EEEN 474 Wireless Communication – Spring 2018

Reference Equations, Tables and Charts

$N = i^2 + ij + j^2$	$C = MS = MkN$	$Q = \sqrt{3N}$
$SIR = \frac{Q^n}{i_0}$	$A = UA_u = U\lambda H$ $Pr[delay > t] = Pr[delay > 0]Pr[delay > t \mid delay > 0]$ $= Pr[delay > 0]exp(-(C-A)t/H)$	
$\lambda = \frac{c}{f}$ $c \approx 3 \cdot 10^8 m/s$	$d_f = \frac{2D^2}{\lambda}$ $\quad d_f \gg D$ $\quad d_f \gg \lambda$	
$PL(d)[dB] = P_t[dB] - P_r(d)[dB]$		
Friis free space equation: $P_r(d) = \frac{P_t G_t G_r \lambda^2}{(4\pi)^2 d^2 L}$	$P_r(d)[dB] = P_r(d_0)[dB] + 20log(\frac{d_0}{d})$ $PL(d)[dB] = PL(d_0)[dB] + 20log(\frac{d}{d_0})$	

Log-distance path loss model:

$$\overline{PL}(d)[dB] = \overline{PL}(d_0)[dB] + 10nlog(\frac{d}{d_0})$$

Log-normal shadowing:

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

$$Pr[P_r(d) > \gamma] = Q(\frac{\gamma - \overline{P_r(d)}}{\sigma})$$ (powers, γ, σ are in dB)

$$Q(z) = 1 - Q(-z) = \frac{1}{2}[1 - erf(\frac{z}{\sqrt{2}})]$$

Link budget:

$$P_r[dBm] = P_t[dBm] + \text{Gains}[dB] - \text{Losses}[dB]$$

Okumura model:

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

$$G(h_{te}) = 20\log(\frac{h_{te}}{200}) \qquad 1000 \text{ m} > h_{te} > 30 \text{ m}$$

$$G(h_{re}) = 10\log(\frac{h_{re}}{3}) \qquad h_{re} \leq 3 \text{ m}$$

$$G(h_{re}) = 20\log(\frac{h_{re}}{3}) \qquad 10 \text{ m} > h_{re} > 3 \text{ m}$$

<table>
<tr><td colspan="6">$$B_S = \frac{1}{T_S}$$</td></tr>
<tr><td colspan="2" rowspan="2">$$\sigma_\tau = \sqrt{\overline{\tau^2} - (\overline{\tau})^2}$$
$$\overline{\tau^2} = \frac{\sum_k P(\tau_k)\tau_k^2}{\sum_k P(\tau_k)}$$
$$\overline{\tau} = \frac{\sum_k P(\tau_k)\tau_k}{\sum_k P(\tau_k)}$$</td><td colspan="4">$B_C = \frac{1}{50\sigma_\tau}$ (Threshold is 0.9 correlation)

$B_C = \frac{1}{5\sigma_\tau}$ (Threshold is 0.5 correlation)</td></tr>
<tr><td colspan="2">$B_S \ll B_C$

$T_S \gg \sigma_\tau$

$T_S \geq 10\sigma_\tau$</td><td colspan="2">$B_S > B_C$

$T_S < \sigma_\tau$</td></tr>
<tr><td>$f_d = \frac{v}{\lambda} \cdot cos\theta$

$f_m = \frac{v}{\lambda}$</td><td colspan="2">$B_D = f_d$

$T_C = \sqrt{\frac{9}{16\pi f_m^2}}$</td><td colspan="2">$T_S > T_C$

$B_S < B_D$</td><td>$T_S \ll T_C$

$B_S \gg B_D$</td></tr>
</table>

Table 3.2 Path Loss Exponents for Different Environments

Environmerlt	Path Loss Exponent, n
Free space	2
Urban area cellular radio	2.7 to 3.5
Shadowed urban cellular radio	3 to 5
In building line-of-sight	1.6 to 1.8
Obstructed in building	4 to 6
Obstructed in factories	2 to 3

