

RECOMMENDATION ITU-R PN.681-1*

PROPAGATION DATA REQUIRED FOR THE DESIGN OF EARTH-SPACE
LAND MOBILE TELECOMMUNICATION SYSTEMS

(Question ITU-R 207/3)

(1990-1994)

The ITU Radiocommunication Assembly,

considering

- a) that for the proper planning of Earth-space land mobile systems it is necessary to have appropriate propagation data and prediction methods;
- b) that the methods of Recommendation ITU-R PN.618 are recommended for the planning of Earth-space telecommunication systems;
- c) that further development of prediction methods for specific application to land mobile-satellite systems is required to give adequate accuracy in all regions of the world and for all operational conditions;
- d) that, however, methods are available which yield sufficient accuracy for many applications,

recommends

- 1. that the methods contained in Annex 1 be adopted for use in the planning of Earth-space land mobile telecommunications systems, in addition to the methods recommended in Recommendation ITU-R PN.618.

ANNEX 1

1. Introduction

Propagation effects in the land mobile-satellite service (LMSS) differ from those of the fixed-satellite service (FSS) primarily because of the greater importance of terrain effects. In the FSS it is generally possible to discriminate against multipath, shadowing and blockage through the use of highly directive antennas placed at unobstructed sites. Therefore, in general, the LMSS offers smaller link availability percentages than the FSS. The prime availability range of interest to system designers is usually from 80% to 99%.

This Annex deals with data and models specifically needed for predicting propagation impairments in LMSS links, which include tropospheric effects, ionospheric effects, multipath, blockage and shadowing. It is based on measurements at 1.5 GHz (L-band) and 870 MHz in the UHF band.

2. Tropospheric effects

2.1 Attenuation

Signal losses in the troposphere are caused by atmospheric gases, rain, fog and clouds. Except at low elevation angles, tropospheric attenuation is negligible at frequencies below about 1 GHz, and is generally small at frequencies up to about 10 GHz. Above 10 GHz, the attenuation can be large for significant percentages of the time on many paths. Prediction methods are available for estimating gaseous absorption (Recommendation ITU-R PN.676) and rain attenuation (Recommendation ITU-R PN.618). Fog and cloud attenuation is usually negligible for frequencies up to 10 GHz.

* This Recommendation should be brought to the attention of Radiocommunication Study Group 8.

2.2 Scintillation

Irregular variations in received signal level and in angle of arrival are caused by both tropospheric turbulence and atmospheric multipath. The magnitudes of these effects increase with increasing frequency and decreasing path elevation angle, except that angle-of-arrival fluctuations caused by turbulence are independent of frequency. Antenna beamwidth also affects the magnitude of these scintillations. These effects are observed to be at a maximum in the summer season. A prediction method is given in Recommendation ITU-R PN.618.

3. Ionospheric effects

Ionospheric effects on Earth-to-space paths are addressed in Recommendation ITU-R P1.531. Values of ionospheric effects for frequencies in the range of 0.1 to 10 GHz are given in Tables 1 and 2 of Recommendation ITU-R PN.680.

4. Shadowing

4.1 Empirical roadside shadowing model

Cumulative 1.5 GHz fade distribution measurements have given rise to the empirical roadside shadowing model. The extent of trees along the roadside is represented by the percentage of optical shadowing caused by roadside trees at a path elevation angle of 45° in the direction of the signal source. The model is valid when this percentage is in the range 55-75%.

$$A(\theta, p) = \alpha(p) + \beta(p)\theta + \gamma(p)\theta^2 \quad (1)$$

for

$$20^\circ \leq \theta \leq 60^\circ$$

$$1\% \leq p \leq 20\%$$

where:

A : fade exceeded in dB with respect to free space propagation

p : percentage of the distance travelled over which the fade is exceeded

θ : path elevation angle to the satellite.

The parameters, $\alpha(p)$, $\beta(p)$, and $\gamma(p)$ are tabulated in Table 1.

