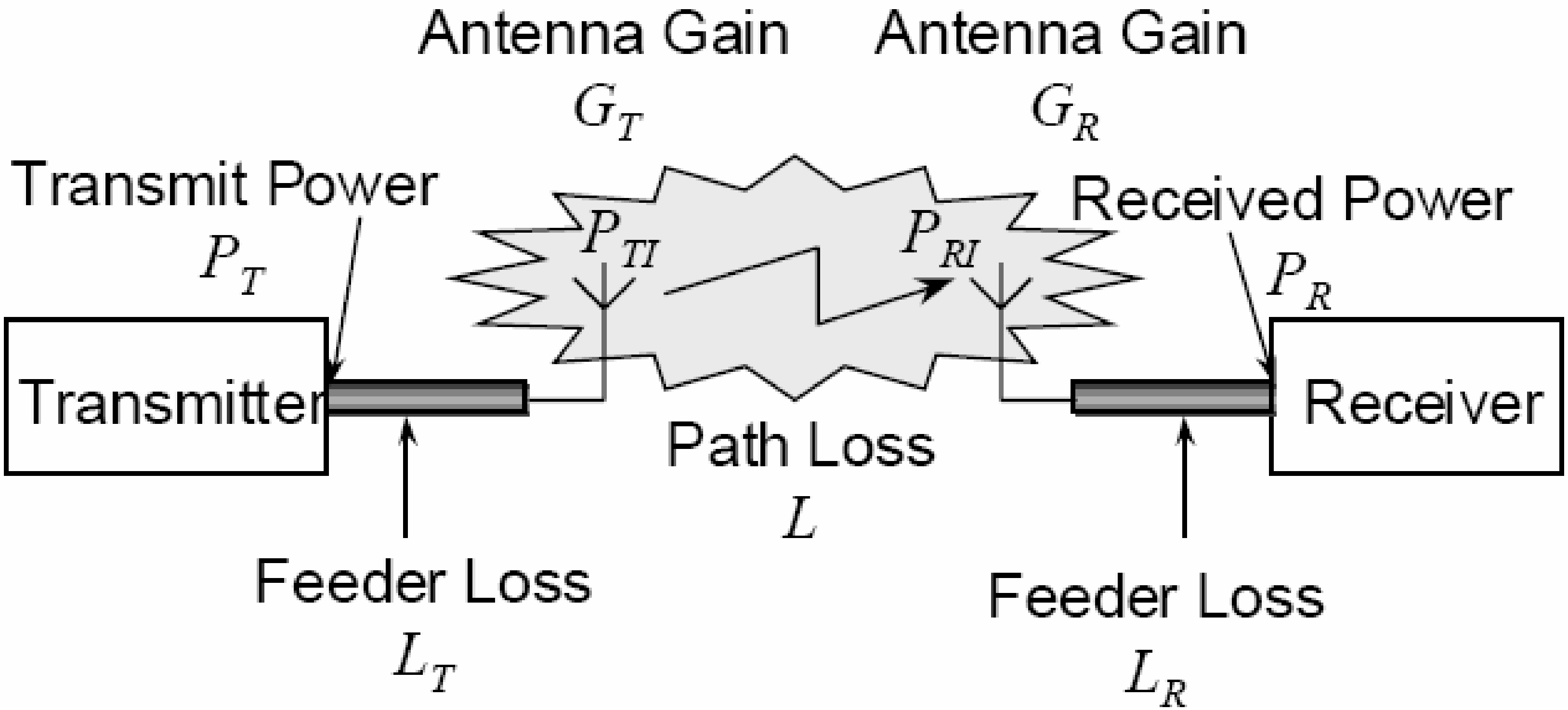
REU-Wireless Communications
Summer 2007
Link Budgets

Richard S. Wolff, Ph. D.
rwolff@montana.edu
406 994 7172
509 Cobleigh Hall

MONTANA STATE UNIVERSITY

Links: What happens between the transmitter and receiver?



