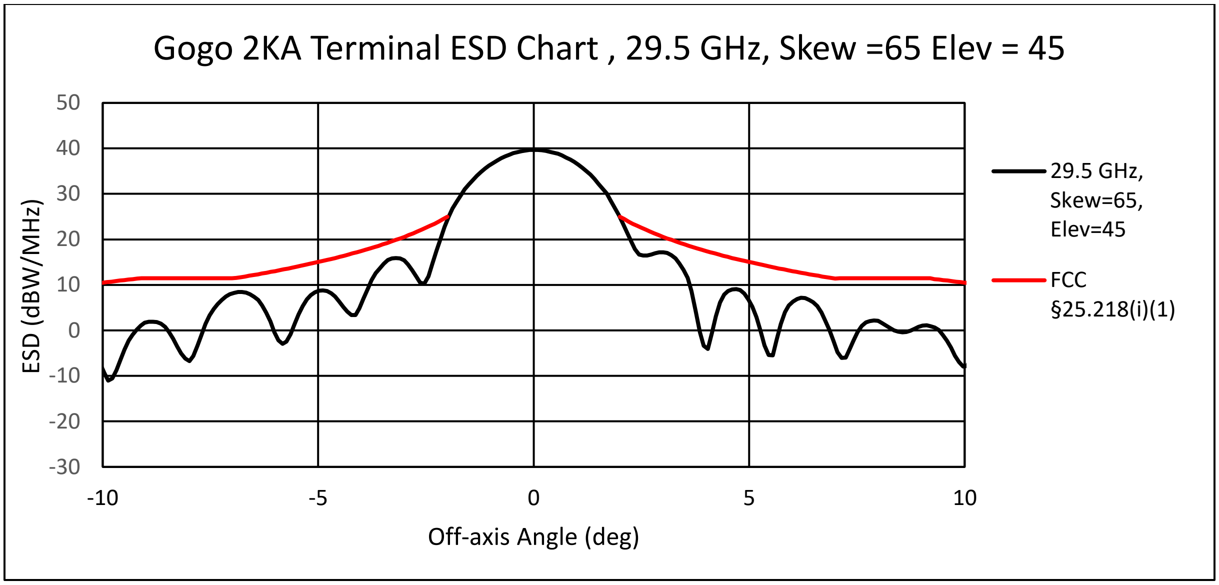


Figure A4-5 – Worst-case ESD for operation on AMC-15, skew = 65˚ and elevation = 45˚. The system will limit ESD to 39.8 dBW/MHz to ensure compliant operation.

2.2.2. AMC-16

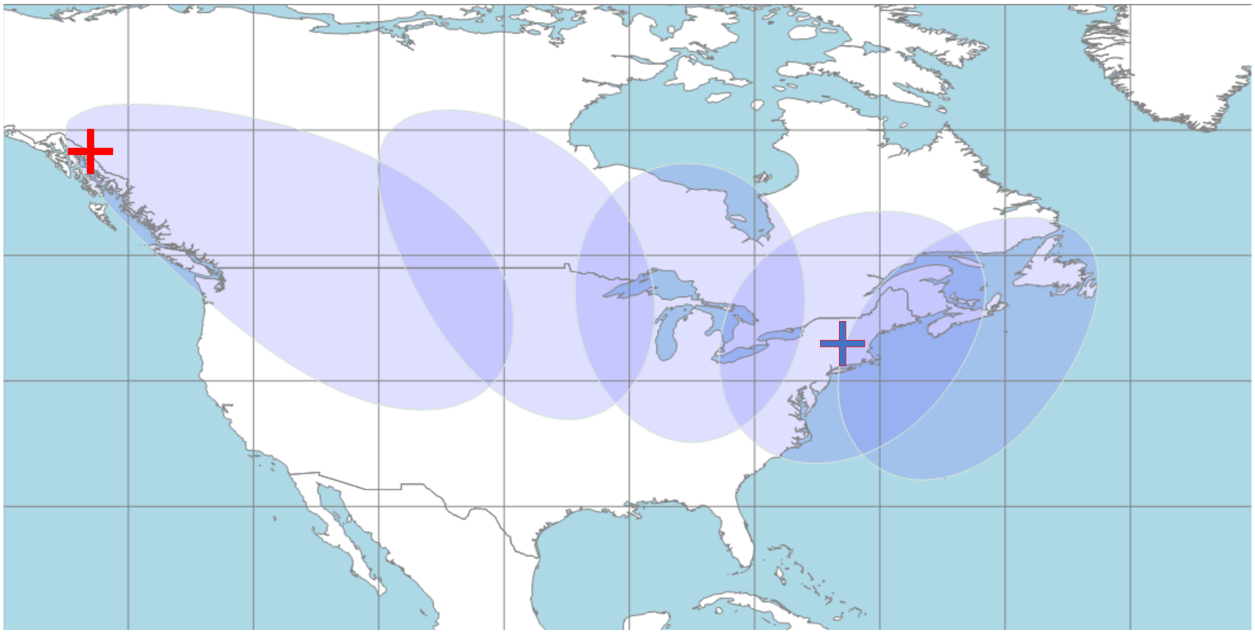


Figure A4-6 – AMC 16 (85˚ W.L.) beams. Worst case operation occurs at skew angle of 30˚ and elevation of 15˚. Best case (+) operation is 15˚ skew and 45˚ elevation.

