

RECOMMENDATION ITU-R P.843-1

COMMUNICATION BY METEOR-BURST PROPAGATION

(Question ITU-R 221/3)

(1992-1997)

The ITU Radiocommunication Assembly,

considering

- a) that scattering from ionization caused by meteor trails can provide a convenient means of communication at HF and VHF;
- b) that two-way telecommunication circuits are in operation with frequencies between 30 and 100 MHz over ranges up to 1 800 km;
- c) that communication relies on bursts of propagation during the occurrence of meteor trails and can support data rates up to 100 Bd when averaged over approximately one hour,

recommends

that the following information should be used in the design and planning of meteor-burst communications systems.

1 Temporal variations in meteor flux

At certain times of the year, meteors occur in the form of showers and may be prolific over durations of a few hours. There is, however, a general background of meteors incident upon the Earth from all directions and it is appropriate to consider only these sporadic meteors for communication-planning purposes.

For sporadic meteors at mid-latitudes there is a roughly sinusoidal diurnal variation of incidence with a maximum at 0600 h and a minimum at 1800 h local time. The ratio of maximum to minimum averages about four. In the Northern Hemisphere there is a seasonal variation of similar magnitude with a minimum in February and maximum in July. Considerable day-to-day variability exists in the incidence of both sporadic and shower meteors.

The annual average flux of meteors incident per unit area and producing electron-line densities q exceeding a threshold q_0 per metre, $I(q > q_0)$ is given as:

$$I(q > q_0) = \frac{160}{q_0} \quad \text{m}^{-2} \text{ s}^{-1} \quad (1)$$

By combining this overall meteor rate with a representative sinusoidal diurnal variation and the seasonal factor, M , from Fig. 1 the average temporal changes in meteor flux can be estimated:

$$\frac{160}{q_0} M \left[1 + 0.6 \left(\sin \frac{\pi T}{12} \right) \right] \quad \text{m}^{-2} \text{ s}^{-1} \quad (2)$$

where:

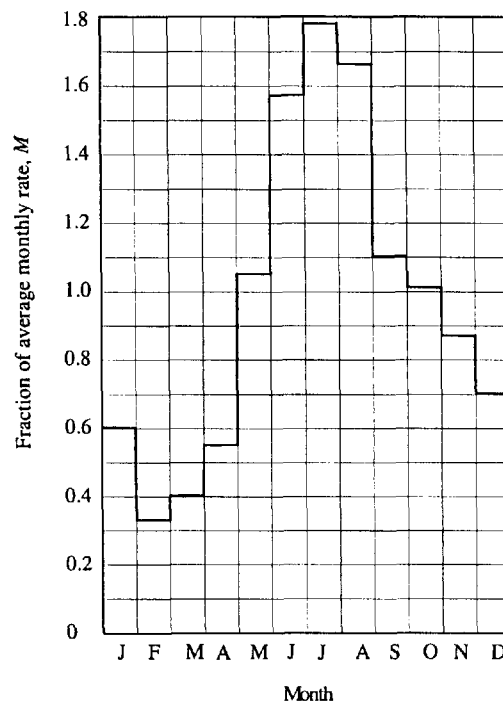
T : local time (h).

For planning purposes it may only be necessary to consider the worst combination of month and local time.

2 Spatial variation in meteor flux

Meteors occur in all parts of the world at all hours but statistical information is incomplete on their geographical distribution and trail directions.

FIGURE 1
Month-to-month variation in sporadic meteor flux rate
relative to the average value



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Until such times as spatial variations are quantified it is recommended that flux estimates based on the method given in § 1 are used at all latitudes.

3 Underdense and overdense trails

The ionized trails caused by meteors are classified as underdense or overdense according to the intensity of the ionization. The division between the two cases occurs for line densities of approximately 2×10^{14} electrons per metre. The amplitude of signals scattered from underdense trails may be calculated by summing the scattered field arising from each individual electron. Overdense trails are those for which the coupling between electrons cannot be ignored, in which case, the reflecting properties are calculated as if the trail were a long metallic cylinder. At frequencies used in practice the echoes from underdense trails show an abrupt start followed by an exponential decay, whereas those from overdense trails have more rounded envelopes and are of longer duration. The relative proportions of underdense and overdense echoes will depend on the system sensitivity.

The relation between number of trails and peak amplitude, A , can be approximated by:

$$\text{Number of trails} \propto (A)^{-\psi}$$

where ψ varies from 1.0 at low signal levels to greater than 2.0 at larger signal levels where the majority of trails are overdense. For many links, the index ψ is of the order of 1.1 to 1.4.

Results in the systems used so far indicate that echoes are predominantly from underdense trails. On this basis it is recommended that planning for a typical system should proceed on the basis that all meteor trails are of the underdense type.

4 Effective length and radius of meteor trails

4.1 Effective length

The ray geometry for a meteor-burst propagation path is shown in Fig. 2 between transmitter T and receiver R. P represents the tangent point and P' a point further along the trail such that $(R'_1 + R'_2)$ exceeds $(R_1 + R_2)$ by half a wavelength. Thus PP' (of length L) lies within the principal Fresnel zone and the total length of the trail within this zone is $2L$. Provided R_1 and R_2 are much greater than L , it follows that for practical cases:

$$L = \left[\frac{\lambda R_1 R_2}{(R_1 + R_2) (1 - \sin^2 \varphi \cos^2 \beta)} \right]^{1/2} \quad (3)$$

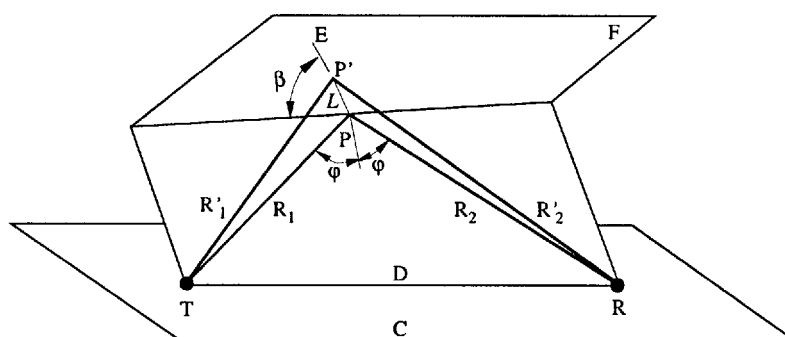
where:

φ : angle of incidence

β : angle between the trail axis and the plane of propagation

λ : wavelength.

FIGURE 2
Ray geometry for a meteor-burst propagation path



C: Earth's surface
D: plane of propagation
E: trail
F: tangent plane
 β : angle between the trail axis and the plane of propagation
T: transmitter
R: receiver

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4.2 Trail radius

In order to evaluate the scattering cross section of the trail it is usual to assume that ambipolar diffusion causes the radial density of electrons to have a Gaussian distribution and that the volume density is reduced while the line density remains constant.

The ionization trail immediately behind a meteor is formed near-instantaneously with a finite width. This is called the initial trail radius, r_0 . An empirical relationship between r_0 and the meteor height is:

$$\log r_0 = 0.035 h - 3.45 \quad (4)$$

where:

h : trail height (km)

r_0 : initial trail radius (m).