Recommendation WG 2.89.023
(Superseded by Rec. WG2.99.052)

OHLOSS
PATH LOSS COMPUTATION FLOWCHART

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Source: Working Group 2

RECOMMENDATION

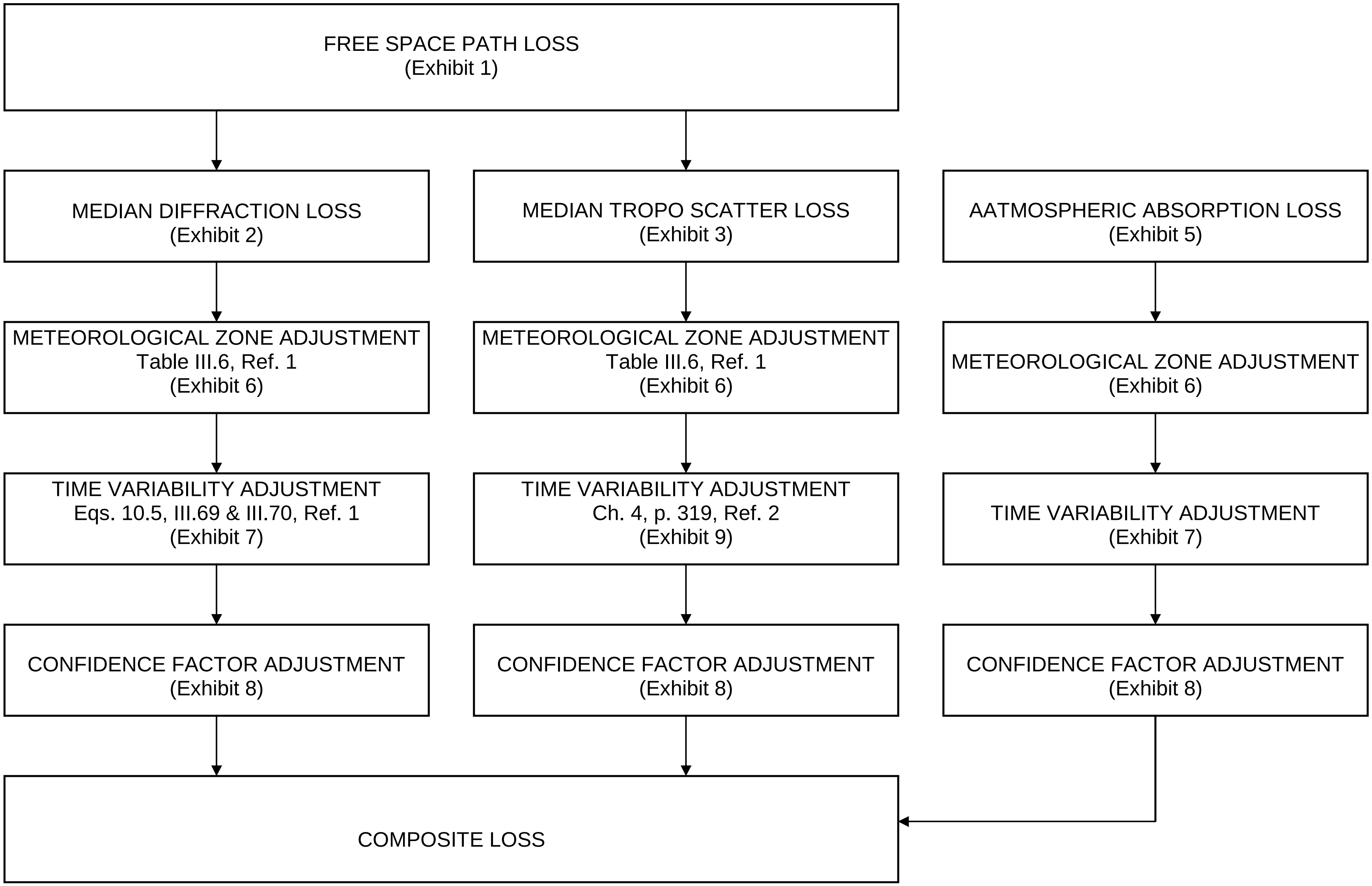
Subject Area: OHLOSS

Title: OHLOSS Path Loss Computation Flowchart

Recommendation:

The attached document should be utilized in the construction of new versions of OHLOSS programs or to bring existing programs into compliance. Use of this information will result in OHLOSS calculations that will yield answers that will have a high degree of agreement with other members of the Association.