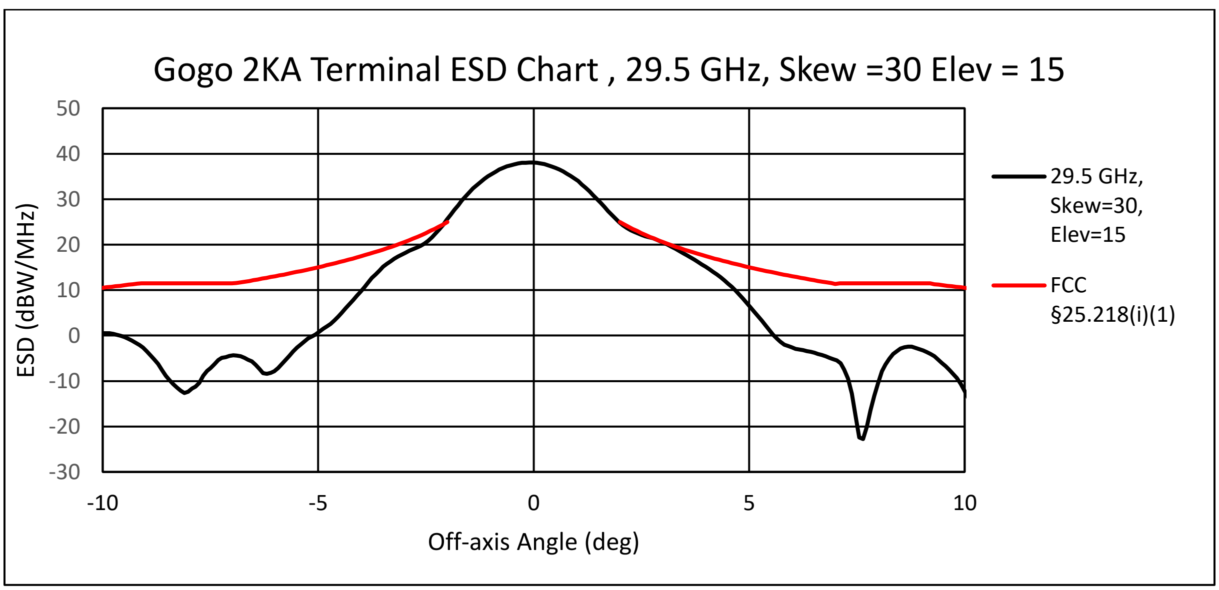


Figure A4-7 – Worst-case ESD for operation on AMC-16, skew=30˚ and elevation = 15˚. The ESD limit would be 38.06 dBW/MHz, however in order to preclude interference into the non-GSO plane the system will limit the ESD to 34.08 dBW/MHz, see Figure A4-8 below.

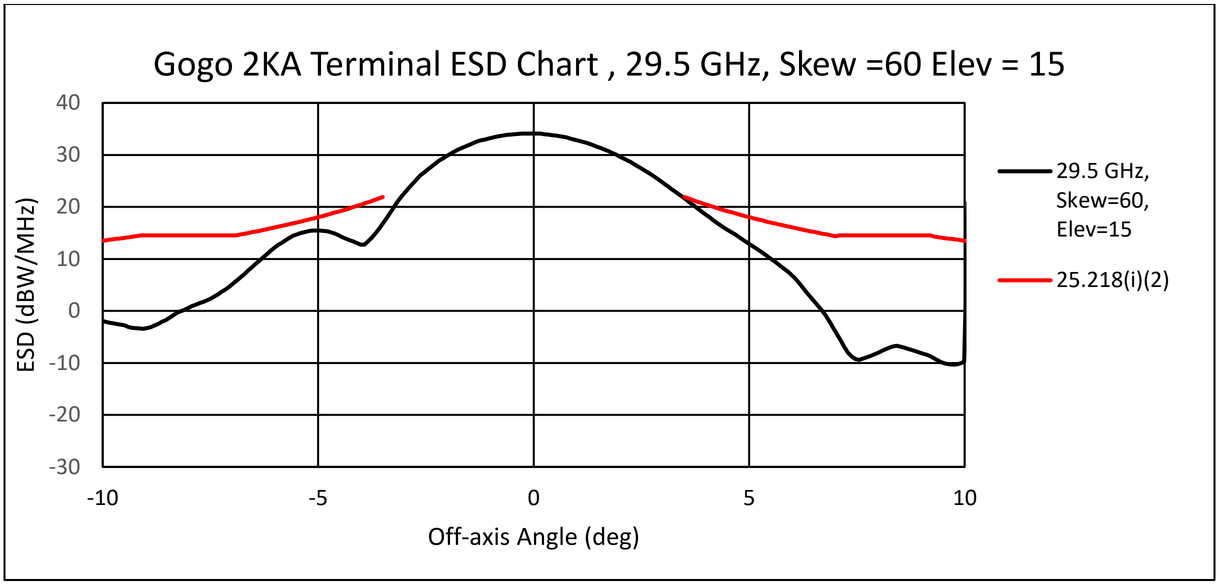


Figure A4-8 – Worst-case ESD for operation with AMC-16 in the non-GSO plane, skew=60˚ and elevation=15˚. The system will limit the ESD to 34.08 dBW/MHz to ensure compliant operation.

