The Hong Kong Polytechnic University

EIE 531

Mobile Radio Communications

Report

Analysis of Okumura and Euro-COST Pathloss Models

Part 1

For each of your designated path loss models for the suburban type of area with medium size: Use MATLAB to plot (as a 3D shaded surface) the "Path Loss(dB), versus Distance(km) and versus Mobile Antenna Height(meters)".

Okumura Model:

Mobile's antenna height, h_{re}	5, 6, 7, 8, 9, 10 meters
Base station's antenna height, h_{te}	50 + 50*k_1 meters
Frequency, f_c	500 MHz
Distance, d	From 1 to 10*(1+k_0)km, with an increment of 5 km

Euro-COST Model:

Mobile's antenna height, h_{re}	5, 6, 7, 8, 9, 10 meters
Base station's antenna height, h_{te}	50 + 10*k_1 meters
Frequency, f_c	1800 MHz
Distance, d	From 1 to 10+k_0 km, with an increment of 1 km

Q1: From your graph, what do you observe about the relationship between distance and received power? Explain why/how this is reasonable (i.e. intuitively expected).

Q2: From your graph, what do you observe about the relationship between mobile antenna height and received power? Explain why/how this is reasonable (i.e. intuitively expected).

The simulation results plotted by MATLAB are shown as below:

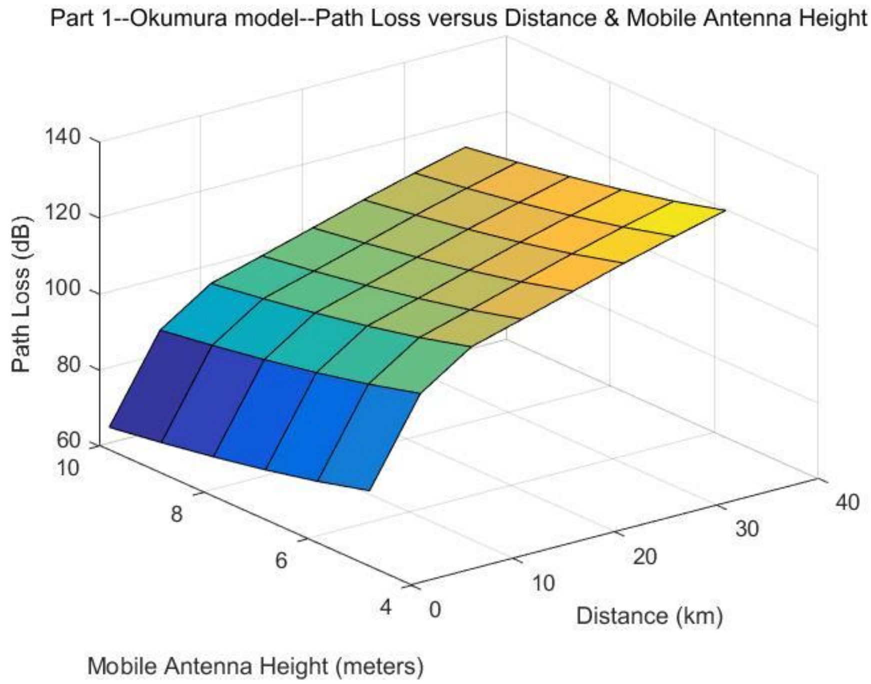

Fig.1 Okumura model in part 1

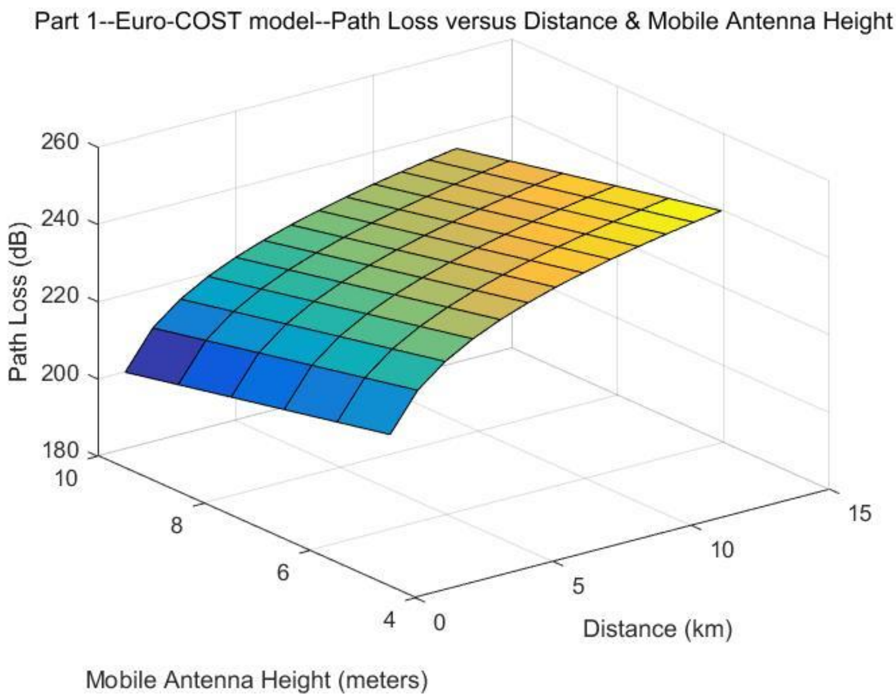

Fig.2 Euro-COST model in part 1

Q1: From your graph, what do you observe about the relationship between distance and received power? Explain why/how this is reasonable (i.e. intuitively expected).

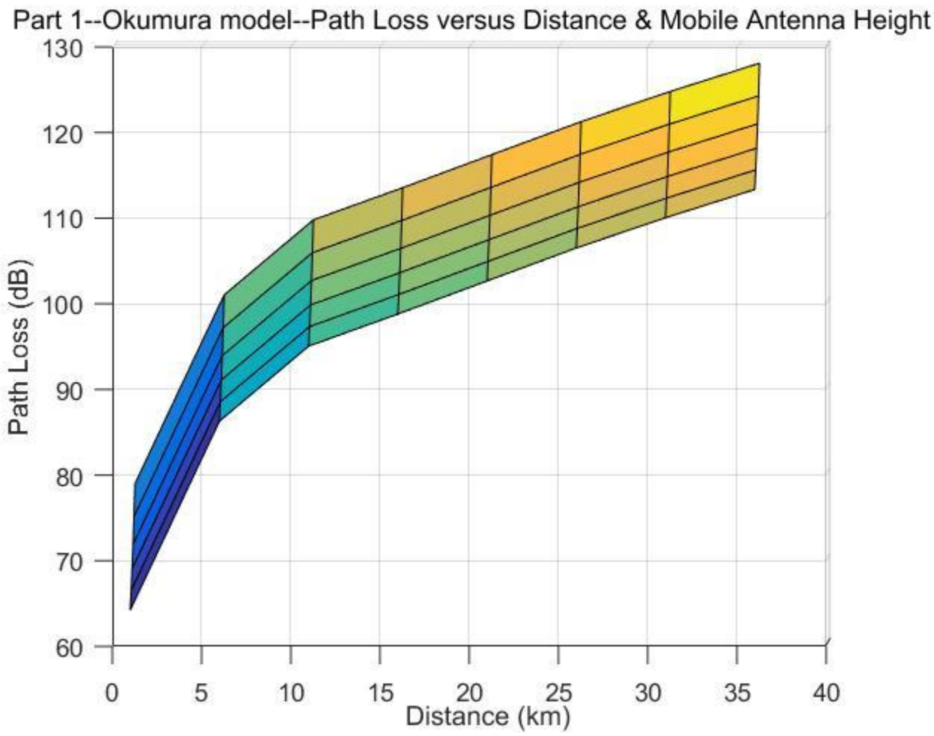

Fig.3 The relationship between distance and pathloss taken from Fig.1

From the Fig.3, we can see that the pathloss increases with distance in general. In particular, the pathloss increases sharply for the first 5 km and then the growth rate becomes flat.

