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COORDINATION OF EARTH STATIONS WITH RESPECT TO TERRESTRIAL STATIONS AS WELL AS OTHER EARTH STATIONS

1 Introduction

This document describes the requirement and procedure of coordination of an earth station with respect to terrestrial stations and earth stations operating in the opposite direction of transmission in bidirectionally allocated bands, applicable only to assignments in the bands allocated with equal rights (as defined in § 1 of Appendix **5** of the Radio Regulations).

2 Requirement of coordination

Article **6** (**CS 37**) of the Constitution of the Union provides, among other things, that all members are bound to abide by the Constitution, the Convention and the Administrative Regulations in all telecommunication offices and stations established or operated by them which are capable of causing harmful interference to the radio services of other countries.

Therefore, it is the responsibility of the administrations to ensure that unacceptable interference does not occur between radio services of other administrations sharing the same frequency bands. The international rights and obligations of administrations in respect of their own and other administrations' frequency assignments is derived from the recording of those assignments in the Master International Frequency Register (the Master Register) or from their conformity, where appropriate, with a plan (No. **8.1**).

Such rights are conditioned by the provisions of the Radio Regulations (RR), such as in Article **9**, to be applied before an administration notifies the Radiocommunication Bureau or brings into use any frequency assignment to a satellite network or an earth station.

Coordination of satellite networks and certain specific types of earth stations governed by the provisions of Nos. **9.7** to **9.14** are explained in detail by other documents presented in the seminar. In the ensuing paragraphs, the procedure for effecting coordination between earth stations and terrestrial stations (under Nos. **9.15** or **9.17**) or between earth stations operating in the opposite direction of transmission (under No. **9.17A**) when it operates in bands allocated with equal rights, is explained.

3 Procedure for effecting coordination of earth stations with respect to terrestrial stations as well as other earth stations operating in the opposite direction of transmission

Coordination of earth stations with respect to terrestrial stations or earth stations operating in the opposite direction of transmission is based on the concept of a coordination area. The procedure for effecting coordination of earth stations involves:

– collection of coordination data using SpaceCap program (see RR Appendix **4** Annex 2), preparing the coordination contour using GIBC/AP7 program (see RR Appendix **7**) and providing coordination information by Administration A to any concerned Administration B;

– action taken by Administration B receiving the coordination information;

– consultation between Administrations A and B as required; and

– conclusion of coordination agreement or disagreement between administrations.

The explanation of the procedure is mainly based on the provisions of Article **9**, Appendix **5** and Appendix **7** of the Radio Regulations.

4 The Modification of Appendix 7 by WRC-19

WRC-19 revised the following elements of Appendix **7 (Rev. WRC-19)**, which will enter into force on 1 January 2021 as mentioned in Article **59** of the Radio Regulations:

- Editorial corrections on some references have been made in various sections of Appendix **7**.
- Some frequency bands or services were added in Tables 7c, 8d and 9b.
- In order to avoid any possible confusion, the word '(mobile)' was deleted from the previous title 'Aircraft (mobile) (all bands)' in Rows 2 and 3 of Table 10.

5 The concept of the coordination area

Appendix **7** of Radio Regulations explains the concept and the detailed methods for the determination of the coordination area around an earth station in the frequency bands between 100 MHz and 105 GHz.

The *coordination area* is defined as "the area surrounding an *earth station* sharing the same frequency band with *terrestrial stations*, or surrounding a transmitting *earth station* sharing the same bidirectionally allocated frequency band with receiving *earth stations*, beyond which the level of *permissible interference* will not be exceeded and coordination is therefore not required" (No. **1.171**).

Methods for determination of the coordination area is based on the *coordination distance* (No. **1.173**) on a given azimuth from an *earth station* sharing the same frequency band with *terrestrial stations*, or from a transmitting *earth station* sharing the same bidirectionally allocated frequency band with receiving *earth stations*, beyond which the level of *permissible interference* will not be exceeded and coordination is therefore not required. The coordination distances in all azimuths around the coordinating earth station define a contour, called the coordination contour, that encloses the coordination area (No. **1.172)**.

