THALES

Thales Avionics, Inc.

Ka-band Earth Station Aboard Aircraft (ESAA)

FCC Authorization Submission

Modification to IBFS File No. SESMFS2019042400544

Call Sign E170068

Technical Narrative

August 18, 2020

Table of Contents

1 Introduction

Thales Avionics, Inc. (“Thales”) seeks to modify its active Ka-band ESAA blanket license[1] authorizing ESAA operation over GSO FSS Ka-band capacity as follows:

1) Adding the Advanced Connectivity Terminal (ACT-A) ThinKom Ka 2517 earth station
2) Increasing uplink EIRP for all carriers and emission designators.

Thales Avionics currently has an active blanket license authorization to operate an ESAA earth station called the Modular Connectivity Terminals, Ka-band (MCT-A) with five FCC-authorized GSO satellites whose Ka-band spot beam coverage areas include CONUS, most of Canada, and portions of Mexico and the Caribbean region. The five points of communication are: AMC-15 (S2180) at 105.0° W.L., AMC-16 (S2181) at 85.0° W.L., Jupiter 1 (S2753) at 107.1° W.L., Jupiter 2 (S2834) at 97.1° W.L, and Telenor Norway satellite Thor-7 at orbital location 0.65° W.L. The ACT-A will also provide services to the all of the above-mentioned coverage areas with these five GSO satellites.

This modification request has been designed to meet the requirements set forth in 47 CFR §25.228 rules for Earth Stations in Motion (ESIM), §25.218 for FSS Ka-band Earth Stations, and §25.220 for non-standard earth stations, as well as FCC precedents set by previous Ka-band ESAA blanket license grants[2].

2 System Description

2.1 Overview

Thales’s Advance Connectivity Terminal (ACT-A) Ka-band terminal using the ThinKom Ka2517 ESAA will operate over the following five satellites, Hughes Jupiter 1 at 107.1° and Jupiter-2 at 97.1°, SES AMC-15 at 105.0° WL, AMC-16 at 85° WL, Thor-7 at 0.65° W.L., and in the Ka band 28.438-28.563 GHz, 29.3 – 30.0 GHz (uplink), and 18.3-19.3 GHz and 19.7 – 20.2 GHz (downlink).

2.1.1 Network Architecture

Thales’s Inter-Flight Connectivity (IFC) network operations will utilize Ka-band GSO satellite, connected hub satellite earth stations and the Hughes Jupiter platform baseband hub equipment, which will communicate with Hughes Jupiter aero modems on the aircraft. A high-level network architecture diagram is shown below in Figure 1. This architecture is very similar to that provided in Thales’s initial filings.

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[1] *See* IBFS File No. SES-LIC-20170217, Call Sign E170068, granted July 7, 2017

[2] *See* ViaSat Ka-band filing Call Sign E120075

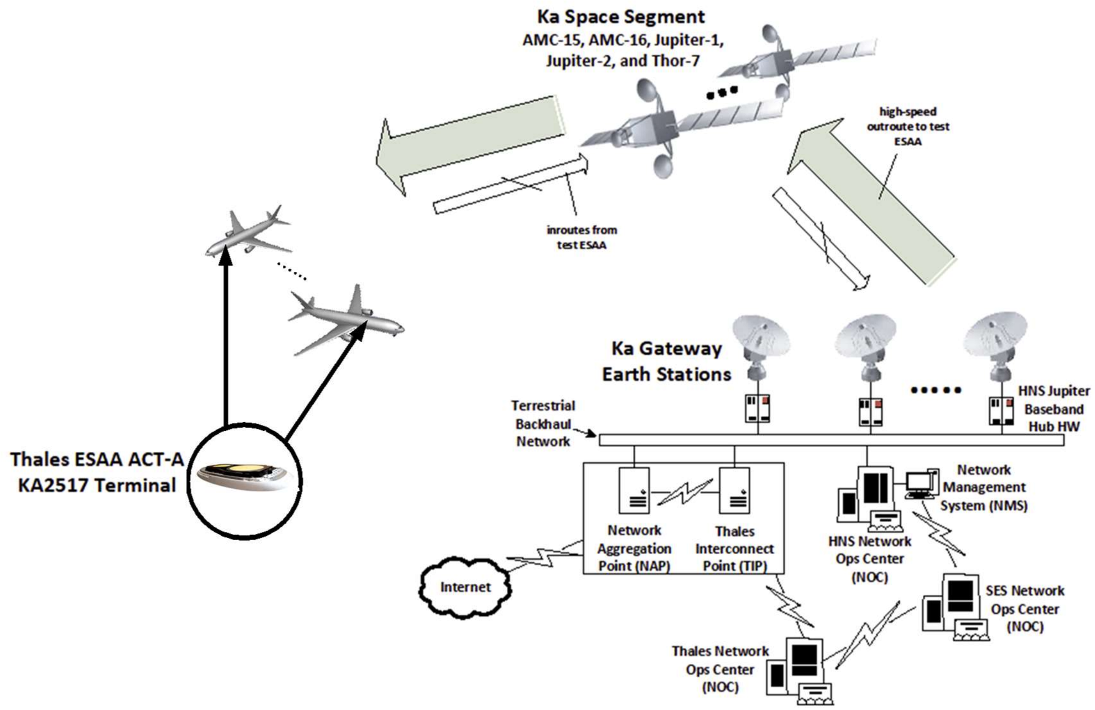


Figure 1 – Thales Aero Connectivity Network Architecture

The network is comprised of:

- a terrestrial IP backhaul network interconnecting the controlling Ka earth station gateways (detailed later in Section 2.4.2), and connecting the baseband hubs to the Virginia-based Network Aggregation Point (NAP) and Thales Interconnect Point (TIP)
- Ka space segment on five Ka-band GSO satellites.
- Thales Ka ESAAs, known as the Advanced Connectivity Terminals, Ka-band (ACT-A) including the Hughes Jupiter aero modem, installed on commercial aircraft

The SES Network Operations Center (NOC) in Bristow, VA remains as the primary NOC for the network. The SES NOC has real-time visibility into the Hughes Jupiter Network Management System (NMS) in Germantown, MD for management and control of every aero modem in the network (on aircraft) and the hub baseband instances (at gateways). The SES NOC also provides the Thales NOC in Orlando, FL with data that Thales requires to deliver and manage the overall service.

2.2 ESAA Segment Details

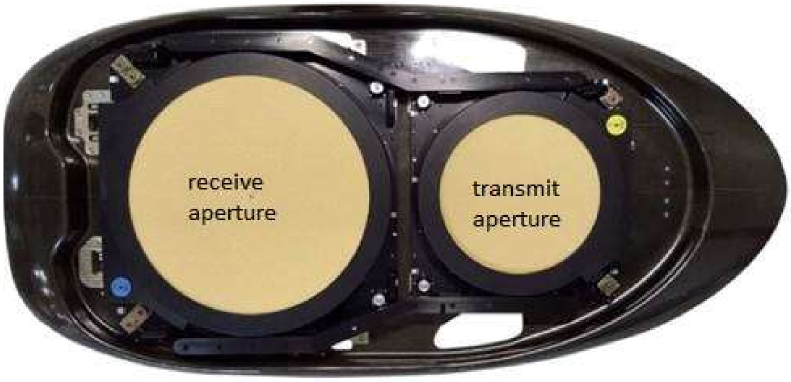
The operational details and specifications of the Thales ACT-A (ESAA) are provided below.

2.2.1 System Description

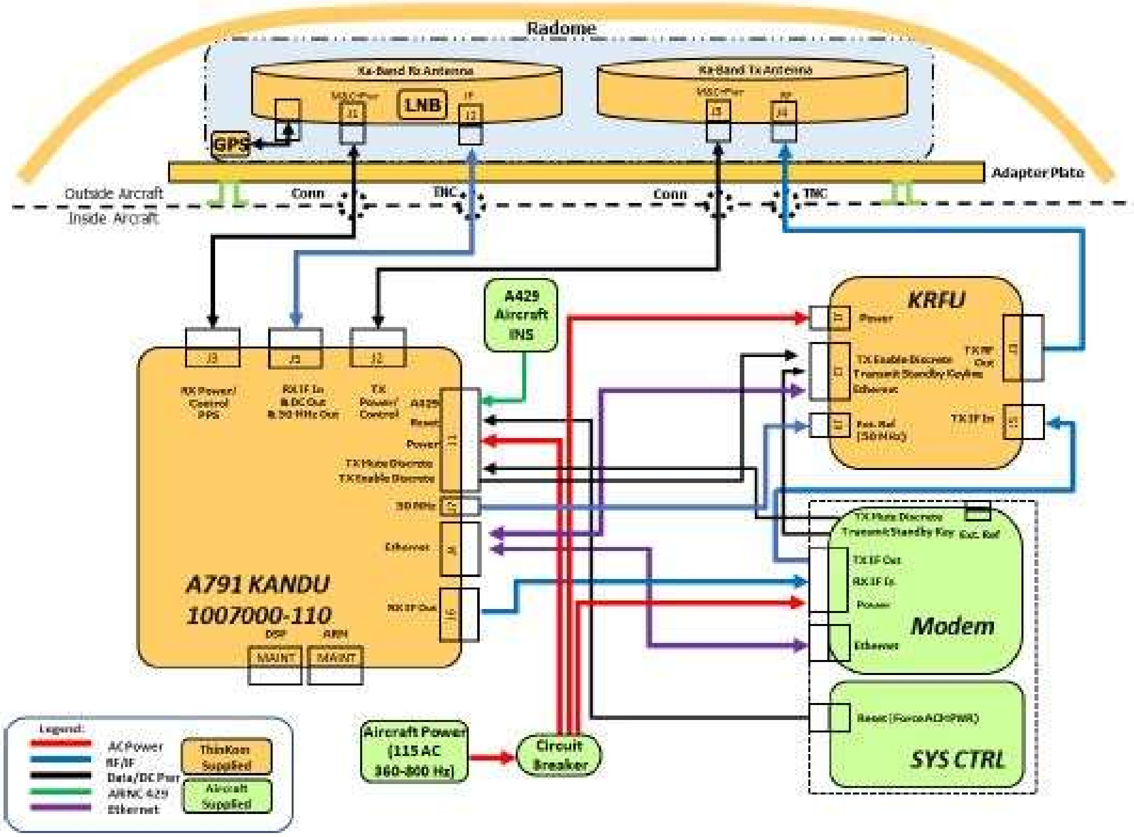
The Thales ACT-A terminal consists of:

- ThinKom Ka2517 antenna
- RF/IF Unit (KRFU)
- Antenna Control Unit (KANDU)
- Thales Modem Manager (TMM)

The ThinKom Ka2517 antenna is an array of 2 flat circular apertures, one for transmitting Ka-band signals and one for receiving, as shown in the picture below:



A block diagram of the ACT-A architecture onboard the aircraft is shown below:



Each aperture is made up of concentric, motorized rotating plates that steer the beams, and the apertures transmit and receive circularly polarized signals (switchable). A low-noise block converter (LNB) is located in the antenna unit, directly below the receive aperture.

The KRFU unit houses an IF-to-RF upconverter and a 25-watt solid-state power amplifier (SSPA).

The KANDU is the antenna control unit. It processes information it receives from the aircraft inertial navigation system (INS) and manages the exchange of the OpenAMIP discrete messages used for antenna pointing and tracking, transmit power control, and transmit muting/unmuting.

The TMM hosts the Hughes Jupiter aeronautical modem and terminal management functions of the ACT-A. In the forward channel direction (ground-to-aircraft), the modman demodulates the received IF signal it receives from the KANDU, and forwards IP packets via Ethernet to the on-board IFC system. In the return channel direction (aircraft-to-ground), user IP data from test PCs is encapsulated by software and proprietary firmware, then coded and modulated on an IF carrier, which is passed to the KRFU.

The ACT-A specifications are provided in Table 1 below.

