International Telecommunication Union

ITU-R
Radiocommunication Sector of ITU

Recommendation ITU-R S.2112-0
(01/2018)

Guidelines to conduct bilateral coordination for explicit agreements, in the frequency band 14.5-14.75 GHz for Regions 1 and 2 countries, or in the frequency band 14.5-14.8 GHz for Region 3 countries, in the fixed-satellite service (Earth-to-space) not for feeder links for the broadcasting-satellite service, in order to protect all existing and planned systems of allocated services in 14.5-14.8 GHz in the territories of those administrations engaging in such agreements

S Series
Fixed-satellite service

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Note: *This ITU-R Recommendation was approved in English under the procedure detailed in Resolution ITU-R 1.*

Electronic Publication
Geneva, 2018

RECOMMENDATION ITU-R S.2112-0[1]

Guidelines[2] to conduct bilateral coordination for explicit agreements, in the frequency band 14.5-14.75 GHz for Regions 1 and 2 countries, or in the frequency band 14.5-14.8 GHz for Region 3 countries, in the fixed-satellite service (Earth-to-space) not for feeder links for the broadcasting-satellite service, in order to protect all existing and planned systems of allocated services in 14.5-14.8 GHz in the territories of those administrations engaging in such agreements

(2018)

Scope

Following the WRC-15 adoption of allocations allowing the deployment of earth stations in some Region 1 and 2 countries in the frequency band 14.5-14.75 GHz, as listed in Resolution **163 (WRC-15)**, and in some Region 3 countries in the frequency bands 14.5-14.8 GHz, as listed in Resolution **164 (WRC-15)**, in the fixed-satellite service (Earth-to-space) not for feeder links for the broadcasting-satellite service, this Recommendation aims at providing a guideline for those administrations which are engaging in bilateral coordination for explicit agreements, in the framework of RR No. **5.509E**, by offering a baseline for discussion to guarantee protection of the existing and planned aeronautical mobile service systems to all administrations involved.

The ITU Radiocommunication Assembly,

considering

a) that WRC-15 adopted allocations that allow the deployment of earth stations in some Regions 1 and 2 countries in the frequency band 14.5-14.75 GHz, as listed in Resolution **163 (WRC-15)**, and in some Region 3 countries in the frequency band 14.5-14.8 GHz, as listed in Resolution **164 (WRC-15)**, in the fixed-satellite service (Earth-to-space) not for feeder links for the broadcasting-satellite service;

b) that the clear intention behind WRC-15 decision was to protect existing and planned systems in the 14.5-14.75 GHz in Region 1 and 2 and in the 14.5-14.8 GHz in Region 3, as per RR No. **5.509F**;

c) that a set of technical and operational constraints as per RR Nos. **5.509B**, **5.509C**, **5.509D** and **5.509E** were agreed for the administrations listed in Resolution **163 (WRC-15)** or in Resolution **164 (WRC-15)**;

d) that among the above listed technical and operational constraints, RR No. **5.509E** requires that, in the frequency band 14.5-14.75 GHz in countries listed in Resolution **163 (WRC-15)** and in the frequency band 14.5-14.8 GHz in countries listed in Resolution **164 (WRC-15)** in the fixed-satellite service (Earth-to-space) not for feeder links for the broadcasting-satellite service, the location of an earth station shall maintain a separation distance of at least 500 km from the border(s) of other countries unless shorter distances are explicitly agreed by all involved administrations;

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[1] This Recommendation should be brought to the attention of ITU-R Study Group 5.

[2] The course of action described in this guiding document does not abrogate the responsibility of administrations to meet the mandatory provisions of the Radio Regulations.

e) that the separation distance of 500 km from the border(s) of other countries was derived to guarantee protection of the existing and planned systems taking into account typical characteristics of earth stations in the fixed-satellite service (Earth-to-space) not for feeder links for the broadcasting-satellite service;

f) that administrations listed in Resolution **163 (WRC-15)** or in Resolution **164 (WRC-15)** are given the possibility to modify the distance of 500 km by means of bilateral coordination for explicit agreements to be conducted among all the involved administrations, taking into account specific characteristics of the earth stations in the fixed-satellite service (Earth-to-space) not for feeder links for the broadcasting-satellite service, as well as specific terrain profile in territories of involved administrations;

g) that due care must be taken to guarantee protection to all the existing and planned operations in the fixed service, mobile service including aeronautical mobile service, and other services, when any bilateral coordination for explicit agreement is discussed;