It is important to note that, although the determination of the coordination area is based on technical criteria, it represents a regulatory concept. Its purpose is to identify the area within which detailed evaluations of the interference potential need to be performed in order to determine whether the coordinating earth station or any of the terrestrial stations, or in the case of a bidirectional

allocation, any of the receiving earth stations that are sharing the same frequency band will experience unacceptable levels of interference.

Hence, the coordination area is not an exclusion zone within which the sharing of frequencies between the earth station and terrestrial stations or other earth stations operating in the opposite direction of transmission is prohibited, but a means for determining the area within which more detailed calculations need to be performed. In most cases, a more detailed analysis will show that sharing within the coordination area is possible since the methods for determination of the coordination area are based on unfavourable assumptions with regard to the interference potential.

The coordination area of the successfully coordinated earth stations will represent a geographical area around the earth station location, where it has the right to operate with its coordinated characteristics and the levels of accepted interference vis-à-vis the terrestrial and earth stations (operating in the opposite direction of transmission) of neighbouring countries. Therefore, an administration intending to put into operation terrestrial stations or earth stations operating in the opposite direction of transmission that are located within the coordination area of an earth station and that have not been considered during the coordination of the earth station, shall request coordination with the administration responsible for the earth station before bringing them into use. The relevant coordination procedures applicable to transmitting terrestrial stations are contained in Section II of Article **9** of the Radio Regulations.

The latest versions of Recommendations ITU-R SM.1488, ITU-R P.452 and ITU-R P.620 may also be referred to.

6 Coordination information (Appendix 4)

The administration responsible for the planned earth station should collect general characteristics of the earth station (such as geographical location, horizon elevation angles, orbital location of the satellite), antenna characteristics (such as transmitting and receiving antenna gain, radiation pattern, receiving system noise temperature) and the characteristics of each group of frequency assignments (such as transmitting and receiving frequency bands and power density).

Coordination contours can now be drawn with the above information by entering these values in an appropriate computer program (AP7 embedded in GIBC), which calculates the coordination distance and prepares the coordination contours for the earth station.

Based on the coordination contour, other administration(s), the territory of which falls partially or completely within the coordination area, can be identified. These are the countries with which coordination is to be effected for the planned earth station (No. **9.28**). Names of these administrations are entered in the Appendix **4** form (column A5/A6) for the earth station along with the other information as described in Annex 2 to Appendix **4.** This form containing all the relevant information along with the coordination contours comprise the coordination information for the earth station and should be captured via the SpaceCap program (one of BR software in BR IFIC DVD-ROM) and the administration can use this data as a input of AP7 program to define the coordination area.

When the administration sends the coordination request to other concerned administration(s) (No. **9.29**), it could use this captured data (as .mdb file) instead of the paper version of Appendix **4** information.

Also, the administration should send a copy of the coordination contour (the output of AP7 program) together with the coordination data (No. **9.31**).

7 Establishment of the coordination area of earth stations in a fixed location (9.15/9.17)

Separate coordination contours are produced for transmitting and receiving assignments of an earth station. Depending on the frequency band, type of service and nature of the satellite orbit, coordination areas could be determined by the predetermined coordination distances or computed by using the methods given in Appendix **7**.

Appendix **7** contains procedures and system parameters for calculating an earth station's coordination area, including predetermined distances.

Brief features of the Appendix **7** are:

- The frequency range where it can be used is 100 MHz-105 GHz.
- Three propagation models corresponding to the frequency ranges 105-790 MHz, 790 MHz-60 GHz and 60-105 GHz.
- Transmitting earth station and receiving earth station are considered separately.
- Different calculation methods to determine the coordination area around an earth station according to different type of space stations (i.e. GSO or non-GSO system).
- A method to determine the coordination area around a transmitting earth station with respect to receiving earth stations (bidirectional case) was added during WRC-2000.
- Auxiliary contours can be drawn for the detailed discussion (as a complementary information subject to an agreement between the coordinating Administration and the coordinated Administration).
- System parameter tables for the unknown terrestrial stations, or the unknown receiving earth stations.
- Predetermined coordination distances for some services and frequency bands.

When the coordination area is based on the detailed method, and not on a predetermined coordination distance, calculations are performed separately for great circle propagation mechanisms (propagation mode (1)) and for scattering from hydrometeors (propagation mode (2)).