Tx RF Parameter	**Performance (w/ Radome)**
Frequencies	27.5 GHz – 30.0 GHz
Antenna Coverage	360° in azimuth, 10-85° in elevation
Instantaneous Bandwidth	500 MHz
Axial Ratio (w/ Radome)	<2.5 dB typical (<29 dBW X-pol EIRP)
Polarization	Circular Switchable
EIRP (@29.5 GHz) typical[1]	49.0 dBW (P_{lin}, 85° elev)
	49.0 dBW (P_{lin}, 70° elev)
	48.0 dBW (P_{lin}, 45° elev)
	46.0 dBW (P_{lin}, 30° elev)
	44.5 dBW (P_{lin}, 20° elev)
	42.0 dBW (P_{lin}, 10° elev)
KRFU Output Flange Power	25 W (P_{lin}), 50 W (P_{sat})
KRFU Reference Signal	50 MHz
IF Input Frequency Range	950 – 1950 MHz
Beamwidth (@29.5 GHz)	<1.8° in ϕ
Sidelobe Suppression	1st E-Plane Sidelobe at least 12dB down from beam

[1] Assumes 2.5 dB SSPB-to-TX feed & interconnecting WG loss

Rx RF Parameter	**Performance (w/ Radome @ Cruise Altitude)**
Frequencies	17.8 GHz – 20.2 GHz
Antenna Coverage	360° in azimuth, 10-85° in elevation
Instantaneous Bandwidth	500 MHz (-1 dB DVB-S2)
Axial Ratio	<2.5 dB typical
Polarization	Circular Switchable
G/T (@19.7 GHz) typical	17.0 dB/K (85° elev)
	17.0 dB/K (70° elev)
	16.0 dB/K (45° elev)
	14.0 dB/K (30° elev)
	12.5 dB/K (20° elev)
	10.0 dB/K (10° elev)
LNB Reference Signal	50 MHz
IF Output Frequency Range	950 – 1950 MHz
Beamwidth (@19.7 GHz)	<1.8° in ϕ
Sidelobe Suppression	1st E-Plane Sidelobe at least 12dB down from beam

Table 1: Ka-band (ACT-A) Specifications

Antenna Pointing System Description

The ACT-A employs both closed-loop and open-loop pointing control to maintain a pointing accuracy of ≤ 0.2°.

The closed-loop pointing system uses INS information, data from gyroscopes located on the antenna, and sensor data from a received signal strength detector. A receive beam conical scan algorithm removes gyro drift to maintain antenna line-of-sight (LOS) stabilization, to keep the apertures peaked on the target satellite. The transmit antenna LOS, which is tightly calibrated to the receive antenna, is locked to the nominal center of the receive antenna conscan.

The electronics and software that monitor and control sensors and actuators update at a rate that allows detection and action to mute the transmitter within 100 milliseconds when required.

This system also contains a frequency-tracking beacon receiver and can utilize E_b/N_0 feedback from the modem to optimize operation in a high adjacent satellite interference (ASI) environment.

2.3 Space System

2.3.1 Satellite System List

Table 1 below provides the complete list of satellites to be used for Thales's ESAA operations. This list includes the Thor-7 satellite being requested as a new Point of Communication, and the four satellites already authorized in Thales's current ESAA blanket license[3]. Thales's ESAA services using these satellites will not use Ka spectrum in the LMDS band 29.1 – 29.25 GHz and per a coordination agreement with Iridium within the first 50 MHz of the MSS band between 29.25-29.3 GHz.

Satellite (Call Sign)	Satellite Operator	GSO Orbital Location (W.L.)	Transmit Spectrum (MHz)	Receive Spectrum (MHz)
Thor-7 (Norway Licensed) [4]	Telenor	0.65°	29500 – 30000	19700 – 20200
Jupiter-1 (S2753)	Hughes	107.1°	28350 – 29100 29250 – 30000	18300 – 19300 19700 – 20200
Jupiter-2 (S2968)	Hughes	97.1°	27850 – 29100 29250 – 30000	18300 – 19300 19700 – 20200
AMC-15 (S2180)	SES	105.05°	28350 – 28600 29500 – 30000	18638 – 18763 19700 – 20200
AMC-16 (S2181)	SES	85.0°	28350 – 28600 29500 – 30000	18638 – 18763 19700 – 20200

Table 1: Satellite List and Spectrum Details for Thales's ESAA Operations

Figure 1 through 5 below show the satellite coverage beams for the five satellites of interest. Also shown are the worst-case excursion with respect to skew and elevation angle for any terminal operating within these beams. A summary of these figures is outlined below:

- Figure 1 – The AMC-15 operating beams with worst case elevation of 25° and skew of 65°
- Figure 2 – The AMC-16 operating beams with worst case elevation of 15° and skew of 30°
- Figure 3 – The Jupiter-1 operating beams with worst case elevation of 30° and skew of 40°
- Figure 4 – The Jupiter-2 operating beams with worst case elevation of 30° and skew of 35°

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[3] *See* IBFS File No. SES-LIC-20170217, Call Sign E170068, granted July 7, 2017

[4] SES-MFS-20190424-00544 requested permanent authority to operate with Thor-7 as a point of communication and to add one new transmit emission designator and two new receive emissions. Accepted For Filing PN Date: 04/01/2020. Grant of Authority 08/17/2020 for Call Sign E170068.

- Figure 5 – The Thor-7 operating beams with worst case elevation of 15° and skew of 40°

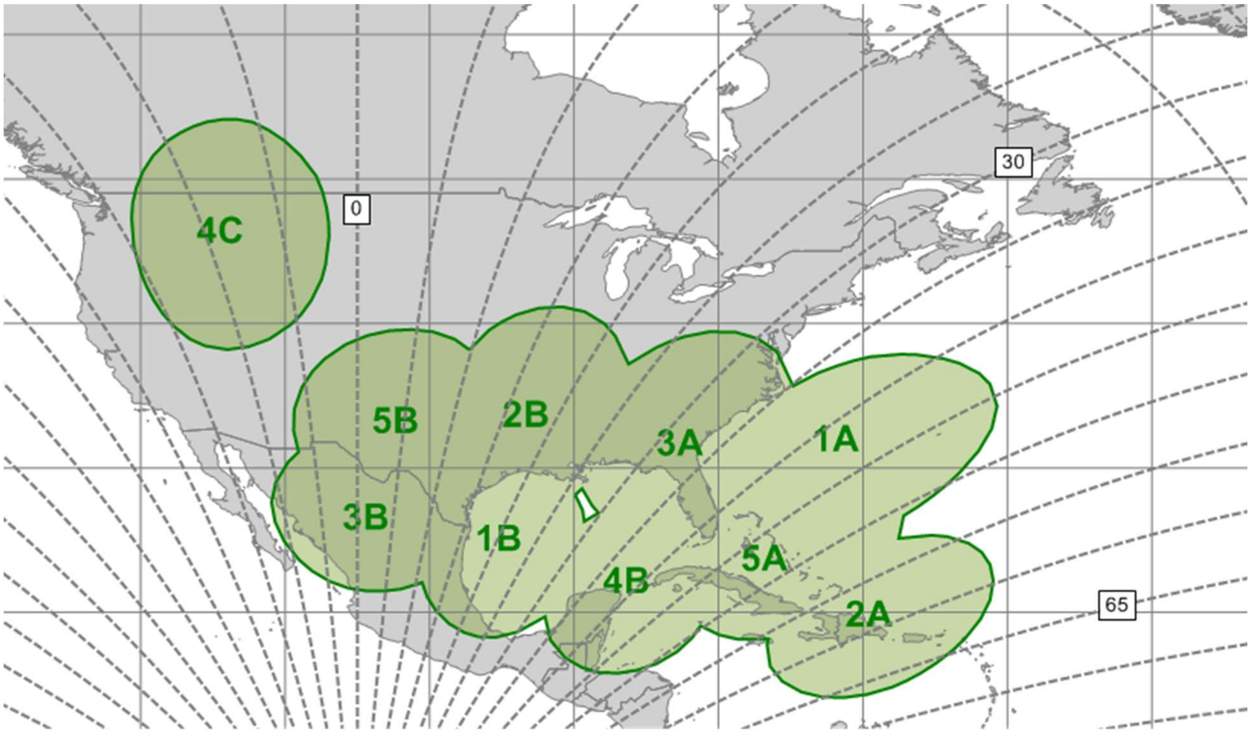

Figure 1: Thales ESAA Operating on AMC-15 - Worst Case Skew Angle of 65° and elevation 25° for Ka Spot Beams 1A, 2A, 3A, 5A, 1B, 2B, 3B, 4B, 5B

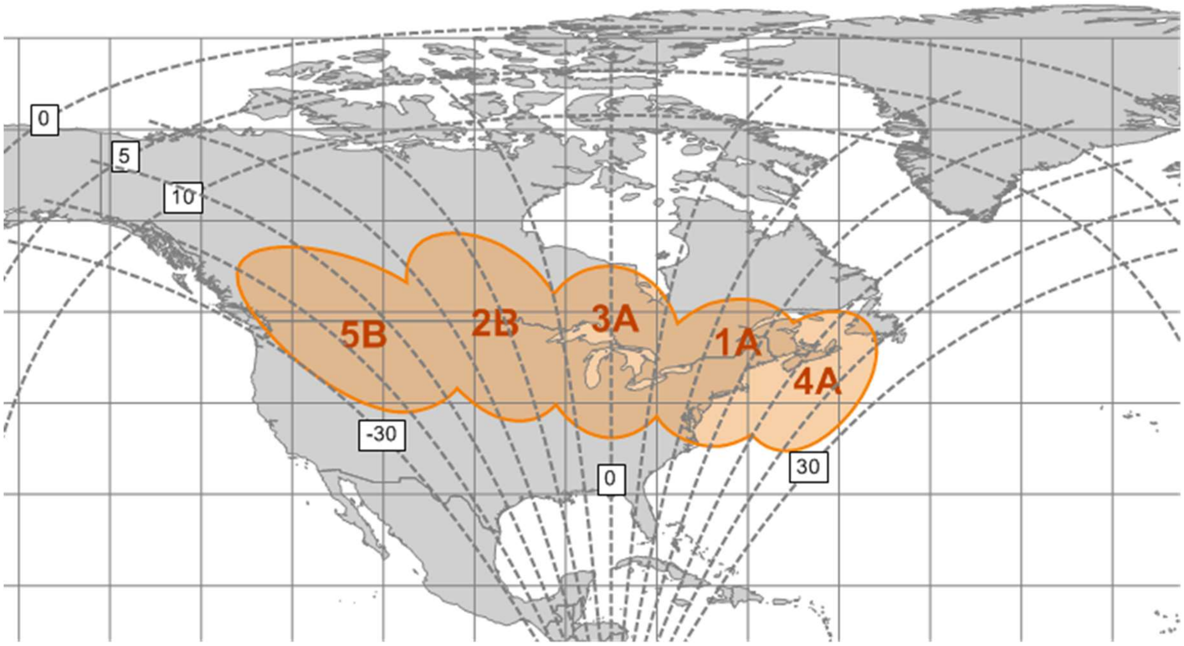

Figure 2: Thales ESAA Operating on AMC-16 - Worst Case Skew Angle of 30° and Elevation 15°, for Ka Spot Beams 1A, 2B, 3A, 4A, and 5B

