MCS Division

Trimble Navigation Ltd.

FCC Form 442

Exhibit 1

September 19, 2017

Prepared by: Robert J Zavrel Jr., RF Engineer, Trimble Navigation Ltd. employee

SYSTEM DESCRIPTION FOR PROGRAM OF EXPERIMENTATION

This exhibit describes in detail a proposed two-year program for research and experimentation for a re-radiation system of signals received from both L1 and L2 GPS satellites. The proposed devices are to be used as experimental radio-navigation-satellite service (RNSS) test equipment for the purpose of testing GPS receivers and systems.

This re-transmission system will employ 40 separate stations all fed from a common receive antenna. The entire system is located at one location: 345 SW Avery Ave., Corvallis, OR 97333, which is also the headquarters for Trimble's MCS Division. These 40 stations are all located indoors at this facility which is occupied only by Trimble personnel and is a controlled-access industrial facility. At this facility Trimble utilizes automated employee badge access only which facilitates strict access to the facility. The receive antenna is located on the facility's two-story roof with access only through the interior of the building. All 40 stations will be located inside the same two-story building at 345 SW Avery Ave. Corvallis, OR 97333.

Trimble has an interest in ensuring that the use of GPS signal re-radiation devices will advance the state-of-the-art in GPS receiver equipment without causing any risk to the safe and reliable operation of GPS equipment already deployed.

NTIA Criterion No. 1: <u>Individual authorization is necessary for each device at a site-specific location:</u>

Trimble proposes to install forty (40) fixed experimental ("XT") GPS signal re-radiation devices for which it presently seeks authorization within the controlled access building located on Avery Avenue in Corvallis, OR, which is under exclusive control of Trimble. The zone of potential interference from these re-radiation devices - all located indoor at the Avery Ave. facility - is limited to the immediate areas in which the devices are located.

The location of the devices are as follows:

	XT Station Location	User	Latitude	Longitude
1.	345 SW Avery Ave.	Trimble Employee	44° 33’8” N	123° 16’09”W
2.	345 SW Avery Ave.	Trimble Employee	44° 33’8” N	123° 16’09”W
3.	345 SW Avery Ave.	Trimble Employee	44° 33’8” N	123° 16’09”W
4.	345 SW Avery Ave.	Trimble Employee	44° 33’8” N	123° 16’09”W
5.	345 SW Avery Ave.	Trimble Employee	44° 33’8” N	123° 16’09”W
6.	345 SW Avery Ave.	Trimble Employee	44° 33’8” N	123° 16’09”W
7.	345 SW Avery Ave.	Trimble Employee	44° 33’8” N	123° 16’09”W
8.	345 SW Avery Ave.	Trimble Employee	44° 33’8” N	123° 16’09”W
9.	345 SW Avery Ave.	Trimble Employee	44° 33’8” N	123° 16’09”W
10.	345 SW Avery Ave.	Trimble Employee	44° 33’8” N	123° 16’09”W
11.	345 SW Avery Ave.	Trimble Employee	44° 33’8” N	123° 16’09”W
12.	345 SW Avery Ave.	Trimble Employee	44° 33’8” N	123° 16’09”W
13.	345 SW Avery Ave.	Trimble Employee	44° 33’8” N	123° 16’09”W
14.	345 SW Avery Ave.	Trimble Employee	44° 33’8” N	123° 16’09”W
15.	345 SW Avery Ave.	Trimble Employee	44° 33’8” N	123° 16’09”W
16.	345 SW Avery Ave.	Trimble Employee	44° 33’8” N	123° 16’09”W
17.	345 SW Avery Ave.	Trimble Employee	44° 33’8” N	123° 16’09”W
18.	345 SW Avery Ave.	Trimble Employee	44° 33’8” N	123° 16’09”W
19.	345 SW Avery Ave.	Trimble Employee	44° 33’8” N	123° 16’09”W
20.	345 SW Avery Ave.	Trimble Employee	44° 33’8” N	123° 16’09”W
21.	345 SW Avery Ave.	Trimble Employee	44° 33’8” N	123° 16’09”W
22.	345 SW Avery Ave.	Trimble Employee	44° 33’8” N	123° 16’09”W
23.	345 SW Avery Ave.	Trimble Employee	44° 33’8” N	123° 16’09”W
24.	345 SW Avery Ave.	Trimble Employee	44° 33’8” N	123° 16’09”W
25.	345 SW Avery Ave.	Trimble Employee	44° 33’8” N	123° 16’09”W
26.	345 SW Avery Ave.	Trimble Employee	44° 33’8” N	123° 16’09”W
27.	345 SW Avery Ave.	Trimble Employee	44° 33’8” N	123° 16’09”W
28.	345 SW Avery Ave.	Trimble Employee	44° 33’8” N	123° 16’09”W
29.	345 SW Avery Ave.	Trimble Employee	44° 33’8” N	123° 16’09”W
30.	345 SW Avery Ave.	Trimble Employee	44° 33’8” N	123° 16’09”W
31.	345 SW Avery Ave.	Trimble Employee	44° 33’8” N	123° 16’09”W
32.	345 SW Avery Ave.	Trimble Employee	44° 33’8” N	123° 16’09”W
33.	345 SW Avery Ave.	Trimble Employee	44° 33’8” N	123° 16’09”W
34.	345 SW Avery Ave.	Trimble Employee	44° 33’8” N	123° 16’09”W
35.	345 SW Avery Ave.	Trimble Employee	44° 33’8” N	123° 16’09”W
36.	345 SW Avery Ave.	Trimble Employee	44° 33’8” N	123° 16’09”W
37.	345 SW Avery Ave.	Trimble Employee	44° 33’8” N	123° 16’09”W
38.	345 SW Avery Ave.	Trimble Employee	44° 33’8” N	123° 16’09”W
39.	345 SW Avery Ave.	Trimble Employee	44° 33’8” N	123° 16’09”W