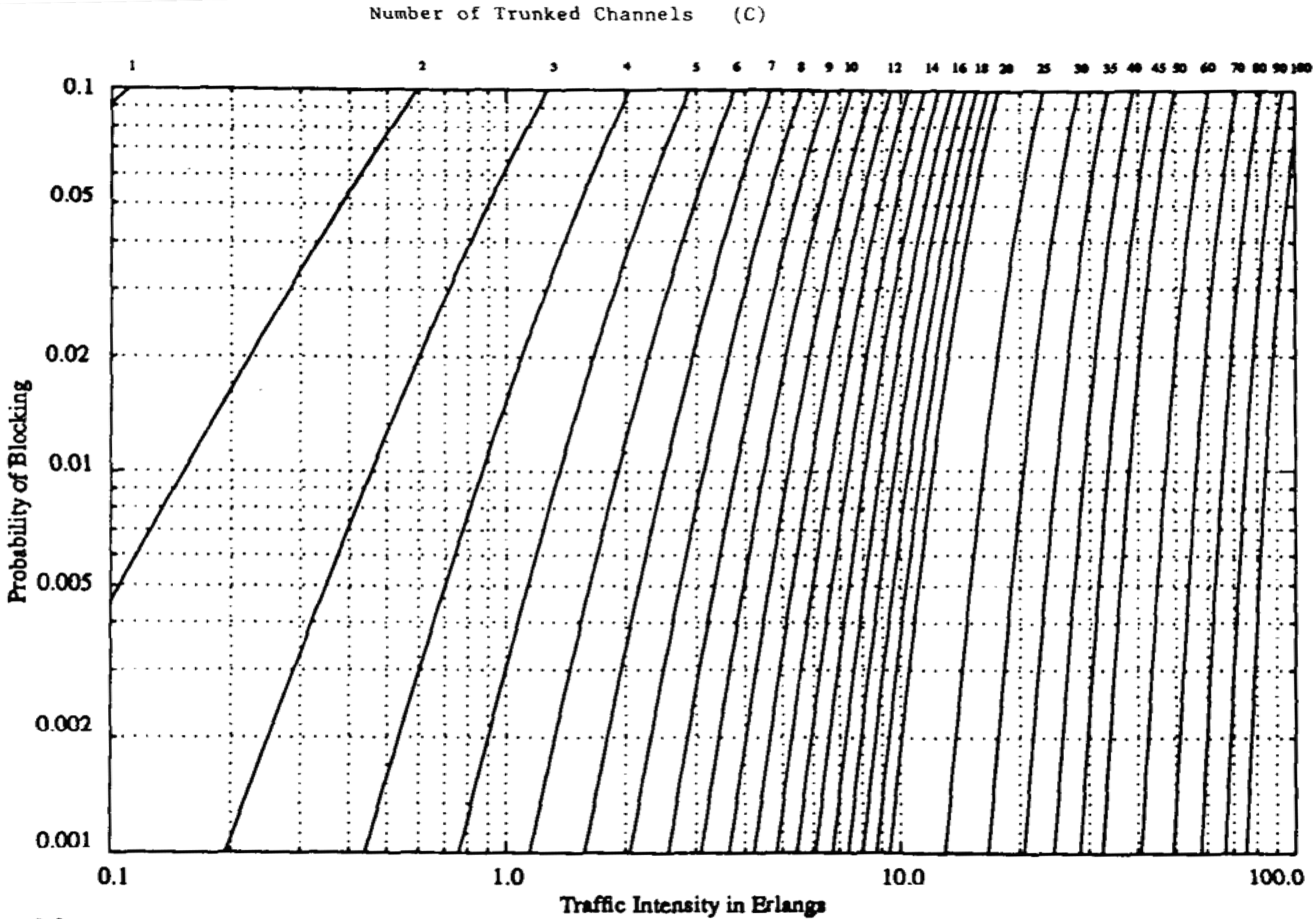


Figure 2.6
The Erlang B chart showing the probability of blocking as functions of the number of channels and traffic intensity in Erlangs.

