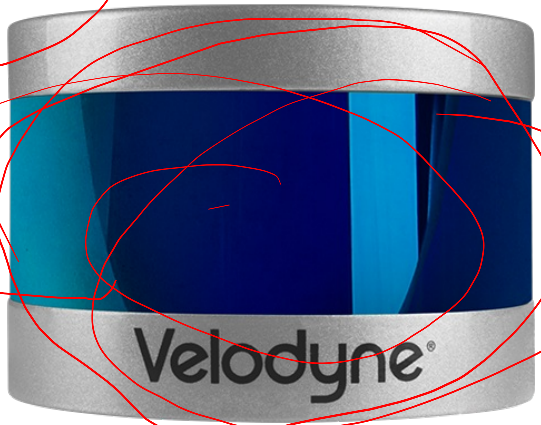
Posicionamiento y Sensores

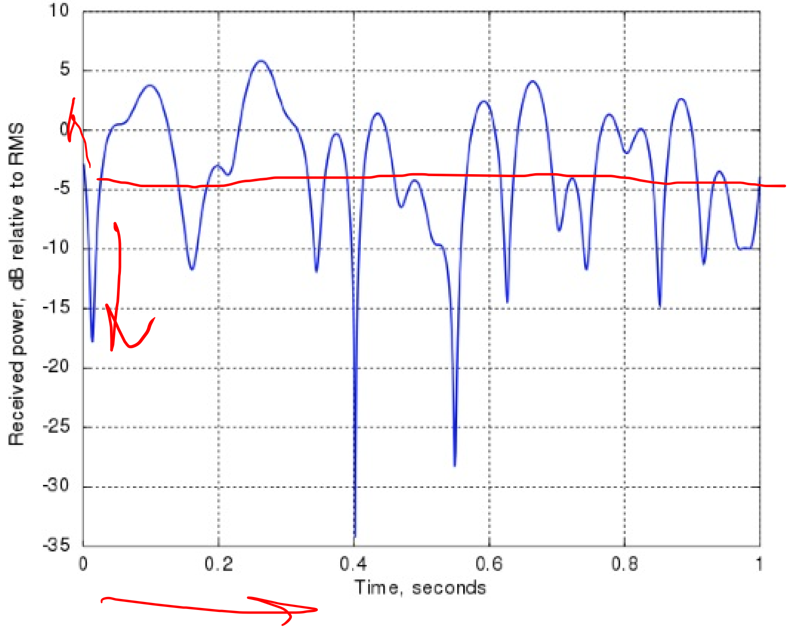
RF

30 m ~

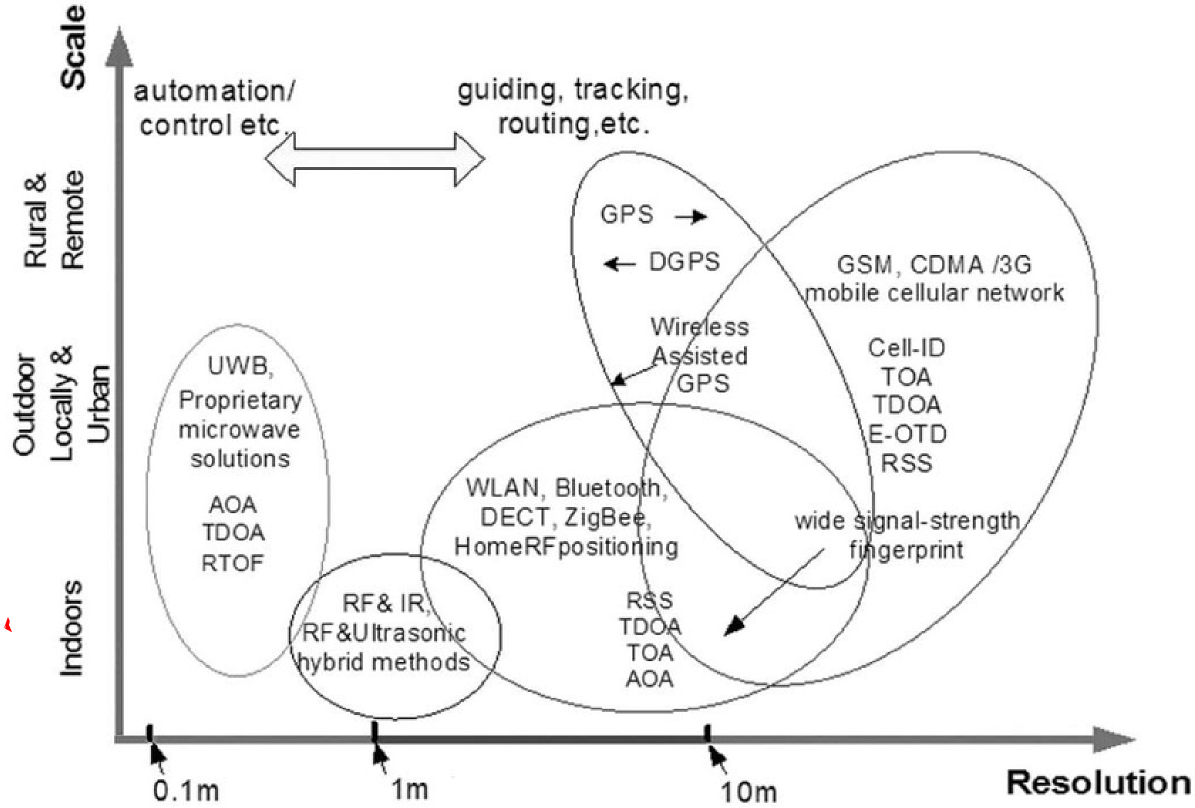


Posicionamiento ubicuo

2.4 Ghz (wifi) 12 cm

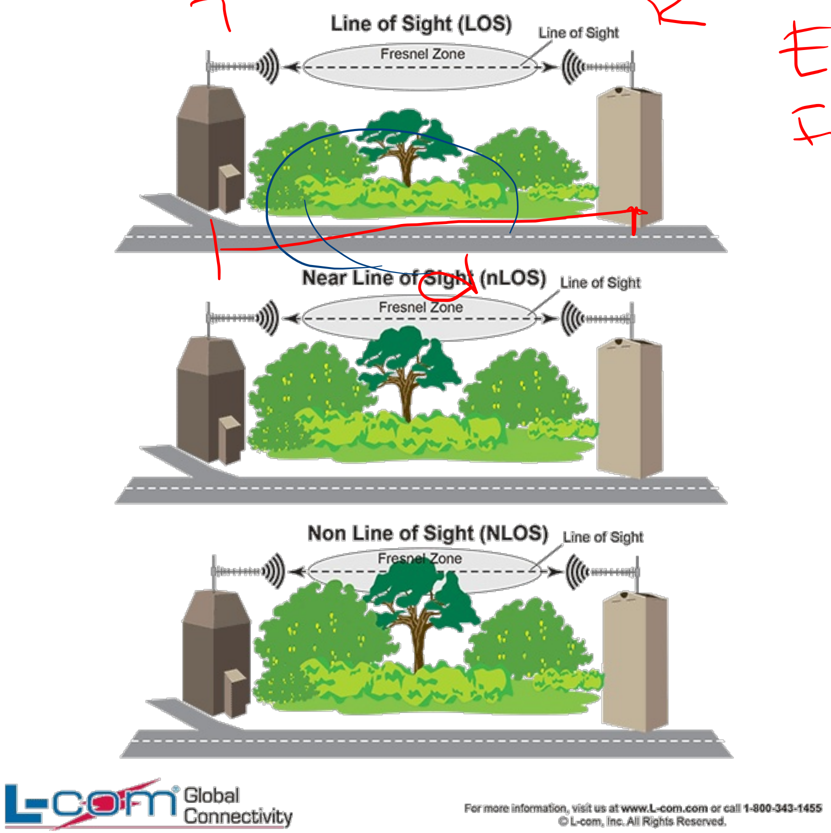


Sistemas de posicionamiento basado en RF



Posicionamiento y RF: Introducción a la propagación de las señales

T R



ESPACIO LIBRE

FREE SPACE

LINEA DE VISTA

LINE OF SIGHT.

