RECOMMENDATION ITU-R BO.795*, **

Techniques for alleviating mutual interference between feeder links to the BSS

(Question ITU-R 86/11)

(1992)

The ITU Radiocommunication Assembly,

considering

a) that interference on the feeder link will impact on the overall broadcasting-satellite service (BSS) system performance;

b) that the number of feeder link stations is limited compared to the number of BSS receiving earth stations;

c) that special measures are possible and feasible to alleviate the impact of mutual interference between feeder links;

d) that the most critical cases of feeder link interference are for the case of cross-polar channels transmitted to co-located satellites;

e) that for the case of co-located satellites advantage can be taken of the difference in directivity between the BSS receive station antenna and the feeder link transmit antenna in order to minimize the interference between cross-polar channels,

recommends

that one or more of the following techniques be considered to alleviate mutual interference between feeder links:

– the use of a homogeneous set of feeder link technical parameters between feeder links serving BSS satellites that are closely spaced in orbit;

– adjustments of the maximum level of e.i.r.p. of potential interfering feeder links or feeder links subject to excessive interference, provided that adequate carrier-to-noise and carrier-to-interference ratios on the adjusted feeder links are maintained;

– when studies indicate that harmful interference could be experienced between closely spaced satellites the off-axis co- and cross-polar side-lobe reference patterns of the earth station transmitting antenna should meet the $29 - 25 \log \theta$ (dBi) side-lobe discrimination pattern down to –10 dBi;

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* This Recommendation should be brought to the attention of Radiocommunication Study Group 4.

** Radiocommunication Study Group 6 made editorial amendments to this Recommandation in 2001 in accordance with Resolution ITU-R 44.

– where insufficient cross-polar isolation is achieved, the off-axis cross-polar side-lobe reference pattern of the earth station transmitting antenna be limited to $24 – 25 \log \theta$ down to –10 dBi for the cross-polar pattern;

– modifying the satellite receiving antenna beam pattern shape, size and/or side-lobe response (e.g., a multiple beam or shaped beam antenna);

– off-setting the beam-pointing direction of the satellite receiving antenna subject to maintaining the target carrier-to-noise ratio;

– setting an upper limit on the feeder link margin allocated to rain attenuation;

– improving the beam pointing accuracy for the satellite receiving antenna;

– separating satellite orbital positions by, for example ± 0.2°, from the nominal position (see Annex 1).

ANNEX 1

Interference between co-located satellites

The most critical cases of feeder-link interference are for cross-polar channels transmitted to co-located satellites.

For the case where co-located satellites use a common cross-polarized channel, a protection ratio of 40 dB is needed. Discrimination of more than about 30 dB from the satellite receiving antenna pattern requires geographical separation of feeder-link service areas. The discrimination is the difference in co-polar gain towards points within the wanted service area and the cross-polar gain towards the closest point in the interfering service area. Satellite antenna patterns are typically given as functions of φ/φ_0 where φ is the exocentric angle between the on-axis direction and the direction of interest, and φ_0 is the 3 dB beamwidth of the satellite antenna. The discrimination between wanted and interfering signals is then the difference between the gain towards the wanted feeder-link station and the gain at angle φ. If the maximum discrimination is taken to be the opposite of the on-axis gain, 40 dB discrimination at the edge of service area would require an on-axis gain of 43 dB and values of φ/φ_0 greater than 2. Satellite antenna gains of 43 dB are not consistent with country-wide feeder-link service areas for many countries. Provisions for inhomogeneities in received signals due to rain attenuation and unequal transmit power levels would require even higher antenna gains. An on-axis gain of 49 dB (0.6° beamwidth) would provide, at best, a 6 dB margin for rain attenuation.

In considering the case where co-located satellites operating on cross-polarized adjacent channels have common feeder-link service areas, it is assumed that the discrimination capabilities are 25 dB for the satellite receiving antenna and 30 dB for the earth-station transmitting antenna. Since the two interference components may be in phase, voltage addition must be used to determine the interference level. In clear skies, the feeder-link C/I for an adjacent channel would be 21.1 dB. When the wanted feeder-link path is subjected to 10 dB rain attenuation, the feeder-link C/I drops to 11.1 dB. The protection ratio of 24 dB implied by the WARC-BS-77 cannot be achieved for this example, even under clear-sky conditions.

One possible solution to the problem of adjacent channel interference is to provide a slight separation between co-located satellites. A study performed in Canada showed that an improvement in isolation can be obtained in the case of two satellites transmitting cross-polarized adjacent channels by separating these satellites by a fraction of a degree such that they are seen as two distinct orbital locations by the feeder-link transmitting antennas but as co-located by the smaller receiving antennas. This removes almost completely the susceptibility of overall link adjacent channel C/I to rain fades on the feeder links at the cost of a small gain loss at the receiving terminal.