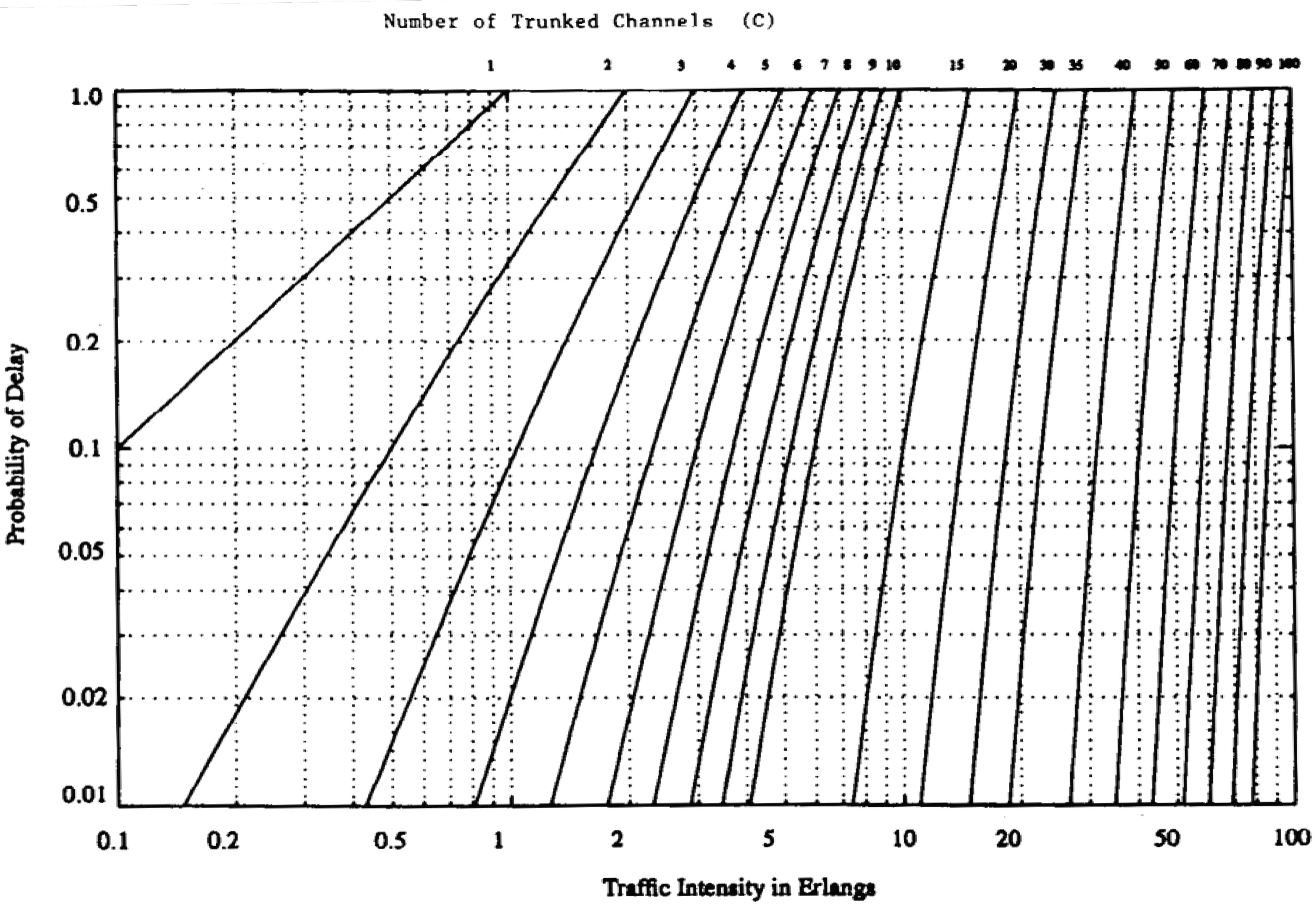
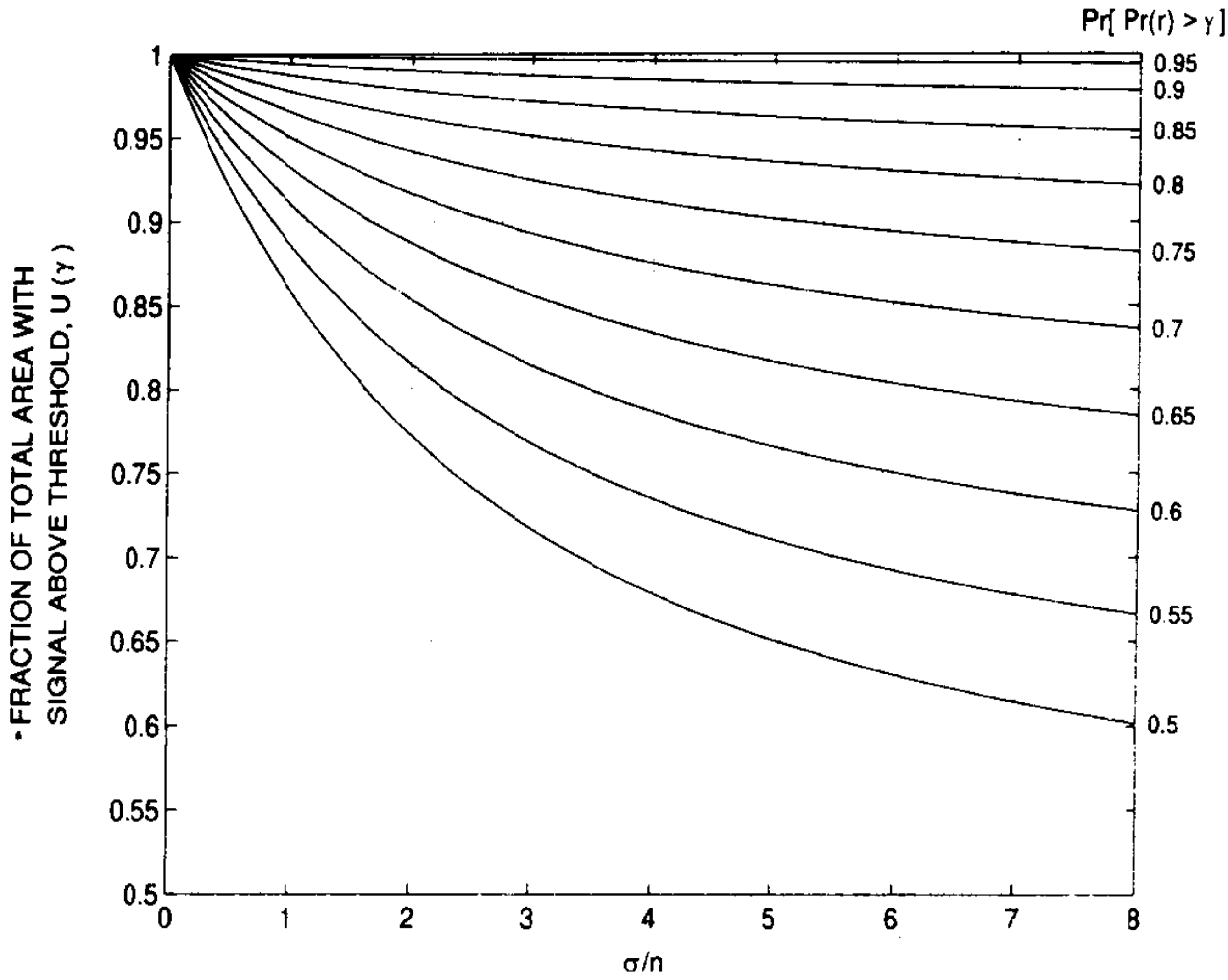