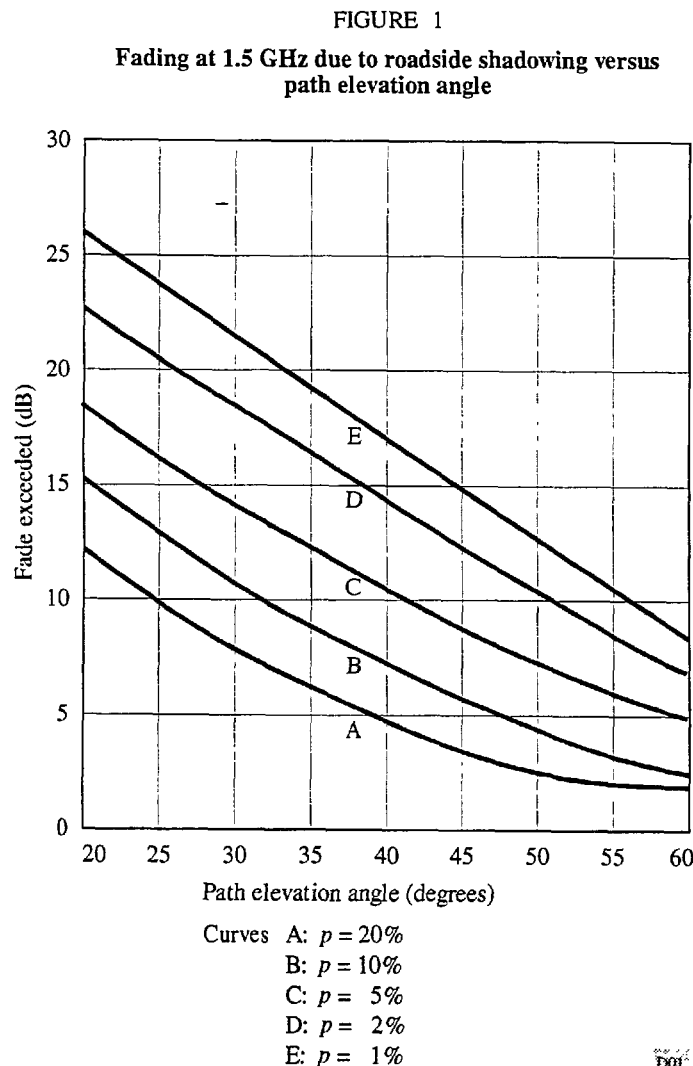
TABLE 1

Values $\alpha(p)$, $\beta(p)$, and $\gamma(p)$ of the empirical roadside model

Percentage (p)	$\alpha(p)$	$\beta(p)$	$\gamma(p)$
20	24.45	-0.7351	5.991×10^{-3}
10	26.84	-0.6775	4.605×10^{-3}
5	29.22	-0.6000	3.219×10^{-3}
2	32.38	-0.5106	1.386×10^{-3}
1	34.76	-0.4430	0.0

The empirical roadside model corresponds to an average propagation condition with the vehicle driving on lanes both sides of the highway (lanes close to and far from roadside trees are included). The model applies to highways and rural roads where the overall aspect of the propagation path is, for the most part, orthogonal to the lines of roadside trees and utility poles and it is assumed that the dominant cause of LMSS signal attenuation is canopy shadowing (see Recommendation ITU-R PN.833).

Figure 1 shows plots of fade exceeded versus the path elevation angle for several constant percentages, p .



Since the measurements that resulted in the development of the model did not discriminate against multipath, it implicitly includes the effect of multipath by roadside trees. The receiving antenna employed in the measurements has an azimuthally omnidirectional radiation pattern with a peak gain of 4 dB.

Fade measurements in the United Kingdom for a mixture of trees and buildings have shown that the model is also valid for mixed environments and that the model may be extended to elevation angles up to 80° .