For each mode of propagation, interference may arise through a range of propagation mechanisms whose individual dominance depends on climate, radio frequency, time percentage in question, distance and path topography. At any given point in time, one or more mechanisms may be present and major propagation phenomena considered in the determination of the interference potential are "Diffraction", "Tropospheric scatter", "Surface ducting", "Elevated layer reflection" and "refraction and hydrometeor scatter", as shown Figure 1.

In Appendix **7**, propagation phenomena are classified into two modes as follows:

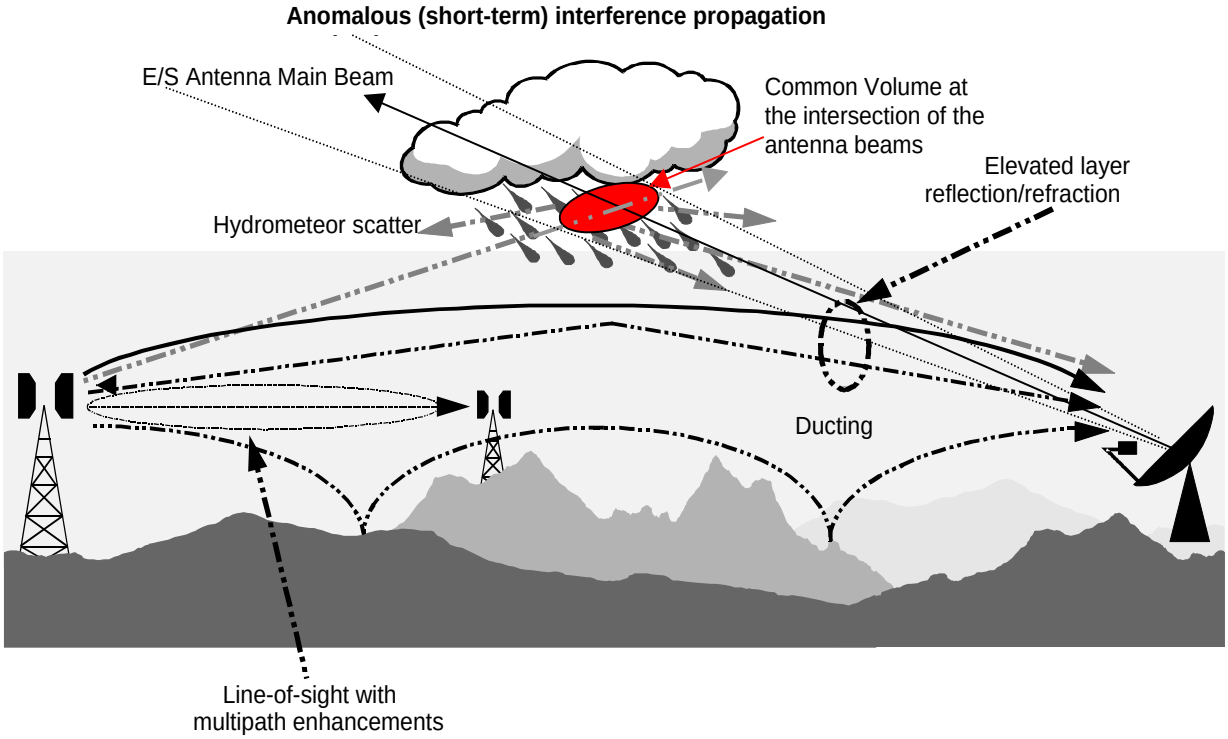
– *Propagation mode (1)*: propagation phenomena in clear air (tropospheric scatter, ducting, layer reflection/refraction, gaseous absorption and site shielding). These phenomena are confined to propagation along the great-circle path.

  The diffraction effect is referred to as "site shielding" associated with elevation angle of the earth station. The remainder of the path along each radial is considered to be flat and therefore free of additional diffraction losses. Therefore, it is important to consider the real horizon elevation angle because the level of attenuation for the propagation mode (1) path loss can be different depend on the *(positive or negative)* horizon elevation angle.

– *Propagation mode (2)*: hydrometeor scatter.