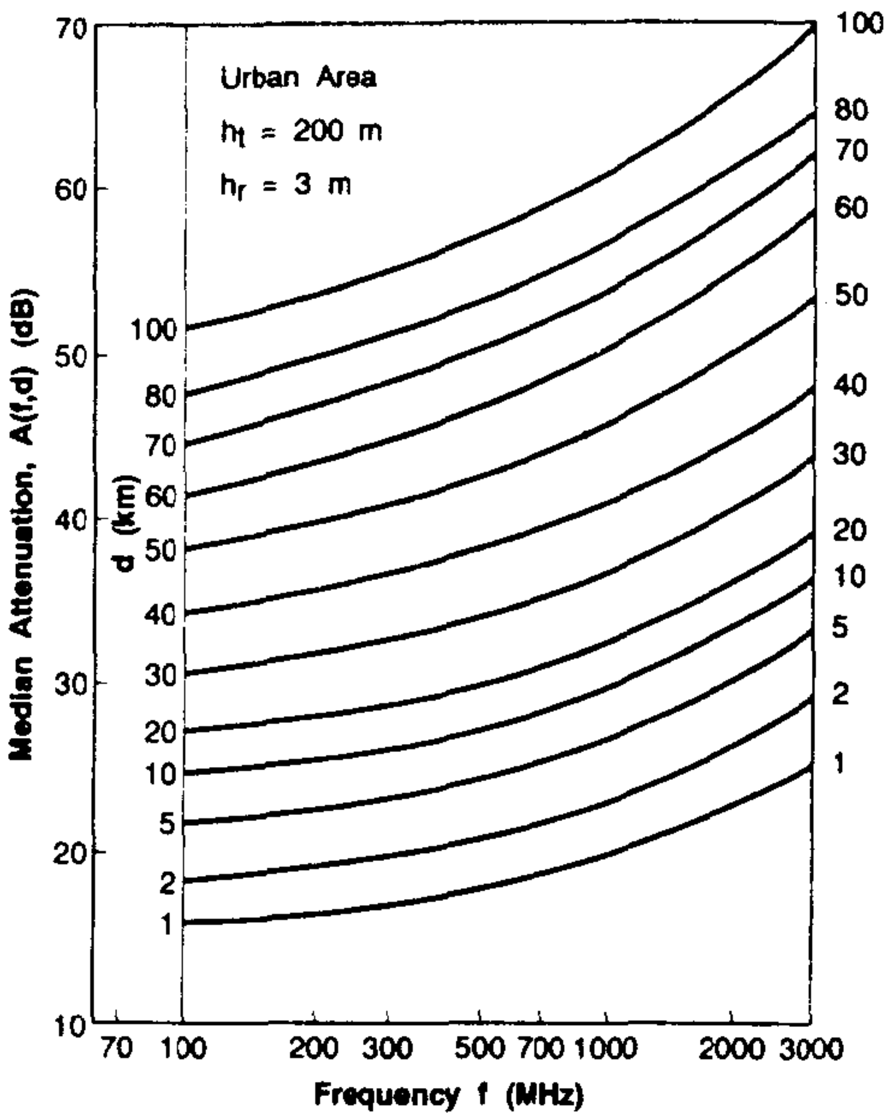