h) that RR No. **5.509D** provided specific mechanism and pfd criteria to guarantee protection to all the existing and planned operations in the fixed service and mobile service including aeronautical mobile service stations operating over international waters, which may be characterized by the impossibility in conducting bilateral coordination for explicit agreement due to the absence of the territory of any other administration within the 500 km distance;

i) that guidance is sought on how to conduct bilateral coordination for explicit agreements, being assured that all existing and planned systems in their territories within the land borderline will be protected,

recognizing

a) that currently there is no guidance in the Radio Regulations for those administrations seeking to engage in bilateral coordination for explicit agreements, listed in Resolution **163 (WRC-15)** or in Resolution **164 (WRC-15)**;

b) that such bilateral coordination for explicit agreements, if not carefully conducted and executed, may lead to the creation of interference scenarios which may impact one or multiple existing or planned systems in the territory of administrations involved in such bilateral coordination;

c) that such bilateral coordination for explicit agreements, when properly conducted and executed, taking into account specific characteristics of an earth station in the fixed-satellite service (Earth-to-space) not for feeder links for the broadcasting-satellite service as well as the specific terrain profile in territories of involved administrations, can lead to the establishment of mitigation techniques able to provide protection to existing and planned systems in the territories of all the involved administrations, despite a resulting distance shorter than 500 km;

d) that WRC-15 instructed the Radiocommunication Bureau to develop a software tool capable of confirming that the power-flux density limit, as referred to in *noting a)*, is complied with,

noting

a) that RR No. **5.509D** states that before an administration brings into use an earth station in the fixed-satellite service (Earth-to-space) not for feeder links for the broadcasting-satellite service in some Region 1 and 2 countries in the frequency band 14.5-14.75 GHz, as listed in Resolution **163 (WRC-15)** and in some Region 3 countries in the frequency band 14.5-14.8 GHz, as listed in Resolution **164 (WRC-15)**, it shall ensure that the pfd produced by this earth station does not exceed −151.5 dB (W/(m^2 · 4 kHz)), corresponding to an I/N of −6 dB criterion for protecting an aeronautical airborne receiver, produced at all altitudes from 0 m to 19 000 m above sea level at

22 km seaward from all coasts, defined as the low-water mark, as officially recognized by each coastal state;

b) that RR No. **5.509E** states that before an administration brings into use an earth station in the fixed-satellite service (Earth-to-space) not for feeder links for the broadcasting-satellite service in some Region 1 and 2 countries in the frequency band 14.5-14.75 GHz, as listed in Resolution **163 (WRC-15)** and in some Region 3 countries in the frequency band 14.5-14.8 GHz, as listed in Resolution **164 (WRC-15)**, it shall maintain a separation distance of at least 500 km (not accounting for terrain obstruction), for protecting aeronautical airborne and transportable ground receiver, from the land borders (s) of the other countries unless shorter distances are explicitly agreed by those administration;

c) that this pfd limit of −151.5 dB (W/(m^2 · 4 kHz)), produced at all altitudes from 0 m to 19 000 m above sea level was derived to guarantee protection to all the existing and planned operations in the fixed service, mobile service, and the aeronautical mobile service (particularly the airborne receiver);

d) that with a known FSS earth station location, to meet interference protection criterion of −6 dB *I*/*N* for aeronautical airborne receiver (with altitude from 0 to 19 000 m above ground or sea level) or transportable ground receiver (with altitude from 0 to 15 m above ground level), the separation distance from the FSS earth station and other countries border could be less than 500 km depending on the terrain and FSS earth station antenna pointing scenario with respect to the land border (s) of the other countries;

e) that the use of pfd limit or other methodologies as guideline for bilateral coordination does not remove the obligations to meet a set of technical and operational previsions as per RR Nos. **5.509B**, **5.509C**, **5.509D** and **5.509E**, with the RR No. **5.509E** being applied to the shorter distance resulting from any bilateral coordination for explicit agreements;

f) that the pfd guideline is derived from existing technical characteristics and protection criteria of AMS (Rec. ITU-R M.2089-0) and MS (Rec. ITU-R M.2068-0);

g) that the pfd limit depends on the respective position of the envisaged FSS earth station with the territory of the country with which it is willing to engage a bilateral coordination,

recommends

1 that, for all configurations where the line of sight between the FSS earth station and the GSO satellite positions does not cross the airspace of any administrations, below the altitude of 8 850 m, not listed in Resolutions **163 (WRC-15)** and **164 (WRC-15)** but engaged in bilateral meetings, the pfd not exceeding –151.5 dB (W/(m^2 · 4 kHz)) from 0 m to 19 000 m above ground level from land borderline may be used as guidance in order to reduce the 500 km minimum distance as defined in RR No. **5.509E**;