$$\lambda = \frac{c}{f}$$

$$P_r = P_T G_T G_R \frac{\lambda^2}{(4\pi d)^2}$$

$$P_r = P_T G_T G_R \frac{c^2}{f^2 (4\pi d)^2}$$

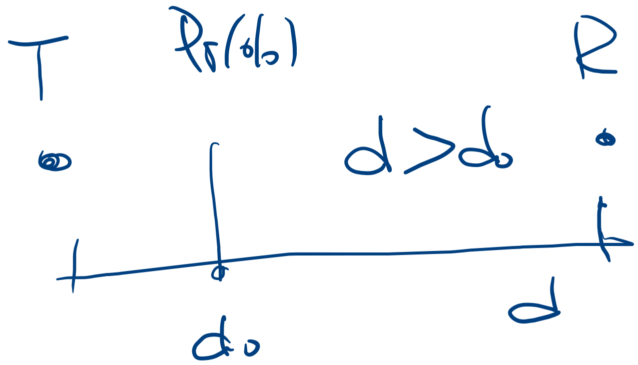
$$P_r(d) = P_T G_T G_R \frac{\lambda^2}{(4\pi d^{\xi})^2}$$

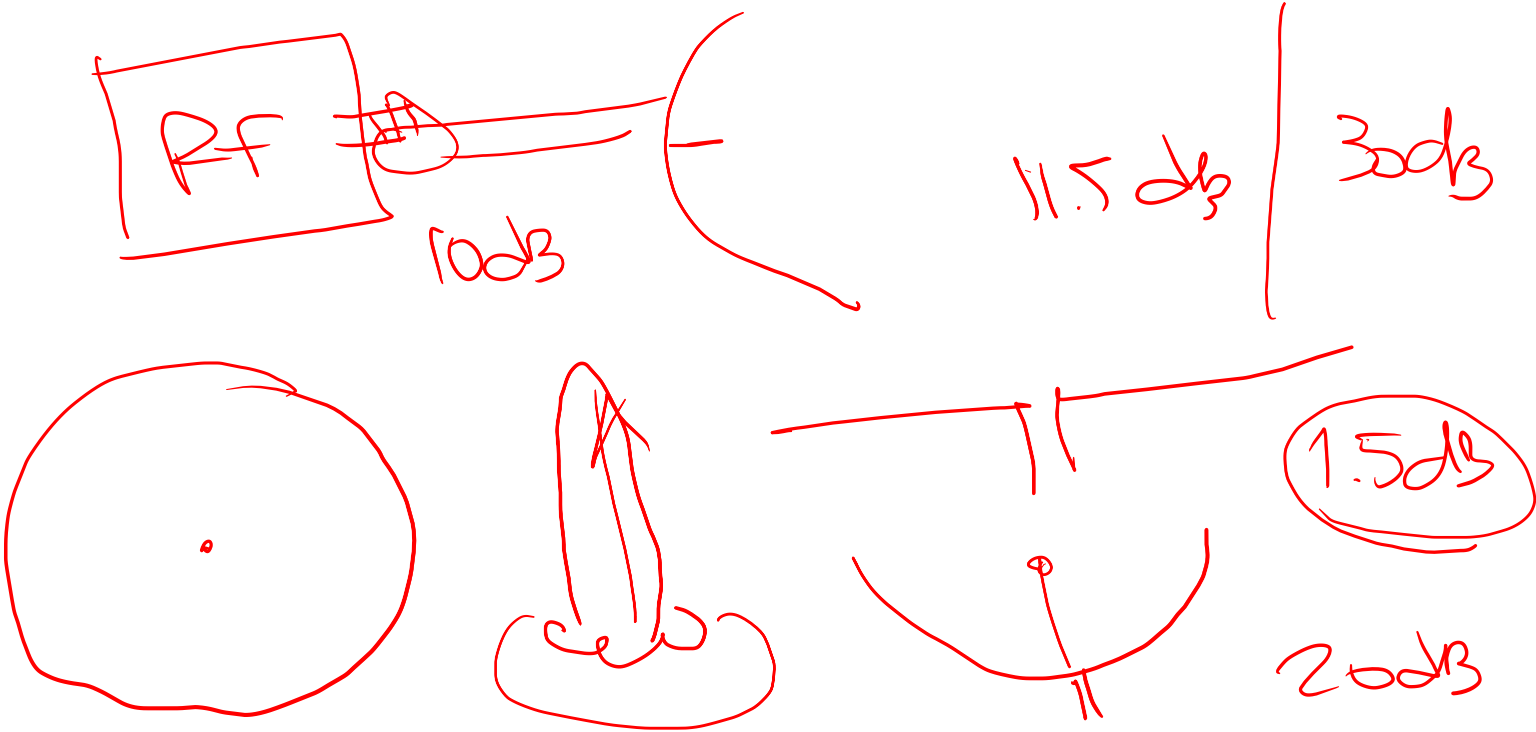
$$P_r(d_0) = P_T G_T G_R \frac{\lambda^2}{(4\pi d_0)^2}$$

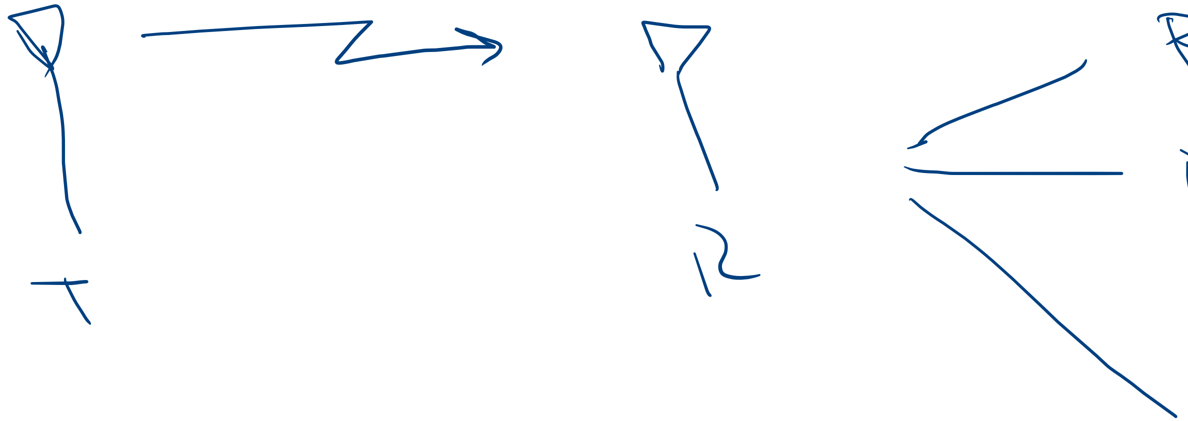
$$P_r(d_0)\,(d_0)^2 = \frac{P_T G_T G_R \lambda^2}{4\pi}$$