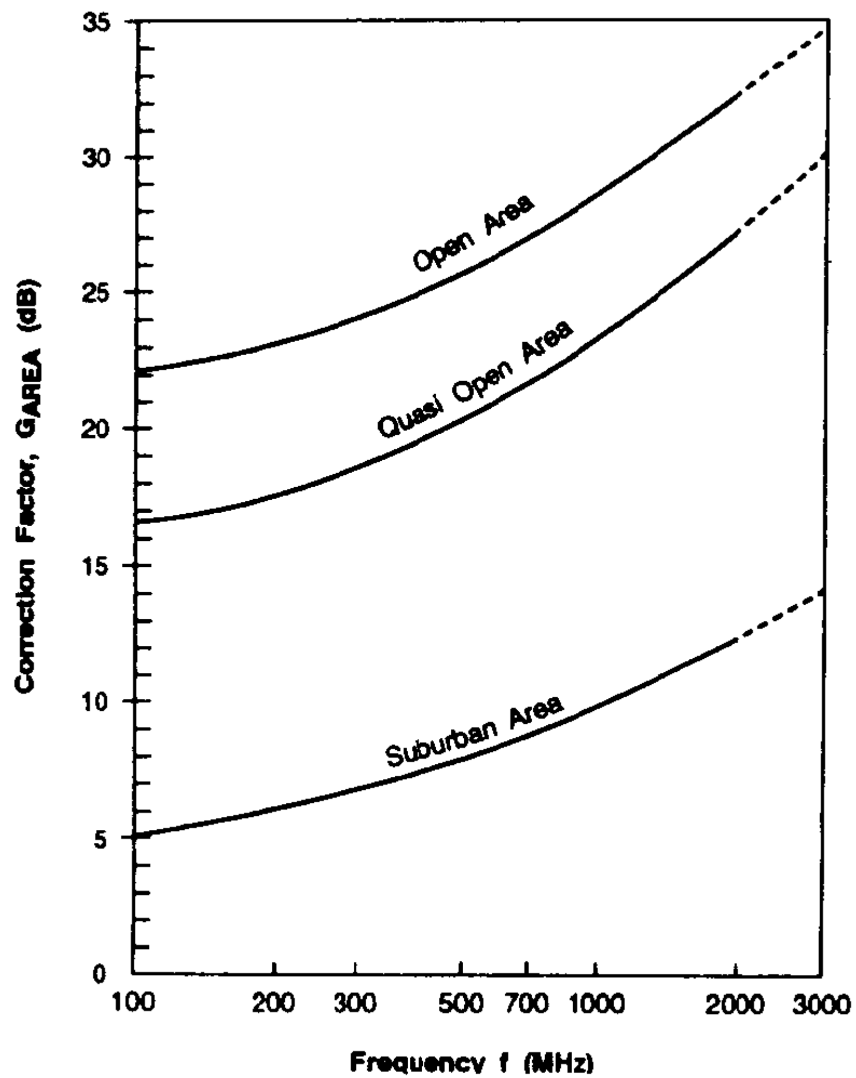
Figure 2.7
The Erlang C chart showing the probability of a call being delayed as a function of the number of channels and traffic intensity in Erlangs.

