Information document for SEAMCAT-3 Wiki Help database

SEAMCAT implementation of Extended Hata and Extended Hata-SRD models

1 EXTENDED HATA MODELS (BUILT IN)

1.1 Input parameters

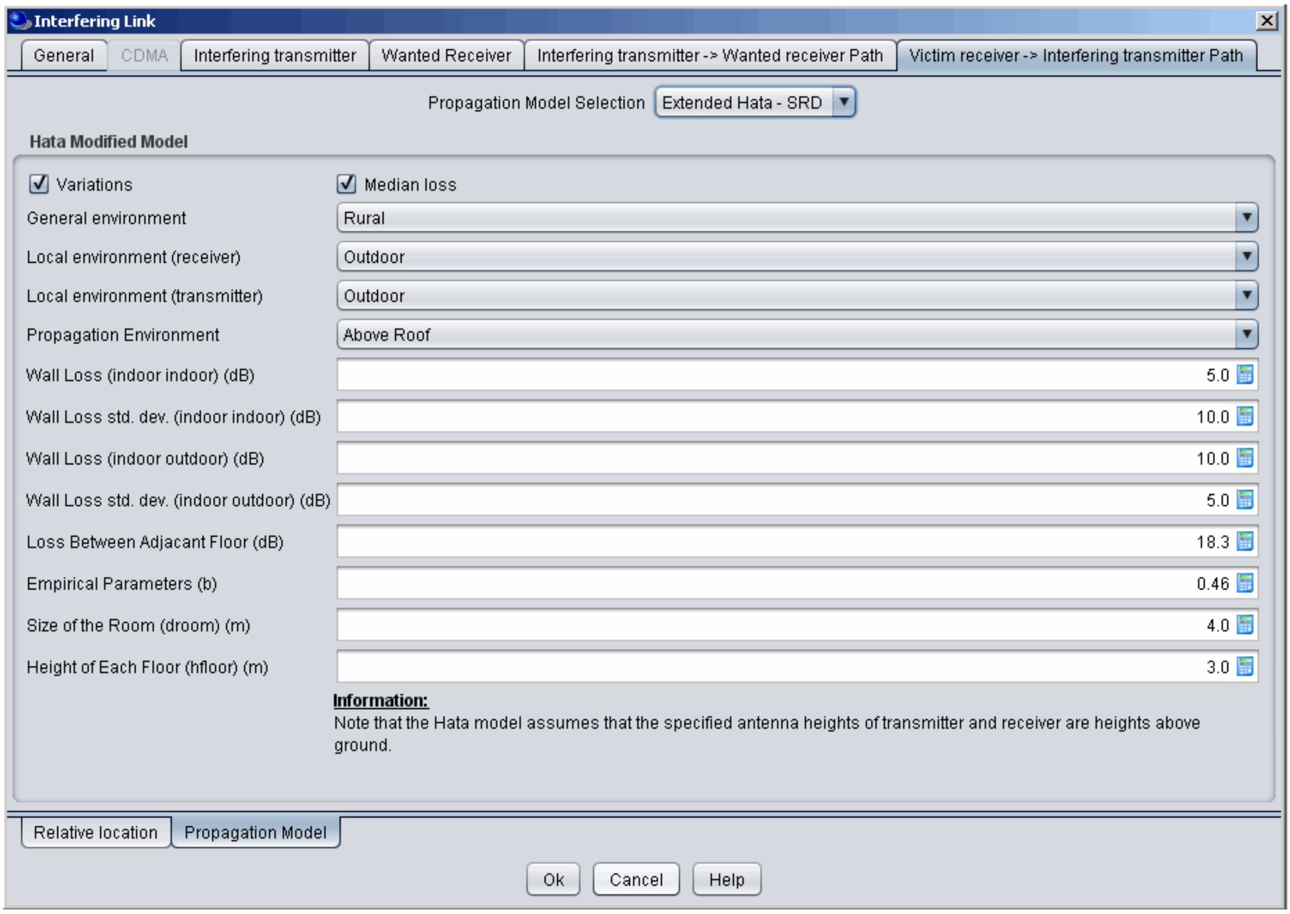

Figure 1: SEAMCAT Interface to the extended Hata (SRD) propagation model

Description	Symbol	Type	Unit	Comments
Variation				Variation in path loss takes into account the uncertainty of building design, furniture, room size, etc. This is a **standard deviation** which refers to the mean of the Median path loss.
Median path loss				Depending of the distance, the environment, the frequency and the height of the antenna. This is a **mean.**
General environment				Environment of the propagation: urban, rural, suburban

