1 | Two Ray Plane Earth

In contrast to the Friss pathloss model, the approximated two-ray-ground-reflection path loss model (ATRPL) [Tom Henderson, 2011], considers both the direct wave and the reflected ground wave. Also the ATRPL does not depend on the frequency, as the Friss path loss model does. The received power depending on the distance is given in (1.1).

$$P_r(d) = \frac{P_t G_t G_r}{L} \left(\frac{h_t h_r}{d^2} \right)^2 \tag{1.1}$$

Where h_t and h_r are the heights of the transmitter and receiver antennas respectively. And L is the system loss. A illustration of a scenario of when to use the ATRPL, can be seen on the following Figure.

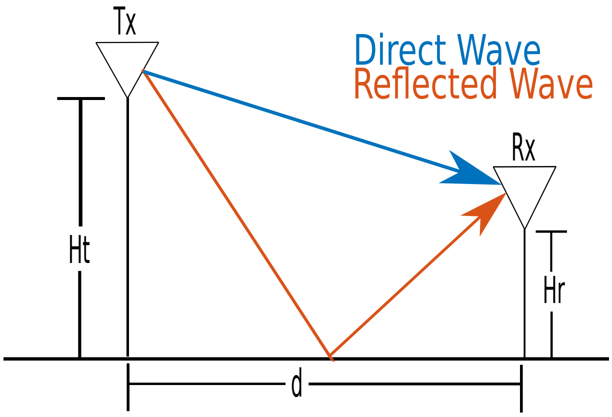

Figure 1.1: Illustration of a scenario of when to use the ATRPL model

The ATRPL is used if the distance d is greater then a critical point d_c given in (1.2) if the condition is false then Friss path loss model can be used.

$$d > d_c \tag{1.2}$$

with d_c given as:

$$d_c = \frac{4\pi \cdot h_t h_r}{\lambda} \tag{1.3}$$

If the condition is false then interference occur which looks like ripples this is caused by the constructive and destructive combination of the two rays. The ATRPL does not account for this.

1.0.1 Critical point calculation

For the measurements done, the condition given in (1.2) is tested:

Calculation example for both transmitter and receiver antennas heights at 2 m, at 858MHz

By inserting the heights and wavelength into (1.3) the critical distance can be found to:

$$d_c = \frac{4\pi \cdot 2m \cdot 2m}{0.3494m} = 143.86m \tag{1.4}$$

So in this case all distances between 1m to 30m, from transmitter to receiver, does not fulfill the condition and thus Friss should be used.

1.0.2 Critical point test for 858Mhz

For $h_r = 0.01m$ set, and $h_t = 0.01m, 0.08m, 0.34m, 2m$, $d = 1m, 2m, 4m, 8m, 15m, 30m$

In the following a Table 1.1 is made to illustrate if the condition stated in 1.2, is met for all distances, 1m,2m,4m,8m,15m and 30m, between the transmitter and receiver for the frequency 858MHz with 0.01m set as transmitter height h_t while the receiver height positions are $h_r = 0.01m, 0.08m, 0.34m, 2m$.

h_t,h_r	Not met	Met
0.01m, 0.01m, d_c = 0.0036m		At all distances
0.01m, 0.08m, d_c = 0.028m		At all distances
0.01m, 0.34m, d_c = 0.12m		At all distances
0.01m, 2m, d_c = 0.72m		At all distances

Table 1.1: Critical distance for h_t = 0.01m

From the above Table 1.1 it can be concluded that the ATRPL can be used.

For $h_t = 0.08m$ set, and $h_r = 0.08m, 0.34m, 2m$, $d = 1m, 2m, 4m, 8m, 15m, 30m$

h_t,h_r	Not met	Met
0.08m, 0.08m,$d_c = 0.23$m		At all distances
0.08m, 0.34, $d_c = 0.97$m		At all distances
0.08m, 2m, $d_c = 5.76$m	1,2 and 4m	At 8,15 and 30m

Table 1.2: Critical distance for $h_t = 0.08$m

For h_t=0.08m and h_r=2m the condition $d < d_c$ for distances of 1m, 2m and 4m, is met. This means that the Friss, can be used. While the rest of the time ATPL shall be used.

For $h_t = 0.34m$ set, and $h_r = 0.34m, 2m$, $d = 1m, 2m, 4m, 8m, 15m, 30m$

h_t,h_r	Not met	Met
0.34m, 0.34m, $d_c = 4.16$m	1,2,4	At 8, 15,30m
0.34m, 2m, $d_c = 24.48$m	1,2,4,8,15	At 30

Table 1.3: Critical distance for $h_t = 0.34$m

For $h_t = 2m$ set, and $h_r = 2m$, $d = 1m, 2m, 4m, 8m, 15m, 30m$

h_t,h_r	Not met	Met
2m,2m. d_c = 144m	At all distances	

Table 1.4: Critical distance for h_t = 2m

1.0.3 Critical point test for 2.58Ghz

For $h_r = 0.01m$ set, and $h_t = 0.01m, 0.08m, 0.34m, 2m$, $d = 1m, 2m, 4m, 8m, 15m, 30m$

h_t,h_r	Met	Not met
0.01m,0.01m d_c = 0.010		At all distances
0.01m, 0.08m d_c = 0.0865		At all distances
0.01m,0.34m d_c = 0.36		At all distances
0.01m,2m d_c = 2.16	1m and 2m	At 4,8,15,30m

Table 1.5: Critical distance for h_t = 0.01m

For $h_t = 0.08m$ set, and $h_r = 0.08m, 0.34m, 2m$, $d = 1m, 2m, 4m, 8m, 15m, 30m$

h_t,h_r	Not met	Met
0.08m,0.08m d_c = 0.69		At all distances
0.08m, 0.34m d_c = 2.94	1, 2m	At, 4,8,15 and 15m
0.08m,2m d_c = 17.31	1,2,4,8 and 15m	At 30m

Table 1.6: Critical distance for h_t = 0.08m

For $h_t = 0.34m$ set, and $h_r = 0.34m, 2m$, $d = 1m, 2m, 4m, 8m, 15m, 30m$

<table>
<tr><td>h_t,h_r</td><td>Not met</td><td>Met</td></tr>
<tr><td>0.34m,0.34m
$d_c = 12.51$</td><td>At 1,2,4
and 8m</td><td>At 15, 30m</td></tr>
<tr><td>0.34m, 2m
$d_c = 73.6$</td><td>At all
distances</td><td></td></tr>
</table>

Table 1.7: Critical distance for $h_t = 0.34$m

For $h_t = 2m$ set, and $h_r = 2m$, $d = 1m, 2m, 4m, 8m, 15m, 30m$

h_t,h_r	Not met	Met
2m,2m $d_c = 432.9$	At all distances	

Table 1.8: Critical distance for $h_t = 2$m

Bibliography

Tom Henderson (2011). 18.2 Two-ray ground reflection model. http://www.isi.edu/nsnam/ns/doc/node218.html.