Note: This recommendation is superseded by Rec. WG2.99.052, *OHLOSS Path Loss Computation*, 8/6/99.



REFERENCES

1. Tech Note 101, National Bureau of Standards
2. A Basic ---- of Radio Wave Propagation by S. Shilman, Wiley and Sons 1987

Exhibit 1
Free Space Path Loss

$$L_{bf} = 96.6 + 20 \log(f) + 20 \log(d) \text{ dB}$$

where: f is frequency in GHz
d is path distance in miles

Reference: Tech Note 101 Equation 2.16

Exhibit 2
Median Diffraction Loss

Case 1: If both transmitter and receiver see approximately the same point as the horizon use Single Knife Edge approach:

$$L_{bd} = A(v,o) + A(o, \rho) + U(v\rho) - G(\bar{h}_1) - G(\bar{h}_2) + L_{bf}$$

where:

$$v = 2.583 \cdot \theta \sqrt{f d_1 d_2 / d}$$

$$A(v,o) = 6.4 + 20 \log(\sqrt{v^2 + 1} + v)$$

$$A(o,\rho) = 6.02 + 5.556\rho + 3.418\rho^2 + 0.256\rho^3$$

$$\rho = 0.676 r^{1/3} f^{-1/6} \sqrt{d / (d_1 d_2)}$$

r is radius of curvature of rounded knife edge crest in KM.
May be estimated as $r = D_s / \theta$

for $v\rho \leq 3$:

$$U(v\rho) = 11.45 v\rho + 2.19(v\rho)^2 - 0.206(v\rho)^3 - 6.02$$

for $3 < v \leq 5$:

$$U(v\rho) = 13.47\, v\rho + 1.058(v\rho)^2 - 0.048(v\rho)^3 - 6.02$$

for $v > 5$:

$$U(v\rho) = 20\, v\rho - 18.2$$

$$\bar{h}_1 \approx = 7.23\, f^{2/3}\, d_{Lt}^{-2/3}\, h_{te}^{4/3} \text{ (MHz, KM)}$$

$$\bar{h}_2 \approx = 7.23\, f^{2/3}\, d_{Lr}^{-2/3}\, h_{re}^{4/3} \text{ (MHz, KM)}$$

$$G(\bar{h}_{1,2}) \approx = 13.8 \log(\bar{h}) - 37.5 (\bar{h})^2 - 0.84 \text{ dB, } (K = .015)$$

Case 2: Transmitter and receiver do not share a common horizon, however the two horizon points are line-of-sight with each other. Path is then Double Knife Edge.

Treat as two single knife edge paths: transmitter-horizon-horizon, and horizon-horizon-receiver.

All computations are as shown for SKE, except that height gain is not computed from horizon to horizon. Only the end point height gains are computed.

Free space path loss is added into L_{bd} only once.

Exhibit 2 (cont.)

Case 3: If path satisfies neither SKE nor DKE criteria then use Irregular Terrain approach covered in Tech Note 101 chapter 8.2:

$$L_{bd} = L_{bf} + G(x_0) - F(x_1) - F(x_2) - 20.03$$

where: $G(x_0) = 0.05751 * x - 10 \log(x)$

$$F(x_{1,\,2}) = 10 \log(7.95 * 10^{-6} + 2 * 10^{-12} * x^4) + 0.022 * x$$

$$b = 90°$$

$$K = 0.015, \text{ for } f \geq 2 \text{ GHz}$$

Reference: Tech Note 101 Chapters 7, 8 and III.2
CCIR Report 715-1 (Mod F)