$L_{50}(dB) = L_F + A_{mu}(f,d) - G(h_{te}) - G(h_{re}) - G_{AREA}$ equation [1]

$L_F(dB) = 10\log\frac{Pt}{Pr} = -10\log\left[\frac{\lambda^2}{(4\pi^2)d^2}\right]$ equation [2]

$G(h_{re}) = 20\log\left(\frac{h_{re}}{3}\right)$ $(10\ m > h_{re} > 3\ m)$ equation [3]

$G(h_{te}) = 20\log\left(\frac{h_{te}}{200}\right)$ $(1000\ m > h_{te} > 30\ m)$ equation [4]

In reality, the signal fades as the distance increases. The following analysis is based on the formula:

In the equation [1], 'd' appears only in L_F and $A_{mu}(f,d)$, where L_F increases with distance in the equation [2]. For $A_{mu}(f,d)$, according to Oku[68], it increases with distance too. Hence, $L_{50}(dB)$ increases with distance. In other words, the received power decreases with distance.

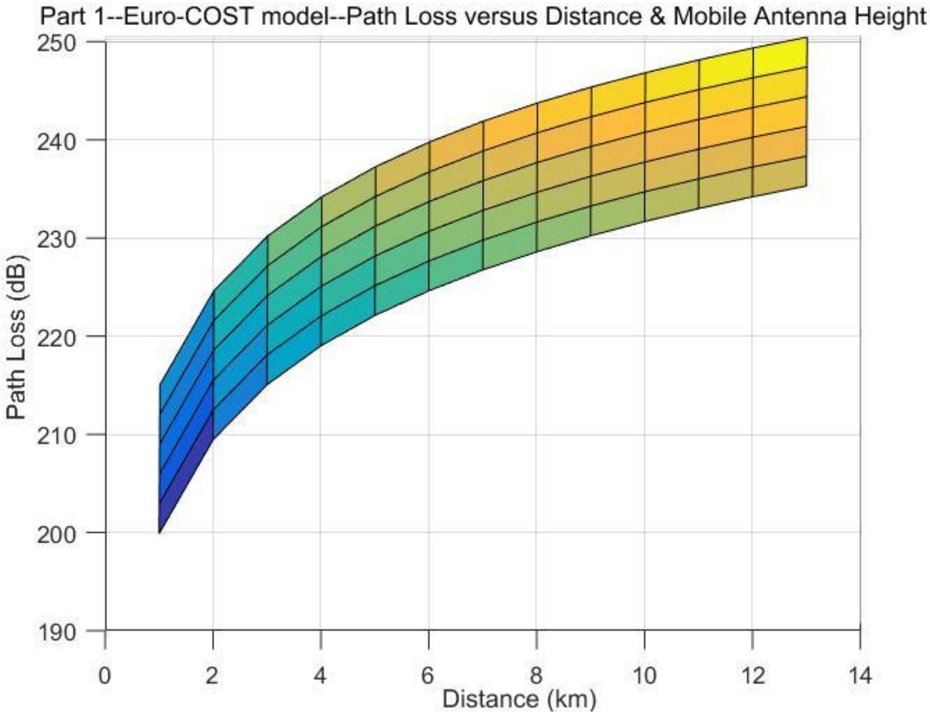

Fig.4 The relationship between distance and pathloss taken from Fig.2

From the Fig.4, we can see that the pathloss increases with distance in general. In particular, the pathloss increases sharply for the first 3 km and then the growth rate becomes flat.

$$L_{50}(dB) = 46.3 + 33.9\log f_c - 13.82\log h_{te} - a(h_{re}) + (44.9 - 6.55\log h_{te})\log d + C_M \qquad \text{equation [5]}$$

$$a(h_{re}) = (1.1\log f_c - 0.7)h_{re} - (1.56\log f_c - 0.8) \quad dB \qquad \text{equation [6]}$$

