AeroSat Experimental Operation
FCC File No.0098-EX-ST-2006

Introduction

This paper addresses questions raised by the FCC staff concerning the design and operation of the proposed experiment. The experiment is intended as a proof of concept. AeroSat does not contemplate seeking reallocations to provide for operations using the "reverse Ku band" topology proposed in the experiment. Instead, if the experimental results demonstrate the feasibility of the approach to be tested, other spectrum outside of this band will be proposed.

As described below, the experiment will involve communications with two aircraft that will fly off the East Coast of the United States between Egg Harbor in New Jersey and Cape Cod in Massachusetts. The test is being conducted by AeroSat under contract with the Federal Aviation Administration (contract number DTFAWA-05-C-00093) and will use FAA aircraft piloted by FAA personnel.

Ground ("Earth") Station

Location

FAA William J. Hughes Technical Center
Egg Harbor Township, NJ
39^{o} 26' 58.11" North Latitude
74^{o} 33' 57.35" West Latitude

There is only one ground station in the experiment. In a fully developed system, AeroSat envisions using a series of ground stations and a "fleet" of airliners in the air to carry two-way high-speed Internet services to aircraft for use by passengers, crews and air traffic control centers. Figure 1 shows the one segment of the ground-to-air and plane-to-plane repeater concept that will be evaluated under this temporary authorization. For this experiment the "radio tower" at the FAA William J Hughes Technical Center is collocated with a ground station that houses the ground access point that provides network connectivity to a high speed data connection through a Tier 1 Internet Service Provider. With aircraft flying at 35,000 feet the radio line-of-site from the aircraft to the ground station is in excess of 225 nautical miles and the air-to-air radio line-of-site is in excess of 450 nautical miles. In order to maintain radio link margin and to minimize the effect of multi-path, the proposed operational air-to-ground range is 150 nautical miles and the proposed operational air-to-air range is 300 nautical miles.

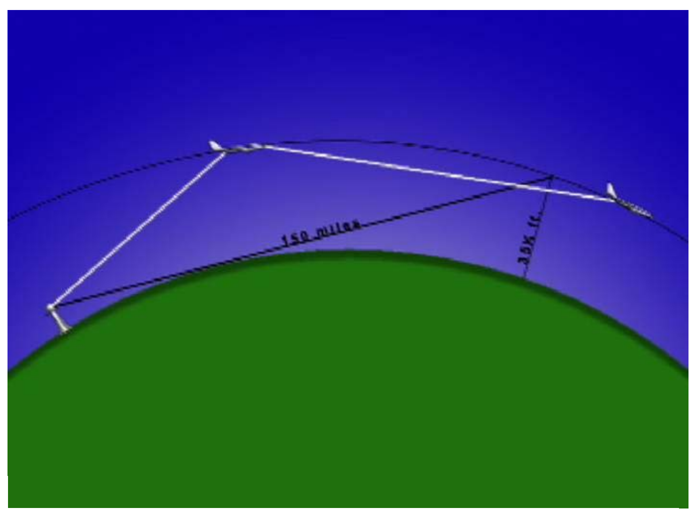


Figure 1 – Communications Link Extended Beyond the Line of Sight

Placing a radio receiver and repeater (a radio relay) on each aircraft allows each aircraft to receive high-speed data from a data network through either a ground station or a nearby aircraft and relay it to like-equipped aircraft in flight. This airplane-to-airplane relay creates an effective T-3 (45 Mbps) data link network backbone. A typical ground Network Access Point Air Interface as envisioned for future use would consist of two 39 inch diameter directional antennas. A Network Relay Air Interface as envisioned for future use would consist of two 6 inch directional antennas for long range connectivity and two omni-direction antennas for short range, less than a few miles, connectivity.