$$P_r = P_r(d_0)\left(\frac{d_0}{d}\right)^2$$

$$\boxed{P_r = P_r(d_0)\left(\frac{d_0^{\xi}}{d}\right)^2}$$




RF
10dB
11.5 db
30dB
1.5dB
20dB



REFLEXION

DIFRACCION

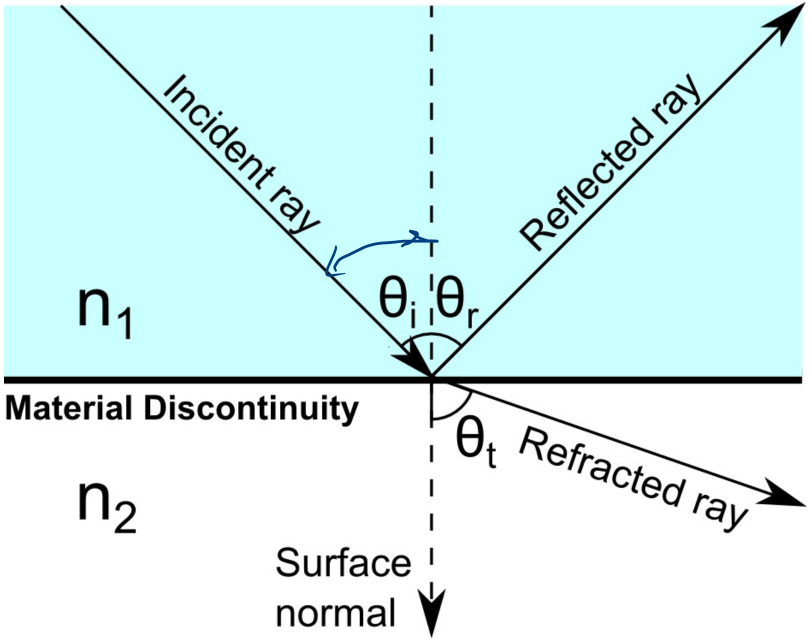
DISPERSION

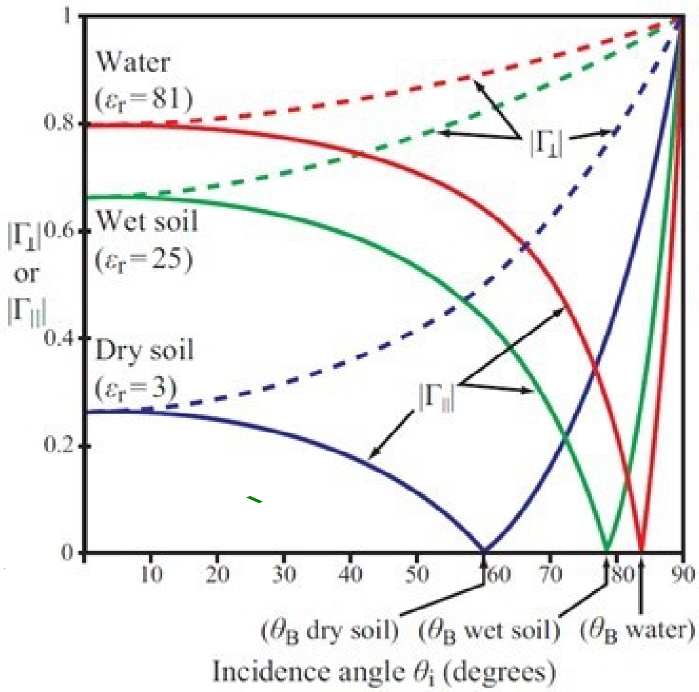
~~EL~~

Métodos de propagación: reflexión

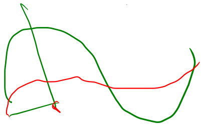
$$\Gamma \rightarrow \Gamma_{\parallel} = \frac{-\varepsilon_r \operatorname{sen}\theta_i + \sqrt{\varepsilon_r - \cos^2\theta}}{\varepsilon_r \operatorname{sen}\theta + \sqrt{\varepsilon_r - \cos^2\theta}}$$

$$\Gamma \rightarrow \Gamma_{\perp}$$

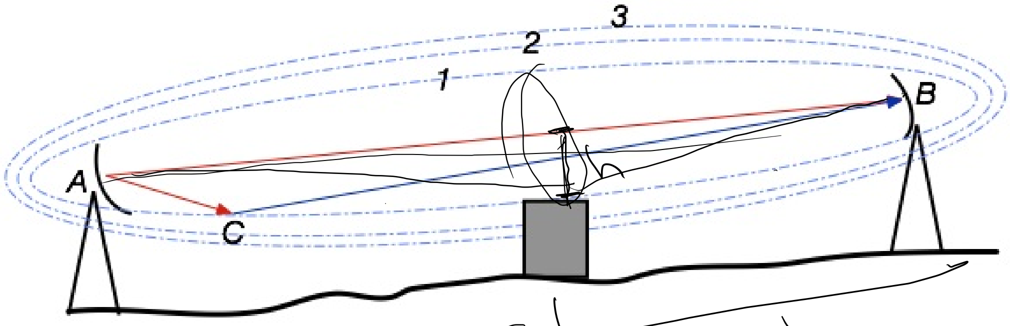




Métodos de propagación: difracción



PRINCIPIO DE HUGHET



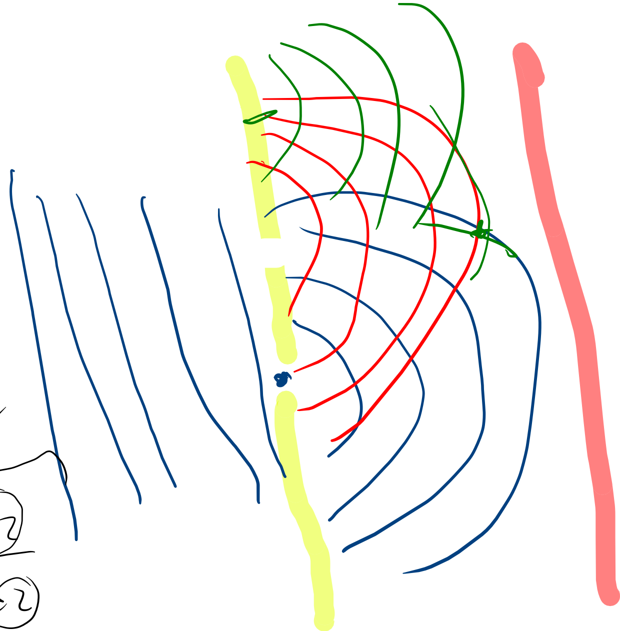
$0.7\,h \approx 2\,km$

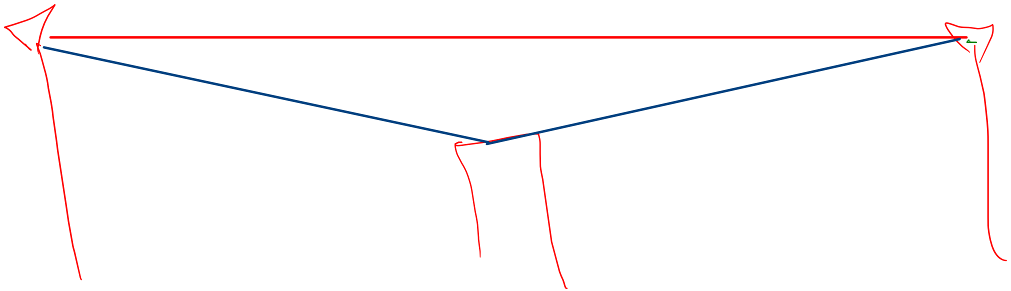
ZONAS DE FRESNEL

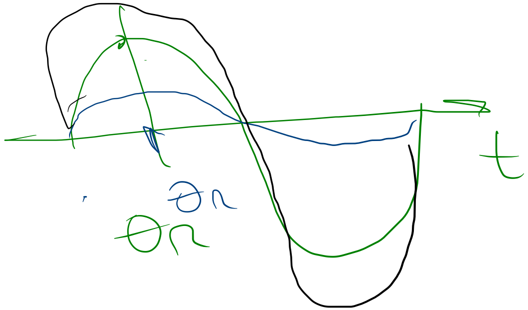
$$\nu = h\sqrt{\frac{2(d_1+d_2)}{\lambda\, d_1 \cdot d_2}}$$

