Radiocommunication Study Groups

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Annex 23 to Joint Task Group 4-5-6-7 Chairman's Report

WORKING DOCUMENT TOWARD PRELIMINARY DRAFT
NEW REPORT ITU-R M.[ARNS-MS]

Compatibility studies of the mobile service with the aeronautical radionavigation service in the frequency band 694-790 MHz in Region 1

1 Introduction

At WRC-12 many developing countries in Region 1 stated the requirement to operate IMT systems in the 700 MHz frequency band to satisfy their needs in the mobile service (MS) and to bridge the communication gap between the developing and developed countries.

Therefore WRC-12 approved Resolution **232 (WRC-12).** In accordance with this Resolution the frequency band 694-790 MHz in Region 1 is allocated to the mobile (except aeronautical mobile) service on a co-primary basis with other services to which this band is allocated on a primary basis and is identified it for IMT. Compatibility between the mobile service and other primary services in the frequency band 694-790 MHz and in the adjacent bands shall be ensured.

Currently the frequency band 694-790 MHz is allocated to the broadcasting service (BS) on a primary basis. At the same time this frequency band is allocated to the aeronautical radionavigation service (ARNS) in some European countries under RR No. **5.312**.

This document contains the results of a compatibility study of MS with ARNS in the frequency band 694-790 MHz in Region 1 for various scenarios and various types of coordination thresholds.
The Report consists of five sections including introduction, background, technical characteristics, analysis, summary and recommendations.

2 Background

Currently the frequency band 694-790 MHz in Region 1 is allocated:

– to BS on a primary basis;
– to ARNS on a primary basis in some countries under RR No. **5.312**;
– to the land mobile service (LMS) on a secondary basis intended for applications ancillary to broadcasting in some countries under RR No. **5.296**;
– to the fixed and mobile except aeronautical mobile services on a secondary basis in several countries of Africa and Middle East under RR No. **5.300**;
– to the broadcasting satellite service (BSS) under RR No. **5.311A** and in accordance with Resolution **549 (WRC-07)**.

In accordance with *resolves* 3 of Resolution **232 (WRC-12)** the operation of MS in the frequency band 694-790 MHz after WRC-15 is subject to agreement obtained under RR No. **9.21** with respect to the aeronautical radionavigation service in countries listed in RR No. **5.312.**

In *invites ITU-R* 4 of Resolution **232 (WRC-12)** the ITU-R is invited to study the compatibility between the mobile service and other services currently allocated in the frequency bands 694-790 MHz and to develop ITU-R Recommendations or Reports. Based on these reports in accordance with *resolves* 5 of this Resolution, WRC-15 is to specify the technical and regulatory conditions applicable to the mobile service allocation in the indicated frequency band.
Taking into account the above mentioned the main goal of the compatibility studies between the MS and ARNS in the frequency band 694-790 MHz is to determine criteria and to develop the corresponding methodology to identify the affected administrations upon applying RR No. **9.21** for the mobile service in relation to ARNS.

3 Technical characteristics

3.1 MS systems characteristics

The following parameters and characteristics shall be used for the IMT systems when carrying out sharing studies.

Specification-related parameters

The following parameters in Table 1 are relevant for the studies in response to WRC-15 agenda item 1.2 and the frequency band 694-790 MHz.

TABLE 1

Specification-related parameters for the frequency band 694-790 MHz

		IMT-Advanced			
	Duplex mode	**FDD**		**TDD**	
No.	**Parameter**	**base station**	**User equipment**	**base station**	**User equipment**
1	Channel bandwidth (MHz)	(1)	(1)	(1)	(1)
2	Signal bandwidth (MHZ)	(1)	(1)	(1)	(1)
3	Transmitter characteristics				
3.3	Power dynamic Range (dB)	(2)	63(18)	(2)	63(18)
3.4	Spectral mask	(3) (17)	(4) (17)	(3) (17)	(4) (17)
3.5	ACLR	(5)(17)	(6)(17)	(5)(17)	(6) (17)
3.6	Maximum output power	(7)	(8)	(7)	(8)
3.7	Spurious emissions	(15), (17)	(16), (17)	(15), (17)	(16), (17)
4	Receiver characteristics				

		IMT-Advanced			
	Duplex mode	**FDD**		**TDD**	
No.	**Parameter**	**base station**	**User equipment**	**base station**	**User equipment**
4.1	Noise Figure	5 dB	9 dB	5 dB	9 dB
4.2	Sensitivity	(9)	(10)	(9)	(10)
4.3	Blocking response	(11)	(12)	(11)	(12)
4.4	ACS	(13)	(14)	(13)	(14)

Notes to the table

(1) See 3GPP Document TS 36.101 v.11.2.0, §5.6. Signal bandwidth in MHz corresponds to "Transmission bandwidth configuration*0.180".

(2) See 3GPP Document TS 36.104 v.11.2.0, § 6.3.2.1.

(3) See 3GPP Document: TS 36 104 v 11.2.0, § 6.6.3.

(4) See 3GPP Document: TS 36 101 v 11.2.0, § 6.6.2.1, 6.6.2.1A, 6.6.2.2 and 6.6.2.2A describe user equipment (UE) spectrum emissions masks for different channel bandwidths. In case multiple UE are transmitting simultaneously on the same carrier they will share the available radio blocks.
As the actual transmission bandwidth is thus decreased the unwanted emissions performance might be improved. This may be taken into account during sharing analysis when measurements or detailed models are available.

(5) See 3GPP Document TS 36.104 v.11.2.0, § 6.6.2.

(6) See 3GPP Document TS 36.101 v.11.2.0, § 6.6.2.3.

(7) See 3GPP Document TS 36.104 v.11.2.0, § 6.2.

(8) See 3GPP Document TS 36.101 v.11.2.0, § 6.2.

(9) See 3GPP Document TS 36.104 v.11.2.0, § 7.2.

(10) See 3GPP Document TS 36.101 v.11.2.0, § 7.3.

(11) See 3GPP Document TS 36.104 v.11.2.0, § 7.6.

(12) See 3GPP Document TS 36.101 v.11.2.0, § 7.6 and § 7.7.

(13) See 3GPP Document TS 36.104 v.11.2.0, § 7.5.

(14) See 3GPP Document TS 36.101 v.11.2.0, § 7.5.

(15) See 3GPP Document TS 36.104 v.11.2.0, § 6.6.4.

(16) See 3GPP Document TS 36.101 v.11.2.0, § 6.6.3.

(17) These unwanted emission limits are the upper limits from SDO specifications for laboratory testing with maximum transmitting power. It is assumed that when the in-band transmitting power is reduced by x dB through power control, the unwanted emission levels would be reduced by x dB in consequence in the coexistence simulations.

(18) See 3GPP Document TS 36.101 v.11.2.0, § 6.3.

REFERENCES FOR SECTION 3

(Documents publically available at http://www.3gpp.org/specification-numbering)

[1] TR 25.942 v 11.0.0 3rd Generation Partnership Project; Technical Specification Group Radio Access Networks; RF System Scenarios (Release 11).

[2] TS 36.101 v.11.2.0, 3rd Generation Partnership Project; Technical Specification Group Radio Access Networks; Evolved Universal Terrestrial Radio Access (E-UTRA); User Equipment (UE) radio transmission and reception (Release 11).

[3] TS 36.104 v.11.2.0, 3rd Generation Partnership Project; Technical Specification Group Radio Access Networks; Evolved Universal Terrestrial Radio Access (E-UTRA); Base Station (BS) radio transmission and reception (Release 11).

[4] TR 36.942 V11.0.0 3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Evolved Universal Terrestrial Radio Access (E-UTRA); Radio Frequency (RF) system scenarios (Release 11) – Note this is a working document.

[5] 3GPP TR 36.912 v11.0.0 3rd Generation Partnership Project; Technical Specification Group Radio Access Network; Feasibility study for Further Advancements for E-UTRA (LTE-Advanced) (Release 11) – Section 16.

Deployment-related parameters

This section describes and proposes values for typical deployment parameters for different deployment scenarios. In many cases the values of these parameters vary within a range, but to facilitate the planned sharing studies wherever possible a single value has been chosen that is representative for use in sharing studies.

These typical parameter values are appropriate for studies concerning the impact of a single IMT cell operating in the presence of another system/service. For some parameters such as transmitted power levels and cell sizes, however, studies to assess the impact of an entire IMT network will in some cases need to take account of the varying nature of an IMT network, in particular power control. Inter-cell interference must be minimised and parameters such as power levels adjusted in order to optimize the operational performance and capacity of the network.

Base station characteristics and cell structure

Deployment-dependent parameters describing the cell structure and other base station related parameters needed to conduct sharing studies are summarized below. In addition, it should be stressed that in the sharing studies it is necessary to select the appropriate deployment type (macro rural/suburban/urban, small cell outdoor/indoor), that corresponds to expected usage of a certain frequency band, as indicated in the parameter tables. For nationwide studies a combination of deployment types could be considered.

Cell size and base station density

FIGURE 1

Macro cell geometry

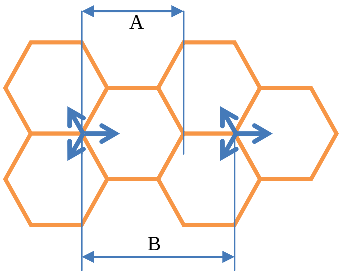


Figure 1 illustrates the geometry for a 3-sector deployment, and defines the parameters cell radius (A) and inter-site distance (B). Each cell (also referred to as a sector) is shown as a hexagon, and in this figure there are 3 cells/sectors per base station site. Cell sizes in IMT networks can vary considerably depending on the environment the network is deployed in. Table 2 indicate typical cell sizes for different types of networks.

Sharing studies using cell radii corresponding to urban and suburban deployment should take into account that those are only deployed in limited areas, central areas of large cities and suburban areas. Furthermore, rural deployments often do not cover all areas in a country/region, as coverage may be provided by other frequency bands, therefore assuming that rural cells have complete coverage will overestimate interference in most of the cases.

Indoor urban cell sizes will also vary depending on frequency band and the configuration of the building interior.

Antenna height

Typical antenna heights when deploying IMT networks are indicated in Table 2 for each type of network. Antennas deployed in indoor urban environments may vary in height depending on the building configuration.

Sectorisation

The numbers of sectors used per site is an important factor to take into account when undertaking sharing studies for compatibility between IMT and other services. It is assumed that the most common way to deploy macro base stations in an IMT network is to use 3 sectors with an azimuthal spacing of 120 degrees at each site. For small cell deployments it is assumed that one sector is being used.

Down tilt

Typical down tilt used in IMT networks are indicated in Table 2. This includes both the electrical down tilt which is built into the antenna as well as the mechanical down tilt which is applied when mounting the antenna on the cell site (tilt brackets).

Frequency reuse

Typical frequency reuse figures used for IMT networks are 1 or 3 but a frequency re-use of 1 is the most common one and it is proposed to be used for all scenarios. Fractional frequency reuse (FFR) may also be used in some IMT network deployments but this option is not included in the table.

Antenna pattern

Recommendation ITU-R F.1336 has been used in the past when conducting sharing studies. It should be noted that the Recommendation states that "it is essential that every effort be made to utilize the actual antenna pattern in coordination studies and interference assessment" (Note 1 to *recommends* 1). In the tables below, parameters to be used with Recommendation ITU-R F.1336 are proposed. These parameters apply to *recommends* 3.1 of Recommendation ITU-R F.1336. The parameters are intended for use in sharing studies. The parameter values are applicable for both average and peak side lobes, noting that the equations for average and peak side lobes are not identical, and are valid in the frequency range 400-6 000 MHz. To implement a tilt it is only necessary to apply a tilt angle values in the equations for the vertical patterns in Annex 10 to obtain the corresponding tilted antenna pattern.

Indoor base station deployment

Base stations are often installed indoors especially in urban areas. Typical percentages of base stations deployed indoors for the different deployment scenarios are indicated in Tables C and D. It is proposed that the floor loss model of Recommendation ITU-R P.1238 is used to determine building penetration loss in the vertical direction (section 3.1, Table 3).

Maximum and average base station output power

Maximum output powers from base stations are indicated in Table 2 for each environment. Additionally, typical average activity of a base station and corresponding average output powers during busy hour are indicated in the table. For further details see Report ITU-R M.2241 section 2.2.3.2. The choice between maximum or average output power depends on the type of study.

In case TDD is used, base station downlink transmission occurs only part of the time, which will further reduce average base station power.

UE parameters

Indoor UE usage and indoor UE penetration loss

A large proportion of IMT UE are used indoors. Table 2 indicates suitable figures for the percentage of terminals that are expected to be used indoors. Additionally, suitable figures for the indoor penetration attenuation are indicated. Note that the indoor penetration losses here include not only the building entry/wall loss but also additional attenuation for the signal to penetrate deeper into the building. This penetration loss may be frequency dependent.

UE density in active mode

In Report ITU-R M.2039 and Document 5-6/180 Annex 2 the density of terminals in "active mode" is indicated. By "active mode" it should be understood that these are terminals with an active communication session but are not necessarily transmitting.

Average transmit power of UE transmitting

The average transmit power of terminals are indicated in Report ITU-R M.2039 and JTG 5-6/180 Annex 2 and should be understood as the average transmit power of the terminals in active mode (i.e. when they have an active communication session). The figures given are including power control and activity factor of the UE. See also section 2.2.3 of Report ITU-R M.2241. It should be noted that as average UE transmitter output power is much lower than the maximum transmitter output power in the transmitting frequency band, an average OOBE level would be much lower than the specified OOBE level.

Antenna gain for UE

Typical values for the antenna gain of a UE are indicated in Table 2. The antenna gain is dependent on operating frequency and type of terminal.

Body loss

Proposed values for body loss are indicated in Table 2. The figure indicated is representative of all different user cases (i.e. speech position, browsing position, etc.)

TABLE 2

Deployment-related parameters

Base station characteristics / Cell structure	
Cell radius	> 5 km (typical 8 km[1]) for macro rural scenario 0.5-5 km (typical 2 km[1]) for macro urban/suburban scenario
Antenna height	30 m (See Note 1)
Sectorization	3 sectors
Down tilt	3 degrees
Frequency reuse	1
Antenna pattern	Recommendation ITU-R F.1336 Annex 10 • k_a = 0.7 • k_p = 0.7 • k_h = 0.7 • k_v = 0.3 Horizontal 3 dB beamwidth 65 degrees Vertical 3 dB beamwidth: Determined from the horizontal beamwidth by equations in Recommendation ITU-R F.1336. Vertical beamwidths of actual antennas may also be used when available.
Antenna polarization	linear / ± 45 degrees
Feeder loss	3 dB
Maximum base station output power	46 dBm in 10 MHz
Typical base station antenna gain	15 dBi
Typical base station output power (e.i.r.p.)	58 dBm in 10 MHz
Average base station activity	50 %
Average base station power/sector (to be used in sharing studies)	55 dBm in 10 MHz

Note 1: In macro rural cases in various regions, typical antenna heights could vary depending on the notion of rural territory, i.e. population density, actual distribution of settlements, infrastructure availability, etc. Based on the available statistics in many cases typical antenna height around 30 metres provides the most representative value for macro rural case. For some specific areas where statistics indicate significantly higher antenna heights than 30 meters, in those cases, antenna heights of 50 metres may be more representative.

[1] According to Document 5-6/180 Annex 2.

UE characteristics	
Indoor UE usage	50% for macro rural scenario 70% for macro urban/suburban scenario
Average Indoor UE penetration loss	15 dB for macro rural scenario 20 dB for macro urban/suburban scenario
UE density in active mode to be used in sharing studies[2]	0.17 / 5MHz/km^2 for macro rural scenario 2.16 / 5 MHz/km^2 for urban/suburban scenario
Maximum UE transmitter output power	23 dBm
Average UE transmitter output power[3]	2 dBm for macro rural scenario –9 dBm for macro urban/suburban scenario
Typical antenna gain for UE	–3 dBi
Typical body loss	4 dB

3.2 BS systems characteristics

The BS system characteristics, which were used in the similar studies in the frequency band 790-862 MHz (see Document 5-6/180 (Appendix 3)), were used to carry out the studies in the frequency band 694-790 MHz.

3.3 ARNS systems characteristics

ARNS parameters and technical characteristics can be found in Recommendation ITU-R M.1830.

Currently, there are no ITU-R Recommendations that deal specifically with the protection criterion for ARNS systems from MS systems in this particular frequency band. However, Recommendation ITU-R M.1461-1 contains a recommended protection criterion for radars in general, when there are no others available in ITU-R Recommendations, when considering potential interference from other services. The recommended criterion of I/N = –6 dB is specified in section 3.3 the Annex of Recommendation ITU-R M.1461-1. This criterion may be used as the required protection level for ARNS, taking into account relevant noise figures in the range of 5 to 10 dB for the considered ARNS systems. In the case of multiple interference sources, this criterion should not be exceeded due to the aggregate interference from these sources.

In case the I/N= –6 dB protection criteria, for different reasons, is not appropriate, the interference field strength levels provided in Table 3 may be considered.

2 Document 5-6/180, Annex 2.

3 According to Document 5-6/180 Annex 2 (except for small cell indoor scenario, which was not covered in that document).

TABLE 3

ARNS type	Predetermined aggregate trigger field-strength values (dB(µV/m))
RSBN	42 at 10 m in a 3 MHz reference bandwidth
RLS 2 (Type 1) (aircraft receiver)	52[1] at 10 000 m in a 4 MHz reference bandwidth
RLS 2 (Type 1) (ground receiver)	29[1] at 10 m in a 4 MHz reference bandwidth
RLS 2 (Type 2)	73 at 10 000 m in a 3 MHz reference bandwidth
RLS 2 (Type 2) (ground receiver)	24[1][2] at 10 m in a 8 MHz reference bandwidth
RLS 1 (Type 1 and 2)	13 at 10 m in a 6 MHz reference bandwidth
Other type ARNS ground stations	13 at 10 m in a 6 MHz reference bandwidth
Other type ARNS airborne stations	52 at 10 000 m in a 4 MHz reference bandwidth

Note 1: The values provided in this table refer to the permissible aggregate co-channel interference field strength values provided for the necessary emission bandwidth (from all services).

4 Analysis

During the work of JTG 5-6 four different types of coordination triggers where discussed, coordination distances, aggregated field strength triggers and single field strength triggers. Each of them has both benefits and drawbacks and can be described as follows:

Coordination distances

The choice of a certain distance as the coordination trigger might be seen as a simple and practical way to decide on when more detailed coordination is needed. However, it might not be the most spectrum efficient and flexible method to use. Since the distance agreed has to be based on certain scenario, any divergence in deployment from that scenario will create differences in the sharing situation between the two services. Sometimes the coordination distance will overprotect the concerned service and sometimes it will fail to protect the concerned service. Another issue is that most mobile usage today is according to technology neutral licenses i.e. the operator might change to a different technology at its own decision. If the technology is changed that means that basis for the calculation of the coordination distance also is changed and again the coordination distance may overprotect or fail to protect the concerned service. The coordination distance trigger may have some disadvantages since it is based on a certain scenario.

Aggregated field strength triggers

An aggregated field strength trigger may be seen as the most accurate way of protect a specific service. Independent of the deployment scenario or the technology used, it will in most cases provide the right amount of protection. At the stage of identifying the possible affected administrations this trigger value can be successfully used.

Single field strength triggers

A Single field strength trigger may be seen as a combination of the methods above, it has to be based on a certain scenario but instead of a coordination distance a field strength trigger for each station is defined. This means that there will be a more accurate protection of the concerned service at the same time as more flexibility and spectrum efficiency is gained. A single field strength trigger will also have the ability to protect the concerned service if the technology used is changed. The single field strength trigger may have some of the disadvantages as the coordination distance trigger since it is based on a certain scenario.

Coordination trigger based on I/N=-6 dB

Trigger ratio I/N = –6 dB may be seen as the way of protecting a specific service, independent of the deployment scenario or the technology used. It should be noted, that this criterion is implemented only for two services MS and ARNS.

4.1 Case A for estimation of interference to ARNS systems caused by MS systems with no interference from broadcasting service

4.1.1 Interference scenario

In compatibility studies of MS with ARNS the following interference scenario from MS to ARNS can be identified interference scenarios from MS to ARNS when there is no interference caused by other radio services.

Depending on the frequency plan of MS systems and overlapping of this plan with ARNS system frequencies, each group indicated above can contain up to four typical interference scenarios (see Figure 2):

a) interference from the MS base stations to the ARNS ground station;

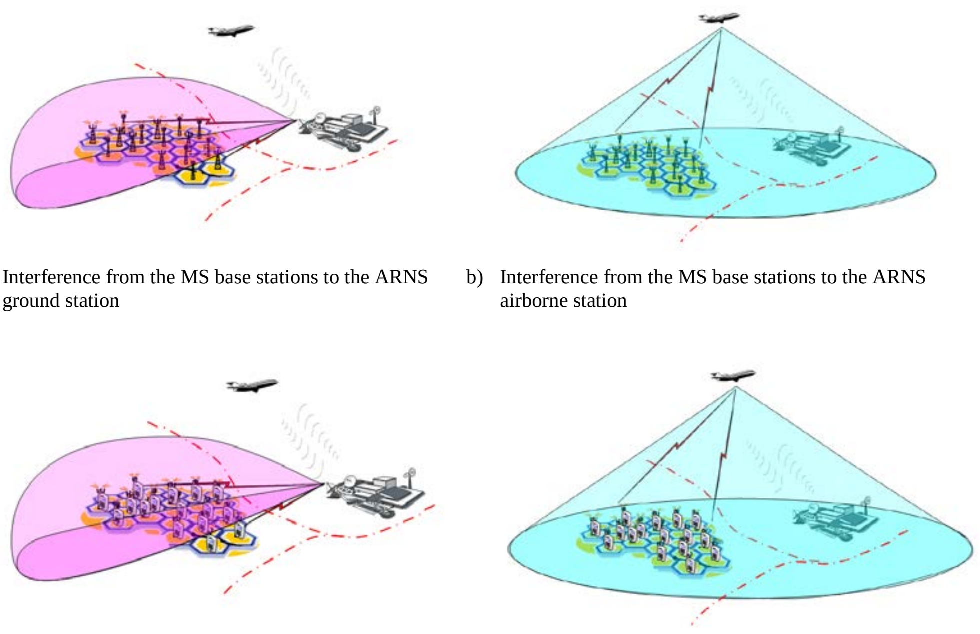
b) interference from the MS base stations to the ARNS airborne station;

c) interference from UE to the ARNS ground station;

d) interference from UE to the ARNS airborne station.

FIGURE 2

Typical interference scenarios from the MS to the ARNS



a) Interference from the MS base stations to the ARNS ground station

b) Interference from the MS base stations to the ARNS airborne station

c) Interference from UE to the ARNS ground station

d) Interference from UE to the ARNS airborne station

4.1.2 Study#A.1

Study#A.1 based on implementation of coordination distances.

4.1.2.1 Assumptions

The technical characteristics were applied in the sharing studies of the IMT and ARNS systems described in section 3.

For the MS base stations the rural, suburban, and urban deployment[4] scenarios have been used. Additionally, a mix of these deployment scenarios has also been evaluated. For the MS terminals, not all combinations of MS bandwidths and environments have been considered.

However, since there are a significant difference in the operation of radars in general and ARNS, it has been can be concluded that this criteria, is not appropriate, and the interference field strength levels provided in Table 3 was considered. This is also in line with the values indicated in Recommendation ITU-R M.1830 and the GE06 agreement.The free space propagation model (Recommendation ITU-R P.525-2) was used for interference assessment to ARNS airborne receivers and the propagation model described in Recommendation ITU-R P.1546-5 was used for interference assessment to ground ARNS receivers. Using Recommendation ITU-R P.1546-5 the calculations were performed for 10% of time and 50% of locations.

4.1.2.2 Methodology to estimate interference caused by MS systems to ARNS systems

The following two situations regarding the interference from MS towards ARNS have been investigated by using a statistical approach[5]. Both emissions from base stations and UE have been studied. The methodology essentially follows that of JTG 5-6 but with updated parameters.
The scenarios are illustrated in Figure 3 and Figure 4 for MS to ground-based ARNS and MS to airborne ARNS, respectively.

For all ground-based types of ARNS stations an ideal antenna pattern with 8° horizontal beamwidth have been assumed. However for the RSBN system, a vertical antenna pattern has been derived and it has also been studied but not used in the summary and conclusions. The derivation of the pattern can be found in Appendix 8. [6]

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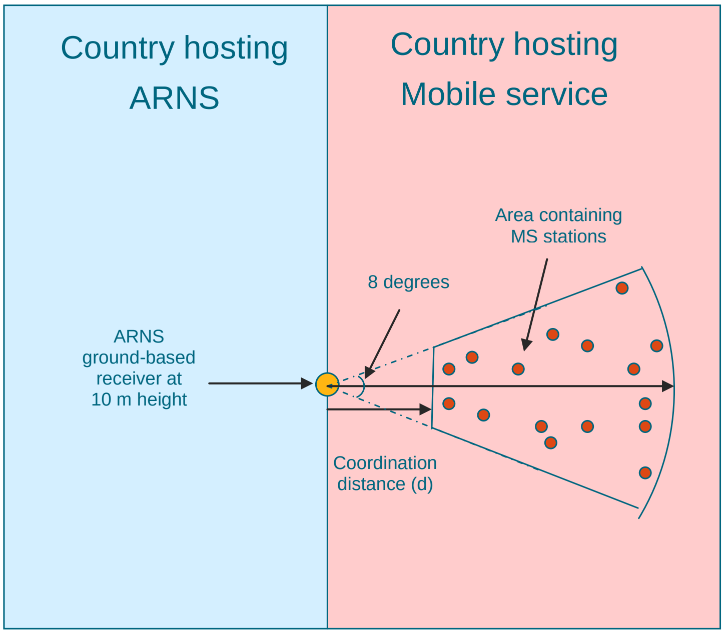
[4] It is assumed that MS base station operates with antenna height 30 m, cell radius is 8 kilometres for rural area, 2 kilometres for suburban area and 2 km for urban area as specified by ITU-R.