Local environment(Vr)				Environment of the receiver antenna: outdoor, indoor
Local environment(Wt)				Environment of the transmitter antenna: outdoor, indoor
Propagation environment				Environment of the propagation: Below roof, Above roof (used for standard deviation calculations) ONLY USED IF VARIATION OPTION IS CHECKED
Wall loss(indoor - indoor)		S	dB	
Wall loss std dev (indoor - indoor)		S	dB	
Wall loss(indoor - outdoor)		S	dB	
Wall loss std dev (indoor - outdoor)		S	dB	
Loss between adjacent floor		S	dB	
Empirical parameters:	b			
Size of the room (d_{room})	d_{room}	S	m	
Height of each floor	h_{floor}	S	m	

Table 1: Description of the Extended Hata and Extended Hata (SRD) models

1.2 Calculation algorithm

The Extended Hata model implemented in SEAMCAT calculates propagation loss between transmitter and receiver as:

$$f_{propage}(f, h_1, h_2, d, env) = L + T(G(\sigma))$$

where:

- *f* : frequency (MHz)
- *h1* : transmitter antenna height, m, above ground
- *h2* : receiver antenna height, m, above ground
- *d* : distance between transmitter and receiver, km
- env : general environment

Symbols:

L = median propagation loss (dB)

H_m = $\min(h_1, h_2)$

H_b = $\max(h_1, h_2)$

The validity ranges identified by COST 231 based on the original work of Okumura and Hata should be applied when using the Extended Hata model in SEAMCAT, i.e. H_m: 1 to 10m and H_b: 30 to 200m (Note that the H_b is assumed to be above roof top).

If H_m is below 1m, a value of 1m should be used instead. If H_b is above 200m, it might also lead to significant errors. This gives the possibility to use this model reciprocally (DL and UL) keeping in mind that $H_m = min(h1, h2)$ and $H_b = max (h1, h2)$ as described in Report ITU-R SM.2028-1.

1.3 Median path loss L

Dist. Range	Env.	Frequency Range	Median Loss
d < 0,04 km			$L=32.4+20\log(f)+10\log\left[d^2+\frac{(H_b-H_m)^2}{10^6}\right]$
$d > 0{,}1Km$	Urban	30 MHz <f ≤ 150 MHz	$L=69.6+26.2\log(150)-20\log(150/f)-13.82\log(\max\{30,H_b\})+[44.9-6.55\log(\max\{30,H_b\})](\log(d))^\alpha-a(H_m)-b(H_b)$
		150 MHz <f ≤ 1500 MHz	$L=69.6+26.2\log(f)-13.82\log(\max\{30,H_b\})+[44.9-6.55\log(\max\{30,H_b\})](\log(d))^\alpha-a(H_m)-b(H_b)$
		1500 MHz <f ≤ 2000 MHz	$L=46.3+33.9\log(f)-13.82\log(\max\{30,H_b\})+[44.9-6.55\log(\max\{30,H_b\})](\log(d))^\alpha-a(H_m)-b(H_b)$
		2000 MHz < f ≤ 3000 MHz	$L=46.3+33.9\log(f)+10\log(f/2000)-13.82\log(\max\{30,H_b\})+[44.9-6.55\log(\max\{30,H_b\})](\log(d))^\alpha-a(H_m)-b(H_b)$
	suburban		$L = L(\text{urban}) -2\cdot\left\{\log\left[\left(\min\left\{\max\left\{150;f\right\};2000\right\}\right)/28\right]\right\}^2 - 5.4$
	open area		$L = L(\text{urban}) - 4.78\cdot\left\{\log\left[\min\left\{\max\left\{150;f\right\};2000\right\}\right]\right\}^2 + 18.33\cdot\log\left[\min\left\{\max\left\{150;f\right\};2000\right\}\right] - 40.94$
$0{,}04km < d < 0{,}1km$			$L=L(0.04)+\frac{[\log(d)-\log(0.04)]}{[\log(0.1)-\log(0.04)]}\times[L(0.1)-L(0.04)]$

Table 2: Description of the median path loss L depending on the distance

Where:

$$a(H_m) = (1.1\log(f) - 0.7)\cdot\min\{10;\mathrm{H_m}\} - (1.56\log(\mathrm{f}) - 0.8) + \max\{0;20\log(\mathrm{H_m}/10)\}$$

$$b(H_b) = \min\{0;20\log(H_b/30)\}$$

$$\alpha = \begin{cases} 1 & \text{d} \le 20\text{ km} \\ 1+(0.14+1.87x10^{-4}xf+1.07x10^{-3}H_b)(\log\frac{d}{20})^{0.8} & 20\text{ km} < \text{d} < 100\text{ km} \end{cases}$$

When L is below the free space attenuation for the same distance, the free space attenuation should be used instead.