40. 345 SW Avery Ave. Trimble Employee 44° 33’8” N 123° 16’09”W

All transmitting devices are of Trimble’s design, Zephyr 2 type modified into a passive re-transmit antenna with a maximum bore-site gain of 2.5 dBic (right-hand circular polarization). All 40 stations will be located within an indoor sphere (using two stories) with a radius of 150 feet.

NTIA Criterion No. 2: Application for frequency assignment should be applied as an XT station with a note indicating that the device is to be used as an “Experimental RNSS Test Device for the purpose of testing stand-alone GPS receivers or GPS receivers that are an integral component of an equipment under test”

Trimble will limit the use of the fixed indoor location GPS re-radiation devices it proposes here to activities in direct furtherance of its business of developing and manufacturing GPS receivers and systems that use GPS signals and augmentations. The RNSS test devices Trimble proposes in this Experimental Radio Service application are for the purpose of Trimble’s testing stand-alone GPS receivers and GPS receivers that are an integral component of equipment or systems under test. This test capability is important as the basic GPS service is upgraded to include additional augmentation systems and ever-increasing performance of the GPS systems proper. The GPS system is in a state of development that requires on-going testing and experimentation. Advancing the utility of these new GPS capabilities is important to advancing the art of GPS radio receivers.

NTIA Criterion No. 3: Approved applications for frequency assignment will be entered in the GMF.

The frequency assignment of each of the forty (40) proposed indoor location GPS signal re-radiation devices at the 40 XT station locations in No. 1 above is at the L1 and L2 GPS frequencies: center frequencies of 1575.42 and 1227.6 MHz respectively.

NTIA Criterion No. 4: The maximum length of the assignment will be two years, with possible renewal.

Trimble requests authorizations with a license term of two years, with the possibility of renewal.

NTIA Criterion No. 5: The operation must be at a specified location and mobile operation is not authorized.