[5] In interference calculation for urban or suburban environments ARNS station was located in the same environments as MS base station transmitters i.e. accordingly in urban and suburban area.

[6] In one case RSBN receiver antenna gain was applied in calculation of field-strength ~~value~~valuess. For RSBN, two cases were investigated; one with additional signal attenuation up to 10 dB, in accordance with the antenna pattern described in Appendix 8, the other with no antenna discrimination.

FIGURE 3

Scenario 1 - MS station to ARNS ground-based receiver



In the case where multiple deployment scenarios, or environments, have been mixed, the separation distance is computed for the weighted sum of field strengths derived for urban, suburban and rural environments, where the separation distance is the same for all environments. More formally, the calculation is as follows. Assume M environments, each generating a field strength $E_{\text{env},m}$, for the given, and common, distance and each contributing a fraction a_m to the total field strength. The aggregate field strength over all environments then becomes.

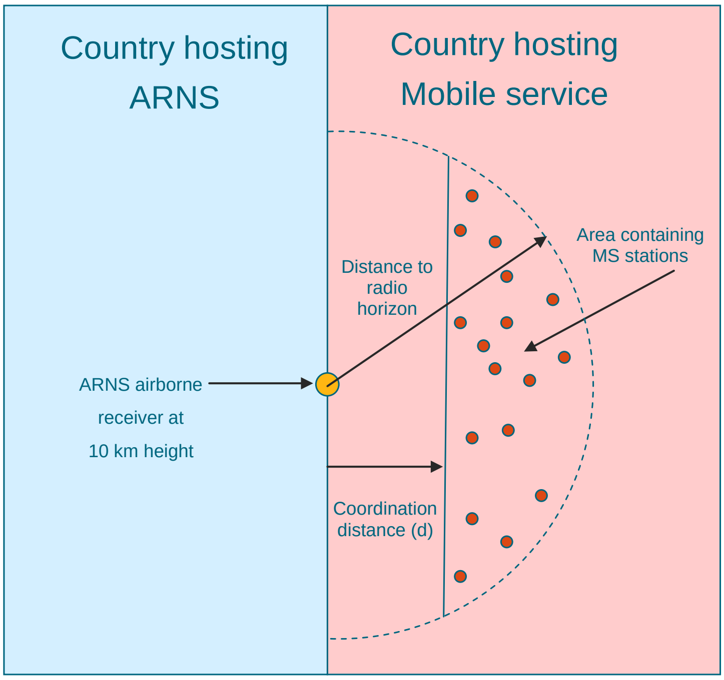
The interference level from MS base stations in a corresponding area was reduced proportionally to the given fraction a_m (part) for each of the considered areas with the assumption that a portion of the interference from different MS base stations does not depend on the distance between ARNS and the MS base stations

$$E_{\text{env,agg}} = 10\log_{10}\left(\sum_{m=1}^{M} a_m 10^{E_{\text{env},m}/10}\right).$$

It should be noted that when mixed environments are employed, each environment is treated separately and thus there is no case of propagation over paths that are a mix of rural, suburban, or urban environments.

FIGURE 4

Scenario 2 - MS station to ARNS airborne receiver



The MS and ARNS systems use different bandwidths and this is taken into account by correcting the aggregate field strength as follows:

$$E_{\text{agg,corr}} = E_{\text{agg}} + 10\log_{10}\left(\min\left(\frac{\text{BW}_{\text{ARNS}}}{\text{BW}_{\text{MS}}},1\right)\right)\quad \text{dB}\mu\text{V/m}$$

4.1.2.3 Calculations

MS base station to ground-based ARNS

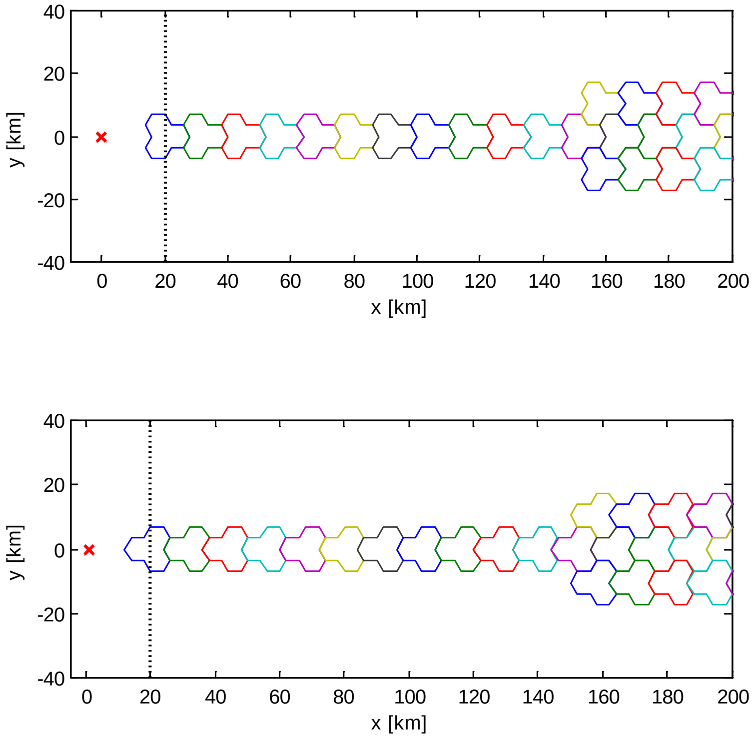
For the situation when MS base stations are interfering with ground based ARNS stations, Figure 3 shows an example of the scenario investigated. For calculating the interfering signal propagation model Recommendation ITU-R P.1546-4 has been used. The MS sites are organized according to a hexagonal structure with the nearest site, or sites, at the coordination distance according to Figure 5.

Two different scenarios are investigated either when the antennas are oriented with a main lobe offset of 60 degrees or 0 degrees with respect to the direction towards the country hosting the ARNS. The mixed scenario consists of 70% rural, 20% suburban, and 10% urban environments.[7]

[7] Interference level from MS base stations in correspond area was reduced in urban area by 100/10=10 times, in suburban area by 100/20=5 times and in rural area by 100/70=1.4 times.

FIGURE 5

Example with 20 km coordination distance showing the coverage area of the three-sector MS sites in relation to the ARNS station. The red 'x' corresponds to the ARNS station. In the upper figure, the main lobes of the antennas of an MS site point at 0°, 120°, and 240°, i.e., the main lobe has a 60° offset w.r.t. the ARNS station. The lower figure illustrates a case of 0° offset. Note: 0° = East



The required coordination distances are indicated in tables below.

TABLE 4

Required coordination distances between MS base stations and terrestrial ARNS receivers, 5 MHz bandwidth and 100% land propagation

ARNS type	Predetermined aggregate trigger field-strength values from a mobile service station (dB(μV/m))	Coordination Distance (km)		
		Main lobe 60° offset[1]	Main lobe 0° offset[2]	0° offset Vertical antenna pattern[3]
RSBN	42 at 10 m in a 3 MHz reference bandwidth	Rural: 11 Suburban: 12 Urban: 3 Mixed: 11	Rural: 15 Suburban: 17 Urban: 5 Mixed: 15	Rural: 10 Suburban: 10 Urban: 4 Mixed: 10
RLS 2 (Type 1) (ground receiver)	29 at 10 m in a 4 MHz reference bandwidth	Rural: 23 Suburban: 39 Urban: 9 Mixed: 25	Rural: 31 Suburban: 70 Urban: 13 Mixed: 40	N/A
RLS 2 (Type 2) (ground receiver)	24 at 10 m in a 8 MHz reference bandwidth	Rural: 32 Suburban: 73 Urban: 13 Mixed: 40	Rural: 45 Suburban: 124 Urban: 18 Mixed: 69	N/A
RLS 1 (Type 1 and 2)	13 at 10 m in a 6 MHz reference bandwidth	Rural: 67 Suburban: 175 Urban: 28 Mixed: 117	Rural: 112 Suburban: 230 Urban: 53 Mixed 171	N/A

Note 1: Result based on condition that MS base stations operate with antenna height 30 m, cell radius is 8 km for rural area, 2 km for suburban and urban area. MS base station e.i.r.p. in direction towards the country hosting the ARNS is not more than 55 dBm in 5 MHz and 3 degrees down tilt of antenna pattern in accordance with Rec. ITU-R F.1336.

Note 2: Result based on condition that MS base station operate with antenna height 30 m, cell radius is 8 km for rural area, 2 km for suburban and urban area. MS base station e.i.r.p. in direction towards the country hosting the ARNS is not more than 55 dBm in 5 MHz and 3 degrees down tilt of antenna pattern in accordance with Rec. ITU-R F.1336.

Note 3: Result based on condition that MS base stations operate with antenna height 30 m, cell radius is 8 km for rural area, 2 km for suburban and urban area and on additional signal attenuation up to 10 dB in accordance with the antenna pattern in Annex 8.

TABLE 5

Required coordination distances between MS basestations and terrestrial ARNS receivers, 5 MHz bandwidth and 50/50% land/sea propagation

ARNS type	Predetermined aggregate trigger field-strength values from a mobile service station (dB(μV/m))	Coordination Distance (km)		
		Main lobe 60° offset[1]	Main lobe 0° offset[2]	0° offset Vertical antenna pattern[3]
RSBN	42 at 10 m in a 3 MHz reference bandwidth	Rural: 14 Suburban:17 Urban: 5 Mixed: 14	Rural: 19 Suburban: 25 Urban: 7 Mixed: 20	Rural: 12 Suburban: 17 Urban: 5 Mixed: 12
RLS 2 (Type 1) (ground receiver)	29 at 10 m in a 4 MHz reference bandwidth	Rural: 30 Suburban: 63 Urban: 13 Mixed: 38	Rural: 42 Suburban: 112 Urban: 18 Mixed: 61	N/A
RLS 2 (Type 2) (ground receiver)	24 at 10 m in a 8 MHz reference bandwidth	Rural: 43 Suburban: 115 Urban: 18 Mixed: 63	Rural: 65 Suburban: 167 Urban: 29 Mixed: 111	N/A
RLS 1 (Types 1 and 2)	13 at 10 m in a 6 MHz reference bandwidth	Rural: 101 Suburban: 216 Urban: 52 Mixed: 161	Rural: 163 Suburban: 274 Urban: 97 Mixed: 212	N/A

Note 1: Result based on condition that MS base stations operate with antenna height 30 m, cell radius is 8 km for rural area, 2 km for suburban and urban area. MS base station e.i.r.p. in direction towards the country hosting the ARNS is not more than 55 dBm in 5 MHz and 3 degrees down tilt of antenna pattern in accordance with Rec. ITU-R F.1336.

Note 2: Result based on condition that MS base station operate with antenna height 30 m, cell radius is 8 km for rural area, 2 km for suburban and urban area. MS base station e.i.r.p. in direction towards the country hosting the ARNS is not more than 55 dBm in 5 MHz and 3 degrees down tilt of antenna pattern in accordance with Rec. ITU-R F.1336.

Note 3: Result based on condition that MS base stations operate with antenna height 30 m, cell radius is 8 km for rural area, 2 km for suburban and urban area and on additional signal attenuation up to 10 dB in accordance with the antenna pattern in Annex 8.

TABLE 6

Required coordination distances between MS base stations and terrestrial ARNS receivers, 10 MHz bandwidth, 100 % land propagation

ARNS type	**Predetermined aggregate trigger field-strength values from a mobile service station (dB(μV/m))**	**Coordination Distance (km)**		
		Main lobe 60° offset[1]	**Main lobe 0° offset[2]**	**0° offset** **Vertical antenna pattern[3]**
RSBN	42 at 10 m in a 3 MHz reference bandwidth	Rural: 10 Suburban: 10 Urban: 3 Mixed: 9	Rural: 13 Suburban: 14 Urban: 4 Mixed: 13	Rural: 7 Suburban: 9 Urban: 3 Mixed: 9
RLS 2 (Type 1) (ground receiver)	29 at 10 m in a 4 MHz reference bandwidth	Rural: 19 Suburban: 27 Urban: 7 Mixed: 20	Rural: 26 Suburban: 49 Urban: 11 Mixed: 30	N/A
RLS 2 (Type 2) (ground receiver)	24 at 10 m in a 8 MHz reference bandwidth	Rural: 30 Suburban: 64 Urban: 12 Mixed: 37	Rural: 42 Suburban: 115 Urban: 17 Mixed: 62	N/A
RLS 1 (Types 1 and 2)	13 at 10 m in a 6 MHz reference bandwidth	Rural: 56 Suburban: 154 Urban: 23 Mixed: 94	Rural: 90 Suburban: 208 Urban: 43 Mixed: 152	N/A
Note 1: Result based on condition that MS base stations operate with antenna height 30 m, cell radius is 8 km for rural area, 2 km for suburban and urban area. MS base station e.i.r.p. in direction towards the country hosting the ARNS is not more than 55 dBm in 5 MHz and 3 degrees down tilt of antenna pattern in accordance with Rec. ITU-R F.1336. Note 2: Result based on condition that MS base station operate with antenna height 30 m, cell radius is 8 km for rural area, 2 km for suburban and urban area. MS base station e.i.r.p. in direction towards the country hosting the ARNS is not more than 55 dBm in 5 MHz and 3 degrees down tilt of antenna pattern in accordance with Rec. ITU-R F.1336. Note 3: Result based on condition that MS base stations operate with antenna height 30 m, cell radius is 8 km for rural area, 2 km for suburban and urban area and on additional signal attenuation up to 10 dB in accordance with the antenna pattern in Annex 8.				

TABLE 7

Required coordination distances between MS basestations and terrestrial ARNS receivers, 10 MHz bandwidth, 50/50% sea/land propagation

ARNS type	Predetermined aggregate trigger field-strength values from a mobile service station (dB(μV/m))	Coordination Distance (km)		
		Main lobe 60° offset[1]	Main lobe 0° offset[2]	0° offset Vertical antenna pattern[3]
RSBN	42 at 10 m in a 3 MHz reference bandwidth	Rural: 12 Suburban: 14 Urban: 4 Mixed: 12	Rural: 16 Suburban: 20 Urban: 6 Mixed: 17	Rural: 11 Suburban: 12 Urban: 4 Mixed: 11
RLS 2 (Type 1) (ground receiver)	29 at 10 m in a 4 MHz reference bandwidth	Rural: 25 Suburban: 46 Urban: 10 Mixed: 28	Rural: 35 Suburban: 85 Urban: 15 Mixed: 46	N/A
RLS 2 (Type 2) (ground receiver)	24 at 10 m in a 8 MHz reference bandwidth	Rural: 40 Suburban: 106 Urban: 17 Mixed: 57	Rural: 60 Suburban: 158 Urban: 26 Mixed: 101	N/A
RLS 1 (Types1 and 2)	13 at 10 m in a 6 MHz reference bandwidth	Rural: 84 Suburban: 195 Urban: 42 Mixed: 139	Rural: 147 Suburban: 251 Urban: 78 Mixed: 192	N/A

Note 1: Result based on condition that MS base stations operate with antenna height 30 m, cell radius is 8 km for rural area, 2 km for suburban and urban area. MS base station e.i.r.p. in direction towards the country hosting the ARNS is not more than 55 dBm in 5 MHz and 3 degrees down tilt of antenna pattern in accordance with Rec. ITU-R F.1336.

Note 2: Result based on condition that MS base station operate with antenna height 30 m, cell radius is 8 km for rural area, 2 km for suburban and urban area. MS base station e.i.r.p. in direction towards the country hosting the ARNS is not more than 55 dBm in 5 MHz and 3 degrees down tilt of antenna pattern in accordance with Rec. ITU-R F.1336.

Note 3: Result based on condition that MS base stations operate with antenna height 30 m, cell radius is 8 km for rural area, 2 km for suburban and urban area and on additional signal attenuation up to 10 dB in accordance with the antenna pattern in Annex 8.

MS base station to airborne ARNS

For the situation when MS base stations are interfering with airborne ARNS stations, Figure 6 and Figure 7 shows an example of the scenario investigated. For calculating the interfering signal the propagation model in Recommendation ITU-R P.525 has been used. The MS sites are organized according to a hexagonal structure with the nearest sites positioned at the coordination distance according to Figure 6. Both rural and urban/suburban scenarios have been examined. Note that the results for urban and suburban are the same since cell sizes and other relevant parameters are equal, and since free-space path loss applies for all environments.

FIGURE 6

Example with 50 km coordination distance showing the coverage area of the three-sector MS sites in relation to the ARNS station. The red 'x' corresponds to the ARNS station. The main lobes of the antennas of a site point in 0°, 120°, and 240°, i.e., the case of 60° offset. The left plot shows the full simulation area, whereas the right plot shows only a part of the full area in order to illustrate the position of the sites w.r.t. the coordination distance.
Note: 0° = East

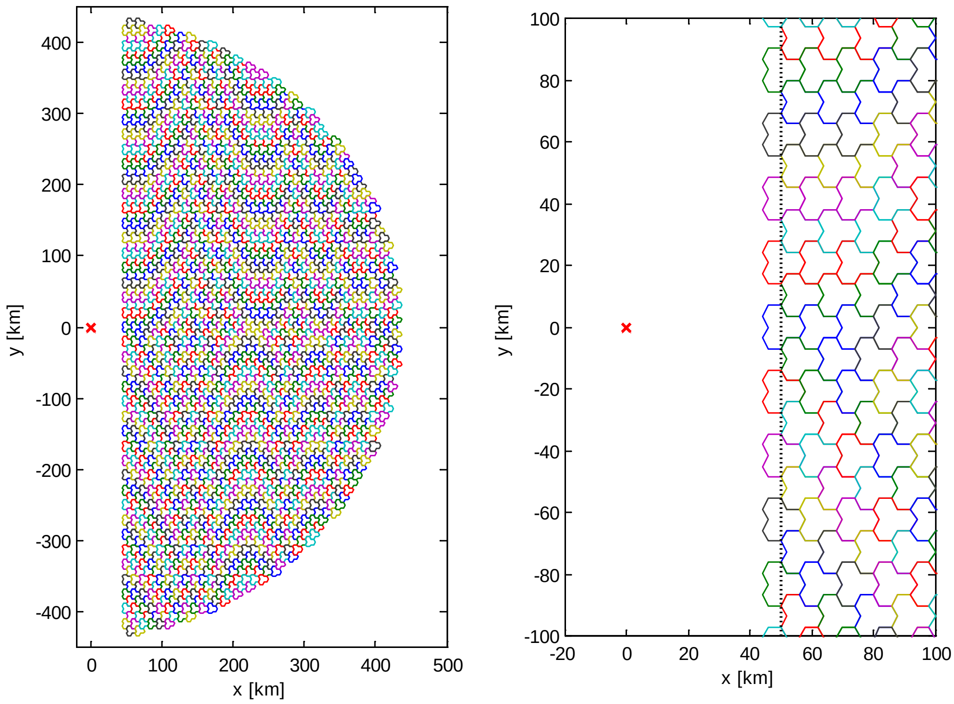
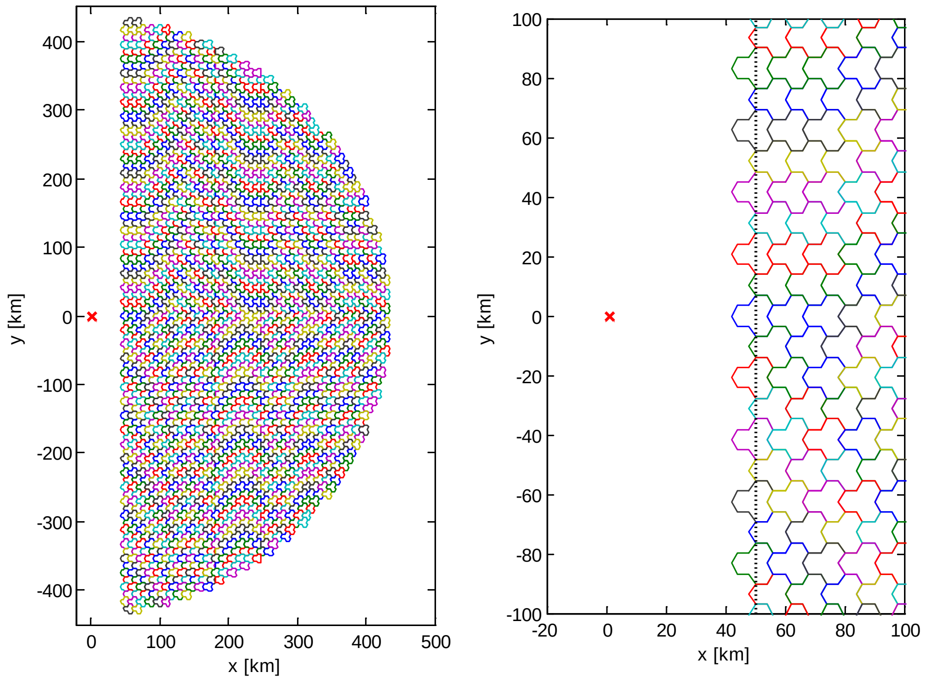


FIGURE 7

Example with 50 km coordination distance showing the coverage area of the three-sector MS sites in relation to the ARNS station. The red 'x' corresponds to the ARNS station. The main lobes of the antennas of a site point in 60°, 180°, and 300°, i.e., the case of 0° offset. The left plot shows the full simulation area, whereas the right plot shows only a part of the full area in order to illustrate the position of the sites w.r.t. the coordination distance.
Note: 0° = East



The required coordination distances are indicated in the tables below.

TABLE 8

Required coordination criteria MS base stations 5 MHz – airborne ARNS receiver

ARNS type	Predetermined aggregate trigger field-strength values from a mobile service station (dB(μV/m))	Coordination Distance (km)	
		Main lobe 60° offset[1]	**Main lobe 0° offset[2]**
RLS 2 (Type 1) (aircraft receiver)	52 at 10 000 m in a 4 MHz reference bandwidth	Rural: 420 Suburban/urban: >RH[3] Mixed: 429	Rural: >RH[3] Suburban/urban: >RH[3] Mixed: >RH[3]
RLS 2 (Type 2) (aircraft receiver)	73 at 10 000 m in a 3 MHz reference bandwidth	Rural: 215 Suburban/urban: 376 Mixed: 333	Rural: 251 Suburban/urban: 403 Mixed: 373

Note 1: Result based on condition that MS base stations operate with antenna height 30 m, cell radius is 8 km for rural area, 2 km for suburban and urban area. MS base station e.i.r.p. in direction towards the country hosting the ARNS is not more than 55 dBm in 5 MHz and 3 degrees down tilt of antenna pattern in accordance with Rec. ITU-R F. 1336.

Note 2: Result based on condition that MS base station operate with antenna height 30 m, cell radius is 8 km for rural area, 2 km for suburban and urban area. MS base station e.i.r.p. in direction towards the country hosting the ARNS is not more than 55 dBm in 5 MHz and 3 degrees down tilt of antenna pattern in accordance with Rec. ITU-R F. 1336.

Note 3: RH =Radio Horizon (The radio horizon for 30m and 10000 m antenna heights are 432 km)

TABLE 9

Required coordination criteria MS basestations 10MHz – terrestrial ARNS receiver

ARNS type	Predetermined aggregate trigger field-strength values from a mobile service station (dB(μV/m))	Coordination Distance (km)	
		Main lobe 60° offset[1]	**Main lobe 0° offset[2]**
RLS 2 (Type 1) (aircraft receiver)	52 at 10 000 m in a 4 MHz reference bandwidth	Rural: 414 Suburban/urban: >RH[3] Mixed: 426	Rural: >RH[3] Suburban/urban: >RH[3] Mixed: >RH[3]
RLS 2 (Type 2) (aircraft receiver)	73 at 10 000 m in a 3 MHz reference bandwidth	Rural: 146 Suburban/urban: 351 Mixed: 292	Rural: 159 Suburban/urban: 386 Mixed: 337

Note 1: Result based on condition that MS base stations operate with antenna height 30 m, cell radius is 8 km for rural area, 2 km for suburban and urban area. MS base station e.i.r.p. in direction towards the country hosting the ARNS is not more than 55 dBm in 5 MHz and 3 degrees down tilt of antenna pattern in accordance with Rec. ITU-R F. 1336.

Note 2: Result based on condition that MS base station operate with antenna height 30 m, cell radius is 8 km for rural area, 2 km for suburban and urban area. MS base station e.i.r.p. in direction towards the country hosting the ARNS is not more than 55 dBm in 5 MHz and 3 degrees down tilt of antenna pattern in accordance with Rec. ITU-R F. 1336.