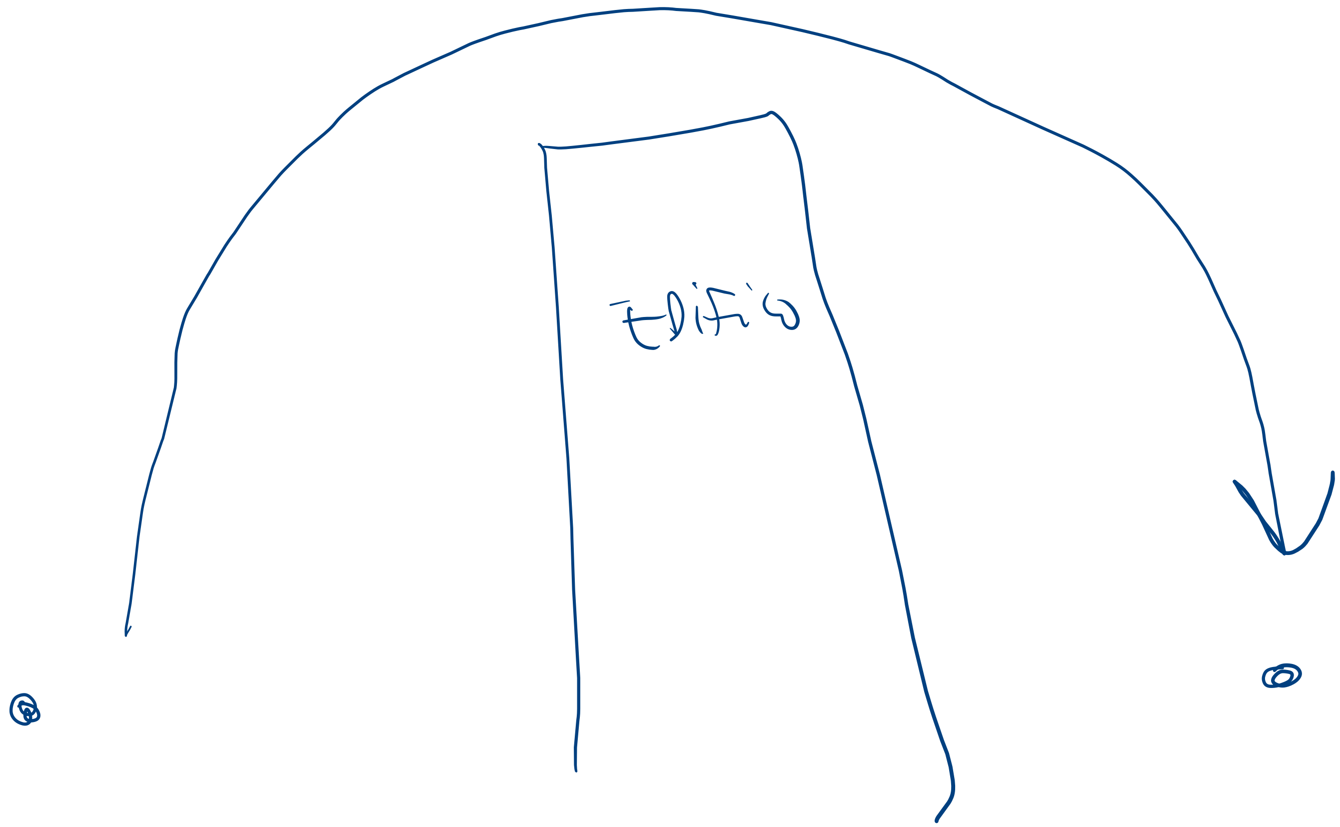
COEF. FRESNEL-KIRCHHOFF

$$r = \sqrt{\frac{n\lambda d_1 d_2}{d_1+d_2}}$$

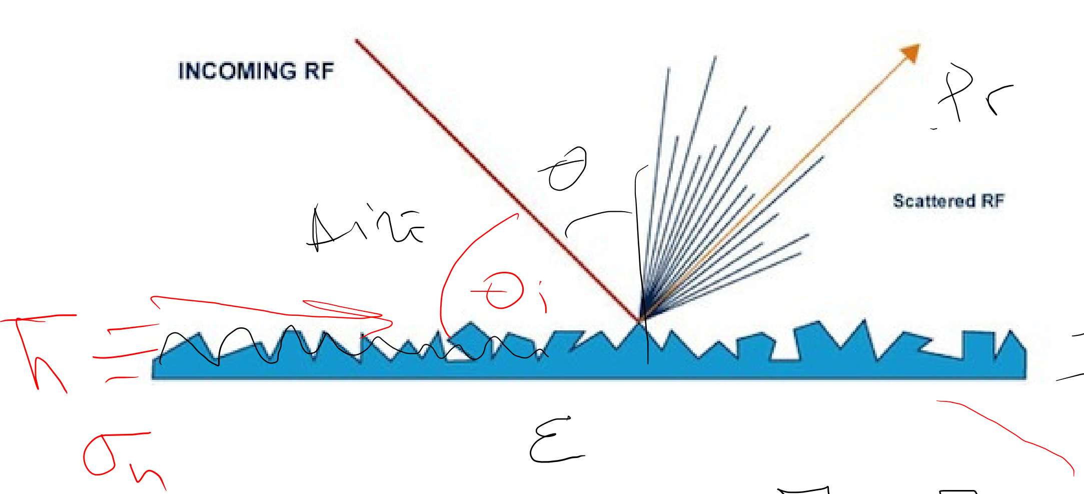





t


Edificio

Métodos de propagación: Scattering



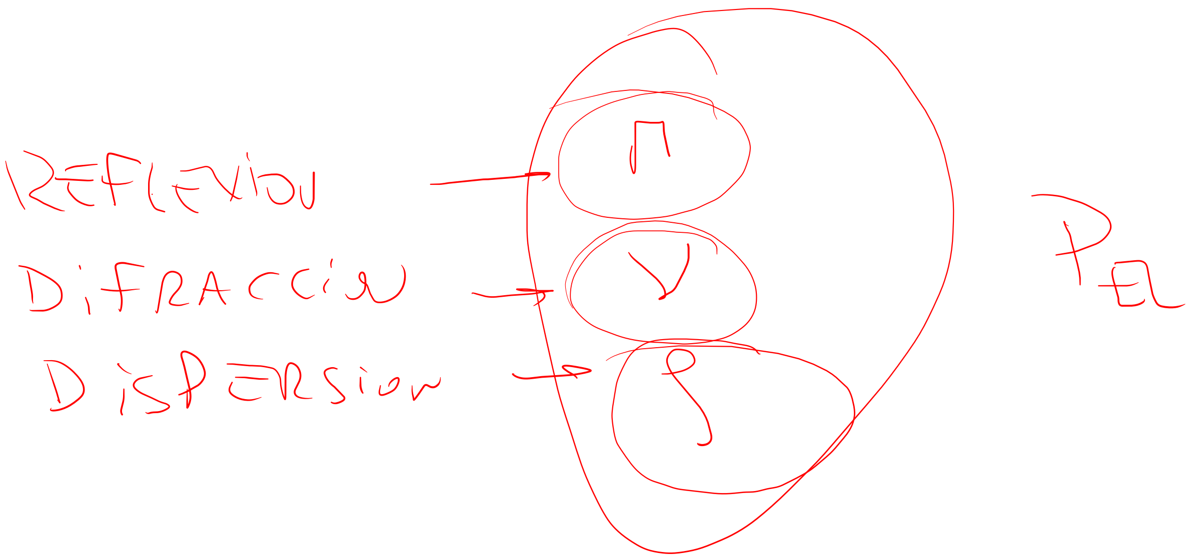
$$P_{r_S} < P_{r_{PURA}}$$

$$= h \sim \lambda$$

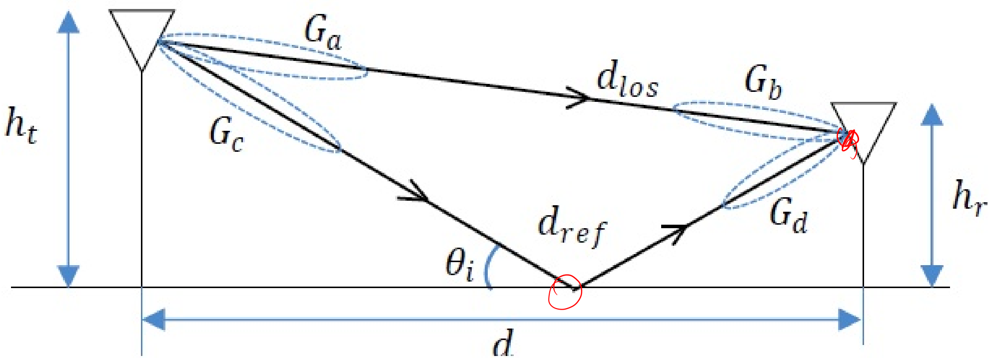
$$\Gamma_S = \Gamma \rho_S$$

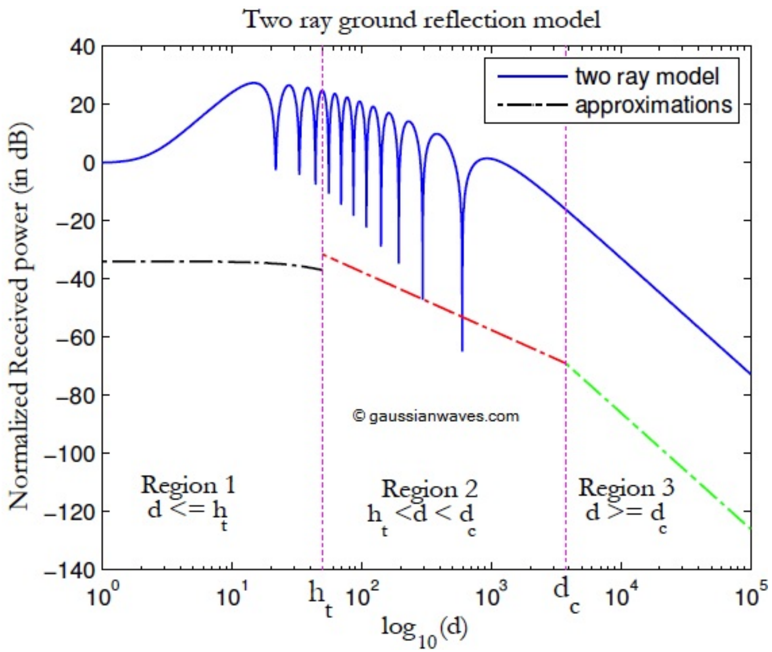
$$\rho_S = e^{\left(-\frac{8\pi\sigma_h \operatorname{sen}\theta_i}{\lambda}\right)^2}$$

$$\bar{h} > h_C = \frac{\lambda}{8 \operatorname{sen}\theta_i}$$


REFLEXION
DIFRACCION
DISPERSION
Γ
ν
ρ
P_EL

Modelos de Propagación: 2 rayos





$$P_r = \overbrace{\frac{P_T G_T G_R \cancel{\lambda^2}}{(\cancel{4\pi} d)^2}}^{P_{TL}} 4 \sin^2(\theta_\Delta/2)$$

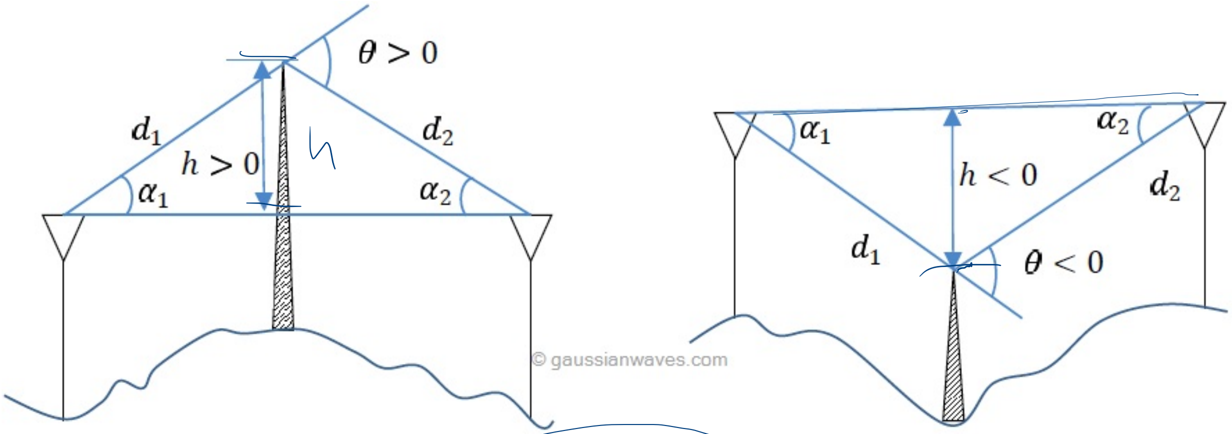