For this experiment, however, the equipment complement is more modest. There would be one antenna in the Ku band and one L band (902 – 928 MHz) for the sole ground station, one antenna in the Ku band on each of the two aircraft, and one L band antenna on each of the two aircraft. The L band link would be used for air-to-air relays during the test and for communications with the aircraft while the aircraft are on the ground. Technical details for the L band operation are set forth in the request for special temporary authorization and will be coordinated through the IRAC.

Antenna Details

The experimental ground transmit antenna is a 1 meter ring-focus parabolic dish antenna. The half power beam-width at 12.2 GHz is 1.6 degrees with a gain of 39.9 dBI. The radiation pattern for the antenna is depicted in Attachment 1. The EIRP will be 43.4 dBW or 2.4 dBW/4 kHz. The transmitter power to the antenna is 2.5 watts. The actual power amplifier is 25 watts but it is coupled with a 10 dB attenuator to the antenna.

The antenna is permanently mounted under a radome on the roof of the FAA William J Hughes Technical Center Hangar, building 306. The top of the radome is approximately 18 feet above the roof of the hangar. The roof of the hangar is approximately 130 feet above mean sea level or 70 feet above ground level. The antenna is steer-able 360^{o} in azimuth and from -23^{o} to 90^{o} in elevation. In actual operation, the antenna would be restricted to azimuths so that the transmitting operations are within a range of azimuths from 45 degrees EN to 210 degrees SSW except for brief periods when the aircraft is engaged in taxi, takeoff and landing, or when the antenna is below 0 degrees in elevation.

Protection of Ground Stations

The proposed test would use the 11.7 – 12.2 GHz band for transmissions to aircraft. Because this band is also utilized as a downlink in the Fixed Satellite Service, AeroSat is cognizant of the need to protect earth stations from harmful interference. The distance to the radio horizon in the range of azimuths to be served looking to the Northeast and East toward the Atlantic Ocean is approximately 12 statute miles. AeroSat has consulted the Commission's records and has also had Comsearch run a search of those records to determine that there are no fixed earth stations within 30 miles of the site of the ground station. Given the remoteness of the location and the operational area directed toward sea, it is unlikely that there would be any temporary earth stations "roaming" into the area. The restriction of the arc over which transmissions are to occur will provide further protection.

Emission Details

Some transmissions will include both QPSK and QAM transmit signal modulations. Simultaneous modulations will be used to verify performance advantages of one type over the other modulation type. The experimental frequency request for the ground to air link for this experimental license is for operation of two transmitters between 11.7 GHz and 12.2 GHz. The following emission designators will be tested simultaneously:

QPSK, emission designator 50MOD7W
QAM, emission designator 50MOF7W

<u>Aircraft Station</u>

Area of Operation

The Aircraft operating are will be north of 35^{o} north latitude, south of 42^{o} north latitude, 76^{o} west longitude and east of 68^{o} west longitude. The aircraft will be transmitting while they are on ground to altitudes of up to 51,000 feet.

Antenna Details

Figure 2 – Aircraft Antenna

The Airborne Ku antenna is an 11.4 inch diameter conical horn with lens mounted on a gimbal. The antenna is steerable continuously 360^{o} in azimuth, from 0^{o} to 90^{o} in elevation and from -110^{o} to 90^{o} in polarization. The airborne antenna uses the location (latitude, longitude and altitude) of the ground station and its own latitude, longitude, altitude and attitude (Roll, pitch and yaw) to direct the airborne antenna in azimuth, elevation and polarization to the ground station. The airborne antenna is capable of transmitting in the 14.0 GHz to 14.5 GHz frequency spectrum. The half power beamwidth at 14.0 GHz is 4.95^{o} with a gain of 31.3 dBi. The radiation pattern for the antenna is depicted in Attachment 2. A 25 Watt power amplifier is connected to the antenna with a feed loss of 1.5 dB making the net EIRP 43.8 dBW or 2.83 dBW/4kHz.