Note 3: RH=Radio Horizon (The radio horizon for 30m and 10000 m antenna heights are 432 km)

MS UE to ARNS

For the situation when MS UE are interfering with ground based ARNS stations propagation model Recommendation ITU-R P.1546-4 has been used. For the situation when MS UE are interfering ARNS airborne stations propagation model Recommendation ITU-R P.525 has been used. For both airborne and ground-based cases, one MS UE has been placed exactly at the coordination distance while all other terminals have been randomly positioned within the respective area.

FIGURE 8

Example of one realization with 20 km coordination distance for MS UE to airborne ARNS station scenario. The red ‘x’ corresponds to the ARNS station. The cell radius is 8 km and there is one MS UE per cell, on average. The left plot shows the full simulation area, whereas the right plot shows only a part of the full area in order to illustrate the position of the terminals w.r.t. the coordination distance

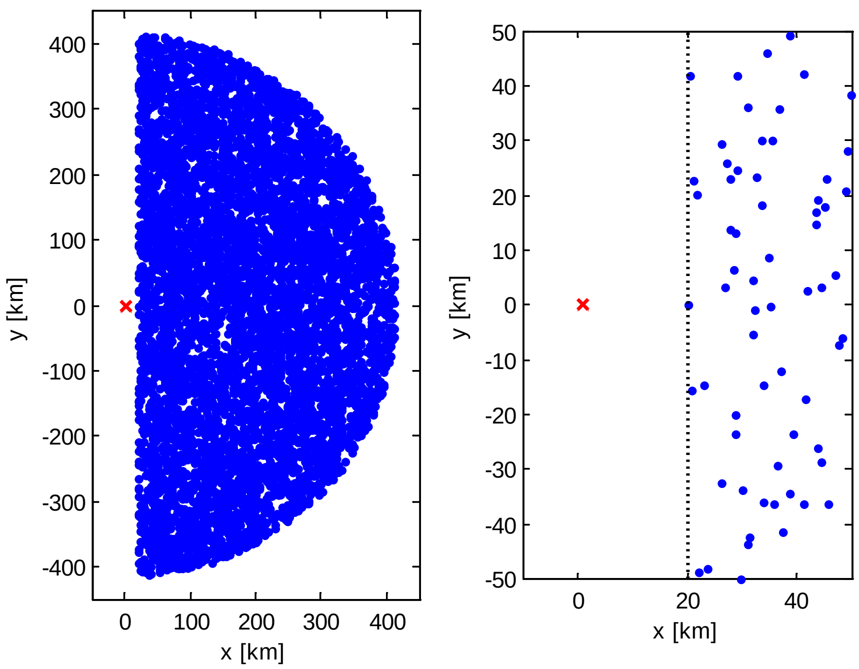
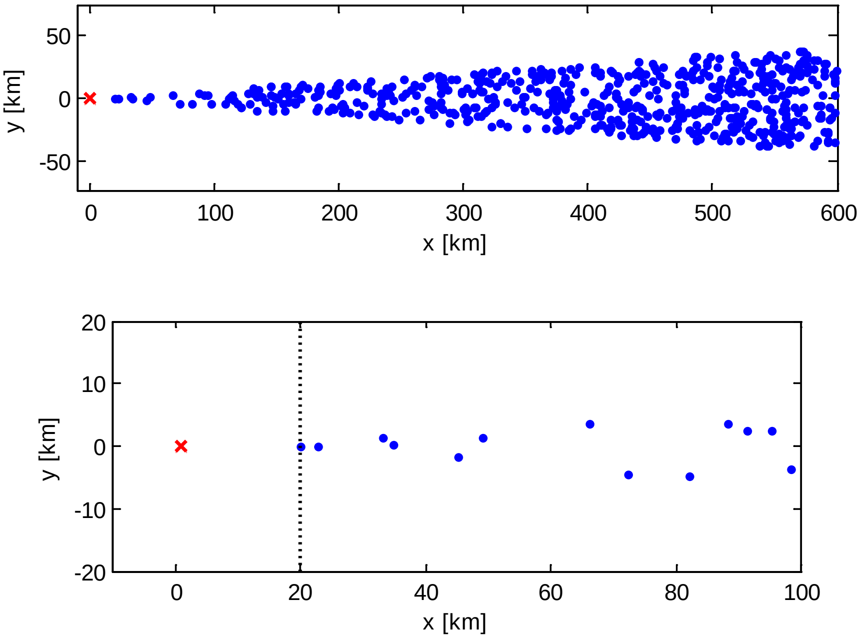


FIGURE 9

Example of one realization with 20 km coordination distance for MS UE to ground-based ARNS station scenario. The red 'x' corresponds to the ARNS station. The cell radius is 8 km and there is one MS UE per cell, on average. The upper plot shows the full simulation area, whereas the lower plot shows only a part of the full area in order to illustrate the position of the terminals w.r.t. the coordination distance



This results in the following coordination distances in Table 11 – Table 14. Note that a number of cases are considered, as described in Table 10.

TABLE 10

Case	Description
A	No power control. All UE with antenna height 1.5 m use average transmit power as specified by ITU-R _UE densities: Rural: 0.17 km^{-2}/5 MHz, suburban/urban: 2.16 km^{-2}/5 MHz,
B	All UE with antenna height 1.5 m transmit with full power (23 dBm). UE densities: Rural: 0.17 km^{-2}/5 MHz, suburban/urban: 2.16 km^{-2}/5 MHz
C	All UE with antenna height 1.5 m transmit with full power. UE densities: 1, 3, or 6 terminals/cell

Case A is based on the UE density and the output power as specified by ITU-R to be used in sharing studies. Case B and C has been included to verify that the coordination distances for the UE are shorter than for the base stations in all relevant cases independent of methodology. Furthermore Case B assumes that all UE in the mobile network are transmitting at full power which isn´t realistic or even possible in a LTE network.

TABLE 11

Required coordination distances, MS UE – ARNS, 5 MHz, Rural

ARNS type	**Predetermined aggregate trigger field-strength values from a mobile service station (dB(μV/m))**	**Case**[1]	**Coordination distance (km)** * = area limited to 600 km from ARNS ground station		
			Air-borne	**50/50% Land/Sea**	**100% Land**
RSBN	42 at 10 m in a 3 MHz reference bandwidth	A		<1	<1
		B		<1*	<1*
		C		<1/<1/<1*	<1/<1/<1*
RLS 2 (Type 1) (aircraft receiver	52at 10 000 m in a 4 MHz reference bandwidth	A	<1		
		B	142		
		C	<1/55/124		
RLS 2 (Type 1) (ground receiver)	29at 10 m in a 4 MHz reference bandwidth	A		<1	<1
		B		1*	<1*
		C		1/1/1*	<1/<1/<1*
RLS 2 (Type 2) (aircraft receiver)	73 at 10 000 m in a 3 MHz reference bandwidth	A	<1		
		B	<1		
		C	<1/<1/<1		
RLS 2 (Type 2) (ground receiver)	24at 10 m in a 8 MHz reference bandwidth	A		<1	<1
		B		2*	1*
		C		2/2/2*	1/1/2*
RLS 1 (Types 1 and 2)	13 at 10 m in a 6 MHz reference bandwidth	A		<1	<1
		B		3*	2*
		C		3/3/3*	2/2/2*
Note 1: See Table A.1-7					

TABLE 12

Required coordination distances, MS UE – ARNS, 5 MHz, Suburban.

ARNS type	**Predetermined aggregate trigger field-strength values from a MS station (dB(µV/m))**		**Coordination distance (km)** * = area limited to 600 km from ARNS ground station		
		Case[1]	**Air-borne**	**50/50% Land/Sea**	**100% Land**
RSBN	42 at 10 m in a 3 MHz reference bandwidth	A		<1*	<1*
		B		<1*	<1*
		C		<1/<1/<1*	<1/<1/<1*
RLS 2 (Type 1) (aircraft receiver	52at 10 000 m in a 4 MHz reference bandwidth	A	<1		
		B	319		
		C	174/277/322		
RLS 2 (Type 1) (ground receiver)	29at 10 m in a 4 MHz reference bandwidth	A		<1*	<1*
		B		<1*	<1*
		C		<1/<1/<1*	<1/<1/<1*
RLS 2 (Type 2) (aircraft receiver)	73 at 10 000 m in a 3 MHz reference bandwidth	A	<1		
		B	<1		
		C	<1/<1/<1		
RLS 2 (Type 2) (ground receiver)	24/at 10 m in a 8 MHz reference bandwidth	A		<1*	<1*
		B		<1*	<1*
		C		<1/<1/<1*	<1/<1/<1*
RLS 1 (Types 1 and 2)	13 at 10 m in a 6 MHz reference bandwidth	A		<1*	<1*
		B		2*	1*
		C		2/2/2*	1/1/1*
Note 1: See Table A.1-7					

TABLE 13

Required coordination distances, MS UE – ARNS, 5 MHz, Urban.

ARNS type	**Predetermined aggregate trigger field-strength values from a MS station (dB(μV/m))**		**Coordination distance (km)** * = area limited to 600 km from ARNS ground station †Not supported by Recommendation ITU-R P.1546		
		Case[1]	**Air-borne**	**50/50% Land/Sea**	**100% Land**
RSBN	42 at 10 m in a 3 MHz reference bandwidth	A			
		B		N/A†	N/A†
		C			
RLS 2 (Type 1) (aircraft receiver	52/at 10 000 m in a 4 MHz reference bandwidth	A	<1		
		B	319		
		C	174/277/322		
RLS 2 (Type 1) (ground receiver)	29/at 10 m in a 4 MHz reference bandwidth	A			
		B		N/A†	N/A†
		C			
RLS 2 (Type 2) (aircraft receiver)	73 at 10 000 m in a 3 MHz reference bandwidth	A	<1		
		B	<1		
		C	<1/<1/<1		
RLS 2 (Type 2) (ground receiver)	24/at 10 m in a 8 MHz reference bandwidth	A			
		B		N/A†	N/A†
		C			
RLS 1 (Types 1 and 2)	13 at 10 m in a 6 MHz reference bandwidth	A			
		B		N/A†	N/A†
		C			
Note 1: See Table A.1-7					

TABLE 14

Required coordination distances, MS UE – ARNS, 10 MHz, Rural

ARNS type	Predetermined aggregate trigger field-strength values from a MS station (dB(μV/m))		Coordination distance (km) * = area limited to 600 km from ARNS ground station		
		Case[1]	**Air-borne**	**50/50% Land/Sea**	**100% Land**
RSBN	42 at 10 m in a 3 MHz reference bandwidth	A		<1	<1
		B		<1*	<1*
		C		<1/<1/<1	<1/<1/<1
RLS 2 (Type 1) (aircraft receiver	52/at 10 000 m in a 4 MHz reference bandwidth	A	<1		
		B	142		
		C	<1/11/55		
RLS 2 (Type 1) (ground receiver)	29/at 10 m in a 4 MHz reference bandwidth	A		<1	<1
		B		<1*	<1*
		C		<1/<1/<1	<1/<1/<1
RLS 2 (Type 2) (aircraft receiver)	73 at 10 000 m in a 3 MHz reference bandwidth	A	<1		
		B	<1		
		C	<1/<1/<1		
RLS 2 (Type 2) (ground receiver)	24/at 10 m in a 8 MHz reference bandwidth	A		<1	<1
		B		2*	1*
		C		2/2/2	1/1/1
RLS 1 (Types 1 and 2)	13 at 10 m in a 6 MHz reference bandwidth	A		<1	<1
		B		3*	2*
		C		3/3/3	2/2/2
Note 1: See Table A.1-7					

4.1.2.4 Results of estimation of interference and conditions for compatibility of MS systems with ARNS systems

Based on the calculations above the coordination distances between MS and ARNS shown in Table 15 below can be concluded. Regarding the coordination distances for the UE, Case A from the table above has been used since this is seen as the most realistic case and are in line with the guidance given by ITU-R. The additional attenuation from the RSBN antenna pattern described in Annex 8 and reviewed in table 5 [could further decrease the coordination distances but] are not taken into account in these results.

TABLE 15

Coordination threshold values of MS stations with ARNS

ARNS station	System type code	Coordination distances for the receiving MS base stations (km)[3]	Coordination distances for the transmitting MS base stations (km)[1]
RSBN	AA8	Rural: <1 Suburban: <1 Urban: N/A	Rural: 15/19*[2] Suburban: 17/25*[2] Urban: 5/7*[2] Mixed: 15/20*[2]
RLS 2 (type 1) (airborne receiver)	BD	Rural: <1 Suburban:<1 Urban: <1	Rural: >RH[4] Suburban/urban: >RH[4] Mixed: >RH[4]
RLS 2 (type 1) (ground receiver)	BA	Rural: <1 Suburban:<1 Urban: N/A[5]	Rural: 31/42* Suburban: 70/112* Urban: 13/18* Mixed: 40/61*
RLS 2 (type 2) (airborne receiver)	BC	Rural: <1 Suburban:<1 Urban: <1	Rural: 251 Suburban/urban: 403 Mixed: 373
RLS 2 (type 2) (ground receiver)	AA2	Rural: <1 Suburban: <1 Urban: N/A[5]	Rural: 45/65* Suburban: 124/167* Urban: 18/29* Mixed: 69/111*
RLS 1 (types 1 and 2) (ground receiver)	AB	Rural: <1 Suburban: <1 Urban: N/A[5]	Rural: 112/163* Suburban: 230/274* Urban: 53/97* Mixed: 171/212*
Other ARNS ground stations	Not applied	Rural: <1 Suburban: <1 Urban: N/A[5]	Rural: 112/163* Suburban: 230/274* Urban: 53/97* Mixed: 171/212*
Other ARNS airborne stations	Not applied	Rural: <1 Suburban:<1 Urban: <1	Rural: >RH[4] Suburban/urban: >RH[4] Mixed: >RH[4]

* 50% ≤ land path ≤ 100% / 0% ≤ land path < 50%.

Note 1: Result based on condition that MS base station operate with antenna height 30 m, cell radius is 8 km for rural area, 2 km for suburban and urban area. MS base station e.i.r.p. in direction towards the country hosting the ARNS is not more than 55 dBm in 5 MHz and 3 degrees down tilt of antenna pattern in accordance with Rec. ITU-R F.1336.

Note 2: Result based on condition that MS base stations operate with antenna height 30 m, cell radius is 8 km for rural area, 2 km for suburban and urban area

Note 3: All terminals with antenna height 1.5 m use average transmit power of 2 dBm for macro rural scenario, –9 dBm for macro urban/suburban scenario and densities of terminals in active mode are: rural: 0.17 UE per km^2/5 MHz, suburban/urban: 2.16 UE per km^2/5 MHz, as specified by ITU-R. Typical body loss of 4 dB was taken into account.

Note 4: RH= radio horizon (The radio horizon for 30m and 10 000 m antenna heights are 432 km)

Note 5: ITU-R Rec. ITU-R P.1546 is not applicable for the urban case since both transmitter and receiver antenna heights are below the clutter height

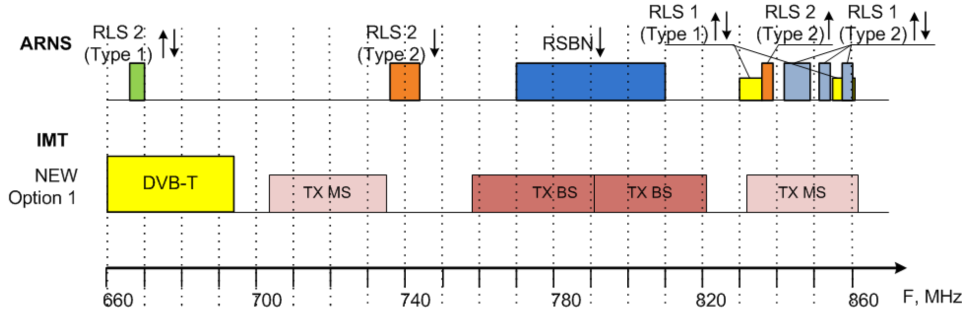
Analysis

It can be concluded that only the coordination distances between MS base stations and ARNS needs to be considered, since the coordination distances between MS UE and ARNS in all cases are considerably smaller than the coordination distances between MS base stations and ARNS.

Further analysing which frequencies the different ARNS systems use, it can also be concluded that only the ground stations of the RSBN system and the ground station of the RLS2 type 2 system are located in the concerned frequency range of 694-790 MHz, as shown in the figure below.

FIGURE 10

ARNS and possible MS frequency utilisation



Conclusions

Based on the discussion above, the coordination distances between ARNS and MS in 694-790 MHz shown in Table 16 below can be concluded. The mixed environment coordination distances are based on the scenarios with mixed environment e.g. 70 % rural, 20 % suburban and 10 % urban.

TABLE 16

Coordination distance required between MS and ARNS in 694-790 MHz

Scenario	Propagation type	Required coordination distance[1] – Mixed environment	Required coordination distance[1] – Rural environment	Required coordination distance[1] – Sub-urban environment	Required coordination distance[1] – Urban environment
MS base station to ARNS	Land path	69 km	45 km	124 km	18 km
MS base station to ARNS	Mixed sea/land path	111 km	65 km	167 km	29 km
Note 1: Result based on condition that MS base station operate with antenna height 30 m, cell radius is 8 km for rural area, 2 km for suburban and urban area, MS base station e.i.r.p. in direction towards the country hosting the ARNS is not more than 55 dBm in 5 MHz and 3 degrees down tilt of antenna pattern in accordance with Rec. ITU-R F.1336.					

For the case that only RSBN ground receivers are concerned (e.g. if lower duplex pair of frequency arrangement A5 of Recommendation ITU-R M.1036-4 is used for the MS implementation) the distances shown in Table 17 below applies. The additional attenuation resulting from the RSBN antenna pattern described in Annex 8 and reviewed in table 5 [could further decrease the coordination distances but]are not taken into account in these results.

TABLE 17

Coordination distance required between MS and ARNS in 694-790 MHz if only RSBN ground receivers of the ARNS system are concerned

Scenario	Propagation type	Required coordination distance[1] – Mixed environment	Required coordination distance[1] – Rural environment	Required coordination distance[1] – Sub-urban environment	Required coordination distance[1] – Urban environment
MS base station to ARNS	Land path	15 km	15 km	17 km	5 km
MS base station to ARNS	Mixed sea/land path	20 km	19 km	25 km	7 km
Note 1: Result based on condition that MS base station operate with antenna height 30 m, cell radius is 8 km for rural area, 2 km for suburban and urban area, MS base station e.i.r.p. in direction towards the country hosting the ARNS is not more than 55 dBm in 5 MHz and 3 degrees down tilt of antenna pattern in accordance with Rec. ITU-R F. 1336. If lower duplex pair of frequency arrangement A5 of Rec. ITU-R M.1036-4 is used for the MS implementation.					

Views from some administrations regarding Study #A.1 are presented in Appendix 7.

4.1.3 Study#A.2 based on implementation of coordination distances

4.1.3.1 Assumptions

The technical characteristics were applied in the sharing studies of the IMT and ARNS systems described in section 3.

In this study the interference field strength levels provided in Table 3 was considered. This is also in line with the values indicated in Recommendation ITU-R M.1830 and the GE06 Agreement. The free space propagation model (Recommendation ITU-R P.525-2) was used for interference assessment to ARNS airborne receivers and the propagation model described in Recommendation ITU-R P.1546-5 was used for interference assessment to ground ARNS receivers. Using Recommendation ITU-R P.1546-5
the calculations were performed for 10% of time and 50% of locations.

4.1.3.2 Methodology to estimate interference caused by MS systems to ARNS systems

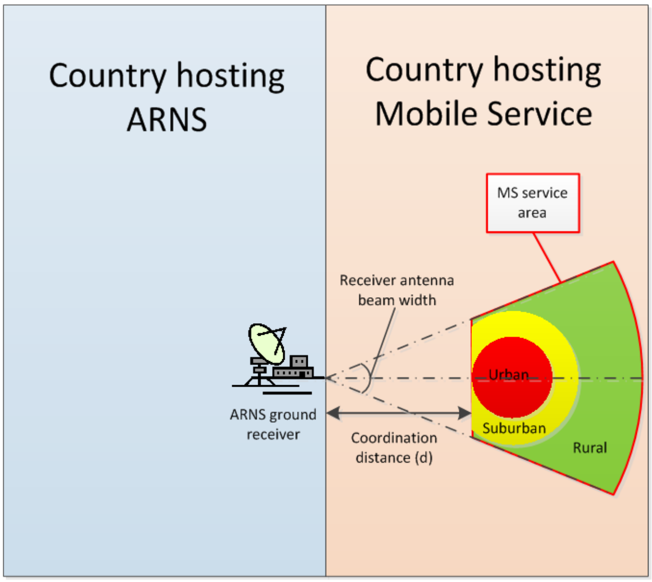
The following two situations regarding the interference from MS towards ARNS have been investigated by using a statistical approach. Both emissions from base stations and UE have been studied. The methodology essentially follows that of JTG 5-6 but with updated parameters.

In the compatibility studies the following scenarios of MS station deployment are considered:

– **Scenario 1** is shown in Fig. 11. In this case it is assumed that MS system transmitters are located behind the line which is at the protection distance from the ground receiver of ARNS. The urban area (with base station cell radius of 0.5 kilometres) surrounded by suburban (with base station cell radius of 2 kilometres) and rural areas (with base station cell radius of 8 kilometres) is located in the vicinity of the receiver. In the estimations in one case the MS base station antenna height of 30 m and urban area of 30 sq. km and suburban area of 90 sq.km are considered. The second case addresses MS base station antenna height of 50 m and urban area of 100 sq. km and suburban area of 300 sq.km. For example Moscow area is 1081 sq.km, Berlin area is 900 sq.km, Helsinki area is 680 sq.km and Prague is 500 sq.km therefore the selected urban areas are optimistic. The ground receiver antenna height was taken as 10 metres. The antenna pattern beamwidth of –3 dB for ARNS earth station is 8 degrees. For the propagation the rural attenuation curves of Recommendation ITU-R P.1546 has been used for all environments.

FIGURE 11

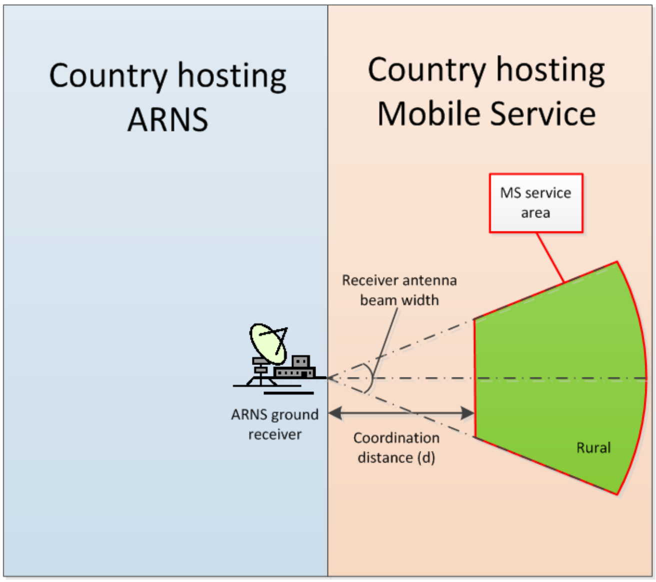
Scenario 1 "Urban- suburban- rural (U-S-R)" interference impact to ARNS ground receiver (urban area is highlighted by red colour, suburban area is highlighted by yellow colour, rural area is highlighted by green colour)



– **Scenario 2** is shown in Fig. 12. In this case it is assumed that MS system transmitters are located behind the line which is at the protection distance from the ARNS ground receiver. Unlike Scenario 1 they are located in the rural area with base station cell radius of 8 kilometres. The IMT base station antenna height was taken as 30 metres and the ground receiver antenna height was 10 m. The antenna pattern beamwidth of –3 dB for ARNS earth station is 8 degrees.

FIGURE 12

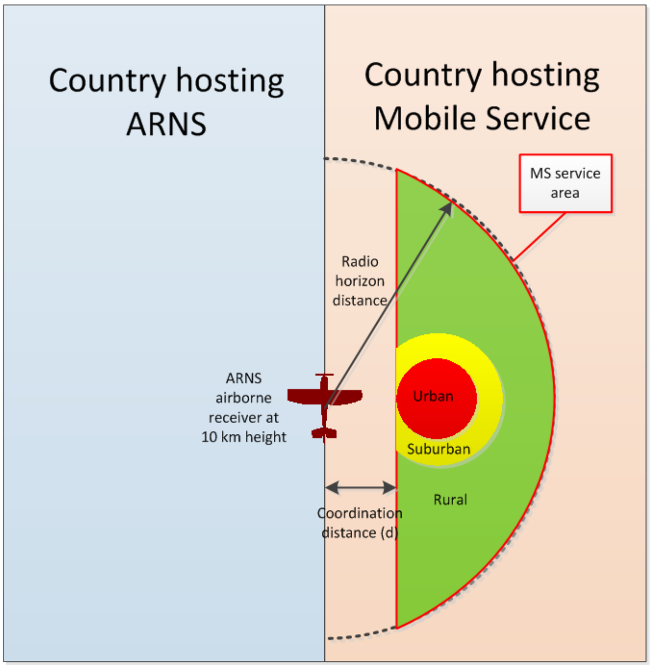
Scenario 2 "Rural" interference impact to ARNS ground receiver (rural area is highlighted by green colour)



– **Scenario 3** is shown in Fig. 13. In this case it is assumed that MS system transmitters are located behind the line which is at the protection distance from the airborne receiver of ARNS. The urban area (with base station cell radius of 0.5 kilometres) surrounded by suburban (with base station cell radius of 2 kilometres) and rural areas (with base station cell radius of 8 kilometres) is located in the vicinity of the receiver. In the estimations in one case the MS base station antenna height of 30 m and urban area of 30 sq. km and suburban area of 90 sq.km are considered. The second case addresses MS base station antenna height of 50 m and urban area of 100 sq. km and suburban area of 300 sq.km. For example Moscow area is 1081 sq.km, Berlin area is 900 sq.km, Helsinki area is 680 sq.km and Prague is 500 sq.km therefore the selected urban areas are optimistic. The airborne receiver antenna height was taken of 10 000 metres.