2.2.3. Jupiter 1 and 2

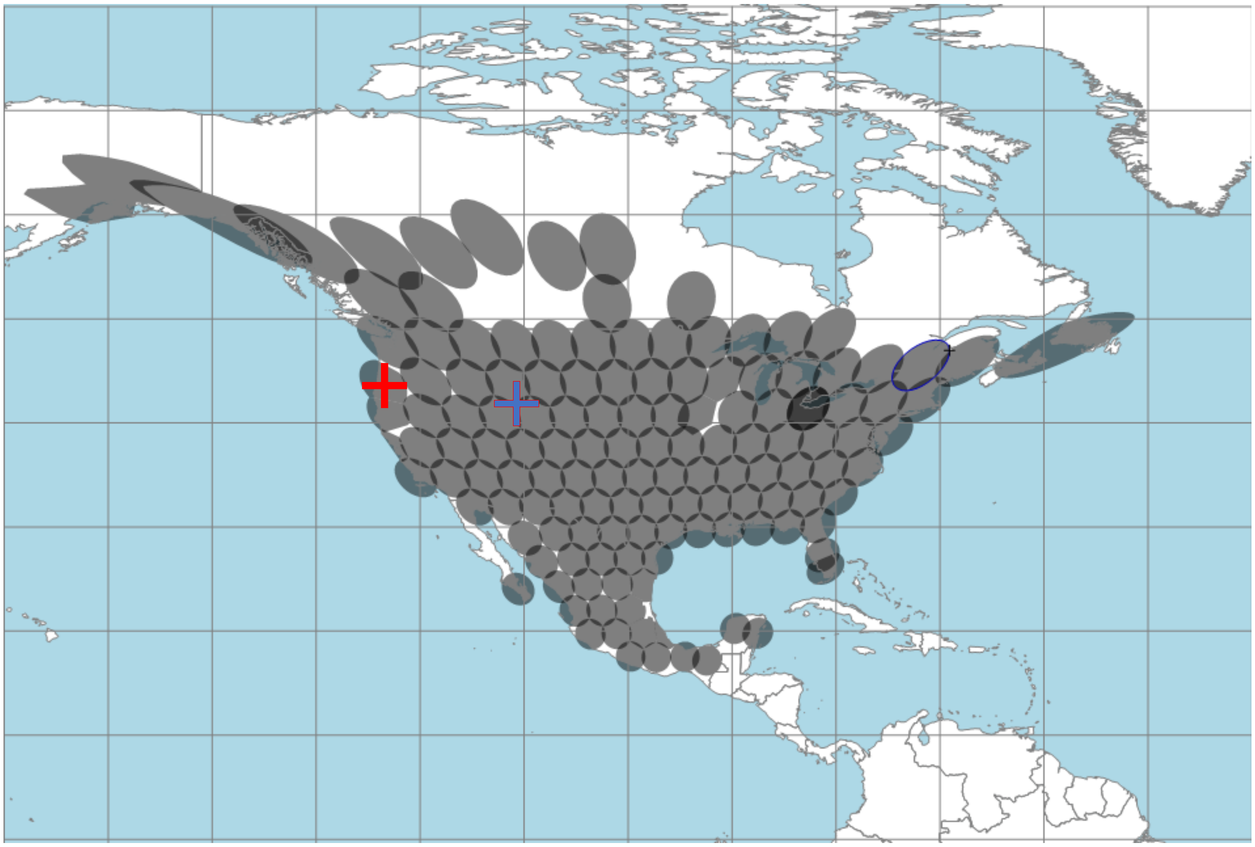


Figure A4-9 – Jupiter 1 (107.1˚ W.L.) and Jupiter 2 (97.1˚ W.L.) beams. Worst case operation occurs at 30˚ elevation and 30˚ skew (+), best case (+) is 45˚elevation and 15˚skew.