Exhibit 3
Median Tropospheric Scatter Loss

$L_{sr} = 36 + 20 \log(f) - 20 \log(d) + F(\theta d) + L_c$

where: f is frequency in MHz
d is path distance in KM

for $.01 < \theta d < 10$:

$$F(\theta d) = 135.82 + .33\ \theta d + 30 \log(\theta d)$$

for $10 < \theta d < 70$:

$$F(\theta d) = 129.5 + .212\ \theta d + 37.5 \log(\theta d)$$

for $\theta d > 70$:

$$F(\theta d) = 119.2 + .157\ \theta d + 45 \log(\theta d)$$

$$F(\theta d, N_s) = F(\theta d) - [0.1 (N_s - 301) * \exp(-\theta d/40)]$$

$$L_c = 0.07 * \exp[0.055 (G_t + G_r)]$$
= 6 dB, if 40 dB antennas are assumed

Scattering Efficiency factor F_0 is assumed to be of negligible importance.

Frequency Gain function H_0 is assumed to be of negligible importance.

References: Tech Note 101 Equation 9.1, III.46 - 48
CCIR Report 569.2 Mod F, 1985, Section 4
CCIR Report 238-4 Mod I

Exhibit 4
Combined Median Loss

$L_{cr} = L_{bd} - R(0.5)$

Reference Tech Note 101 equation 9.14 and figure 9.9

An alternate method is power summation:

$L_{cr} = -10 \log[10**(-L_{bd}/10) + **(-L_{sr}/10)]$

Exhibit 5
Atmospheric Absorption Loss

$$Y_{o+w} = \left[7.19 * 10^{-3} + \frac{6.09}{f^{2} + .227} + \frac{4.81}{(f-57)^{2} + 1.50}\right] * f^{2} * 10^{-3}$$

$$+ \left[0.067 + \frac{3}{(f-22.3)^{2} + 7.3}\right] * f^{2} * \rho * 10^{-4} \text{ dB/KM}$$

where: $\rho < 12$ g/m^3 (7.5 is typical)
f (frequency in GHz) < 30

Reference: Tech Note 101, Chapter 3
CCIR Report 719-1 Mod F, 1985

Exhibit 6
Climatic Adjustment

$L_n(0.5) = L_{cr} - V_n(0.5, d_e)$ KM

where: v(0.5) is given in equation form in Tech Note 101 equation III.69 and III.70. Parameters are supplied for various climates in Table III.5

for $d \leq d_L + d_{s1}$:

$$d_e = 130 * d / (d_L + d_{s1}) \text{ KM}$$

for $d > d_L + d_{s1}$:

$$d_e = 130 + d - (d_L + d_{s1}) \text{ KM}$$

where: $d_{s1} = 301.7 * f^{-1/3}$

$d_L = 4.24 (\sqrt{h_{te}} + \sqrt{h_{re}})$ KM

h_{te} and h_{re} are in meters
f is in MHz

Reference: Tech Note 101 Equation 10.4 and Section III.7

Exhibit 7
Time Variability Factors

$L_n(q) = L_n(0.5) - Y_n(q,d_e)$

where: n denotes a particular climate region
q denotes % of time predicted loss will not be met
d_e, effective distance derived in exhibit 6

$Y_n(0.1, d_e)$ is given in equation form in Tech Note 101 Equation III.69 and III.70. Parameters for various climatic regions are supplied in Table III.6

Variability for other percentages of time are derived as follows:

$Y_n(.2)$	=	.6567	* $y_n(.1)$
$Y_n(.0001)$	=	3.33	* $y_n(.1)$
$Y_n(.00005)$	=	3.45	* $y_n(.1)$
$Y_n(.000025)$	=	3.61	* $y_n(.1)$

Reference: Tech Note 101 Equation 10.5 and Section III.7
CCIR Report 569-2 (Mod F)
CCIR Report 238-4 (Mod I)