FIGURE 13

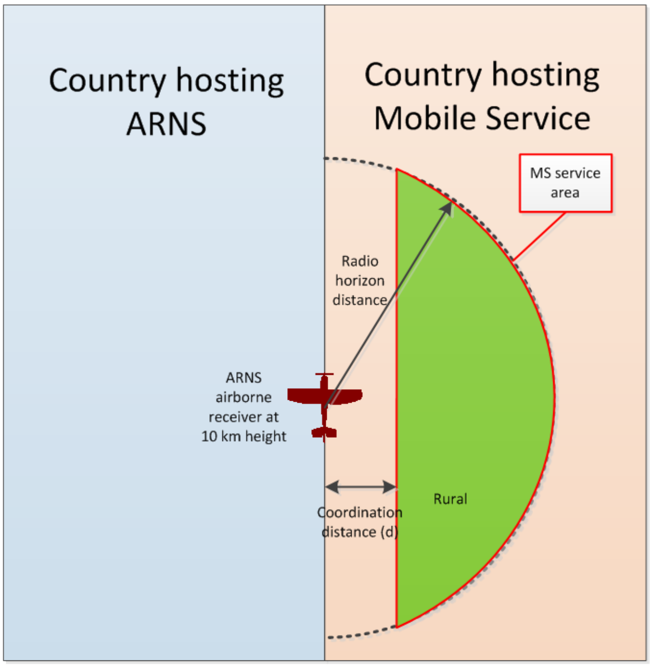
Scenario 3 “Urban- suburban- rural (U-S-R)” interference impact to ARNS airborne receiver (urban area is highlighted by red colour, suburban area is highlighted by yellow colour, rural area is highlighted by green colour)



– **Scenario 4** is shown in Fig. 14. In this case it is also assumed that MS system transmitters are located beyond the line which is at the protection distance from the ARNS airborne receiver. Unlike Scenario 3 they are located in the rural area with deployment density (with base station cell radius of 8 kilometres). The IMT base station antenna height was taken as 30 metres and the ARNS airborne receiver antenna height was 10 000 metres.

FIGURE 14

Scenario 4 "Rural" interference impact to ARNS airborne receiver (rural area is highlighted by green colour)



4.1.3.3 Calculations

MS base station to Ground-Based ARNS (Scenario 1 and Scenario 2)

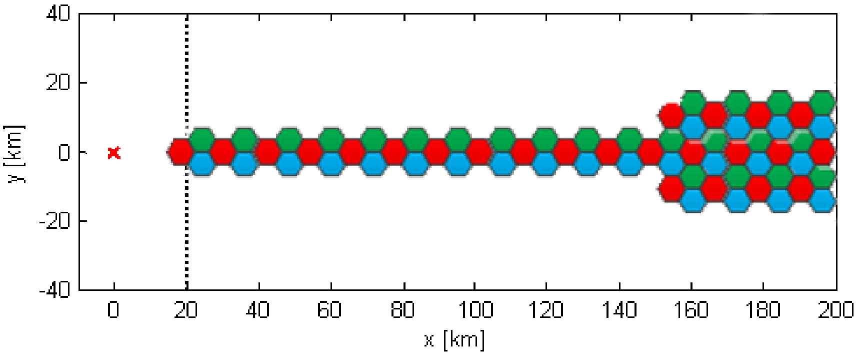
For the situation when MS base stations are interfering with ground based ARNS stations, Figure 11 shows an example of the scenario investigated. For calculating the interfering signal propagation model Recommendation ITU-R P.1546-4 has been used[8].

The MS sites are organized according to a hexagonal structure with the nearest site, or sites, at the coordination distance according to Figure 15. The antenna pattern mainbeam of MS is pointed towards the ARNS station in the cell as it is shown in Fig. 15. This case of the antenna pattern mainbeams pointing in MS cell was considered for Scenario 1 and Scenario 2 as it is shown in Fig. 11 and Fig. 12 accordingly.

[8] The rural attenuation curves of Recommendation ITU-R P.1546 have also been used for sub-urban and urban environments.

FIGURE 15

Example with 20 km coordination distance showing the coverage area of the three-sector MS sites in relation to the ARNS station. The red 'x' corresponds to the ARNS station. The main lobes of the antennas of an MS site point at 60°, 180° and 300°



The required coordination distances are indicated in tables below.

TABLE 18

Required coordination distances between MS base stations and terrestrial ARNS receivers, 5 MHz bandwidth and 100% land propagation

ARNS type	Predetermined aggregate trigger field-strength values from a mobile service station (dB(μV/m))	Separation Distance (km)		Coordination Distance (km)
		(Rural - Scenario 2)	(Urban Suburban Rural – Scenario 1)	
RSBN	42 at 10 m in a 3 MHz reference bandwidth	20[1]	50[2]/75[3]	50[2]/75[3]
RLS 2 (Type 1) (ground receiver)	29 at 10 m in a 4 MHz reference bandwidth	55[1]	140[2]/185[3]	140[2]/185[3]
RLS 2 (Type 2) (ground receiver)	24 at 10 m in a 8 MHz reference bandwidth	120[1]	210[2]/250[3]	210[2]/250[3]
RLS 1 (Type 1 and 2)	13 at 10 m in a 6 MHz reference bandwidth	225[1]	300[2]/350[3]	300[2]/350[3]

Note 1: Result based on conditions that the MS base stations operate with antenna height 30 m, cell radius is 8 km for rural area and power of the MS base stations is 55 dBm in 5 MHz due orientation of main beam antenna pattern towards ARNS station. No downtilt of the MS base station antennas has been applied. Antenna pattern only in horizontal plane from Recommendation ITU-R F.1336 has been used.

Note 2: Result based on conditions that MS base stations operate with antenna height 30 m, cell radius is 8 km for rural area, 2 km for suburban area (S=90 km^2) and 0.5 km for urban area (S=30 km^2), power of MS base stations is 55 dBm in 5 MHz due orientation of main beam antenna pattern towards ARNS station. The rural attenuation curves of Recommendation ITU-R P.1546 have been used for all environments. No downtilt of the MS base station antennas has been applied. Antenna pattern only in horizontal plane from Recommendation ITU-R F.1336 has been used.

Note 3: Result based on conditions that MS base stations operate with antenna height 50 m, cell radius is 8 km for rural area, 2 km for suburban area (S=300 km^2) and 0.5 km (S=100 km^2) for urban area, power of MS base stations is 55 dBm in 5 MHz due orientation of main beam antenna pattern towards ARNS station. The rural attenuation curves of Recommendation ITU-R P.1546 have been used for all environments. No downtilt of the MS base station antennas has been applied. Antenna pattern only in horizontal plane from Recommendation ITU-R F.1336 has been used.

TABLE 19

Required coordination distances between MS base stations and terrestrial ARNS receivers, 5 MHz bandwidth and 50/50% land/sea propagation

ARNS type	Predetermined aggregate trigger field-strength values from a mobile service station (dB(μV/m))	Separation Distance (km)		Coordination Distance (km)
		(Rural - Scenario 2)	(Urban Suburban Rural – Scenario 1)	
RSBN	42 at 10 m in a 3 MHz reference bandwidth	25[1]	65[2]/90[3]	65[2]/90[3]
RLS 2 (Type 1) (ground receiver)	29 at 10 m in a 4 MHz reference bandwidth	65[1]	165[2]/200[3]	165[2]/200[3]
RLS 2 (Type 2) (ground receiver)	24 at 10 m in a 8 MHz reference bandwidth	135[1]	235[2]/275[3]	235[2]/275[3]
RLS 1 (Type 1 and 2)	13 at 10 m in a 6 MHz reference bandwidth	235[1]	335[2]/375[3]	335[2]/375[3]

Note 1: Result based on conditions that MS base stations operate with antenna height 30 m, cell radius is 8 km for rural area and power of MS base stations is 55 dBm in 5 MHz due orientation of main beam antenna pattern towards ARNS station. No downtilt of the MS base station antennas has been applied. Antenna pattern only in horizontal plane from Recommendation ITU-R F.1336 has been used.

Note 2: Result based on conditions that MS base stations operate with antenna height 30 m, cell radius is 8 km for rural area, 2 km for suburban area (S=90 km^2) and 0.5 km for urban area (S=30 km^2), power of MS base stations is 55 dBm in 5 MHz due orientation of main beam antenna pattern towards ARNS station. The rural attenuation curves of Recommendation ITU-R P.1546 have been used for all environments. No downtilt of the MS base station antennas has been applied. Antenna pattern only in horizontal plane from Recommendation ITU-R F.1336 has been used.

Note 3: Result based on conditions that MS base stations operate with antenna height 50 m, cell radius is 8 km for rural area, 2 km for suburban area (S=300 km^2) and 0.5 km (S=100 km^2) for urban area, power of MS base stations is 55 dBm in 5 MHz due orientation of main beam antenna pattern towards ARNS station. The rural attenuation curves of Recommendation ITU-R P.1546 have been used for all environments. No downtilt of the MS base station antennas has been applied. Antenna pattern only in horizontal plane from Recommendation ITU-R F.1336 has been used.

TABLE 20

Required coordination distances between MS base stations and terrestrial ARNS receivers, 10 MHz bandwidth, 100 % land propagation

ARNS type	Predetermined aggregate trigger field-strength values from a mobile service station (dB(μV/m))	Separation Distance (km)		Coordination Distance (km)
		(Rural - Scenario 2)	(Urban Suburban Rural – Scenario 1)	
RSBN	42 at 10 m in a 3 MHz reference bandwidth	18[1]	40[2]/60[3]	40[2]/60[3]
RLS 2 (Type 1) (ground receiver)	29 at 10 m in a 4 MHz reference bandwidth	40[1]	120[2]/160[3]	120[2]/160[3]
RLS 2 (Type 2) (ground receiver)	24 at 10 m in a 8 MHz reference bandwidth	90[1]	180[2]/225[3]	180[2]/225[3]
RLS 1 (Type 1 and 2)	13 at 10 m in a 6 MHz reference bandwidth	190[1]	270[2]/320[3]	270[2]/320[3]

Note 1: Result based on conditions that MS base stations operate with antenna height 30 m, cell radius is 8 km for rural area and power of MS base stations is 55 dBm in 5 MHz due orientation of main beam antenna pattern towards ARNS station. No downtilt of the MS base station antennas has been applied. Antenna pattern only in horizontal plane from Recommendation ITU-R F.1336 has been used.

Note 2: Result based on conditions that MS base stations operate with antenna height 30 m, cell radius is 8 km for rural area, 2 km for suburban area (S=90 km^2) and 0.5 km for urban area (S=30 km^2), power of MS base stations is 55 dBm in 5 MHz due orientation of main beam antenna pattern towards ARNS station. The rural attenuation curves of Recommendation ITU-R P.1546 have been used for all environments. No downtilt of the MS base station antennas has been applied. Antenna pattern only in horizontal plane from Recommendation ITU-R F.1336 has been used.

Note 3: Result based on conditions that MS base stations operate with antenna height 50 m, cell radius is 8 km for rural area, 2 km for suburban area (S=300 km^2) and 0.5 km (S=100 km^2) for urban area, power of MS base stations is 55 dBm in 5 MHz due orientation of main beam antenna pattern towards ARNS station. The rural attenuation curves of Recommendation ITU-R P.1546 have been used for all environments. No downtilt of the MS base station antennas has been applied. Antenna pattern only in horizontal plane from Recommendation ITU-R F.1336 has been used.

TABLE 21

Required coordination distances between MS base stations and terrestrial ARNS receivers, 10 MHz bandwidth, 50/50% sea/land propagation

ARNS type	Predetermined aggregate trigger field-strength values from a mobile service station (dB(μV/m))	Separation Distance (km)		Coordination Distance (km)
		(Rural - Scenario 2)	(Urban Suburban Rural – Scenario 1)	
RSBN	42 at 10 m in a 3 MHz reference bandwidth	20[1]	50[2]/75[3]	50[2]/75[3]
RLS 2 (Type 1) (ground receiver)	29 at 10 m in a 4 MHz reference bandwidth	50[1]	140[2]/180[3]	140[2]/180[3]
RLS 2 (Type 2) (ground receiver)	24 at 10 m in a 8 MHz reference bandwidth	100[1]	210[2]/245[3]	210[2]/245[3]
RLS 1 (Type 1 and 2)	13 at 10 m in a 6 MHz reference bandwidth	200[1]	300[2]/340[3]	300[2]/340[3]

Note 1: Result based on conditions that MS base stations operate with antenna height 30 m, cell radius is 8 km for rural area and power of MS base stations is 55 dBm in 5 MHz due orientation of main beam antenna pattern towards ARNS station. No downtilt of the MS base station antennas has been applied. Antenna pattern only in horizontal plane from Recommendation ITU-R F.1336 has been used.

Note 2: Result based on conditions that MS base stations operate with antenna height 30 m, cell radius is 8 km for rural area, 2 km for suburban area (S=90 km^2) and 0.5 km for urban area (S=30 km^2), power of MS base stations is 55 dBm in 5 MHz due orientation of main beam antenna pattern towards ARNS station. The rural attenuation curves of Recommendation ITU-R P.1546 have been used for all environments. No downtilt of the MS base station antennas has been applied. Antenna pattern only in horizontal plane from Recommendation ITU-R F.1336 has been used.

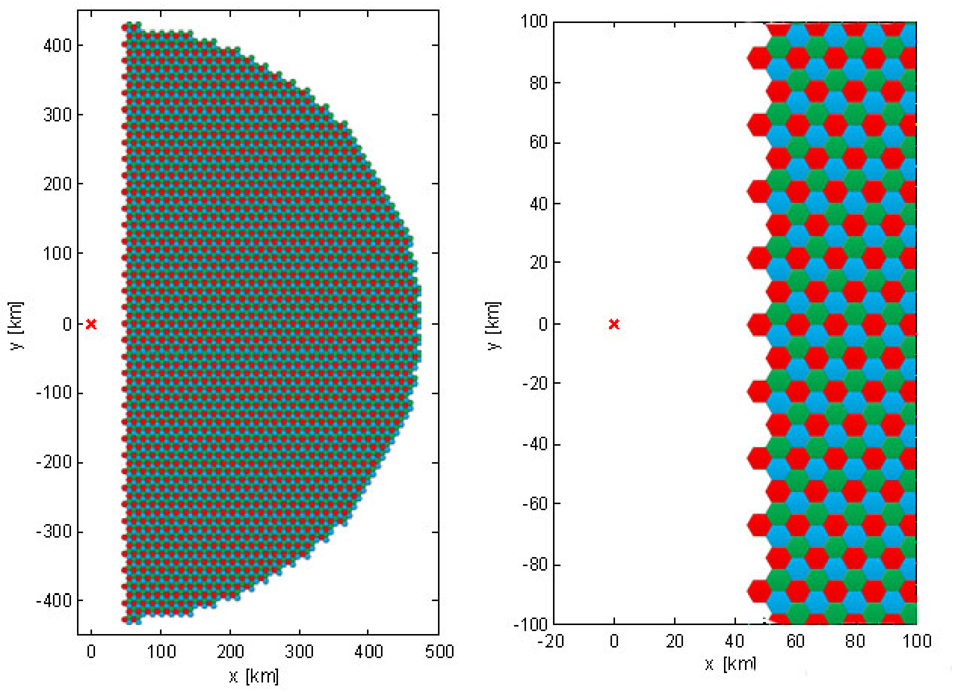
Note 3: Result based on conditions that MS base stations operate with antenna height 50 m, cell radius is 8 km for rural area, 2 km for suburban area (S=300 km^2) and 0.5 km (S=100 km^2) for urban area, power of MS base stations is 55 dBm in 5 MHz due orientation of main beam antenna pattern towards ARNS station. The rural attenuation curves of Recommendation ITU-R P.1546 have been used for all environments. No downtilt of the MS base station antennas has been applied. Antenna pattern only in horizontal plane from Recommendation ITU-R F.1336 has been used.

MS base station to airborne ARNS (Scenario 3 and Scenario 4)

For the situation when MS base stations are interfering with airborne ARNS stations, Figure 6 and Figure 14 shows an example of the scenario investigated. For calculating the interfering signal the propagation model in Recommendation ITU-R P.525 has been used. The MS sites are organized according to a hexagonal structure with the nearest sites positioned at the coordination distance according to Figure 6. The antenna pattern mainbeam of MS is pointed towards the ARNS airborne station. This case of the antenna pattern mainbeams pointing in MS cell was considered for Scenario 3 and Scenario 4 as it is shown in Fig. 13 and Fig. 14 accordingly.

FIGURE 16

Example with 50 km coordination distance showing the coverage area of the three-sector MS sites in relation to the ARNS station. The red 'x' corresponds to the ARNS station. The main lobes of the antennas of a site point in 60°, 180° and 300°. The left plot shows the full simulation area, whereas the right plot shows only a part of the full area in order to illustrate the position of the sites w.r.t. the coordination distance



The required coordination distances are indicated in the tables below.

TABLE 22

Required coordination distance between MS base stations 5 MHz and airborne ARNS receiver

ARNS type	Predetermined aggregate trigger field-strength values from a mobile service station (dB(µV/m))	Separation Distance (km)		Coordination Distance (km)
		(Rural – Scenario 4)	(Urban Suburban Rural – Scenario 3)	
RLS 2 (Type 1) (aircraft receiver)	52 at 10 000 m in a 4 MHz reference bandwidth	434[1]	434[2]/441[3]	441[3]
RLS 2 (Type 2) (aircraft receiver)	73 at 10 000 m in a 3 MHz reference bandwidth	345[1]	360[2]/400[3]	400[3]

Note 1: Result based on conditions that MS base stations operate with antenna height 30 m, cell radius is 8 km for rural area and power of MS base stations is 55 dBm in 5 MHz due orientation of main beam antenna pattern towards ARNS station.
No downtilt of the MS base station antennas has been applied. Antenna pattern only in horizontal plane from Recommendation ITU-R F.1336 has been used.

Note 2: Result based on conditions that MS base stations operate with antenna height 30 m, cell radius is 8 km for rural area, 2 km for suburban area (S=90 km^2) and 0.5 km for urban area (S=30 km^2), power of MS base stations is 55 dBm in 5 MHz due orientation of main beam antenna pattern towards ARNS station. No downtilt of the MS base station antennas has been applied. Antenna pattern only in horizontal plane from Recommendation ITU-R F.1336 has been used.

Note 3: Result based on conditions that MS base stations operate with antenna height 50 m, cell radius is 8 km for rural area, 2 km for suburban area (S=300 km^2) and 0.5 km (S=100 km^2) for urban area, power of MS base stations is 55 dBm in 5 MHz due orientation of main beam antenna pattern towards ARNS station. No downtilt of the MS base station antennas has been applied. Antenna pattern only in horizontal plane from Recommendation ITU-R F.1336 has been used.

TABLE 23

Required coordination criteria MS base stations 10 MHz – terrestrial ARNS receiver

ARNS type	Predetermined aggregate trigger field-strength values from a mobile service station (dB(µV/m))	Separation Distance (km)		Coordination Distance (km)
		(Rural - Scenario 4)	(Urban Suburban Rural – Scenario 3)	
RLS 2 (Type 1) (aircraft receiver)	52 at 10 000 m in a 4 MHz reference bandwidth	432[1]	434[2]/441[3]	441[3]
RLS 2 (Type 2) (aircraft receiver)	73 at 10 000 m in a 3 MHz reference bandwidth	295[1]	310[2]/340[3]	340[3]

Note 1: Result based on conditions that MS base stations operate with antenna height 30 m, cell radius is 8 km for rural area and power of MS base stations is 55 dBm in 5 MHz due orientation of main beam antenna pattern towards ARNS station.
No downtilt of the MS base station antennas has been applied. Antenna pattern only in horizontal plane from Recommendation ITU-R F.1336 has been used.

Note 2: Result based on conditions that MS base stations operate with antenna height 30 m, cell radius is 8 km for rural area, 2 km for suburban area (S=90 km^2) and 0.5 km for urban area (S=30 km^2), power of BS MS is 55 dBm in 5 MHz due orientation of main beam antenna pattern towards ARNS station. No downtilt of the MS base station antennas has been applied. Antenna pattern only in horizontal plane from Recommendation ITU-R F.1336 has been used.

Note 3: Result based on conditions that MS base stations operate with antenna height 50 m, cell radius is 8 km for rural area, 2 km for suburban area (S=300 km^2) and 0.5 km (S=100 km^2) for urban area, power of MS base stations is 55 dBm in 5 MHz due orientation of main beam antenna pattern towards ARNS station. No downtilt of the MS base station antennas has been applied. Antenna pattern only in horizontal plane from Recommendation ITU-R F.1336 has been used.

ARNS system impact to MS BS receivers

For the situation when MS UE are interfering with ground based ARNS stations propagation model Recommendation ITU-R P.1546-4 has been used. For the situation when MS UE are interfering ARNS airborne stations propagation model Recommendation ITU-R P.525 has been used.

The interference estimation from a single UE with radiated power of 23 dBm in 5 MHz shows that separation distance between UE and various types of ARNS stations will range from 2 to 10 kilometres. It should be noted that MS UE are not notified in ITU BR therefore coordination of UE with ARNS stations cannot be carried out.

This coordination can be carried out based on the notified MS base stations. Therefore it is required to consider the impact from single ARNS station to MS BS receiver.

TABLE 24

Required coordination distances for protection MS base stations from ARNS, 5 MHz

ARNS type	**Predetermined trigger «interference/noise» values for mobile service station protection, *I/N* (dB)**	**Separation Distance (km)**		**Coordination Distance (km)**
		Air-borne	**Land 50/50**	**Land**
RSBN (aircraft transmitter)	-6 at 30 m or 50m in a 5 MHz reference bandwidth	434[1]/441[2]	-	441[2]
RLS 2 (Type 1) (aircraft transmitter)	-6 at 30 m or 50m in a 5 MHz reference bandwidth	434[1]/441[2]	-	441[2]
RLS 2 (Type 1) (ground transmitter)	-6 at 30 m or 50m in a 5 MHz reference bandwidth	-	130[2]/165[2]*	130[2]/165[2]*
RLS 2 (Type 2) (aircraft transmitter)	-6 at 30 m or 50m in a 5 MHz reference bandwidth	434[1]/441[2]	-	441[2]
RLS 2 (Type 2) (ground transmitter)	-6 at 30 m or 50m in a 5 MHz reference bandwidth	-	405[2]/445[2]*	405[2]/445[2]*
RLS 1 (Type 1 and 2) (ground transmitter)	-6 at 30 m or 50m in a 5 MHz reference bandwidth	-	405[2]/445[2]*	405[2]/445[2]*
* 50% ≤ land path ≤ 100% / 0% ≤ land path < 50%.				
Note 1: Result based on conditions that BS MS operate with antenna height 30 m. Note 2: Result based on conditions that BS MS operate with antenna height 50 m.				

TABLE 25

Required coordination distances for protection MS base stations from ARNS, 10 MHz

ARNS type	Predetermined trigger «interference/noise» values for mobile service station protection, I/N (dB)	Separation Distance (km)		Coordination Distance (km)
		Air-borne	Land 50/50	Land
RSBN (aircraft transmitter)	-6 at 30 m or 50m in a 5 MHz reference bandwidth	434[1]/441[2]	-	441[2]
RLS 2 (Type 1) (aircraft transmitter)	-6 at 30 m or 50m in a 5 MHz reference bandwidth	434[1]/441[2]	-	441[2]
RLS 2 (Type 1) (ground transmitter)	-6 at 30 m or 50m in a 5 MHz reference bandwidth	-	105[2]/140[2]	105[2]/140[2]
RLS 2 (Type 2) (aircraft transmitter)	-6 at 30 m or 50m in a 5 MHz reference bandwidth	434[1]/441[2]	-	441[2]
RLS 2 (Type 2) (ground transmitter)	-6 at 30 m or 50m in a 5 MHz reference bandwidth	-	375[2]/425[2]	375[2]/425[2]
RLS 1 (Type 1 and 2) ground transmitter)	-6 at 30 m or 50m in a 5 MHz reference bandwidth	-	375[2]/425[2]	375[2]/425[2]
* 50% ≤ land path ≤ 100% / 0% ≤ land path < 50%.				
Note 1: Result based on conditions that BS MS operate with antenna height 30 m. Note 2: Result based on conditions that BS MS operate with antenna height 50 m.				