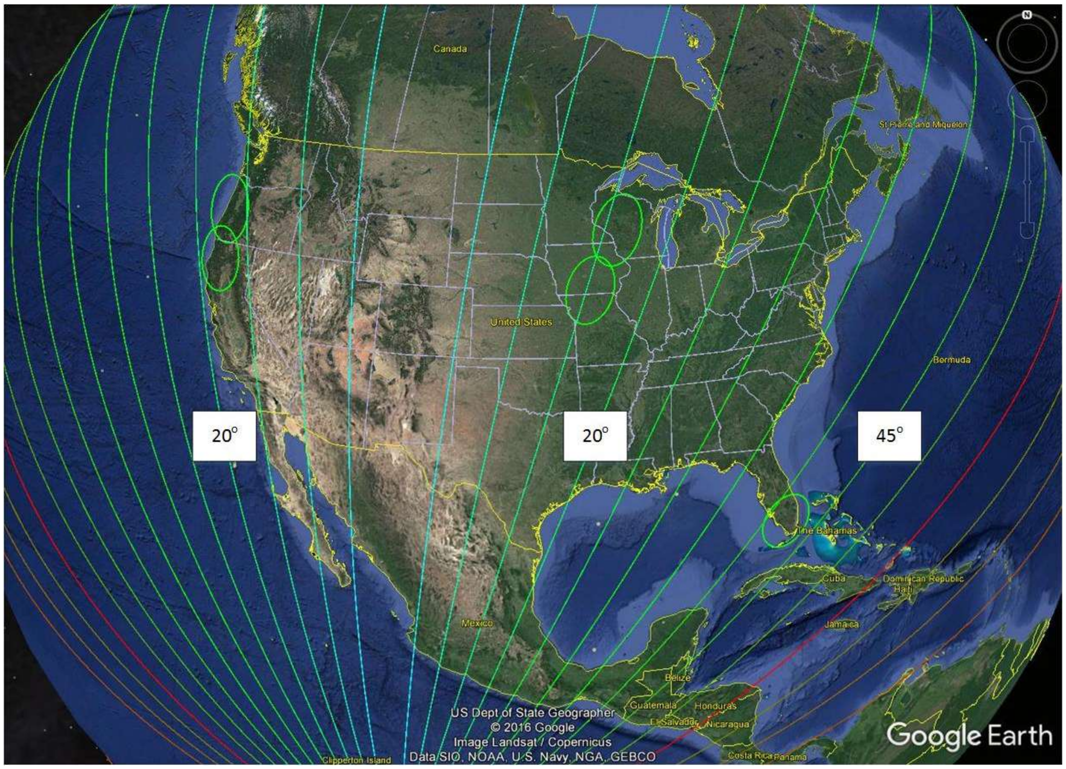

Figure 3: Thales's Jupiter-1 Coverage Area and Skew Angles (Worst-Case Skew 45°, Elevation 30°)

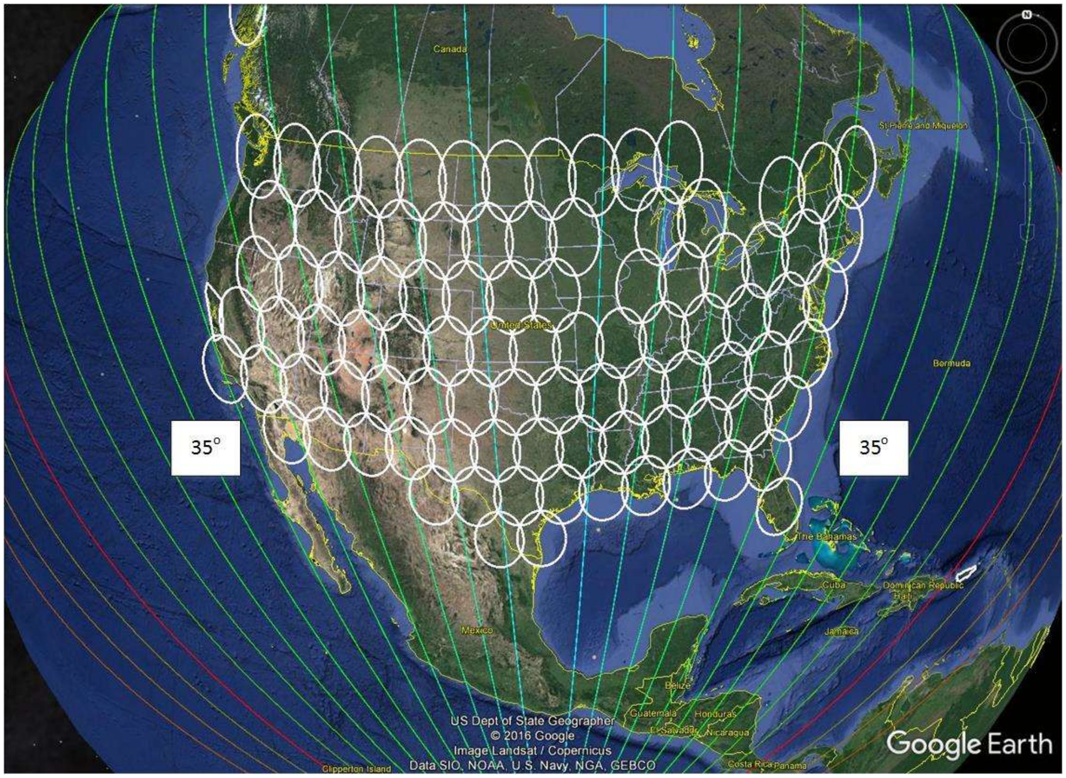

Figure 4: Jupiter-2 Coverage Area and Skew Angles (Worst-Case Skew 35°, Elevation 30°)

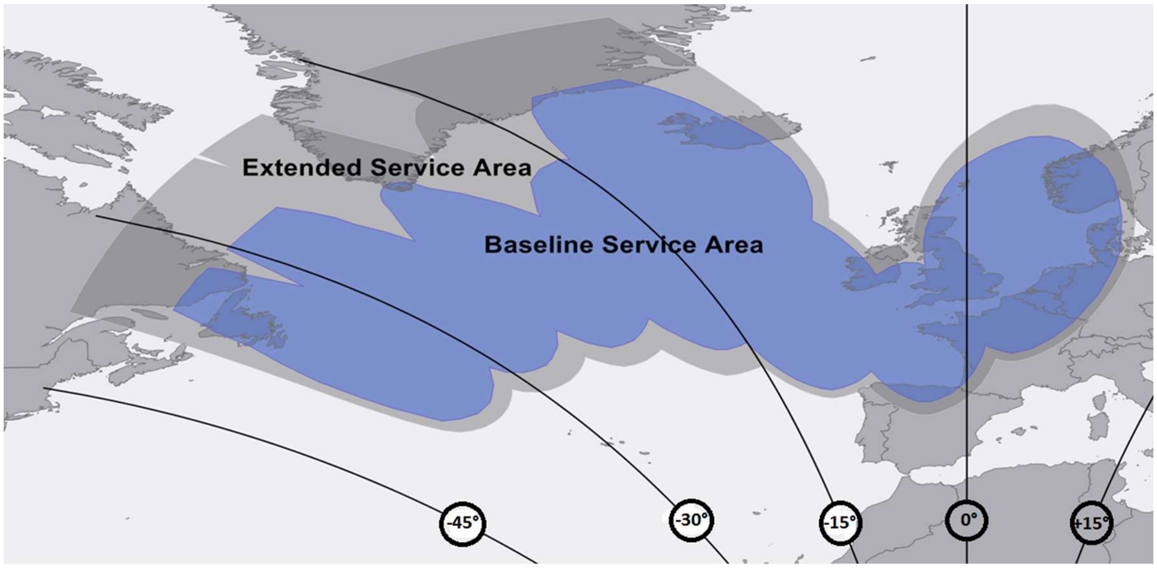

Figure 5: Thor-7 Coverage Area and Skew Angles for Thales ESAA Operation (Worst-Case Skew Angle of ~40°, Elevation 15°)

2.4 Ground Segment

2.4.1 Remote Control Network Operations Centers (NOCs)

The network operations centers (NOCs) as described in Thales's current authorization are not affected by this amendment request. The SES NOC remains as the primary NOC for this network:

SES Network Operations Center - Manassas
8000 Gainsford Court
Bristow, VA 20136

The SES NOC 24/7/365 phone number is +1 703-330-3305, Option 1

The Thales NOC is also responsible for overall management of the service and can be reached 24/7/365:

Thales Network Operations Center
7415 Emerald Dunes Drive, Suite 2000
Orlando, FL 32822

The Thales NOC phone number is 407-812-2538, and the email address is: MOC@us.thalesgroup.com

2.4.2 Network Gateway Earth Stations

Thales's service will use FCC-licensed hub antennas at the gateway earth stations to communicate with AMC-15 and AMC-16. Full remote control of the ESAA terminals and the network will be possible from the Thales NOC. Satellite specific hub earth stations are identified below:

AMC-15 Earth Stations:

9815 West Hallett Road
Spokane, WA 99224
FCC callsign E040572

SES Washington Media Port
8000 Gainsford Court
Bristow, VA 20136

AMC-16 Earth Stations:

AMV Westar
777 Westar Lane
Cedar Hill, TX 75104

Media Networks Services
13619 Cabezut Drive (Unitec Industrial)
Laredo, TX 78045

Jupiter 1 and Jupiter 2:

Thales's service will use Hughes's authorized gateway hub antennas to communicate with Jupiter-1 and Jupiter-2. Full remote control of the ESAA terminals and the network will be possible from the Thales NOC.

Thor-7:

Thales's service over Thor-7 will use Telenor's authorized gateway earth station antennas for Earth-to-space uplinks and space-to-Earth downlinks between the gateways and the satellite. Full remote control of the ESAA terminals and the network is possible from the Thales NOC.

2.5 ACT-A Necessary Emission Designators and Power

The waveforms and capabilities of the return link (inbound) channels and the forward link (outbound) channels as detailed in Thales's current authorization are not changing as a result of this modification request. However, Thales's ESAA operations is requesting require higher power for the return channel (from ESAA). This is due to the superior performance of the ATC-

A Terminal. Full details on all the carriers requested are shown i in Table 2 below and in the Form 312 submitted with this modification request. Note the gateway operations are not included in this FCC filing and have been granted under separate FCC authorizations.

Link	**Emission Designator**	**Carrier Symbol Rate (Msps)**	**Carrier EIRP**		**Frequency Spectrum (MHz)**	
			dBW	**dBW/4 kHz**	**Earth-to-Space**	**Space-to-Earth**
ESAA Return (Inbound)	1M00G7D	1.0	43.0	19.0	29500 – 30000	19700-20200
ESAA Return (Inbound)	2M05G7D	2.05	46.1	19.0	29500 – 30000, 28438 - 28563	18300 – 19300, 19700 - 20200
ESAA Return (Inbound)	4M10G7D	4.1	49.1	19.0	29500 – 30000, 28438 - 28563	18300 – 19300, 19700 - 20200
ESAA Return (Inbound)	6M10G7D	6.1	49.1	19.4	29500 – 30000	18300 – 19300, 19700 - 20200
Gateway Forward (Outbound)	11M4G7D	11.4	55.3	31.3	28483 – 28975	19700 – 20200
Gateway Forward (Outbound)	22M8G7D	22.8	58.3	34.3	28483 – 28975	19700 – 20200

Table 2: Carriers and Carrier EIRP Density Levels for ACT-A ESAA Operation

Link budgets provided in Exhibit B of this narrative confirm that the power density level of the new return carrier is equal to highest level in Thales's current authorization.

2.5.1 NOC Monitoring and Control

At all times the SES NOC and the Thales NOC will monitor and have control of the transmission parameters of all Thales ESAA operating in the network on all satellites, including the ability to remotely disable terminals in the event of harmful interference.

3 Protection of Other Services

3.1 Protection of Other Ka-band Services

3.1.1 GSO

Thales intends to operate its ESAA network compliant with FCC rule parts 25.228, 25.218, and 25.220. Specifically, the ACT-A terminal will comply with the EIRP Special Density requirements specified in 25.218(i)(1)-(5). Thales has worked with SES, Hughes, and Telenor to ensure that the off-axis emissions will comply with all applicable inter-satellite coordination agreements (see Exhibit C). The Thales system can limit emission power relative to the terminal's elevation and skew angle. For many such positions the terminal can achieve a maximum emission of 43 dBW/MHz, which is the highest EIRP spectral density requested in this filing. For other, more extreme, skew and elevation angles, Thales will limit the ESD as shown in the sections below.