In reality, the signal fades as the distance increases. The following analysis is based on the formula:

In the equation [5], 'd' appears only in $(44.9\text{-}6.55\log h_{te})\log d$. When $h_{te} = 50+10*k1 = 100$ m, $(44.9\text{-}6.55\log h_{te}) > 0$, so $(44.9\text{-}6.55\log h_{te})\log d$ increases with distance. Hence, $L_{50}(dB)$ increases with distance. In other words, the received power decreases with distance.

Q2: From your graph, what do you observe about the relationship between mobile antenna height and received power? Explain why/how this is reasonable (i.e. intuitively expected).

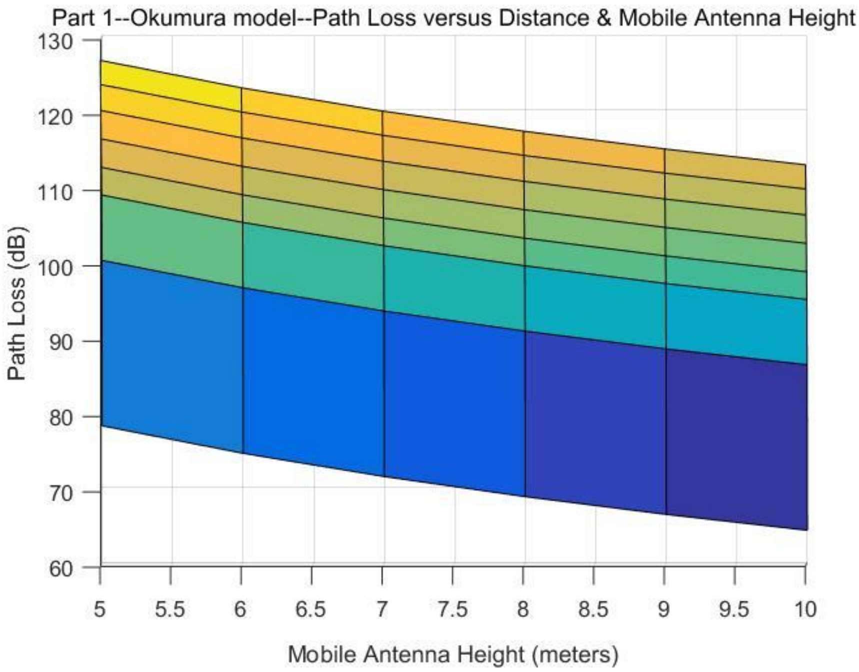

Fig.5 The relationship between mobile antenna height and pathloss taken from Fig.1

From the Fig.5, we can see that the pathloss decreases gradually with mobile antenna height.

$$L_{50}(dB) = L_F + A_{mu}(f,d) - G(h_{te}) - G(h_{re}) - G_{AREA} \qquad \text{equation [1]}$$

$$L_F(dB) = 10\log\frac{Pt}{Pr} = -10\log\left[\frac{\lambda^2}{(4\pi^2)d^2}\right] \qquad \text{equation [2]}$$

$$G(h_{re}) = 20\log\left(\frac{h_{re}}{3}\right) \qquad (10\text{ m} > h_{re} > 3\text{ m}) \qquad \text{equation [3]}$$

$$G(h_{te}) = 20\log\left(\frac{h_{te}}{200}\right) \qquad (1000\text{ m} > h_{te} > 30\text{ m}) \qquad \text{equation [4]}$$

In reality, the higher the antenna, the more power it emits. The following analysis is based on the formula:

In the equation [1], 'h_{re}' appears only in $G(h_{re})$, where $G(h_{re})$ increases with h_{re} in the equation [3]. Hence, $L_{50}(dB)$ decreases with mobile antenna height. In other words, the received power increases with mobile antenna height.