4.1.3.4 Results of estimation of interference and conditions for compatibility of MS systems with ARNS systems

Based on the calculations above the coordination distances between MS and ARNS shown in Table 26 below can be concluded.

TABLE 26

Coordination threshold values of MS stations with ARNS

ARNS station	System type code	Coordination distances for the receiving MS base stations (km)[3]	Coordination distances for the transmitting MS base stations (km)
RSBN (ground receiver)	AA8	441[1]	75[2] / 90[2]*
RLS 2 (type 1) (airborne receiver)	BD	130[1]/165[1]*	441[2]
RLS 2 (type 1) (ground receiver)	BA	441[1]	185[2] / 200[2]*
RLS 2 (type 2) (airborne receiver)	BC	405[1]/445[1]*	400[2]
RLS 2 (type 2) (ground receiver)	AA2	441[1]	250[2] / 275[2]*
RLS 1 (types 1 and 2) (ground receiver)	AB	405[1]/445[1]*	350[2] / 375[2]*
Other ARNS ground stations	Not applied	405[1]/445[1]*	350[2] / 375[2]*
Other ARNS airborne stations	Not applied	405[1]/445[1]*	441[2]
* 50% ≤ land path ≤ 100% / 0% ≤ land path < 50%.			
Note 1: Result based on conditions that MS base stations operate with antenna height 50 m. No downtilt of the MS base station antennas has been applied. Antenna pattern only in horizontal plane from Recommendation ITU-R F.1336 has been used. Note 2: Result based on conditions that MS base stations operate with antenna height 50 m, cell radius is 8 km for rural area, 2 km for suburban area (S=300 km^2) and 0.5 km (S=100 km^2) for urban area, power of MS base stations is 55 dBm in 5 MHz due orientation of main beam antenna pattern towards ARNS station. No downtilt of the MS base station antennas has been applied. Antenna pattern only in horizontal plane from Recommendation ITU-R F.1336 has been used.			

ARNS station	System type code	Coordination distances for the receiving MS base stations (km)[3]	Coordination distances for the transmitting MS base stations (km)
Note 3: The figures given are based on the estimated distance to protect the IMT from ARNS.			

These results can be used for choosing the frequency plan of the MS.

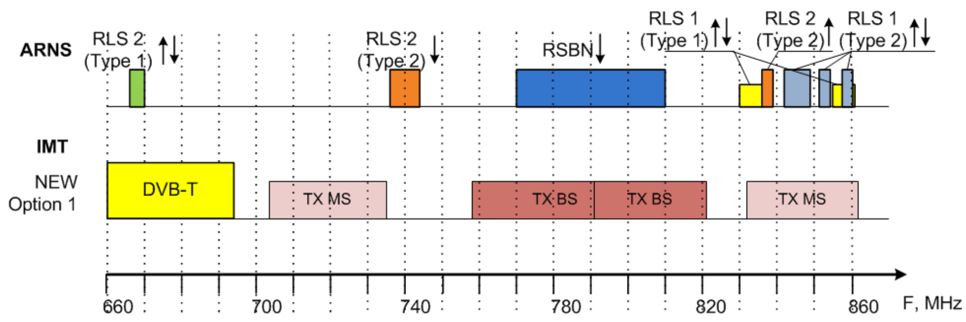
Analysis

Both direction of separation distances between MS base stations and ARNS as well as coordination distances between ARNS and receiving base stations MS need to be considered.

Further analysing which frequencies the different ARNS systems use, it can be seemed that only the ground stations of the RSBN system and the ground station of the RLS2 type 2 system are located in the concerned frequency range of 694-790 MHz, as shown in the figure below (Figure 17). However it should be noted that occupation of the frequency band 694-790 MHz by typical ARNS systems is given in Figure 17. The ARNS stations operating in other carriers in the frequency band 694-790 MHz are notified in MIFR. It is confirmed by the information given in Appendix 5 of Section 2 “Summary of assignments of ARNS stations recorded in the MIFR”. Therefore it is required to take into account all types of ARNS stations given in Table 26.

FIGURE 17

Typical systems of ARNS and possible MS frequency utilisation



Conclusions

Based on the discussion above, the coordination distances between ARNS and MS in 694-790 MHz shown in Table 27 below can be concluded.

TABLE 27

Coordination distance required between MS and ARNS in 694-790 MHz

ARNS station	System type code	Coordination distances for the receiving MS base stations (km) [3]	Coordination distances for the transmitting MS base stations (km)
RSBN (ground receiver)	AA8	441[1]	75[2] / 90[2]*
RLS 2 (type 1) (airborne receiver)	BD	130[1]/165[1]*	441[2]
RLS 2 (type 1) (ground receiver)	BA	441[1]	185[2] / 200[2]*
RLS 2 (type 2) (airborne receiver)	BC	405[1]/445[1]*	400[2]
RLS 2 (type 2) (ground receiver)	AA2	441[1]	250[2] / 275[2]*
RLS 1 (types 1 and 2) (ground receiver)	AB	405[1]/445[1]*	350[2] / 375[2]*
Other ARNS ground stations	Not applied	405[1]/445[1]*	350[2] / 375[2]*
Other ARNS airborne stations	Not applied	405[1]/445[1]*	441[2]

* 50% ≤ land path ≤ 100% / 0% ≤ land path < 50%.

Note 1: Result based on conditions that MS base stations operate with antenna height 50 m. No downtilt of the MS base station antennas has been applied. Antenna pattern only in horizontal plane from Recommendation ITU-R F.1336 has been used.

Note 2: Result based on conditions that MS base stations operate with antenna height 50 m, cell radius is 8 km for rural area, 2 km for suburban area (S=300 km^2) and 0.5 km (S=100 km^2) for urban area, power of MS base stations is 55 dBm in 5 MHz due orientation of main beam antenna pattern towards ARNS station. No downtilt of the MS base station antennas has been applied. Antenna pattern only in horizontal plane from Recommendation ITU-R F.1336 has been used.

Note 3: The figures given are based on the estimated distance to protect the IMT from ARNS.

Views from some administrations regarding Study #A.2 are presented in Appendix 7.

4.1.4 Study#A.3

Study#3 based on implementation of coordination distances

4.1.4.1 Assumptions

The technical characteristics were applied in the sharing studies of the IMT and ARNS systems described in section 3.

The free space propagation model (Recommendation ITU-R P.525-2) was used for interference assessment to ARNS on-board receivers and the propagation model described in Recommendation ITU-R P.1546-5 was used for interference assessment to ground ARNS receivers. Using Recommendation ITU-R P.1546-5 the calculations were performed for 10% of time and 50% of locations.

4.1.4.2 Methodology to estimate interference caused by MS systems to ARNS systems

If the broadcasting service is not operated in the frequency band 694-790 MHz or is operated beyond the area of interference impact to ARNS in this case ARNS systems can be affected by interference from MS systems only (i.e. the broadcasting service impact is not taken into account).

As it was pointed out in section 3.3 of this document, there are no new types of ARNS systems in the frequency band 694-790 MHz in comparison with the systems operating in the frequency band 790-862 MHz .Therefore if the MS systems similar to those operating in the frequency band 790-862 MHz operate in the frequency band 694-790 MHz and there are no interference caused by the broadcasting service then the characteristics of stations and interference scenarios from the MS to the

ARNS in the frequency band 694-790 MHz will be similar to those that were considered in the same studies in the frequency band 790-862 MHz.

With account of the above, the similar methodology that was applied in the same studies in the frequency band 790-862 MHz (Document 5-6/180 (Appendix 8)) was used as the evaluation methodology of interference caused by MS to ARNS in the frequency band 694-790 MHz.

4.1.4.3 Calculations of estimation of interference and conditions for compatibility of MS systems with ARNS systems

Calculations of estimation interference caused by MS systems to ARNS systems when there are no interference caused by other radio services presented in Document 5-6/180 (Appendix 9).

4.1.4.4 Results of estimation of interference and conditions for compatibility of MS systems with ARNS systems with no interference from other radio services

The performed studies showed that ARNS systems operating in the frequency band 694-790 MHz are similar to the systems that were considered in the frequency band 790-862 MHz in the studies on WRC-12 agenda item 1.17. The MS system characteristics in the frequency band 694-790 MHz are also similar to the MS characteristics which were applied in the studies on WRC-12 agenda item 1.17.

Therefore the results obtained earlier (at WRC-12) for the frequency band 790-862 MHz reflected in Resolution **749 (Rev. WRC-12)** and presented in Table 28 below may be applied for protection of ARNS from MS in the frequency band 694-790 MHz.

TABLE 28

Coordination threshold values of MS stations with ARNS

ARNS station	System type code	Coordination distances for the receiving MS base stations (km)[1]	Coordination distances for the transmitting MS base stations (km) [1]
RSBN	AA8	50	125/175*
RLS 2 (type 1) (airborne receiver)	BD	410	432
RLS 2 (type 1) (ground receiver)	BA	50	250/275*
RLS 2 (type 2) (airborne receiver)	BC	150	432
RLS 2 (type 2) (ground receiver)	AA2	50/75*	300/325*
RLS 1 (types 1 and 2) (ground receiver)	AB	125/175*	400/450*
Other ARNS ground stations	Not applied	125/175*	400/450*
Other ARNS airborne stations	Not applied	410	432

* 50% ≤ land path ≤ 100% / 0% ≤ land path < 50%.

Note 1: The results are not based on the updated IMT parameters specified by ITU-R, but used the results in Res 749 (Rev. WRC-12)

These results can be used for choosing the frequency plan of the MS systems in the frequency band 694-790 MHz in order to minimize compatibility problems with ARNS systems.

Views from some administrations regarding Study #A.3 are presented in Appendix 7.

4.2 Case B for estimation interference caused by MS systems to ARNS systems when there are interference caused by broadcasting service

4.2.1 Interference scenario

In compatibility studies of MS with ARNS the following interference scenario from MS to ARNS can be identified taking into account the existing allocations and also areas of interference impact to ARNS stations: interference scenarios from MS to ARNS when there is interference caused by BS (for example at the boundary of three countries or “across a country”). (see Appendix 2).

Depending on the frequency plan of MS systems and overlapping of this plan with ARNS system frequencies, each group indicated above can contain up to four typical interference scenarios (see Figure 18):

a) interference from the MS base stations to the ARNS ground station;

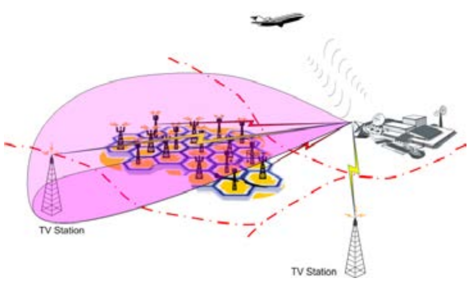
b) interference from the MS base stations to the ARNS airborne station;

c) interference from UE to the ARNS ground station;

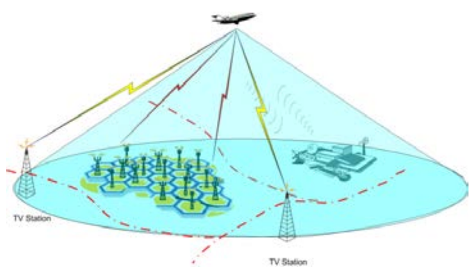
d) interference from UE to the ARNS airborne station.

FIGURE 18

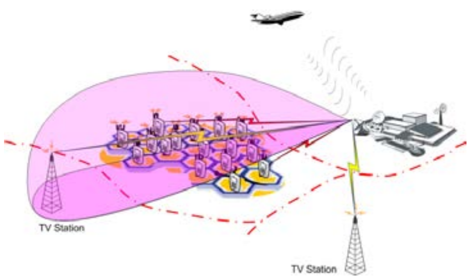
Typical interference scenarios from the MS to the ARNS



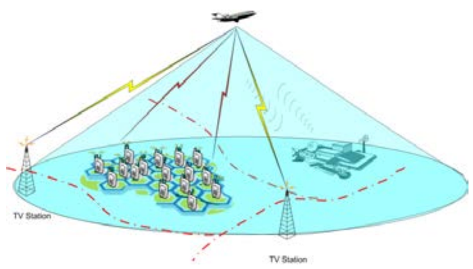
a) Interference from the MS base stations to the ARNS ground station



b) Interference from the MS base stations to the ARNS airborne station



c) Interference from UE to the ARNS ground station



d) Interference from UE to the ARNS airborne station

4.2.2 Study #B.1

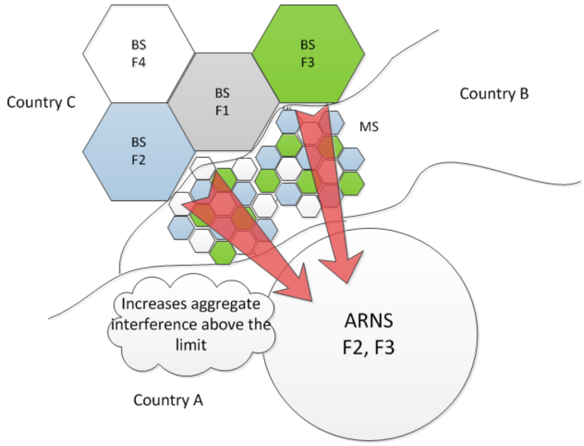
Study #B.1 based on implementation of aggregated field strength triggers.

4.2.2.1 Assumptions

Currently the frequency band 694-790 MHz is widely used by the broadcasting service (see Annex 2). Therefore interference to ARNS stations from the MS stations were considered taking into account interference caused by the existing and future stations of the broadcasting service. Typical scenario of the aggregate interference impact of two services BS and MS to the ARNS is shown in Figure 19.

FIGURE 19

Typical scenario for aggregate interference to ARNS from broadcasting and mobile services in the frequency band 694-790 MHz



The technical characteristics of MS (IMT) systems and ARNS described in section 3 were applied in the studies.

The free space propagation model (Recommendation ITU-R P.525-2) was used for interference assessment to ARNS on-board receivers and the propagation model described in Recommendation ITU-R P.1546-4 was used for interference assessment to ground ARNS receivers. Using Recommendation ITU-R P. 1546-4 the calculations were performed for 10% of time and 50% of location.

4.2.2.2 Methodology

4.2.2.2.1 Consideration of MS base stations impact to ARNS stations

In applying criteria proposed in Table 3 the estimation of interference caused by newly notified MS stations to ARNS shall be performed with account of interference from the previously notified MS stations and also from BS assignments, registered in MIFR or notified under Article **11** RR.

The following shall be taken into account:

1) BS assignments, registered in MIFR or notified under RR Article **11** which potentially cause interference to ARNS;

2) assignments of MS base station entered in MIFR or earlier notified for coordination under RR No. **9.21**, that have frequency overlap with ARNS stations, in the frequency band 694-790 MHz.

Depending on the considered ARNS stations two interference scenarios are possible:

1) interference to airborne ARNS receiver;

2) interference to ground ARNS receiver.

Interference evaluation on each scenario is given below.

4.2.2.2.1.1 MS base stations impact to airborne ARNS receiver

The typical airborne ARNS receiver is located at the altitude of 10 000 m and can be located at any point of service area of associated transmitting ground station (which is notified in ITU).

Visibility zone for the airborne ARNS station is determined in accordance with the equation:

$$Dvi = 4.1 \times (\sqrt{H1i} + \sqrt{H2}), \qquad (1)$$

where

$H1i$ is antenna altitude of ARNS *i*-receiver;

H2 is transmitter antenna altitude of the notified MS base station. The height of the MS base station transmit antenna is taken from the notice. If this value is not available in the notice, the height of the MS base station transmitter antenna should be considered as 50 m.

In consideration of interference impact of the notified MS base station to ARNS airborne stations the following algorithm to determine the affected ARNS assignments is proposed:

1) The distance ***Dci*** is determined from the notified MS base station in the direction of ARNS ground stations which are notified in ITU in the frequency band of a new MS base station (see Fig. 20).

2) To condition to be checked:

$$Dci > Rzi + Dvi, \qquad (2)$$

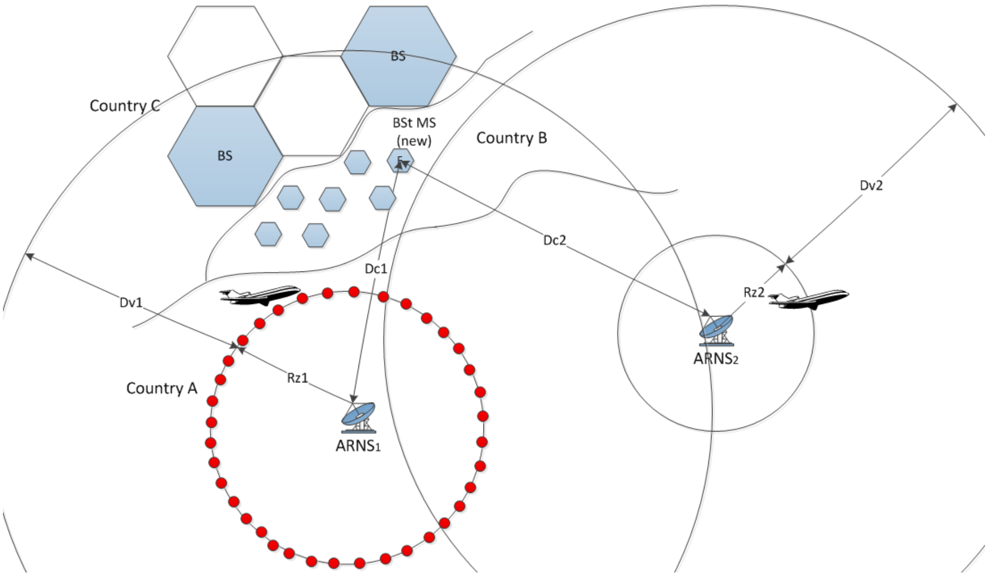
where

Rzi – service area radius of ARNS ground *i*-th station, where the associated receiving airborne ARNS station can be located (indicated in filing for ARNS station).

If the requirement is met then obtaining agreement for new MS base station under RR No. **9.21** with respect to the specific ARNS station is not required (Fig. 20 with respect to ARNS2 station).

FIGURE 20

How to determine affected frequency assignments of ARNS airborne receivers



3) For each ARNS *i*-th station located at the distance less or equal to $\boldsymbol{D_{vi}+R_{zi}}$ the following is determined:

a) the MS base station assignments entered in MIFR or earlier notified to obtain agreement under RR No. **9.21** which completely or partially fall into the line-of-sight area of ARNS airborne receiver (these assignments are highlighted by blue colour in Fig. 20);

b) the broadcasting assignments, registered in MIFR or notified under RR Article **11**, or which notified for inclusion in the GE06 Plan which completely or partially fall into the line-of-sight area of ARNS airborne receiver (Fig. 20 these assignments and allotments are highlighted by blue colour.)

4) The field strength $\boldsymbol{E_{ijk}}$ is calculated in the k-boundary point of the service area of *i*-th ARNS ground receiver (these are red pointsin Fig. 4.3) from each *j*-th interference source identified in item 3 above including a new notified MS base station assignment. The calculation is performed by application of Recommendation ITU-R P.525-2.

Field strength $\boldsymbol{E_{ijk}}$ is calculated taking into account the overlapping frequency bands ratio. *N*- index, that takes into account interference power portion, entering the ARNS receiver, dB:

$$N = \begin{cases} 10\log(B_I / B_W), B_I < B_W \\ 0, B_I = B_W \end{cases} \quad (3)$$

B_W – interferer's bandwidth, MHz;

B_I – bandwidth overlap of the interferer and the ARNS receiver, MHz.

It should be noted that the test points (where calculations are performed) are chosen at the boundary of the service area of *i-th* ARNS ground receiver with definite interval (for example 1 degrees) (currently used under the GE06 Agreement) (the points on the service area boundary of ARNS1 receiver are highlighted in red in Fig. 20).

5) The aggregate field strength ***Eik*** is calculated in each k-th point of the service area of i-th ARNS ground receiver by application of the data obtained in section 4 above and in accordance with the equation:

$$E_{ik} = 10\log\left(\sum_{j=1}^{n} 10^{0.1\,E_{ijk}}\right) \qquad (4)$$

6) The aggregate field strength $\boldsymbol{E_{ik}}$ in each k-th boundary point is compared with the protection criteria $\boldsymbol{Ereq_i}$ of *i*-th ARNS airborne receiver. If the condition $\boldsymbol{E_i > Ereq_i}$ is met then obtaining agreement for new notified MS base station under RR No. **9.21** with regard to the specific ARNS station is required.

4.2.2.2.1.2 MS base station impact to ARNS ground receiver

In consideration of MS base station impact to ground ARNS receiver it is required to take into account the fact that ARNS ground station antennas are directional. Therefore in compatibility estimation MS assignments and BS assignments, registered in MIFR or notified under Article **11** RR, which fall into the main lobe of the ARNS station antenna pattern were taken into account. It should be noted, that the parameter with width of the main lobe of the ARNS earth station's antenna on –3 dB level should be added to Appendix **4** RR as a mandatory parameter for notification. In the absence of this parameter in the notification the width of the main lobe of the ARNS earth station's antenna by –3 dB level should be assumed equal to 8 degrees.

Interference outside the ARNS station antenna pattern main lobe was taken into account by adding 4 dB[9] to the interference which will be calculated in the angle sector of the ARNS station antenna pattern main lobe. (Justification presented in Appendix 4).

Depending on location of the affected ARNS station the sector radius is determined where interference sources should be taken into account. In GE06 Agreement and Recommendation ITU-R P.1546-4 distance of 1 000 kilometres is taken as this sector radius. The same distance is used in ITU-R Bureau for checking the filings for modification of GE06 Plan with respect to ARNS stations.

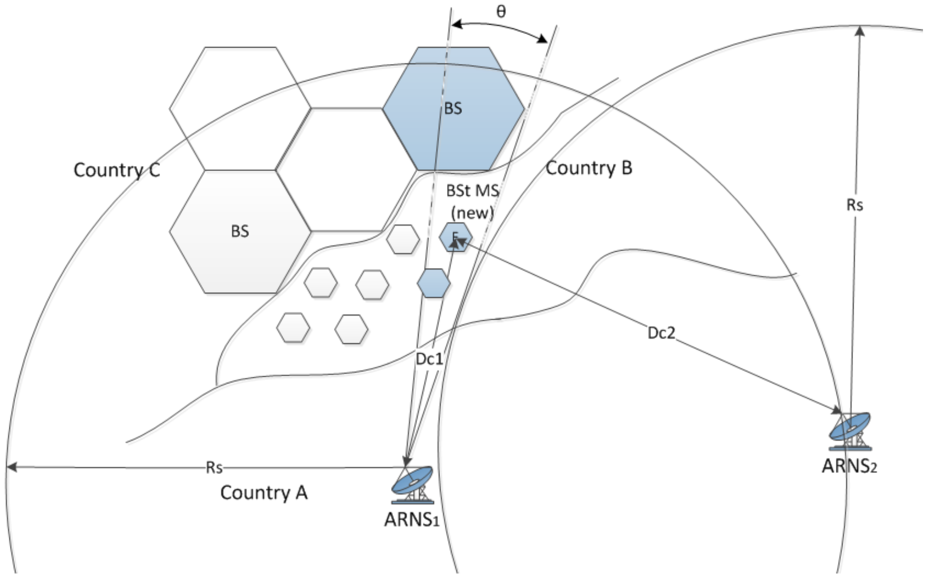
However, taking into account that Recommendation ITU-R P.1546-4 is applied for different climatic areas and wide frequency range therefore the sector radius $\boldsymbol{R_s}$ where interference sources are taken into account, is limited up to distance of 600 kilometres –for ARNS stations located higher of 48 degrees north latitude and up to 800 kilometres for ARNS stations located at of 48 degrees north latitude and lower (The Black Sea region).

Therefore if the MS base station is located in the main beam of ARNS station antenna pattern but at the distance $\boldsymbol{R_s}$ of more than 600 kilometres or 800 kilometres (as the case may be) then it is proposed not to take into account such station in the interference calculation for ARNS stations (see Fig. 21).

[9] This ~~value~~value highly depends on the distance between the ARNS station and the MS stations and the methodology in appendix 6 is not representative for all cases.

FIGURE 21

How to determine affected frequency assignments of ground ARNS receivers



Taken into account the above mentioned while considering interference impact of the notified MS base station to the ARNS ground stations the following procedure to determine the affected ARNS is applied:

1) Around the notified new MS base station towards the ARNS ground stations which are notified in ITU in new MS base station frequency band the distance $\boldsymbol{D_{ci}}$ is determined (see Fig. 21).

2) The condition to be checked:

$$Dci > Rs, \quad (5)$$

where Rs =600 km or =800 km depending on latitude of ARNS *i*-th station.

If the requirement is met then obtaining agreement for new MS base station under RR No. **9.21** with respect to the specific ARNS station is not required (This relates to ARNS2 station in Fig. 21).

3) With respect to each ARNS *i*-th station which is located nearer than $\boldsymbol{D_{ci} \leq R_s}$ the MS base station assignments entered in MIFR or earlier notified to obtain agreement under RR No. **9.21** and also broadcasting assignments of GE06 Plan are determined which completely or partially fall into the main beam sector of ARNS ground station directed to a new notified MS base station. This sector is limited by the distance *Rs (*in Fig. 21 these assignments and allotments are highlighted in blue.)