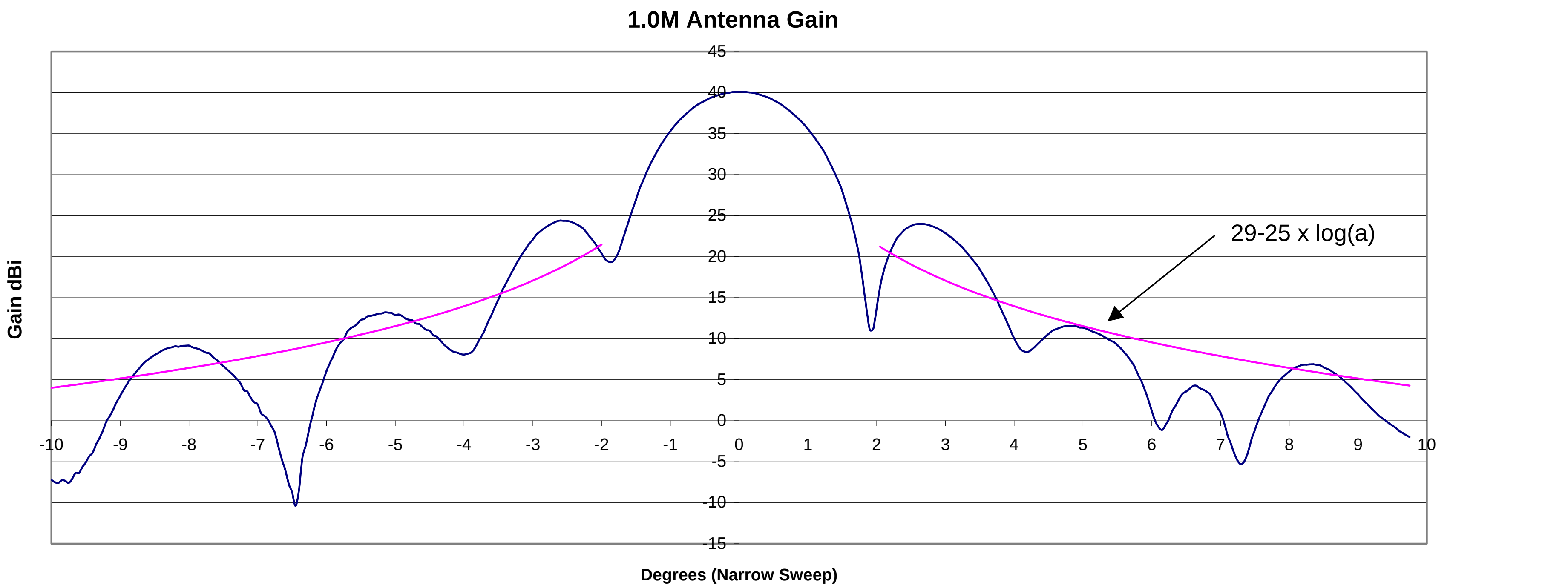
Space Station Protection

Because the aircraft will transmit to the ground in the 14.0 – 14.5 GHz band that is utilized as a satellite uplink, AeroSat is cognizant of the need to protect satellites from receiving any radiation from the aircraft that could cause harmful interference. The field of view of the airborne antenna will be restricted to prevent its pointing toward any satellites orbiting in the Clark Belt and the software controlling the transmitter will configured to prevent transmission should the attitude of the aircraft ever place the aircraft in such a position that the airborne antenna could be oriented within 10 degrees above or below the Clark Belt. Figure 2 depicts an antenna of the kind to utilized aboard the aircraft.

Description of the service

Digital data scripts will be transmitted to measure bit error rate performance. FAA and general data structures will be used to simulate potential operational scenarios. For most flights two different modulation schemes will be evaluated against each other.

