GPS Re-Radiation System Technical Description
Revision 4 (10/17/2018)

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Purpose of this application
The purpose of this application is to obtain a 2-year experimental license to operate a GPS re-radiation system supporting the testing of GPS systems within notebook and tablet computing devices.

Why we are applying for a license
Hewlett Packard Inc. (HPi) is a designer and manufacturer of computing devices and peripheral equipment. Many of our computing devices and accessories may include integrated GPS receivers. In an effort to ensure quality of our product to our customers, and validate the designs, HPi has the need to setup a GPS retransmission solution for our R&D and testing facility in Spring, Texas.

The use of a GPS re-radiation system in this facility is appropriate for these reasons:

- HPi is involved in the test of GPS receiving systems as part of the development and test of computing devices with integrated GPS receivers.
- The number of computing devices that are tested on a daily basis within our facility can be on the order of hundreds, making the use of indoor solutions like GPS “hoods” impractical within our facility.
- Testing outdoors is not always feasible due to the heat, humidity and rains within our geographic area.
- The GPS re-radiation system will comply with all NTIA requirements.

Compliance with NTIA requirements

This installation will comply with all requirements stated in section 8.3.28 of the NTIA "Manual of Regulations and Procedures for Federal Radio Frequency Management (Redbook)" May 2013 edition: *Use of Fixed Devices That Re-Radiate Signals Received from the Global Positioning System*.

a. Individual authorization is for indoor use only, and is required for each device at a specific site.
Operation will only be conducted indoors at the location identified above and as the station location in the application form 422.

b. 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.

HPi concurs with the XT station class. The description of device use is below in the section entitled "System use".

c. Approved applications for frequency assignment will be entered in the GMF.

HPi concurs with this requirement.

d. The maximum length of the assignment will be two years, with possible renewal.

HPi concurs with this requirement.

e. The area of potential interference to GPS reception (e.g., military or contractor facility) has to be under the control of the user.

The location identified above is under HPi control.

f. 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.)

Calculations are supplied below in the section entitled "System technical description" and comply with this requirement. The computations include no allowance for additional attenuation.

g. GPS users in the area of potential interference to GPS reception must be notified that GPS information may be impacted for periods of time.

HPi will comply with this requirement.

h. The use is limited to activity for the purpose of testing RNSS equipment/systems.

The use of this system will be limited to testing RNSS equipment and systems.

i. A "Stop Buzzer" point of contact for the authorized device must be identified and available at all times during GPS re-radiator operations.
Stop buzzer contacts are provided in the next section.

Stop Buzzer Contacts

Primary Stop Buzzer: Isaac Lagnado Desk: 281-971-8761 Mobile: 713-550-3336
Secondary Stop Buzzer: Jim Cottrell Desk: 281-927-8715 Mobile: 832-868-3298

System technical description

HPi will be using a GPS Source “GLI-Metro Kit” to re-radiate external GPS L1 signals inside of the location mentioned above. Technical descriptions of each of these components are attached to the application.

The HPi facility is located at latitude North 30 6 14 and Longitude West 95 26 15 on 10300 Energy Drive Spring, TX, 77389. This facility is located at 10 miles from the nearest runway at the airport.

This GPS re-radiation system comprises:

- A roof-mounted GPS Source L1LA active antenna,
- A GPS Source GLI-METRO “smart” GPS amplifier and controller,
- An GPS Source 8X1 GPS Splitter with 8 outputs, and
- Six internally mounted L1-PL-NF passive antennas.
- Coaxial feedline cables (LMR400).
- An illuminated wall-mounted power switch.

A diagram of the system is included in Figure 3 - GPS re-radiation system diagram.

