

RECOMMENDATION ITU-R F.698-2

PREFERRED FREQUENCY BANDS FOR TRANS-HORIZON
RADIO-RELAY SYSTEMS

(Question ITU-R 103/9)

(1990-1992-1994)

The ITU Radiocommunication Assembly,

considering

- a) that the World Administrative Radio Conference (Geneva, 1979) (WARC-79), in its Recommendation No. 100 asked the ex-CCIR to prepare a Recommendation concerning the specific frequency bands found preferable for trans-horizon radio-relay systems, taking into account allocations to other services, particularly allocations to space services;
- b) that the WARC-79 and the World Administrative Radio Conference for Dealing with Frequency Allocations in Certain Parts of the Spectrum (Malaga-Torremolinos, 1992) (WARC-92) made additional allocations of frequency bands for the space services in view of their increasing development;
- c) that Recommendation No. 100 of the WARC-79 notes that the proliferation of trans-horizon systems in all frequency bands, and particularly in those shared with the space systems, is bound to aggravate an already difficult situation;
- d) that there are optimum frequency ranges for trans-horizon radio-relay systems from the viewpoint of thermal and intermodulation noise due to propagation, depending on the distance of links;
- e) that the power limits specified in Article 27 of the Radio Regulations (RR) are applicable to transmitters of trans-horizon radio-relay systems, sharing the frequency bands with space radiocommunication services (Earth-to-space) except for certain frequency bands,

recommends

- 1. that in selecting frequency bands for trans-horizon radio-relay systems, the following factors should be taken into account from the viewpoint of the total noise including thermal and intermodulation noises due to propagation:

1.1 on links of approximately 400 to 700 km relatively low frequencies below about 1 GHz with large antennas are optimum to provide adequate performance including low intermodulation noise. The transmission capacity will normally be small. Operation above 1 GHz may result in poor performance except for very favourably sited terminals and for very favourable propagation conditions;

1.2 on links of approximately 200 to 400 km the transmission capacity may be somewhat greater. Multipath intermodulation noise may be a major factor; frequencies around 2 GHz may be preferable to lower frequencies in order to reduce intermodulation noise;

1.3 for shorter links (approximately 100 to 200 km) operation at frequencies up to about 5 GHz is possible, resulting in low multipath intermodulation noise even with relatively small antennas. Frequencies between about 2 GHz and 3 GHz may be optimum for high transmission capacities on such links;

- 2. that in selecting frequency bands for trans-horizon radio-relay systems, priority should be given to bands which are not shared with space radiocommunication services;

- 3. that, in general, frequency bands shared with space radiocommunication services (Earth-to-space) should not be used for trans-horizon radio-relay systems (see Note 1);

- 4. that frequency bands shared with space radiocommunication services (space-to-Earth) may be used for trans-horizon radio-relay systems, provided that due consideration is given, on the basis of Recommendation ITU-R IS 847, to avoiding interference from trans-horizon radio-relay systems to earth station receivers in space radiocommunication services (see Notes 2 and 3);

Documents

Document Sharing Hub

5. that in selecting frequency bands for trans-horizon radio-relay systems, due consideration should be given to avoiding interferences to line-of-sight radio-relay systems in accordance with Recommendation ITU-R F.302 (see Note 4);
6. that the additional information given in Annex 1 should be referred to for the application of this Recommendation;
7. that the following Notes should be treated as part of this Recommendation.

Note 1 – Trans-horizon radio-relay systems cannot generally operate under the power limits applicable to all systems in the fixed service shared with space radiocommunication services (Earth-to-space), as specified in RR Article 27 (see also § 3.1 of Annex 1).

Note 2 – When frequency bands shared with space radiocommunication services (space-to-Earth) are used for trans-horizon radio-relay systems, it should be confirmed that space stations in space radiocommunication services complying with Recommendation ITU-R SF.358 (or, with RR Article 28 for 1 525-2 500 MHz bands) do not cause unacceptable interference into trans-horizon systems. It should be taken into account that the space stations may be in geostationary or non-geostationary-satellite orbits.

Note 3 – Further study is required concerning frequency sharing between trans-horizon radio-relay systems and receiving earth stations in the broadcasting-satellite service.

Note 4 – It should be also confirmed that interference into trans-horizon radio-relay systems caused by line-of-sight radio-relay systems is within acceptable limits.

ANNEX 1

Factors affecting the choice of frequency bands for trans-horizon radio-relay systems

1. Introduction

This Annex identifies various factors affecting the choice of frequency bands for trans-horizon radio-relay systems. At first the optimum frequency range of a trans-horizon radio-relay link system is determined from propagation considerations, taking into account the antenna diameter and the transmitting power. Then, interference problems relating to frequency sharing with other systems, including line-of-sight radio-relay systems and space radiocommunication systems, are discussed.

