Thales Avionics, Inc.
Request for Special Temporary Authority
for
Thales Advanced Connectivity Terminal, Ka-band (ACT-A) ESAA

Applicant Description

Thales Avionics, Inc. with its InFlyt Experience operations in Melbourne and Orlando, FL and Irvine, CA is a global leader in providing leading-edge, connected inflight entertainment systems and services, including high-speed Internet connectivity, to commercial airlines worldwide. Thales is currently developing and will be testing a new Advanced Connectivity Terminal, Ka-band (ACT-A) that is a key component of Thales's end-to-end inflight connectivity (IFC) service offerings to commercial airlines. Thales's IFC service using the ACT-A will enable airlines to meet the increasing demands of passengers' inflight connectivity needs and provide access to critical, real-time inflight data to improve airline operational efficiencies.

Thales Avionics has an active blanket license authorization[1] to operate ESAA called Modular Connectivity Terminals, Ka-band (MCT-A) with four 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 four points of communication are: AMC-15 (S2180) at 105.0° W.L., AMC-16 (S2181) at 85.0° W.L., EchostarXVII (S2753) at 107.1° W.L., and Jupiter 2 (S2834) at 97.1° W.L.

Thales is currently preparing, and will submit shortly to the FCC, an application seeking modification to its blanket authorization to add the ACT-A terminal.

STA Request

While Thales's license modification application, filing, and processing are ongoing, Thales seeks STA to allow developmental and performance testing of up to four (4) ACT-A terminals. The ACT-A ESAA will communicate in the conventional Ka-band with the aforementioned points of communication, using the spectrum shown in the following table[2]:

Point of Communication (Call Sign)	Satellite Operator	GSO Orbital Location (W.L.)	Transmit Spectrum (MHz)	Receive Spectrum (MHz)
Echostar XVII (Jupiter-1) (S2753)	Hughes	107.1°	29300 – 30000	18300 – 19300 19700 – 20200
Jupiter-2 (S2968)	Hughes	97.1°	29300 – 30000	18300 – 19300 19700 – 20200
AMC-15 (S2180)	SES	105.0°	28438 – 28563 29500 – 30000	18638 – 18763 19700 – 20200
AMC-16 (S2181)	SES	85.0°	28438 – 28563 29500 – 30000	18638 – 18763 19700 – 20200

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[1] See Call Sign E170068, File No. SES-LIC-20170217-00183, granted July 7, 2017.

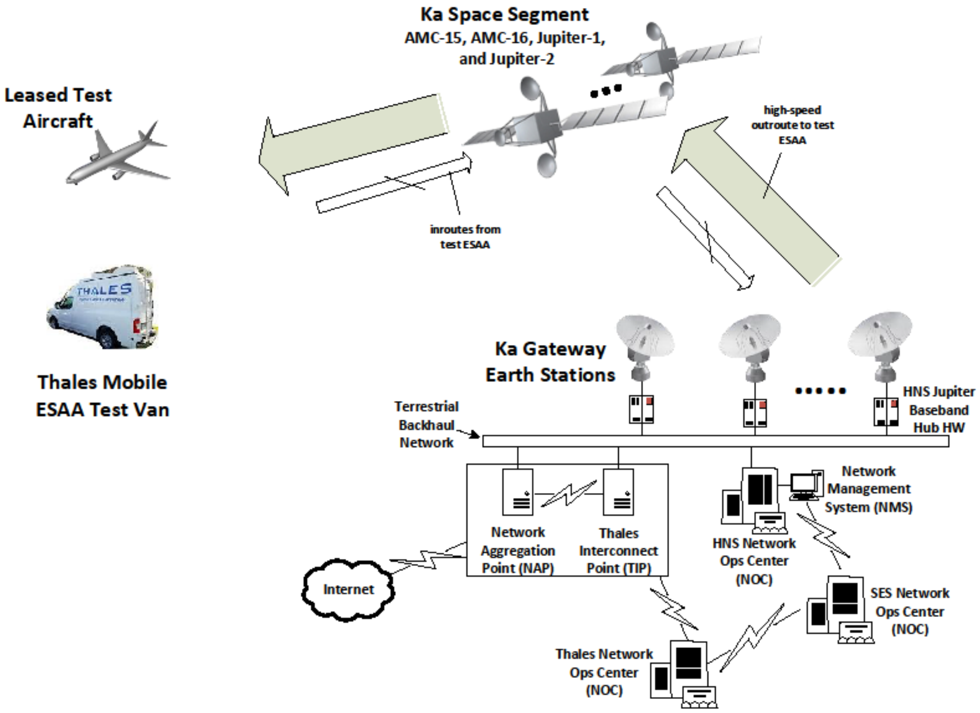
[2] The points of communication and spectrum in this STA request are identical to those authorized in Thales's active ESAA blanket license referenced in Footnote 1.