1.4 Variation in path loss

The variation in path loss is achieved by applying the log-normal distribution (slow-fading). The relative standard deviation is given by the following equations:

Dist. Range	Propagation mode	Standard Deviation
$d \le 0.04km$		$\sigma = 3.5$
$0.04km < d \le 0.1km$	above roof	$\sigma = 3.5 + \frac{(12-3.5)}{(0.1-0.04)} \times (d-0.04)$
	below roof	$\sigma = 3.5 + \frac{(17-3.5)}{(0.1-0.04)} \times (d-0.04)$
$0.1km < d \le 0.2km$	above roof	$\sigma = 12$
	below roof	$\sigma = 17$
$0.2km < d \le 0.6km$	above roof	$\sigma = 12 + \frac{(9-12)}{(0.6-0.2)}(d-0.2)$
	below roof	$\sigma = 17 + \frac{(9-17)}{(0.6-0.2)}(d-0.2)$
$0.6km < d$		$\sigma = 9$

Table 3: Variation in path loss

1.5 Indoor-outdoor propagation

Use of the modified Hata model for indoor-outdoor propagation introduces the following additional terms

Median loss

$$L_{indoor-outdor}^{hata} = L_{outoor-outdor}^{hata} + L_{we}$$

where : L_{we} is the attenuation due to external walls

Variation in path loss

Uncertainty on materials and relative location in the building increases the standard deviation of the log-normal distribution :

$$\sigma_{indoor-outdor}^{hata} = \sqrt{(\sigma_{outoor-outdor}^{hata})^2 + (\sigma_{add})^2}$$

1.6 Indoor-indoor propagation

Use of the modified Hata model for indoor-indoor propagation introduces following adjustments according to the relative location of the pair of transmitter and receiver.

Same-building condition

The first step is to estimate whether the transmitter and the receiver are located in the same building. This is done trough a statistic trial. Let us denote *P* the probability that the transmitter and the receiver are located in the same building. *P* is calculated according to the following scheme:

Dist. Range	Same Building Probability
$d \le 0.02km$	*P=1*
$0.02km < d \le 0.05km$	$P = \frac{(0.05-d)}{0.03}$
$0.05km < d$	*P=0*

Transmitter and Receiver in different buildings

When transmitter and receiver are located in different buildings, the calculation mode is similar to the indoor-outdoor propagation mode but with doubled additional values.

Median path loss

$$L^{hata}_{indoor-indoor} = L^{hata}_{outdoor-outdoor} + 2 \times L_{we}$$

where : L_{we} is the attenuation due to external walls

Variation in path loss

$$\sigma^{\ hata}_{\ indoor-indoor} = \sqrt{(\sigma^{\ hata}_{\ outoor-outdor})^2 + (2\sigma_{\ add})^2}$$

Transmitter and Receiver in same building

In this latter case a specific propagation model is used:

$$f_{propag}(f, h_1, h_2, d, env) = L + T(G(\sigma))$$

Median Loss

The corresponding median loss is given by the following formula :

$$L(indoor - indoor) = -27.6 + 20\log(d) + 20.\log(f) + fix(\frac{d}{d_{room}}).\, L_{wi} + k_f^{\left[\frac{k_f+2}{k_f+1} - b\right]}.\, L_f$$ where

$$k_f = fix(\frac{|h_2 - h_1|}{h_{floor}})$$

and where :

L_{wi} : loss of wall (default 5 dB)

L_f : loss between adjacent floor (default 18.3 dB)

b : empirical parameter (default 0.46)

d_{room} : size of the room (default 4 m)

h_{floor} : height of each floor (default 3 m)

Variation in path loss

Variation in path loss is modelled as an additional log-normal distribution, in order to take into account the uncertainty of building design, furniture of the rooms, etc. Typically it is set to 10 dB.

2 EXTENDED HATA (SRD) - SE24 DEVELOPED PROPAGATION MODEL

This model is a modified version of the Extended SE21 Hata model, developed in CEPT within the Project Team SE24 for studies of Short Range Devices (SRD). The basis for modification was an assumption, that although SRD devices are usually operated at low antenna heights (typically person-carried devices, i.e. with antenna height of ca. 1.5 m), but the interference would usually occur at relatively short distances (up to 100 m or so) when direct- or near-LOS might be assumed. Therefore the expression of $b(H_b)$ parameter in the standard Hata model, giving large extra losses for transmitter antenna heights below 30 m, was considered to be unnecessarily severe. Therefore the only difference between Hata-SRD and Hata model lies in the new expression for the antenna gain factor $b(H_b)$, which for Hata-SRD model is expressed as

b = min(0, 20 log(Hb/30));

to be replaced by :

*b = (1.1 log(f) - 0.7) * min(10, Hb) - (1.56 log(f) - 0.8) + max(0, 20 log(Hb / 10));*

Note: *This expression assumes that antenna heights should not exceed 1.5-3 m.*