3.1.1.1 AMC-15 Off-Axis EIRP Spectral Density

On AMC-15, Thales will limit their ESAA operation for the worst-case skew angle of 65° and elevation angle of 45° for off-axis EIRP emission in the GSO plane, as shown below in Figure 6.

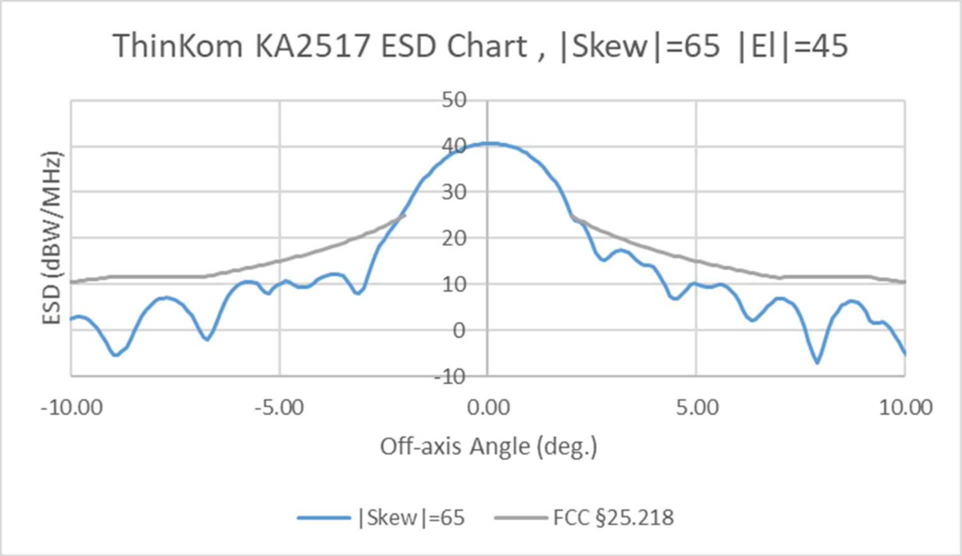

Figure 6 – AMC-15 Skew = 65 degrees and Elevation = 45 degrees ESD. The chart represents a highest power level of 40.4 dBW/MHz (16.4 dBW/4kHz). Thales system will limit power to this level when at this position.

3.1.1.2 AMC-16 Off-Axis EIRP Spectral Density

Thales ESAA operation on AMC-16 at 85° W.L. will utilize spot beams covering northern USA and southern Canada. As shown in Figure 7 below the worst-case skew angles will be around 30 degrees with a corresponding elevation angle of 15 degrees. Thales will maintain their uplink EIRP densities to comply with the limits set in §25.1218(i)(1) or the coordination agreements set by their satellite operator.

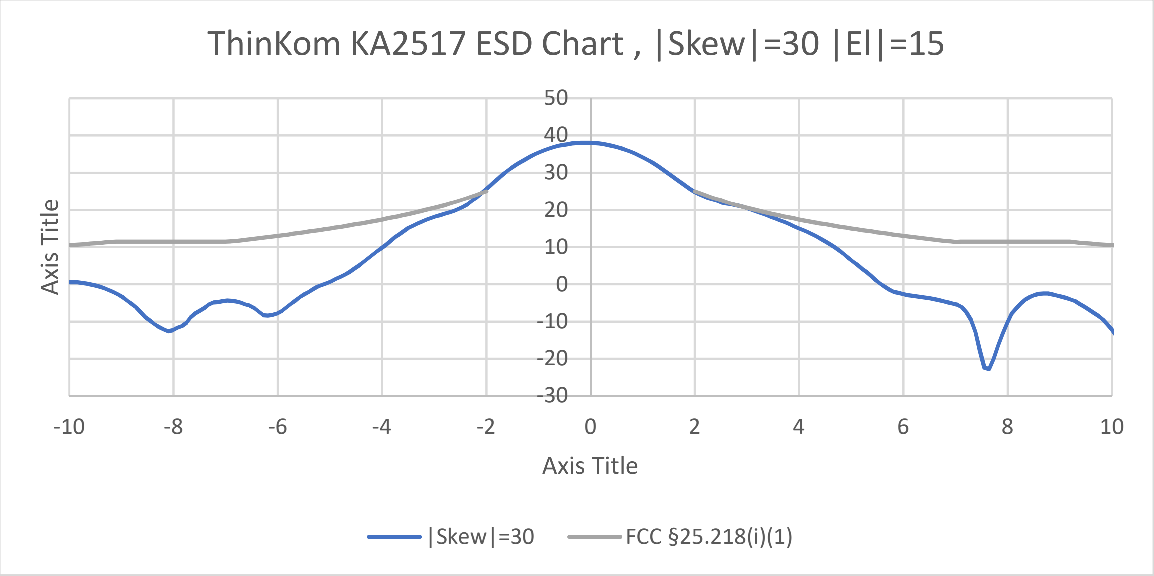

Figure 7 – AMC-16 worst case ESD operation. The highest power level for this operation is 38.1 dBW//MHz (14.1 dBW/4kHz)

3.1.1.3 Jupiter-1 Off-Axis EIRP Spectral Density

On Jupiter-1, Thales will limit their ESAA operation to the worst-case skew performance at a skew angle of 45° and corresponding elevation angle of 30° for off-axis EIRP emission in the GSO plane, as shown in Figure 8 below.

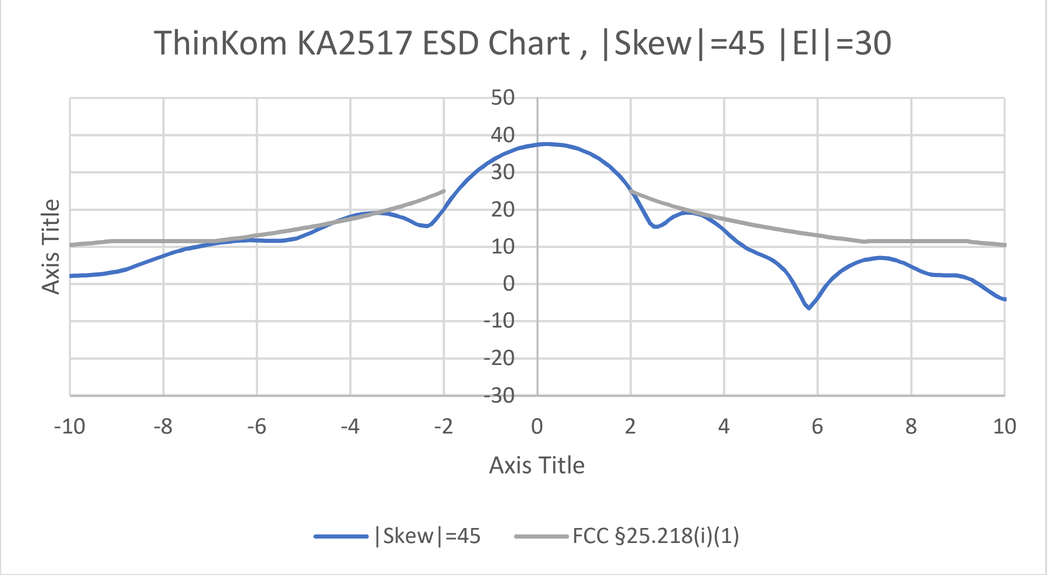

Figure 8 – Worst-case ESD for skew and elevation angles for Jupiter-1. In order to operate within the 25.218 ESD mask Thales will limit maximum EIRP Spectral Density to 37.6 dBW/MHz (13.6 dBW/4kHz) when operating at this position.

3.1.1.4 Jupiter-2 Off-Axis EIRP Spectral Density

As shown earlier in Figure 5, Thales ESAA operation on Jupiter-2 at orbital location 97.1° W.L. will utilize spot beams covering most of CONUS, and will be limited to a worst-case skew angle of 35° with corresponding elevation angle of 30°.

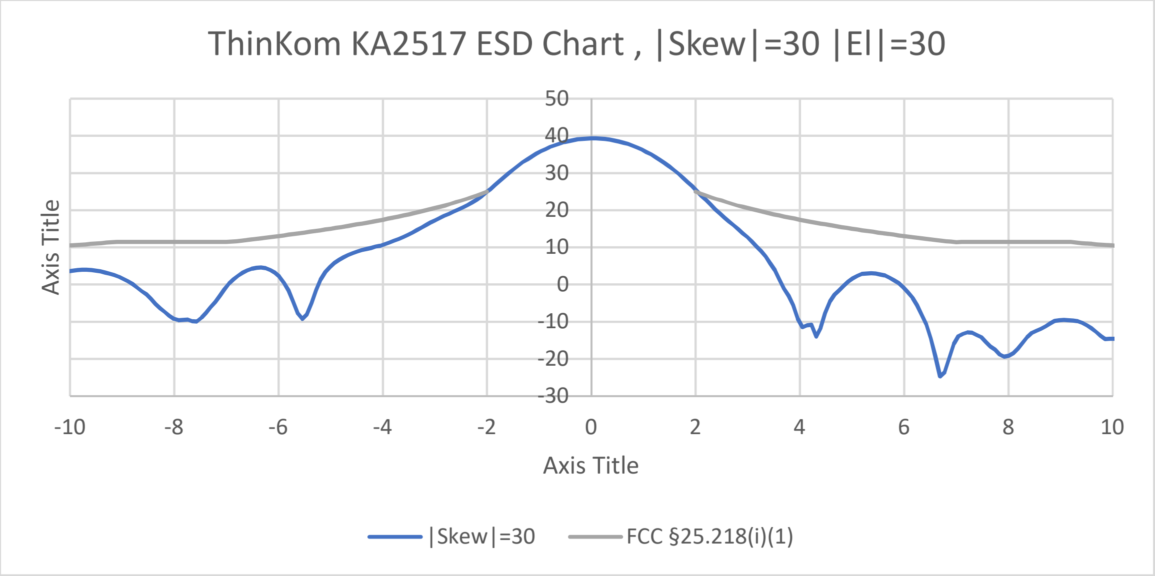

Figure 9 – Worst-case ESD for skew and elevation angles for Jupiter-2. Thales will limit power to 39.3 dBW/MHz (14.3 dBW/4kHz) when operating at this worst-case position.

3.1.1.5 Thor-7 Off-Axis EIRP Spectral Density

On Thor-7, Thales will limit their ESAA operation to the worst-case skew angle of 40° with corresponding elevation angle of 15° for off-axis EIRP emission in the GSO plane.

The plots below in Figure 10.

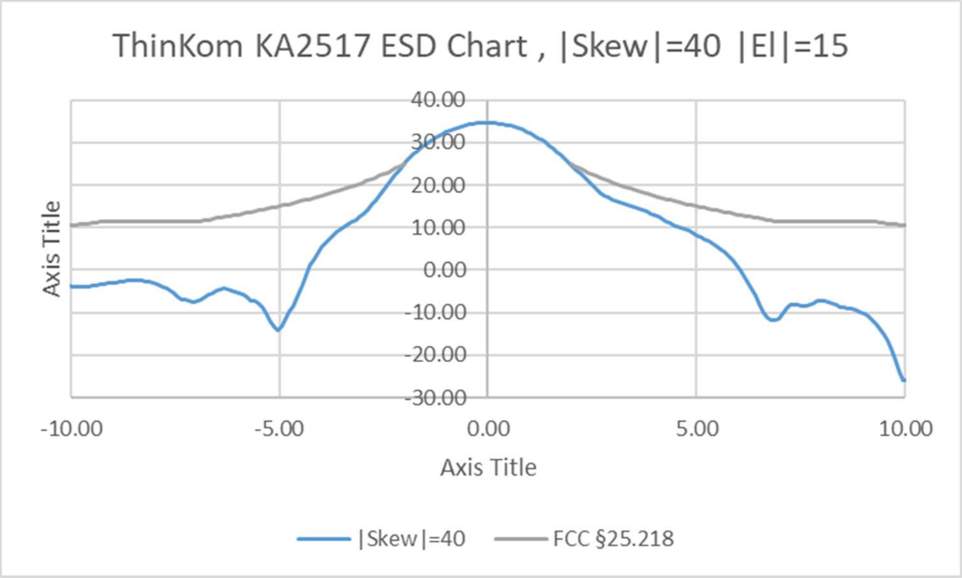

Figure 10 – Worst-case operation on Thor-7. The Thales system will limit power to 36.1 dBW/MHz when operating at this elevation and skew angle.