Attachment 1 – Ground Station Antenna Pattern


1.0M Antenna Gain
Gain dBi
45
40
35
30
25
20
15
10
5
0
-5
-10
-15
-10
-9
-8
-7
-6
-5
-4
-3
-2
-1
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4
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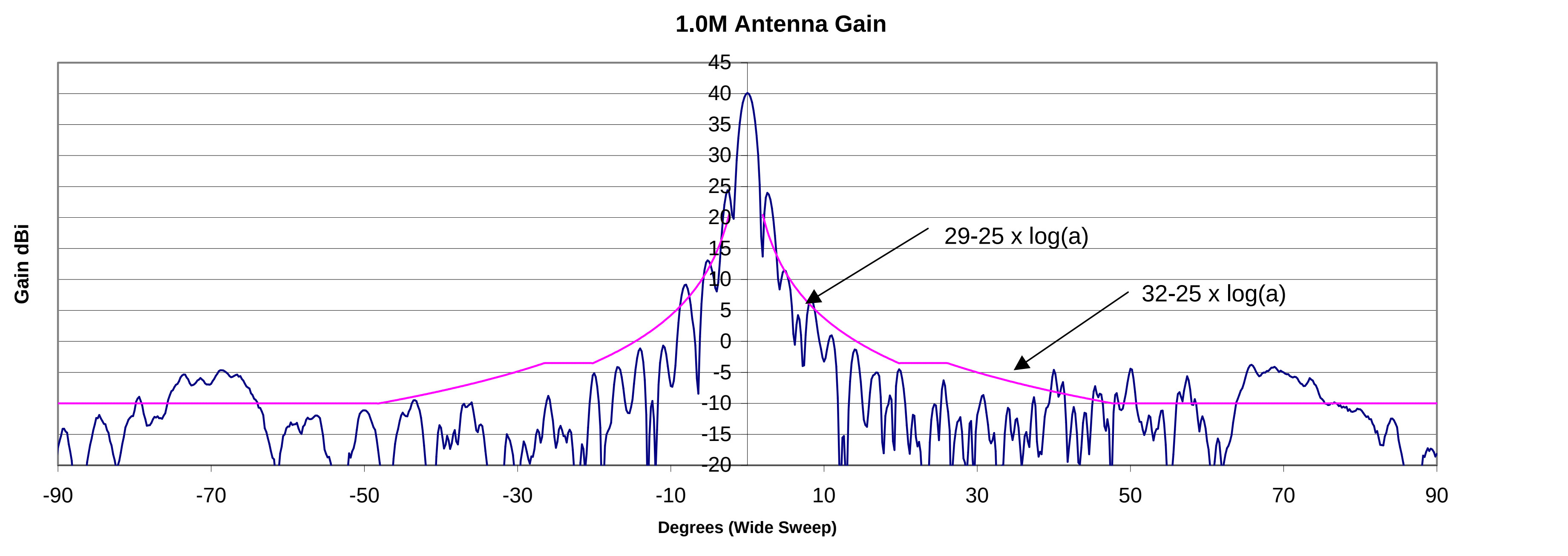
6
7
8
9
10
29-25 x log(a)
Degrees (Narrow Sweep)