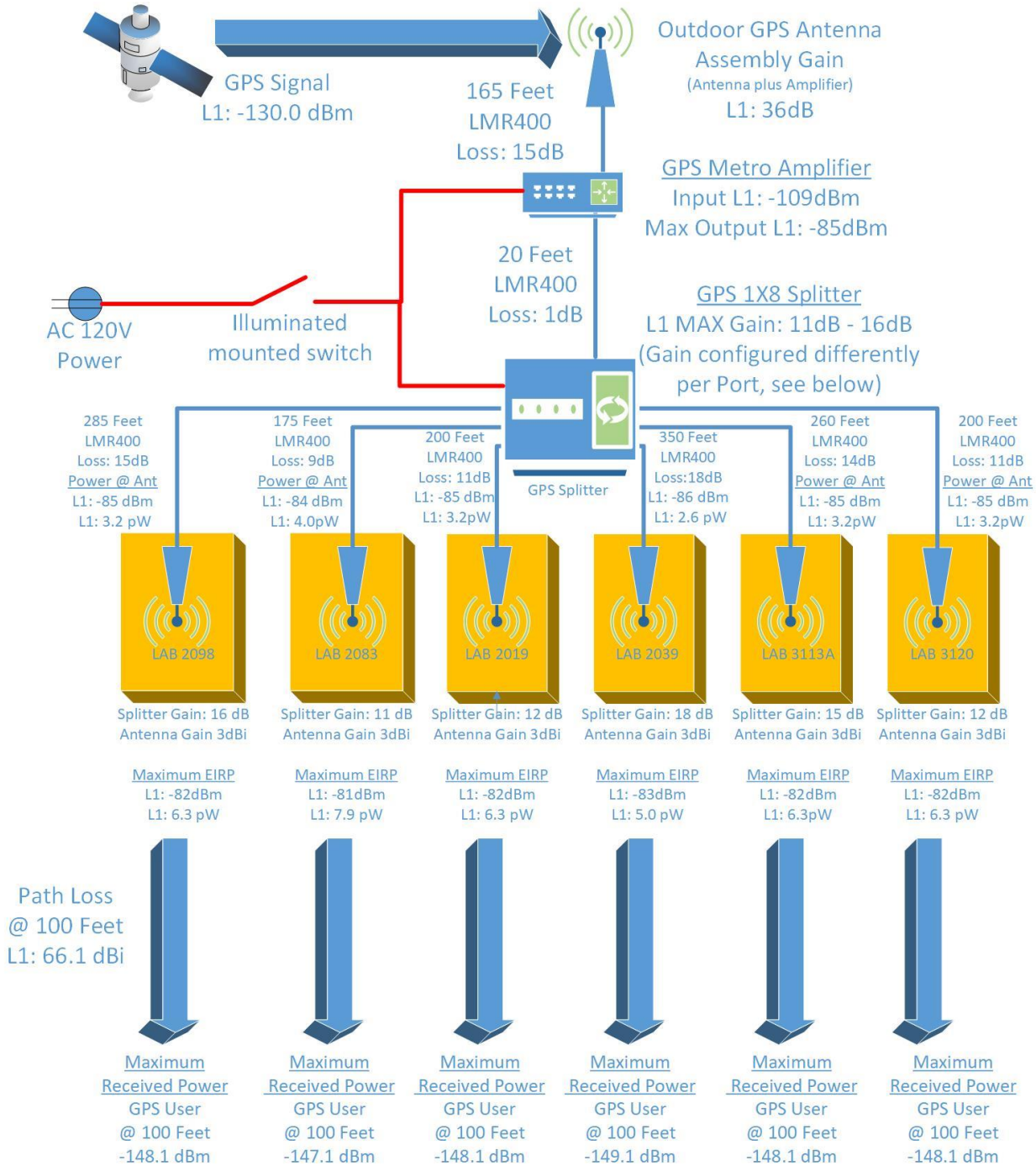

Figure 3 - GPS re-radiation system diagram

	Antenna 1	Antenna 2	Antenna 3	Antenna 4	Antenna 5	Antenna 6
Antenna Location	LAB 2098	LAB 2083	LAB 2019	LAB 2039	LAB 3113A	LAB 3120
L1 Amplifier Output	-85 dBm	-85 dBm	-85 dBm	-85 dBm	-85 dBm	-85 dBm
Cable Loss to Splitter	1 dB (20 ft)	1 dB (20 ft)	1 dB (20 ft)	1 dB (20 ft)	1 dB (20 ft)	1 dB (20 ft)
L1 Splitter Gain	16 dB	11 dB	12 dB	18 dB	15 dB	12 dB
Cable Loss to Antenna	15 dB (285 ft)	9 dB (175 ft)	11 dB (200 ft)	18 dB (350 ft)	14 dB (260 ft)	11 dB (200 ft)
Maximum Power at Ant	-85 dBm 3.2 pW	-84 dBm 4.0 pW	-85 dBm 3.2 pW	-86 dBm 2.6 pW	-85 dBm 3.2 pW	-85 dBm 3.2 pW
Antenna Gain	3 dBi	3 dBi	3 dBi	3 dBi	3 dBi	3 dBi
Maximum EIRP	-82 dBm 6.3 pW	-81 dBm 7.9 pW	-82 dBm 6.3 pW	-83 dBm 5.0 pW	-82 dBm 6.3 pW	-82 dBm 6.3 pW
Max Received Power @ 100 ft	-148.1 dBm	147.1 dBm	-148.1 dBm	149.1 dBm	-148.1 dBm	-148.1 dBm

Table 1: Calculation for Max EIRP and Max Received Power from each GPS re-transmission antenna

Note 1: All L1 GPS cabling is LMR400 with a loss of 5 dB/100 ft.

Note 2: The L1 Path loss at 100 feet is -66.1 dBi.

