**Extracted from SE40(20)56A3: [Some modifications proposed by IARU into the SE40 Forum ahead of SE40 Meeting Number 70]**

## Propagation model: [For Further Discussion – This needs to account for path terrain and clutter at the receiver end]

1. Other propagation models, suitable for maritime and aeronautical receivers should be added

The goal is to estimate the dimension of interference areas. For doing so, several propagation models can be used; such as ITU-R P.452, ITU-R P.1546 or other models used for mobile radio planning, such as Okumura-Hata. The CEPT Monte-Carlo analysis SEAMCAT tool (See ECC Report 252 Annex 17) includes these models and additionally the Extended Okamura-Hata model.

For each of the models cited above, the following considerations can be made:

* Okumura-Hata is relatively easy to use and it is well known for its general reliability, but it has the limitation that ideally the transmitting station should be at least 30 m. The model is intended to calculate the media loss over a pixel of terrain at distance d from the transmitter. Because of this, if the model is used to calculate interference area, a margin factor should be inserted in the analysis in order to take into account the spatial variability of the electromagnetic field. If one applies Okumura-Hata, he must be aware of the limitations on its paramaters, including a maximum distance of 10 km, a minimum BS antenna height of 30 m. On the other side, since Okumura-Hata is conceived for frequencies up to 1500 MHz, its frequency range suites the case at hand. Within the ECO SEAMCAT tool this is implemented as “Extended Okumura-Hata” and can typically be used for mobile services and other services working in non-LOS/cluttered environments up to 3 GHz.
* ITU-R P. 1546 does not have the limitation on antenna height of the TX (it can be as low as 10 m), but it has a limitation on the minimum distance, that should be at least 1 km. This model has the advantage of having built in location and time probabilities, so that it can be directly used for the analysis of interference areas.
* On the other side, ITU-R ITU-1812 is more versatile because it does not have significant limitations on the TX antenna height and the minimum distance, and it considers antenna probability. The minimum distance at which it can be used is 250 m.

For the models ITU-R P.1546 and ITU-R 1812 a tested Matlab implementation is available to ITU members.

The ECO hosts a WiKi page at [https://wiki.cept.org/display/SH/A17+Propagation+models](https://wiki.cept.org/display/SH/A17%2BPropagation%2Bmodels) that provides useful information on the models implemented in the SEAMCAT tool.

A useful comparison of the P.1546 model and the Extended Hata model can be found at [https://wiki.cept.org/display/SH/A17.1.3+Using+the+Extended+Hata+vs.+P.1546+models](https://wiki.cept.org/display/SH/A17.1.3%2BUsing%2Bthe%2BExtended%2BHata%2Bvs.%2BP.1546%2Bmodels).

For reference, the following figure gives the curves of propagation loss, along a path of 100 km, over rural terrain at 1300 MHz, for a transmitting antenna height of 10 meters, a receiving antenna height of 1.5, and a rural terrain. The two curves refer to two location probabilities, namely of 50% and 1%.



Figure 1

If one is interested in the magnitude of interference at very short distances, in the order of magnitude of a few hundreds of meters, more detailed analyses should be conducted, where the case of light of sight and free space propagation is also considered.

### Time variability effects

Due to the variation in the atmospheric conditions and propagation conditions, such as ducting, the interfering signal can show time variability. These phenomena are taken into account by the models ITU-R. P. 1546 and ITU-R. P. 1812, however, these time effects are mostly relevant over long distances, while at short distances they tend to be negligible.

### Space variability effects

The other aspect to be considered is the space variability of the electromagnetic field. By the way it is conceived, a propagation model such as Okumura-Hata gives the estimated median value of the received power in a given pixel of terrain. Inside this pixel of terrain, you can still have slow fading and fast fading. The effect of local statistical variations f the EM field also needs to be taken into account.

In order to appreciate this fact, consider a pixel of terrain 50x50 m wide. Assume that the maximum tolerable interfering power for the RNSS receiver is $P\_{int}^{MAX}$. In order to declare that the pixel is free from interference it is not sufficient to verify that the interfering received power from the radio amateur station, calculated with the chose propagation model, is equal or below $P\_{int}^{MAX}$. For instance, when its value is exactly equal to $P\_{int}^{MAX}$ this means that 50% of the locations inside the pixel will be still be above this value. For this reason, the analysis of interference shall be conducted in such a way that, for a given pixel to be declared interference free, the interfering EM field shall below the reference threshold for, say, X=99% of its locations.

It is therefore necessary to have statistical model of the spatial variability of the EM field for a given pixel. In general, such a variation is composed of a slow variation (shadow fading) and fast variation (fast fading), that it due to multipath effects[[1]](#footnote-1).

A characterization of the spatial variability of the field strength in various frequency band and for different propagation scenarios (the clutter at the location of the RX plays a fundamental role), is implicitly contained in the curves of ITU-R. 1546 and it is also treated in ITU-R. P1812, but it is excluded by Hata. Should one use Hata, an additional margin for fading should be added, in the same way it is added when Hata is used for mobile radio planning.

If one considers, for instance ITU-R. P.1812, for an outdoor location, at 1.5 meters, in the frequency band 1300 MHz, the standard deviation of spatial variation of the received power (that is assumed to be lognormal) is 5.5 dB for the 1300 MHz (see section 4.8 and Table 6). A value of 5.5 dB and the assumption of a lognormal fading clearly refer to the slow variation of the field, while the fast variation is not considered.

The following table gives a comparison of the propagation models presented above.

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| --- | --- | --- | --- | --- | --- |
| Model | Scope | Limitations | Clutter loss consideration | Advantages | Drawbacks |
| ITU-R P.1546 | Point to area | Tx height $\in [10;3000]$ mDistance $\in [1;1000]$ km | The clutter heights around the transmitter and the receiver are represented by two parameters | Can be used without specific terrain data.Works with sea paths.Implemented in SEAMCAT. |  |
| ITU-R P.1812 | Point to area | Distance > 250 m | 1) At each point on the profile between the transmitter and receiver point a clutter height is added to the terrain height.  This profile is used in the diffraction calculation (the antenna heights are also adjusted depending on the clutter at each end). 2) A terminal clutter correction is also applied, dependant on the clutter at the transmit and receiving end; this is the same as in P. 1546 | Representative of terrain, works with sea paths. | Requires detailed terrain height data along the path.Not implemented in SEAMCAT |
| Okumura-Hata | PtP, broadcast | Tx height > 30 mMobile station height $\in [1; 10]$ mDistance $\in [1;10]$ km | Fit on measured data from urban environment, not terrain specific | Easy to use | Not representative of terrain configurations. Not path specific |
| Extended Okumura-Hata in SEAMCAT | Mobile services and other services working in non-LOS/cluttered environment . Urban, sub-urban and open area environments considered.  |  | Statisitical variation of path loss included. | Easy to use and implemented in SEAMCAT.Low-height mobile terminals moving in cluttered environment. | Not path specific |

1. A comprehensive discussion of fast and slow fading can be found, for instance, in Parsons, *The Mobile Radio Propagation Channel*, 2nd Edition, Wiley. [↑](#footnote-ref-1)