Where the coordinating earth station antenna beam intersects a rain cell, a common volume may be formed with a terrestrial station beam or an earth station beam. This can be represented by a vertical cylinder filled with hydrometeors that give rise to isotropically scattered signals. The size of the common volume, and the number of scattered signals within that volume, increases as the gain of the earth station antenna decreases.

FIGURE 1



The coordination contour is then determined using the greater of the two distances predicted by the propagation mode (1) and propagation mode (2) calculations for each azimuth around the coordinating earth station.

The methodology of calculation of the coordination area of an earth station is, obviously, based on the most unfavourable case assumptions as regards parameters of unknown terrestrial or earth stations and its interference potential, such as the maximum transmitting e.i.r.p. and constant value of receiving antenna gain of terrestrial stations in all directions. In practice, these worst-case assumptions do not correspond to reality. Practical experience has shown that, in many cases, the separation distance required for the coordinating earth station, on any azimuth, can in fact be substantially less than the coordination distance, due to the fact that the terrestrial station antenna gain (or e.i.r.p.), or receiving earth station antenna gain in the case of earth stations operating in the opposite direction of transmission, in the direction of the coordinating earth station, is less than that assumed in calculating the coordination contour. In the interest of simplifying coordination, therefore, auxiliary contours are drawn which use the same method as that used to determine the corresponding main contour.

The minimum required loss progressively reduced by, for example, 5 dB, 10 dB, 15 dB or 20 dB, etc., below the value derived from the parameters assumed (for example in Tables 7, 8 or 9 of Appendix **7**) for the corresponding main propagation mode (1) contour and/or main beam avoidance

angles of 2.0°, 3.0°, 4.0° or 5.0°, etc. for propagation mode (2) can be drawn as auxiliary contours in the same manner as the main coordination contours. For example, if the difference between the actual antenna gain and the gain of the generic antenna is 5 dB, then the –5 dB auxiliary contour in Mode1 should be used. If the main beam of the coordinating earth station does not intersect exactly with the terrestrial station antenna beam, but intersects with the offset of 2.0°, then the 2.0° auxiliary contour in Mode 2 should be used.

8 Predetermined coordination distances for mobile earth stations and earth stations in specific services and specific frequency bands with respect to terrestrial stations (Nos. 9.15/9.17)

The coordination area of mobile earth stations is determined by the service area in which it is intended to operate typical earth stations, extended in all directions by the coordination distance. Table 10 of Appendix **7** provides the predetermined coordination distances in the case of mobile earth stations with respect to airborne mobile stations.

In addition, WRCs have introduced various predetermined coordination distances in Table 10 for specific services or specific frequency bands between earth stations and terrestrial stations.

In order to apply any predetermined coordination distance, however, the Administration is kindly requested to carefully review all frequency allocations with the relevant footnotes in Article **5** of Radio Regulations related to the planned frequency bands, and then to apply the suitable distance from Table 10 with regard to the related terrestrial service.

8.1 Airborne earth stations with respect to ground-based terrestrial stations or ground based earth stations with respect to airborne terrestrial stations

If a planned earth station is on aircraft, a 500-km predetermined coordination distance is to be applied with respect to any ground-based terrestrial station. Similarly, for a planned ground-based earth station with respect to terrestrial station onboard aircraft, a 500-km predetermined coordination distance is to be applied.

When it is not clear from the frequency allocation table in Article 5 that the same frequency band is allocated to the aeronautical mobile service or aeronautical radionavigation service in the concerned neighbouring countries because the band is allocated to a generic terrestrial service like the mobile service or the radionavigation service, the coordination situation should be verified between the concerned administrations in order to determine whether the 500-km predetermined coordination distance should be considered or not.

8.2 Airborne earth stations with respect to airborne terrestrial stations

If the planned earth station is onboard an aircraft, a 1 000-km predetermined coordination distance is to be applied with respect to airborne terrestrial stations.

When it is not clear from the frequency allocation table in Article 5 that the same frequency band is allocated to the aeronautical mobile service or aeronautical radionavigation service in the concerned neighbouring countries because the band is allocated to a generic terrestrial service like the mobile service or the radionavigation service, the coordination situation should be verified between the concerned administrations in order to determine whether the 1000-km predetermined coordination distance should be considered or not.