$$\theta_\Delta = \frac{2\pi}{\lambda} \frac{h_T * h_R}{d}$$

$\theta_\Delta < 0.2$ rad

$$\sin(\theta_\Delta/2) \simeq \frac{\theta_\Delta}{2}$$

$$P_r = P_{TL} \cdot 4 \left(\frac{\cancel{\pi}}{\cancel{\lambda}} \frac{h_T h_R}{d}\right)^2 = \frac{P_T G_T G_R}{4} \frac{(h_T h_R)^2}{d^4}$$

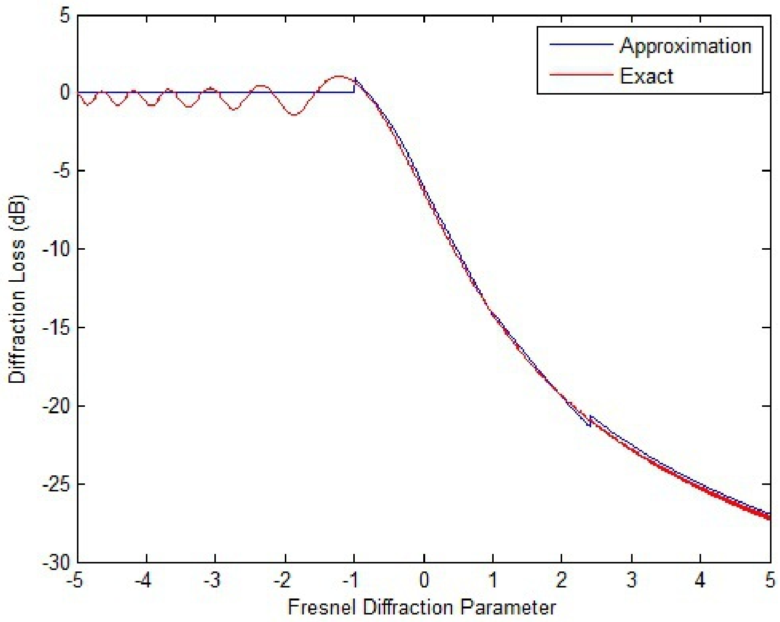
Modelos de Propagación: Filo de Cuchillo



(a) (b)

$$\nu = h\sqrt{\frac{2(d_1+d_2)}{\lambda\, d_1 \cdot d_2}}$$

Modelos de Propagación: Filo de Cuchillo



$$
\begin{aligned}
G_d(\mathrm{dB}) &= 0 && \nu \leqq -1 \\
&= 20\log(0{,}5 - 0{,}62\nu) && \nu \in (-1;0] \\
&= 20\log(0{,}5\exp(-0{,}95\nu)) && \nu \in (0;1] \\
&= 20\log(0{,}4 - \sqrt{0{,}1184 - (0{,}38 - 0{,}1\nu)^2}) && \nu \in (1;2{,}4] \\
&= 20\log(0{,}225/\nu) && \nu > 2{,}4
\end{aligned}
$$