2 that, for all configurations where the line of sight between the FSS earth station and the GSO satellite positions crosses the airspace of any administrations, below the altitude of 8 850 m, not listed in Resolutions **163 (WRC-15)** and **164 (WRC-15)** but engaged in bilateral meetings and the FSS earth station is located at more than 17 km from any part of the border of the country engaging in a bilateral coordination, the pfd not exceeding −151.5 dB (W/(m^2 · 4 kHz)) produced at all altitudes from 0 m to 19 000 m above ground level from land borderline may be used as guidance to reduce the 500 km minimum distance as defined in RR No. **5.509E**;

3 that, for all configurations where the line of sight between the FSS earth station and the GSO satellite positions crosses the airspace of any administrations, below the altitude of 8 850 m, not listed in Resolutions **163 (WRC-15)** and **164 (WRC-15)** but engaged in bilateral meetings, and the FSS earth station is located at less than 17 km from any part of the border of the country engaging in a bilateral coordination, the pfd not exceeding −151.5 dB (W/(m^2 · 4 kHz)) produced at

all altitudes from 0 m to 19 000 m above ground level from land borderline and −170.2 dB (W/(m^2 · 4 kHz)) for the protection of an AMS ground station produced at all altitudes from 0 m to 15 m above ground level from all land borderline may be used as guidance to reduce the 500 km minimum distance as defined in RR No. **5.509E**.

4 that, alternatively to the 17 km distance, mentioned in *recommends* 2 and 3 above, which is valid for an FSS earth station elevation of 10 degrees, should any administration seek for a more geographically specific analysis, equation (1) from Annex 2 may be used in order to derive a reference value for the deployment distance (in km) for the FSS earth station, from the land border of a country not listed in Resolutions **163 (WRC-15)** and **164 (WRC-15)** but involved in bilateral meetings;

5 that the pfd levels in the above recommends be updated, should there be subsequent updates of *I*/*N* criterion to protect AMS or other applicable parameters in Recommendations ITU-R M.2089-0 and ITU-R M.2068-0 that would affect these levels;

6 that the administrations involved in such bilateral coordination for explicit agreements may use the tools developed by the Bureau for verifying RR No. **5.509D** in the context of this Recommendation;

Annex 1

Formulas for converting *I*/*N* value to pfd value for protecting airborne and transportable ground receiver in the aeronautical mobile service

Power-flux density limit (pfd_{limit}) referred in *recommends* 1 to 4 for protecting airborne receivers and transportable ground receivers operating on land, both operating in the aeronautical mobile service (AMS) are derived from the following formulas using parameters of Table 1 coming from Recommendations ITU-R M.2089-0 (AMS) and ITU-R M.2068-0 (MS).

$$pfd_{limit} = I/N_{AMS} + N_T - A_{eff} + 10 \log (4/1000) \qquad (\text{dB(W/m}^2\text{)/4 kHz})$$

where:

I/N_{AMS}: *I*/*N* criterion to protect AMS (dB) = −6 dB

N_T[3]: station receiving system noise power level = $k\,T\,B$ (W)

k: Boltzmann's constant = 1.38×10^{-23} (J/K)

T: AMS station receiving system effective noise temperature (T should be calculated by the following formula:

$10 \log T = NF + 10 \log T_0$

where NF (dB) is the receiver noise figure and T_0 should be assumed as 290 K

B: reference bandwidth = 1 MHz

A_{eff}: effective aperture in 1 m^2 = $R_{xGain}\,\lambda^2 / (4\,\pi)$

[3] Different methods of calculating Noise Power (N_T) based on noise figure could result up to 1 dB difference. Due to that reason, the station receiving system noise power and calculated *I*/*N* here have ~ 0.7 dB difference from the model used at WRC-15.

R_{xGain} : receive AMS Antenna Gain in direction of FSS earth station (dBi)

λ : wavelength = $3*10^8$ / *freq* (m)

freq : frequency (Hz).