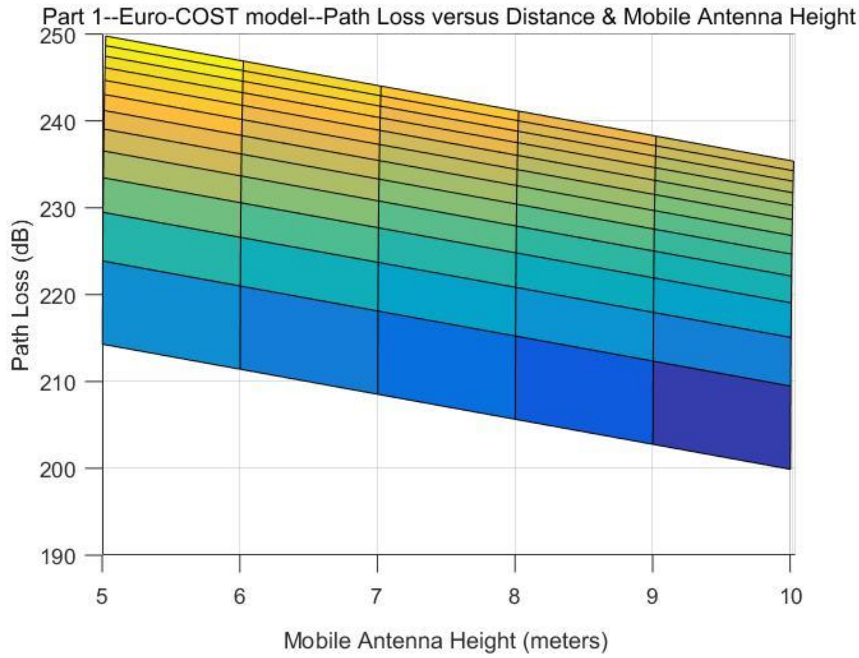

Fig.6 The relationship between mobile antenna height and pathloss from Fig.2

From the Fig.6, we can see that the pathloss decreases gradually with mobile antenna height.

$L_{50}(dB) = 46.3 + 33.9logf_c - 13.82logh_{te} - a(h_{re}) + (44.9\text{-}6.55logh_{te})\ logd + C_M$ equation [5]

$a(h_{re}) = (1.1logf_c - 0.7)h_{re} - (1.56logf_c - 0.8)$ dB equation [6]

In reality, the higher the antenna, the more power it emits. The following analysis is based on the formula:

In the equation [5], 'h_{re}' appears only in $a(h_{re})$. When f_c= 1800 MHz, $(1.1logf_c - 0.7) > 0$, so $(1.1logf_c - 0.7)h_{re}$ increases with h_{re} in the equation [6], then $a(h_{re})$ increases with h_{re}. Hence, $L_{50}(dB)$ decreases with mobile antenna height. In other words, the received power increases with mobile antenna height.

Part 2

For each of your designated path loss models for the suburban type of area with medium size: Use MATLAB to plot the "Path Loss(dB) versus Mobile Antenna Height(meters)". Your figure should have six curves. Each curve should be for a different frequency, f_c.

Okumura Model:

Mobile's antenna height, h_{re}	5, 6, 7, 8, 9, 10 meters
Base station's antenna height, h_{te}	k_1+ 10h_{re} meters
Frequency, f_c	100, 200, 300, 500, 700, 1000 MHz
Distance, d	k_0+ 10 km

Euro-COST Model:

Mobile's antenna height, h_{re}	5, 6, 7, 8, 9, 10 meters
Base station's antenna height, h_{te}	50 + 10*h_{he} meters
Frequency, f_c	1500, 1650, 1800, 1850, 1900, 2000 MHz
Distance, d	k_0+10 km

Q3: From your graph, how is the path loss affected by the mobile antenna height? Explain why/how this is reasonable (i.e. intuitively expected).