$$P_R = \frac{P_T G_T G_R}{L_T L L_R}$$

Link performance considerations

- Need a minimum signal level at the receiver, S_{min}
- Received signal level will be a function of transmitted power and intermediate gains and losses
- Ratio of signal S to noise N, will determine whether the signal is usable
- S/N=SNR
- At receiver, $S=P_R$

Link Budget

Minimal received signal power required

$$P_R = P_T + G_{Tt} + G_R - L_T - L - L_R \geq S_{\min} + M$$

M is called the link margin

$S_{\min}$ is the minimum received signal power needed for communications

When M is > 0, the link has positive margin, more than enough power to receive the signal

Free Space Path Loss

Free Space Path Loss

$$L = \left(\frac{4\pi d}{\lambda} \right)^2$$

$$L\ (dB) = -20 \log \left(\frac{\lambda}{4\pi d} \right)$$

General Path Loss formula

$$L\ (d) = L\ (d_0) + 10\gamma \log \left(\frac{d}{d_0} \right)$$

where $L(d_o)$ is path loss at the reference distance d_0
loss exponent γ is the slope of the average increase in path loss with dB-distance,

Path Loss

Table I. The path loss parameters over all buildings

Environment	PL_0	γ	σ
LOS Commercial	43.7	2.07	2.3
NLS Commercial	47.3	2.95	4.1
LOS Residential	45.9	2.01	3.2
NLS Residential	50.3	3.12	3.8