Thales expects ACT-A testing to commence on or about May 1, 2018 and continue for a period of 180 days. Grant of the requested STA will allow Thales to improve and expand its overall IFC service offerings to its airline customers by improving end-user experience with higher throughput rates, and allowing Thales to offer services to airlines with trans-equatorial flight routes, where high skew angle conditions prevent two-axis, flat panel ESAA operations.

Description of Testing

Mobile testing will be performed throughout CONUS with the ACT-A terminal installed on a leased test aircraft and Thales mobile test van. This will allow Thales to verify and optimize terminal performance while it is operating in a wide range of skew angles, elevation angles, and link conditions.

A high-level diagram Thales's IFC network architecture to be used for testing the ACT-A terminal is shown below:



Thales intends to test the ACT-A in CONUS and its territorial waters only; no testing will be conducted in Canada, Mexico, the Caribbean, or over any international waters. The area of testing is shown below, within the red line.

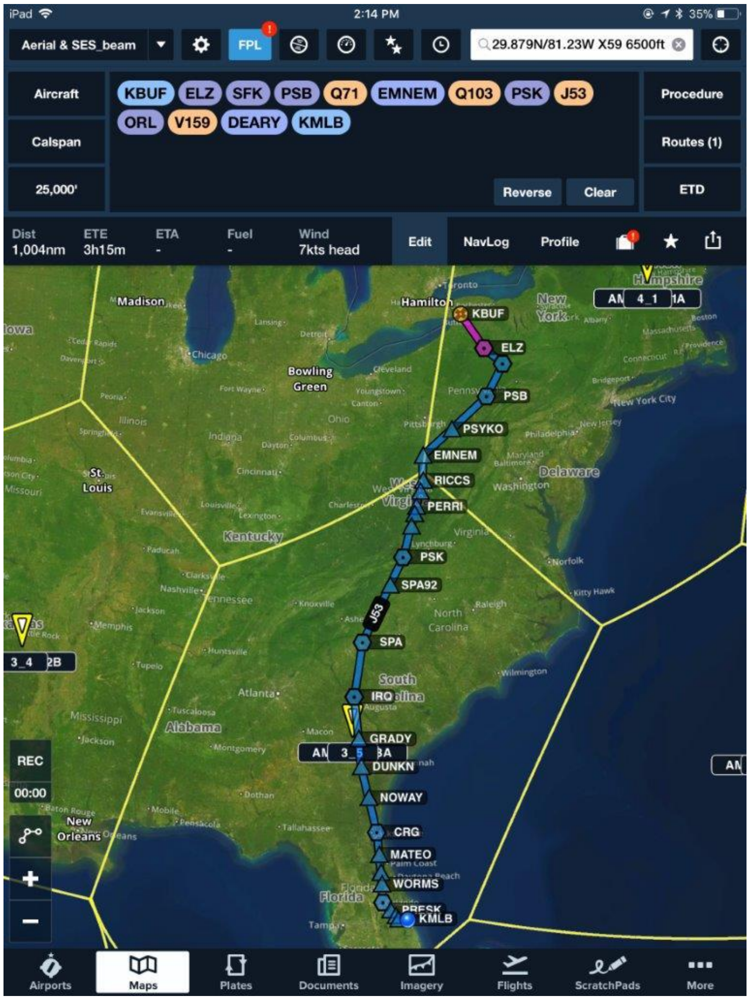
The ACT-A will transmit return channel carriers to the satellites using OQPSK modulation. Return channel symbol rates will range from 1.024 Msps to 8.192 Msps, using code rates between ½ and 9/10. Spectral spreading may also be used at rates of 2x and 4x. During all testing the ACT-A will remain compliant with the EIRP spectral density limits defined in §25.138, as detailed later in this request.