The fixed locations of the 40 GPS re-radiation devices proposed by Trimble are at the specified indoor locations specified in No. 1 above.

NTIA Criterion No. 6: The area of potential interference to GPS reception (e.g. military or contractor facility) has to be under the control of the user.

As indicated above, the area in the controlled access building in which all 40 proposed fixed indoor GPS re-radiation devices are to be located are exclusively used for Trimble operations, including testing. The zone of potential interference from the indoor fixed GPS re-radiation devices, and the fixed indoor transmitting devices is limited within the controlled-access building in which the devices will be located. The fixed indoor location for each of the 40 proposed GPS re-radiation devices will be suspended about 1-2 feet above the desk or bench of a Trimble employee and located a minimum of 6 feet from the exterior walls of the building. All doors to the Trimble facility that permit entry from the outside are locked. Entry is provided by an automated door lock system. The door is unlocked by a two-stage security system: a current Trimble badge and a hand-applied password to a keypad that must match the specific Trimble badge. The re-radiation system is not connected at any point to the internet, therefore "hacking" from the outside is not physically possible. Each of the 40 stations is in complete control by qualified Trimble employees.

NTIA Criterion No. 7: The maximum equivalent radiated power must be such that the calculated emissions are no greater than -140dBm/24 MHz 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 building attenuation.

The maximum equivalent isotropic radiated power (EIRP) from the proposed re-radiation device is such that the calculated emissions are substantially more restrictive that -140 dBm/24 MHz at the distance of 30 meters mandated by Section 8.3.28 of the NTIA Manual and thus more than meets the NTIA limits. Exhibit 1, Attachment 1 includes Trimble's essential calculations regarding these specifications. These calculations are based upon the assumption of free space attenuation (any possible contribution of additional attenuation from the building structural is ignored).

NTIA Criterion No. 8: GPS users in the area of potential interference to GPS reception must be notified that GPS information may be impacted for periods of time.

Trimble will post signs within the Avery Ave. building indicating that interference to GPS receivers might be experienced. The zone of potential interference will not extend outside the building nor beyond the Trimble property lines.

NTIA Criterion No. 9: The use is limited to activity for the purpose of testing RNSS equipment/systems.
Trimble will limit the use of the GPS re-radiation devices proposed here to activities in direct furtherance of its business of developing and manufacturing GPS receivers and systems that use GPS equipment.

NTIA Criterion No. 10: 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.

Each re-radiation device is used by and under the control of a single Trimble employee in the cubicles where they are installed.

Point of contact:
Tony Hewson
e-mail tony_hewson@trimble.com
Daytime phone: 541-750-9380
Mobile phone:
After hours home phone:

EXHIBIT 1

Attachment 1.

Calculation of maximum permitted EIRP based upon NTIA Criterion No. 7

NTIA EIRP restriction:
-140 dBm/24 Mhz at 30 meters (assuming free space attenuation)

Free space attenuation will be less for L2 (longer wavelength) therefore the L2 frequency of 1227.6 MHz or λ=0.244 meters is used for the following calculations. Isotropic-to-isotropic free (numeric) space attenuation is:

$$P_r = P_t \left(\frac{\lambda}{4\pi r}\right)^2$$

Therefore, the isotropic-to-isotropic path loss for the NTIA criterion is 63.8 dB. And thus the maximum permitted radiated power is -140 dBm + 63.8 dB = -76.2 dBm EIRP.

The Trimble re-radiation system will employ small passive RHCP GPS antennas (modified passive Trimble Zephyr 2) with a maximum RHCP gain of 2.5 dBic. This reduces the maximum allowed power to the antennas to -78.7 dBm.

The proposed maximum radiated power from each re-transmission antenna is -92.5 dBm (for GPS band L2) providing for a margin of 13.8 dB. Attachment 2 provides a detailed quantification of the power budget within the re-transmission system.

Attachment 2.