3.1.2 Protection of NGSO Systems

For operation on AMC-15, AMC-16, Jupiter 1, Jupiter-2, and Thor-7 Thales does not intend to operate in spectrum allocated to NGSO systems. The NGSO transmit band is 28.6-29.1 GHz[5]. Thales will only operate between 28.438 – 28.563 GHz in the lower band and 29.5 – 30.0 GHz in the upper portion of the band. Thales agrees to coordinate with any authorized NGSO users in the GSO band which may be impacted by their ESAA operation. At the time of this filing there appears to be one such NGSO system authorized to use 28.438-28.563 GHz portion of the band which will not overlap with the Thales operational spectrum[6]. Thales agrees to coordinate with any users of this band as is required in the future.

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[5] See, e.g., Redesignation of the 17.7-19.7 GHz Frequency Band, Blanket Licensing of Satellite Earth Stations in the 17.7-20.2 GHz and 27.5-30.0 GHz Frequency Bands, and the Allocation of Additional Spectrum in the 17.3-17.8 GHz and 24.75-25.25 GHz Frequency Bands for Broadcast Satellite-Serv. Use, 16 FCC Rcd 19808, at ¶ 23 (2001)

[6] O3B is currently authorized to operate in the 28.35-28.4 GHz band, see FCC File No.1 SES-LIC-20100723-00952. This upper band edge is below the Thales lower band edge of 28.438 GHz.

3.1.3 Protection of LMDS Systems

The nearest allocation for LMDS service is 27.5 – 28.350 GHz[7] and, as noted in Section 3.1.2 above, Thales will not operate within this band.

3.1.4 Protection of Mobile Satellite Systems at Ka-band

For ESAA operations on all satellites, Thales does not intend to operate in the 29.25 – 29.3 GHz band, which is allocated to GSO FSS and NGSO MSS feeder links on a co-primary basis.

3.1.5 Radiation Hazard Study

A radiation hazard study provided is provided in Exhibit D.

3.2 List of Exhibits

The following four exhibits are provided in this document:

- Exhibit A contains the link budgets for ACT-A Terminal for all points of communication.
- Exhibit B contains the certification letters for the ACT-A Terminal.
- Exhibit C contains the compliance tables for §25.228, §25.218, and §25.220.
- Exhibit D contains the radiation hazard study.
- Exhibit E contains the receive and transmit antenna gain and EIRP spectral density (ESD) plots and tables for the elevation angles 15 and 45 degrees for skew angles 0. 15, 40, and 75 degrees.

4 Conclusion

The grant of this license modification will serve the public interest by enabling Thales to enhance their ESAA services using the ACT-A terminal which will be utilized by commercial airlines, their passengers, and crew, in a manner fully consistent with the FCC rules. As such, Thales respectfully requests grant of this license modification.

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[7] Rulemaking to Amend Parts 1, 2, 21, and 25 of the Commission's Rules to Redesignate the 27.5-29.5 GHz Frequency Band, to Reallocate the 29.5-30.0 GHz Frequency Band, to Establish Rules and Policies for Local Multipoint Distribution Service and for Fixed Satellite Services, First Report and Order, 11 FCC Rcd 19005 ¶ 85 (1996).

5 Exhibit A – Link Budgets

		AMC-15 - Return Link Budget
General Parameters		
Orbital location	°E.L.	-105.05
Uplink Frequency	MHz	29687.5
Downlink Frequency	MHz	20012.5
Transmit Earth station		
Antenna diameter	m	0.43
Antenna elevation angle	degrees	48.5
Antenna Gain	dBi	38.80
Earth station transmit EIRP/carrier	dBW	49.1
Pointing loss	dB	0.25
Receive earth station		
Antenna diameter	m	9.10
Antenna elevation angle	degrees	34.2
Rx E/S G/T clear sky	dB/K	38.7
Receive pointing loss	dB	0.25
Carrier		
Information rate	Mbps	4.000
FEC Coding		1/2
Modulation		OQPSK
Symbol rate	Msps	4.000
Allocated bandwidth	MHz	5.000
Uplink		
Uplink path loss	dB	213.3
Uplink atmospheric loss	dB	0.54
C/N uplink	dB-Hz	5.0
C/I Uplink Prior to ASI	dB-Hz	30.0
On-axis power spectral density	dBW/4 kHz	-24.9
Downlink		
Downlink atmospheric loss	dB	0.36
Downlink path loss	dB	210.1
Carrier downlink EIRP at BC	dBW	34.5
Downlink EIRP density at beam peak	dBW/Hz	-29.02
C/N downlink	dB-Hz	25.3
C/I Downlink Prior to ASI	dB-Hz	11.5
End-to-End		
C/I adjacent spacecraft interference:	dB-Hz	19.6
C/(N+I) total:	dB-Hz	4.0
Link margin:	dB	1.0

6 Exhibit B – Satellite Operator Certification Letters

The certification letters are being provided by SES, Hughes, and Telenor for all satellites of interest. These letters will be submitted to the FCC when received by the operators.

7 Exhibit C - §25.228, §25.218, and §25.220 Rules Compliance Tables

FCC Rules 25.228 Compliance Table		
Rule Part	**Description**	**Comments**
25.228(a)	(a) ESIM transmissions must comport with the applicable EIRP density limits in §25.218, unless coordinated pursuant to the requirements in §25.220.	Will comply, with Certification Letters per 25.220
25.228(b)	(b) Each ESIM must be self-monitoring and, should a condition occur that would cause the ESIM to exceed its authorized off-axis EIRP density limits, the ESIM must automatically cease transmissions within 100 milliseconds, and not resume transmissions until the condition that caused the ESIM to exceed those limits is corrected.	Comply Section 2.2.1
25.228(c)	(c) Each ESIM must be monitored and controlled by a network control and monitoring center (NCMC) or equivalent facility. Each ESIM must comply with a “disable transmission” command from the NCMC within 100 milliseconds of receiving the command. In addition, the NCMC must monitor the operation of each ESIM in its network, and transmit a “disable transmission” command to any ESIM that operates in such a way as to exceed the authorized off-axis EIRP density limit for that ESIM or for all ESIMs that simultaneously transmit on the same frequency to the same target satellite receiving beam. The NCMC must not allow the ESIM(s) under its control to resume transmissions until the condition that caused the ESIM(s) to exceed the authorized EIRP density limits is corrected.	Comply Section 2.2.1
25.228(d)	(d) ESIM licensees must ensure installation of ESIM terminals on vehicles by qualified installers who have an understanding of the antenna's radiation environment and the measures best suited to maximize protection of the general public and persons operating the vehicle and equipment. An ESIM terminal exhibiting radiation exposure levels exceeding 1.0 mW/cm2 in accessible areas, such as at the exterior surface of the radome, must have a label attached to the surface of the terminal warning about the radiation hazard and must include thereon a diagram showing the regions around the terminal where the radiation levels could exceed the maximum radiation exposure limit specified in 47 CFR 1.1310 Table 1.	Comply Exhibit D

25.228(e)	(e) The following requirements govern all ESV operations:	N/A
25.228(f)	(f) For all VMES operations, there must be a point of contact in the United States, with phone number and address, available 24 hours a day, seven days a week, with authority and ability to cease all emissions from the VMESs.	N/A
25.228(g)	(g) The following requirements govern all ESAA operations:	
25.228(g)(1)	(1) There must be a point of contact in the United States, with phone number and address, available 24 hours a day, seven days a week, with authority and ability to cease all emissions from the ESAAs.	Comply, Section 2.4.1
25.228(g)(2)	(2) All ESAA terminals operated in U.S. airspace, whether on U.S.-registered civil aircraft or non-U.S.-registered civil aircraft, must be licensed by the Commission. All ESAA terminals on U.S.-registered civil aircraft operating outside of U.S. airspace must be licensed by the Commission, except as provided by section 303(t) of the Communications Act.	Comply
25.228(g)(3)	(3) Prior to operations within a foreign nation's airspace, the ESAA operator must ascertain whether the relevant administration has operations that could be affected by ESAA terminals, and must determine whether that administration has adopted specific requirements concerning ESAA operations. When the aircraft enters foreign airspace, the ESAA terminal must operate under the Commission's rules, or those of the foreign administration, whichever is more constraining. To the extent that all relevant administrations have identified geographic areas from which ESAA operations would not affect their radio operations, ESAA operators may operate within those identified areas without further action. To the extent that the foreign administration has not adopted requirements regarding ESAA operations, ESAA operators must coordinate their operations with any potentially affected operations.	Comply
25.228(i)	(i) For ESAA transmissions in the 14.0-14.5 GHz band from international airspace within line-of-sight of the territory of a foreign administration where fixed service networks have primary allocation in this band, the maximum power flux density (pfd) produced at the surface of the Earth by emissions from a single aircraft carrying an ESAA terminal must not exceed the following values unless the foreign Administration has imposed other conditions for protecting its fixed service stations:	N/A

25.228(j)	(j) The following requirements govern all ESIMs transmitting to GSO satellites in the Fixed-Satellite Service in the 14.0-14.5 GHz band:	N/A

Compliance Matrix §25.218 Off-axis EIRP density envelopes for FSS earth stations transmitting in certain frequency bands.

Rule Part	Description	Comments
25.218(a)	(a) This section applies to applications for fixed and temporary-fixed FSS earth stations transmitting to geostationary space stations in the conventional C-band, extended C-band, conventional Ku-band, extended Ku-band, or conventional Ka-band, and applications for ESIMs transmitting in the conventional C-band, conventional Ku-band, or conventional Ka-band, except for applications proposing transmission of analog command signals at a band edge with bandwidths greater than 1 MHz or transmission of any other type of analog signal with bandwidths greater than 200 kHz.	
25.218(b)	(b) Earth station applications subject to this section may be routinely processed if they meet the applicable off-axis EIRP density envelopes set forth in this section.	
25.218(c)(1)	(c) *Analog earth station operation in the conventional or extended C-bands.* (1) For co-polarized transmissions in the plane tangent to the GSO arc, as defined in §25.103:	N/A
25.218(d)(1)	(d) *Digital earth station operation in the conventional or extended C-bands.* (1) For co-polarized transmissions in the plane tangent to the GSO arc:	N/A
25.218(e)(1)	(e) *Analog earth station operation in the conventional Ku-band.* (1) For co-polarized transmissions in the plane tangent to the GSO arc:	N/A
25.218(f)(1)	(f) *Digital earth station operation in the conventional Ku-band.* (1) For co-polarized transmissions in the plane tangent to the GSO arc:	N/A
25.218(g)(1)	(g) *Analog earth station operation in the extended Ku-band.* (1) For co-polarized transmissions in the plane tangent to the GSO arc:	N/A
25.218(h)(1)	(h) *Digital earth station operation in the extended Ku-band.* (1) For co-polarized transmissions in the plane tangent to the GSO arc:	N/A