Forward channel performance and information rates transmitted to and received by the ACT-A will be characterized and optimized during testing. The forward channels use the DVB-S2 standard, have a symbol rate of 47 Msps, and use QPSK and 8PSK modulation with code rates between ¼ and 9/10.

Flight Testing

Flight test will be conducted with the ACT-A installed on a test aircraft (expected to be a Gulfstream G3 as of the time of this request). The test aircraft will fly several flight routes throughout CONUS that will enable the ACT-A to make intrasatellite beam-to-beam handovers, as well as intersatellite beam handovers.

The expected flight routes as of the time of this request are as follows:



29.879N/81.23W X59 6500ft

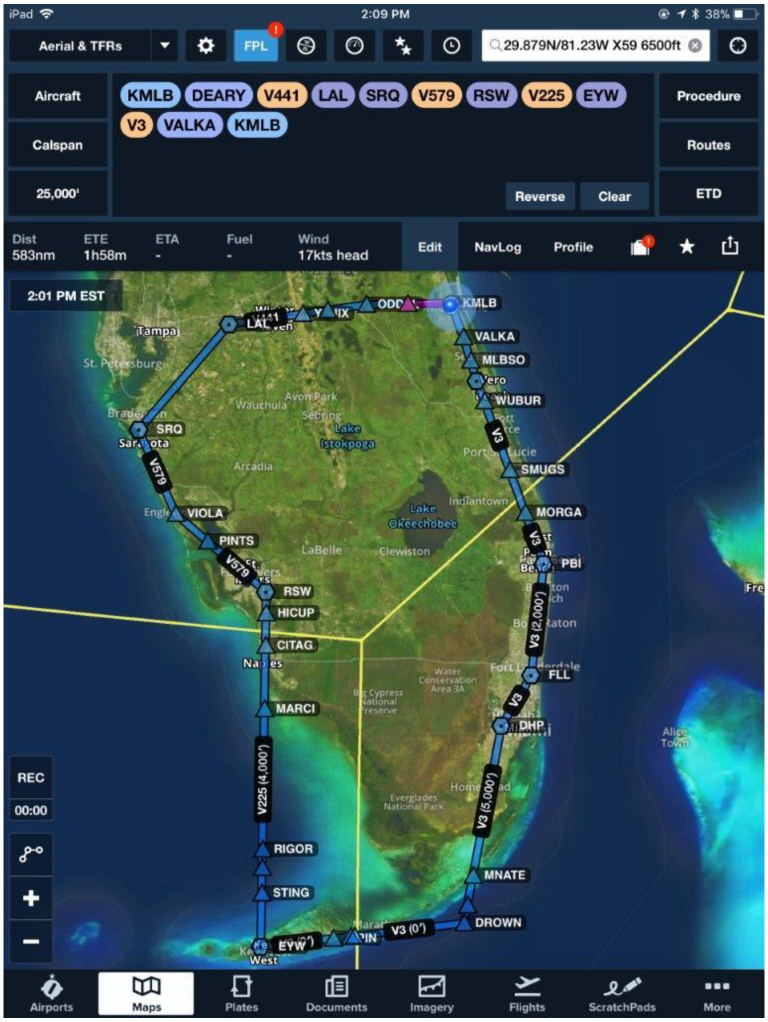
Route: KBUF ELZ SFK PSB Q71 EMNEM Q103 PSK J53 ORL V159 DEARY KMLB

Calspan

25,000'

