RECOMMENDATION ITU-R S.1431

METHODS TO ENHANCE SHARING BETWEEN NON-GSO FSS SYSTEMS (EXCEPT MSS FEEDER LINKS) IN THE FREQUENCY BANDS BETWEEN 10-30 GHz

(2000)

The ITU Radiocommunication Assembly,

considering

a) that WRC-97 confirmed the application of No. S9.12 of the RR (referred to in Resolution 46 (Rev.WRC-97)) in the bands 18.8-19.3 GHz (space-to-Earth) and 28.6-29.1 GHz (Earth-to-space) for use by non-GSO FSS systems;

b) that the use of these bands will be in accordance with RR No. S5.523A;

c) that the services using these bands are to coordinate their use of frequencies in accordance with Resolution 46 (Rev.WRC-97);

d) that Resolution 130 (WRC-97) provides the regulatory framework for the use of non-GSO FSS systems in certain frequency bands;

e) that Resolution 130 (WRC-97) calls for further studies relating to the sharing criteria to be applied for determining the need for coordination between non-GSO FSS systems;

f) that several non-GSO FSS systems are proposed to operate in the Resolution 130 (WRC-97) frequency bands and the RR No. S5.523A frequency bands;

g) that studies have shown, without the use of interference mitigation techniques, it will be impracticable for multiple non-GSO FSS systems to share the same frequency band unless they employ truly homogeneous orbital characteristics;

h) that, to promote efficient spectrum sharing, methods need to be identified to enhance sharing between multiple non-GSO FSS systems in the same frequency band;

j) that studies have shown that there are several different interference mitigation techniques that may allow multiple non-GSO FSS systems to share the same frequency band;

k) that there are system performance and interference reduction trade-offs involved in the use of certain frequency sharing methods;

l) that, in the Resolution 130 (WRC-97) frequency bands, non-GSO FSS systems are required to protect GSO FSS systems,

recommends

1 that the mitigation techniques described in Annex 1 of this Recommendation should be considered for use to achieve satisfactory sharing between co-frequency, co-directional non-GSO FSS satellite networks.

ANNEX 1

Mitigation techniques

This Annex provides a summary of mitigation techniques that may be used by non-GSO FSS systems to facilitate sharing between such networks. Seven techniques for mitigating interference between non-GSO FSS networks have been identified and studied. This Annex does not represent an exhaustive list of mitigation techniques, others may be identified in the future. These interference mitigation techniques and combinations thereof are useful to different degrees in facilitating sharing between non-GSO FSS networks.

1 Homogeneous orbits

Several non-GSO FSS systems can share the same frequency band when they employ nearly identical orbital parameters (height, inclination, etc.) and that either their orbital planes are interleaved, or their orbital planes are coincident while their satellites within a plane are interleaved, or both. Some studies have shown that interference mitigation techniques might be required if the two systems are not truly homogeneous and further studies are required to determine the level of difference between orbital and transmission characteristics that can be tolerated before the systems are no longer considered homogeneous.

2 Avoidance of in-line interference events

2.1 Satellite diversity (switching to another satellite)

The use of satellite diversity has been considered as a mitigation technique to avoid main beam-to-main beam interference by switching traffic to an alternative satellite in view whenever such in-line coupling instances occur (see Note 1). This technique has a number of system design and network operational implications which network operators have to consider before implementing it.

NOTE 1 – In-line events occur when one non-GSO satellite is directly between an earth station and another non-GSO satellite.

Satellite diversity means that near main beam-to-main beam coupling situations are avoided by the non-GSO system selecting another visible satellite whenever the current satellite approaches an in-line event with a satellite operating in another non-GSO FSS system. Satellite diversity implies performing a handover (switching) process due to reselecting the satellite for interference avoidance. Satellite diversity may require a complex process involving cooperation among the systems involved. The ability to share spectrum using this technique depends on whether the considered systems can avoid near in-line situations dynamically with the prior information of non-GSO satellite locations. It should be noted that most proposed systems intend to implement some type of satellite switching methodology to avoid the GSO arc.

To enhance interference mitigation (and, hence, sharing) through satellite diversity, it is necessary for non-GSO FSS systems to be designed to have multiple satellites capable of serving a given earth station location simultaneously. Statistics have been compiled for several proposed 14/11 GHz and 30/20 GHz-band LEO and MEO systems and have shown that the majority of the systems have at least two satellites in view of earth station locations at most latitudes of interest.

Two levels of the implementation of satellite diversity have been identified:

a) avoidance of near in-line events with all satellites of other non-GSO FSS systems;

b) avoidance of near in-line events with satellites of other non-GSO FSS systems that are capable of serving, at the considered point in time, that given earth station location.