1.0M Antenna Gain
Gain dBi
45
40
35
30
25
20
15
10
5
0
-5
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-20
-90
-70
-50
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-10
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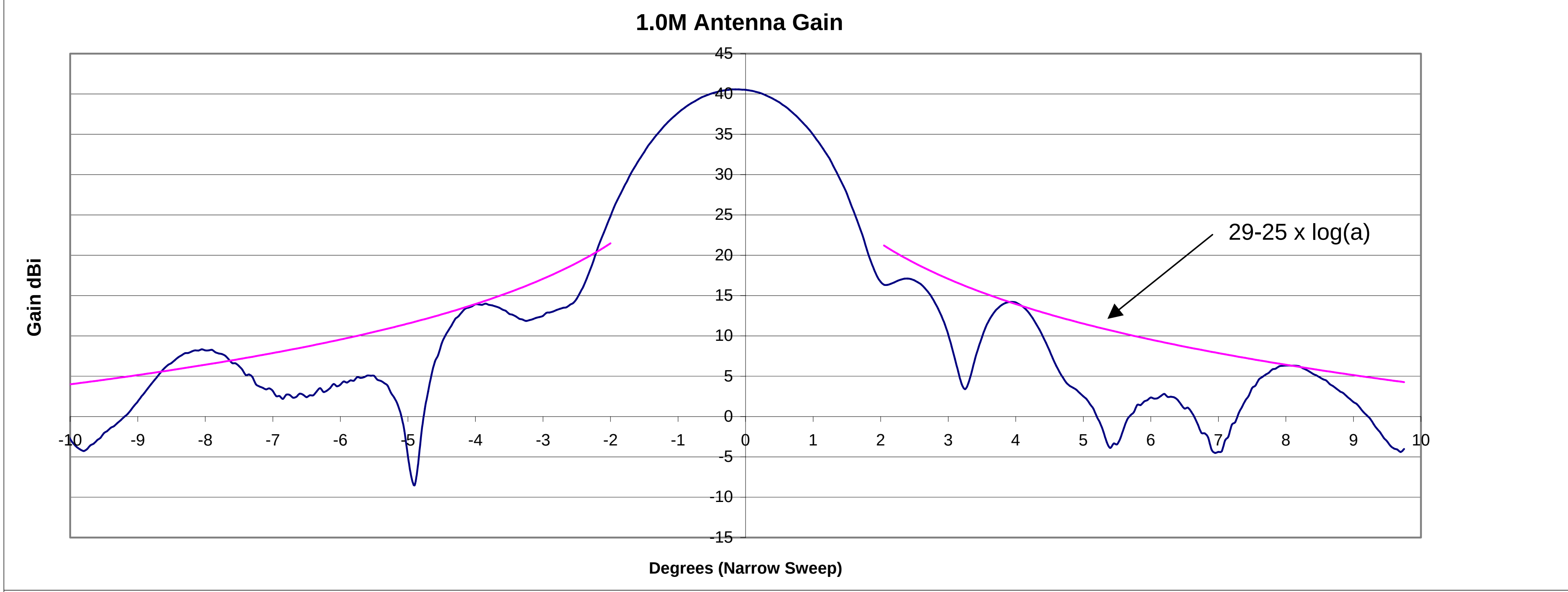
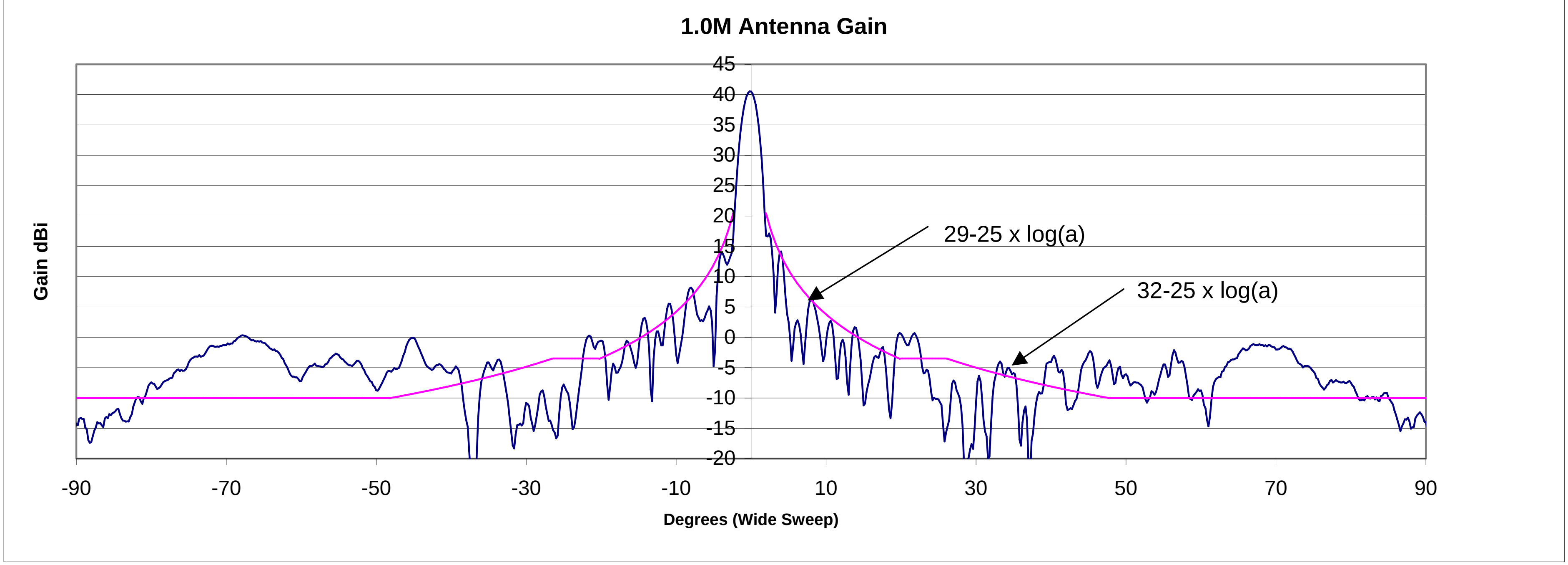
50
70
90
29-25 x log(a)
32-25 x log(a)
Degrees (Wide Sweep)


