

GPS Re-Radiation (Re-Rad) System to Support Military Aircraft Production

The Boeing Company
Lambert Field, Bldg. 73-75
St. Louis, MO

GPS L1 1575.42 MHz Emission 24M0G1D

Power at antenna:

Main lobe to aircraft under test point: Maximum -74.0 dBm or 39.8 Pico watts

Side lobe to NTIA measurement point: Maximum -84.5 dBm or 3.5 Pico watts

Reference: WB9XXP File Number 0357-EX-ST-2004

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by

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Revision

This is a revised technical description that corrects the original document dated 10/26/04. The radiated RF power was stated as -98.6 dBW or 72 Pico watts. An improved calculation shows the value as -104.0 dBW or -74.0 dBm or 39.8 Pico watts.

This revised technical description focuses on showing compliance with NTIA Chapter 8.3.28. The RF units of measurement references have been changed from dBW to dBm conforming to the standards in Chapter 8.3.28.

Introduction

The purpose of this application was to extend operations as authorized by WB9XXP (STA) by applying for a full 2-year experimental license. Since then, the application was set-aside, the STA expired and operations ceased. Boeing has been notified that the application is again in a pending status.

Boeing - St. Louis built a new production hanger (Building 73-75) to replace the 1950's era production/flight test operation and to make way for the St. Louis Lambert Field International Airport Expansion. The building is located at 38-45-4.1 N 90-21-23.8 W NAD83. The facilities are used to manufacture military aircraft (F-15E, F/A-18E/F, and T-45C.) The following are the contract numbers:

N00019-99-C-1226 (F/A-18)
F33657-00-C-0013 (F-15)
N00019-03-C-6528 (T-45)

The facility also supports many other military programs that make use of flight test operations co-located with the production operations. The ability to perform GPS avionics checkout and troubleshooting inside the production hanger is an important and cost effective aspect for production operations.

Technical Description

The all metal building is 450 long and 250 feet wide. There are 9 metal hanger doors on each side. The doors are 50 feet wide and 30 feet high and allow passage of aircraft. Weather permitting, the doors are opened. The following analysis shows how the GPS re-radiating system is used with the doors open and still meet the NTIA -140 dBm/24 MHz rule.

The system receives the GPS signals from a roof top antenna and re-transmits the signals inside the hanger to allow our production and flight test personnel to perform testing and troubleshooting of the aircraft's GPS based systems. There are a maximum of 8 GPS re-rad antennas located inside the building, each one illuminates a corresponding aircraft test station. Each antenna is located 30 feet above the factory floor illuminating an area directly below it about 100 feet in diameter where the aircraft is located. The antennas are placed no less than 75 feet from any building outside edge perimeter. The intent is to have the GPS signal available 24/7 with or without the hanger doors open.

The roof mounted antenna has a built-in band-pass filter with -60 dB skirts at +/- 1.0 MHz and provides 38 dB gain. A variable attenuator follows and is used to calibrate the total system gain and maintain the NTIA maximum of -140 dBm/24 MHz at 100 feet from the building.

Calibration begins with establishing the effective radiated power in the antenna's main lobe. This is done by using 2 GPS receivers (that are the same) to reduce ambiguous measurements that might be observed with just one receiver. The system gain was adjusted to a level where the receivers just barely detect the re-radiated signal at a measurement spot directly on the floor below. Since a minimum detectable signal is about -130 dBm and the 30 foot path loss is calculated as -56 dB, then the effective radiated power directed to the floor by the antenna's main lobe must be -74 dBm or 39.8 Pico watts. This includes the main lobe gain of about 3.0 dB.

However, the side lobe and not the main lobe becomes the extended hypotenuse path to the NTIA measurement point. The side lobe has a loss of -7.5 dB (that is relative to unity gain) at the -9.7 degree lobe of negative tilt from the horizontal to the NTIA measurement point. Therefore, the front (downward) to side lobe loss when referenced to the main lobe's 3 dB gain is actually -10.5 dB. The hypotenuse path is 177.6 feet and attributes to about 0.1 dB difference from a 175 foot path and will be ignored. Therefore...

75 feet min. from any antenna to building perimeter + 100 feet to measurement point = 175 foot free space path loss

Main lobe power at each antenna + Side lobe loss to negative tilt = Side lobe power from any antenna toward the corresponding measurement point

$$(-74.0 \text{ dBm}) + (-10.5 \text{ dB}) = -84.5 \text{ dBm or } 3.5 \text{ Pico watts}$$

