

# Flight Test Bed Operations GPS Re-Radiation (Re-Rad) System Technical Description

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## Purpose for the Application

The purpose of this application is to obtain a 2-year experimental license to operate a GPS re-radiation system supporting aircraft development and testing.

## Why we are Applying for a License

The Boeing Company would like the ability to perform functional testing of receive GPS systems inside a building to support testing of aircraft subsystems with integrated GPS receivers.

## Technical Description

This technical description shows compliance with all NTIA items in Chapter 8.3.28.

1. Individual authorization is for indoor use only and is required for each device at a specific site. **Operation will be conducted indoors. The device information is provided in application and specific site information provided below.**
2. Applications for frequency assignment should be applied for as an XT station class with a note indicating the device is to be used as an "Experimental RNSS Test Equipment for the purpose of testing GPS receivers" and describing how the device will be used.
3. Approved applications for frequency assignment will be entered in the GMF. **Boeing concurs.**
4. The maximum length of the assignment will be two years, with possible renewal. **Boeing concurs.**
5. The area of potential interference to GPS reception (e.g., military or contractor facility) must be under the control of the user. **The site is under Boeing's control.**
6. The maximum equivalent isotropically radiated power (EIRP) must be such that the calculated emissions are no greater than -140 dBm/24 MHz as received by an isotropic antenna at a distance of 100 feet (30 meters) from the building where the test is being conducted. The calculations showing compliance with this requirement must be provided with the application for frequency assignment and should be based on free space propagation with no allowance for additional attenuation (e.g., building attenuation.) **Link budgets provided below and meet specified levels. Calculations do not allow for building attenuation.**
7. GPS users in the area of potential interference to GPS reception must be notified that GPS information may be impacted for periods of time. **GPS users in area will be notified.**
8. The use is limited to activity for the purpose of testing RNSS equipment/systems. **Use will be limited to testing RNSS equipment.**
9. A "Stop Buzzer" point of contact for the authorized device must be identified and available at all times during GPS re-radiation operation of the device under any condition. **Stop Buzzer information provided below.**

## Location

Two GPS Re-Radiation systems to be installed in one building at 6161 Aviation Dr Berkeley, MO 63134-2019. The specific location of the systems are:

System 1: 38 44 57.7788N 090 21 08.7906W

System 2: 38 44 56.31N 090 21 08.7726W

## Military Contract Numbers

The facilities identified above support work accomplished under contract. The current contract numbers are:

- 1) FA8634-20-F-0022 F-15EX contract supporting development/integration testing.
- 2) FA8617-18-D-6219 ET-7A contract supporting development/integration testing.
- 3) USAF & USN Research & Development contracts, various...

## Stop Buzzer

Primary Stop Buzzer:

Johnathon R. Hendrickson

Work Desk: 636-793-2195

Home Phone: 815-222-5790

Backup Stop Buzzer:

Adam Gann

Work Desk: 314-304-0153

Home Phone: 217-549-5631

## Technical Description

System:

Receiving and transmitting antennas with LNAs and attenuators to control radiating power.

Frequency: L1 1575.42 MHz

Emission: 24M0G1D

Frequency: L2 1227.60 MHz

Emission: 24M0G1D

Boeing Flight Test Bed Operations Laboratory GPS Re-Radiator Design 08/21/2024

Requirements:

1. Provide range limited GPS repeater capability to the Boeing Flight Test Bed Operations Laboratory Hanger, located at 6161 Aviation Dr Berkeley, MO 63134-2019.
2. Use the following equipment to control the Re-radiated GPS RF power (or equivalent):
  - a. Roof-top antenna with built in 30 dB LNA (GPS Source GNSS-3A GPS Antenna with built in LNA plus an additional 40 dB LNA (GPS Source A114M 40 dB In-line LNA)
  - b. Low Loss RF Cable – 49 Ft (Times Microwave LMR-600-DB)
  - c. RF directional Isolator preventing reverse RF signal conduction.
  - d. Power Divider for cabled connected GPS signal distribution
  - e. Variable Attenuator to further attenuate the GPS RF as needed based on GPS receiving.
  - f. Flexible RF Cable – 91 Ft. (Times Microwave LMR-600-UF)
  - g. GPS Re-radiating antenna (GPS Source GNSS-3P)
  - h. See Figure 1 below for the proposed Boeing Building 60B Flight Test Bed Operations Lab Re-Radiator System
3. Range limitation (Based on an NTIA maximum of -140 dBm/24 MHz at 100 feet):
  - a. L1: Total re-radiated power across a 24 MHz band centered at 1572.42 MHz shall not exceed -140 dBm at a distance of 100 Ft.
  - b. L2: Total re-radiated power across a 24 MHz band centered at 1227.60 MHz shall not exceed -140 dBm at a distance of 100 Ft.