Both of these options will require close cooperation between the satellite systems once operational. Option a) requires knowledge of the orbital characteristics of other satellite systems. Option b) requires this knowledge and may require the knowledge of the beam pointing algorithm and traffic of the satellites in the other systems. It is therefore more complex to implement option b) than option a). However, using the option b) may allow for a wider angle of avoidance since more visible satellites may be available for a given non-GSO FSS system. In the Resolution 130 (WRC-97) frequency bands, non-GSO FSS systems are required to protect GSO systems. In all proposed non-GSO FSS systems, this is done through some type of avoidance of the GSO arc (either earth-based or satellite-based). Using the knowledge of which satellites in other non-GSO FSS systems are not serving a particular area due to GSO arc avoidance will decrease the number of satellites that need to be avoided, thereby increasing the number of satellites that a given non-GSO FSS system has available to it for switching.

The satellite diversity technique involves the identification of a suitable diversity switching angle for non-GSO FSS systems to facilitate co-frequency, co-directional sharing with other non-GSO FSS systems.

It has been shown, in the case of two non-GSO satellite systems, that having both systems employ satellite avoidance simultaneously does not enhance the sharing situation. For more than two systems, sharing may also be achieved by distributing the burden among all of the systems. Regardless of how the sharing burden is distributed between all the systems, the sharing situation between any given pair will not be improved by having both of them use an angular avoidance about the other simultaneously.

2.2 Avoidance without switching to another satellite

In § 2.1, it is assumed that non-GSO FSS systems will be designed such that there is another satellite available to an earth station when near in-line events between two satellites in separate systems occur. Another option for non-GSO FSS operators is to cease transmission (not switch to another satellite) and accept the outage/loss of coverage when a near in-line event occurs.

3 Satellite selection strategies

The algorithm chosen for satellite selection by a given non-GSO FSS system may enhance the ability of that system to share with other non-GSO FSS systems. In general, earth stations will communicate with the highest elevation satellite. If a system chooses to use a different tracking technique, such as selecting the satellite that has the largest angular discrimination with respect to the satellites of other non-GSO FSS systems, the sharing situation may improve with the expense of added complexity and/or reduced capacity in system operation. This technique requires further study to assess the impact both on the sharing and on non-GSO FSS system design.

4 Satellite antenna side lobes

Low non-GSO FSS satellite antenna side-lobe levels will reduce the amount of interference to and from the main beam of non-GSO FSS earth station antennas in the case of in-line interference when the non-GSO satellite is serving a different area than the location of the earth station. In some cases, the use of low side-lobe antennas may also reduce the necessary avoidance angle (in the case of Earth-to-space avoidance) if the coverage area of a satellite does not include the specific earth station location. The impact to non-GSO FSS system design will be in the antenna cost and overall weight of the satellite.

5 Earth station antenna side lobes

The use of low side-lobe antennas on earth terminals will decrease the interference to non-GSO satellite systems on the Earth-to-space link and should allow for a smaller avoidance angle. Accompanying this technique would be antenna design costs.

6 Frequency channelization

Frequency channelization is defined as sub-dividing the authorized band into smaller bands. Each sub-band is then assigned a separate beam that is spatially separated from its nearest co-frequency beam to increase C/I levels. Dividing the frequency band in this manner may provide;

– interference reduction by decreasing the probability of overlap;

– lower interference into a wider bandwidth signal.

In addition to reducing capacity, this may complicate satellite design and may require close coordination between the non-GSO systems.

7 Link balancing

For downlink transmissions, link balancing aims at having different non-GSO FSS systems operating with near equal power flux-densities (pfd) at any given point on the surface of the Earth. If one system is operating at a certain pfd level, it appears that subsequent systems should consider operating at a similar pfd level to optimize sharing. Higher pfd levels will result in interference to the previous systems operating in the band and lower pfd levels will probably result in interference to the system entering the band.

For uplink transmissions, link balancing refers to the design of non-GSO FSS links to homogenize their transmission parameters to avoid large discrepancies between the carrier levels in one system relative to the other system.

To balance the transmission environment, the non-GSO FSS carriers in the more sensitive system could be operated with larger fixed margins to protect themselves from interference from other non-GSO carriers. Since this interference is typically short term in nature, the probability of a large fading event occurring simultaneously with an in-line interference event is small.

8 Alternate polarization

Two networks can potentially share the same frequency bands if they use opposite polarization within a given area. However, the use of polarization isolation is only useful for sharing between two systems. A third system could not maintain opposite polarization to the other two systems. This technique would require close coordination among non-GSO FSS systems.