Diagram of the proposed re-radiation system

The system is to be fed by a rooftop receive antenna (Trimble Zephyr 2) including a 50 dB gain amplifier for both L1 and L2 signals. The output of the antenna is -128 dBm for L1 and -130 dBm for L2. With amplifier gain, the outputs from the Zephyr device is

-78 dBm for L1
-80 dBm for L2

The system creates more 6.0 dB more attenuation at L1 than at L2 (the lower frequency) as detailed later.

To the extent possible, each station's signal passes through the same number and identical splitters (identical attenuations) and also the same types of cable. Cable lengths vary but the power calculations are performed using the station with the lowest attenuation path from the receiver to re-transmit antenna. Attenuators of proper values will be placed in-line where necessary to hold the power appearing at the re-transmitting antenna inputs to the -95 dBm system specification. However, all attenuation values are deterministic which will bring the entire system within the objective tolerance, Nonetheless, empirical loss measurements were taken of the entire system. The empirical measurements will assume the output levels of the Zephyr antenna is as above. A calibrated CW signal generator was used to inject the appropriate signal to the input of SRG-1. A calibrated spectrum analyzer will then measure the power provided to the re-transmission antennas, and thus the actual attenuation computed.

Referring to Figure 2, all 40 re-transmission stations use SRG-1, SPL-1, SPL-2, and the station splitters. All 40 re-transmission stations also use either SPL-3,4,5,6,7,8, or 9. SPL-5 will use a 3 dB attenuator to equalize its level with SPL 3,4,6,7,8, and 9.

Therefore, the over-all minimum attenuation for each station will be 15 dB (-80 dBm from the receive antenna pre-amp to the re-transmission antenna terminals, one each for the 40 stations). All interconnecting and feeder cables are types LMR-400 and LMR-240 with N-connectors, as shown on Figure 2. The splitter at each station uses SMA connectors for the short feeds to the re-transmission antennas. A splitter is provided at each station to facilitate a separate lead for conducted testing (direct inputs to GPS receiver antenna ports, not involving re-transmission). Under no circumstances will two re-transmission antennas be permitted at any station. The cable between the station splitters and re-transmission antennas is LMR-100 type cable. The re-transmission antennas will be Trimble Zephyr 2 models with the pre-amplifiers removed. The maximum gain for these antennas is 2.50 dBic (right-hand circular) for both the L1 and L2 frequencies.