9 Coordination area of earth stations with respect to other earth stations operating in the opposite direction of transmission in bidirectionally allocated bands (No. 9.17A)

9.1 Transmitting earth stations

The procedure for determining the coordination area of a transmitting earth station with respect to other earth stations operating in the opposite direction in bidirectionally allocated bands is described in § 3 of Appendix **7**. Tables 9a and 9b of Annex 7 of Appendix **7** list the parameters required for the determination of the coordination distance of a transmitting earth station with respect to other earth stations (operating in the opposite direction of transmission in bidirectionally allocated bands) (No. **9.17A**).

9.2 Receiving earth stations

No methodology exists for calculating the coordination area for a receiving earth station with respect to another earth station operating in the opposite direction of transmission in bidirectionally allocated bands. Therefore, the coordination requirement of a receiving earth station with respect to transmitting earth stations operating in bidirectionally allocated bands is determined by using the coordination area information of the existing transmitting earth stations of your neighboring countries and any additional coordination area information received from other administrations for their planned transmitting earth stations, to verify whether or not the planned receiving earth station falls within the coordination area of any of those transmitting earth stations of other administrations. Thereafter, the notifying administration shall proceed with the coordination process stated in Nos.**9.29** and **9.31**, as required.

At the notification stage, for a receiving earth station with respect to another earth station operating in the opposite direction of transmission in bidirectionally allocated bands or a transmitting terrestrial station with respect to a receiving earth station in equally allocated bands, the Bureau examines whether the earth station/terrestrial station is located inside of the coordination area of any other relevant system(s) of neighbouring counties which is/are already recorded in the Master International Frequency Register (MIFR).

10 Computer program

If coordination contours are to be calculated using the detailed methods of Appendix **7**, administrations are urged to use the latest version of the computer programs AP7 embedded in GIBC, along with the associated BR software (i.e. ITU Digital World Map (IDWM) and GIMS) that are available in BR IFIC DVD-ROM.

11 Case study

Administration A (Malta for example) is planning to bring into use:

- frequency assignments for a transmitting earth station in the frequency bands shared with equal rights with terrestrial services; and
- frequency assignments for a receiving earth station in the frequency bands shared with equal rights with terrestrial services; and
- frequency assignments for a transmitting earth station in the frequency bands shared with equal rights with earth stations operating in the opposite direction of transmission in bidirectionally allocated bands.

The earth station's geographical coordinates are known and other required data referred to in paragraph 6, above, for the determination of the coordination contour are assembled, such as the transmitting antenna gain (58.5 dB), receiving antenna gain (59.3 dB), the horizon elevation angle (nil), longitude of the satellite (1 W operating with receiving earth station and 18 W operating with transmitting earth station), the antenna radiation pattern and the receive system noise temperature (100 K), maximum power density (–32 dBW/Hz) supplied to the input of the transmitting antenna, minimum and maximum transmitting or receive frequencies.

The coordination contours (modes (1) and (2)) for the receiving earth station, operating in the 4 GHz band with respect to terrestrial stations, and for the transmitting earth station, operating in 8 GHz with respect to another earth station, are then calculated, as provided in Appendix **7** and drawn to scale on an appropriate map. Example outputs of AP7 program are presented in Figures 2 to 5. From these coordination contours, coordination has to be sought with the concerned countries (affected administrations) for the respective cases.

During coordination, auxiliary contours (for reduction factors of -10 and -20 dB) can also be plotted to possibly eliminate certain existing or planned terrestrial stations for which the actual characteristics are more favourable than those assumed in the calculation of the main contour.

FIGURE 2

Transmitting GSO ES in fixed-satellite service W.R.T. receiving terrestrial stations