Q4: From your graph, how is the path loss affected by frequency? Explain why/how this is reasonable (i.e. intuitively expected).

The simulation results plotted by MATLAB are shown as below:

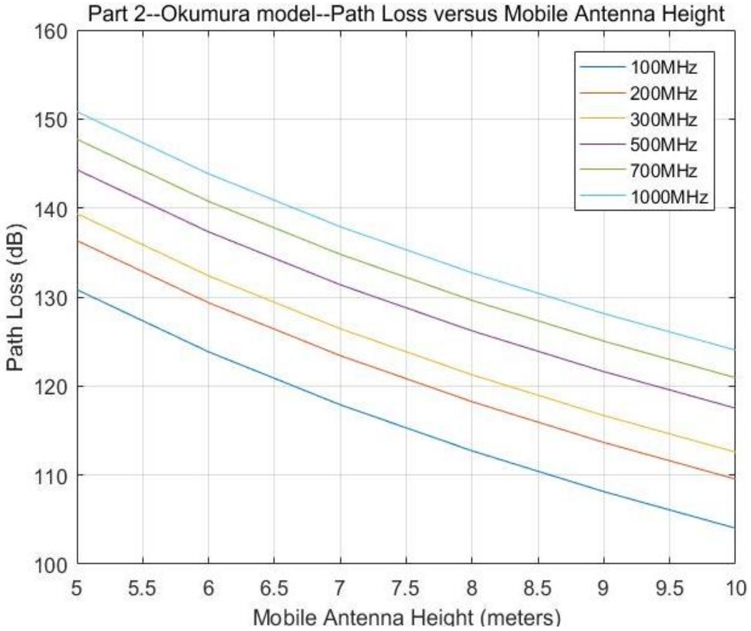

Fig.7 Okumura model in part 2

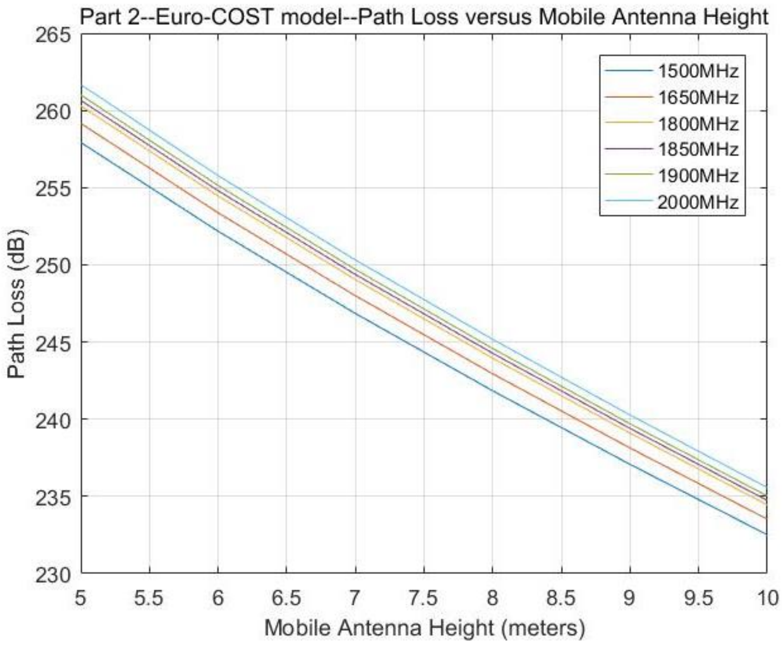

Fig.8 Euro-COST model in part 2

Q3: From your graph, how is the path loss affected by the mobile antenna height? Explain why/how this is reasonable (i.e. intuitively expected).