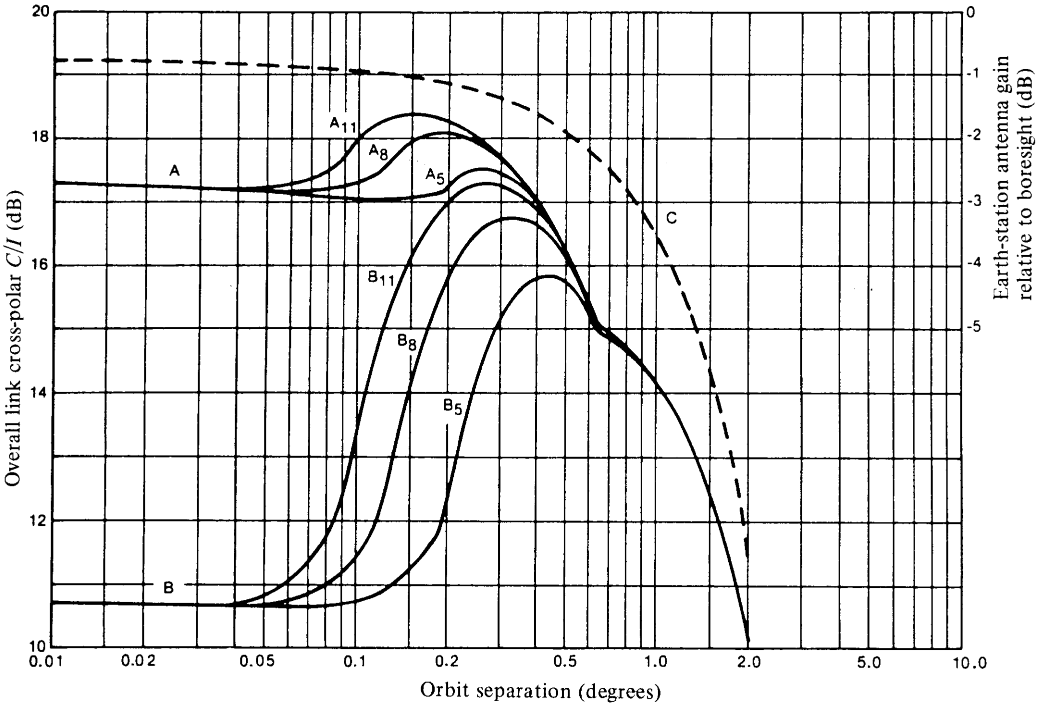
Figure 1 shows the results of a parametric study giving the overall adjacent channel C/I as a function of orbital separation and for different transmitting antenna sizes. The technical parameters adopted at the RARC SAT-83 including the transmit and receive antenna mispointings were used in this analysis. The figure also gives the variation in receiving antenna gain as a function of the orbital separation. It should be noted that 1 dB receiving gain loss due to mispointing is already taken into account in the earth-station G/T calculation.

The optimum orbital separation is the point of best polarization discrimination for faded condition on the feeder link. This represents the best trade-off between feeder-link polarization discrimination and down-link loss in gain. This optimum is found to be 0.4° for 5 m feeder-link transmitting antennas. This separation was used in the development of the plan for Region 2 at the RARC SAT-83. The use of larger transmitting antennas will shift this optimum to smaller orbital separation (e.g. 0.3° for 8 m antennas and 0.27° for 11 m antennas).

The WARC ORB-88 decided that administrations could place the satellites of a same "group" of satellites (i.e., sharing the same nominal position in the Plan) at any position no further than 0.2° away from the nominal position, provided that the agreement of the other administrations on that orbital position is obtained. The advantage of this arrangement is that it permits additional discrimination between feeder links (large transmitting antennas) whilst for the purposes of reception of the down link (small antennas) these satellites can still be considered as being at the same position.

FIGURE 1

Cross-polar *C/I* improvement through orbital separation



Curves A : clear-air conditions on feeder links and down link

B : 10 dB rainfall attenuation on the wanted feeder link

C : degradation of the earth-station receive co-polar gain

A_5 : overall link cross-polar *C/I* for 5 m antennas at the feeder-link sites (clear-air situation)

A_8 : overall link cross-polar *C/I* for 8 m antennas at the feeder-link sites (clear-air situation)

A_{11} : overall link cross-polar *C/I* for 11 m antennas at the feeder-link sites (clear-air situation)

B_5 : overall link cross-polar *C/I* for 5 m antennas at the feeder-link sites (10 dB fade situation)

B_8 : overall link cross-polar *C/I* for 8 m antennas at the feeder-link sites (10 dB fade situation)

B_{11} : overall link cross-polar *C/I* for 11 m antennas at the feeder-link sites (10 dB fade situation)

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