2. Optimum frequency range of a trans-horizon system

2.1 As a function of received level (considering thermal noise only)

Existing trans-horizon radio-relay systems normally use transmitter powers which are of the same order of magnitude for different frequency ranges. The sensitivity of modern receivers is, to a large extent, independent of the frequency band used.

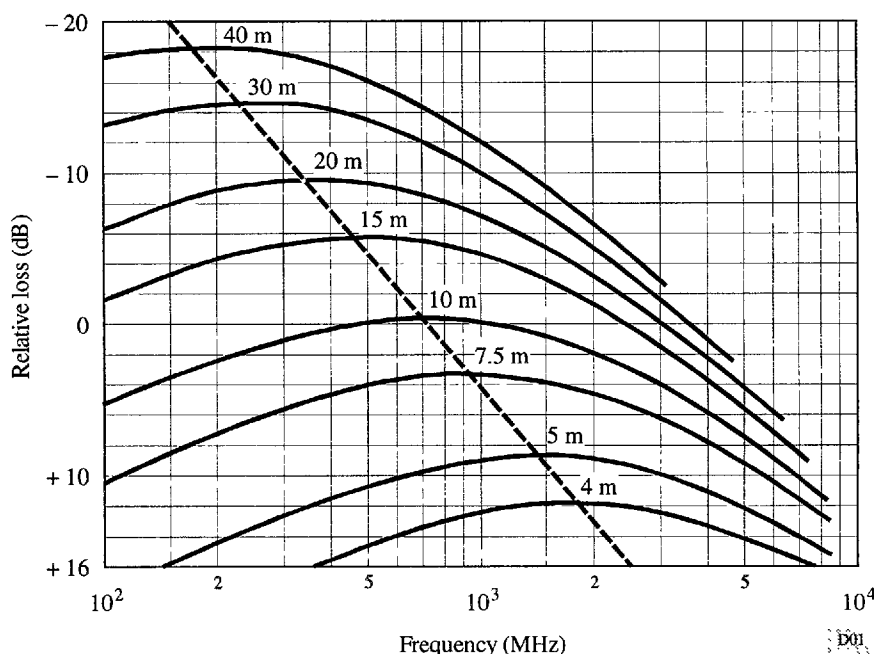
Long-term variations in received power levels, as a function of carrier frequency, depend essentially on three phenomena:

- the loss between isotropic antennas; it is usually assumed that this loss is proportional to the cube of the frequency;
- the free-space gain of the antennas used; for an antenna of a given diameter this gain is proportional to the square of the frequency;
- the drop in antenna gain; for an antenna of a given diameter this drop depends on the frequency and can be calculated from Fig. 1 of Recommendation ITU-R F.1106.

The effect of variations of all these three parameters, as a function of the frequency for antenna diameters between 4 and 40 m, is shown in Fig. 1.

Figure 1 represents the relative loss between the terminals of two antennas of the same diameter, located at the two ends of a trans-horizon radio-relay system; the reference loss (0 dB) is taken as that which exists under the same conditions between two antennas 10 m in diameter at 1 000 MHz. As regards the length of the connection, the validity of Fig. 1 is the same as that giving the loss in antenna gain, i.e. the link under consideration is assumed to be between about 150 and 500 km in length.

FIGURE 1
Relative loss between antennas of a given diameter



It can be seen that, for an antenna of given diameter, the relative loss passes through a minimum at a particular frequency and increases on either side; at the lower frequencies, because the relative dimensions of the antenna measured in wavelengths decrease (with a consequent decrease in free-space gain) and at the upper frequencies, because the drop in antenna gain increases as the free-space gain increases. The optimum operating frequency lies between 200 MHz for an antenna with a diameter of 40 m and 2 GHz for an antenna 4 m in diameter. However, the minimum is very flat and a frequency departure on either side in the ratio of 2/1 is possible without substantially increasing the relative loss.

2.2 As a function of total noise (including thermal and intermodulation) for analogue systems

The reduction of intermodulation noise due to propagation may demand higher antenna gains than would be strictly necessary for the reduction of thermal noise. For a given antenna gain, the dimensions of the antennas are obviously smaller at high frequencies. The choice of frequency does not depend essentially on the intermodulation noise if the antenna gain is fixed, but this is not true if the antenna diameter is fixed.

Regarding intermodulation noise, theoretical considerations have shown that intermodulation noise increases in proportion to the fourth power of multipath delay in the radio path.

The multipath delay on the path is proportional to the beamwidths of the antennas employed, and the antenna beamwidth is inversely proportional to the radio frequency, therefore the intermodulation noise decreases in inverse-proportion to the fourth power of the radio frequency when the antenna diameter employed is constant. An estimate of the intermodulation noise for each radio-frequency band and channel capacity is shown in Fig. 2 for a path length of 200 km and an antenna diameter of 10 m.