AC BidCo LLC

Request for Experimental License

Experimental Operations Narrative

March 23, 2018

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1 Overview

AC BidCo LLC doing business as Gogo (Gogo) is seeking experimental authority to perform testing of a new K3 Aeronautical Earth Station (AES) terminal. Gogo is the world's leading provider of in-flight broadband connectivity products and services for commercial and general aviation. Gogo offers worldwide service through a combination of technologies including an 800 MHz terrestrial air-to-ground network in the United States and Canada and multiple worldwide satellite networks. Gogo holds an ESAA license (Call sign: E120106) which covers purpose-built Ku-band terminals operating on over 800 aircraft flown by multiple airlines. Gogo has transponder agreements with numerous satellite operators, including SES, Intelsat, Eutelsat, Yamal, Asiasat, and Arsat that authorize communications with dozens of satellites in the Ku-band.

North American airlines that use a combination of Gogo's terrestrial and satellite networks include Delta Airlines, American Airlines, United, Virgin America, Alaska Airlines, and Air Canada. Other international airlines that offer Gogo's Ku-band satellite service include British Airways, GOL, Air France, Japan Airlines, Aeromexico, KLM, Aer Lingus, Iberia, Australia, LATAM, Virgin Atlantic, and Cathay Pacific.

Gogo seeks an experimental license to allow it to test and evaluate a new Ku-band satellite terminal for ESAA operations, known as the K3, suitable for installation on smaller general aviation aircraft, including those aircraft that belong to a number of federal agencies that have worldwide operations. Due to the smaller fuselage size and higher maneuverability of general aviation aircraft, a new terminal design and placement must be evaluated before final production design is approved. In order to perform the full system testing on the K3 terminal, Gogo is requesting an experimental license for 12 months starting on April 10, 2018.

2 Gogo K3 AES Terminal Experimental Tests

Gogo seeks authority to test the K3 terminal in both fixed and mobile operations. Testing will occur at multiple sites: the Gogo Business Aviation headquarters in Broomfield, CO; Gogo's main headquarters in Chicago, IL; and the locations of Gogo's integration partners' in Los Angeles and San Diego, CA. At each site there will be initial stationary testing followed by mobile testing using a K3 terminal mounted to the roof of a van, as shown in Figures 1 and 2 below. Gogo also proposes to perform testing over the satellite beam for each of these locations, which will require an area of several hundred kilometers in order to cover the operational area of each beam. A full description of the planned testing is provided below.

2.1 Test Transmission Parameters

The K3 terminal return link will use Gilat's proprietary multi-frequency time division multiple access (MF-TDMA) technique. MF-TDMA supports multi-frequency sharing of return link carriers, although the terminal will be assigned to only one in-route carrier with fixed data rate, modulation and coding parameters. Frequency and time slot parameters will be managed by the Gilat hub. Terminal transmit EIRP is also power controlled so that the minimum power is used to close the satellite link. The proposed operations under this experimental authority using MF-TDMA will range from 1.5 Mbits/second to 7.5 Mbits/second using occupied bandwidths between 2.048 MHz and 10.24 MHz.

The forward link will consist of a single DVB-S2 (or DVB-S2X) carrier which may occupy up to a full transponder and operate in saturation. Data may be multiplexed on this carrier for multiple terminals. DVB-S2 is a widely adopted standard for digital data and video broadcasting over satellite. The DVB-S2 standard supports Adaptive Coding and Modulation (ACM) with QPSK, 8PSK, and 16APSK modulations and Low-Density Parity Check Coding rates between 0.25 and 0.9.

The hub earth stations are FCC-licensed facilities equipped with a Gilat hub at each location, and the interface to the Internet and other content sources. The Gilat hub will consist of a DVB-S2 modulator and a Gilat MF-TDMA demodulator. Operation of the network will be controlled by a Network Operations Center (NOC) in Chicago, IL subject to Gogo's direction and control. The NOC will maintain the ability to inhibit transmissions from any terminal in the network, including the hub and AES terminals, at any time.

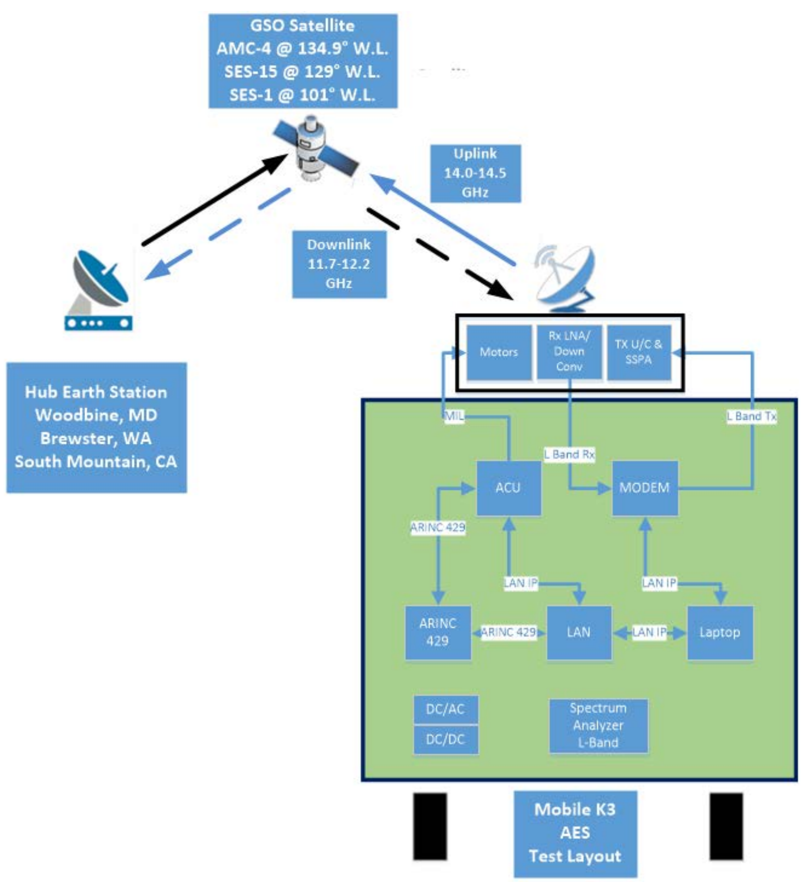

Figure 1 –Mobile test layout. Mobile testing consists of the K3 unit placed on roof panel van.