TABLE 1

Parameters used to derive pfd limit to protect AMS airborne and transportable ground receiver in a main lobe to main lobe interference scenario

Parameter	FSS ES –> AMS Ground Receiver	FSS ES –> AMS Airborne Receiver	Unit
Rx AMS antenna gain in direction of FSS earth station	45	27	dBi
Rx AMS noise figure	*4*	*4*	dB
I/N Criterion to protect AMS	*–6*	*−6*	dB

Annex 2

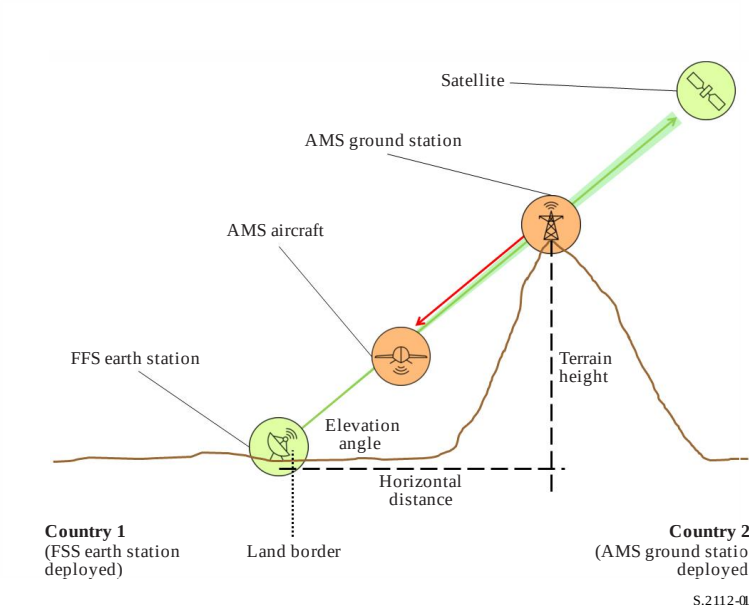
Consideration concerning the main lobe to main lobe interference scenario for AMS ground station with FSS earth station at 10 degree minimum elevation angle

The scope of this Annex is to assess the risk for main lobe to main lobe interference from FSS earth station into the AMS ground station when an FSS earth station is deployed within the territory of any of the countries listed in Resolutions **163 (WRC-15)** and **164 (WRC-15)** and located in the proximity of the land border of any country.

As shown in Fig. 1, the main lobe to main lobe interference scenario could only occur when an AMS ground station is operating and deployed at an altitude that is high enough to allow an AMS aircraft to fly below the associated ground station, in the airspace limited between the border of the country where the FSS earth station is deployed and the altitude of the terrain where the AMS ground station is deployed.

FIGURE 1

Configuration where main lobe to main lobe interference scenario from FSS earth station to AMS ground station may occur



This Annex shows configuration when it is required to take into account the main lobe to main lobe interference scenario for AMS ground station.

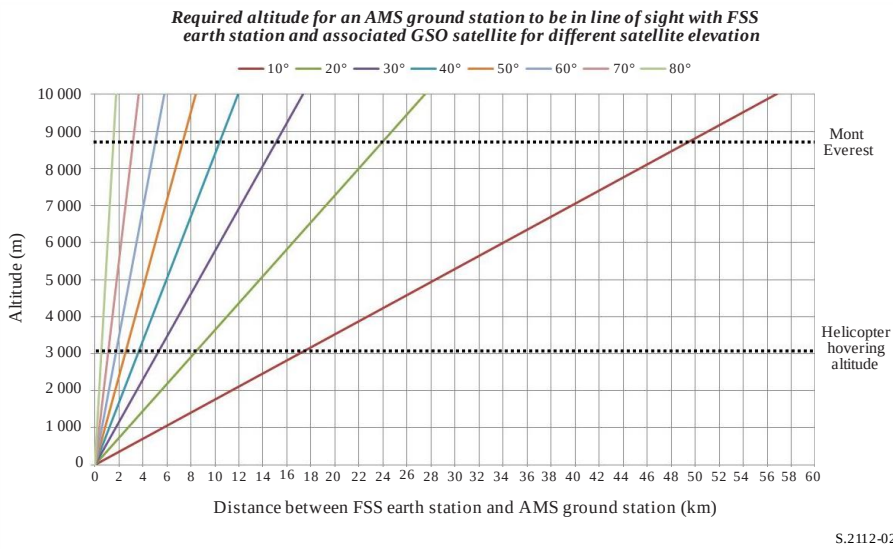
1 Considerations about the operational conditions and requirements of the FSS earth stations deployed in countries listed in Resolutions 163 (WRC-15) and 164 (WRC-15)

For all administrations land border it is possible to introduce some trigonometric considerations to define what is the minimum terrain altitude where an AMS ground station should be installed in order for that AMS ground station to be able to suffer from main lobe interference caused by any FSS earth station, considering that any operational FSS earth station can look at the GSO satellite position with a minimum elevation angle of 10 degrees and that the tallest peak on Earth is as high as 8,850 metres (despite the fact that it may be commonly agreed that no AMS ground station would likely be deployed on the top of the mount Everest).

