

**Exhibit 4: GPS Link Budget Calculations**  
FCC File Number: 0157-EX-CM-2017

**Satellite to Ground Link Budget**

**GPS Satellite Link Budget (Down Link)**

**GPS Satellite Downlink Power**

Frequency L1	1575.42	MHz
Satellite Transmitter power	25	Watts
	13.98	dBW
RF Losses in transmitter path	1.25	dB
Antenna Gain (Isotropic)	13.5	dBi
<b>Satellite Effective Radiated Power</b>	<b>26.23</b>	<b>dBW</b>

**Propagation Losses**

Frequency L1	1575.42	MHz
	1.58E+09	Hz
Distance from Satellite to Earth	2.52E+07	Meters
	2.52E+04	Kilometers
Atmospheric and polarization loss	0.05	dB
Speed of Light	3.00E+08	M/Sec
Wavelength (C/F)	1.90E-01	Meters
Free Space Pathloss	184.43	dB
<b>Received Power on Earth</b>	<b>-158.25</b>	<b>dBW</b>
	<b>-128.25</b>	<b>dBm</b>

**Power At Receive Antenna on Earth**

Received Power on Earth	-158.25	dBW
	-128.25	dBm

## Indoor Link Budget Receive antenna to Re-radiating Antenna

### *Indoor Link Budget (Receive antenna to Re-radiating Antenna)*

#### **Location: Chantilly Room 11**

Frequency L1	1575.42	MHz
ANT-1 Antenna Receive Gain	38	dBic
RF Cable Loss (from Receive Antenna to Amplifier Input)	3.3	dB
LA-1 Line Amplifier Gain (Variable 0 - 30 dBm)	16	dB
RF Cable Loss (from Amplifier to Amplified Splitter Input)	0.1	dB
AS-1 Amplified Splitter Port 1 Gain	3	dB
RF Cable Loss (from Amplifier to Passive Antenna)	5.1	dB
Additional Attenuation	0	dB
RF Power at input to Re-radiating antenna	-79.75	dBm
ANT-2 Passive Re-Radiating Antenna Gain	4	dB
<b>Re-radiated ERP Indoors</b>	<b>-75.75</b>	<b>dBm</b>
Pathloss Target Distance	100	ft
	30.480	meters
Pathloss at 100 ft	66.08	dB
<b>RF Power Level at 100 ft from antenna</b>	<b>-141.82</b>	<b>dBm</b>
<b>Required RF Power Level at 100 ft</b>	<b>-140</b>	<b>dBm/24 MHz</b>

### *Indoor Link Budget (Receive antenna to Re-radiating Antenna)*

#### **Location: Chantilly Room 13**

Frequency L1	1575.42	MHz
ANT-1 Antenna Receive Gain	38	dBic
RF Cable Loss (from Receive Antenna to Amplifier Input)	3.3	dB
LA-1 Line Amplifier Gain	16	dB
RF Cable Loss (from Amplifier to Amplified Splitter Input)	0.1	dB
AS-1 Amplified Splitter Port 2 Gain	3	dB
RF Cable Loss (from Amplifier to Passive Antenna)	5.9	dB
Additional Attenuation	0	dB
RF Power at input to Re-radiating antenna	-92.30	dBm
ANT-3 Passive Re-Radiating Antenna Gain	4	dB
<b>Re-radiated ERP Indoors</b>	<b>-88.30</b>	<b>dBm</b>
Pathloss Target Distance	100	ft
	30.480	meters
Pathloss at 100 ft	66.08	dB
<b>RF Power Level at 100 ft from antenna</b>	<b>-154.38</b>	<b>dBm</b>
<b>Required RF Power Level at 100 ft</b>	<b>-140</b>	<b>dBm/24 MHz</b>

**Indoor Link Budget (Receive antenna to Re-radiating Antenna)**

**Location: Chantilly Room 69**

Frequency L1	1575.42	MHz
ANT-1 Antenna Receive Gain	38	dBic
RF Cable Loss (from Receive Antenna to Amplifier Input)	3.3	dB
LA-1 Line Amplifier Gain	16	dB
RF Cable Loss (from Amplifier to Amplified Splitter Input)	0.1	dB
AS-1 Amplified Splitter Port 3 Gain	3	dB
RF Cable Loss (from Amplifier to Passive Antenna)	11.8	dB
Additional Attenuation	0	dB
RF Power at input to Re-radiating antenna	-98.20	dBm
ANT-4 Passive Re-Radiating Antenna Gain	4	dB
<b>Re-radiated ERP Indoors</b>	<b>-94.20</b>	<b>dBm</b>
Pathloss Target Distance	100	ft
	30.480	meters
Pathloss at 100 ft	66.08	dB
<b>RF Power Level at 100 ft from antenna</b>	<b>-160.28</b>	<b>dBm</b>
<b>Required RF Power Level at 100 ft</b>	<b>-140</b>	<b>dBm/24 MHz</b>