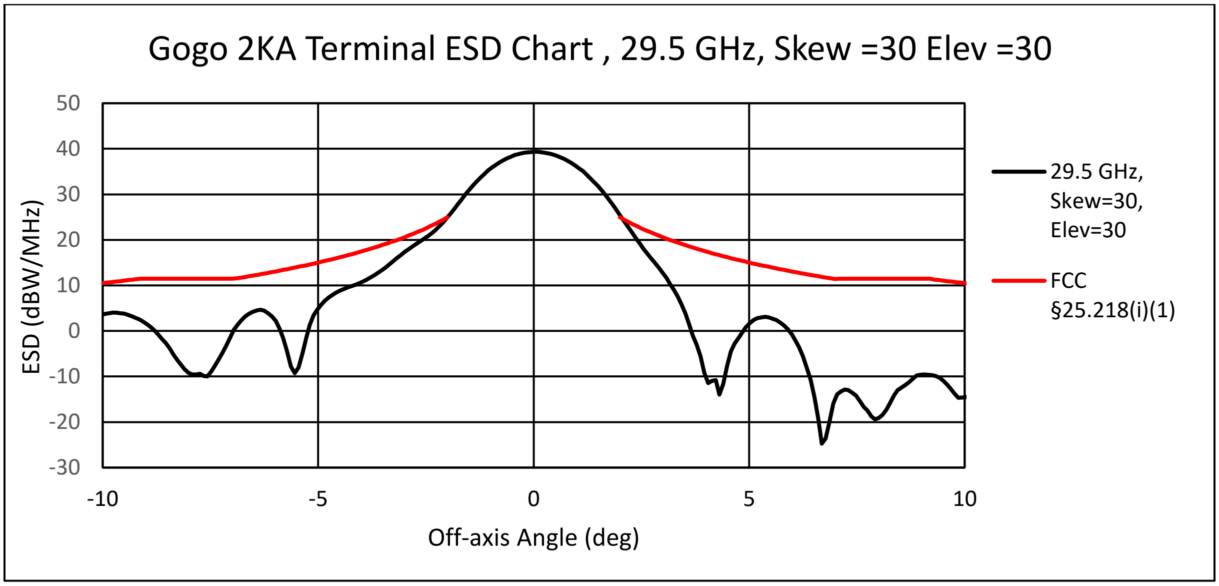


Figure A4-10 – Worst case GSO operation on Jupiter 2, skew =30˚ and elevation = 30˚. The system will limit the ESD to 39.35 dBW/MHz to ensure compliant operation.

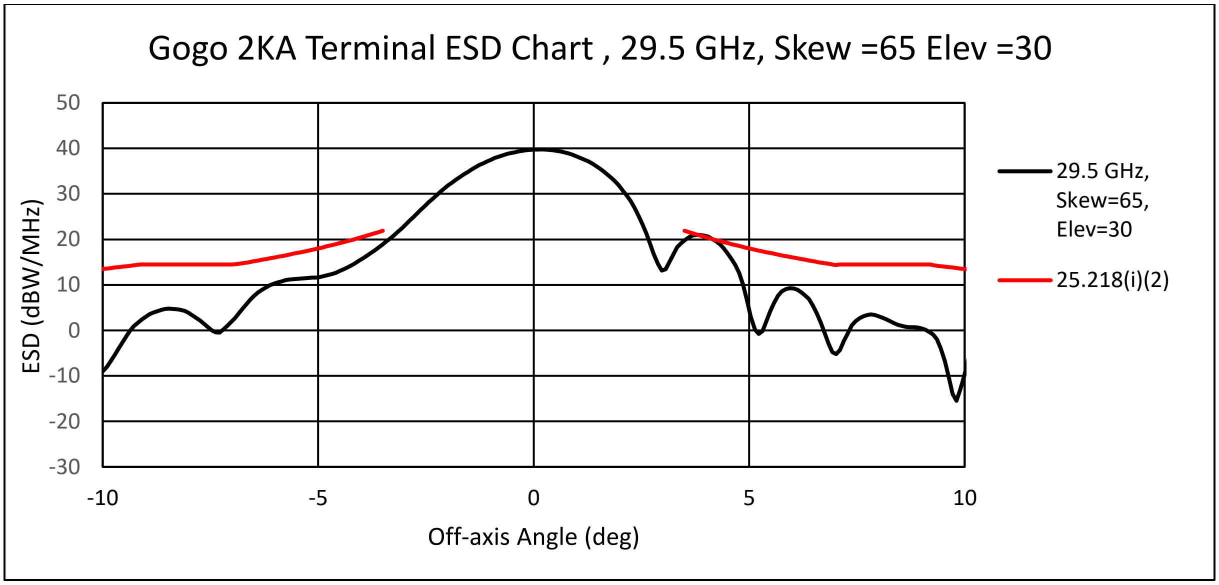


Figure A4-11 – ESD plot for non-GSO worst-case operation on Jupiter 2. The system will limit the ESD to 39.3 dBW/MHz to ensure compliant operation in both planes.