Figure 2 – Gogo K3 mobile test configuration. Antenna will be mounted to roof of van. Electronics and control inside.

2.2 Emissions and Power Levels

Table 1 below provides a summary of the test carriers for the K3 terminal. The tests will be conducted in the Ku-band between 14.0-14.5 GHz. Gogo will be testing a range of modulation, coding, and spreading schemes. Some specific emissions and power levels are shown.

Carrier Data Rate (Mbit/s)	Modulation	FEC	Symbol Rate (MSym/s)	EIRP (dBW)	EIRP SD (dBW/4 kHz)	RF Power (dBW/4kHz)
1.5196	QPSK	0.371	2.048	30.180	3.09	-26.99
4.5588	QPSK	0.371	6.144	35.010	3.15	-26.93
7.59808	QPSK	0.371	10.240	41.100	7.02	-23.06

Frequency Band (GHz)	ED	Output Power (W)	ERP (dBW)	Modulating Signal
14.0 - 14.5	2M048G7D	635	28.030	QPSK/.371
14.0 - 14.5	6M14G7D	1932	32.860	QPSK/.371
14.0 - 14.5	10M3G7D	7854	38.950	QPSK/.371

Table 1 – Range of Data Rates and Power levels to be tested. The worst-case transmissions will not exceed §25.227 ESAA EIRP Spectral Density limits, as shown in Section 4.

2.3 Static and Mobile Testing Areas

The stationary tests will be performed primarily at Gogo's facility in Broomfield, CO. Additional stationary testing will occur at the facility of Gogo's integration partners in San Diego, CA and in Los Angeles, CA. Additional testing at the main Gogo facilities near Chicago, IL will also be required. The test locations sites are:

Site 1 - Denver

105 Edgeview Drive
Bromfield, CO 80021
Latitude : 39.919297° North
Longitude: 105.104251° West
Mobile Zone to cover SES-15 Beam 19 and up to three contours for AMC-4 and SES-1 and could extend up 300 km (see Figure 3 below)

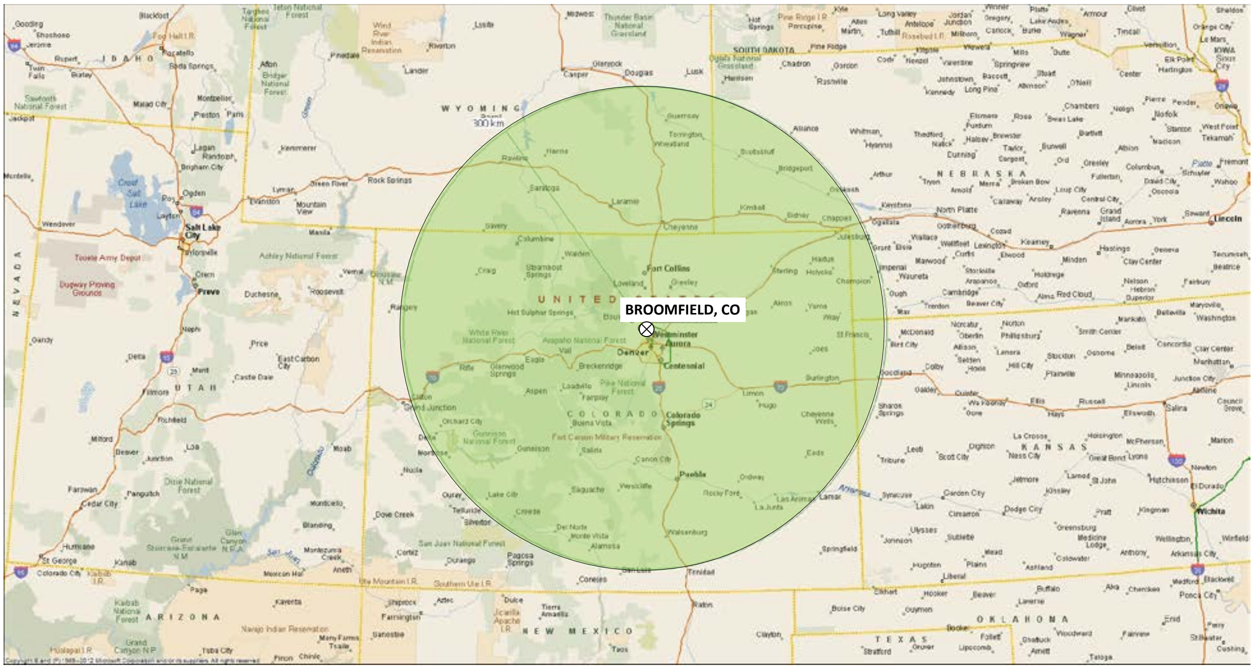

Figure 3 – Mobile test area near Denver, CO. Testing will occur within 300 km of Gogo offices in Broomfield, CO. This will allow simulation of operational satellite beams.

Site 2 - San Diego

7606 Miramar Road, Suite 7100
San Diego, CA 92126
Latitude: 32.886054° North
Longitude: 117.152624° West
Satellite: SES-15 Beam 28 and AMC-4 CONUS Beam

Site 3 – Los Angeles

31186 La Baya Drive,
Westlake Village, CA 91362
Latitude: 34.156757° North
Longitude: 118.801679° West
Mobile Operational Area to Cover SES-15 Beam 28 and AMC-4 and SES-1 contours and could extend up to 400km (see figure 4 below)

Figure 4 – Mobile test area near Los Angeles, CA. Testing will occur up to 400 km from testing location in Los Angeles, CA. This will allow simulation of operational extent of SES-15 Beam 28.