1.0M Antenna Gain
Gain dBi
Degrees (Narrow Sweep)
29-25 x log(a)


1.0M Antenna Gain
Gain dBi
Degrees (Wide Sweep)
29-25 x log(a)
32-25 x log(a)

Attachment 2 – Aircraft Station Antenna Pattern

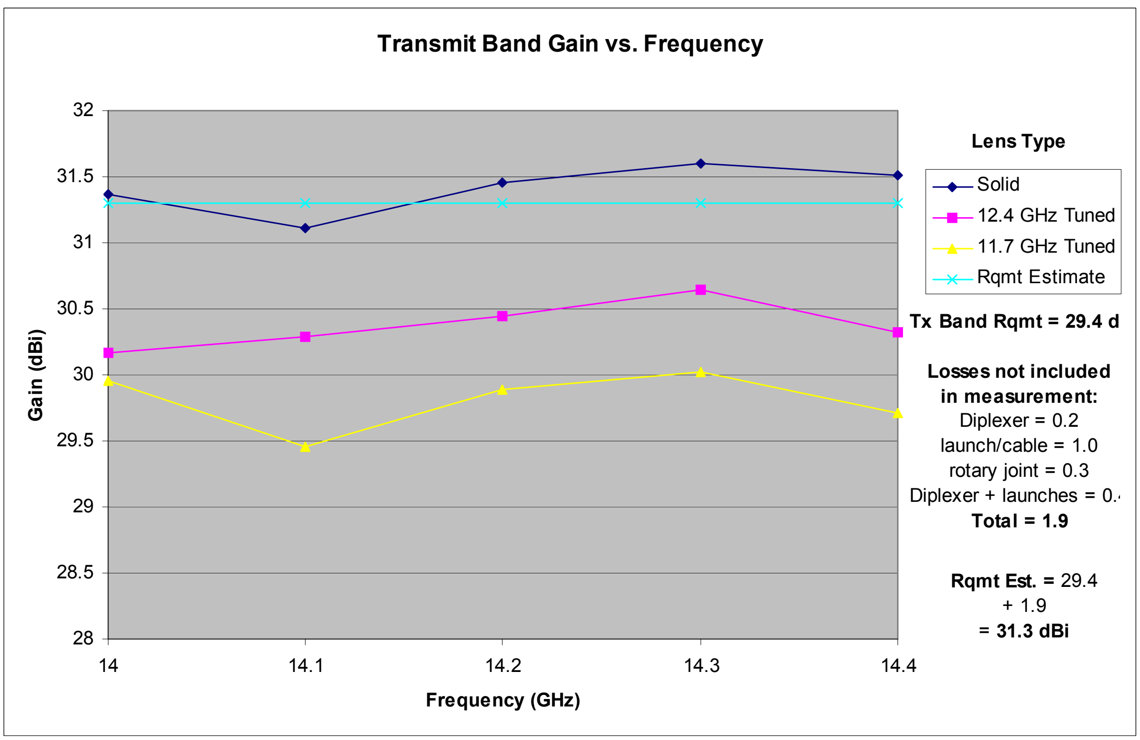
AeroSat Avionics LLC
62 State Route 101A, Suite 2B
Amherst, New Hampshire 03031