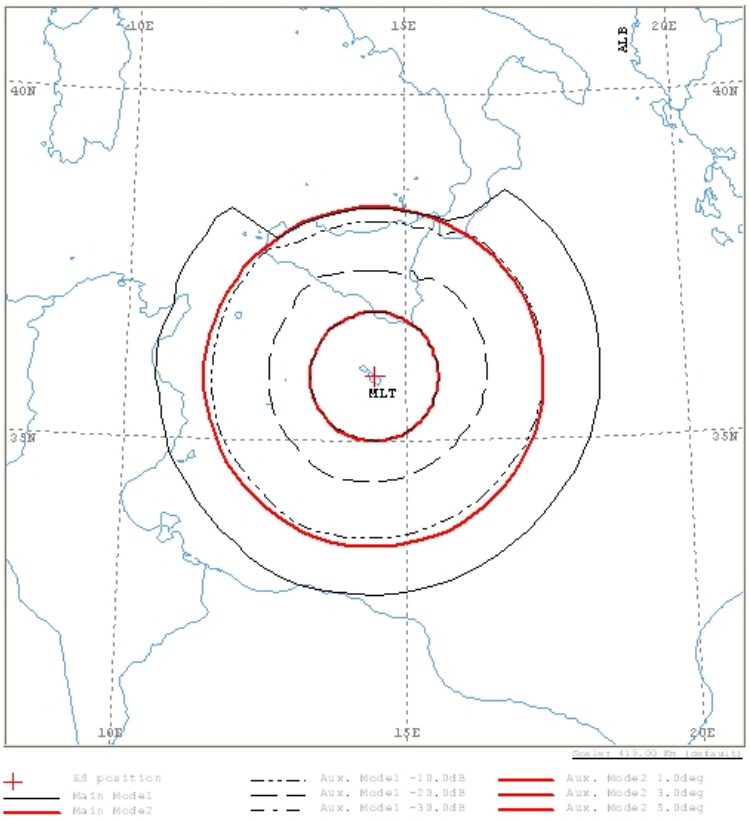


FIGURE 3

Transmitting GSO ES in fixed-satellite service W.R.T. receiving NGSO ES in EESS

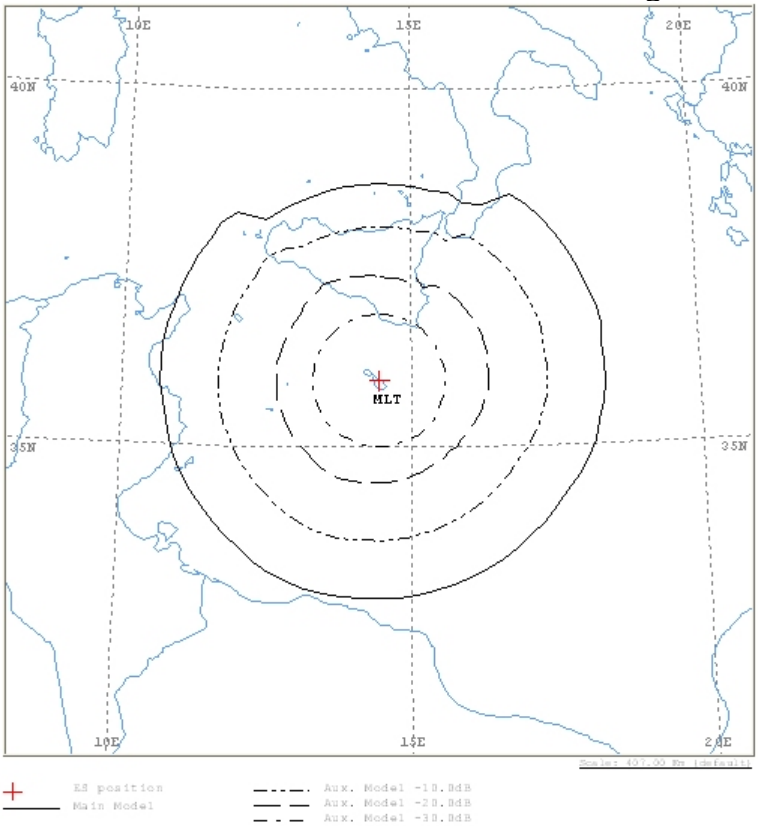


FIGURE 4

Transmitting GSO ES in fixed-satellite service W.R.T. receiving GSO ES in EESS

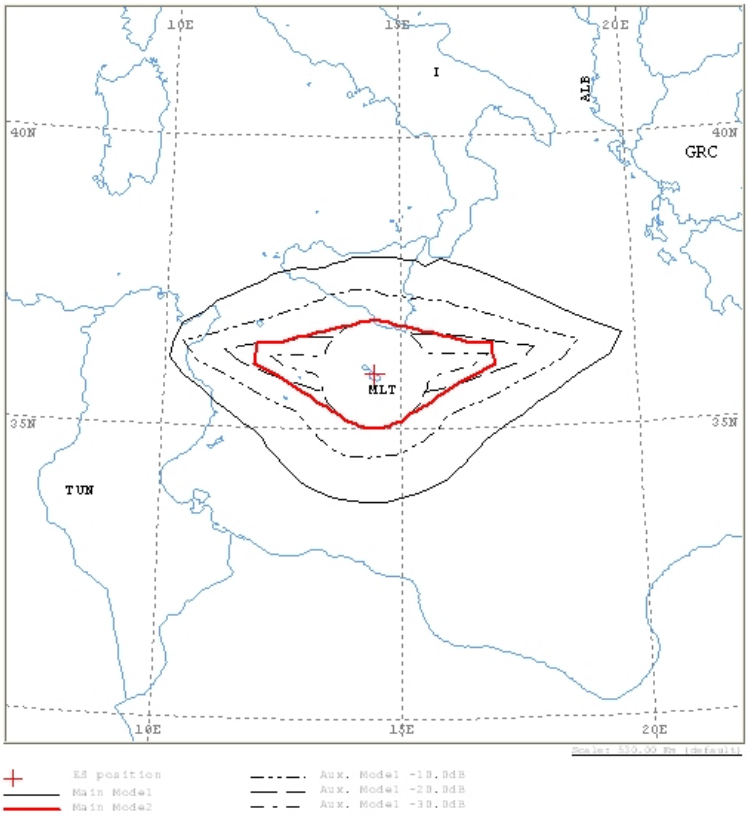
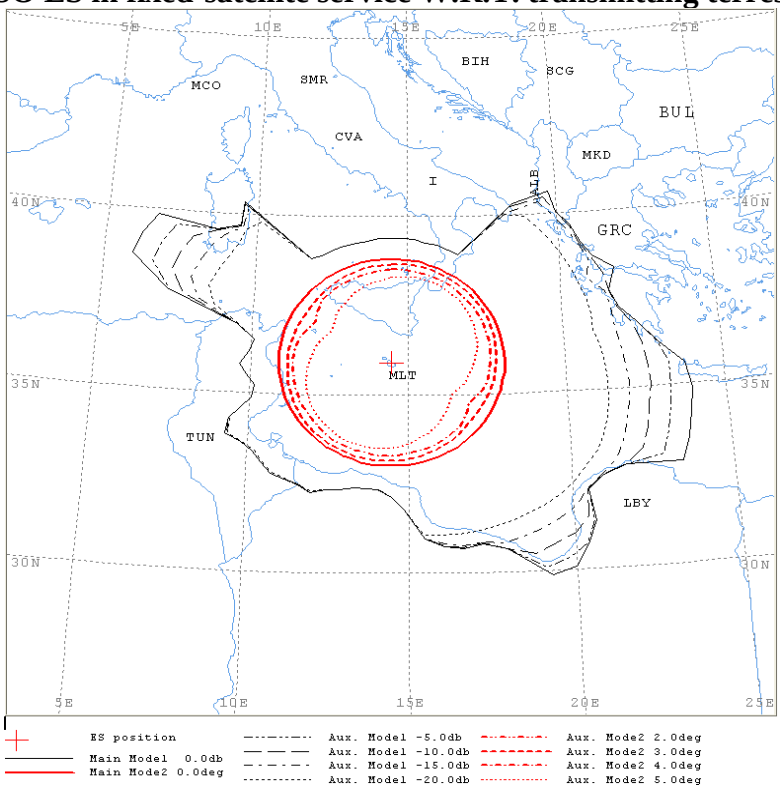


FIGURE 5

Receiving GSO ES in fixed-satellite service W.R.T. transmitting terrestrial stations



12 Coordination request

Coordination information (database (.mdb file) or paper copy of Appendix **4** form, and a copy of AP7 diagram), as discussed in paragraph 6 above, shall be sent (Nos. **9.29, 9.31**) by the requesting administration (Administration A) to all administrations (Administration B) identified using the coordination area.

The coordination is, normally, expected to be concluded within a period of four months but may take longer in many cases due to the requirement for detailed interference calculations between the earth station and existing or planned terrestrial stations.

