

**The current mission requires teams to transmit a picture from inside a structure to a point 3km away. This can be done directly or by any number of relays. For logistical reasons, it will be convenient for the judges to view your entry's telemetry near the structures being interrogated. This can be achieved by putting a "pad" on your data link receiver to physically simulate the free space loss associated with transmission through the structure itself, and the 3 km trip back to the launch point. The pad is merely a resistive attenuator that diminishes your received signal by an amount appropriate to losses expected. This requires the judges to modify your hardware by installing the pad and having the necessary interface connectors on hand.**

**A logistically simpler solution is to require the teams to show analytically that their transmitter network can get a signal 3km with an acceptable signal-to-noise ratio such that one would expect to receive an adequately strong signal at that range.**

**To date, it has been assumed by the teams that they would have a remote receiver 3km distant. This document clarifies the procedure to be used by the judges in this regard. The actual receiver site can be collocated with the team's ground station monitoring equipment located near the launch point (within several hundred meters of the McKenna MOUT site structures). During Static Judging, the teams attempting Levels 3 and/or 4 will submit a "Link Margin" calculation report which proves that their data link network can physically reach 3km reliably. Manufacturer's data sheets for the equipment to be used in this part of the entry must be provided as part of this report (typically transmitter, antenna, and receiver data sheets). The judges will verify that this equipment is in fact in place on the day of the competition, such that were an actual power level measurement to be made at a distance of 3km, sufficient power would be detected (such spot checks may be conducted).**

**Certain assumed parameters are being provided for your use in constructing a Link Margin report that is comparable to that of each other team:**

**Range = 3km**

**Temperature = 305°K**

**Precipitation Loss = 3dB, All other Miscellaneous Losses = 3 dB**

**Sufficient reliability will be defined as a Link Margin = 10dB**

**Concrete block wall attenuation similar to that found at the McKenna MOUT site = 18dB**

(ref: Stone, William C., NIST Construction Automation Program Report No. 3 Electromagnetic Signal Attenuation in Construction Materials, NISTIR 6055, National Institute of Standards and Technology: Maryland, October 1997)

The following discussion is designed to aid teams in the construction of their Link Margin report. For uniformity, use the simplified formulas provided.

### DEFINITIONS:

## Processing Gain

$$\text{Processing Gain (dB)} = 10 \log_{10} \left[ \frac{\text{TransmittedBandwidth}}{\text{InformationBandwidth}} \right]$$

## Signal-to-Noise Ratio (S/N)

The signal-to-noise ratio (S/N) can be calculated as:

$$\begin{aligned} \log_{10}(S/N) = & \log_{10}(\text{ERP}_{\text{Trans.}}) + \\ & \log_{10}(\text{Gain}_{\text{Rec.}}) + \\ & \log_{10}(kT) - \log_{10}(B) - \log_{10}(F) - \\ & \log_{10}[(4\pi R/\lambda)^2] - \\ & \log_{10}(\text{precipitation loss}) - \\ & \log_{10}(\text{misc. losses}) \end{aligned}$$

where,

**ERP** = Effective Radiated Power (product of the isotropic transmitted power and the transmitter's antenna gain)

**k** = Boltzman Constant ( $1.3054 \times 10^{-23}$  J/K)

**T** = Temperature (°K)

**R** = Range

**$\lambda$**  = Wavelength

**B** = Noise Bandwidth of the Receiver

**F** = Noise Figure of the Receiver

# Link Margin

Now, knowing the **available S/N ratio** (in dB), subtract the **required S/N ratio** (in dB) to obtain the **Fade Margin**.

If the **Fade Margin** is at least 10 dB, then that is your **Link Margin**. If the Fade Margin is insufficient, then incorporate some means of **Processing Gain**† which can then be added to the Fade Margin to come up with an improved **Link Margin** such that:

$$\text{Link Margin (dB)} = \text{Fade Margin (dB)} + \text{Processing Gain (dB)}$$

† **Processing Gain** is anything that you do to your signal to improve the signal-to-noise ratio apart from increasing the transmitter power or antenna gains. Signal integration over time would be an example of a processing gain technique. Be able to prove that your processing gain technique does in fact produce an improvement in gain as part of your report should you decide to use processing gain to augment your Fade Margin.