4) The field strength ***Eij*** is calculated in the location of *i*-th ARNS ground receiver (in Fig. 21 this is ARNS1) from each *j*-th MS base station assignment entered in MIFR or earlier notified to obtain agreement under RR No. **9.21** and GE06 Plan assignment including a new notified MS base station assignment. The field strength E_{ij} shall be calculated with account of overlapping frequency band ratio.

N- index, that takes into account interference power portion, entering the ARNS receiver, dB:

$$N = \begin{cases} 10\log(B_I / B_W), B_I < B_W \\ 0, B_I = B_W \end{cases} \quad (6)$$

B_W – interferer's bandwidth, MHz;

B_I – bandwidth overlap of the interferer and the ARNS receiver, MHz.

The calculation is performed by application of Recommendation ITU-R P.1546-4 for 10% of time and 50% of location.

5) The aggregate field strength $\boldsymbol{E_i}$ is calculated in the i-th ARNS ground receiver location by application of the data obtained in section 4 above and in accordance with the following equation:

$$E_i = 10\log\left(\sum_{j=1}^{n} 10^{0.1E_{ij}}\right) + 4 \quad (7)$$

6) The aggregate field strength $\boldsymbol{E_i}$ is compared with the protection criteria $\boldsymbol{E_{reqi}}$ of *i*-th ARNS ground receiver (see. Table 3). If the requirement $\boldsymbol{E_i > E_{reqi}}$ is met then obtaining agreement for new MS base station under RR No. **9.21** with respect to the *i*-th ARNS station is required.

4.2.2.2.2 Consideration of MS UE impact to ground and aircraft ARNS stations

In case of CDMA or TDD MS systems, it is expected that interference caused by MS UE to ARNS stations will not exceed interference from MS base station. Therefore, in these cases it is sufficient to use the methodology specified in section 4.2.2.2.1 above.

In case of FDD MS systems interference caused by UE to ARNS stations will impact in other frequency bands than interference form MS base station. Therefore in this case other approaches are required to be applied to determine the affected ARNS assignments.

In case of notification of MS systems with FDD when a notifying administration indicates in the filing that the aggregate e.i.r.p. value of all UE operating simultaneously with the notified base station does not exceed 21 dBm per 1 MHz (this corresponds to the coordination distance of 70 km specified in Table 1 of Annex 1 to Resolution **749 (Rev.WRC-12)**) then this value should be used in the interference calculation.

Otherwise, the value of 31 dBm per 1 MHz (this corresponds to the coordination distance of 150 km specified in Table 1 of Annex 1 to Resolution **749 (Rev.WRC-12)**) can be used as the aggregate e.i.r.p. value of all UE operating simultaneously with the notified base station or to use other e.i.r.p. values notified by the administration.

Using these aggregate values of UE (21 dBm or 31 dBm, as appropriate) operating with one MS base station one can determine the affected ARNS assignments upon applying the methodology presented in section 4.2.2.2.1 above. However, receiving MS base station should be considered instead of transmitting MS base station, and aggregate e.i.r.p. of all UE operating simultaneously with notified MS base station should be considered instead of e.i.r.p. of MS base station (see above).

4.2.2.3 Calculations

4.2.2.3.1 Example of interference calculation from the notified MS base station (country B) to ARNS on-board systems without consideration of TV GE06 Plan assignments but with MS base station assignments entered in MIFR (country B)

Initial data:

TABLE 29

Characteristics of notified MS base station

Station name	Antenna height (h), m	Base station e.i.r.p. , dBm	Base station cell radius (R_{BS}), km	Carrier frequency (Fcar), MHz	Signal bandwidth (ΔF), MHz	Coordinates
MS new	65	55	8	F1	5	See Fig. 4.5

TABLE 30

Characteristics of MS base station entered in MIFR

Station name	Antenna height (h), m	Base station e.i.r.p. , dBm	Base station cell radius (R_{BS}), km	Carrier frequency (Fcar), MHz	Signal bandwidth (ΔF), MHz	Coordinates
MS1	65	55	8	F1	5	See Fig. 4.5
MS2	65	55	8	F1	5	See Fig. 4.5
MS3	65	55	8	F1	5	See Fig. 4.5
MS4	65	55	8	F1	5	See Fig. 4.5
MS5	65	55	8	F1	5	See Fig. 4.5
MS6	65	55	8	F1	5	See Fig. 4.5
MS7	65	55	8	F1	5	See Fig. 4.5

TABLE 31

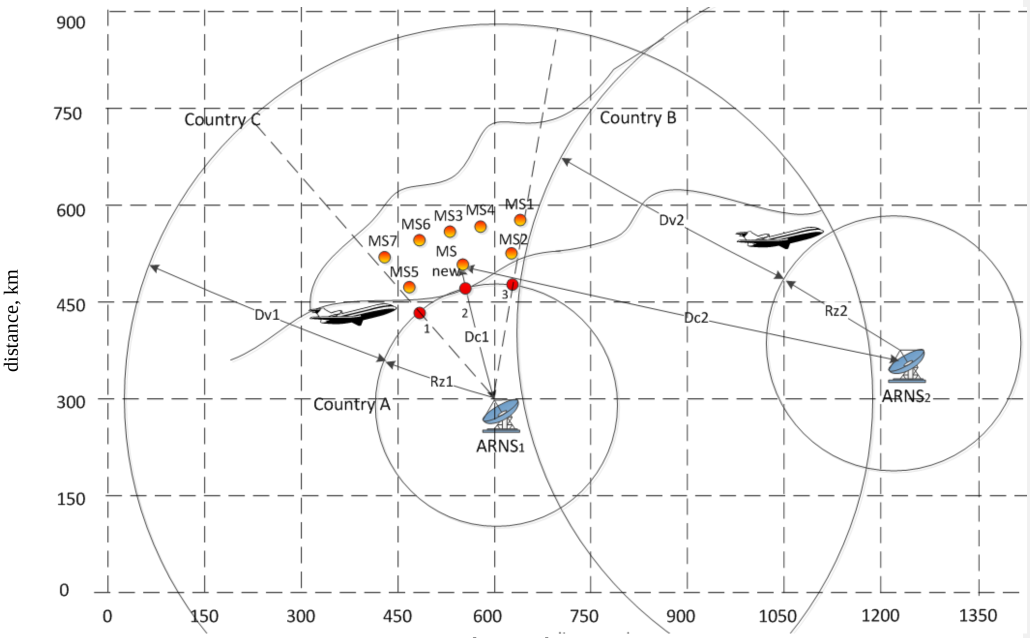
Characteristics of ARNS on-board stations

Station name	Antenna height (h), m	Protection criterion Ereqi, dB(μV/m)	Carrier frequency (Fcar), MHz	Signal bandwidth (ΔF), MHz	Coordinates
ARNS1	10 000	73	F1	3	See Fig. 4.5
ARNS2	10 000	73	F1	3	See Fig. 4.5

In the theoretical example of calculation presented below the overlapping frequency bands between the assignments to ARNS stations and MS base station were taken into account.

FIGURE 22

Example of identification of the affected assignments of ARNS on-board receivers



In accordance with methodology presented in section 4.2.2.2.1.1 the ARNS typical airborne receiver is located at the altitude of 10 000 m and can be located at any point of service area of associated transmitting ground station which is notified in ITU.

Step 1

Identify potentially affected ARNS stations for which the following conditions are met simultaneously (in accordance with item 1 of the methodology). The location of the notified MS stations corresponds to the condition: *Dci≤Rzi+Dvi,*

where:

Rzi – service area radius of ARNS ground transmitting *i*-th station, where the associated receiving airborne ARNS station can be located;

Dvi – line- of -sight area of airborne receiver located in the service area of ARNS ground transmitting *i*-th station (around 450 km).

Figure 22 and data from Table 29, Table 30 and Table 31 show that condition for ARNS 1 station is met and is not met for ARNS 2 station therefore for new MS base station obtaining agreement with respect to ARNS 1 station is required under RR No. **9.21**.

Step 2

The aggregate field strength ***Eijk*** is calculated in the k-th boundary point of *i*-th ARNS airborne receiver (in this example 3 points at the distance of 50 kilometres and located in the nearest point of the border of country B are taken).

TABLE 32

The calculation of field strength *Eijk* in 1st point of ARNS1 on-board receiver location from MS base station assignments entered in MIFR

MS base station station parameters						ARNS1 station parameters				Calculations		
Station name	h, m	base station e.i.r.p., dBm	R_{BS}, km	F car., MHz	ΔF, MHz	h, m	F car., MHz	ΔF, MHz	Ereqi, dB (μV/m)	d, km	Az, deg	E_{ij1} from base station, dB(μV/m)
MS1	65	55	8	F1	5	10 000	F1	3	73	179.5	29.1	54.59
MS2	65	55	8	F1	5	10 000	F1	3	73	131.1	39.6	57.30
MS3	65	55	8	F1	5	10 000	F1	3	73	137.1	13.1	56.92
MS4	65	55	8	F1	5	10 000	F1	3	73	157.7	23.1	55.71
MS5	65	55	8	F1	5	10 000	F1	3	73	35	342.3	68.46
MS6	65	55	8	F1	5	10 000	F1	3	73	122.4	2.4	57.90
MS7	65	55	8	F1	5	10 000	F1	3	73	94.5	340.6	60.12
Σ Ems dB(μV/m)												70.15

TABLE 33

The calculation of field strength *Eijk* in 1st point of ARNS1 on-board receiver location from notified MS base station

MS base station station parameters						ARNS 1 station parameters				Calculations		
Station name	h, m	base station e.i.r.p., dBm	R_{BS}, km	F car., MHz	ΔF, MHz	h, m	F car., MHz	ΔF, MHz	Ereqi, dB (μV/m)	d, km	Az, deg	E_{ij1} from base station, dB(μV/m)
MS new	65	55	8	F1	5	10 000	F1	3	73	62.4	36.4	63.67

TABLE 34

The calculation of field strength *Eijk* in the 2nd point of ARNS1 on-board receiver location from MS base station assignments entered in MIFR

MS base station station parameters						ARNS 1 station parameters				Calculations		
Station name	**h, m**	**Base station e.i.r.p., dBm**	**R_{BS}, km**	**F car., MHz**	**ΔF, MHz**	**h, m**	**F car., MHz**	**ΔF, MHz**	**Ereqi, dB (µV/m)**	**d, km**	**Az, deg**	**E_{ij1} from base station, dB (µV/m)**
MS1	65	55	8	F1	5	10 000	F1	3	73	143.3	21	56.54
MS2	65	55	8	F1	5	10 000	F1	3	73	91.2	31	60.43
MS3	65	55	8	F1	5	10 000	F1	3	73	111.3	357.3	58.72
MS4	65	55	8	F1	5	10 000	F1	3	73	125.1	11.9	57.71
MS5	65	55	8	F1	5	10 000	F1	3	73	49.3	283.4	65.65
MS6	65	55	8	F1	5	10 000	F1	3	73	104.9	342.8	59.23
MS7	65	55	8	F1	5	10 000	F1	3	73	95.8	314.7	60.01
Σ Ems dB(µV/m)												69.24

TABLE 35

The calculation of field strength *Eijk* in the 2nd point of ARNS1 on-board receiver location from notified MS base station

MS base station station parameters						ARNS 1 station parameters				Calculations		
Station name	h, m	Base station e.i.r.p., dBm	R_{BS}, km	F car., MHz	ΔF, MHz	h, m	F car., MHz	ΔF, MHz	Ereqi, dB(µV/m)	d, km	Az, deg	E_{ij1} from base station, dB(µV/m)
MS new	65	55	8	F1	5	10 000	F1	3	73	27.8	0	70.27

TABLE 36

The calculation of field strength *Eijk* in the 3rd point of ARNS1 on-board receiver location from MS base station assignments entered in MIFR

MS base station station parameters						ARNS 1 station parameters				Calculations		
Station name	h, m	Base station e.i.r.p., dBm	R_{BS}, km	F car., MHz	ΔF, MHz	h, m	F car., MHz	ΔF, MHz	Ereqi, dB(μV/m)	d, km	Az, deg	E_{ij1} from base station, dB(μV/m)
MS1	65	55	8	F1	5	10 000	F1	3	73	111.3	2.6	58.72
MS2	65	55	8	F1	5	10 000	F1	3	73	55.6	0	64.64
MS3	65	55	8	F1	5	10 000	F1	3	73	103.2	330	59.37
MS4	65	55	8	F1	5	10 000	F1	3	73	102.2	348.4	59.45
MS5	65	55	8	F1	5	10 000	F1	3	73	96.3	264.2	59.96
MS6	65	55	8	F1	5	10 000	F1	3	73	110.7	315.3	58.76
MS7	65	55	8	F1	5	10 000	F1	3	73	124.2	291.9	57.77
Σ Ems dB(μV/m)												68.89

TABLE 37

The calculation of field strength *Eijk* in the 3rd point of ARNS1 on-board receiver location from notified MS base station

MS base station station parameters						ARNS 1 station parameters				Calculations		
Station name	h, m	Base station e.i.r.p., dBm	RBS, km	F car., MHz	ΔF, MHz	h, m	F car., MHz	ΔF, MHz	Ereqi, dB(μV/m)	d, km	Az, deg	Eij1 from base station, dB(μV/m)
MS new	65	55	8	F1	5	10 000	F1	3	73	48	277	65.87

Step 3

The aggregate field strength $\boldsymbol{E_{ik}}$ in *k*-boundary point of service area of ***i-th*** ARNS airborne receiver is calculated using the data obtained at Step 2.

TABLE 38

The calculation of aggregate field strength *Eik* in the 1st point of ARNS1 on-board receiver location from notified MS base station taking into account MS base station assignments entered in MIFR

Σ Ems dB(μV/m)	Eijk from MS base station dB(μV/m)	Eik, dB(μV/m)	Ereqi, dB(μV/m)	Eik > Ereqi
70.15	63.67	71.03	73	No

As Table 38 shows the notified MS base station does not meet the condition ***Eik > Ereq$_i$*** therefore based on the calculation in 1st point of ARNS1 on-board receiver location, obtaining agreement for notified MS base station with respect to ARNS 1 station is not required under RR No. **9.21**.

TABLE 39

The calculation of aggregate field strength *Eik* in the 2nd point of ARNS1 onboard receiver location from notified MS base station taking into account MS base station assignments entered in MIFR

Σ Ems dB(μV/m)	Eijk from MS base station dB(μV/m)	Eik, dB(μV/m)	Ereqi, dB(μV/m)	Eik > Ereqi
69.24	70.27	72.80	73	No

As Table 39 shows the notified MS base station does not meet the condition ***Eik > Ereq$_i$*** therefore based on the calculation in 2nd point of ARNS1 on-board receiver location obtaining agreement for notified MS base station with respect to ARNS 1 station is not required under RR No. **9.21**.

TABLE 40

The calculation of aggregate field strength *Eik* in the 3rd point of ARNS1 onboard receiver location from notified MS base station taking into account MS base station assignments entered in MIFR

Σ Ems dB(μV/m)	Eijk from MS base station dB(μV/m)	Eik, dB(μV/m)	Ereqi, dB(μV/m)	Eik > Ereqi
68.89	65.87	70.65	73	No

As Table 40 shows the notified MS base station does not meet the condition ***Eik > Ereq$_i$*** therefore based on the calculation in 3rd point of ARNS1 on-board receiver location obtaining agreement for notified MS base station with respect to ARNS 1 station is not required under RR No. **9.21**.

Common conclusion: based on the results of the methodology application presented in Section 4.2.2.2 obtaining agreement under RR No. **9.21** for the notified MS base station with respect to ARNS1 station is not required.

4.2.2.3.2 Example of interference calculation from the notified MS base station (country B) to ARNS on-board systems taking into account TV assignments of GE06 Plan (country C)

Initial data:

TABLE 41

Characteristics of the notified MS base station

Station name	Antenna height (h), m	Base station e.i.r.p., dBm	Base station cell radius (R_{BS}), km	Carrier frequency (Fcar), MHz	Signal bandwidth (ΔF), MHz	Coordinates
MSnew	65	55	8	F1	5	See Fig. 4.6

TABLE 42

Characteristics of TV station assignments

Station name	Antenna height (h), m	base station e.i.r.p. , dBm	Carrier frequency (Fcar), MHz	Signal bandwidth (ΔF), MHz	Coordinates
BS1	55	70	F1	8	See Fig. 4.6
BS2	100	70	F1	8	See Fig. 4.6
BS3	80	65	F1	8	See Fig. 4.6
BS4	90	67	F1	8	See Fig. 4.6
BS5	70	65	F1	8	See Fig. 4.6
BS6	80	63	F1	8	See Fig. 4.6
BS7	90	65	F1	8	See Fig. 4.6
BS8	115	67	F1	8	See Fig. 4.6

TABLE 43

Characteristics of ARNS onboard stations

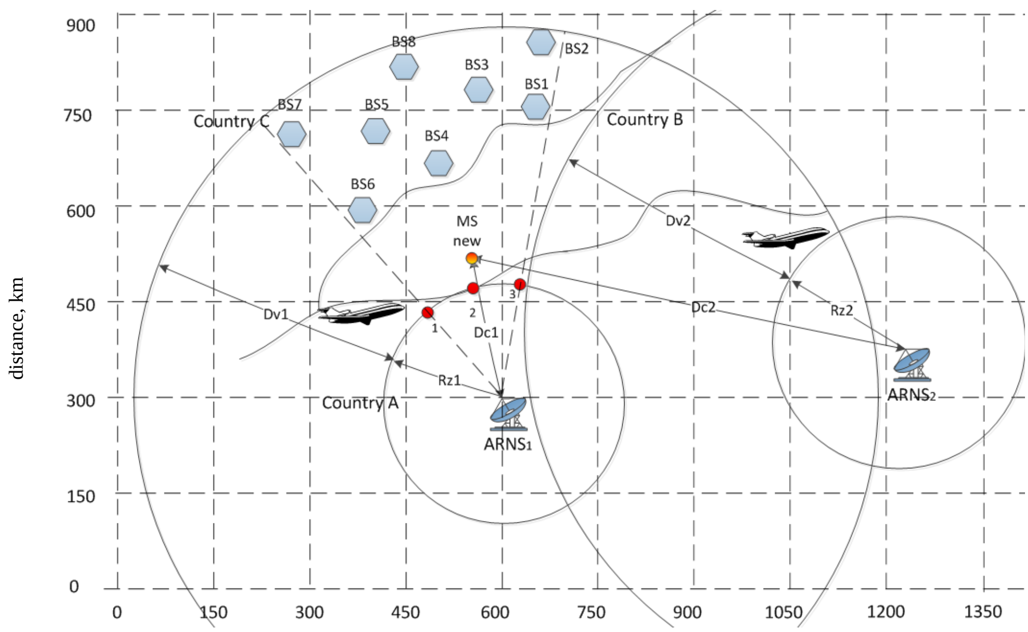
Station name	Antenna height (h), m	Protection criteria Ereqi, dB(µV/m)	Carrier frequency (Fcar), MHz	Signal bandwidth (ΔF), MHz	Coordinates
ARNS1	10 000	73	F1	3	See Fig. 4.6
ARNS2	10 000	73	F1	3	See Fig. 4.6

It should be noted that the methodology assumes the following: if the notified MS base station is coordinated with ARNS then the issue of agreement of the notified MS base station assignment with assignments\allotments of GE06 Plan is not associated with this coordination and is resolved separately.

In addition it should be noted that the theoretical example which is given below takes into account overlapping frequency bands between the assignments of ARNS stations with MS base station stations and TV.

FIGURE 23

Example of identification of the affected frequency assignments of ARNS on-board receivers



In accordance with methodology presented in section 4.2.2.2.1.1 the ARNS typical airborne receiver is located at the altitude of 10 000 metres and can be located at any point of service area of associated transmitting ground station which is notified in ITU.

Step 1

Identify potentially affected ARNS stations for which the following conditions are met simultaneously (in accordance with item 1 of the methodology). The location of the notified MS stations corresponds to the condition: $Dci \leq Rzi + Dvi$,

where :

Rzi service area radius of ARNS ground transmitting *i*-th station, where the associated receiving airborne ARNS station can be located;

Dvi line- of -sight area of airborne receiver located in the service area of *i*-th ARNS ground transmitting station (around 450 km).

Figure 23 and data from Table 41, Table 42 and Table 43 show that condition for ARNS1 station is met and is not met for ARNS2 station therefore for new MS base stations obtaining agreement with respect to ARNS 1 station is required under RR No. **9.21**.

Step 2

The aggregate field strength ***Eijk*** is calculated in the k-th boundary point of *i*-th ARNS airborne receiver (in this example 3 points at the distance of 50 km and located in the nearest point of the border of country B are taken).

TABLE 44

The calculation of field strength *Eijk* in 1st point of ARNS1 onboard receiver location from TV assignments of GE06 Plan

TV station parameters					ARNS 1 station parameters				Calculations		
Station name	**h, m**	**Base station e.i.r.p., dBm**	**F car., MHz**	**ΔF, MHz**	**h, m**	**F car., MHz**	**ΔF, MHz**	**Ereqi, dB(µV/m)**	**d, km**	**Az, deg**	**E_{ij1} from TV, dB(µV/m)**
BS1	55	70	F1	8	10 000	F1	3	73	347.4	15.4	61.82
BS2	100	70	F1	8	10 000	F1	3	73	445.2	12.2	59.67
BS3	80	65	F1	8	10 000	F1	3	73	381.5	7.2	56.01
BS4	90	67	F1	8	10 000	F1	3	73	244.8	2.3	61.86
BS5	70	65	F1	8	10 000	F1	3	73	306.5	348.9	57.91
BS6	80	63	F1	8	10 000	F1	3	73	216.9	338.1	58.91
BS7	90	65	F1	8	10 000	F1	3	73	316.4	337.1	57.63
BS8	115	67	F1	8	10 000	F1	3	73	412.2	356.7	57.34
Σ Ebs dB(µV/m)											68.39

TABLE 45

The calculation of field strength *Eijk* in 1st point of ARNS1 onboard receiver location from notified MS base station

MS base station station parameters						ARNS 1 station parameters				Calculations		
Station name	**h, m**	**Base station e.i.r.p., dBm**	**R_{BS}, km**	**F car., MHz**	**ΔF, MHz**	**h, m**	**F car., MHz**	**ΔF, MHz**	**Ereqi, dB(µV/m)**	**d, km**	**Az, deg**	**E_{ij1} from base station, dB(µV/m)**
MSnew	65	55	8	F1	5	10 000	F1	3	73	62.4	36.4	63.67

TABLE 46

The calculation of field strength *Eijk* in 2nd point of ARNS1 onboard receiver location from TV assignments of GE06 Plan

TV station parameters					**ARNS 1 station parameters**				**Calculations**		
Station name	**h, m**	**Base station e.i.r.p., dBm**	**F car., MHz**	**ΔF, MHz**	**h, m**	**F car., MHz**	**ΔF, MHz**	**Ereqi, dB(μV/m)**	**d, km**	**Az, deg**	**E_{ij1} from TV, dB(μV/m)**
BS1	55	70	F1	8	10 000	F1	3	73	317.3	10.6	62.61
BS2	100	70	F1	8	10 000	F1	3	73	416.5	8.4	60.25
BS3	80	65	F1	8	10 000	F1	3	73	356.1	2.3	56.61
BS4	90	67	F1	8	10 000	F1	3	73	223.9	353.6	62.63
BS5	70	65	F1	8	10 000	F1	3	73	294.5	341.5	58.25
BS6	80	63	F1	8	10 000	F1	3	73	214.4	327.1	59.01
BS7	90	65	F1	8	10 000	F1	3	73	313.3	329.8	57.72
BS8	115	67	F1	8	10 000	F1	3	73	393.8	351.7	57.73
Σ Ebs dB(μV/m)											68.93

TABLE 47

The calculation of field strength *Eijk* in 2nd point of ARNS1 onboard receiver location from notified MS base station

MS base station station parameters						**ARNS 1 station parameters**				**Calculations**		
Station name	**h, m**	**Base station e.i.r.p., dBm**	**R_{BS}, km**	**F car., MHz**	**ΔF, MHz**	**h, m**	**F car., MHz**	**ΔF, MHz**	**Ereqi, dB(μV/m)**	**d, km**	**Az, deg**	**E_{ij1} from base station, dB(μV/m)**
MSnew	65	55	8	F1	5	10 000	F1	3	73	27.8	0	70.27

TABLE 48

The calculation of field strength *Eijk* in 3rd point of ARNS1 onboard receiver location from TV assignments of GE06 Plan

TV station parameters					ARNS 1 station parameters				Calculations		
Station name	**h, m**	**TV Tx e.i.r.p., dBm**	**F car., MHz**	**ΔF, MHz**	**h, m**	**F car., MHz**	**ΔF, MHz**	**Ereqi, dB(μV/m)**	**d, km**	**Az, deg**	**E_{ij1} from TV, dB(μV/m)**
BS1	55	70	F1	8	10 000	F1	3	73	289.5	2.9	63.40
BS2	100	70	F1	8	10 000	F1	3	73	389.7	2.8	60.82
BS3	80	65	F1	8	10 000	F1	3	73	335	355.1	57.14
BS4	90	67	F1	8	10 000	F1	3	73	212.7	340.8	63.08
BS5	70	65	F1	8	10 000	F1	3	73	293	332	58.30
BS6	80	63	F1	8	10 000	F1	3	73	227.5	314.6	58.49
BS7	90	65	F1	8	10 000	F1	3	73	322.2	321.2	57.47
BS8	115	67	F1	8	10 000	F1	3	73	381.7	344.9	58.00
Σ Ebs dB(μV/m)											69.30

TABLE 49

The calculation of field strength *Eijk* in 3rd point of ARNS1 onboard receiver location from notified MS base station

MS base station station parameters						ARNS 1 station parameters				Calculations		
Station name	**h, m**	**Base station e.i.r.p., dBm**	**RBS, km**	**F car., MHz**	ΔΦ, ΜΗζ	η, μ	Φ χαρ., ΜΗζ	ΔΦ, ΜΗζ	Ερεθι, δΒ(⌈ς/μ)	**d, km**	**Az, deg**	**Eij1 from Base station, dB(μV/m)**
MSnew	65	55	8	F1	5	10 000	F1	3	73	48	277	65.87

Step 3

The aggregate field strength ***Eik*** in k-boundary point of service area of ***i-th*** ARNS airborne receiver using the data obtained at Step 2.