Site 4 - Chicago

1331 E Business Center Drive
Mt Prospect IL, 60056,
Latitude: 42.078369° North
Longitude: 87.915636° West
Mobile Operational Area to cover SES-15 Beam 11 as well as several AMC-4 and SES-1 contours and could extend to 300 km (see Figure 5 below)

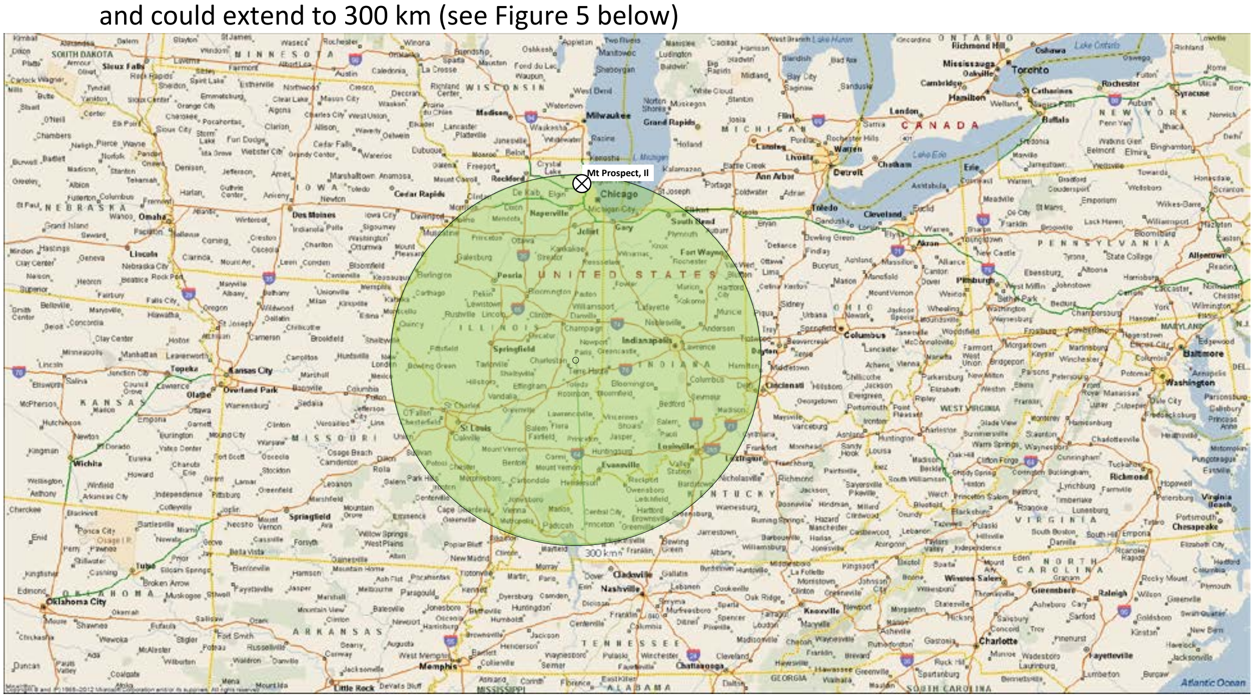

Figure 5– Mobile test area near Chicago, Il. Testing will occur up 300 km south of Gogo offices in Mt. Prospect, IL. This will allow simulation of operational extent of satellite operational contours.

3 The Gogo K3 AES System

3.1 System Specifications for the K3 AES Tests

The K3 (AES) test terminal is composed of three Gilat subsystems and a Gogo Inertial Navigation System (INS) system which will be used for pointing control:

- Antenna Subsystem which includes the AES antenna (SAU) and support electronics (SSPA and upconverter). P/N P60000-102
- A receive and transmit subsystem which includes the modem and antenna controller. P/N P60000-101
- An INS which is used by the Antenna Control Unit (ACU) to monitor and control the terminal's relative orientation and keep it properly aligned with the spacecraft.

The K3 system specifications are summarized in Table 2 below. The terminal is shown in Figure 6 below.

Specifications	
Frequency bands	Ku
Receive	RF: 10.95-12.75 GHz, split into 2 bands Intermediate Frequency: 950-2000 in 2 bands
Transmit	RF: 14 –14.5 GHz Intermediate Frequency: 950 -1700
Antenna	
Aperture	11.25”
Polarization	Single Linear transmit, Single Linear Receive
Receive G/T	6.5 to 8 dB/K, at approx 30˚ elevation
Transmit Gain	30.1 dBi at 14.25 GHz
EIRP	42.3 dBW (24W)
Transmit Power	Up to 24W P_{1dB} Output power @ 1dB compression point
Positioner Performance	
Azimuth Travel Range	Continuous
Elevation Travel Range	5˚to 85˚ relative to mounting plate
Polarization Travel Range	270˚ total, +/- 90˚ from vertical to horizontal
Vel (AZ/EL/POL)	30˚/sec minimum
Accel (AZ/EL/POL)	40˚/sec^2
Radome	
Loss estimated	L = 1.25 to 5 dB

