Okumura – Hata

- <u>Okumara's model</u> is an empirical model for signal prediction in urban areas. [4]

Applicable for:

- *frequencies* -> 150 MHZ - 1920 MHZ (extended up to 3000MHZ)
- *base station antenna height* -> 30m – 100m
- *mobile station antenna height* -> 1m – 3m
- *distances* -> 1km - 100 km

Okumura Path Loss

$$PL_{ok}(50)(dB) = L_{FSPL} + A_{mu} - Gh_{tr} - Gh_{tt} - G_{area}$$

La: propagation loss of free space
A_{mu} is the median attenuation relative to free space
$G(h_{tr})$: base station antenna height gain factor in dB
$G(h_{tt})$: mobile antenna height gain factor in dB
G_{area}: gain due to the type of environment

$$where\ G(h_{tt}) = 10\log_{10}\frac{h_{tt}}{200}, \qquad for\ h_{tt} < 3m$$

$$G(h_{tt}) = 20\log_{10}\frac{h_{tt}}{200}, \qquad for\ 3m < h_{tt} < 10m$$

$$G(h_{tr}) = 20\log_{10}\frac{h_{tr}}{3}$$

- <u>The Hata model</u> is the empirical mathematical relationship to describe the graphical path loss data provided by Okumura's model. [2]
  Applicable for:
  - *carrier frequency(fc): 150 MHZ - 1500 Megahertz*
  - *effective base station antenna height(h_{tr}): 30m - 200m*
  - *effective mobile antenna height(h_{tt}): 1m - 10m*

Hata Path Loss

- For **urban** area:

$$PL_{HA}(\mathrm{dB}) = 69.55 + 26.16\log_{10}(f) - 13.82\log_{10} h_{tr} - \mathrm{a}(h_{tt}) + (44.9 - 6.55\log_{10} h_{tr}) * \log_{10} d$$

a(h_{tt}): correction factor for effective mobile antenna height in km

- *For small or medium-sized city*

$$a_{htt} = 0.8 + (1.1\log_{10} f - 0.7)h_{tt} - 1.56\log_{10} f$$

- *For large cities*

$$a_{htt} = 8.29(\log_{10}(1.54h_{tt}))^2 - 1.1, \qquad if\ 150 \le f \le 200$$
$$a_{htt} = 3.2(\log_{10}(11.75h_{tt}))^2 - 4.97, \qquad if\ 200 < f \le 1500$$

- For **suburban** area:

$$PL_{HA}(\mathrm{db}) = 69.55 + 26.16\log_{10}(f) - 13.82\log_{10} h_{tr} - \mathrm{a}(h_{tt}) + (44.9 - 6.55\log_{10} h_{tr}) * \log_{10} d - 5.4 + 2[\log_{10}(\frac{f}{28})]^2$$

where $a_{htt} = 0.8 + (1.1\log_{10} f - 0.7)h_{tt} - 1.56\log_{10} f$ (same as for the small city)

- For **open** area:

$$PL_{HA}(\mathrm{db}) = 69.55 + 26.16\log_{10}(f) - 13.82\log_{10}(h_{tr}) - \mathrm{a}(h_{tt}) + (44.9 - 6.55\log_{10}(h_{tr})) * \log_{10}(d) - 40.99 - 4.78\,[\log_{10}(f)]^2 + 18.33\log_{10}(f)$$

where $a_{htt} = 0.8 + (1.1\log_{10} f - 0.7)h_{tt} - 1.56\log_{10} f$ (same as for the small city)

f: carrier frequency in Megahertz
h_{tr}: base station antenna height in m
d: transmitter-receiver distance in km

This model gives the better result in urban and suburban area but in the rural areas its efficiency decreases. This model is not suitable for personal communication systems.