The results are hereby reported in Fig. 2, for all Elevations from 10 to 80 degrees and for the cases when the horizontal distance between the FSS earth station and an AMS ground station is comprise between 0 (co-location) and 60 km. The Azimuth does not play any role in this calculation, as a trigonometric linear distance is calculated, and that is valid regardless of the Azimuth values). For all the cases, the minimum terrain height (delta between the FSS earth station altitude and the AMS ground station altitude) is calculated, for an AMS ground station to have the possibility to be in the line of sight between an FSS earth station and a GSO satellite position.

FIGURE 2

Minimum configuration requirements for the main lobe to main lobe interference scenario depicted in Fig. 1 to occur



From Fig. 2, it is possible to see that, even without performing deeper studies, the configuration proposed in Fig. 1 can only occur when the required altitude for an AMS ground station to be in line of sight with FSS earth station and associated GSO satellite position is lower than the envisaged altitude for the AMS ground station. If the AMS Ground Station is located on the top of the Mount Everest and the envisaged FSS earth station transmits with an elevation of 10 degrees, this FSS earth station shall be located at 50 km from an AMS ground station. With an elevation of 40 degrees, this distance is reduced to around 10 km.

In addition, following specific discussion on the matter, and recognizing the uniqueness of the case corresponding to the 50 km distance, a more thorough assessment can be made. In fact, it can be noted that the highest terrain points on the planet, that also are within 500 km from the land border of any country neighbouring any of the 39 countries listed in Resolutions **163 (WRC-15)** and **164 (WRC-15)**, in different continents, are Mount Aconcagua (6 961 m) in South America, Mount Elbrus (5 642 m) in Central Eurasia), and Mount Puncak Jaya (4 884 m) in Oceania. It is therefore possible to calculate the distance in km where an FSS earth station could be installed from, assuming that an AMS ground station was installed on those mountain tops and assuming an FSS earth station operating with an elevation of 10 degrees (i.e. the minimum operational elevation on the horizon for transmissions in the 14.5-14.8 GHz frequency range). The resulting minimum distance from Mount Aconcagua is 39 km; from Mount Elbrus is 32 km; from Mount Puncak Jaya is 28 km.

It is also possible to consider that the maximum hovering altitude of any helicopter is 10 000 feet, corresponding to approximately 3 050 m. This implies that no helicopter could carry, for installation purposes, any AMS ground station on a mountain top that is higher than 3 050 m. Therefore, it is possible to calculate the minimum distance beyond which the main lobe to main lobe interference scenario is not a geometrically viable option, and the result is approximately 17 km.

As a consequence of the above, it is possible to conclude that the pfd approach has full validity as a guideline to reduce the 500 km distance for land borders, as long as a minimum distance of 17 km is respected by the FSS earth station, without needing to consider any main lobe to main lobe interference between the FSS earth station and the AMS ground station.

It is also suggested that, for the sake of a more detailed assessment, each administration willing to engage in bilateral coordination meetings, uses the below formula to derive the appropriate

minimum horizontal distance between their land border, potentially different from the 17 km and, consequently, the location for the FSS earth stations deployment; in fact, this formula allows the administrations to take into account the very specific terrain conditions (i.e. maximum altitude) within their territories:

$$dist = alt / (1\,000 \bullet tan(elev)) \quad (1)$$

where:

dist : required deployment distance (in km) for the FSS earth station from the land border a country not listed in Resolutions **163** or **164 (WRC-15)** but involved in bilateral meetings to be in the main lobe to main lobe interference scenario

alt : maximum AMS ground station deployment altitude (in m)

elev : elevation (in degree) of the envisaged FSS earth station to be implemented.

In any case, it is also important to notice that the main lobe to main lobe interference scenario described in Fig. 1 is only possible if perfect tri-dimensional alignment of lines of sight between FSS earth station and satellite, and AMS ground station and AMS aircraft, happens. This is due to the fact the FSS earth station beam has a very high directivity/gain, in virtue of its required minimum antenna diameter of 6 meters associated to the 14.5-14.8 GHz operating frequency.

2 Considerations related to AMS aircraft antenna configuration

One other very relevant fact to consider is that, in order for it to communicate with the AMS ground station, the antenna installed on board the AMS aircraft is installed on the lower surface of the aircraft and not on the upper surface. By looking at Fig. 1, it is now possible to notice that for that configuration to occur, the AMS aircraft should fly at a significantly lower altitude than the one where the AMS ground station is deployed, therefore posing a serious threat to its own communications, as the body of the AMS aircraft would represent a continuous obstacle to the link with the AMS ground station.