Attachment 1

Compliance with NTIA GPS Re-Radiation Criteria – Section 8.3.28 of NTIA Regulations Maximum Equivalent Isotropically Radiated Power

The system re-radiates the GPS L1 (1575.42 MHz) and L2 (1227.60 MHz) signals. A common system (dual band) consisting of one active antenna, one passive antenna, and one amplifier is used for both frequencies at each site. Calculations are performed based on Section 8.3.28 of the NTIA regulations1, wherein item 6 states "the maximum equivalent isotropically 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." Additionally, building attenuation has been ignored. This calculation shows that the re-radiated signal strength in compliance with NTIA requirements. The calculations are performed for each of the repeater sites in parts A, B, and C below.

(1) $P_{sig} = P_{Rec} + G_{rant} + G_{ramp} - L_l + G_{rramp} + G_{rran}t - L_s + 2.148$

Where: P_{sig} = Re-radiated signal strength 100ft outside the building (EIRP)
P_{Rec} = Received power from GPS Satellites (-130 dBm)
G_{rant} = Roof active antenna, (Antcom PN: 2.3G1215A-XRS-4) = 4.7dB (L1) And 3.3 dB (L2)
G_{ramp} = Roof active antenna amplifier gain = 33dB (L1) and 35dB (L2)
L_l = Coaxial cable attenuation, roof antenna to re-radiating amplifier
= (L1) 9.1dB/100ft x cable length
= (L2) 8.6 dB/100ft x cable length
G_{rramp} = Re-radiating amplifier, (Minicircuits PN: ZX60-2522M) = 23.5dB
G_{rrant} = Re-radiating antenna gain (Antcom PN: 2.3G1215P-XRS-4) = 5.36dB
L_s = Free space loss (equation 2 below)
2.148 = conversion from ERP to EIRP

(2) $L_s = 36.6 + 20Log_{10}((D/5280)*1575)$ - free space loss for L1
$L_s = 36.6 + 20Log_{10}((D/5280)*1227)$ - free space loss for L2

Where: D = Distance (d) from antenna to outer wall in feet + 100ft

1 *See Manual of Regulations and Procedures for Federal Radio Frequency Management P 8.3.28(6)* (Rev. Sept 2006).

Part A
Determination of the signal strength at 100 feet from Building 2 in the south Nashua, NH facility;

Determination of the free space loss-
D = 80ft + 100ft
=180ft
Inserting the values for D into equation (2) yields:

$L_s = 36.6 + 20Log_{10}((180/5280)*1575)$ - for L1
= 70.18 dBm
and
$L_s = 36.6 + 20Log_{10}((180/5280)*1227)$ - for L2
= 68.01 dBm

Determination of the cable loss for Building 2–
Ll = 80ft * (9.1/100) -for L1
= 5.46dB
Ll = 80ft * (8.6/100) -for L2
= 5.16dB

Inserting these values into equation 1 yields

$P_{sig\ (EIRP)} = -130 + 4.7 + 33 – 5.46 + 23.5 + 4.7 – 70.18 +2.147$ - for L1
= -137.59 dBm – L1 signal strength at 100ft excluding building attenuation
This value does not meet the requirements, so a 3dB attenuator will be included in this system to reduce the signal strength to below the required -140dBm
= -137.59 – 3
= -140.59 dBm at 100 feet from the building for L1

Since the equation above determines the signal strength at a distance from the building and is based on EIRP (Equivalent isotropically radiated power) we will now convert this value to ERP (Effective Radiated Power) at the systems transmit antenna by removing the free space loss and the conversion factor of 2.148 dB applied above using the formula below

For Ll -
$P_{ERP} = P_{sig(ERIP)} – 2.148 - L_s$
= -140.59 – 2.148 – (-70.18)
= -72.56 dBm ERP

And
$P_{sig\ (EIRP)} = -130 + 3.3 + 33 -5.16 + 23.5 + 3.3 – 68.01+ 2.147$ - for L2
= -137.92 dBm – L2 signal strength at 100ft excluding building attenuation
This value does not meet the requirements, applying the 3 dB of attenuation added to the system for L1 above yields:
= -137.92 – 3
= -140.92 dBm EIRP at 100 feet from the building

Since the equation above determines the signal strength at a distance from the building and is based on EIRP (Equivalent isotropically radiated power) we will now convert this value to ERP (Effective Radiated Power) at the systems transmit antenna by removing the free space loss and the conversion factor of 2.148 dB applied above using the formula below

For L2 -

$P_{ERP} = P_{sig(ERIP)} – 2.148 - L_s$

$= -140.92 – 2.148 – (-70.18)$

$= -75.06$ dBm ERP

We will now convert dBm to pW (Pico-Watts) units using this formula:

$$pW = 10^{((dBm+30)/10)} * (10^{12})$$

Where $10^{((dBm+30)/10)}$ converts the dBm value to watts by raising ten to the exponential value of the power in dBm (milliwatts) and the + 30 factor converts to Watts and then multiplying the value of the power in watts by 10^{12} changes the units from watts to pico-watts. (pico = 10^{-12})

Applying the conversion for each frequency we get-

$$pW = 10^{((-71.38 – 30)/10)} * (10^{12})$$

= 55.46 pW for L1

and

$$pW = 10^{((-75.06 – 30)/10)} * (10^{12})$$

= 31.19 pW for L2

Part B

Determination of signal strength at 100 feet from Building 6 at the south Nashua facility:

Determination of the free space loss-

D = 120 ft + 100ft

= 220 feet

Inserting the values for D into equation (2) yields:

$L_s = 36.6 + 20Log_{10}((220/5280)*1575)$ - for L1

= 72.94 dBm

and

$L_s = 36.6 + 20Log_{10}((220/5280)*1227)$ - for L2

= 70.77 dBm

Determination of the cable loss for Building 6–

Ll = 120ft * (9.1/100) -for L1

= 10.92dB

Ll = 120ft * (8.6/100) -for L2

= 10.32dB

Inserting these values into equation 1 yields

$P_{sig\ (EIRP)} = -130 + 4.7 + 33 - 10.92 + 23.5 + 4.7 - 72.94 + 2.147$ - for L1

= -145.81 dBm – L1 signal strength at 100ft excluding building attenuation

Since the equation above determines the signal strength at a distance from the building and is based on EIRP (Equivalent isotropically radiated power) we will now convert this value to ERP (Effective Radiated Power) at the systems transmit antenna by removing the free space loss and the conversion factor of 2.148 dB applied above using the formula below

For Ll -

$P_{ERP} = P_{sig(ERIP)} - 2.148 - L_s$

= -145.81 – 2.148 – (-72.94)

= -75.02 dBm ERP

And equation 1 computed for L2:

$P_{sig\ (EIRP)} = -130 + 3.3 + 33 -10.32 + 23.5 + 3.3 - 70.77+ 2.147$ - for L2

= -145.84 dBm – L2 signal strength at 100ft excluding building attenuation

Since the equation above determines the signal strength at a distance from the building and is based on EIRP (Equivalent isotropically radiated power) we will now convert this value to ERP (Effective Radiated Power) at the systems transmit antenna by removing the free space loss and the conversion factor of 2.148 dB applied above using the formula below

For L2-

$P_{ERP} = P_{sig(ERIP)} - 2.148 - L_s$

= -145.84 – 2.148 – (-70.77)

= -77.22 dBm ERP

We will now convert dBm to pW (Pico-Watts) units using this formula:

$$pW = 10^{((dBm+30)/10)} * (10^{12})$$

Where $10^{((dBm+30)/10)}$ converts the dBm value to watts by raising ten to the exponential value of the power in dBm (milliwatts) and the + 30 factor converts to Watts and then multiplying the value of the power in watts by 10^{12} changes the units from watts to pico-watts. (pico = 10^{-12})

Applying the conversion for each frequency we get-

$$pW = 10^{((-75.02 - 30)/10)} * (10^{12})$$

= 31.48 pW for L1

and

$$pW = 10^{((-77.22 - 30)/10)} * (10^{12})$$

= 18.97 pW for L2

Part C
Determination of signal strength at 100 feet from Building 2 at the Hudson, NH (Pope Technical Park) facility:

Determination of the free space loss-
D = 80 ft + 100ft
= 180 feet
Inserting the values for D into equation (2) yields:

$L_s = 36.6 + 20Log_{10}((180/5280)*1575)$ - for L1
= 71.20 dBm

and

$L_s = 36.6 + 20Log_{10}((180/5280)*1227)$ - for L2
= 69.03 dBm

Determination of the cable loss for Building 6–
Ll = 80ft * (9.1/100) -for L1
= 7.28dB
Ll = 120ft * (8.6/100) -for L2
= 6.88dB

Inserting these values into equation 1 yields

$P_{sig\ (EIRP)} = -130 + 4.7 + 33 – 10.92 + 23.5 + 4.7 – 72.94 + 2.147$ - for L1
= -145.81 dBm – L1 signal strength at 100ft excluding building attenuation

Since the equation above determines the signal strength at a distance from the building and is based on EIRP (Equivalent isotropically radiated power) we will now convert this value to ERP (Effective Radiated Power) at the systems transmit antenna by removing the free space loss and the conversion factor of 2.148 dB applied above using the formula below

$P_{ERP} = P_{sig(ERIP)} – 2.148 - L_s$

For L2-
= -140.43 – 2.148 – (-71.20)
= -71.38 dBm ERP

And equation 1 computed for L2:

$P_{sig\ (EIRP)} = -130 + 3.3 + 33 -10.32 + 23.5 + 3.3 – 70.77+ 2.147$ - for L2
= -145.84 dBm – L2 signal strength at 100ft excluding building attenuation

Since the equation above determines the signal strength at a distance from the building and is based on EIRP (Equivalent isotropically radiated power) we will now convert this value to ERP (Effective Radiated Power) at the systems transmit antenna by removing the free space loss and the conversion factor of 2.148 dB applied above using the formula below

$P_{ERP} = P_{sig(ERIP)} – 2.148 - L_s$

For L2-

$= -140.66 – 2.148 – (-70.77)$

$= -73.78$ dBm ERP

We will now convert dBm to pW (Pico-Watts) units using this formula:

$$pW = 10^{((dBm+30)/10)} * (10^{12})$$

Where $10^{((dBm+30)/10)}$ converts the dBm value to watts by raising ten to the exponential value of the power in dBm (milliwatts) and the + 30 factor converts to Watts and then multiplying the value of the power in watts by 10^{12} changes the units from watts to pico-watts. (pico = 10^{-12})

Applying the conversion for each frequency we get-

$$pW = 10^{((-71.38 – 30)/10)} * (10^{12})$$

= 72.78 pW for L1

and

$$pW = 10^{((-73.78 – 30)/10)} * (10^{12})$$

= 41.88 pW for L2