Note: AZ = Azimuth, EL = Elevation, POL = Polarization

Table 2 – Gogo K3 terminal specifications

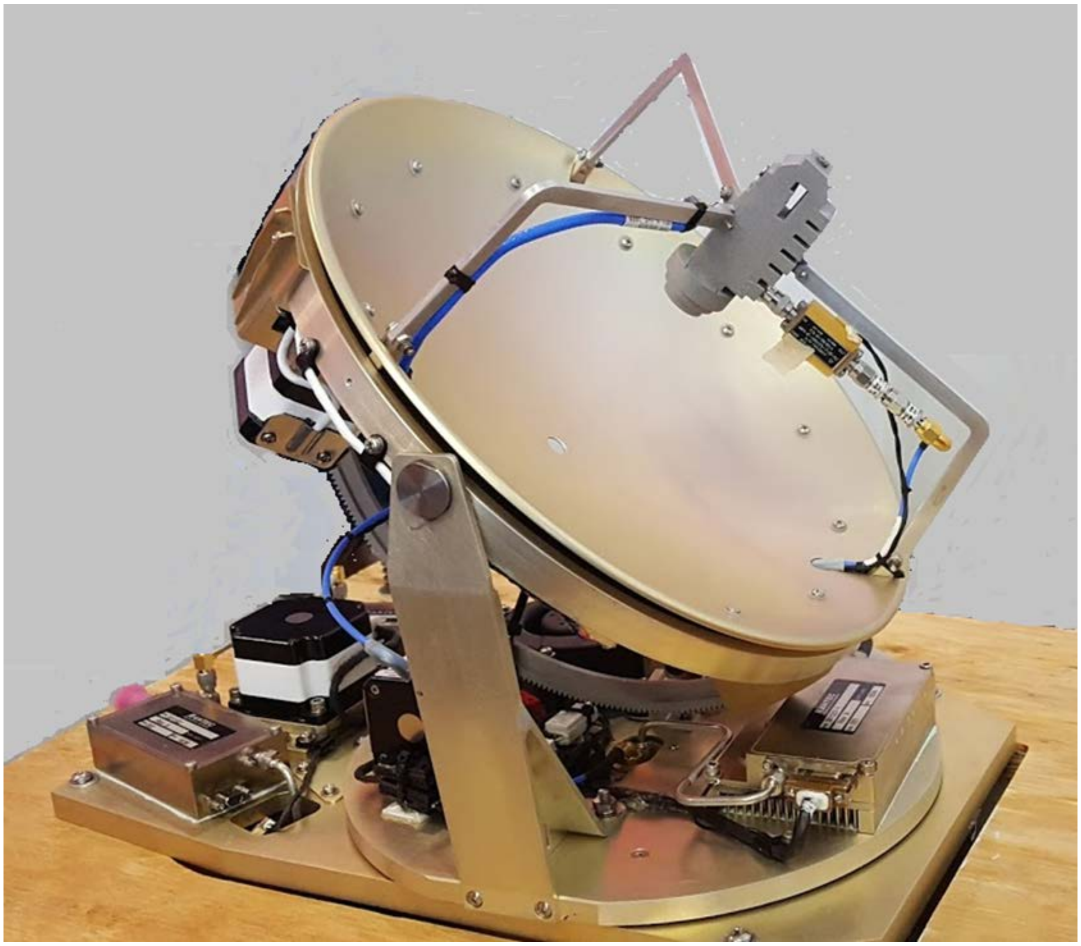

Figure 6 - The parabolic dish antenna and RF system for a tail mount satellite terminal.

3.2 Gogo Network

The testing will use the Gogo ESAA network as illustrated in Figure 7 below, consisting of the following components:

- Space segment capacity consisting of leased satellite transponders. The terminal will be provisioned to prioritize high-throughput (HTS) satellites in the existing network where available. The air interface is engineered and configured by Gogo engineering.
- An AES consisting of a steered mechanical dish and other onboard sub-systems.
- A teleport segment consisting of one or more satellite land earth stations linked by leased capacity on a terrestrial network.
- A network operations center and ground network segment currently operated by Gogo.

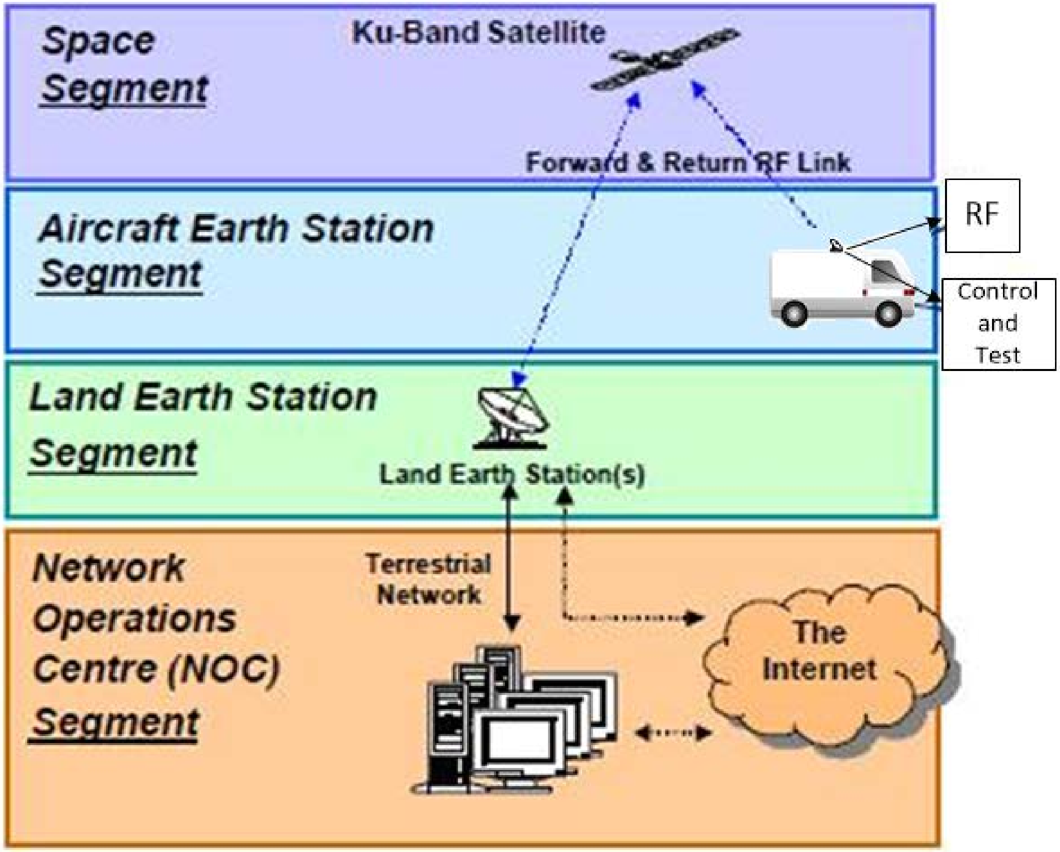

Figure 7 – K3 AES test terminal will utilize the Gogo ESAA network, including the network GSO satellites, the hub equipment and Network Operations Center (NOC)

3.2.1 Space Segment

The space segment will utilize transponders of existing Geo-synchronous Orbit (GSO) satellites which are authorized to serve the U.S. Specifically, three satellites are to be used during testing: AMC-4 at 134.9° W.L., SES-1 at 101° W.L., and SES-15 at 129° W.L. The forward link data to be received by the K3 terminal will be uplinked from a teleport to the GSO satellite using the Ku- or Ka-band and then downlinked from the satellite to the AES in the 11.7-12.2 GHz band. Similarly, return link data will be uplinked from the K3 AES to the satellite using the 14.0-14.5 GHz band and then downlinked from the satellite back to the teleport using either Ku- or Ka-band frequencies.