To: File
File: L3 TME Antenna Lens Measurements 20040608a for the FAA Demonstration
Date: 04/12/2006

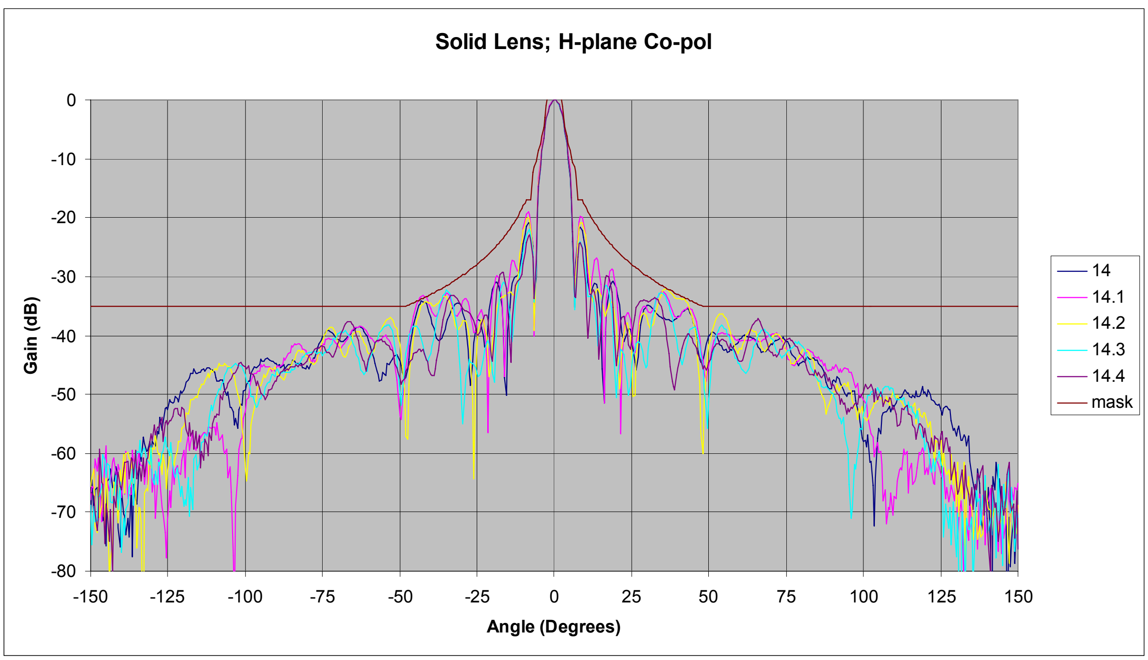
From: Frank Blanda
Subject: L3 TME Antenna Lens Measurements

Summary

The figures on the following two pages show the relative antenna gain results made at the L3 Compact Range in Salt Lake City on one of the antenna models proposed for the FAA demonstration. The absolute gain for the antenna versus frequency is shown in the figure on this page labeled "Solid". It is the blue line with the diamonds. So in general once you get beyond 75° the absolute gain is -10 dBi.



Transmit Band Data



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