GPS signals are received and amplified by the active rooftop antenna. The amplified signals are conducted through a 165-foot coaxial cable to the GLI-METRO smart amplifier. The output of this amplifier is conducted through 20-foot low-loss coaxial cable to the 8X1 GPS splitter. From each port of the 8X1 GPS splitter the signal travels through 175-feet to 350-feet of low-loss coaxial cable before reaching the designated passive antenna which re-radiates the signals. Each port of the 8X1 GPS splitter has a custom configured gain from 11- 16dB to compensate for the different feedline lengths (losses), such that the final EIRP at each antenna is similar in EIRP Transmit power.

The roof mounted active antenna provides gain which compensates for the loss in the 165-feet of cable leading to the GLI-METRO device, and improves the S/N ratio at the input of the amplifier. The gains are as follows:

- For the L1 signal, the antenna provides about 3 dB element gain and 33 dB amplifier gain for a total gain of about 36 dB.

The GLI-METRO device is the heart of the system. Unlike a typical GPS amplifier, it regulates power *output* so that maximum EIRP is regulated. It requires a power input of between -155 and -85 dBm and produces a *regulated* power output that can be adjusted to be between -85 and -65 dBm. The combination of the regulated power output and the various self-test capabilities greatly reduces the risk of harmful interference to other GPS users.

The GLI-METRO comprises the following features:

- Filters that pass only the L1 GPS signals.
- Precise control of the output signal level (-85 to -65 dBm) such that the re-radiated power levels are below the NTIA maximum of -140 dBm/24 MHz at 100 ft.
- Oscillation detection and mitigation to prevent harmful interference due to malfunctioning components.
- Built in testing which alerts and mitigates:
    - High gain
    - Low gain
    - Short/Open circuit
    - Internal component failures
    - Inadequate input signal conditions

The passive antennas are mounted in corners of each specified lab room and is facing downward and away from the exterior of the facility and is in a position such that the re-radiated GPS signals are usable by all required staff in each of the appropriate HPi test labs.

The position and location of each antenna is shown in Figure 4 and Figure 5.

Figure 4 - Location of antenna in the HPi Facility – Second Floor test labs

Figure 5 - Location of antenna in the HPi Facility – Third Floor test labs

Figure 6 – View from outside of the HPi facility

EIRP Computation

Unlike many other GPS signal amplifiers, the GLI-METRO regulates *output power.* As long as the input power is within the acceptable range of -115 to -85 dBm it will produce the custom installer-set regulated output power of -85 to -65 dBm. As a result, the output EIRP of the system is based *only* on the following items:

- The power output setting of the GLI-METRO, which we have set to being -85 dBm.
- The loss of the feedline (20 feet) from the output of the GLI-METRO to the input of the GPS 8X1 splitter, which is computed as 1 dB.
- The gain of the 8X1 GPS Splitter is dependent upon which port the antenna is attached. The gain for each port is between 11 – 16dB. Table 1 details the custom configured gain for each port.
- The loss of the feedline (11 – 18dB) from the output of the GPS 8X1 splitter depends on which antenna is used and is adjusted depending on the feedline cable lengths (175 – 350 feet). Table 1 details the feedline loss associated with each antenna.
- The directivity gains of the transmitting antenna, which is stated by the manufacturer as about 3 dBi.

EIRP = Max Output (-85dBm) + Cable Loss to Splitter (1dB) + Splitter Gain (Dependent on Port) + Cable Loss to Antenna (Dependent on Location) + Antenna Gain (3dBi)

Each port of the 8X1 GPS splitter has a custom configured gain from 11- 16dB to compensate for the different feedline lengths (175 feet to 350 feet), such that the final EIRP at each antenna is similar in EIRP Transmit power. Table 1 calculates each EIRP for each antenna location.

The GLI-METRO device will enter a fault condition if the input power is outside of the acceptable range and will inhibit the amplification of the GPS signals so as to eliminate the risk of harmful interference.

Note: The GLI-METRO device will be adjusted during installation to produce *the minimum power necessary* to perform the required testing with the maximum power being that shown in the analysis above and results in radiated signals with the NTIA limits.

Path loss to a distant isotropic receiver is computed as PL = -37.88 + 20 log(F_{MHz}) + 20 log (d_{ft}). For L1 the path loss at 100 feet is 66.1 dB.

Maximum received Power for a user 100 feet away from the building for all antennas is calculated in Table 1 and is below -140dBm to comply with all NTIA requirements.

System use

This system will operate *only* when GPS equipment testing is needed to be performed. Access to activate and/or deactivate the equipment will be made available within the equipment riser room by the technicians/engineers that are in charge of the GPS system that is in operation.

An illuminated power switch will be activated by the technician or engineer conducting the test and will be deactivated with the testing is complete. The switch illumination helps remind the technicians/engineers that the GPS re-transmission system is in operation.

The GLI-METRO device monitors a number of parameters and mitigates equipment failures so as to greatly reduce the risk of harmful interference to other GPS users.