Exhibit 8
95% Confidence Adjustment

Predicted loss for a given time percentage, q, using 95% confidence is given as follows:

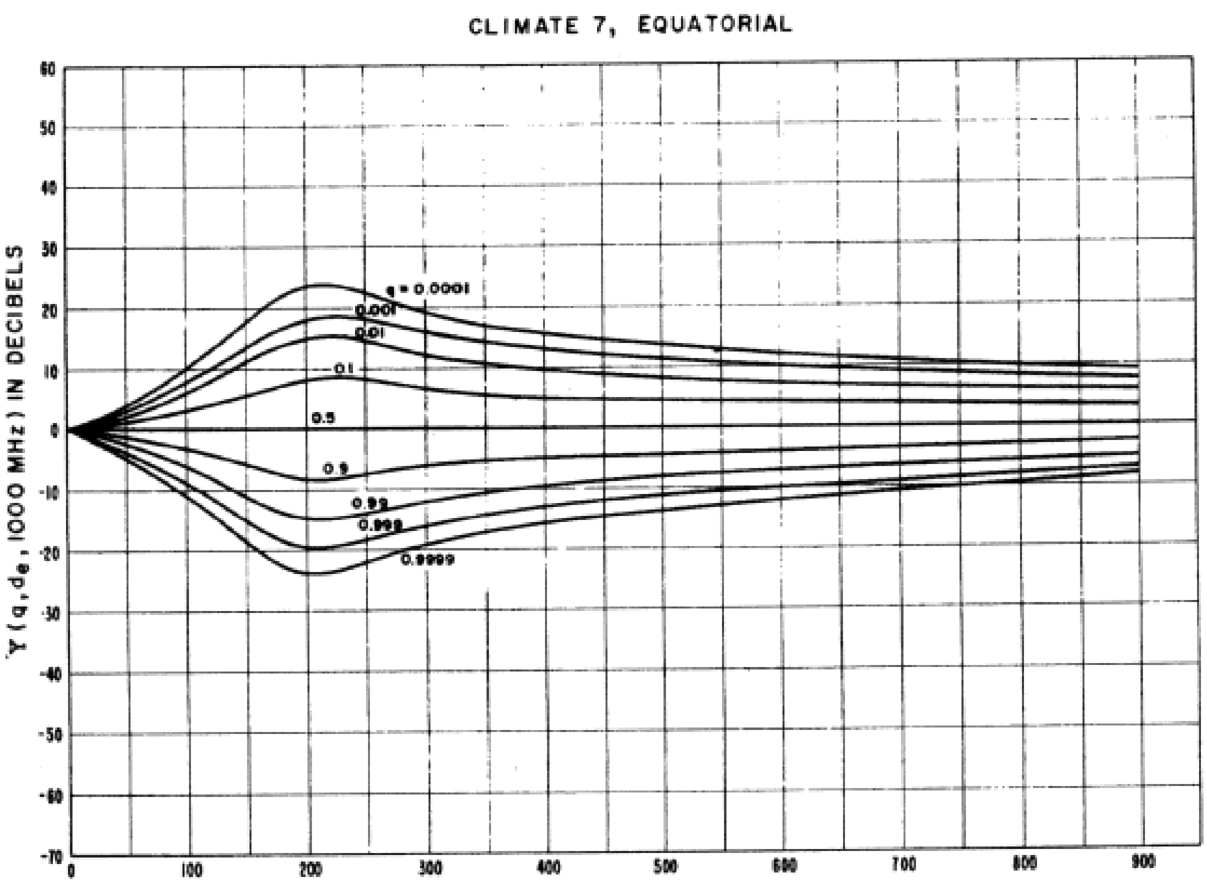
$$L_n(q) - 1.64\sqrt{12.73 + 0.12 * Y^2}(q)$$