3.2.2 Teleport

The ground segment or hub will use leased capacity on existing commercial teleports in each region. Each of the teleports provides the uplinks and downlinks to the space segment and is connected to the NOC using leased capacity on a private terrestrial network. The AES system will connect directly to the internet using the existing Gogo infrastructure.

3.2.3 Network Operations Center and Ground Segment

The Gogo NOC and ground segment will provide the central monitoring and management capability for the AES network. The NOC is connected to each of the teleports in the system using Gogo leased capacity on private terrestrial networks and serves all the satellite coverage regions in the AES network. The Total Network Management System (NMS) coordinates the handover of mobile test transitioning between two satellite coverage regions. The NOC will be capable of tracking the K3 AES test van while in motion, ensuring the AES is connected to the satellite network, is performing properly, and can notify the mobile terminal of problems involving power or tracking.

4 Protection of Other Services

4.1 GSO Satellite Services

4.1.1 Off-Axis Emissions

The K3 AES tests is designed to comply with the technical parameters set forth in Part 25 of the Commission's rules, including Section 25.227, which governs ESAA operations. As discussed above, the mobile testing performed pursuant to the experimental license will not involve any aeronautical operations, but instead will involve use of an AES terminal mounted on top of a van. However, the technical standards applicable to vehicle-mounted earth station (VMES) operations under Section 25.226 are the same as those in Section 25.227. The off-axis emissions in all co-polarized and cross-polarized planes will meet the EIRP spectral masks provided in Section 25.227(a)(1). Provided below are the h-plane co-polarized and cross-polarized masks at 14.25 GHz.

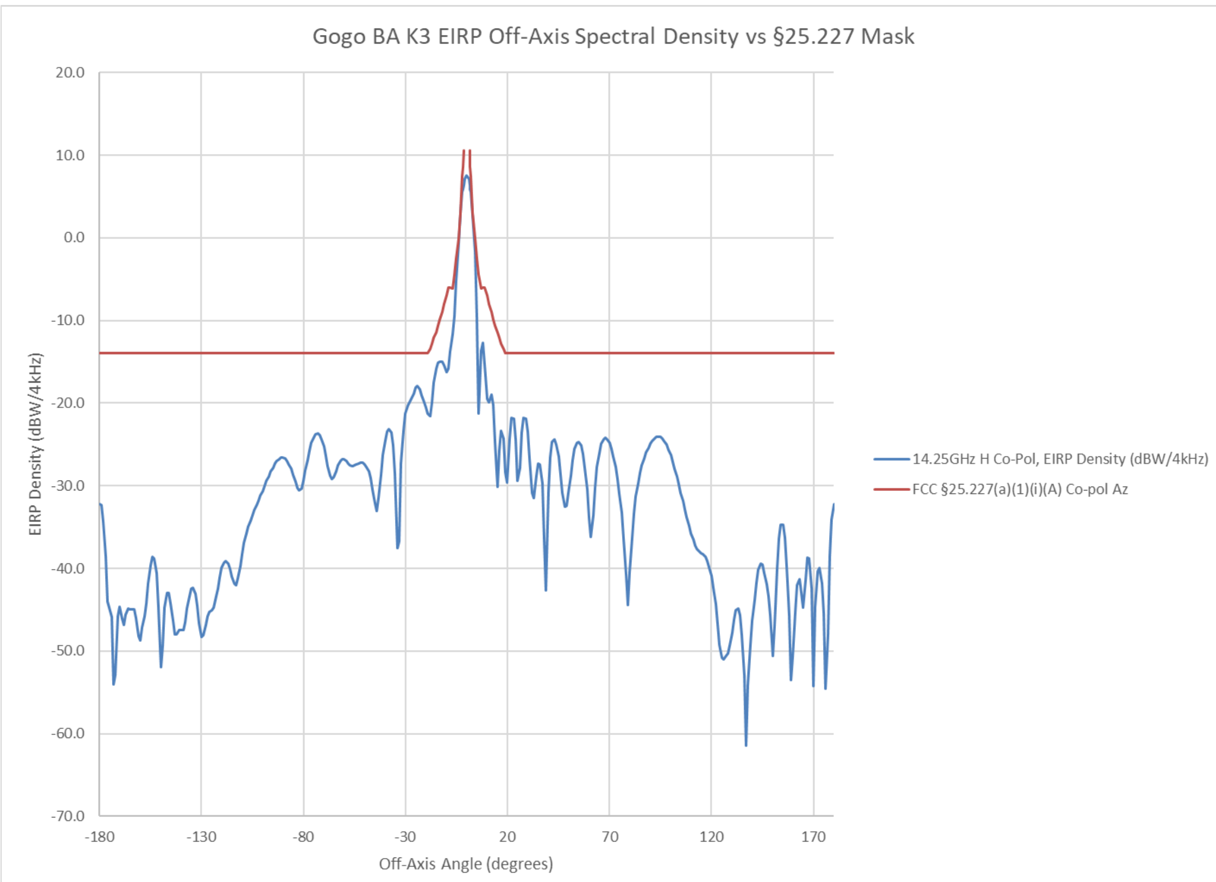

Figure 8 – K3 AES terminal h-plane co-polarized 14.25 GHz off-axis emissions, +/- 180 degrees. Worst case ESD is 7.6 dBW/4kHz. All sidelobes fall under § 25.227(a)(1) mask.