Dist	ETE	ETA	Fuel	Wind
1,004nm	3h15m	-	-	7kts head

Buffalo, NY to Melbourne, FL



29.879N/81.23W X59 6500ft

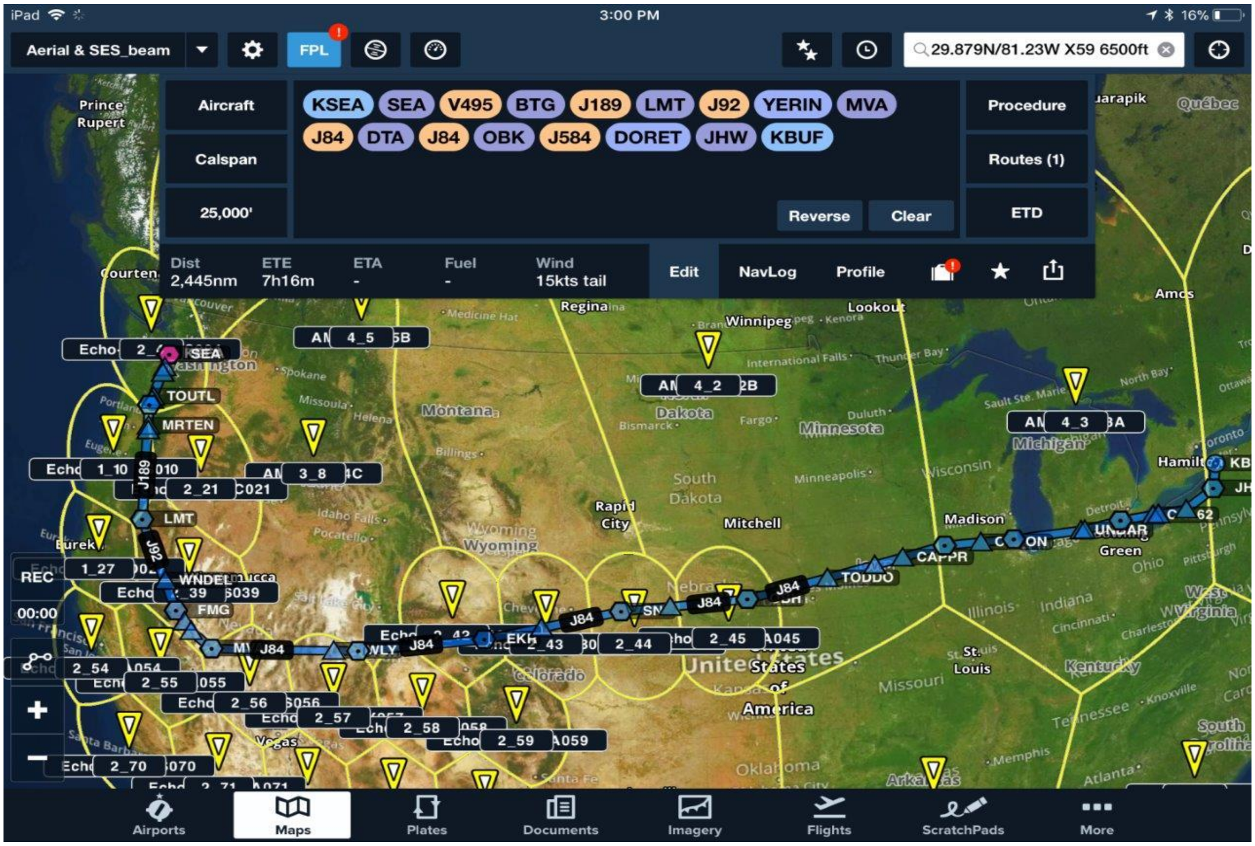
Aircraft: Calspan

25,000'