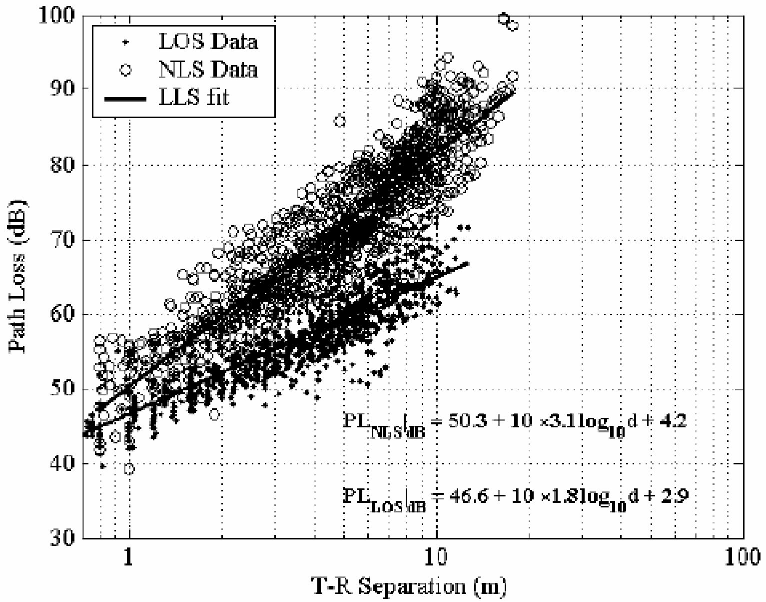


Fig. 2. Path loss vs. T-R separation in residential environments

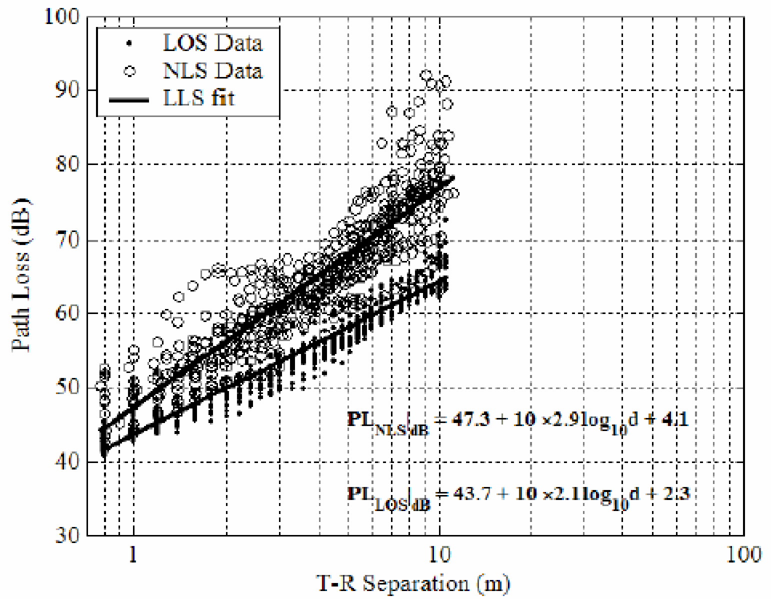
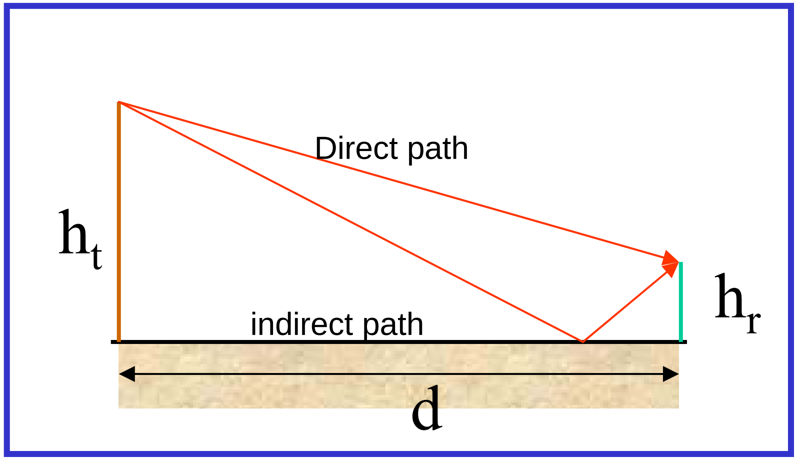


Fig. 3. Path loss vs. T-R separation in commercial environments

Ghassemzadeh,SS et al., "UWB Indoor Path Loss Model for Residential and Commercial Buildings"

Path loss over reflecting surface



$$E_s = \left[1 + \alpha_r e^{j\Delta\theta}\right]E \approx -Ej\Delta\theta$$

$\alpha_r \approx -1$ is reflection coefficient

$\Delta\theta$ Is phase difference between direct path and indirect path

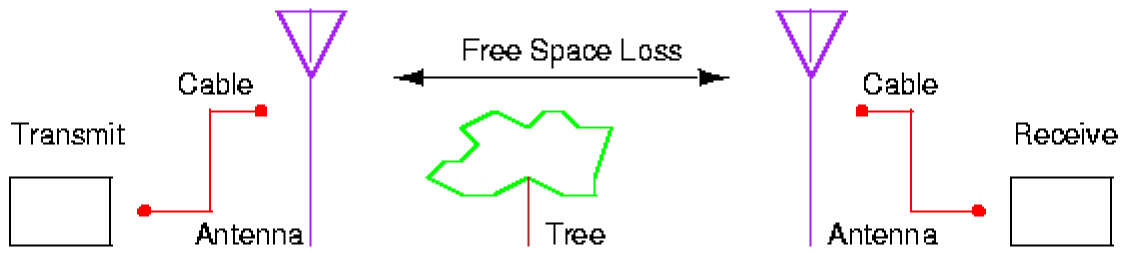
$$P_r = \left(\frac{h_t h_r}{d^2}\right)^2 \frac{P_t G_t G_r}{L_o}$$

$$P_R(dB) = P_T + 20\log\left(\frac{h_T h_R}{d^2}\right) + G_T + G_R - L_T - L_R$$

Link budget calculations

Lots of tools on the web to assist you!

- http://www.ecommwireless.com/cgi-local/wireless.cgi



Link budget calculations

Lots of tools on the web to assist you!

- http://www.wirelessconnections.net/calcs/BudgetCalc.asp