

ITU-R

Radiocommunication Sector of ITU

Recommendation ITU-R P.1816-3 (07/2015)

The prediction of the time and the spatial profile for broadband land mobile services using UHF and SHF bands

P Series
Radiowave propagation



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RA	Radio astronomy
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SA	Space applications and meteorology
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Note: This ITU-R Recommendation was approved in English under the procedure detailed in Resolution ITU-R 1.

Electronic Publication
Geneva, 2015

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RECOMMENDATION ITU-R P.1816-3

The prediction of the time and the spatial profile for broadband land mobile services using UHF and SHF bands

(Question ITU-R 211/3)

(2007-2012-2013-2015)

Scope

The purpose of this Recommendation is to provide guidance on the prediction of the time and the spatial profile for broadband land mobile services using the frequency range 0.7 GHz to 9 GHz for distances from 0.5 km to 3 km for non-line of sight (NLoS) environments and from 0.05 km to 3 km for line of sight (LoS) environments in both urban and suburban environments.

The ITU Radiocommunication Assembly,

considering

- a) that there is a need to give guidance to engineers in the planning of broadband mobile services in the UHF and SHF bands;
- b) that the time-spatial profile can be important for evaluating the influence of multipath propagation;
- c) that the time-spatial profile can best be modelled by considering the propagation conditions such as building height, antenna height, distance between base station and mobile station, and bandwidth of receiver,

noting

- a) that the methods of Recommendation ITU-R P.1546 are recommended for point-to-area prediction of field strength for the broadcasting, land mobile, maritime and certain fixed services in the frequency range 30 MHz to 3 000 MHz and for the distance range 1 km to 1 000 km;
- b) that the methods of Recommendation ITU-R P.1411 are recommended for the assessment of the propagation characteristics of short-range (up to 1 km) outdoor systems between 300 MHz and 100 GHz;
- c) that the methods of Recommendation ITU-R P.1411 are recommended for estimating the average shape of the delay profile for the line-of-sight (LoS) case in an urban high-rise environment for micro-cells and pico-cells;
- d) that the methods of Recommendation ITU-R P.1407 are recommended for specifying the terminology of multipath and for calculating the delay spread and the arrival angular spread by using the delay profile and the arrival angular profile, respectively;
- e) that the methods of Recommendation ITU-R M.1225 are recommended for evaluating the IMT-2000 system performance affected by multipath propagation,

recommends

- 1 that the content of Annex 1 should be used for estimating the long-term envelope and power delay profiles for broadband mobile services in urban and suburban areas using the UHF and SHF bands;

2 that the content of Annex 2 should be used for estimating the long-term power arrival angular profile at the BS (base station) for broadband mobile services in urban and suburban areas using the UHF and SHF bands;

3 that the content of Annex 3 should be used for estimating the long-term power arrival angular profile at the MS (mobile station) for broadband mobile services in urban and suburban areas using the UHF and SHF bands.

Annex 1

1 Introduction

The importance of the delay profile is indicated in Recommendation ITU-R P.1407 as follows.

Multipath propagation characteristics are a major factor in controlling the quality of digital mobile communications. Physically, multipath propagation characteristics imply multipath number, amplitude, path-length difference (delay), and arrival angle. These can be characterized by the transfer function of the propagation path (amplitude-frequency characteristics), and the correlation bandwidth.

As mentioned, the delay profile is a fundamental parameter for evaluating the multipath characteristics. Once the profile is modeled, multipath parameters such as delay spread and frequency correlation bandwidth can be derived from the profile.

Propagation parameters related to the path environment affect the shape of the profile. A profile is formed by multiple waves that have different amplitudes and different delay times. It is known that long delayed waves have low amplitude because of the long path travelled. The averaged delay profile (long-term delay profile) can be approximated as an exponential or power functions as shown in previous works.

Both the number and the period of arriving waves in a delay profile depend on the receiving bandwidth because the time resolution is limited by the frequency bandwidth of the receiver. In order to estimate the delay profile, the limitation of frequency bandwidth should be considered. This limitation is closely related to the method used to divide the received power into multiple waves.

In order to take the frequency bandwidth or path resolution into consideration, the delay profile consisting of discrete paths is defined as the path delay profile.

In Recommendation ITU-R P.1407, various delay profiles and their processing methods are defined as shown in Fig. 1.

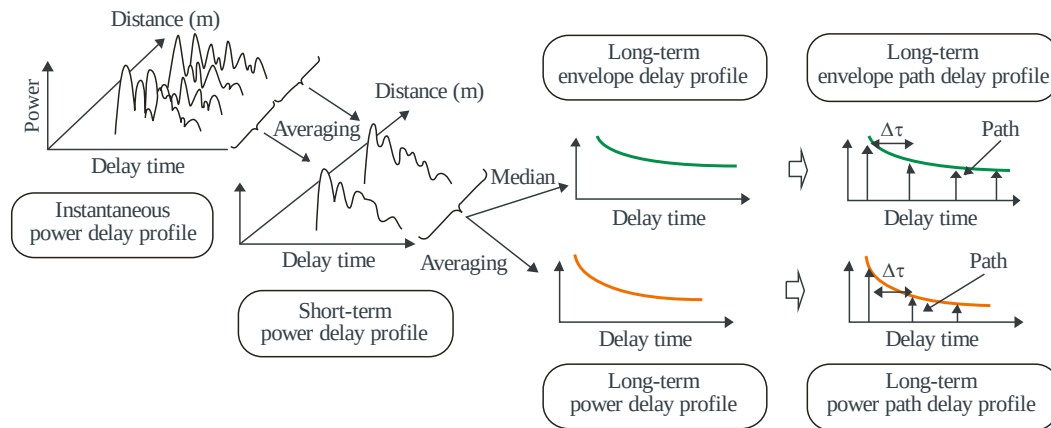
Instantaneous power delay profile is the power density of the impulse response at one moment at one point. Short-term power delay profiles are obtained by spatial averaging the instantaneous power delay profiles over several tens of wavelengths in order to suppress the variation of rapid fading; long-term power delay profiles are obtained by spatial averaging the short-term power delay profiles at the approximately the same distance from the base station (BS) in order to also suppress the variations due to shadowing.