KMLB DEARY V441 LAL SRQ V579 RSW V225 EYW V3 VALKA KMLB

Dist	ETE	ETA	Fuel	Wind
583nm	1h58m	-	-	17kts head

Regional Florida



29.879N/81.23W X59 6500ft

Aircraft: Calspan

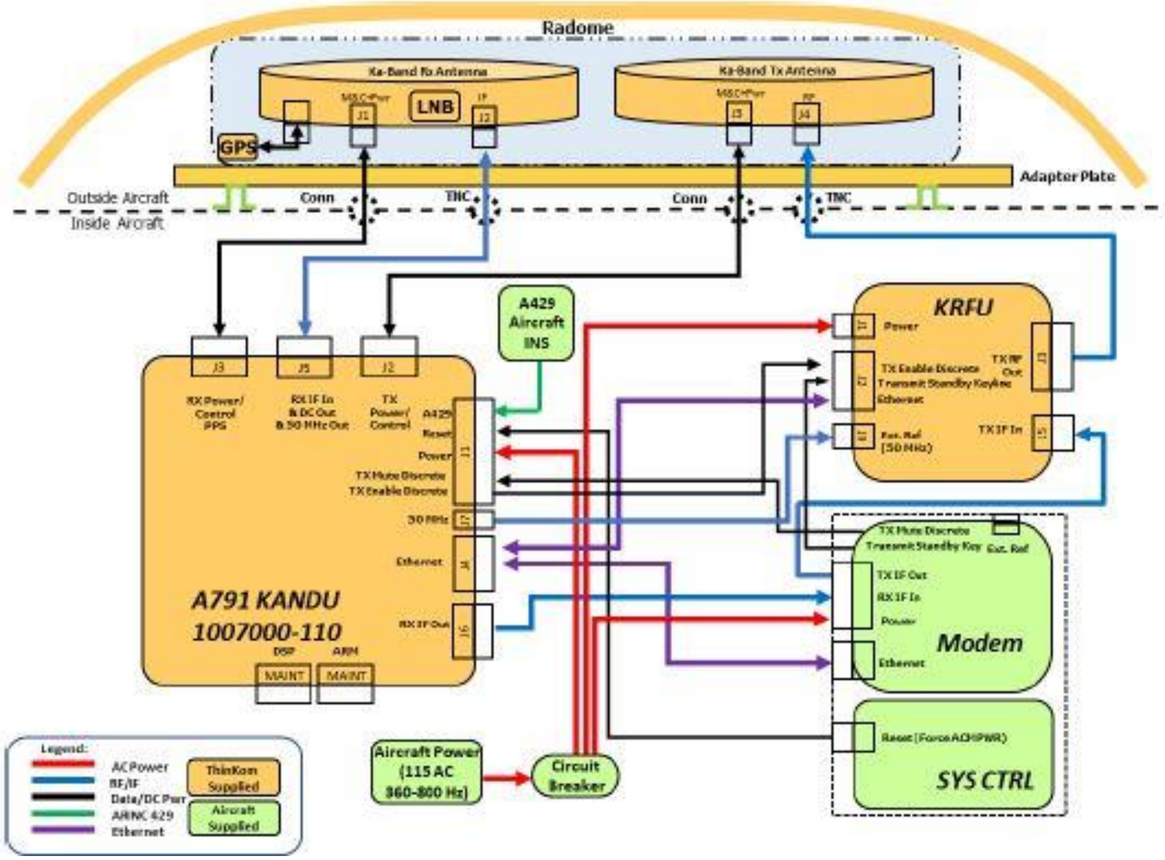
25,000'

KSEA SEA V495 BTG J189 LMT J92 YERIN MVA J84 DTA J84 OBK J584 DORET JHW KBUF

Dist	ETE	ETA	Fuel	Wind
2,445nm	7h16m	-	-	15kts tail

Seattle, WA to Buffalo, NY

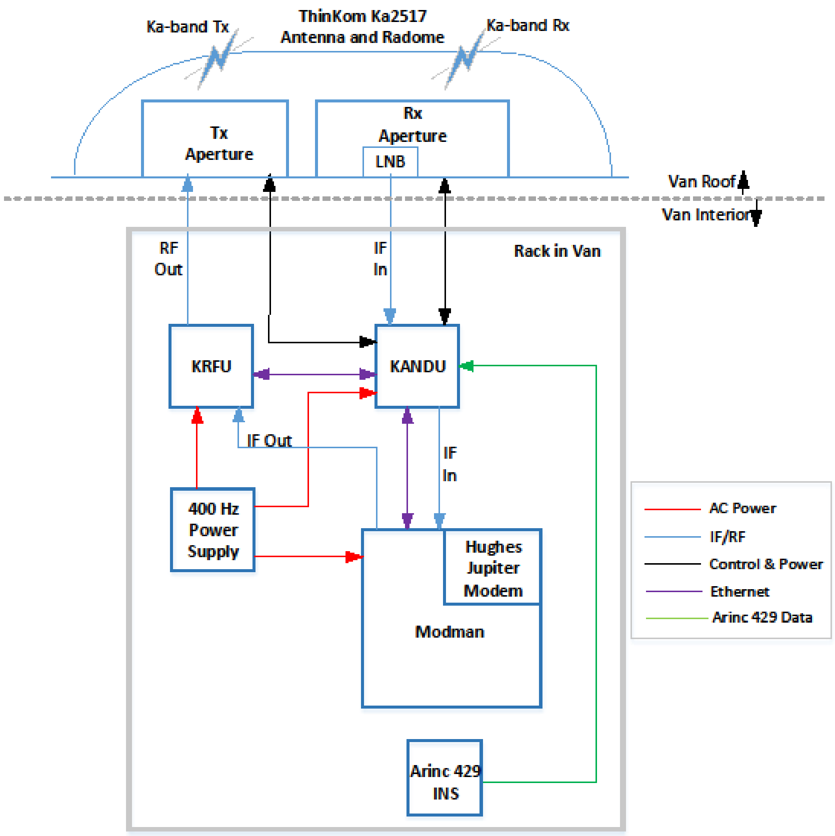
A block diagram of the ACT-A architecture onboard the test aircraft is shown below:



Mobile Van Testing

Thales will conduct ground mobile testing throughout CONUS utilizing the ACT-A installed on the roof of Thales's ESAA test van.

A block diagram of the ACT-A architecture installed on the test van is shown below:

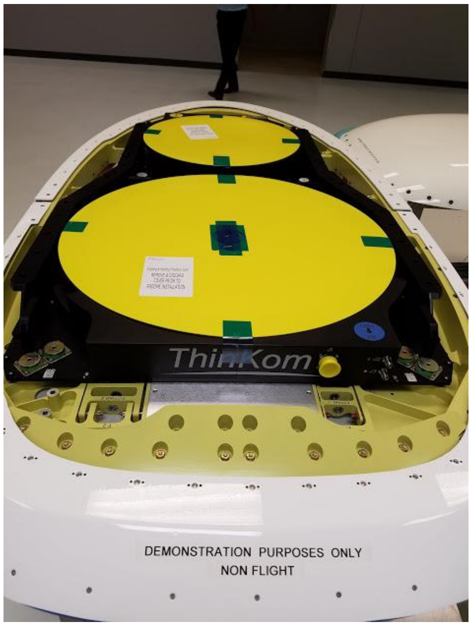


System Description

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 pictures 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 50-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.

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.

Protection of Other Services

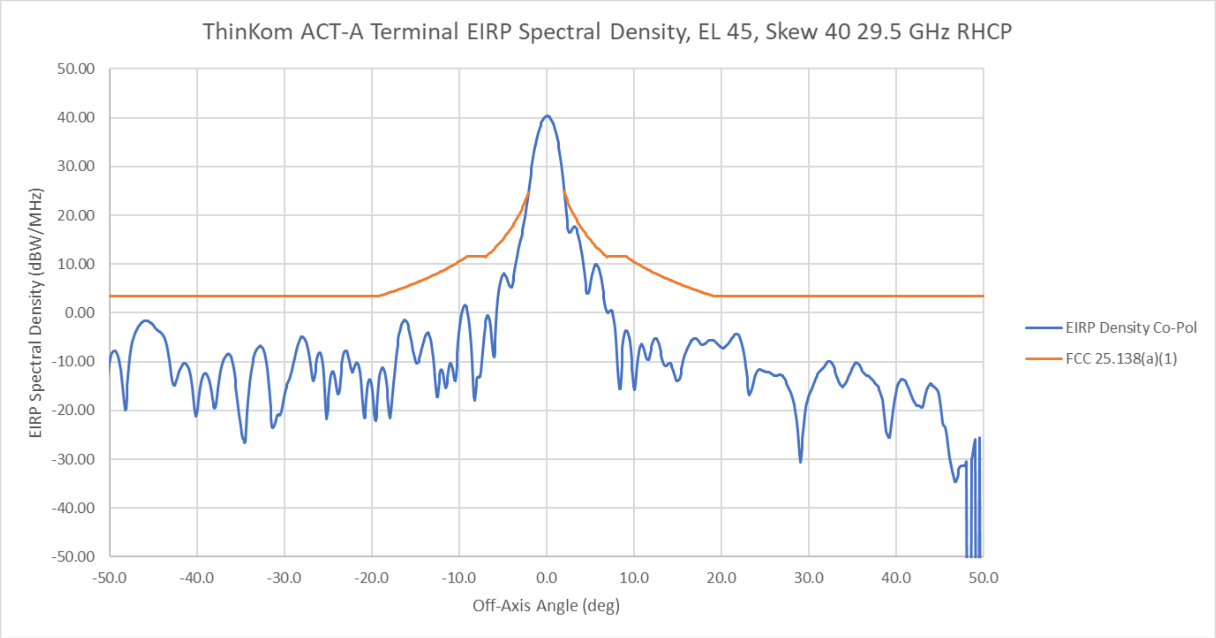
Off-Axis Emissions