Reference: Tech Note 101 Equation V.40

Exhibit 9
Time Variability Factors

$L_n(q) = L_n(0.5) - y_n(q, d_e)$

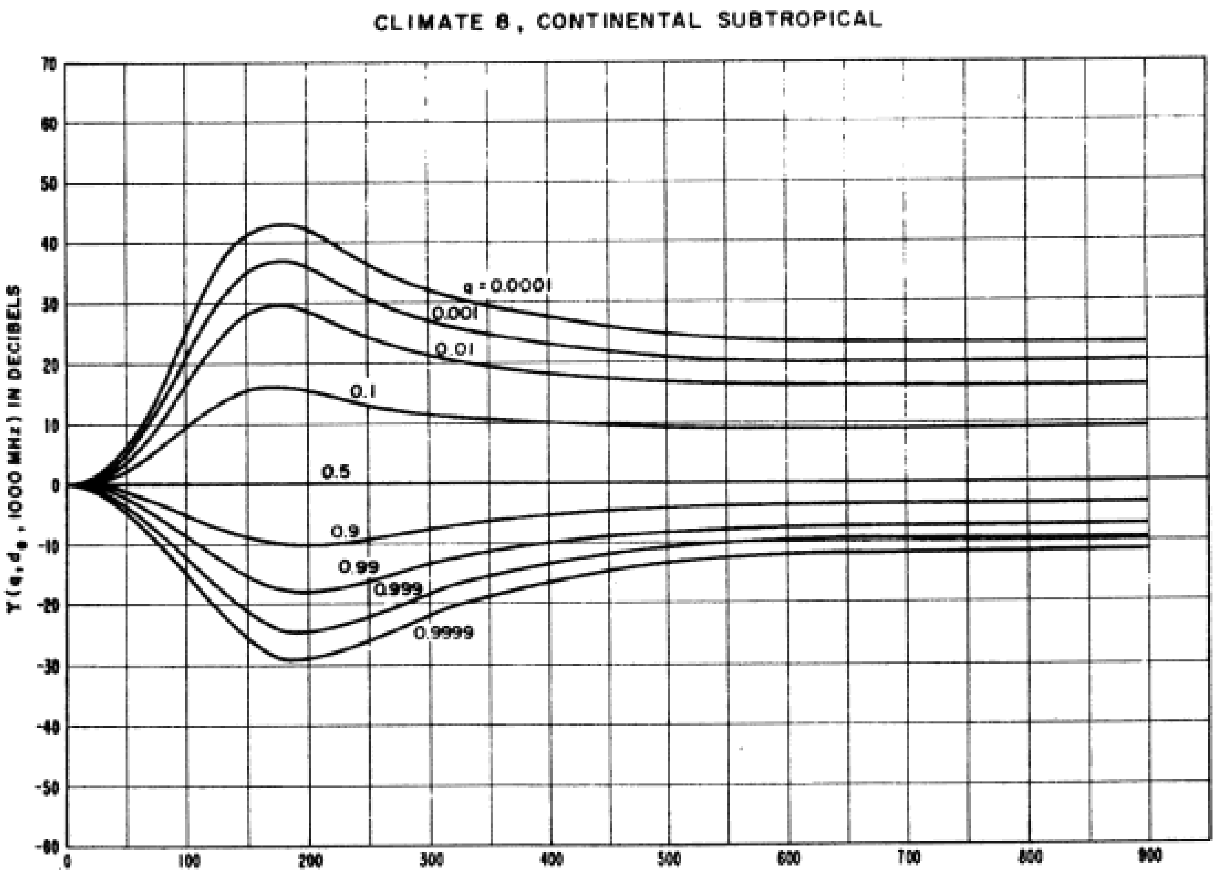
where: n denotes a particular climate region
q denotes % of time predicted loss will no be
d_e denotes effective distance derived in Exhibit 6



EFFECTIVE DISTANCE, d_e, IN KILOMETERS

Figure III.28

Exhibit 9 (cont.)



EFFECTIVE DISTANCE, d_e, IN KILOMETERS

Figure III.29

Original Recommendation Approved :	04-25-89
To Membership:	05-05-89
Source:	Working Group 2

Note: This recommendation is superseded by Rec. WG2.99.052, 8/6/99.