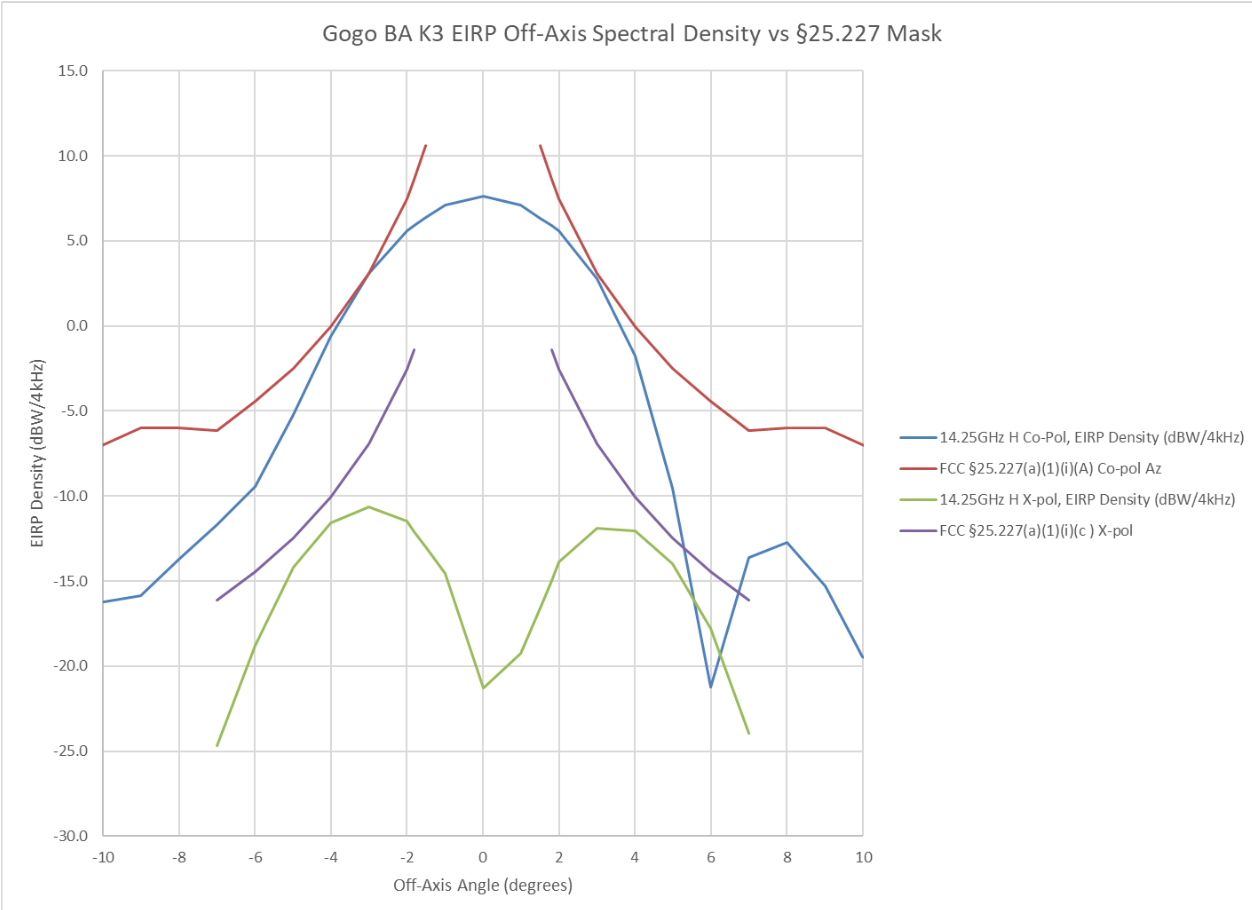

Figure 9 – K3 AES h-plane co-polarized (in blue) and cross-polarized (in purple) 14.25 GHz emissions. All sidelobes fall under the §25.227(a)(1) mask.

4.1.2 Antenna Pointing Accuracy

Gogo will use simulated A429 data when conducting static/fixed testing, which will yield manually pointed accuracy within 0.2 degrees by fixing on a peaked signal response. For mobile testing, Gogo will reduce the power (by 0.6 dB) to be below the FCC 25.227 PSD limits. The operator of the system will inspect log data (e.g. Receive SNR) to validate that the antenna is correctly pointed, muting the ARINC antenna if it is not accurately pointed. Gogo will be testing a system that self-mutes by monitoring the ARINC 429 data to detect aircraft motion patterns where the pointing accuracy may be affected (e.g. buffeting). If the system detects that the pointing accuracy is affected by the motion pattern, transmission mutes within 100 ms. The system then monitors the aircraft motion patterns to detect when the pointing accuracy is within 0.2° and un-mutes the transmission at that point.

In addition to the above, Gogo will:

- Maintain a point of contact available 24 hours per day, seven days per week, with the authority and ability to terminate operations of the Gogo K3 AES system and to discuss interference concerns with other licensees and U.S. Government agencies; and
- Collect and maintain for one year records of the following data for each operating AES: location (latitude, longitude, altitude); vehicle attitude (pitch, yaw, roll); transmit frequency and occupied bandwidth; data rate; EIRP and target satellite.

4.2 Protection of Other Services

4.2.1 Government Services

Gogo will not operate in areas near the NASA TDRS earth station locations, including the White Sands complex in New Mexico and the Blossom Point facility in Maryland. Additionally, the testing will protect National Science Foundation Radio Astronomy Services by not operating within the 14.47-14.5 GHz frequencies during testing.

4.2.2 NGSO Systems

The K3 terminal and its operations during the testing is designed to comply with FCC §25.227 in the azimuth, elevation, and cross-polarized planes, which will ensure protection of any NGSO systems which may commence operations during the requested testing time period.