Physical Design:

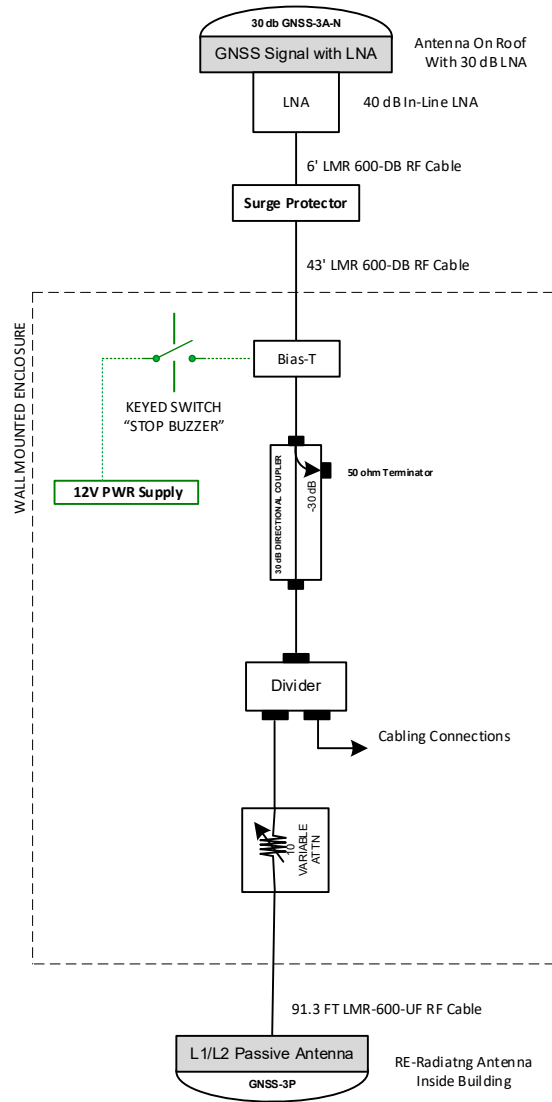


Figure 1, Building 60B Flight Test Bed Operations Lab Re-Radiator System

Functional Description:

GPS Satellite signals received and amplified by the roof-top antenna are conducted through a 49-foot transmission line (coaxial cable) into the Boeing Building 60B Flight Test Bed Operations Lab wall mounted junction box. The roof-top antenna will be mounted on a pole and not be higher than 2 ft from roof surface. The wall mounted junction box contains a Bias-T to provide DC power to the roof top LNA and antenna. There is also a variable attenuator necessary to reduce the re-radiated signal level below the target GPS receiver's maximum input. This variable attenuator will also allow the ability to lower the re-radiated signal level to manage potential multipath portions of the signal below.

From the wall mounted junction box, the re-radiating antenna is tethered by a 91.3 foot flexible cable. The re-radiating antenna will be ceiling mounted in a location centered inside the hanger. Power levels at 100-foot distance from the re-radiating antenna approaching -142 dBm (-172 dBW) smaller than the 100 ft requirement.

Below are the calculations demonstrating NTIA compliance at 100 Feet.

Part No	Description	Multiplier length (ft) attn (dB)	L1 RF Power delta (dB)	L1 RF Power (dBm)	L2 RF Power delta (dB)	L2 RF Power (dBm)
	Frequency		1575.42		1227.60	
	GPS Satellite Signal at Earth's Surface			-130.00		-133.00
GNSS-3A	GPS Active Antenna Gain (dB) (L1= 3.0, L2=0.0, LNA = +30.0)		33.0	-97.00	30.0	-103.00
A114M	40 dB in-line LNA		40	-57.00	40	-63.00
LMR-600 + Surge	External, RF Cables	49	-2.20	-59.2	-2.00	-65.00
SM4234	RF Flange Adapter		-0.05	-59.25	-0.05	-65.05
PE3481-12	RF Cable - SMA/TNC	1.0	-0.342	-59.592	-0.3281	-65.3781
PE1604	Bias Tee		-0.1	-59.692	-0.1	-65.4781
PE3481-6	RF Cable - SMA/TNC	0.5	-0.2711	-59.9631	-0.2638	-65.7419
PE2201-30	Coupler		-0.2	-60.1631	-0.2	-65.9419
PE3481-6	RF Cable - SMA/TNC	0.5	-0.2711	-60.4342	-0.2638	-66.2057
PE20DV2102	Power Divider		-3.3	-63.7342	-3.3	-69.5057
PE3481-12	RF Cable - SMA/TNC	1.0	-0.342	-64.0762	-0.3281	-69.8338
50DR-055-SMA	Variable Attenuator	0.8	-0.8	-64.8762	-0.8	-70.6338
PE3481-12	RF Cable - SMA/TNC	1.0	-0.342	-65.2182	-0.3281	-70.962
SM4234	RF Flange Adapter		-0.05	-65.2682	-0.05	-71.0119
LMR-600-UF	Low Loss, RF Cable	91.3	-3.5	-68.7682	-3.1	-74.1119
GNSS-3P	GPS passive Antenna	@90°	-7	-75.7682	-10	-84.1119
<b>Maximum GPS Radiated Power @ 100ft = -140 dBm / 24MHz</b>						
Free Space Loss @ 100ft						
		100	-66.051		-63.88	
Radiated Power @ 100ft				<b>-141.82</b>		<b>-147.99</b>