TABLE 50

The calculation of aggregate field strength *Eijk* in the 1st point of ARNS1 onboard receiver location from notified MS base station taking into account TV assignments of GE06 Plan

Σ Ebs dB(μV/m)	Eijk from MS base station dB(μV/m)	Eik, dB(μV/m)	Ereqi, dB(μV/m)	Eik > Ereqi
68.39	63.67	69.65	73	No

As Table 50 shows the notified MS base station does not meet the condition ***Eik > Ereq***$_i$ therefore based on the calculation in 1st point of ARNS1 onboard receiver location obtaining agreement for notified MS base station with respect to ARNS 1 station is not required under RR No. **9.21**.

TABLE 51

The calculation of aggregate field strength *Eijk* in the 2nd point of ARNS1 onboard receiver location from notified MS base station taking into account TV assignments of GE06 Plan

Σ Ebs dB(μV/m)	Eijk from MS base station dB(μV/m)	Eik, dB(μV/m)	Ereqi, dB(μV/m)	Eik > Ereqi
68.93	70.27	72.66	73	No

As Table 51 shows the notified MS base station does not meet the condition ***Eik > Ereq***$_i$ therefore based on the calculation in 2nd point of ARNS1 onboard receiver location obtaining agreement for notified MS base station with respect to ARNS 1 station is not required under RR No. **9.21**.

TABLE 52

The calculation of aggregate field strength *Eijk* in the 3rd point of ARNS1 onboard receiver location from notified MS base station taking into account TV assignments of GE06 Plan

Σ Ebs dB(μV/m)	Eijk from MS base station dB(μV/m)	Eik, dB(μV/m)	Ereqi, dB(μV/m)	Eik > Ereqi
69.30	65.87	70.93	73	No

As Table 52 shows the notified MS base station does not meet the condition ***Eik > Ereq***$_i$ therefore based on the calculation in 3rd point of ARNS1 onboard receiver location obtaining agreement for notified MS base station with respect to ARNS 1 station is not required under RR No. **9.21**.

Common conclusion: based on the results of the methodology application presented in section 4.2.2.2 obtaining agreement under RR No. **9.21** for the notified MS base station with respect to ARNS1 station is not required.

4.2.2.4 Results

Interference impact scenario from MS to ARNS without interference from the broadcasting service and also with interference are considered. In the studies of interference impact the protection criteria for ARNS given in Table 3 were used.

The performed calculations showed that in case of absence of interference from the broadcasting when the broadcasting service stations operate at large distance more than 450 km from ARNS stations then compatibility of MS stations of one country with ARNS stations of other country is feasible. With this MS stations can be located in the nearest point of the country border where ARNS is operated.
The minimum distance between MS stations and country border where ARNS is operated can be several tens km and depends on location features of ARNS stations and MS networks in the neighbouring countries.

In practice the interference scenario from MS to ARNS with interference caused by the broadcasting service where BS stations will operate at the distance of 450 km from ARNS stations is mostly likely in the frequency band 694-790 MHz. This is confirmed by large number of BS assignments implemented in the frequency band 694-790 MHz.

In the studies it was assumed that in the neighbouring countries various services can operate (BS in one country, MS in other one and ARNS in the third country).

The performed studies showed that compatibility of MS stations of one country with ARNS stations of other country with BS in the third country is feasible. With this restrictions to MS stations from ARNS are not so significant as it was expected. In practice the minimum distance between MS stations and the country border operating ARNS does not exceed several tens km. These restrictions mostly depend on implementation features of BS stations and MS networks in the neighbouring countries.

Views from some administrations regarding Study #B.1 are presented in Appendix 7.

4.2.3 Study #B.2

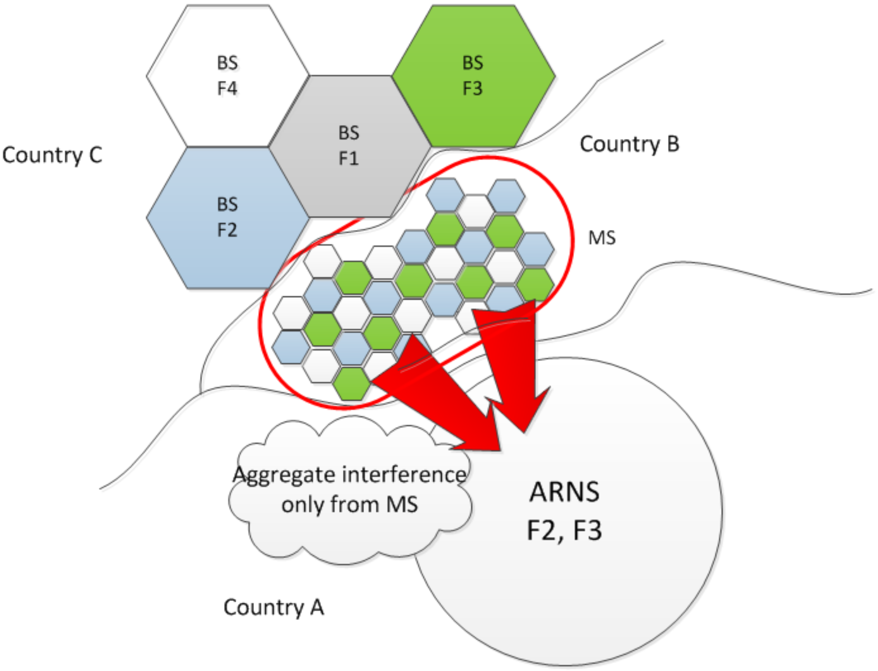
Study #B.2 based on implementation of I/N=–6 dB

4.2.3.1 Assumptions

This criterion for ARNS stations give possibility to estimate interference from MS to ARNS without taking into account interference caused by stations of the broadcasting service. Typical scenario of the aggregate interference impact from MS to the ARNS is shown in Figure 24.

FIGURE 24

Typical scenario for aggregate interference to ARNS from mobile services in the frequency band 694-790 MHz



The technical characteristics of MS (IMT) systems and ARNS described in Section 3 were applied in the studies.

The free space propagation model (Recommendation ITU-R P.525-2) was used for interference assessment to ARNS on-board receivers and the propagation model described in Recommendation ITU-R P.1546-4 was used for interference assessment to ground ARNS receivers. Using Recommendation ITU-R P.1546-4 the calculations were performed for 10% of time and 50% of location.

4.2.3.2 Methodology

4.2.3.2.1 Consideration of MS base stations impact to ground and aircraft ARNS stations

In applying criteria based on I/N = -6 dB the estimation of interference caused by newly notified MS stations to ARNS shall be performed with account of interference from the previously notified MS stations.

Assignments of MS base station entered in MIFR or earlier notified for coordination under RR No. **9.21**, that have frequency overlap with ARNS stations, in the frequency band 694-790 MHz shall be taken into account.

Depending on the considered ARNS stations two interference scenarios are possible:

1) interference to airborne ARNS receiver;

2) interference to ground ARNS receiver.

Interference evaluation on each scenario is given below.

4.2.3.2.1.1 MS base station impact to ARNS aircraft receiver

The typical airborne ARNS receiver is located at the altitude of 10 000 m and can be located at any point of service area of associated transmitting ground station (which is notified in ITU).

Visibility zone for the airborne ARNS station is determined in accordance with the equation:

$$Dvi = 4.1 \times (\sqrt{H1i} + \sqrt{H2}) \qquad (8)$$

where:

H1i is antenna altitude of ARNS *i*-receiver;

H2 is transmitter antenna altitude of the notified MS base station.

The height of the MS base station transmit antenna is taken from notice. If this value is not available in notice, the height of the MS base station transmitter antenna should be considered as 50 m.

In consideration of interference impact of the notified MS base station to ARNS airborne stations the following algorithm to determine the affected ARNS assignments is proposed:

1) The distance ***Dci*** is determined from the notified MS base station in the direction of ARNS ground stations which are notified in ITU in the frequency band of a new MS base station (see Fig. 25).

2) To condition to be checked:

$$D\mathrm{c}i > Rzi + Dvi\ , \qquad (9)$$

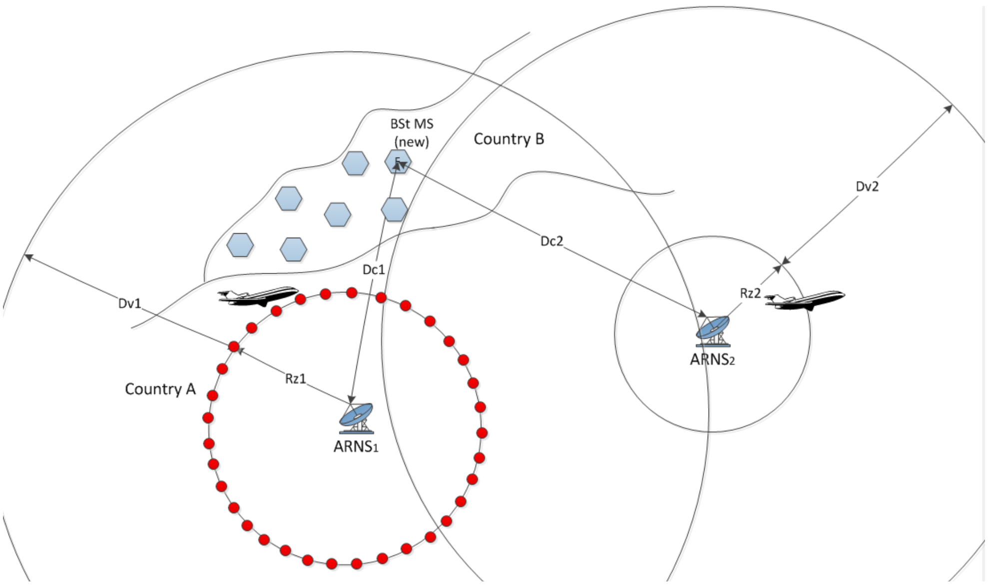
where

Rzi – service area radius of ARNS ground *i*-th station, where the associated receiving airborne ARNS station can be located (indicated in filing for ARNS station).

If the requirement is met then obtaining agreement for new MS base station under RR No. **9.21** with respect to the specific ARNS station is not required (Fig. 25 with respect to ARNS2 station).

FIGURE 25

How to determine affected frequency assignments of ARNS airborne receivers



3) For each ARNS *i*-th station located at the distance less or equal to $\boldsymbol{D_{vi}+R_{zi}}$ the following is determined the MS base station assignments entered in MIFR or earlier notified to obtain agreement under RR No. **9.21** which completely or partially fall into the line-of-sight area of ARNS airborne receiver (these assignments are highlighted by blue colour in Fig. 25)

4) The interference level $\boldsymbol{I_{ijk}}$ is calculated in the k-boundary point of the service area of *i*-th ARNS ground receiver (these are red points in Fig. 25) from each *j*-th interference source identified in item 3 above including a new notified MS base station assignment.
The calculation is performed by application of Recommendation ITU-R P.525-2.

Interference level $\boldsymbol{I_{ijk}}$ is calculated taking into account the overlapping frequency bands ratio.
N- index, that takes into account interference power portion, entering the ARNS receiver, dB:

$$N = \begin{cases} 10\log(B_I / B_W), B_I < B_W \\ 0, B_I = B_W \end{cases} \quad (10)$$

B_W – interferer's bandwidth, MHz;

B_I – bandwidth overlap of the interferer and the ARNS receiver, MHz.

It should be noted that the test points (where calculations are performed) are chosen at the boundary of the service area of *i-th* ARNS ground receiver with definite interval (for example 1 degrees) (currently used under the GE06 Agreement) (the points on the service area boundary of ARNS1 receiver are highlighted by red colour in Fig. 25).

5) The aggregate interference level $\boldsymbol{I_{ik}}$ is calculated in each *k-th* point of the service area of *i-th* ARNS ground receiver by application of the data obtained in item 4 above and in accordance with the equation:

$$\mathrm{I}_{ik} = 10\log\left(\sum_{j=1}^{n} 10^{0.1 I_{ijk}}\right) \quad (11)$$

6) The aggregate interference level $\boldsymbol{I_{ik}}$ in each k-th boundary point is compared with the protection criteria $\boldsymbol{Ereq_i}$ of *i*-th ARNS airborne receiver. If the condition $\boldsymbol{I_{ik} > Ireq_i}$ is met then obtaining agreement for new notified MS base station under RR No. **9.21** with regard to the specific *i*-th ARNS station is required. $\boldsymbol{Ireq_i}$ calculation is based on ***I/N*** = - 6 dB criterion. Based on $\boldsymbol{N_i}$ for certain type of ARNS system, then $\boldsymbol{Ireq_i = N_i}$ – 6.

4.2.3.2.1.2 MS base station impact to ARNS ground receiver

In consideration of MS base station impact to ground ARNS receiver it is required to take into account the fact that ARNS ground station antennas are directional. Therefore in compatibility estimation MS assignments which fall into the main lobe of the ARNS station antenna pattern were taken into account. It should be noted, that the parameter with width of the main lobe of the ARNS earth station's antenna on -3 dB level should be added to Appendix **4** RR as mandatory parameter for notification. In the absence of this parameter in the notification the width of the main lobe of the ARNS earth station's antenna by -3 dB level should be assume equal to 8 degrees.

Interference outside the ARNS station antenna pattern main lobe was taken into account by adding 4 dB[10] to the interference which will be calculated in the angle sector of the ARNS station antenna pattern main lobe. (Justification presented in Appendix 4)

Depending on location of the affected ARNS station the sector radius is determined where interference sources should be taken into account. In the GE06 Agreement and Recommendation ITU-R P.1546-4 distance of 1 000 kilometres is taken as this sector radius. The same distance is used in ITU-R Bureau for checking the filings for modification of GE06 Plan with respect to ARNS stations.

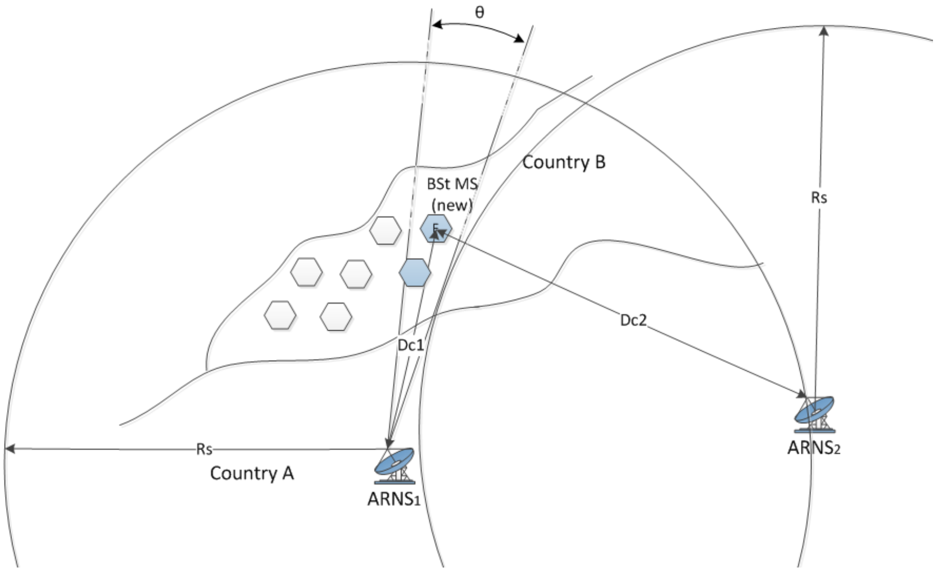
However, taking into account that Recommendation ITU-R P.1546-4 is applied for different climatic areas and wide frequency range therefore the sector radius $\boldsymbol{R_s}$ where interference sources are taken into account, is limited up to distance of 600 km –for ARNS stations located higher of 48 degrees north latitude and up to 800 kilometres for ARNS stations located at 48 degrees north latitude and lower (The Black Sea region).

Therefore if the MS base station is located in the main beam of ARNS station antenna pattern but at the distance $\boldsymbol{R_s}$ of more than 600 kilometres or 800 kilometres (as the case may be) then it is proposed not to take into account such station in the interference calculation for ARNS stations (see Fig. 26).

[10] This value highly depends on the distance between the ARNS station and the MS stations for the methodology in appendix 6 and is not representative for all cases.

FIGURE 26

How to determine affected frequency assignments of ARNS ground receivers



Taken into account the above mentioned while considering interference impact of the notified MS base station to the ARNS ground stations the following procedure to determine the affected ARNS is applied:

1) Around the notified new MS base station towards the ARNS ground stations which are notified in ITU in new MS base station frequency band the distance $\boldsymbol{D_{ci}}$ is determined (see Fig. 26).

2) The condition to be checked:

$$Dci > Rs, \quad (12)$$

where Rs =600 km or =800 km depending on latitude of ARNS *i*-th station.

If the requirement is met then obtaining agreement for new MS base station under RR No. **9.21** with respect to the specific ARNS station is not required (This relates to ARNS2 station in Fig. 26).

3) With respect to each ARNS *i*-th station which is located nearer than ***Dci***≤ ***Rs*** the MS base station assignments entered in MIFR or earlier notified to obtain agreement under RR No. **9.21** are determined which completely or partially fall into the main beam sector of ARNS ground station directed to a new notified MS base station. This sector is limited by the distance ***Rs*** (in Fig. 26 these assignments and allotments are highlighted by blue colour.)

4) The interference level $\boldsymbol{I_{ij}}$ is calculated in the location of i-th ARNS ground receiver (in Fig. 26 this is ARNS1) from each j-th MS base station assignment recorded in MIFR or previously notified to obtain agreement under RR No. **9.21** including new notified MS base station assignment.

Interference level $\boldsymbol{I_{ij}}$ shall be calculated with account of overlapping frequency band ratio. *N*- index, that takes into account interference power portion, entering the ARNS receiver, dB:

$$N = \begin{cases} 10\log(B_I / B_W), B_I < B_W \\ 0, B_I = B_W \end{cases} \quad (13)$$

B_W – interferer's bandwidth, MHz;

B_I – bandwidth overlap of the interferer and the ARNS receiver, MHz.

The calculation is performed by application of Recommendation ITU-R P.1546-4 for 10% of time and 50% of location.

5) The aggregate interference level ***Ii*** is calculated in the i-th ARNS ground receiver location by application of the data obtained in item 4 above and in accordance with the following equation:

$$I_i = 10\log\left(\sum_{j=1}^{n} 10^{0.1 I_{ij}}\right) + 4 \quad (14)$$

6) The aggregate interference level ***Ii*** is compared with the protection criteria $\boldsymbol{I_{reqi}}$ of *i*-th ARNS ground receiver. If the requirement $\boldsymbol{I_i > I_{reqi}}$ is met then obtaining agreement for new MS base station under RR No. **9.21** with respect to the *i*-th ARNS station is required. $\boldsymbol{Ireq_i}$ calculation is based on ***I/N*** = -6 dB criterion. Based on $\boldsymbol{N_i}$ for certain type of ARNS system, then $\boldsymbol{Ireq_i = N_i} - 6$.

4.2.3.2.2 Consideration of MS UE impact to ARNS ground and aircraft stations

In case of CDMA or TDD MS systems, it is expected that interference caused by MS UE to ARNS stations will not exceed interference from MS base station. Therefore, in these cases it is sufficient to use the methodology specified in section 4.2.3.2.1 above.

In case of FDD MS systems interference caused by UE to ARNS stations will impact in other frequency bands than interference form MS base station. Therefore in this case other approaches are required to be applied to determine the affected ARNS assignments.

In case of notification of MS systems with FDD when a notifying administration indicates in the filing that the aggregate e.i.r.p. value of all UE operating simultaneously with the notified base station does not exceed 21 dBm per 1 MHz (this corresponds to the coordination distance of 70 kilometres specified in Table 1 of Annex 1 to Resolution **749 (Rev.WRC-12)**) then this value should be used in the interference calculation.

Otherwise, the value of 31 dBm per 1 MHz (this corresponds to the coordination distance of 150 kilometres specified in Table 1 of Annex 1 to Resolution **749 (Rev.WRC-12)**) can be used as the aggregate e.i.r.p. value of all UE operating simultaneously with the notified base station or to use other e.i.r.p. values notified by administration.

Using these aggregate values of UE (21 dBm per 1 MHz or 31 dBm per 1 MHz, as appropriate) operating with one MS base station can determine the affected ARNS assignments upon applying methodology presented in section 4.2.3.2.1 above. However, receiving MS base station should be considered instead of transmitting MS base station, and aggregate e.i.r.p. of all UE operating simultaneously with notified MS base station should be considered instead of e.i.r.p. of MS base station (see above).

4.2.3.3 Calculations

The estimation approach is presented in Section 4.2.2.3. The difference is that the protection criteria of ARNS is based on the permissible interference-to-noise” ratio of I/N=-6 dB.

4.2.3.4 Results

In the studies the protection criteria for ARNS interference-to-noise I/N = –6 dB indicated in Section 3 were used. It was assumed that different services can operate in neighbouring countries (BS in one country, MS in other and ARNS in the third country). However unlike Study B.1 in estimation of interference from MS stations to ARNS station the protection criterion for ARNS interference-to-noise ratio allows to estimate interference not taking into account interference from stations in broadcasting service even notwithstanding their actual existence.

The performed studies showed that compatibility of MS stations of one country with ARNS stations of another country with BS in a third country is feasible.

Views from some administrations regarding Study #B.2 are presented in Appendix 7.

4.3 Study #B.3

4.3.1 Assumptions

The technical characteristics were applied in the sharing studies of the IMT and ARNS systems described in section 3.

Currently, there are no ITU-R Recommendations that deal specifically with the protection criterion for ARNS systems from MS systems in this particular frequency band. However, Recommendation ITU-R M.1461-1 contains a recommended protection criterion for radars in general, when there are no others available in ITU-R Recommendations, when considering potential interference from other services. The recommended criterion of I/N = –6 dB is specified in section 3.3 of the Annex of Recommendation ITU-R M.1461-1. Assuming that noise figure NF=5 dB, I/N criterion = –6 dB (Table 53) can be recalculated in the protected field strength value for each system of ARNS in the frequency band 694-790 MHz.

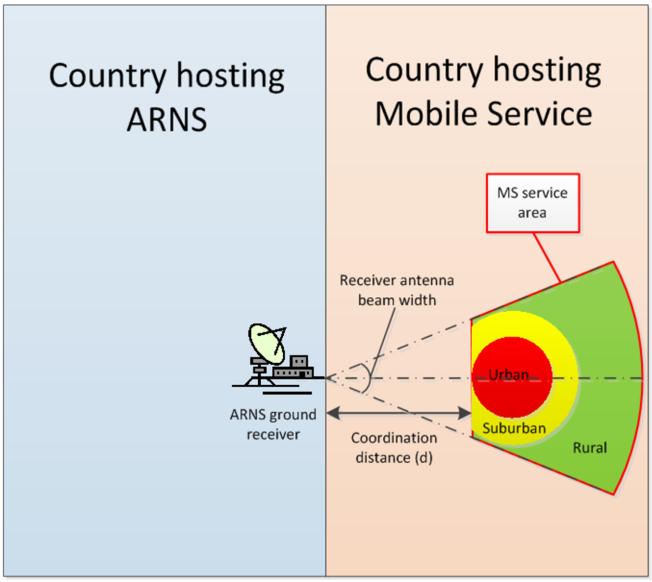
4.3.2 Methodology

In the compatibility studies the following scenarios of IMT station deployment are considered:

– Scenario 1 is shown in Fig. 27. In this case it is assumed that MS system transmitters are located behind the line which is at the protection distance from the ground receiver of ARNS. The urban area (with base station cell radius of 0.5 kilometres) surrounded by suburban (with base station cell radius of 2 kilometres) and rural area (with base station cell radius of 8 kilometres) is located in the vicinity of the receiver. In the estimations in one case the MS base station antenna height of 30 metres and urban area of 30 sq. kilometres and suburban area of 90 sq.km are considered. The second case addresses MS base station antenna height of 50 metres and urban area of 100 sq. km and suburban area of 300 sq.km. For example Moscow area is 1081 sq.km, Berlin area is 900 sq.km, Helsinki area is 680 sq.km and Prague is 500 sq.km therefore the selected urban areas are optimistic. The ground receiver antenna height was taken of 10 metres. The antenna pattern beamwidth of -3 dB for ARNS earth station is 8 degrees.