5 Points of Contact

The Gogo K3 test 24/7 Point of Contact (POC) for this testing is provided below:

Name:	NOC Engineer on Duty
Telephone:	+1 866-943-4662
Email:	noc@gogoair.com.
Address:	Gogo Network Operations Center,
	111 North Canal Street,
	Chicago, IL, 60606

For information related to this Experimental Authorization request please contact:

Name:	Michael Susedik
Title:	Gogo Engineering
Address:	111 North Canal Street
	Chicago, IL 60606
Telephone:	312-517-6332
Email:	MSusedik@gogoair.com

Attachment 1 – Satellite Link Analysis

Link Budget SES-15

Monday 12 March 2018 | Modcod: Manual

Site	Up	Down	Units	Satellite	Value	Units
Latitude	34.1567N	34.3N	degrees	Longitude	129W	degrees
Longitude	118.80W	119W	degrees	Transponder	LTWTA	
Site altitude	0.362	0.508	km	G/T(ref)	18.3	dBK
Frequency	14.367	18.542	MHz	SFD(ref)	-97.82	dBW/m2
Polarization	Horz	Circ	G/T(site)	18.1	dBK	
Availability (av.yr)	N/A	99.5000	%	FCA	0	dB
Ant. aperture	0.28575	9.2	metres	Effective SFD	-97.62	dBW/m2
Ant. efficiency / gain	55	+58.08	% or dBi	ALC	0	dB
Coupling loss	1.2	0	dB	EIRPsat	49.5	dBW
Ant. mispoint	0	0	dB	Transponder BW	36	MHz
Other path losses	1.25	0	dB	IBO(total)	4	dB
LNB noise fig/temp	+40	dB or K	OBO(total)	3	dB	
Ant. noise	40.00	K	C/IM	19.40	dB	
HPA OBO	0	dB				
HPA carriers	1	dB	Up: BEAM 28 BP			
UPC	0	dB	Down: SOUTH MOUNTAIN			
HPA power required	4	W				

Carrier	Value	Units	General	Up	Down	Units
Modulation	4-(A)PSK	Elevation	48.82	48.72	degrees	
Reqd. Eb/No	2.6	dB	Azimuth	197.77	197.37	degrees
FEC code rate	.371	Compass AZ	185.68	185.22	degrees	
Spreading gain	0	dB	Ant Gain	30.08	58.08	dBi
(1 + roll off factor)	1.2	Ant. Efficiency	55.00	20.11	%	
Carr. spacing factor	1.2	Flange EIRP density	-63.06	-200.04	dBW/Hz	
Info rate	4.5588	Mbps	HPA power reqd	6.02	dBW	
Info rate + OH	4.5588	Mbps	HPA size reqd.	4.00	W	

Uplink	Clear	RainUp	RainDn	Downlink	Clear	RainUp	RainDn
EIRP(carr) dBW	34.90	34.90	34.90	EIRP(carr) dBW	19.25	19.25	19.25
IBO(carr) dB	31.25	31.25	31.25	OBO(carr) dB	30.25	30.25	30.25
FSL dB	206.99	206.99	206.99	FSL dB	209.21	209.21	209.21
Atm. absorption dB	0.13	0.13	0.13	Atm. absorption dB	0.27	0.27	0.37
Trop. scintillation dB	0.00	0.00	0.00	Trop. scintillation dB	0.00	0.00	0.13
Cloud attenuation dB	0.00	0.00	0.00	Cloud attenuation dB	0.00	0.00	0.22
Rain attenuation dB	0.00	0.00	0.00	Rain attenuation dB	0.00	0.00	1.05
Total attenuation dB	0.13	0.13	0.13	Total attenuation dB	0.27	0.27	1.65
Other pathloss dB	1.25	1.25	1.25	Other pathloss dB	0.00	0.00	0.00
UPC available dB	0.00	0.00	0.00	Rain noise Inc dB	0.00	0.00	2.27
UPC used dB	0.00	0.00	0.00	G/T dB/K	38.12	38.12	35.85
C/No(thermal) dB.Hz	73.23	73.23	73.23	C/No(thermal) dB.Hz	76.49	76.49	72.84

C/Io dB	82.38	82.38	82.38	C/Io dB	85.34	85.34	85.30
C/(No+Io) dB.Hz	72.73	72.73	72.73	C/(No+Io) dB.Hz	75.96	75.96	72.60

End-to-End	***Clear***	***RainUp***	***RainDn***	***Space Segment***	***Value***	***Units***
C/No (thermal) dB.Hz	71.55	71.55	70.02	Overall Availability	99.5000	%
C/N (thermal) dB	3.66	3.66	2.14	Transmit rate	12.2880	Mbps
C/ACI dB	19.63	19.63	19.63	Symbol rate	6.1440	Mbaud
C/ASI dB	16.40	16.40	16.40	Noise BW	67.8845	dB.Hz
C/XPI dB	21.40	21.40	21.30	Occupied BW	7.3728	MHz
C/IM dB	19.04	19.04	19.04	Allocated BW	7.3730	MHz
C/(No+Io) dB.Hz	71.04	71.04	69.65	Link efficiency	0.618	bps/Hz
C/(N+I) dB	3.15	3.15	1.77	% BW used	20.48	
Impln. loss dB	0.00	0.00	0.00	Power used	19.25	dBW
System margin dB	0.00	0.00	0.00	% Power used	0.19	
Net Eb/No dB	4.45	4.45	3.07	Max. carriers	4.88	
Reqd. Eb/No dB	2.60	2.60	2.60	Limited by:	Bandwidth	
Excess margin dB	1.85	1.85	0.47	Power eqiv. BW	0.0678	MHz

Attachment 2 – Radiation Hazard Study

Radiation Hazard Analysis
Gogo K3 AES Terminal

This analysis predicts the radiation levels around a proposed earth station terminal, comprised of one parabolic dish 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 K3 AES system will typically operate above 10 degree elevation. The system is equipped with a 24 watt amplifier and has 1.5 dB of output circuit losses plus an additional 1.2 dB of radome losses. The worst-case operating scenario, in terms of worst power density levels, has been presented here.

