REPORT 811-2

BROADCASTING-SATELLITE SERVICE

Planning elements including those used in the establishment of Plans of frequency assignments and orbital positions for the broadcasting-satellite service in the 12 GHz band

(Question 1/10 and 11, Study Programme 1A/10 and 11)

(1978-1982-1986)

1. Introduction

The first step in establishing a plan of frequency assignments and orbital positions for the broadcasting-satellite service is to select various system characteristics in the light of their implications for planning. This Report considers the fullest possible list of such characteristics which served as bases for the Plans in the band 11.7 to 12.5 GHz in Region 1, in the band 11.7 to 12.2 GHz in Region 3, and in the band 12.2 to 12.7 GHz in Region 2.

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2. Planning elements

The planning elements used in the development of plans depend to a large extent on the amount of detail desired in the plans. However, it must be remembered that, in order to establish the workability of a plan, it must be tested by computer analysis. Although there are other factors that bear significantly on the operational workability of a plan, its technical feasibility depends mainly on meeting the agreed interference criteria for all systems that are part of the plan. Therefore, the tests must include the computation of interference from all sources, and this requires the use of specific values for all parameters that are relevant to this computation. When the plan allows ranges of values for some parameters, the values leading to the generation of the greatest interference and to the greatest vulnerability to interference should be used in the tests. These values cannot always be predicted and must be determined by the tests themselves. Because of the extremely large number of parameter combinations that would have to be tested, such exhaustive tests are, in general, impractical. This limits the number of parameters for which ranges can be allowed. The RARC SAT-83 recognized this difficulty and explicitly incorporated the stipulation that parameter values different from the ones specified may be used provided that the systems using them create no more interference than they would if they used the specified values.

Table I is a summary of the planning elements used in the establishment of the broadcasting-satellite service Plans for Regions 1 and 3 at the WARC-BS-77 and for Region 2 at the RARC SAT-83. The following sections provide additional details on some of the elements contained in this table.

3. System characteristics

3.1 *Polarization*

Circular polarization was adopted for the planning of the broadcasting-satellite service down links by both the WARC-BS-77 and the RARC SAT-83. The technical factors affecting the choice of polarization are treated in Report 814, and its effect on sharing is treated in Reports 809 and 631.

3.2 *Angle of elevation*

The satellite position, and so the angle of elevation of the satellite in the service area, should be chosen such that the weight and cost of the satellite which provides an acceptable signal strength during rain conditions is minimized, subject to the constraint that the angle of elevation throughout the service area is large enough so that the shadowing due to buildings, trees and surrounding terrain is not severe, and so that tropospheric fading and multipath effects do not become a dominant factor.

In addition, consideration of eclipse protection will affect the choice of satellite orbital position. In general, satellites are located west of their service areas in order to assure that the onset of eclipse is after the local midnight of that service area.

For coverage zones located in latitudes above 60°, the angle of elevation is bound to be less than 20°. In favourable terrain conditions almost normal service might be provided with angles of elevation as low as 10°. Special measures are needed, however, if service is planned to be extended under this angle or to areas with a less favourable terrain. For mountainous areas even an angle of elevation of 20° may be insufficient. In the Alpine valleys, for example, which are deep and populated, an angle of at least 30° may be essential to provide an acceptable service.

Subject to these constraints, the choice of the angle of elevation to the satellite to minimize weight and cost of most satellites is equivalent to the choice of angle of elevation to minimize tube output powers. In this minimization the following factors should be considered:

- the rain attenuation,
- the variation in antenna gain with the solid angle subtended at the satellite by the specified coverage area,
- the variation in total system noise temperature (including the effect of rain-induced fading),
- the variation in propagation path length.

The above factors plus the gain of the receive terminal determine the carrier-to-noise temperature (C/T) achievable for a given satellite transmitter power. Therefore to minimize the required satellite power for a given receiver G/T the satellite position could be chosen to maximize C/T.

A general formulation of the problem of determining the optimum longitudinal location of a geostationary communications satellite for a specified beam coverage region is described in [Sinha, 1982].

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TABLE I – *Summary of planning elements*

BSS down links	Regions 1 and 3 (1)	Region 2 (1)
Propagation model	Annex 5, § 2	Annex 5, § 2
Modulation	FM or equivalent	FM or equivalent
Polarization	Circular	Circular
C/N (dB)	14 (exceeded for 99% of worst month)	14 (exceeded for 99% of worst month)
Protection ratio (dB)	Co-channel: 31 Adjacent channel: 15	Co-channel: 28 Adjacent channel: 13.6
Channel spacing (MHz)	38.36 between second adjacent channels	29.16 between second adjacent (co-polarized) channels
Minimum receiving installation G/T (dB(K^{-1}))	Individual reception: 6 Community reception: 14	Individual reception: 10
Receiving antenna half-power beamwidth (degrees)	Individual reception: 2.0 Community reception: 1.0	Individual reception: 1.7
Receiving antenna reference pattern	Annex 5, § 3.7.2, Fig. 7	Annex 5, § 3.7.2, Fig. 8
Necessary bandwidth (MHz)	For 625-line systems: 27 For 525-line systems: 27	24 (for some administrations using 625-line systems: 27)
Guard bands	Lower: 14 Upper: 11	Lower: 12 Upper: 12
Satellite station-keeping (degrees)	± 0.1 for both N-S and E-W	± 0.1 for both N-S (2) and E-W
Minimum elevation angle (degrees)	20-40; < 20 acceptable for arid and high latitude areas	20-40; < 20 acceptable for arid and high latitude areas
Satelite transmitting beam cross-section	Elliptical or circular	Elliptical or circular
Satellite transmitting antenna reference pattern	Annex 5, § 3.13.3, Fig. 9	Annex 5, § 3.13.3, Figs. 10 and 11
Satellite antenna pointing accuracy (degrees)	0.1 from boresight ± 2 in rotation about axis	0.1 from boresight ± 1 in rotation about axis
Satellite transmitter power tolerance (dB)	0.25 above nominal	0.25 above nominal
PFD at edge of coverage area (exceeded for 99% of worst month) (dB(W/m^2))	Individual reception: −103 Community reception: −111	Individual reception: −107
Ratio of e.i.r.p. at beam centre to e.i.r.p. at edge of coverage area (dB)	⩽ 3	⩽ 3
Use of energy dispersal (dB/4 kHz)	22 (3)	22 (3)

(1) References are to Appendix 30 (ORB-85) of the Final Acts of the WARC ORB-85.

(2) Recommended but not required in the N-S direction for Region 2.

(3) Corresponds to a peak-to-peak deviation of 600 kHz.

The important conclusion from this analysis is that a broad range of elevation angles can be used with only a minor variation in C/T under *all* climatic conditions. Even though there is an "optimum" satellite location, depending upon the specific system characteristics and the shape and orientation of the service area, the actual variation in C/T with elevation angle is generally quite small, of the order of a few tenths of a dB down to elevation angles as low as 20°.

3.3 *Service quality and availability objectives*

It is considered that planning should be on the basis of achieving the following carrier-to-noise ratio objectives at the edge of the service area:

a) 14 dB exceeded for 99% of the worst month;

b) 10 dB exceeded for 99.9% of the worst month.

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