**Annex 3.1.**

**General aspects of international frequency coordination**

**Introduction**

All administrations have sovereign right to use the spectrum on the whole territory of their countries. However physical behaviour of radio wave propagation does not allow to fully preclude signals radiation on the territory of other countries, especially for signal transmission towards or close to border areas.

This is why possible harmful interference from stations of different services of one administration into the territory and associated stations of neighbouring administration may occur.

**Responsibility of authorities for link planning and link availability**

For many authorities it is the major task to take care for compatibility issues only with regard to other stations especially from other operators.

This is the reason why the main focus of the handbook covers all important aspects for coordination.

Regulatory concepts can be applied, where parts of bands are pre assigned to operators, where it is their responsibility to avoid harmful interference between their own stations.

Authorities may define conditions for minimum data rate, possible channel bandwidths for reasons of spectrum efficiency, but also on minimum link length and maximum eirp-limits specified for the different bands.

For shorter links further reduced eirp-limits can be demanded, in order to optimize possibilities for frequency reuse.

This is the reason why in many cases authorities don´t care and don´t check predicted link availability with respect to the wanted signal planning.

This kind of planning is usually up to the operator and his responsibility.

Detailed topological and special morphological data is useful for such detailed link planning, especially also actual data for buildings and other obstacles such as wind farms.

The influence of wind farms on link planning is a recent matter of interest for further research and studies.

Links crossing wind farm zones suffer from time dependent obstacles within their geometrical transmission area depending on rotor arm shapes and link polarization.

Circular polarization seems to be most critical in such cases.

For most authorities the responsibility for adapting links according to avoid negative influence caused by existing or planned future wind farms is up to the operator and not under the responsibility of the authority.

1. **General method 1: Idealized coordination method**

 The most efficient method for coordination of FS stations in a border region is frequency assignment planning, where neighboring administrations have entire information regarding parameters of planned and operated FS stations of the affected administrations. In such a case the impact of harmful interference can be calculated during coordination of the planned FS station.
Although the situation just described is very rare in border coordination practice, such approach shows the idealized coordination process providing maximum efficiency at minimum probability of neglecting harmful interference. For such an approach no difference is done between determination of coordination trigger and the calculation to determine the mutual impact of a new or modified frequency assignment of requesting administration to stations of the affected administrations.

In order to determine coordination trigger for FS radio relay stations, which is actually the limit between accaptabel and harmful interference according to this approach, the maximum permissible threshold sensitivity degradation (TD) for the victim receiver is used as the relevant criterion

 The receiver threshold sensitivity is determined as a minimum signal level providing the required quality of received signal affected by the receiver thermal noise only. For example a received signal quality with a BER=10--6 for digital FS systems can be defined. To maintain the specified quality figure, the signal level should be increased by the TD value under the combined impact of harmful interference and the receiver thermal noise.

The TD value can be derived from the equation:

), (1)

where:

TD – permissible threshold degradation of receiver sensitivity (dB);

Iperm(20%) – permissible input interference level exceeded 20% of time (dBW);

N = 10lg(k×T0×BRx)+NF – receiver noise in necessary signal bandwidth, BRx (dBW);

NF – receiver noise factor (dB);

k= 1,38\*10-23 – Boltzmann's constant (J/К);

T0= 290К – normal receiver noise temperature in Kelvin;

BRx – necessary receiver bandwidth (Hz).

 Estimating the “long-term” harmful interference impact during coordination of frequency assignment to FS radio relay station, the recommended TD level is usually defined within the range 0.5 to 1 dB.

The relation between TD level and I/N is defined according to equation 1. TD=1dB corresponds to I/N= –6 dB and TD=0.5 dB corresponds to I/N= –10 dB.