From the Fig.7(Okumura model), we can see that the pathloss decreases gradually with mobile antenna height.

$$L_{50}(dB) = L_F + A_{mu}(f, d) - G(h_{te}) - G(h_{re}) - G_{AREA} \qquad \text{equation [1]}$$

$$L_F(dB) = 10\log\frac{Pt}{Pr} = -10\log\left[\frac{\lambda^2}{(4\pi^2)d^2}\right] \qquad \text{equation [2]}$$

$$G(h_{re}) = 20\log\left(\frac{h_{re}}{3}\right) \qquad (10\text{ m} > h_{re} > 3\text{ m}) \qquad \text{equation [3]}$$

$$G(h_{te}) = 20\log\left(\frac{h_{te}}{200}\right) \qquad (1000\text{ m} > h_{te} > 30\text{ m}) \qquad \text{equation [4]}$$

In reality, the higher the antenna, the more power it emits. The following analysis is based on the formula:

In the equation [1], 'h_{re}' appears only in $G(h_{re})$, where $G(h_{re})$ increases with h_{re} in the equation [3]. Hence, pathloss decreases with mobile antenna height.

From the Fig.8(Euro-COST model), we can see that the pathloss decreases gradually with mobile antenna height.

$$L_{50}(dB) = 46.3 + 33.9\log f_c - 13.82\log h_{te} - a(h_{re}) + (44.9 - 6.55\log h_{te})\log d + C_M \qquad \text{equation [5]}$$

$$a(h_{re}) = (1.1\log f_c - 0.7)h_{re} - (1.56\log f_c - 0.8) \quad dB \qquad \text{equation [6]}$$

In reality, the higher the antenna, the more power it emits. The following analysis is based on the formula:

In the equation [5], 'h_{re}' appears only in $a(h_{re})$. When $1500MHz \le f_c \le 2000MHz$, $(1.1\log f_c - 0.7) > 0$, so $(1.1\log f_c - 0.7)h_{re}$ increases with h_{re} in the equation [6], then $a(h_{re})$ increases with h_{re}. Hence, pathloss decreases with mobile antenna height.

Q4: From your graph, how is the path loss affected by frequency? Explain why/how this is reasonable (i.e. intuitively expected).

From the Fig.7(Okumura model), we can see that the pathloss increases with frequency.

$L_{50}(dB) = L_F + A_{mu}(f,d) - G(h_{te}) - G(h_{re}) - G_{AREA}$ equation [1]

$L_F(dB) = 10\log\frac{Pt}{Pr} = -10\log\left[\frac{\lambda^2}{(4\pi^2)d^2}\right]$ equation [2]

$G(h_{re}) = 20\log\left(\frac{h_{re}}{3}\right) \quad (10\ m > h_{re} > 3\ m)$ equation [3]

$G(h_{te}) = 20\log\left(\frac{h_{te}}{200}\right) \quad (1000\ m > h_{te} > 30\ m)$ equation [4]

In reality, the higher the frequency, the more power it emits. The following analysis is based on the formula:

In the equation [1], 'f_c' appears only in L_F and $A_{mu}(f,d)$. And λ decreases with frequency according to the equation $C=\lambda f_c$. Then L_F increases with frequency in the equation [2]. For $A_{mu}(f,d)$, according to Oku[68], it increases with frequency too. Hence, pathloss increases with frequency.

From the Fig.8(Euro-COST model), we can see that the pathloss increases with frequency.

$L_{50}(dB) = 46.3 + 33.9\log f_c - 13.82\log h_{te} - a(h_{re}) + (44.9 - 6.55\log h_{te})\log d + C_M$ equation [5]

$a(h_{re}) = (1.1\log f_c - 0.7)h_{re} - (1.56\log f_c - 0.8)$ dB equation [6]

In reality, the higher the frequency, the more power it emits. The following analysis is based on the formula:

In the equation [5], 'f_c' appears only in $33.9\log f_c$ and $a(h_{re})$. For $a(h_{re})$ in the equation [6] and $33.9\log f_c$, when $5m \le h_{re} \le 10m$, $(33.9 - 1.1 * h_{re} + 1.56) > 0$, so $[33.9\log f_c - a(h_{re})]$ increases with frequency, Hence, pathloss increases with frequency.