The ACT-A AES testing will operate at EIRP spectral densities which comply with FCC §25.138(a)(1). Operations within CONUS and its territorial waters will require elevation and skew angles which provide off-axis emissions below the mask. The worst emissions, PSDs, and maximum EIRPs are summarized below:

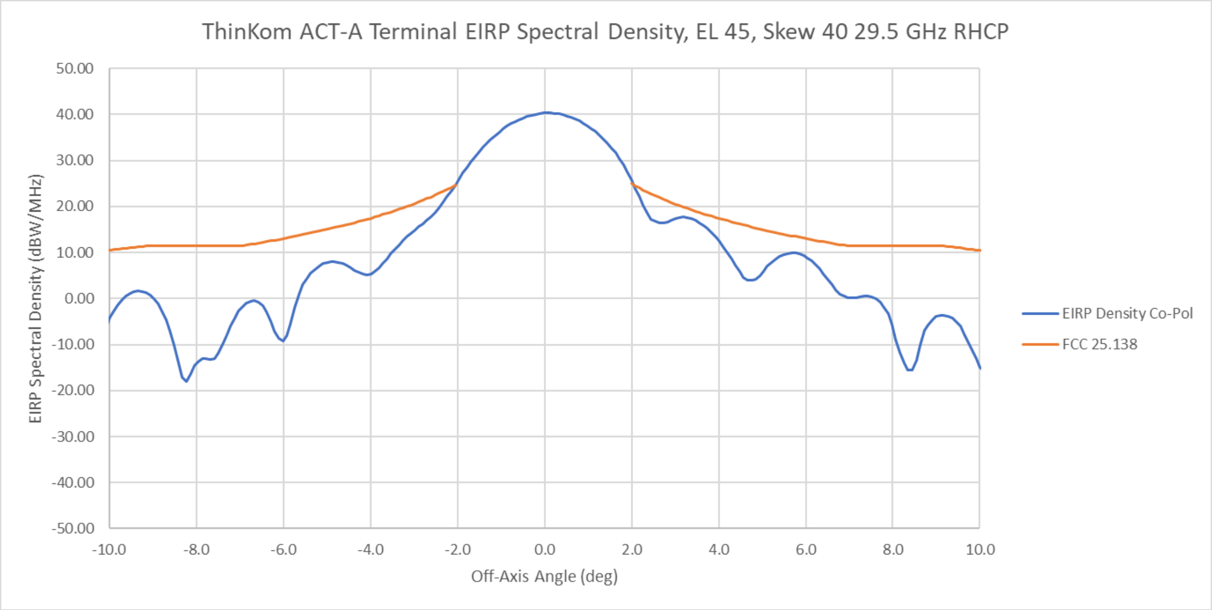
Emission (Msym/s)	EIRP (dBW)	Gain at EIRP (dBi)	EIRP Spectral Density (dBW/MHz)	RF Power (Watts)	ERP (dBW)	ERP (kW)
8.190	49.5	36.5	40.327	19.77	47.31	53.83
6.144	48.2	36.5	40.325	14.83	46.06	40.36

Summary of Test Emissions and Power Requirements

The following charts show that the operation of the ACT-A terminal will comply with §25.138(a) EIRP spectral density masks.