The permissible input interference exceeded 20% of time, can be defined as:

, (2)

or permissible power flux density (PFD) of harmful interference at the antenna input at height above ground level (agl), exceeded no more than 20% of time, :

. (3)

The interference level of interfering transmitter stations causing harmful interference at the input of receive station is defined as:

 (4)

or PFD of harmful interference from the transmit station caused at the input of the receive antenna at height agl, exceeded no more than 20% of time:

-, (5)

where:

– output power of interfering transmit station (dBW);

– antenna and feeder loss of transmit station (dB);

– maximum antenna gain of interfering transmit station (dB);

– propagation loss (dB);

*d* – distance between victim receive station and interfering transmit station (km);

*f* – operating frequency of interfering transmit station (MHz);

 – height of transmit antenna agl (m);

 – height of receive antenna agl (m);

 – maximum antenna gain of victim receive station (dB);

– antenna and feeder loss of victim receive station (dB);

 – attenuation of interference, due to antenna radiation pattern of interfering transmit station and radiation pattern of receive station, as well as polarizations used by transmit and receive stations (dB);

*MD* – attenuation of interference taking into account mask of interfering transmit spectrum and frequency selectivity of receiver, (dB).

 (6)

where:

*P*(*f*) – power density of harmful interference;

*H*(*f*) – frequency selectivity of receiver;

*BTx –* necessary radiation bandwidth of interfering transmitter;

*BRx –* necessary receiver bandwidth (3dB).

A concept of “reference bandwidth”, *Bref,* is introduced to simplify the calculations. *Bref* is to be selected as follows:

Bref ≤ min(BTx, BRx), (7)

 Bref is to be selected according to the possible parameters of radio relay stations, and may be equal to 1 Hz or 4 kHz or 1 MHz.

To determine the level of harmful interference at the receiver input, it is necessary to calculate propagation loss for known initial propagation data considering path profile and morphological data of radio-climatic zones within geographical areas under the method given in Recommendation ITU-R P.452-14.

 For a correct application of this method and calculation of , digitized maps containing data on surface profile (topographical data) and codes of radio-climatic zones within geographical areas (morphological data) will be required. .

## General method 2: Application of permissible power levels

In many cases the complete information on FS station parameters of neighbor administrations is not available and calculation of harmful interference during coordination of planned FS station is not possible in an exact manner. Therefor some assumptions on possible FS station parameters of neighbor administrations are required, in order to determine the coordination trigger.

This is done by replacing parameters of unknown FS stations in equations (4) and (5) by system parameters of FS stations. Then it is possible to pass on to the determination of harmful interference on border and territory of the affected neighbor administration using parameters of a coordination area around FS stations of the requesting administration with a new or modified frequency assignment.

This section describes procedures and system parameters needed for calculation of the coordination area around FS stations.

The coordination area around FS stations for the determination of a coordination trigger:

, is the area around transmit/receive *station of fixed service* outside which permissible interference is not exceeded and, hence, coordination of frequency assignments is not required. Coordination area is defined on the basis of conservative or known characteristics of coordinated FS station and on the basis of the conservative or known initial data for propagation path and for system parameters of the unknown stations sharing the same frequency band with the FS station. The coordination area is not an exclusion area in which sharing between FS station and other stations is prohibited, but rather defined an area, where detailed analysis for existence has to be undertaken. In most cases more detailed analysis shows that sharing within a coordination area is possible, because the procedure for determination of the coordination area is based on worst case assumptions of possible interference. For the determination of coordination area it is necessary to consider two separate cases:

* FS transmitter stations, which could cause interference to FS receiver stations;
* FS receiver stations, which could be interfered by transmitter stations of other services.

Considering that definition of coordination area is based on the concept of permissible harmful interference to radio relay receiver stations in the Fixed Service, propagation loss in order to limit interference level is defined by «minimum required loss» along propagation path, which shall be equal to *p%=*20% of time.

*Coordination distance,* *dcoord*, taking into account equations (1), (2), (4) and (7), may be derived from the following equation:

, (8)

or taking into account equations (1), (3), (5) and (7):

-

, (9)

where:

output power of transmit station within reference bandwidth, *Bref* (dBW/*Bref*);

power flux density within reference bandwidth, *Bref*, which can be exceeded *p*% of time at the input of receive antenna at the height *HRx* (dBW(/Hz×m2)).

## General method 3: Use of coordination distances for ITU purpose

When defining necessity for coordination of the FS radio relay station, based on the known system parameters of coordinated station, system parameters of the unknown FS radio relay station and conservative initial data for propagation path, the maximum coordination distance is taken as coordination trigger, provided that equiprobable mutual orientation of radio relay station antennas covers 99% of cases.

For this case equation (8) will take the following form:

. (16)

Equation (9) in this case will be as follows:

, (17)

where:

 – transmit radio relay antenna gain in the direction of off-axis angle ;

 – receive radio relay antenna gain in the direction of off-axis angle .

