Example: Mars Pathfinder X-band Downlink Budget

Item	Symbol	Value (linear units)	Value (logarithmic units)
Transmit power	W_t	10 W	+10 dBW
Transmit antenna gain	G_t	251.1	+24.0 dBi
Effective isotropic radiated power	EIRP	2.51 kW	+34 dBW
Free space path loss	$(\frac{\lambda}{4\pi R})^2$	220×10^{-30}	-276.6 dB
Received isotropic power	W_r/G_r	554×10^{-27} W	-242.6 dBW
Receive antenna gain	G_r	6.31×10^3	68.0 dBi
Power at receiver	W_r	3.49×10^{-18} W	-174.6 dBW or -144.6 dBm

Details

Item	Value
Operating frequency	8420 MHz
Mars-Earth distance as of 4-Jul-97	191×10^6 km

The operating wavelength is $c/f = 3.56$ cm, which is used in the path loss calculation.

To put things in perspective, a standard cellular phone would require approximately -100 dBm of received power to even properly recover a signal. The NASA receiver is obviously much more sensitive (approximately 45 dB more sensitive, or 31,600 times as sensitive).

The NASA Deep Space Network uses a series of large reflector antennas to receive signals from distance probes. The antenna used here was a 34 m reflector antenna. An ideal aperture of this area would produce $D = \frac{4\pi}{\lambda^2}(\pi \cdot 17^2) = 69.5$ dBi of gain. Most reflectors have an aperture efficiency of 70%, so after you account for this the gain shown in the table matches well with this simple calculation.

Reference: `http://www.ka9q.net/mpf_budget.html`