ACT-A AES terminal RHCP co-polarized 29.5 GHz off-axis emissions, +/- 50°. Worst case ESD is 40.3 dBW/MHz. All sidelobes fall under §25.138(a)(1) mask. The above example considers an 8.19 MSym/s carrier with an EIRP of 49.46 dBW.



ACT-A AES terminal RHCP co-polarized 29.5 GHz emissions, +/- 10 degrees. All sidelobes fall under the §25.138(a)(1) mask.

Radiation Hazard Study

Included as Attachment A is a radiation hazard study. Thales will ensure that all testing will protect the general public and all trained personnel working on or around the terminal.

Points of Contact

In case of any inadvertent reported interference, Thales will cease ACT-A transmissions as soon as possible upon notification to Thales's 24/7 points of contact:

1) Martin Matura
   phone: 321-292-0878
   email: martin.matura@us.thalesgroup.com

2) Thales Network Operations Center (NOC)
   phone: 949-754-6985

Attachment A – 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 as shown in Table 1 below. The system is equipped with a 50-watt amplifier, and has 3 dB of output back-off and 1 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	0.444 meters
Antenna Surface Area	0.1873 sq. meters
Antenna Isotropic Gain	36.5 dBi @ 45° elevation angle
Number of Identical Adj. Antennas	1
Nominal Frequency	29.5 GHz
Nominal Wavelength (λ)	0.0102 meters
Maximum Transmit EIRP / Carrier	49.5 dBW
Number of Carriers	1
Total HPA Power	50.00 Watts
SSPA Output Backoff	3 dB
W/G Loss from Transmitter to Feed	1 dB

Total Feed Input Power	19.91 Watts
AES Terminal EIRP	49.5 dBW @ 45° elevation angle
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:

$PD_{refl} = 4P/A =$ **42.519** 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:

$PD_{nf} = (16\varepsilon P)/(\pi D^2) =$ **8.345** 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}: 38.4m @45° elevation

Controlled Environment Safe Operating Distance,(meters), R_{safec}: 7.7m @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

$PD_{ff} =$ **4.611** mW/cm² at R_{ff} @45° ,

4.61138 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

$PD_{1.5\text{ deg off-axis}} = PD_{ff} x\ 446.68/G = 0.6514$ 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:

$PD_{nf(off\text{-}axis)} = PD_{nf} /100 =$ **0.08345** mW/cm² at D off axis (6) @45°

0.08345 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:

$$S = (\mathrm{Deff}/ \sin \alpha) + (2(h-\mathrm{GDeff}) - \mathrm{Deff} - 2)/(2 \tan \alpha) \quad (7)$$

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 = 0.49 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	0.49	meters	
Antenna Centerline	ACL	3.0	meters	Mount on test van ~9’
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}	50.00	watts	
HPA to Antenna Loss	L_{tx}	4.0	dB	3 dB OBO + 1 dB OCL
Transmit Power at Flange	P	12.99	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	19.63%	n/a	$G_{es} / (PI * Df / \lambda)^2$
Maximum EIRP	EIRP	49.5	dBi	Varies with elevation
1. Reflector Surface Region Calculations		@45°		
Reflector Surface Power Density	PDas	425.19	W/m^2	$(16 * P)/(\pi * Deff^2)$
Reflector Surface Power Density	PDas	**42.519**	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	83.45	W/m^2	$(16 * \eta * P)/(\pi * Deff^2)$
Near Field Power Density	PDnf	8.345	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	83.45	W/m^2	$(16 * \eta * P)/(\pi * Deff^2)$
Worst Case Transition Region Power Density	PDtr	**8.345**	mW/cm^2	**Does Not Meet Uncontrolled Limits**
		@45°		**Does not Meet Controlled Limits**

Uncontrolled Environment Safe Operating Distance	Rsu	38.4	m	=(PDnf)*(Rnf)/Rsu
Controlled Environment Safe Operating Distance	Rsc	7.7	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	46.11	W/m^2	$(G_{es} * P) / (4 * \pi * Rf^2)$
On-Axis Power Density in the Far Field	PDff	**4.611**	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	6.514	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 8.5 dB down at 1.5 deg
Off-Axis Power Density		0.6514	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	0.8345	W/m^2	$((16 * \eta * P)/ (\pi * Deff^2))/100$
		0.08345	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.				