We assume that . The may be defined as degree as the specified permissible number of equiprobable azimuthal mutual orientation of antennas.

Propagation path loss for this case is calculated using conservative initial data for propagation path without considering path profile and for propagation above land. Also the following mechanisms of interference propagation were considered: line-of-sight, diffraction over spherical Earth, and troposcatter.

Initial data for use of coordination distance are:

1) Planned transmit (receive) frequency *f*Tx, (*f*Rx), GHz;

2) Geographic coordinates for the location of radio relay station:

i) Latitude ϕTx (degrees, minutes, seconds);

ii) Longitude ψTx (degrees, minutes, seconds).

3) Digitized maps, containing coordinates of borders between geographical areas of administrations, administration designations (codes) in geographical areas.

Table 1 shows maximum coordination distances, , calculated for system parameters from Table 1 of Attachment С for specified frequency bands.

Table 1

| Frequency bands | Maximum coordination distance, km |
| --- | --- |
| >1 000-5 000 MHz | 300 |
| >5 000-10 000 MHz | 170 |
| >10 000 MHz-12 GHz | 100 |
| >12-20 GHz | 100 |
| >20-24,5 GHz | 80 |
| >24,5-30 GHz | 80 |
| >30-39,5 GHz | 80 |
| >39,5-43,5 GHz | 80 |

 The maximum coordination distance from the Table is used to determine the necessity for coordination of any notifying radio relay station depending on notified frequency assignments and real minimum distance from the territories of foreign administrations.

The procedure for defining the necessity for coordination consists of calculation of coordination area around the notifying transmitter or receiver radio relay station, with the coordinates of the area center coinciding with the location of the radio relay station, and the radius of coordination contour equal to the maximum coordination distance from Table 1 for the frequency band, which covers the planned frequency assignment of the station. In case, when the calculated coordination area overlaps territory of foreign administration, coordination is necessary, in opposite case – coordination isn’t necessary.

## Agreement between administrations on a method to determine whether the criteria has been exceeded

The process of identification of affected stations of neighbouring administrations begins with a preliminary identification of the sites, where the new systems will be deployed. Based on this list, which presents the geographic coordinates of each station, and considering the position of the stations of the neighbouring systems operating close to the border and that use the same frequency band, it is possible to map, at the same graphic, all stations affected. New stations close to the border have a restricted range, which can be measured, or in some cases, specified as a medium value for these sites. It allows to clasify stations according to their distance to the border, which means to identify the critical and potentially interfering stations as described below:



 It is possible to focus consideration only on those sites, whose deployment can effectively result in harmful interference on receiver stations on the other side of the border.

In order to ensure the correct interference free operation of terrestrial systems, the deployment of new stations located within the border zones makes interference analyses necessary. A reference level for the signal has to be taken into account. Table 9.1.1 defines a maximum signal level to the boundary line, considering the range given by Table 9.1.2, whose distances are referenced to the boundary line.

Table 2.

|  |  |
| --- | --- |
| Frequency band(MHz) | Maximum signal level at border line (dBm) |
| TBD | TBD |

TABLE 3.

|  |  |  |
| --- | --- | --- |
| Frequency band(MHz) | Minimum distance(km) | Maximum distance(km) |
| >1 000-5 000 MHz | TBD | 300 |
| >5 000-10 000 MHz |  | 170 |
| >10 000 MHz-12 GHz |  | 100 |
| >12-20 GHz |  | 100 |
| >20-24,5 GHz |  | 80 |
| >24,5-30 GHz |  | 80 |
| >30-39,5 GHz |  | 80 |
| >39,5-43,5 GHz |  | 80 |

 Stations to be deployed within the range of the minimum distance can be indicated as “critical” and are strongly recommended to be submitted for further detailed interference analyses .

Stations, which are between the maximum and minimum distance, may be indicated to be submitted to interference analyses, if the signal level on the boundary line is equal or greater than the maximum signal value of Table 2.

 Stations located beyond the maximum distance may not be considered relevant for sharing studies.

## General method 5: Use of coordination distances for HCM purpose

 Values are defined in Annex 11 of HCM Agreement.

**References:**

* Radio Regulations (Edition 2012)
* ITU-R Recommendations (F)
* HCM Agreement (2014)