25.218(i)(1)	(i) *Digital earth station operation in the conventional Ka-band.* (1) For co-polarized transmissions in the plane tangent to the GSO arc:	See Section 3.1
	32.5-25log(θ) dBW/MHz for 2.0° ≤ θ ≤ 7°.	
	11.5 dBW/MHz for 7° ≤ θ ≤ 9.2°.	
	35.5-25log(θ) dBW/MHz for 9.2° ≤ θ ≤ 19.1°.	
	3.5 dBW/MHz for 19.1° < θ ≤ 180°.	
	where θ is as defined in paragraph (c)(1) of this section.	
25.218(i)(2)	(2) For co-polarized transmissions in the plane perpendicular to the GSO arc:	
	35.5-25log(θ) dBW/MHz for 3.5° ≤ θ ≤ 7°.	
	14.4 dBW/MHz for 7° < θ ≤ 9.2°.	
	38.5-25log(θ) dBW/MHz for 9.2° < θ ≤ 19.1°.	
	6.5 dBW/MHz for 19.1° < θ ≤ 180°.	
	where θ is as defined in paragraph (c)(1) of this section.	
25.218(i)(3)	(3) The EIRP density levels specified in paragraphs (i)(1) and (2) of this section may be exceeded by up to 3 dB, for values of θ > 7°, over 10% of the range of theta (θ) angles from 7-180° on each side of the line from the earth station to the target satellite.	
25.218(i)(4)	(4) For cross-polarized transmissions in the plane tangent to the GSO arc and in the plane perpendicular to the GSO arc:	
	22.5-25log(θ) dBW/MHz for 2.0° < θ ≤ 7.0°.	
	where θ is as defined in paragraph (c)(1) of this section.	
25.218(i)(5)	(5) A license application for earth station operation in a network using variable power density control of earth stations transmitting simultaneously in shared frequencies to the same target satellite receiving beam may be routinely processed if the applicant certifies that the aggregate off-axis EIRP density from all co-frequency earth stations transmitting simultaneously to the same target satellite receiving beam, not resulting from colliding data bursts transmitted pursuant to a contention protocol, will not exceed the off-axis EIRP density limits permissible for a single earth station, as specified in paragraphs (i)(1) through (4) of this section.	N/A
25.218(j)	(j) Applications for authority for fixed earth station operation in the conventional C-band, extended C-band, conventional Ku-band, extended Ku-band, or conventional Ka-band that do not qualify for routine processing under relevant criteria in this	Comply, see 25.220 Compliance Chart in this Exhibit

	section, §25.211, or §25.212 are subject to the requirements in §25.220.	

Compliance Matrix §25.220 Non-routine transmit/receive earth station operations.

Rule Part	Description	Comments
25.220(a)	(a) The requirements in this section apply to applications for, and operation of, earth stations transmitting in the conventional or extended C-bands, the conventional or extended Ku-bands, or the conventional Ka-band that do not qualify for routine licensing under relevant criteria in §25.211, §25.212, or §25.218.	Understand
25.220(b)	(b) Applications filed pursuant to this section must include the information required by §25.115(g)(1).	See Section 2 and FCC Form 312
25.220(c)	(c) [Reserved]	
25.220(d)(1)	(d)(1) The applicant must submit the certifications listed in paragraphs (d)(1)(i) through (d)(1)(iv) of this section. The applicant will be authorized to transmit only to the satellite systems included in the coordination agreements referred to in the certification required by paragraph (d)(1)(ii) of this section. The applicant will be granted protection from receiving interference only with respect to the satellite systems included in the coordination agreements referred to in the certification required by paragraph (d)(1)(ii) of this section, and only to the extent that protection from receiving interference is afforded by those coordination agreements.	Comply, Thales is securing certification letters from all satellite operators
25.220(d)(1)(i)	(i) [Reserved]	
25.220(d)(1)(ii)	(ii) A statement from the satellite operator that it has coordinated the operation of the subject non-conforming earth station accessing its satellite(s), including its required downlink power density based on the information contained in the application, with all adjacent satellite networks within 6° of orbital separation from its satellite(s), and the operations will operate in conformance with existing coordination agreement for its satellite(s) with other satellite systems, except as set forth in paragraph (d)(4) of this section.	Will Comply
25.220(d)(1)(iii	(iii) A statement from the satellite operator that it will include the subject non-conforming earth station operations in all future satellite network coordinations, and	Will Comply
25.220(d)(1)(iv)	(iv) A statement from the earth station applicant certifying that it will comply with all coordination agreements reached by the satellite operator(s).	Will Comply

25.220(d)(2)	(2) Unless the non-routine uplink transmission levels are permitted under a coordination agreement with the space station operator, or unless coordination with the operator is not required pursuant to §25.140(d)(3) or (d)(4), the operator of an earth station licensed pursuant to this section must reduce its transmitted EIRP density to levels at or within relevant routine limits:	Understand
25.220(i)	(i) Toward the part of the geostationary orbit arc within one degree of a subsequently launched, two-degree-compliant space station receiving in the same uplink band at an orbital location within six degrees of the earth station's target satellite, and	Understand
25.220(i)(ii)	(ii) Toward a two-degree-compliant space station receiving in the same uplink band at an orbital location more than six degrees away from the target satellite if co-frequency reception by the space station is adversely affected by the non-routine earth station transmission levels.	Understand
25.220(d)(3)	(3) In the event that a coordination agreement discussed in paragraph (d)(1)(ii) of this section is reached, but that coordination agreement does not address protection from interference for the earth station, that earth station will be protected from interference to the same extent that an earth station that meets the requirements of §25.209 of this title would be protected from interference.	Understand
25.220(d)(4)	(4) Notwithstanding paragraph (d)(1)(ii) of this section, a party applying for an earth station license pursuant to this section will not be required to certify that its target satellite operator has reached a coordination agreement with another satellite operator whose satellite is within 6° of orbital separation from its satellite in cases where the off-axis EIRP density level of the proposed earth station operations will be less than or equal to the levels specified by the applicable off-axis EIRP envelope set forth in §25.218 of this chapter in the direction of the part of the geostationary orbit arc within 1° of the nominal orbit location of the adjacent satellite.	Understand
25.220(e)-((f)	(e)-(f) [Reserved]	
25.220(g)	(g) Applicants filing applications for earth stations pursuant to this section must provide the following information for the Commission's public notice:	Comply, see section 2 and Form 312B
25.220(g)(1)	(1) Detailed description of the service to be provided, including frequency bands and satellites to be used. The applicant must identify either the specific satellites with	Section 2.5 and Form 312B

	which it plans to operate, or the eastern and western boundaries of the geostationary satellite orbit arc it plans to coordinate.	
25.220(g)(2)	(2) The diameter or equivalent diameter of the antenna.	Secction 2, Form 312B
25.220(g)(3)	(3) Proposed power and power density levels.	Section 2.5, Form 312B
25.220(g)(4)	(4) Identification of any rule or rules for which a waiver is requested.	Comply

8 Exhibit D – Radiation Hazard Study

Radiation Hazard Analysis

Thales Avionics, Inc - ThinKom AES 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 a uncontrolled environment. Note that the worse-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 Thales ThinKom AES system will typically operate above 15 degrees elevation. The main beam gain of the antenna will vary with elevation, the radhaz calculations have been performed at 45-degree elevation and maximum EIRP. The system is equipped with a 25-watt amplifier and has 0 dB of output back-off and 1.4 dB of output circuit losses. The worst-case scenario, in terms of worst power density levels, involves the high elevation angle and has been presented here.

Table 1 - Earth Station Technical Parameter Table

Antenna Aperture major axis	0.433 meters
Antenna Surface Area	0.1873 sq. meters
Antenna Isotropic Gain	36.5 dBi @45°
Number of Identical Adj. Antennas	1
Nominal Frequency	29.5 GHz
Nominal Wavelength (λ)	0.0102 meters
Maximum Transmit EIRP / Carrier	49.1 dBW
Number of Carriers	1
Total HPA Power	25 Watts
SSPA Output Back (dB)	0 dB
W/G Loss from Transmitter to Feed	1.4 dB
Total Feed Input Power	12.6 dBW1dBW
AES Terminal EIRP	49.1 dBW @45°
Near Field Limit	$R_{nf} = D^2/4\lambda = 4.600$ meters
Far Field Limit	$R_{ff} = 0.6\ D^2/\lambda = 11.0$ meters
Transition Region	R_{nf} to R_{ff}

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 is 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:

$PD_{nf} = (16\varepsilon P)/(\pi D^2)$ = **12.33** 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: $4.60 < R < 11.04$ 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_{safeu}: 56.7m @45° elevation

Controlled Environment Safe Operating Distance,(meters), R_{safec}: 11m @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: $R > R_{ff} = 11.0$ meters

$PD_{ff} =$ 4.196 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_{safeu} : See Section 3

Controlled Environment Safe Operating Distance,(meters), R_{safec} : 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 Thales AES 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 degree off axis at the far-field limit, we can calculate the power density as:

G_{off} = 26.50 dBi = 3981.07 numeric @45° elevation

$PD_{1.5\ deg\ off\text{-}axis} = PD_{ff} x\ 446.68/G = .5927\ mW/cm^2$ (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:

$PD_{nf(off\text{-}axis)} = PD_{nf}/100 =$ 0.1233 mW/cm^2 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:

$$S = (D_{eff} / \sin \alpha) + (2(h - GD_{eff}) - D_{eff} - 2)/(2 \tan \alpha) \quad (7)$$

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 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:

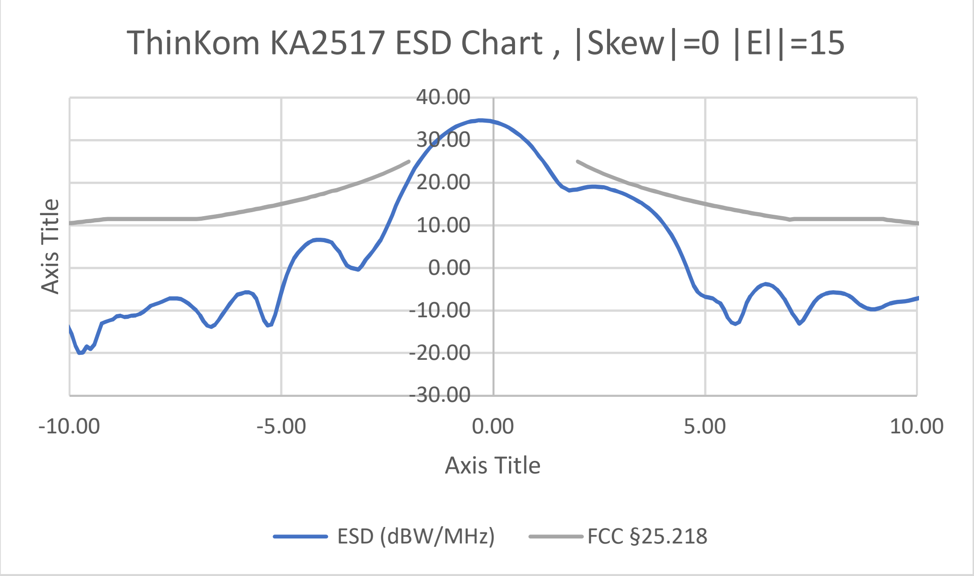
> *Condition 5208 - The licensee shall take all necessary measures to ensure that the antenna does not create potential exposure of humans to radiofrequency radiation in excess of the FCC exposure limits defined in 47 CFR 1.1307(b) and 1.1310 wherever such exposures might occur. Measures must be taken 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.*