$P_r = P_{EL} + G_{dif}$

Multiple knife-edge diffraction – used to calculate propagation in rough terrain

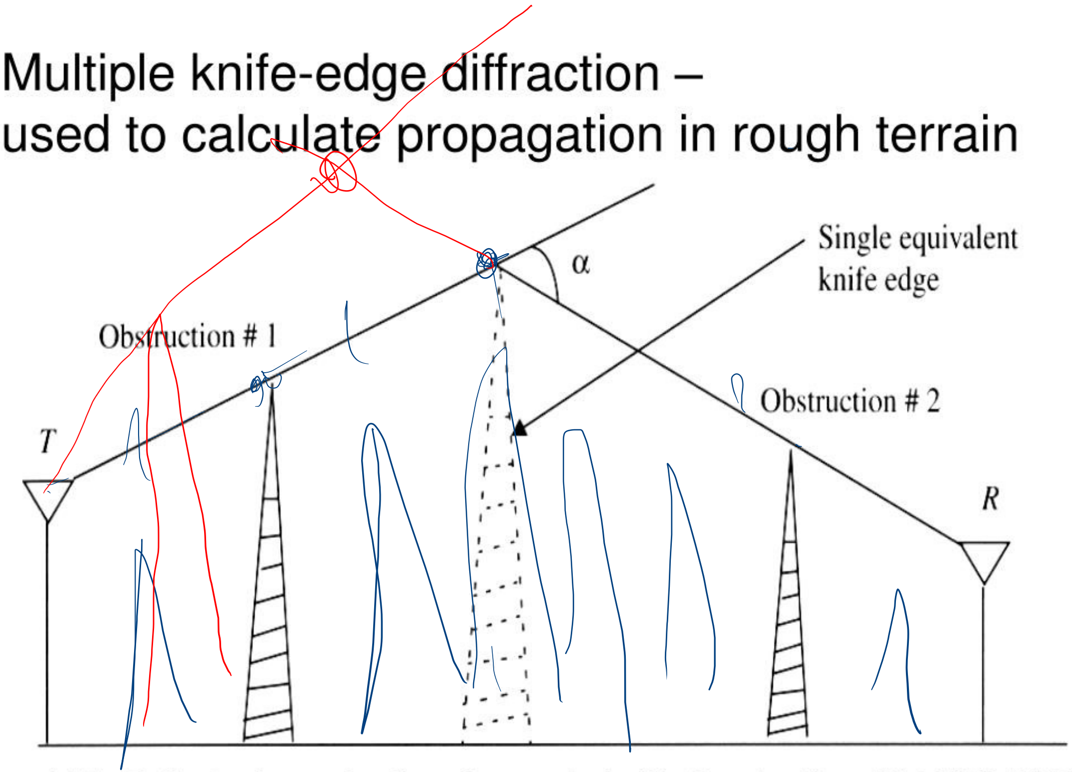
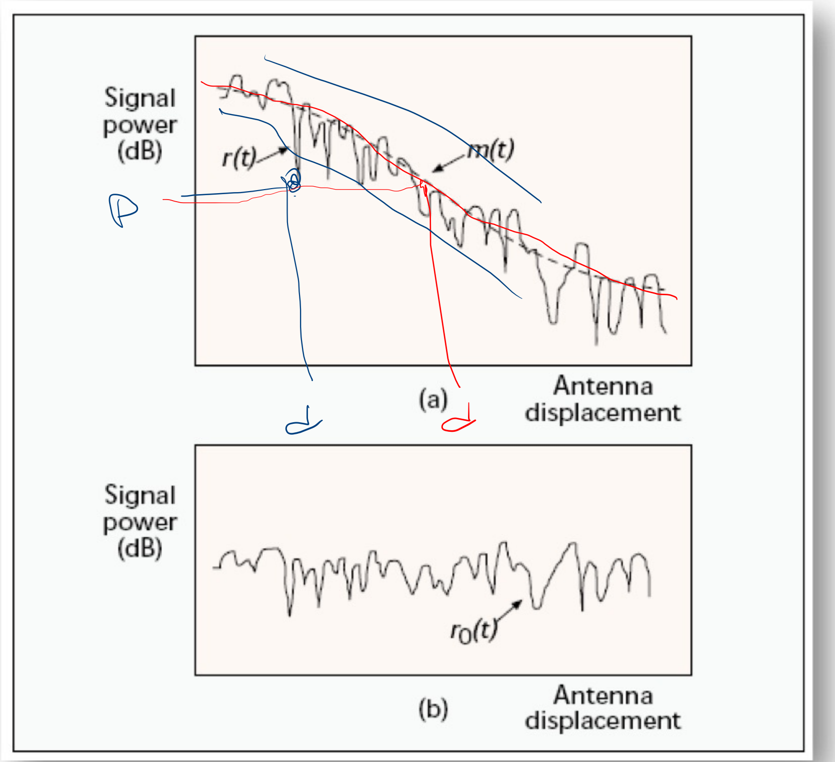


Figure 4.15 Bullington's construction of an equivalent knife edge [from [Bul47] © IEEE].

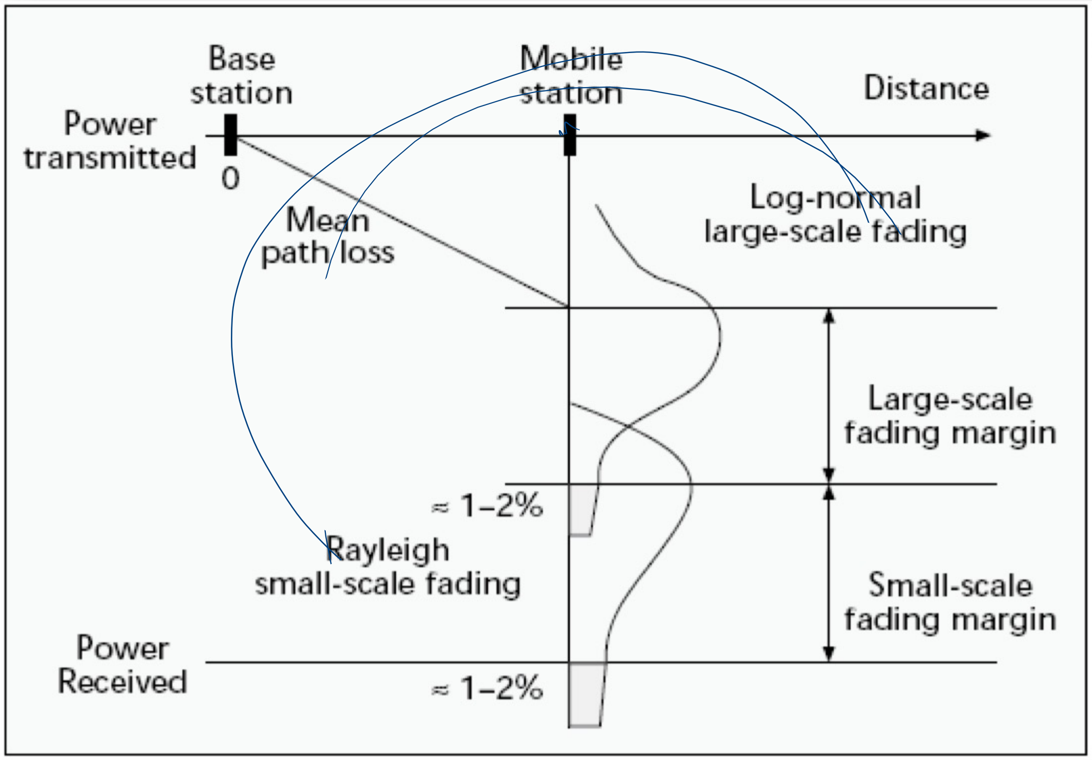
Potencia vs. Distancia



GRAN ESCALA (d >> 2d)

PEQUEÑA ESCALA Δd < d

Enlace de RF



Base station
Mobile station
Distance
Power transmitted
0
Mean path loss
Log-normal large-scale fading
Large-scale fading margin
≈ 1–2%
Rayleigh small-scale fading
Small-scale fading margin
Power Received
≈ 1–2%