2.2.4. Thor 7

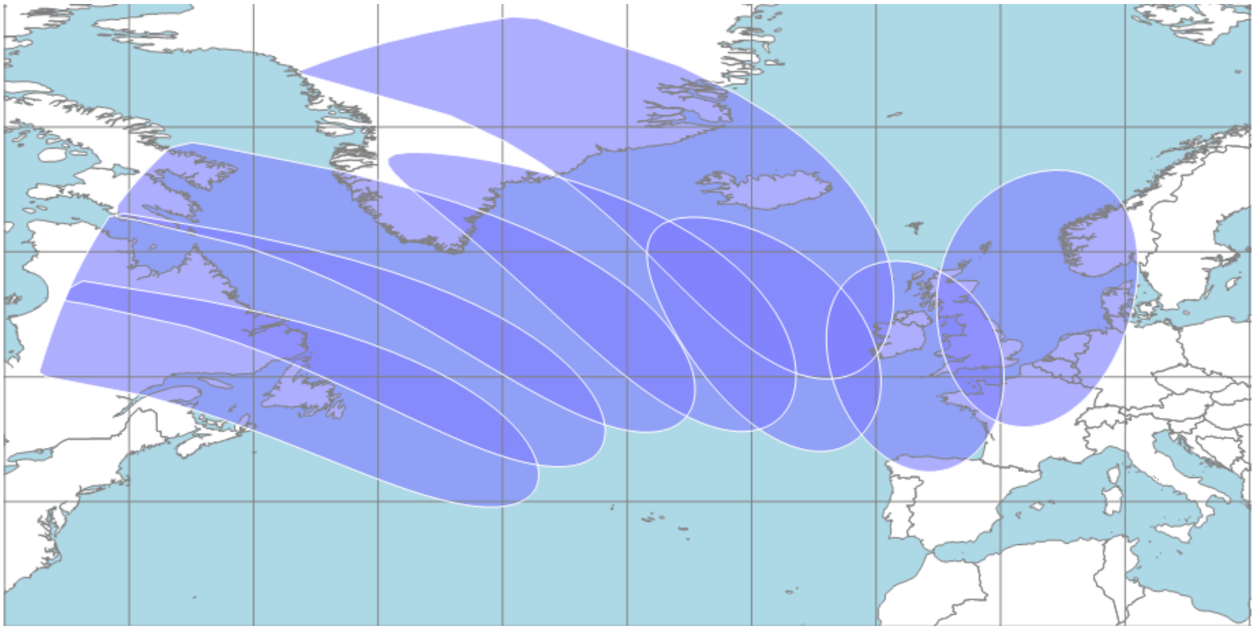


Figure A4-12 – Thor-7 (0.65˚ W.L.) beams. Worst case operation occurs at skew angle of 45˚ and elevation angle of 15˚.

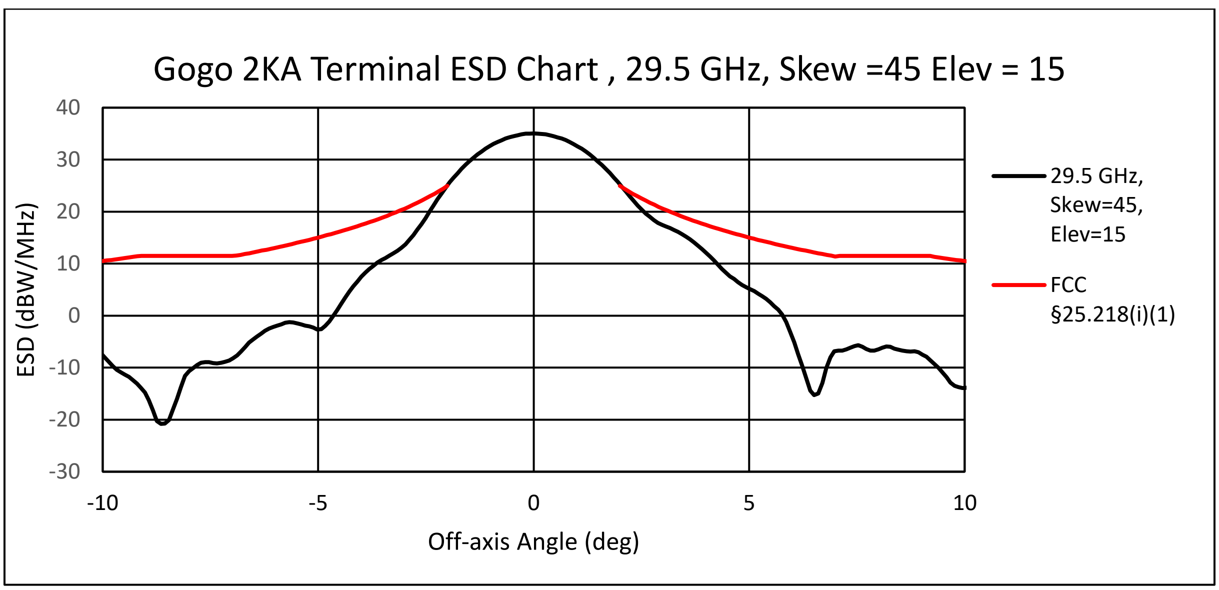


Figure A4-13 – ESD plot for worst case GSO operation on Thor-7, skew=45˚ and elevation =15˚. In this case the ESD will be limited to 34.94 dBW/MHz to ensure compliance with both the §25.218(i)(1) and §25.218(i)(2) masks.

3.0 Conclusions

The Gogo 2Ka system will operate in an FCC compliant manner and will supplement Gogo's existing Ku-band ESAA services. The ThinKom terminal is well suited for this service as it provides a streamlined design with high power and the ability to protect other satellite and terrestrial based systems.