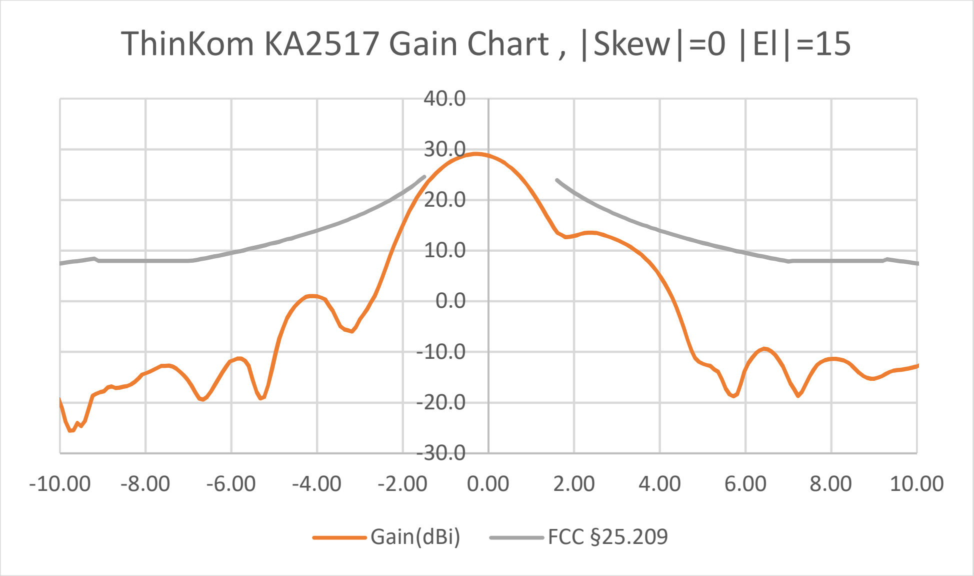
The following table summarizes all of the above calculations:

Table - Summary of All RadHaz Parameters				**ThinKom AES 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	29.5	GHz	
Wavelength	λ	0.0102	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	25.01%	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	4.600	meters	$Dma^2 / (4 * \lambda)$
Extent of Near Field	Rnf	15.09	feet	
Near Field Power Density	PDnf	123.30	W/m^2	$(16 * \eta * P)/(\pi * Deff^2)$
Near Field Power Density	PDnf	12.330	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	4.60	meters	$Dma^2 / (4 * \lambda)$
Extent of Transition Region (min)		15.09	feet	
Extent of Transition Region (max)	Rtr	11.04	meters	$(0.6 * Dma^2)/\lambda$
Extent of Transition Region (max)		36.21	feet	
Worst Case Transition Region Power Density	PDtr	123.30	W/m^2	$(16 * \eta * P)/(\pi * Deff^2)$
Worst Case Transition Region Power Density	PDtr	**12.330**	mW/cm^2	**Does Not Meet Uncontrolled Limits**
		@45°		**Does not Meet Controlled Limits**
Uncontrolled Environment Safe Operating Distance	Rsu	56.7	m	=(PDnf)*(Rnf)/Rsu
Controlled Environment Safe Operating Distance	Rsc	11.3	m	=(PDnf)*(Rnf)/Rsc
4. On-Axis Far Field Calculations		@45°		
Distance to the Far Field Region	Rff	11.0	meters	$(0.6 * Dma^2)/\lambda$
		36.21	feet	
On-Axis Power Density in the Far Field	PDff	41.96	W/m^2	$(G_{es} * P) / (4 * \pi * Rf^2)$
On-Axis Power Density in the Far Field	PDff	**4.196**	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	5.927	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		0.5927	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	1.2330	W/m^2	$((16 * \eta * P)/(\pi * Deff^2))/100$
		0.12330	mW/cm^2	**Meets Uncontrolled Limits**
7. Off-Axis Safe Distances from Earth Station				$S = (Deff/ \sin \alpha) + 2(h - GD - 2)/(2 \tan \alpha)$
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.

9 Exhibit E – Antenna ESD and Gain Plots


ThinKom KA2517 ESD Chart , |Skew|=0 |El|=15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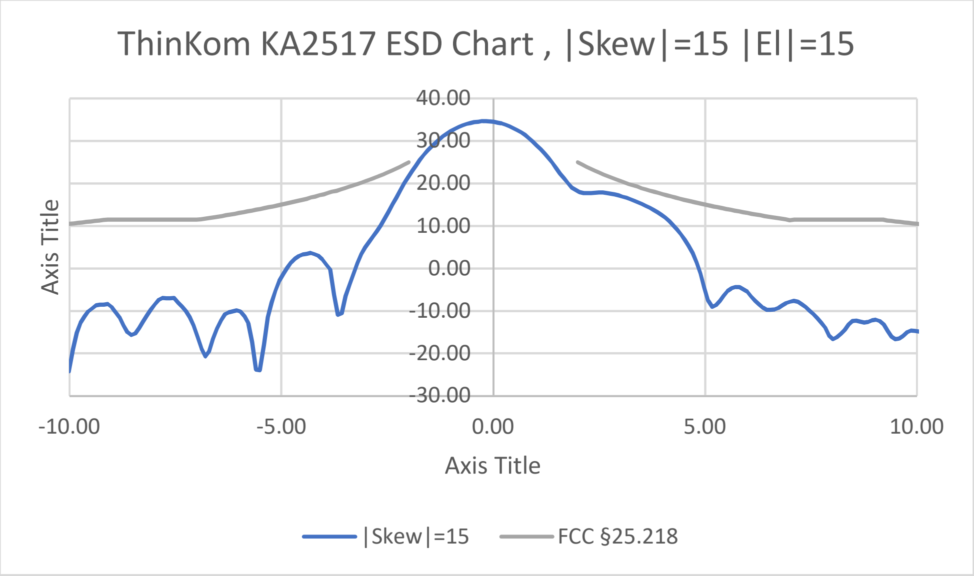
ThinKom KA2517 ESD Chart , |Skew|=15 |El|=15
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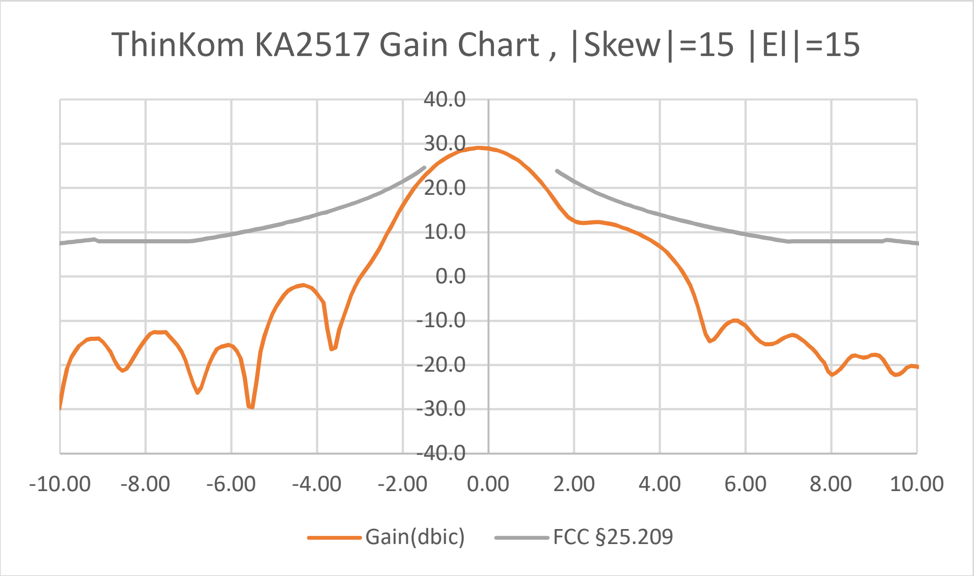
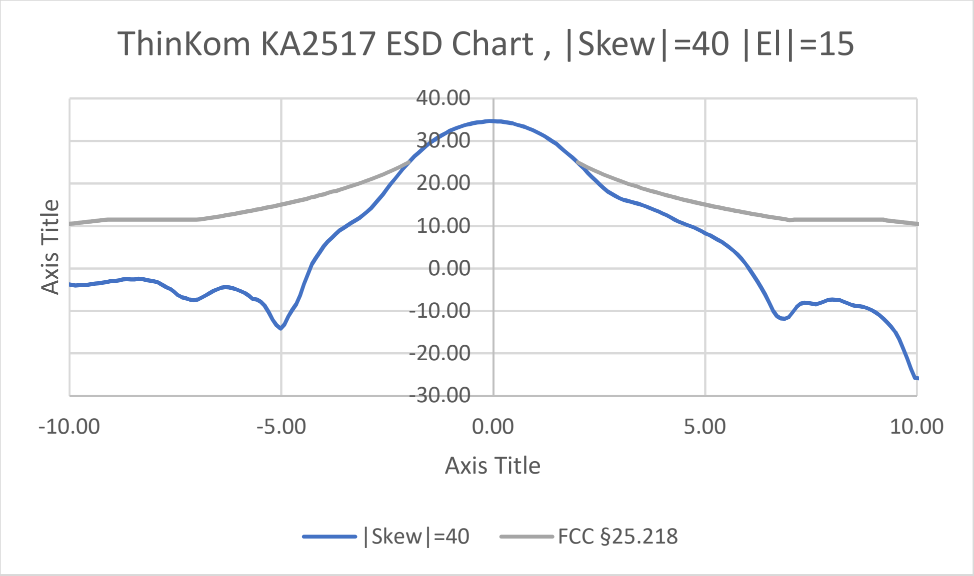
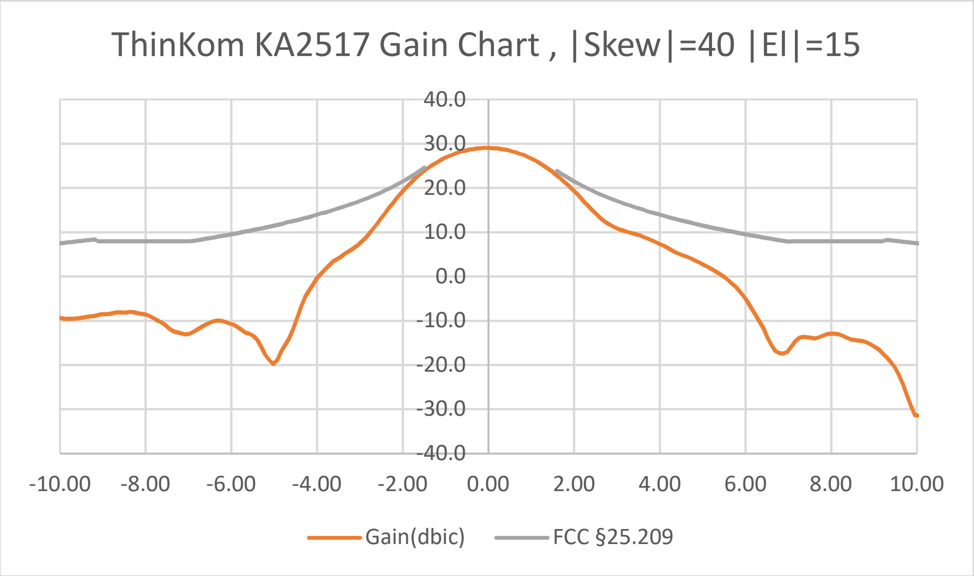
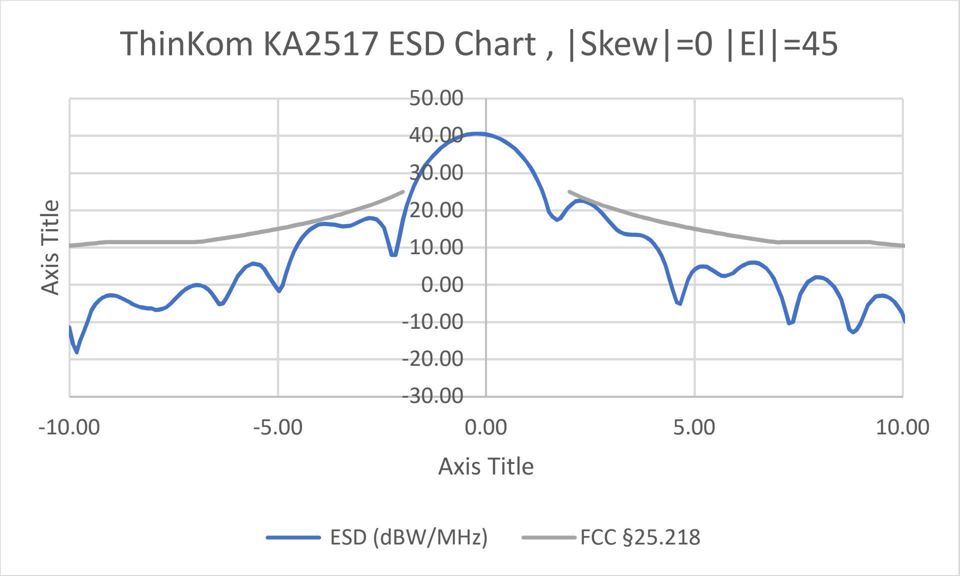
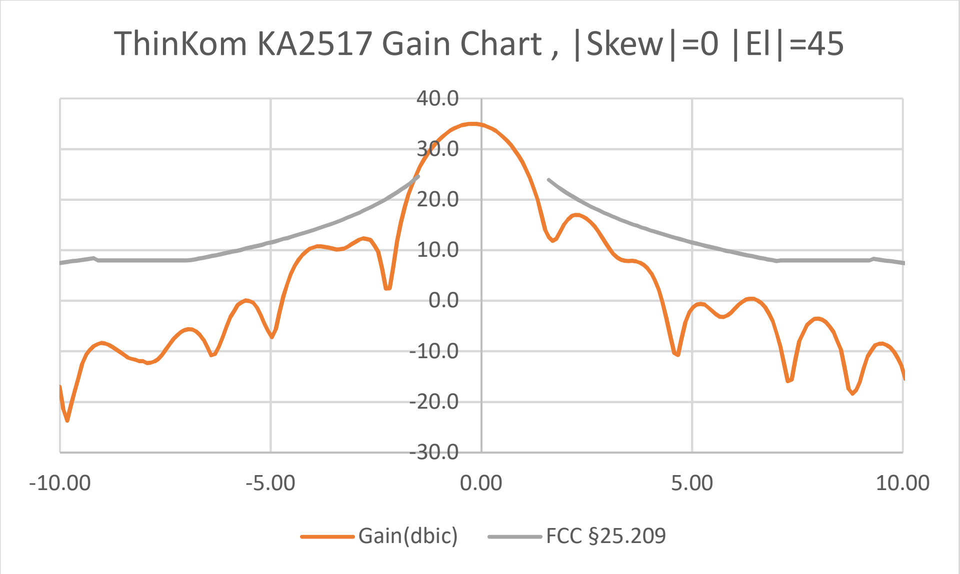
30.00
20.00
10.00
0.00
-10.00
-20.00
-30.00
Axis Title
-10.00
-5.00
0.00
5.00
10.00
Axis Title
|Skew|=15
FCC §25.218