Table Summary of RadHaz Parameters				**K3 AES Terminal**
Parameter	Abbr.		Units	Formula
Dish #		K3		
Antenna Diameter	Df	0.28600	meters	
Antenna Centerline	h	2.0	meters	
Antenna Surface Area	Sa	0.1	$meters^2$	$(\pi * Df^2)/4$
Frequency of Operation	f	14.25	GHz	
Wavelength	λ	0.0211	meters	c / f
HPA Output Power	P_{HPA}	24.0	watts	
HPA to Antenna Loss	L_{tx}	2.7	dB	(+ 1.2 dB Radome Loss)
Transmit Power at Flange	P	11.1	dBW	$10 * Log(P_{HPA}) - L_{tx}$
		12.89	watts	
Antenna Gain	G_{es}	30.0	dBi	
		1001.8	n/a	
EIRP	EIRP	41.1	dBW	
PI	π	3.1415927	n/a	
Antenna Aperture Eff.	η	55.00%	n/a	$G_{es} / (PI * Df / \lambda)^2$

Table 1 - Earth Station Technical Parameter Table

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 = 80.258 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:

$PD_{nf} = (16\eta P)/(\pi D^2)$ = 35.06 mW/cm² (2)

from 0 to 0.97 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: $0.97 < R < 2.33$ 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}: 34.1 m

Controlled Environment Safe Operating Distance (meters), R_{safec}: 6.8 m

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: $R > R_{ff} = 2.3$ meters

$PD_{ff} =$ 15.019 mW/cm^2 at $R_{ff,}$

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 Gogo AES antenna at 1.0 degrees off axis the antenna gain is:

G_{off} = 29.89 dBi at 1.0 degree

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 1.0 degree off axis at the far-field limit, we can calculate the power density as:

G_{off} = 29.89 dBi = 975.0 numeric

$PD_{1.0 \text{ deg off-axis}} = PD_{ff} \times 975/G = 1.8415 \text{ mW/cm}^2$ (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 of the antenna's main beam, the power density exposure is at least 20 dB below the main beam level as follows:

$PD_{nf(off\text{-}axis)} = PD_{nf}/100$ = **0.35063** mW/cm^2 at D off axis (6)

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:

$S = (Deff/ \sin \alpha) + (2(h-GDeff) - Deff - 2)/(2 \tan \alpha)$ (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.

α = minimum elevation angle of antenna		10	deg	
h = maximum height of object to be cleared		2.0	m	
GD = Ground Elevation Delta antenna-obstacle		1.0	m	K3 mounted on van roof
elevation angle	10	0.8	m	
	15	0.6	m	
	20	0.4	m	
	25	0.4	m	
	30	0.3	m	

This is test system with a van rooftop 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 panel van, and it is pointed upward. 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 terminal. 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				K3 AES Terminal
Parameter	Abbr.		Units	Formula
Dish #		K3		
Antenna Diameter	Df	0.28600	meters	
Antenna Centerline	h	2.0	meters	
Antenna Surface Area	Sa	0.1	meters^2	$(\pi * Df^2)/ 4$
Frequency of Operation	f	14.25	GHz	
Wavelength	λ	0.0211	meters	c / f
HPA Output Power	P_{HPA}	24.0	watts	
HPA to Antenna Loss	L_{tx}	2.7	dB	(+ 1.2 dB Radome Loss)
Transmit Power at Flange	P	11.1	dBW	$10 * Log(P_{HPA}) - L_{tx}$
		12.89	watts	
Antenna Gain	G_{es}	30.0	dBi	
		1001.8	n/a	
EIRP	EIRP	41.1	dBW	
PI	π	3.1415927	n/a	
Antenna Aperture Efficiency	η	55.00%	n/a	$G_{es} / (PI * Df /\lambda)^2$
1. Reflector Surface Region Calculations				
Reflector Surface Power Density	PDas	802.58	W/m^2	$(16 * P)/(\pi * D^2)$
		80.258	mW/cm^2	**Does Not Meet Uncontrolled Limits**
				Does Not Meet Controlled Limits
2. On-Axis Near Field Calculations				
Extent of Near Field	Rn	0.97	meters	$D^2 / (4 *\lambda)$
		3.19	feet	
Near Field Power Density	PDnf	350.60	W/m^2	$(16 * \eta * P)/ (\pi *D^2)$
		35.060	mW/cm^2	**Does Not Meet Uncontrolled Limits**
				Does Not Meet Controlled Limits
3. On-Axis Transition Region Calculations				
Extent of Transition Region (min)	Rtr	0.97	meters	$D^2 / (4 *\lambda)$
Extent of Transition Region (min)		3.19	feet	
Extent of Transition Region (max)	Rtr	2.33	meters	$(0.6 * D^2) /\lambda$
Extent of Transition Region (max)		7.65	feet	
Worst Case Transition Region Power Density	PDtr	350.60	W/m^2	$(16 *\eta * P)/ (\pi * D^2)$
		35.060	mW/cm^2	**Does Not Meet Uncontrolled Limits**
				Does Not Meet Controlled Limits
Uncontrolled Environment Safe Operating Distance	Rsu	34.1	m	=(PDnf)*(Rnf)/Rsu
Controlled Environment Safe Operating Distance	Rsc	6.8	m	=(PDnf)*(Rnf)/Rsc
4. On-Axis Far Field Calculations				
Distance to the Far Field Region	Rf	2.3	meters	$(0.6 * D^2) /\lambda$
		7.65	feet	
On-Axis Power Density in the Far Field	PDff	150.19	W/m^2	$(G_{es} * P) / (4 * \pi * Rf^2)$
		15.019	mW/cm^2	**Does Not Meet Uncontrolled Limits**
				Does Not Meet Controlled Limits
5. Off-Axis Levels at the Far Field Limit and Beyond				
Reflector Surface Power Density	PDs	18.415	W/m^2	$(G_{es} * P) / (4 * \pi * Rf^2)*(Goa/Ges)$
Goa/Ges at example angle θ 1 degree		0.123		Goa = @ 1deg 29.89 dBi
		1.8415	mW/cm^2	**Does Not Meet Uncontrolled Limits**
6. Off-axis Power Density in the Near Field and Transitional Regions Calculations				
Power density 1/100 of Wn for one diameter removed	PDs	3.5060	W/m^2	$((16 * \eta * P)/ (\pi *D^2))/100$
		0.35060	mW/cm^2	**Meets Controlled Limits**
8. Off-Axis Safe Distances from Earth Station				$S = (D/ \sin \alpha) + (2h - D - 2)/(2 \tan \alpha)$
α = minimum elevation angle of antenna		10	deg	
h = maximum height of object to be cleared, meters		2.0	m	
GD = Ground Elevation Delta antenna-obstacl		1.0	m	
elevation angle	10	0.8	m	
	15	0.6	m	
	20	0.4	m	
	25	0.4	m	
	30	0.3	m	