The requesting administration may, therefore, sometimes receive a copy of the diagram indicating the location of existing terrestrial radiocommunication stations and/or the ones planned to be brought into use in the next three years within the coordination area of the earth station, together with relevant basic characteristics and with such suggestions to achieve a satisfactory solution to the problem.

If, for any reason, an administration cannot act in accordance with the proper coordination procedure, it can seek the assistance of the Bureau under No. **9.33**.

12.1 Action to be taken by Administration B responsible for the terrestrial station or earth station operating in the opposite direction of transmission

When Administration B, responsible for the terrestrial station or earth station operating in the opposite direction of transmission, receives the form containing the data prescribed in Appendix **4**, including the diagrams showing the earth station’s coordination area, it shall, within 30 days from the date of the request, acknowledge receipt by telegram to the requesting administration **(**No. **9.45)**.

Thereafter, it shall promptly examine the matter by collecting the technical data of its own terrestrial stations or earth stations operating in the opposite direction of transmission, falling within the coordination area, in operation or to be operated prior to the date of bringing the earth station assignment into service, or brought into use in the next three years from the date of dispatch of the coordination data under No. **9.29**, whichever is the longer.

The data collected is examined with respect to the assignments of the requested earth station and Administration B's decision is to be communicated to the requesting Administration A within four months from the date of dispatch of the coordination request **(**No. **9.52)**.

12.2 Technical examination

In order to identify the terrestrial stations or earth stations operating in the opposite direction of transmission of Administration B, which could possibly be affected by or affect the earth station of Administration A, a preliminary examination can be effected whereby the frequency overlap is checked.

Where assigned frequency bands of the terrestrial station or the earth station overlap entirely or partially, Administration B can use auxiliary contours which may make it possible to eliminate from detailed coordination terrestrial stations or earth stations that are located in the coordination area and hence have been identified. Any terrestrial station or earth station that lies outside an auxiliary contour and has an antenna gain towards the coordinating earth station that is less than the gain represented by the relevant auxiliary contour need not be considered further as a significant source of, or subject to, interference.

After the above calculations, if the possibility of interference still exists, a more precise examination is required. At this stage, more information is needed such as terrain profiles, precise e.i.r.p. value, sensitivity and type of modulation. It is possible to seek more information, if required, from the other concerned administration by either of the administrations – the one seeking coordination or the one receiving the coordination request – in order to assess the interference to its own assignments as provided for under the provisions of No. **9.54**.

Both administrations may use any other technical method or period if it is required by their agreement (Nos. **9.50.1** and **9.50.2**).

After detailed examination, the administrations may or may not be able to reach coordination agreement.

12.3 Agreement on coordination reached or continuation of coordination

In the case where Administration B agrees to the request for coordination, it shall, within four months of the date of dispatch of the coordination data, inform the requesting administration of its agreement (No. **9.51A**).

After detailed examination, Administration B might wish to continue the coordination of the earth station by requesting the inclusion of its radiocommunication station into the coordination process.

In that case, it should send to the administration requesting coordination the full characteristics of the above-mentioned stations. Moreover, administrations wishing to record the assignments to their terrestrial stations or earth stations operating in the opposite direction of transmission in bidirectionally allocated bands, not yet recorded in the Master Register, may (under Nos. **11.2** or **11.9**) send to the Bureau at the same time all information as specified in Appendix **4** to the Radio Regulations. In this case, the Bureau will take into account the assignments, which are either in operation or will be operational within the next three years (No. **9.52B**).

12.4 Administration B does not agree to the request for coordination

In the case where Administration B does not agree to the request for coordination, it shall, within four months of the date of dispatch of the coordination data, inform the requesting administration of its disagreement and shall provide information concerning its own assignments upon which that disagreement is based (No. **9.52**).

It shall also make such suggestions as it deems necessary, with a view to satisfactory resolution of the matter. A copy of that information shall be sent to the Bureau.
Where the information provided by Administration B relates to terrestrial stations or earth stations operating in the opposite direction of transmission within the coordination area of the earth station, only that information relating to existing radiocommunication stations or to those to be brought into use within the next three months for terrestrial stations, or three years for earth stations, shall be treated as notifications under Nos. **11.2** or **11.9**.

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