T

Modelo de gran escala: Log-Normal

EL $n=2$

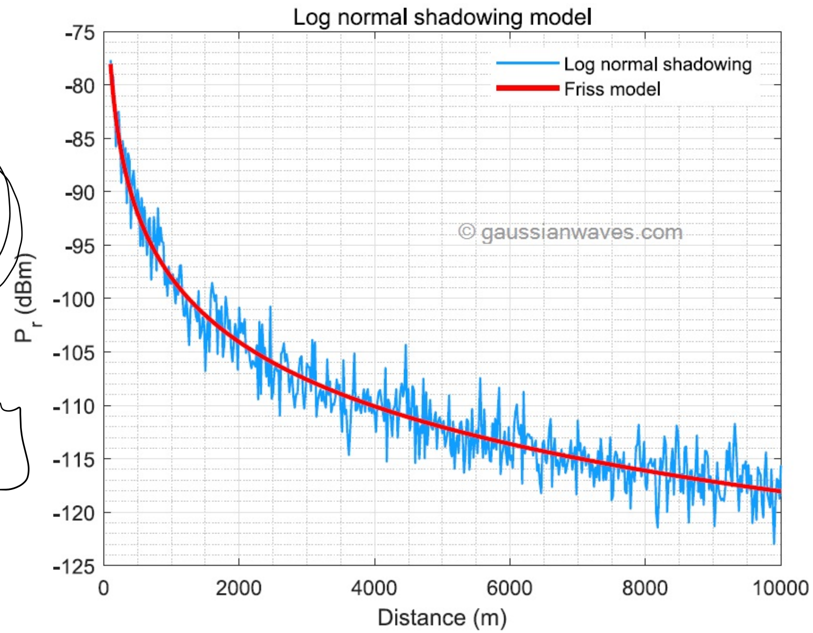
REAL $n=4$

$$\overline{PL}[dB] = \overline{PL}(d_0) + 10n\log\frac{d}{d_0} + X_\sigma$$

σ

$[2, 16]$

$$P_r[dB] = P_t[dB] - \overline{PL}[dB]$$



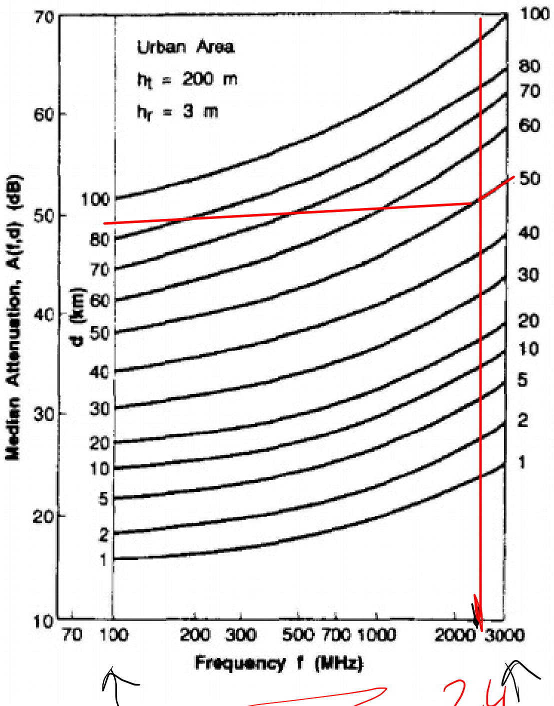
PATH LOSS

EDIFICIO $n = [2.4, 6]$

Modelo de gran escala: Okumura

MEDIANA

$$L_{50}[dB] = L_F + A_{mu}(f,d) - G(h_{re}) - G(h_{te}) - G_{AREA}$$

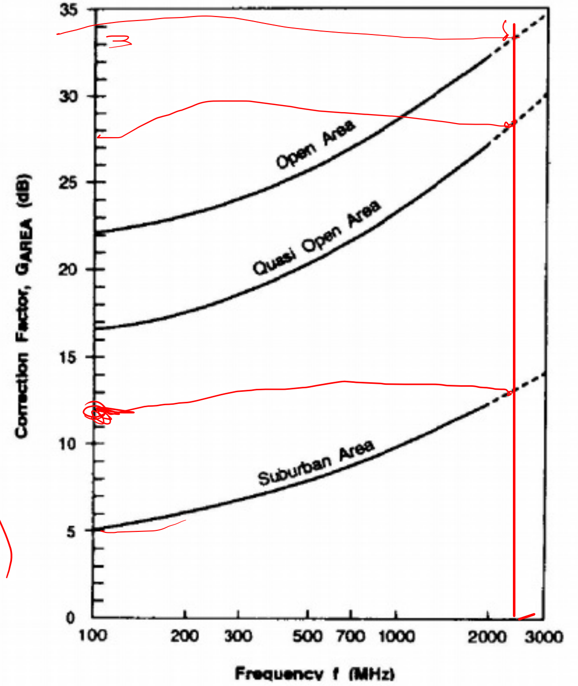


$G(h_{re}) = 10 \log\left(\frac{h_{re}}{3}\right)$

$h_{re} < 3m$

$G(h_{re}) = 20\left(\frac{h_{re}}{3}\right)$

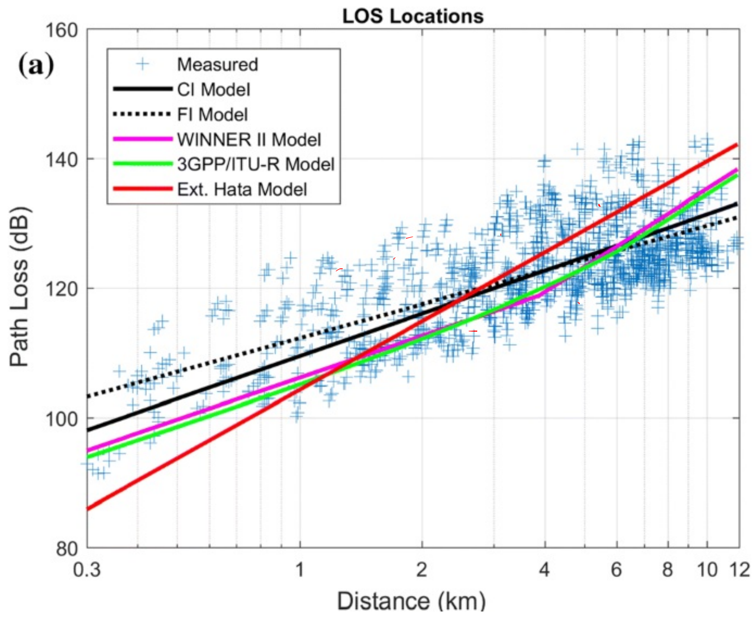
$G(h_{te}) = 20 \log\left(\frac{h_{te}}{200}\right)$



Modelo de gran escala: Hata

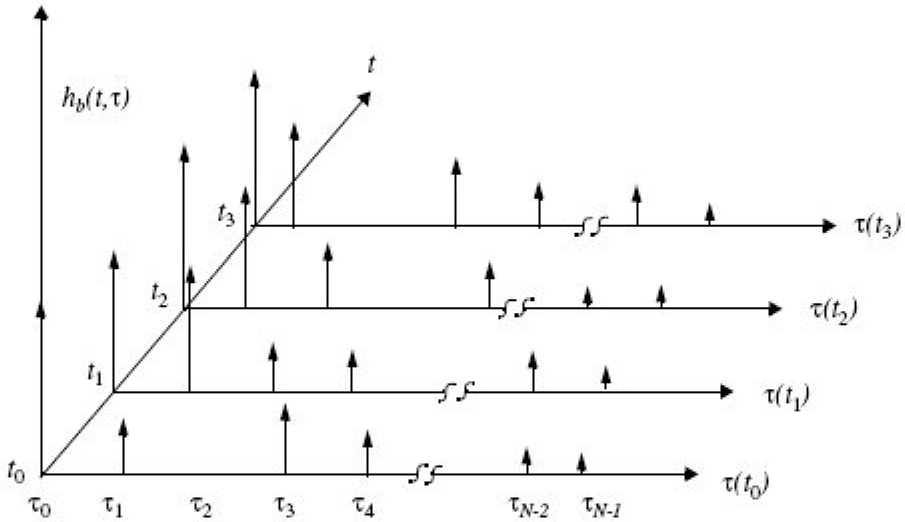
$$L_{50}[dB] = L_{50}[urbana, dB] - 2(\log(f_c/28))^2 - 5.4$$