Annex 5 - Radiation Hazard Analysis
Gogo CA Licenses LLC
ThinKom Ka-Band Antenna

This analysis predicts the radiation levels around a proposed earth station terminal, comprised of one array type antenna. This report is developed in accordance with the prediction methods contained in OET Bulletin No. 65, Evaluating Compliance with FCC Guidelines for Human Exposure to Radio Frequency Electromagnetic Fields, Edition 97-01, pp 26-30. The maximum level of non-ionizing radiation to which personnel may be exposed is limited to a power density level of 5 milliwatts per square centimeter (5 mW/cm^2) averaged over any 6 minute period in a controlled environment and the maximum level of non-ionizing radiation to which the general public is exposed is limited to a power density level of 1 milliwatt per square centimeter (1 mW/cm^2) averaged over any 30 minute period in an uncontrolled environment. Note that the worst-case radiation hazards exist along the beam axis. Under normal circumstances, it is highly unlikely that the antenna axis will be aligned with any occupied area since that would represent a blockage to the desired signals, thus rendering the link unusable and disabling the transmitter.

The Gogo ThinKom Ka-band system will typically operate above 15 degrees elevation. The main beam gain of the antenna will vary with elevation as shown in Table 1 below. The system is equipped with a 25 watt amplifier. The worst-case scenario, in terms of highest power density levels, involves the high elevation angle and has been presented here.

Table 1 - Earth Station Technical Parameter Table

Antenna Aperture major axis	0.444 meters
Antenna Surface Area	0.1873 sq. meters
Antenna Isotropic Gain	For 29.75 GHz: 36.5 dBi @45°, 34.3 dBi @ 30˚, 31.1 dBi @ 15˚
Number of Identical Adj. Antennas	1
Nominal Frequency	29.75 GHz
Nominal Wavelength (λ)	0.0102 meters
Maximum Transmit EIRP / Carrier	49.1 dBW
Number of Carriers	1
Total HPA Power	25 Watts
W/G Loss from Transmitter to Feed	1.4 dB
Total Feed Input Power	18.1 Watts
AES Terminal EIRP	49.1 dBW @45°
Near Field Limit	$R_{nf} = D^2/4\lambda$ = 4.64 meters
Far Field Limit	$R_{ff} = 0.6\ D^2/\lambda$ = 11.1 meters
Transition Region	Rnf to Rff

In the following sections, the power density in the above regions, as well as other critically important areas, will be calculated and evaluated. The calculations are done in the order discussed in OET Bulletin 65.

1.0 At the Antenna Surface

The power density at the antenna radiating surface can be calculated from the expression:

PD_{refl} = 4P/A = **49.29** mW/cm² (1)
Where: P = total power at feed, milliwatts
A = Total area of reflector, sq. cm

In the normal range of transmit powers for satellite antennas, the power densities at or around the reflector surface are expected to exceed safe levels. This area will not be accessible to the general public. Operators and technicians shall receive training specifying this area as a high exposure area. Procedures have been established that will assure that all transmitters are rerouted or turned off before access by maintenance personnel to this area is possible.

2.0 On-Axis Near Field Region

The geometrical limits of the radiated power in the near field approximate a cylindrical volume with a diameter equal to that of the antenna. In the near field, the power density is neither uniform nor does its value vary uniformly with distance from the antenna. For the purpose of considering radiation hazard it is assumed that the on-axis flux density is at its maximum value throughout the length of this region. The length of this region, i.e., the distance from the antenna to the end of the near field, is computed as Rnf above.

The maximum power density in the near field is given by:

$PD_{nf} = (16\varepsilon P)/(\pi D^2)$ = 12.12 mW/cm² (2) @45° Elevation
from 0 to 4.600 meters

Evaluation
Uncontrolled Environment: **Does Not Meet Uncontrolled Limits**
Controlled Environment: **Does not Meet Controlled Limits**

3.0 On-Axis Transition Region

The transition region is located between the near and far field regions. As stated in Bulletin 65, the power density begins to vary inversely with distance in the transition region. The maximum power density in the transition region will not exceed that calculated for the near field region, and the transition region begins at that value. The maximum value for a given distance within the transition region may be computed for the point of interest according to:

PD_t = $(PD_{nf})(R_{nf})/R$ = dependent on R (3)
where: PD_{nf} = near field power density
R_{nf} = near field distance
R = distance to point of interest
For: $4.64 < R < 11.1$ meters

We use Eq (3) to determine the safe on-axis distances required for the two occupancy conditions:

Evaluation

Uncontrolled Environment Safe Operating Distance,(meters), R_{su}: 56.2 m @45° elevation

Controlled Environment Safe Operating Distance,(meters), R_{sc}: 11.2 m @45° elevation

4.0 On-Axis Far-Field Region

The on- axis power density in the far field region (PD_{ff}) varies inversely with the square of the distance as follows:

PD_{ff} = $PG/(4\pi R^2)$ = dependent on R (4)
where: P = total power at feed
G = Numeric Antenna gain in the direction of interest relative to isotropic radiator
R = distance to the point of interest
For: $R > R_{ff}$ = 11.1 meters
PD_{ff} = **4.64.125** mW/cm² at R_{ff} @45° ,

We use Eq (4) to determine the safe on-axis distances required for the two occupancy conditions:

Evaluation

Uncontrolled Environment Safe Operating Distance,(meters), R_{su} : See Section 3
Controlled Environment Safe Operating Distance,(meters), R_{sc} : See Section 3

5.0 Off-Axis Levels at the Far Field Limit and Beyond

In the far field region, the power is distributed in a pattern of maxima and minima (sidelobes) as a function of the off-axis angle between the antenna center line and the point of interest. Off-axis power density in the far field can be estimated using the antenna radiation patterns prescribed for the antenna in use. This will correspond to the antenna gain pattern for an off-axis angle. For the Gogo antenna at 1.5 degrees off axis the antenna gain is:

G_{off} = 26.50 dBi at 1.5 degree @45°

Considering that satellite antenna beams are aimed skyward, power density in the far field will usually not be a problem except at low look angles. In these cases, the off-axis gain reduction may be used to further reduce the power density levels.

For example: At 1.5 degrees off axis at the far-field limit, we can calculate the power density as:

G_{off} = 26.50 dBi = 446.68 numeric @45° elevation

$PD_{1.5\ deg\ off\text{-}axis}$ = PD_{ff} x 446.68/G = 0.5827 mW/cm² (5)

6.0 Off-Axis power density in the Near Field and Transitional Regions

According to Bulletin 65, off-axis calculations in the near field may be performed as follows: assuming that the point of interest is at least one antenna diameter removed from the center of the main beam, the power density at that point is at least a factor of 100 (20 dB) less than the value calculated for the equivalent on-axis power density in the main beam. Therefore, for regions at least Deff meters away from the center line of the antenna, whether behind, below, or in front under of the antenna's main beam, the power density exposure is at least 20 dB below the main beam level as follows:

$PD_{nf(off\text{-}axis)} = PD_{nf} /100 =$ **1.2124** mW/cm² at D off axis (6) @45°

See Section 7 for the calculation of the distance vs. elevation angle required to achieve this rule for a given object height.

7.0 Evaluation of Safe Occupancy Area in Front of Antenna

The distance (S) from a vertical axis passing through the antenna center to a safe off axis location in front of the antenna can be determined based on the effective antenna diameter rule (Item 6.0). Assuming a flat area in front of the antenna, the relationship is:

S = (Deff/ sin α) + (2(h-GDeff) - Deff - 2)/(2 tan α) (7)

Where: α = minimum elevation angle of antenna
D = effective antenna diameter in meters
h = maximum height of object to be cleared, meters

For distances equal or greater than determined by equation (7), the radiation hazard will be below safe levels.

For	D =	0.433 meters
	h =	2.0 meters
	GD =	1 meters - elevated height of earth station above ground (min)
Then:		
	α	S
	15	0.9 meters
	25	0.6 meters
	35	0.4 meters
	45	0.4 meters

This is a fuselage mounted antenna, and all persons working on or near the antenna will be properly trained regarding radiation hazard. The antenna transmitter will be disabled any time work inside the radome is in progress.

8.0 Summary

The earth station site will be protected from uncontrolled access. The terminal is mounted under a radome, on the top of the aircraft fuselage, and it is pointed upward. The terminal may also be mounted on top of a test van. Access to the terminal will be limited to trained operations personnel. There will also be proper emission warning signs placed, and all operating personnel will be aware of the human exposure levels at and around the earth station. The applicant agrees to abide by the conditions specified in Condition 5208 provided below:

> *Condition 5208 - The licensee shall take all necessary measures to ensure that the antenna does not create potential exposure of humans to radiofrequency radiation in excess of the FCC exposure limits defined in 47 CFR 1.1307(b) and 1.1310 wherever such exposures might occur. Measures must be taken to ensure compliance with limits for both occupational/controlled exposure and for general population/uncontrolled exposure, as defined in these rule sections. Compliance can be accomplished in most cases by appropriate restrictions such as fencing. Requirements for restrictions can be determined by predictions based on calculations, modeling or by field measurements. The FCC's OET Bulletin 65 (available on-line at www.fcc.gov/oet/rfsafety) provides information on predicting exposure levels and on methods for ensuring compliance, including the use of warning and alerting signs and protective equipment for worker.*

The following table summarizes all of the above calculations:

Table - Summary of All RadHaz Parameters				ThinKom KA2517 Antenna
Parameter	Abbr.		Units	Formula
Antenna Elevation Angle Operation Scenario		@45°		
Antenna Dimensions	Dma	0.433	meters	major axis (azimuth)
Effective Aperture Diameter	Deff	0.43	meters	
Antenna Centerline	ACL	3.0	meters	Typically over 10 m
Antenna Surface Area	Sa	0.1873	$meters^2$	$(\pi * Deff^2)/ 4$
Frequency of Operation	f	29.75	GHz	
Wavelength	λ	0.0101	meters	c / f
HPA Output Power	P_{HPA}	25.00	watts	
HPA to Antenna Loss	L_{tx}	1.4	dB	3 dB OBO + 1 dB OCL
Transmit Power at Flange	P	12.58	dBW	$10 * Log(P_{HPA}) - L_{tx}$
Antenna Gain	G_{es}	36.50	dBi	Varies with elevation
		4466.8	n/a	
PI	π	3.1416	n/a	
Antenna Aperture Efficiency	η	24.60%	n/a	$G_{es} / (PI * Df /\lambda)^2$
Maximum EIRP	EIRP	49.1	dBi	Varies with elevation
1. Reflector Surface Region Calculations		@45°		
Reflector Surface Power Density	PDas	492.92	W/m^2	$(16 * P)/(\pi * Deff^2)$
Reflector Surface Power Density	PDas	**49.292**	mW/cm^2	**Does Not Meet Uncontrolled Limits**
				Does not Meet Controlled Limits
2. On-Axis Near Field Calculations		@45°		
Extent of Near Field	Rnf	4.639	meters	$Dma^2 / (4 *\lambda)$
Extent of Near Field	Rnf	15.22	feet	
Near Field Power Density	PDnf	121.24	W/m^2	$(16 * \eta * P)/ (\pi *Deff^2)$
Near Field Power Density	PDnf	12.124	mW/cm^2	**Does Not Meet Uncontrolled Limits**
				Does not Meet Controlled Limits
3. On-Axis Transition Region Calculations		@45°		
Extent of Transition Region (min)	Rtr	4.64	meters	$Dma^2 / (4 *\lambda)$
Extent of Transition Region (min)		15.22	feet	
Extent of Transition Region (max)	Rtr	11.13	meters	$(0.6 * Dma^2) /\lambda$
Extent of Transition Region (max)		36.52	feet	
Worst Case Transition Region Power Density	PDtr	121.24	W/m^2	$(16 *\eta * P)/ (\pi * Deff^2)$
Worst Case Transition Region Power Density	PDtr	**12.124**	mW/cm^2	**Does Not Meet Uncontrolled Limits**
		@45°		**Does not Meet Controlled Limits**
Uncontrolled Environment Safe Operating Distance	Rsu	56.2	m	=(PDnf)*(Rnf)/Rsu
Controlled Environment Safe Operating Distance	Rsc	11.2	m	=(PDnf)*(Rnf)/Rsc
4. On-Axis Far Field Calculations		@45°		
Distance to the Far Field Region	Rff	11.1	meters	$(0.6 * Dma^2) /\lambda$
		36.52	feet	
On-Axis Power Density in the Far Field	PDff	41.25	W/m^2	$(G_{es} * P) / (4 * \pi * Rf^2)$
On-Axis Power Density in the Far Field	PDff	**4.125**	mW/cm^2	**Does Not Meet Uncontrolled Limits**
				Meets Controlled Limits
5. Off-Axis Levels at the Far Field Limit and Beyond		@45°		
Reflector Surface Power Density	PDs	5.827	W/m^2	$(G_{es} * P) / (4 * \pi * Rf^2)*(Goa/Ges)$
Goa/Ges at example angle θ 1.5 degree		0.141		GoA approx 10 dB down at 1.5 deg

Off-Axis Power Density		0.5827	mW/cm^2	**Meets Uncontrolled Limits**
6. Off-axis Power Density in the Near Field and Transitional Regions Calculations				
6. Off-axis Power Density in the Near Field and Transitional Regions Calculations		@45°		
Power density 1/100 of Wn for one diameter removed	PDs	1.2124	W/m^2	((16 * η * P)/ (π *Deff^2))/100
		0.12124	mW/cm^2	**Meets Uncontrolled Limits**
7. Off-Axis Safe Distances from Earth Station				S = (Deff/ sin α) + 2(h - GD - 2)/(2 tan α)
α = minimum elevation angle of antenna			deg	
h = maximum height of object to be cleared, meters		2.0	m	
GD = Ground Elevation Delta antenna-obstacle		1.0	m	
		S		
15		0.9	m	
25		0.6	m	
35		0.4	m	
45		0.4	m	
Note: Maximum FCC power density limits for 14 GHz is 1 mW/cm^2 for general population/uncontrolled exposure as per FCC OE&T Bulletin No. 65, Edition 97-01 August 1997, Appendix A page 67.				

ANNEX 6:

Gogo Certifications

Gogo CA Licenses LLC ("Gogo"), in support of the foregoing ESAA application, hereby certifies as follows:

1. The Gogo ESAA terminal is self-monitoring and capable of automatically ceasing or reducing emissions within 100 milliseconds if the transmitter exceeds the relevant off-axis EIRP density limits.
2. Gogo's proposed ESAA operations will comply with all coordination agreements reached by the target satellite operator(s).

By: *<u>/s/ Timothy Joyce</u>*
Timothy Joyce
VP of RF Engineering, Gogo LLC
for Gogo CA Licenses LLC

October 6, 2020