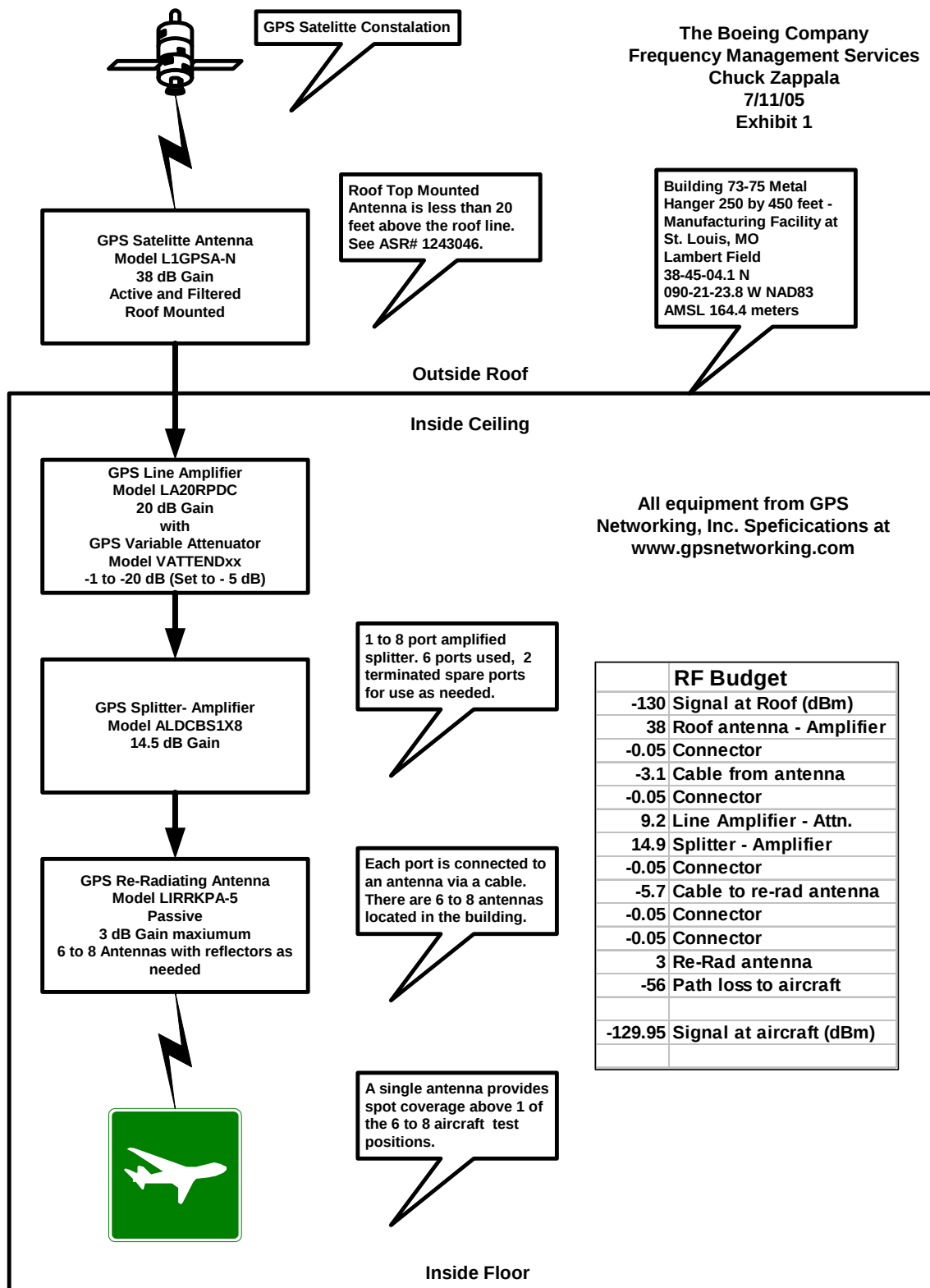
Therefore, using the free space equation: $\text{dB(D)} := \text{FT} + 20 \cdot \log(\text{D}) + 20 \cdot \log(\text{F})$ the...

Side lobe power from any antenna + 175 foot path loss = **RF at 100 feet from building perimeter**

$$(-84.5 \text{ dBm}) + (-70.9 \text{ dB}) = \textbf{-155.4 dBm}$$

This value exceeds the requirements of Item 7 by 15.4 dB.

Adjustment or replacement of antennas, reflectors or other system components is not permitted without performing another calibration.



Certification of compliance for NTIA Chapter 8.3.28

Item 1. Comply.

Item 2. The GPS re-radiation system noted in this document will be used as an Experimental RNSS Test Equipment for the purpose of testing GPS receivers.

Item 3. NA.

Item 4. Boeing will accept a two-year grant with possible renewal.

Item 5. The operation is at a specific fixed location as is not mobile.

Item 6. The GPS re-radiation system noted in this document will be under the control the appropriate Boeing employees at all times.

Item 7. As illustrated in this document, Boeing complies with the -140 dBm/24 MHz at a distance of 100 feet from the building where the test is being conducted.

Item 8. GPS users in the area of the potential interference to GPS reception will be notified that GPS information may be impacted for periods of time. The appropriate signage will be displayed in and around the building.

Item 9. The GPS re-radiation system noted in this document will be used only for the purpose of testing RNSS equipment/systems.

Item 10. The "Stop Buzzer" points of contact are:

<u>Name</u>	<u>Office Desk</u>	<u>Office Mobile</u>	<u>Office Pager</u>	<u>Home Phone</u>
Gary Hart	314-777-7296	314-705-2358	314-507-0668	636-225-8235
Glen Segantredo	314-777-7298	314-705-2349	314-318-5206	618-637-2246
Ross Dunagan	314-777-4109	314-306-4632	None	636-940-7350