

## GPS L1 Link Budget

### Satellite Transmitter

|                                                |                  |                     |
|------------------------------------------------|------------------|---------------------|
| Transmitter Power (25 Watts)                   | 14.25 dBW        |                     |
| RF Losses in trasmitter path                   | -1.25 dB         |                     |
| Antenna Gain (with respect to an isotrope)     | 13.5 dBi         |                     |
| <b>Satellite EIRP (wrt isotropic radiator)</b> | <b>26.50 dBW</b> | <b>446.68 Watts</b> |

### Propagation

|                                     |         |
|-------------------------------------|---------|
| Atmospheric and Polarization Losses | -0.5 dB |
|-------------------------------------|---------|

|                                                                                                             |                                                        |
|-------------------------------------------------------------------------------------------------------------|--------------------------------------------------------|
| $\text{Free Space Path Loss} = -10 \times \log_{10} \left[ \left( \frac{4\pi d}{\lambda} \right)^2 \right]$ |                                                        |
| where d = distance from antenna =                                                                           | 2.52E+07 meters                                        |
| c = speed of light =                                                                                        | 3.00E+08 m/sec                                         |
| f = frequency =                                                                                             | 1.58E+09 Hz                                            |
| lambda = wavelength = c/f =                                                                                 | 1.90E-01 meters                                        |
|                                                                                                             | $= -10 \log_{10} \left[ 3.17E+08 / 1.90E-01 \right]^2$ |
|                                                                                                             | $= -10 \log_{10} \left[ 1.67E+09 \right]^2$            |
| Free Space Path Loss over Distance                                                                          | -184.43 dB                                             |

### Received Power on Earth

|                    |                    |
|--------------------|--------------------|
| <b>-158.43 dBW</b> |                    |
| <b>-128.43 dBm</b> | <b>1.44E-04 pW</b> |

|                         |         |
|-------------------------|---------|
| Gain of Receive Antenna | 38 dBic |
|-------------------------|---------|

|                                                                                                 |         |
|-------------------------------------------------------------------------------------------------|---------|
| RF losses in 300 feet of LMR400UF cabling and connectors from Receive Antenna to Line Amplifier | -6.7 dB |
| Gain of Line Amplifier                                                                          | 20 dB   |

|                                                  |                   |                 |
|--------------------------------------------------|-------------------|-----------------|
| <b>RF Power at Input to Re-Radiating Antenna</b> | <b>-77.13 dBm</b> | <b>19.36 pW</b> |
|--------------------------------------------------|-------------------|-----------------|

|                                      |        |
|--------------------------------------|--------|
| Gain of Passive Re-Radiating Antenna | 3 dBic |
|--------------------------------------|--------|

|                                                  |                   |                 |
|--------------------------------------------------|-------------------|-----------------|
| <b>Re-Radiated EIRP (wrt isotropic radiator)</b> | <b>-74.13 dBm</b> | <b>38.64 pW</b> |
|--------------------------------------------------|-------------------|-----------------|

|                                              |                   |                 |
|----------------------------------------------|-------------------|-----------------|
| <b>Re-Radiated ERP (wrt dipole radiator)</b> | <b>-76.28 dBm</b> | <b>23.55 pW</b> |
|----------------------------------------------|-------------------|-----------------|

$$Free\ Space\ Path\ Loss = -10 \times \log_{10} \left[ \left( \frac{4\pi d}{\lambda} \right)^2 \right]$$

where d = distance from antenna = 100 feet

$$= -10 \log_{10} \left[ 383.023 / 1.90E-01 \right]^2$$

$$= -10 \log_{10} \left[ 2.01E+03 \right]^2$$

Free Space Path Loss over Distance -66.07 dB

**RF power level at 100 ft distance =**

|                    |                       |
|--------------------|-----------------------|
| <b>-140.20 dBm</b> | wrt isotropic antenna |
| <b>-142.35 dBm</b> | wrt dipole antenna    |