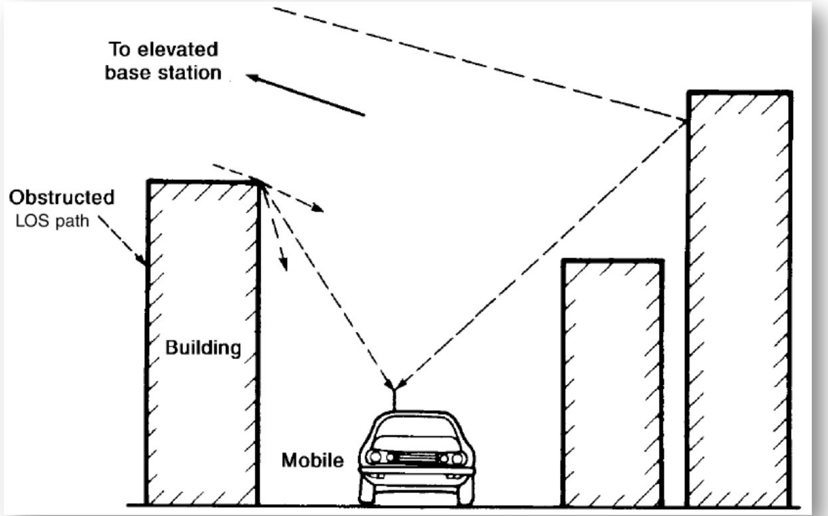
$$L_{50}[urbana, dB] = 69.55 + 26.16\log(f_c) - 13.82\log(h_{te}) - a(h_{re}) + (44.9 - 6.55\log(h_{te}))\log(d)$$



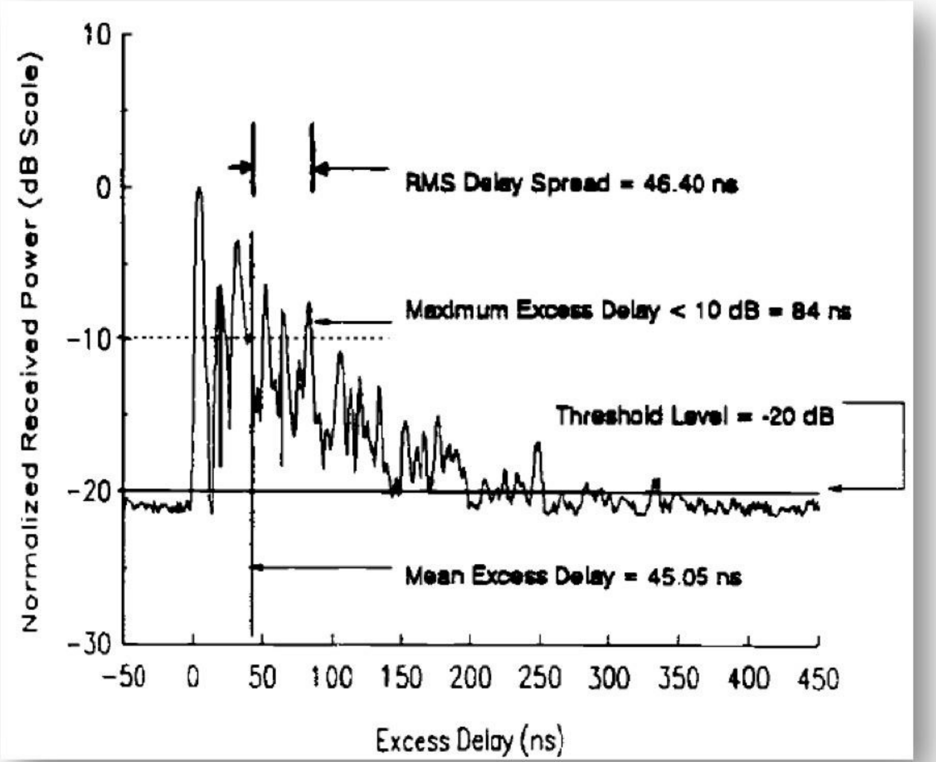
Measurements and path loss models for a TD-LTE network at 3.7 GHz in rural areas

Modelo de pequeña escala





Modelo de pequeña escala

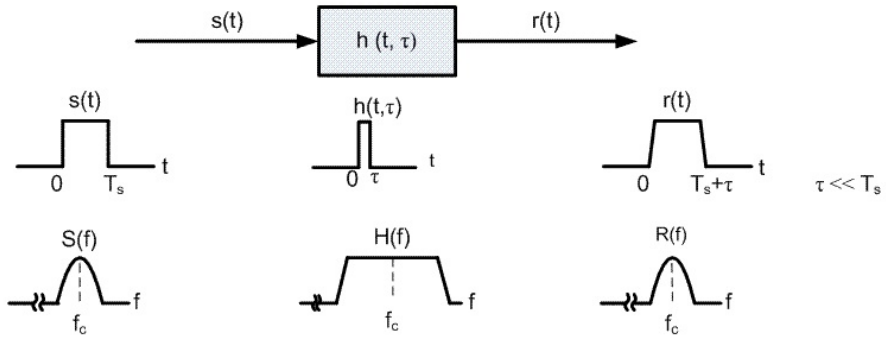


$$\bar{\tau} = \frac{\sum_k (p(\tau_k).\tau_k)}{\sum_k p(\tau_k)}$$

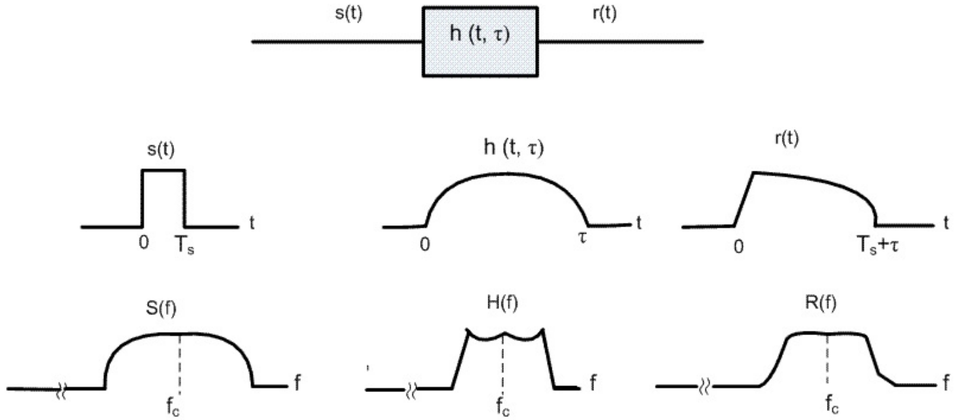
$$\overline{\tau^2} = \frac{\sum_k (p(\tau_k).\tau_k^2)}{\sum_k p(\tau_k)}$$

$$\sigma_\tau = \sqrt{\overline{\tau^2} - \bar{\tau}^2}$$

Modelo de pequeña escala



(a) Flat fading channel characteristics



(b) Frequency selective fading channel characteristics

Modelo de pequeña escala

Small-Scale Fading
(Based on multipath time delay spread)

Flat Fading
1. BW of signal < BW of channel
2. Delay spread < Symbol period

Frequency Selective Fading
1. BW of signal > BW of channel
2. Delay spread > Symbol period

Small-Scale Fading
(Based on Doppler spread)

Fast Fading
1. High Doppler spread
2. Coherence time < Symbol period
3. Channel variations faster than base-band signal variations

Slow Fading
1. Low Doppler spread
2. Coherence time > Symbol period
3. Channel variations slower than baseband signal variations

Efectos en el Posicionamiento