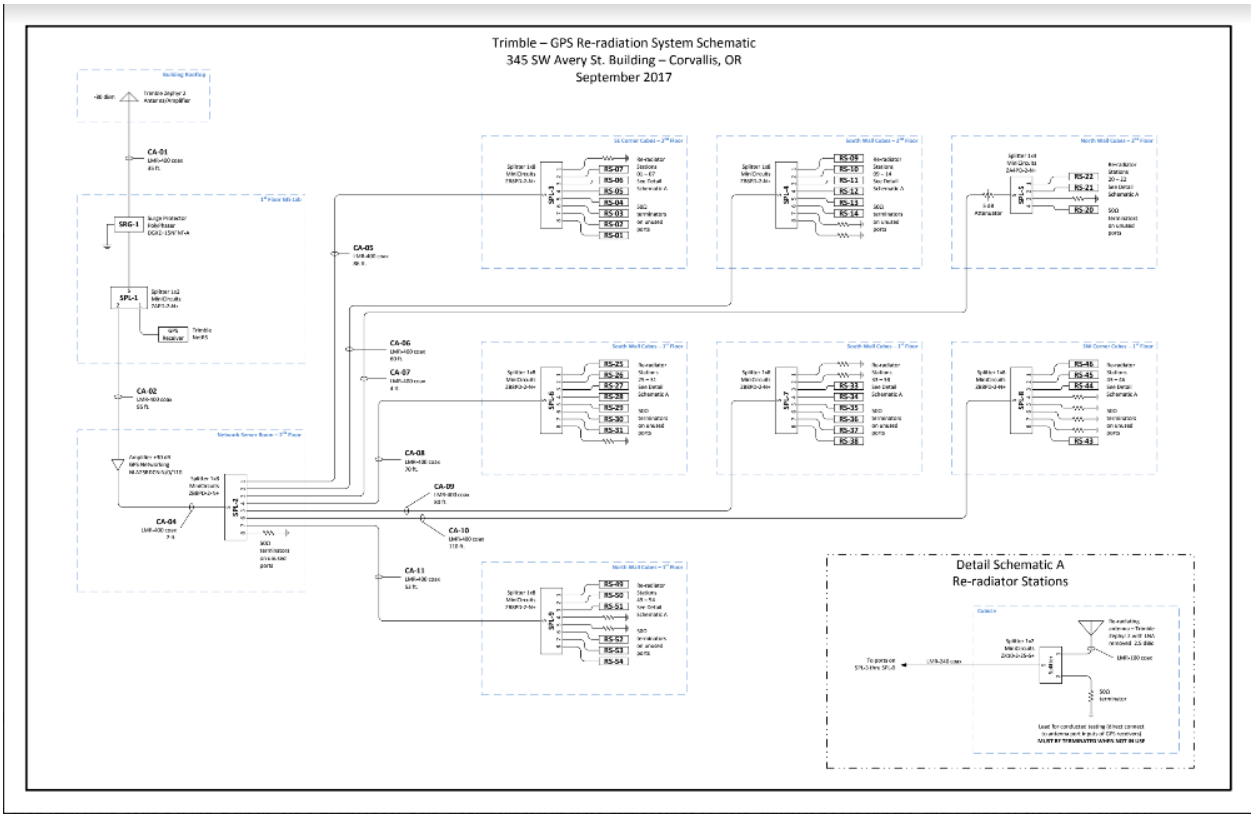
Figure 1 shows the calculation for the station with minimum attenuation in the system, and therefore also the maximum EIRP calculation of a re-transmission system for L2. The system of cables, splitters and the amplifier result in the L1 signal being 4.0 dB lower than L1 signal (measured empirically). Therefore, the L1 re-transmitted signal will be -96.5 dBm maximum. Variation among the 40 stations is 2.9 dB EIRP. Therefore the station with the lowest EIPR will radiate -99.4 dBm at L1 and -97.9 dBm at L2. Figure 1 displays the sequential series of gain through the various elements of the system. A schematic diagram of the same system is provided in Figure 2.

The station with the maximum EIRP will be -92.5 dBm appearing at L2. This is 13.8 dB below the NTIA maximum permitted radiated power of -78.7 dBm.

Figure 1

Element	Gain	Power at output
Roof-mounted Zephyr 2	-80 dBm at L2 (power output)	-80 dBm
35 ft. LMR-400	-1.5 dB	-81.5 dBm
Surge protector	-0.1 dB	-81.6 dBm
SPL-1	-3.2 dB	-84.8 dBm
100 ft. LMR-400	-6.9	-91.7 dBm
AMP 1	+30 dB	-61.7 dBm
5 ft. LMR-400	-.2 dB	-67.9 dBm
SPL-2	-9.4 dB	-77.3 dBm
20 ft. LMR-400	-1.0 dB	-78.3 dBm
SPL-9	-9.4 dB	-87.7 dBm
25 ft. LMR-240	-2.0 dB	-89.7 dBm
Station 2-way splitter	-3.8 dB	-93.5 dBm
5 ft. LMR-100	-1.5 dB	-95.0 dBm
Passive Zephyr 2 re-transmission antenna	+2.5 dBic	-92.5 dBm circular polarized radiated power for L2 and -96.5 dBm for L1.

Figure 2


Trimble – GPS Re-radiation System Schematic
345 SW Avery St. Building – Corvallis, OR
September 2017
Detail Schematic A
Re-radiator Stations