With regard to the long-term delay profile, two different profiles can be defined. One, the envelope delay profile, is based on the median value of each delay profile; it expresses the shape of the

profile at the area being considered as shown in Fig. 1. The other is the power delay profile based on the average power value of each delay profile.

Furthermore, with regard to the long-term envelope and power delay profiles, path delay profiles consisting of discrete paths are also defined in order to obtain the variation in path number with path resolution, which depends on the frequency bandwidth.

FIGURE 1
Delay profiles



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2 Parameters

- τ : excess delay time, (μs)
- i : excess delay time normalized by time resolution $1/B$ and $i = 0, 1, 2, \dots$ (here $i = 0$ means the first arrival path without excess delay time and $i = k$ means excess delay time of k/B (μs))
- $\langle H \rangle$: average building height (5-50 m: height above the mobile station ground level), (m)
- h_b : base station antenna height (5-150 m: height above the mobile station ground level), (m)
- d : distance from the base station (0.5-3 km for NLoS environment, 0.05-3 km for LoS environment), (km)
- W : street width (5-50 m), (m)
- B : chip rate (0.5-50 Mcps), (Mcps)
(occupied bandwidth can be converted from chip rate B and applied baseband filter)
- f : carrier frequency (0.7-9 GHz), (GHz)
- $\langle R \rangle$: average power reflection coefficient of building side wall, (<1)
- γ_{dB} : constant value (-16 dB—12 dB), (dB)
- γ : $10^{\gamma_{dB}/10}$
- ΔL : the level difference between the peak path's power and cut-off power, (dB).

3 Long-term delay profile for NLoS environment in urban and suburban areas

3.1 Envelope delay profile normalized by the first arrival path's power

The envelope path delay profile $PDP_{NLoS,env}(i, d)$ divided by time resolution $1/B$ normalized by the first arrival path's power at distance d is given as follows:

$$PDP_{NLoS,env}(i, d) = 10^{PDP_{dB}(i, d)/10} \quad (1)$$

where:

$$PDP_{dB}(i, d) = a(i) \cdot PDP_{high}(i, d) \quad (\text{dB}) \quad (2)$$

$$PDP_{high}(i, d) = -\{19.1 + 9.68 \log(h / \langle H \rangle)\} B^{\{-0.36 + 0.12 \log(h_b / \langle H \rangle)\}} d^{\{-0.38 + 0.21 \log(B)\}} \log(1 + i) \quad (\text{dB}) \quad (2-1)$$

$$a(i) = \left(0.4 + (1 - 0.4) \exp \left[-0.2 \left(\langle H \rangle / h_b \right)^4 \right] \right) + \left(\left(\langle H \rangle / h_b \right) \left(1 - \exp \left[-0.4 \left(\langle H \rangle / h_b \right)^2 \right] \right) \right) (i / B) \quad (2-2)$$

The envelope delay profile $PDP_{NLoS,env}(\tau, d)$

with continuous excess delay time normalized by the first arrival path's power at distance d is given as follows:

$$PDP_{NLoS,env}(\tau, d) = PDP_{NLoS,env}(B\tau, d) \quad (3)$$

In deriving equation (3), the relation $(\tau = i / B \Rightarrow i = B\tau)$ is used.

3.2 Power delay profile normalized by the first arrival path's power

The power path delay profile $PDP_{NLoS,pow}(i, d)$ divided by time resolution $1/B$ normalized by the first path's power at distance d is given as follows:

$$PDP_{NLoS,pow}(i, d) = c(i) \cdot 10^{PDP_{dB}(i, d)/10} \quad (4)$$

where:

$$c(i) = \begin{cases} 1 & (i = 0) \\ \min \left(0.63, \left\{ 0.59 e^{-0.0172B} + (0.0172 + 0.0004B) \langle H \rangle \right\} e^{-\{0.077 - 0.00096B - (0.0014 - 0.000018B) \langle H \rangle\} i} \right) & (i \geq 0) \end{cases} \quad (5)$$

Here, function $\min(x, y)$ selects the minimum value of x and y .

The power delay profile $PDP_{NLoS,pow}(\tau, d)$ with continuous excess delay time normalized by the first arrival path's power at distance d is given as follows:

$$PDP_{NLoS,pow}(\tau, d) = PDP_{NLoS,pow}(B\tau, d) \quad (6)$$