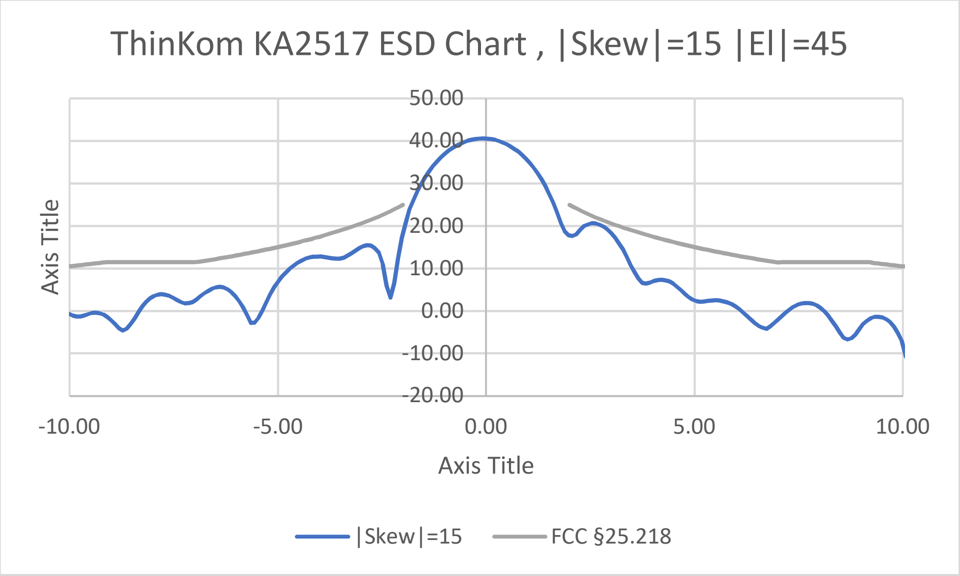

ThinKom KA2517 Gain Chart , |Skew|=15 |El|=15
40.0
30.0
20.0
10.0
0.0
-10.0
-20.0
-30.0
-40.0
-10.00
-8.00
-6.00
-4.00
-2.00
0.00
2.00
4.00
6.00
8.00
10.00
Gain(dbic)
FCC §25.209

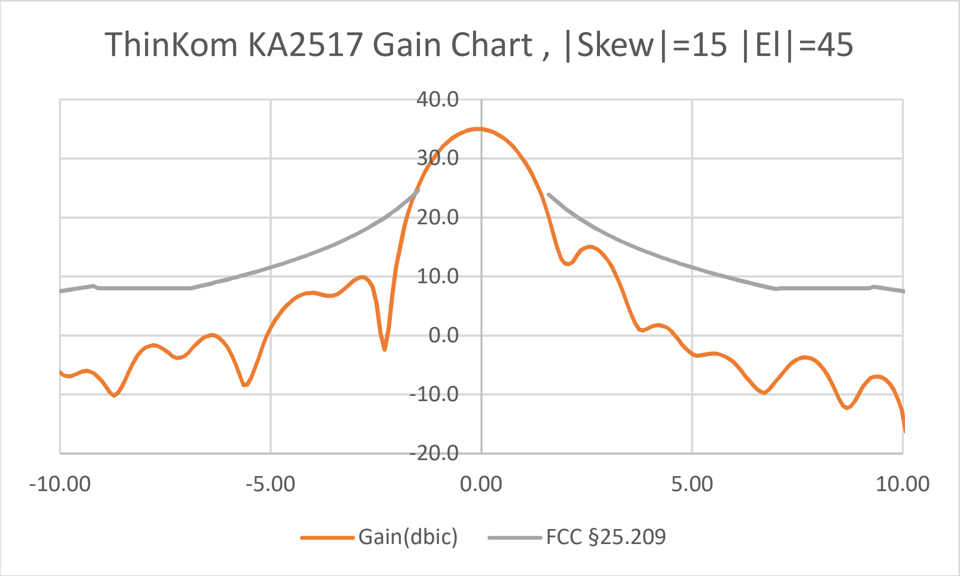

ThinKom KA2517 ESD Chart , |Skew|=40 |El|=15

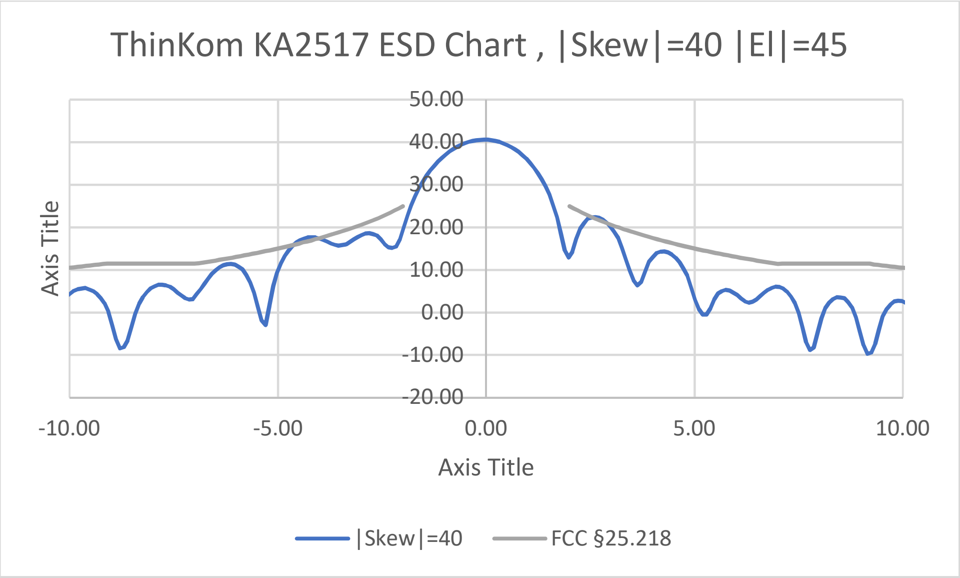

ThinKom KA2517 Gain Chart , |Skew|=40 |El|=15

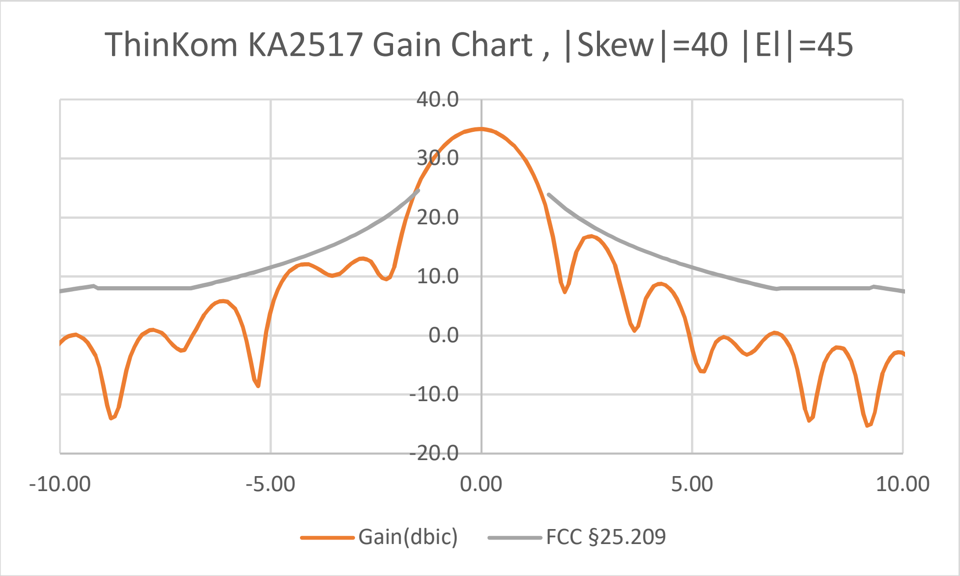

ThinKom KA2517 ESD Chart , |Skew|=0 |El|=45
Axis Title
50.00
40.00
30.00
20.00
10.00
0.00
-10.00
-20.00
-30.00
-10.00
-5.00
0.00
5.00
10.00
Axis Title
ESD (dBW/MHz)
FCC §25.218


ThinKom KA2517 Gain Chart , |Skew|=0 |El|=45
40.0
30.0
20.0
10.0
0.0
-10.0
-20.0
-30.0
-10.00
-5.00
0.00
5.00
10.00
Gain(dbic)
FCC §25.209


ThinKom KA2517 ESD Chart , |Skew|=15 |El|=45


ThinKom KA2517 Gain Chart , |Skew|=15 |El|=45


ThinKom KA2517 ESD Chart , |Skew|=40 |El|=45
50.00
40.00
30.00
20.00
10.00
0.00
-10.00
-20.00
Axis Title
-10.00
-5.00
0.00
5.00
10.00
Axis Title
|Skew|=40
FCC §25.218


ThinKom KA2517 Gain Chart , |Skew|=40 |El|=45
40.0
30.0
20.0
10.0
0.0
-10.0
-20.0
-10.00
-5.00
0.00
5.00
10.00
Gain(dbic)
FCC §25.209