Table D.2 Tabulation of the Error Function *erf(z)*

z	$erf(z)$	z	$erf(z)$
0.1	0.11246	1.6	0.97635
0.2	0.22270	1.7	0.98379
0.3	0.32863	1.8	0.98909
0.4	0.42839	1.9	0.99279
0.5	0.52049	2.0	0.99532
0.6	0.60385	2.1	0.99702
0.7	0.67780	2.2	0.99814
0.8	0.74210	2.3	0.99885
0.9	0.79691	2.4	0.99931
1.0	0.84270	2.5	0.99959
1.1	0.88021	2.6	0.99976
1.2	0.91031	2.7	0.99987
1.3	0.93401	2.8	0.99993
1.4	0.95228	2.9	0.99996
1.5	0.96611	3.0	0.99998




Urban Area
h_t = 200 m
h_r = 3 m
d (km)
100
80
70
60
50
40
30
20
10
5
2
1
70
60
50
40
30
20
10
70 100 200 300 500 700 1000 2000 3000
Median Attenuation, A(f,d) (dB)
Frequency f (MHz)


Open Area
Quasi Open Area
Suburban Area
35
30
25
20
15
10
5
0
100 200 300 500 700 1000 2000 3000
Correction Factor, G_{AREA} (dB)
Frequency f (MHz)