FIGURE 27

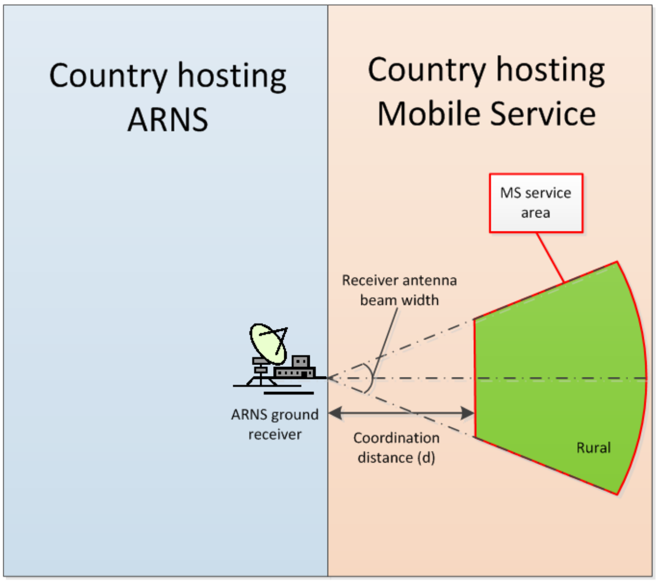
Scenario 1 "Urban- suburban- rural (U-S-R)" interference impact to ARNS ground receiver (urban area is highlighted in red, suburban area is highlighted in yellow, rural area is highlighted in green)



– Scenario 2 is shown in Fig. 28. In this case it is assumed that IMT system transmitter is located behind the line which is at the protection distance from the ARNS ground receiver. Unlike Scenario 1 they are located in the rural area with base station cell radius of 8 kilometres. The IMT base station antenna height was taken as 30 metres and the ground receiver antenna height was 10 metres. The antenna pattern beamwidth of –3 dB for ARNS earth station is 8 degrees.

FIGURE 28

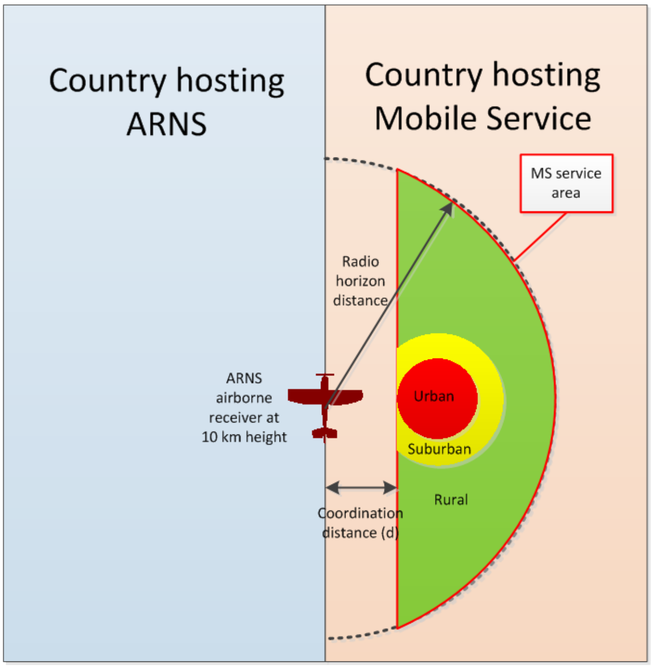
Scenario 2 "Rural" interference impact to ARNS ground receiver (rural area is highlighted in green)



– Scenario 3 is shown in Fig. 29. In this case it is assumed that MS system transmitters are located behind the line which is at the protection distance from the airborne receiver of ARNS. The urban area (with base station cell radius of 0.5 km) surrounded by suburban (with base station cell radius of 2 km) and rural areas (with base station cell radius of 8 kilometres) is located in the vicinity of the receiver. In the estimations in one case the MS base station antenna height of 30 metres and urban area of 30 sq. km and suburban area of 90 sq.km are considered. The second case addresses MS base station antenna height of 50 metres and urban area of 100 sq. km and suburban area of 300 sq.km. For example Moscow area is 1081 sq.km, Berlin area is 900 sq.km, Helsinki area is 680 sq.km and Prague is 500 sq.km therefore the selected urban areas are optimistic. The airborne receiver antenna height was taken of 10 000 metres.

FIGURE 29

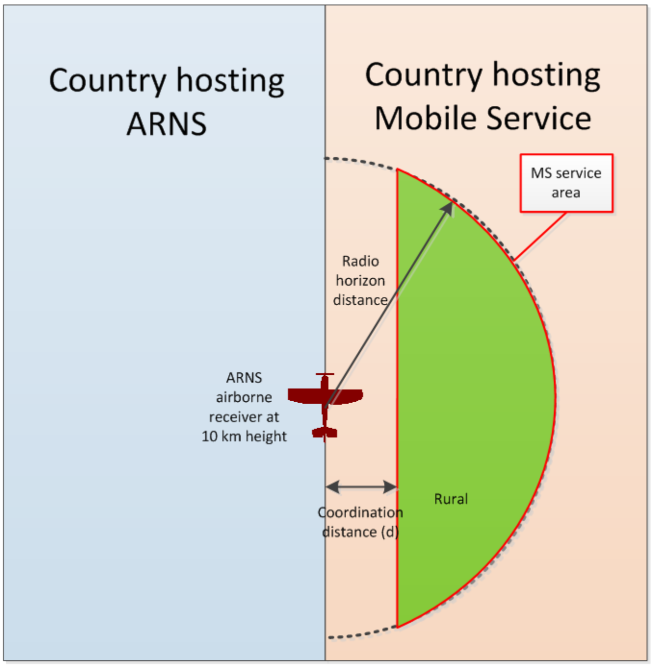
Scenario 3 "Urban- suburban- rural (U-S-R)" interference impact to ARNS airborne receiver (urban area is highlighted in red, suburban area is highlighted in yellow, rural area is highlighted in green)



– Scenario 4 is shown in Fig. 30. In this case it is also assumed that MS system transmitters are located behind the line which is at the protection distance from the ARNS airborne receiver. Unlike Scenario 3 they are located in the rural area with deployment density (with base station cell radius of 8 kilometres). The IMT base station antenna height was taken as 30 metres and the ARNS airborne receiver antenna height was 10 000 metres.

FIGURE 30

Scenario 4 "Rural" interference impact to ARNS airborne receiver (rural area is highlighted in green)



4.3.3 Calculations of estimation of interference and conditions for compatibility of MS systems with ARNS systems

MS base station to ground-based ARNS (Scenario 1 and Scenario 2)

The required coordination distances are indicated in tables below.

TABLE 53

Required coordination distances between MS base stations and terrestrial ARNS receivers, 5 MHz bandwidth and 100% land propagation

ARNS type	Predetermined aggregate trigger field-strength values from a mobile service station based on I/N (dB(μV/m))	Separation Distance (km)		Coordination Distance (km)
		(Rural - Scenario 2)	(Urban Suburban Rural – Scenario 1)	
RSBN	1 at 10 m in a 3 MHz reference bandwidth	330[1]	405[2]/455[3]	405[2]/455[3]
RLS 2 (Type 1) (ground receiver)	7 at 10 m in a 4 MHz reference bandwidth	275[1]	355[2]/400[3]	355[2]/400[3]
RLS 2 (Type 2) (ground receiver)	-1 at 10 m in a 8 MHz reference bandwidth	415[1]	480[2]/530[3]	480[2]/530[3]
RLS 1 (Type 1 and 2)	-3.5 at 10 m in a 6 MHz reference bandwidth	425[1]	490[2]/545[3]	490[2]/545[3]

Note 1: Result based on conditions that MS base stations operate with antenna height 30 m, cell radius is 8 km for rural area and power of MS base stations is 55 dBm in 5 MHz due orientation of main beam antenna pattern towards ARNS station. No downtilt of the MS base station antennas has been applied. Antenna pattern only in horizontal plane from Recommendation ITU-R F.1336 has been used.

Note 2: Result based on conditions that MS base stations operate with antenna height 30 m, cell radius is 8 km for rural area, 2 km for suburban area (S=90 km^2) and 0.5 km for urban area (S=30 km^2), power of MS base stations is 55 dBm in 5 MHz due orientation of main beam antenna pattern towards ARNS station. The rural attenuation curves of P.1546 have been used for all environments. No downtilt of the MS base station antennas has been applied. Antenna pattern only in horizontal plane from Recommendation ITU-R F.1336 has been used.

Note 3: Result based on conditions that MS base stations operate with antenna height 50 m, cell radius is 8 km for rural area, 2 km for suburban area (S=300 km^2) and 0.5 km (S=100 km^2) for urban area, power of MS base stations is 55 dBm in 5 MHz due orientation of main beam antenna pattern towards ARNS station. The rural attenuation curves of ITU-R P.1546 have been used for all environments. No downtilt of the MS base station antennas has been applied. Antenna pattern only in horizontal plane from Recommendation ITU-R F.1336 has been used.

TABLE 54

Required coordination distances between MS base stations and terrestrial ARNS receivers, 5 MHz bandwidth, 50/50% sea/land propagation

ARNS type	Predetermined aggregate trigger field-strength values from a mobile service station based on I/N (dB(μV/m))	Separation Distance (km)		Coordination Distance (km)
		(Rural - Scenario 2)	(Urban Suburban Rural – Scenario 1)	
RSBN	1 at 10 m in a 3 MHz reference bandwidth	340[1]	445[2]/480[3]	445[2]/480[3]
RLS 2 (Type 1) (ground receiver)	7 at 10 m in a 4 MHz reference bandwidth	290[1]	385[2]/425[3]	385[2]/425[3]
RLS 2 (Type 2) (ground receiver)	-1 at 10 m in a 8 MHz reference bandwidth	425[1]	510[2]/550[3]	510[2]/550[3]
RLS 1 (Type 1 and 2)	-3.5 at 10 m in a 6 MHz reference bandwidth	435[1]	525[2]/565[3]	525[2]/565[3]

Note 1: Result based on conditions that MS base stations operate with antenna height 30 m, cell radius is 8 km for rural area and power of MS base stations is 55 dBm in 5 MHz due orientation of main beam antenna pattern towards ARNS station. No downtilt of the MS base station antennas has been applied. Antenna pattern only in horizontal plane from Recommendation ITU-R F.1336 has been used.

Note 2: Result based on conditions that MS base stations operate with antenna height 30 m, cell radius is 8 km for rural area, 2 km for suburban area (S=90 km^2) and 0.5 km for urban area (S=30 km^2), power of MS base stations is 55 dBm in 5 MHz due orientation of main beam antenna pattern towards ARNS station. The rural attenuation curves of Rec. ITU-R P.1546 have been used for all environments. No downtilt of the MS base station antennas has been applied. Antenna pattern only in horizontal plane from Recommendation ITU-R F.1336 has been used.

Note 3: Result based on conditions that MS base stations operate with antenna height 50 m, cell radius is 8 km for rural area, 2 km for suburban area (S=300 km^2) and 0.5 km (S=100 km^2) for urban area, power of MS base stations is 55 dBm in 5 MHz due orientation of main beam antenna pattern towards ARNS station. The rural attenuation curves of Rec. ITU-R P.1546 have been used for all environments. No downtilt of the MS base station antennas has been applied. Antenna pattern only in horizontal plane from Recommendation ITU-R F.1336 has been used.

TABLE 55

Required coordination distances between MS base stations and terrestrial ARNS receivers, 10 MHz bandwidth and 100% land propagation

ARNS type	Predetermined aggregate trigger field-strength values from a mobile service station based on I/N (dB(µV/m))	Separation Distance (km)		Coordination Distance (km)
		(Rural - Scenario 2)	(Urban Suburban Rural – Scenario 1)	
RSBN	1 at 10 m in a 3 MHz reference bandwidth	300[1]	375[2]/420[3]	375[2]/420[3]
RLS 2 (Type 1) (ground receiver)	7 at 10 m in a 4 MHz reference bandwidth	245[1]	320[2]/370[3]	320[2]/370[3]
RLS 2 (Type 2) (ground receiver)	-1 at 10 m in a 8 MHz reference bandwidth	375[1]	440[2]/495[3]	440[2]/495[3]
RLS 1 (Type 1 and 2)	-3.5 at 10 m in a 6 MHz reference bandwidth	390[1]	455[2]/510[3]	455[2]/510[3]

Note 1: Result based on conditions that MS base stations operate with antenna height 30 m, cell radius is 8 km for rural area and power of MS base stations is 55 dBm in 5 MHz due orientation of main beam antenna pattern towards ARNS station. No downtilt of the MS base station antennas has been applied. Antenna pattern only in horizontal plane from Recommendation ITU-R F.1336 has been used.

Note 2: Result based on conditions that MS base stations operate with antenna height 30 m, cell radius is 8 km for rural area, 2 km for suburban area (S=90 km^2) and 0.5 km for urban area (S=30 km^2), power of MS base stations is 55 dBm in 5 MHz due orientation of main beam antenna pattern towards ARNS station. The rural attenuation curves of Rec. ITU-R P.1546 have been used for all environments. No downtilt of the MS base stations antennas has been applied. Antenna pattern only in horizontal plane from Recommendation ITU-R F.1336 has been used.

Note 3: Result based on conditions that MS base stations operate with antenna height 50 m, cell radius is 8 km for rural area, 2 km for suburban area (S=300 km^2) and 0.5 km (S=100 km^2) for urban area, power of MS base stations is 55 dBm in 5 MHz due orientation of main beam antenna pattern towards ARNS station. The rural attenuation curves of Rec. ITU-R P.1546 have been used for all environments. No downtilt of the MS base station antennas has been applied. Antenna pattern only in horizontal plane from Recommendation ITU-R F.1336 has been used.

TABLE 56

Required coordination distances between MS base stations and terrestrial ARNS receivers, 10 MHz bandwidth, 50/50% sea/land propagation

ARNS type	Predetermined aggregate trigger field-strength values from a mobile service station based on I/N (dB(μV/m))	Separation Distance (km)		Coordination Distance (km)
		(Rural - Scenario 2)	(Urban Suburban Rural – Scenario 1)	
RSBN	1 at 10 m in a 3 MHz reference bandwidth	310[1]	400[2]/445[3]	400[2]/445[3]
RLS 2 (Type 1) (ground receiver)	7 at 10 m in a 4 MHz reference bandwidth	250[1]	350[2]/390[3]	350[2]/390[3]
RLS 2 (Type 2) (ground receiver)	-1 at 10 m in a 8 MHz reference bandwidth	380[1]	475[2]/520[3]	475[2]/520[3]
RLS 1 (Type 1 and 2)	-3.5 at 10 m in a 6 MHz reference bandwidth	395[1]	435[2]/530[3]	435[2]/530[3]

Note 1: Result based on conditions that MS base stations operate with antenna height 30 m, cell radius is 8 km for rural area and power of MS base stations is 55 dBm in 5 MHz due orientation of main beam antenna pattern towards ARNS station. No downtilt of the MS base station antennas has been applied. Antenna pattern only in horizontal plane from Recommendation ITU-R F.1336 has been used.

Note 2: Result based on conditions that MS base stations operate with antenna height 30 m, cell radius is 8 km for rural area, 2 km for suburban area (S=90 km^2) and 0.5 km for urban area (S=30 km^2), power of MS base stations is 55 dBm in 5 MHz due orientation of main beam antenna pattern towards ARNS station. The rural attenuation curves of Recommendation ITU-R P.1546 have been used for all environments. No downtilt of the MS base station antennas has been applied. Antenna pattern only in horizontal plane from Recommendation ITU-R F.1336 has been used.

Note 3: Result based on conditions that MS base stations operate with antenna height 50 m, cell radius is 8 km for rural area, 2 km for suburban area (S=300 km^2) and 0.5 km (S=100 km^2) for urban area, power of MS base stations is 55 dBm in 5 MHz due orientation of main beam antenna pattern towards ARNS station. The rural attenuation curves of Recommendation ITU-R P.1546 have been used for all environments. No downtilt of the MS base station antennas has been applied. Antenna pattern only in horizontal plane from Recommendation ITU-R F.1336 has been used.

MS base station to airborne ARNS (Scenario 3 and Scenario 4)

For calculating the interfering signal the propagation model in Recommendation ITU-R P.525 has been used.

The required coordination distances are indicated in tables below.

TABLE 57

Required coordination criteria MS base stations 5 MHz – airborne ARNS receiver

ARNS type	Predetermined aggregate trigger field-strength values from a mobile service station based on I/N (dB(μV/m))	Separation Distance (km)		Coordination Distance (km)
		(Rural – Scenario 4)	(Urban Suburban Rural – Scenario 3)	
RLS 2 (Type 1) (aircraft receiver)	21 at 10 000 m in a 4 MHz reference bandwidth	434[1]	434[2]/441[3]	441[3]
RLS 2 (Type 2) (aircraft receiver)	20 at 10 000 m in a 3 MHz reference bandwidth	434[1]	434[2]/441[3]	441[3]

Note 1: Result based on conditions that MS base stations operate with antenna height 30 m, cell radius is 8 km for rural area and power of MS base stations is 55 dBm in 5 MHz due orientation of main beam antenna pattern towards ARNS station. No downtilt of the MS base station antennas has been applied. Antenna pattern only in horizontal plane from Recommendation ITU-R F.1336 has been used.

Note 2: Result based on conditions that MS base stations operate with antenna height 30 m, cell radius is 8 km for rural area, 2 km for suburban area (S=90 km^2) and 0.5 km for urban area (S=30 km^2), power of MS base stations is 55 dBm in 5 MHz due orientation of main beam antenna pattern towards ARNS station. No downtilt of the MS base station antennas has been applied. Antenna pattern only in horizontal plane from Recommendation ITU-R F.1336 has been used.

Note 3: Result based on conditions that MS base stations operate with antenna height 50 m, cell radius is 8 km for rural area, 2 km for suburban area (S=300 km^2) and 0.5 km (S=100 km^2) for urban area, power of MS base stations is 55 dBm in 5 MHz due orientation of main beam antenna pattern towards ARNS station. No downtilt of the MS base station antennas has been applied. Antenna pattern only in horizontal plane from Recommendation ITU-R F.1336 has been used.

TABLE 58

Required coordination criteria MS base stations 10 MHz – airborne ARNS receiver

ARNS type	Predetermined aggregate trigger field-strength values from a mobile service station based on I/N (dB(μV/m))	Separation Distance (km)		Coordination Distance (km)
		(Rural – Scenario 4)	(Urban Suburban Rural – Scenario 3)	
RLS 2 (Type 1) (aircraft receiver)	21 at 10 000 m in a 4 MHz reference bandwidth	434[1]	434[2]/441[3]	441[3]
RLS 2 (Type 2) (aircraft receiver)	20 at 10 000 m in a 3 MHz reference bandwidth	434[1]	434[2]/441[3]	441[3]

Note 1: Result based on conditions that MS base stations operate with antenna height 30 m, cell radius is 8 km for rural area and power of MS base stations is 55 dBm in 5 MHz due orientation of main beam antenna pattern towards ARNS station. No downtilt of the MS base station antennas has been applied. Antenna pattern only in horizontal plane from Recommendation ITU-R F.1336 has been used.

Note 2: Result based on conditions that MS base stations operate with antenna height 30 m, cell radius is 8 km for rural area, 2 km for suburban area (S=90 km^2) and 0.5 km for urban area (S=30 km^2), power of MS base stations is 55 dBm in 5 MHz due orientation of main beam antenna pattern towards ARNS station. No downtilt of the MS base station antennas has been applied. Antenna pattern only in horizontal plane from Recommendation ITU-R F.1336 has been used.

Note 3: Result based on conditions that MS base stations operate with antenna height 50 m, cell radius is 8 km for rural area, 2 km for suburban area (S=300 km^2) and 0.5 km (S=100 km^2) for urban area, power of MS base stations is 55 dBm in 5 MHz due orientation of main beam antenna pattern towards ARNS station. No downtilt of the MS base station antennas has been applied. Antenna pattern only in horizontal plane from Recommendation ITU-R F.1336 has been used.

ARNS system impact to MS base station receivers

For the situation when MS UE are interfering with ground based ARNS stations propagation model Recommendation ITU-R P.1546-4 has been used. For the situation when MS UE are interfering ARNS airborne stations propagation model Recommendation ITU-R P.525 has been used.

The interference estimation from single UE with radiated power of 23 dBm in 5 MHz shows that separation distance between UE and various types of ARNS stations will range from 2 to 10 kilometres. It should be noted that MS UE are not notified in ITU BR therefore coordination of UE with ARNS stations cannot be carried out.

Coordination can be carried out based on the notified MS base stations. Therefore it is required to consider the impact from single ARNS station to MS BS receiver.

TABLE 59

Required coordination distances for protection MS base stations from ARNS, 5 MHz

ARNS type	Trigger «interference/noise» values fo mobile service station protection, *I/N* (dB)	Separation distance (km)		Coordination Distance (km)[3]
		Air-Borne[3]	Land[3]	
RSBN (aircraft transmitter)	-6 at 30 m or 50 m in a 5 MHz reference bandwidth	434[1]/441[2]	-	441[2]
RLS 2 (Type 1) (aircraft transmitter)	-6 at 30 m or 50 m in a 5 MHz reference bandwidth	434[1]/441[2]	-	441[2]
RLS 2 (Type 1) (ground transmitter)	-6 at 30 m or 50 m in a 5 MHz reference bandwidth	-	130[2]/165[2]*	130[2]/165[2]*
RLS 2 (Type 2) (aircraft transmitter)	-6 at 30 m or 50 m in a 5 MHz reference bandwidth	434[1]/441[2]	-	441[2]
RLS 2 (Type 2) (ground transmitter)	-6 at 30 m or 50 m in a 5 MHz reference bandwidth	-	405[2]/445[2]*	405[2]/445[2]*
RLS 1 (Type 1 and 2) (ground transmitter	-6 at 30 m or 50 m in a 5 MHz reference bandwidth	-	405[2]/445[2]*	405[2]/445[2]*
* 50% ≤ land path ≤ 100% / 0% ≤ land path < 50%.				
Note 1: Result based on conditions that MS base stations operate with antenna height 30 m. Note 2: Result based on conditions that MS base stations operate with antenna height 50 m. Note 3: The figures given are based on the estimated distance to protect the IMT from ARNS.				

TABLE 60

Required coordination distances for protection MS base stations from ARNS, 10 MHz

ARNS type	Trigger «interference/noise» values fo mobile service station protection, *I/N* (dB)	Separation distance (km)		Coordination Distance (km)[3]
		Air-Borne[3]	Land[3]	
RSBN (aircraft transmitter)	-6 at 30 m or 50 m in a 10 MHz reference bandwidth	434[1]/441[2]	-	441[2]
RLS 2 (Type 1) (aircraft transmitter)	-6 at 30 m or 50 m in a 10 MHz reference bandwidth	434[1]/441[2]	-	441[2]
RLS 2 (Type 1) (ground transmitter)	-6 at 30 m or 50 m in a 10 MHz reference bandwidth	-	105[2]/140[2]	105[2]/140[2]
RLS 2 (Type 2) (aircraft transmitter)	-6 at 30 m or 50 m in a 10 MHz reference bandwidth	434[1]/441[2]	-	441[2]
RLS 2 (Type 2) (ground transmitter)	-6 at 30 m or 50 m in a 10 MHz reference bandwidth	-	375[2]/425[2]	375[2]/425[2]
RLS 1 (Type 1 and 2) (ground transmitter)	-6 at 30 m or 50 m in a 10 MHz reference bandwidth	-	375[2]/425[2]	375[2]/425[2]
* 50% ≤ land path ≤ 100% / 0% ≤ land path < 50%.				
Note 1: Result based on conditions that MS base stations operate with antenna height 30 m. Note 2: Result based on conditions that MS base stations operate with antenna height 50 m. Note 3: The figures given are based on the estimated distance to protect the IMT from ARNS.				

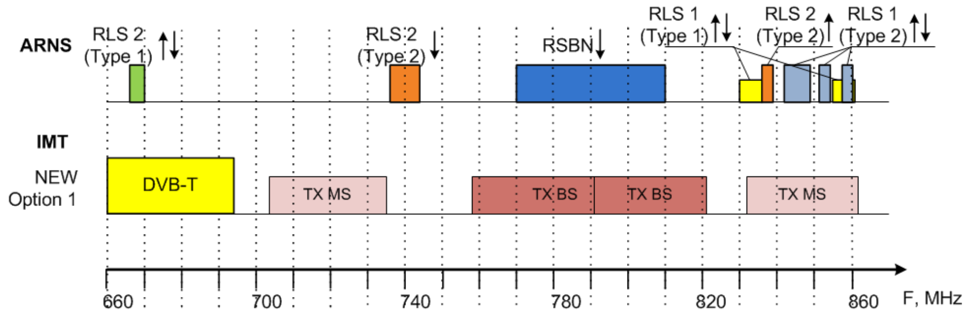
4.3.4 Results of estimation of interference and conditions for compatibility of MS systems with ARNS systems

It can be concluded that both coordination distances between MS base stations and ARNS as well as coordination distances between ARNS and receiving base stations MS needs to be considered.

Further analysing which frequencies the different ARNS systems use, it can be seemed that only some types of ARNS stations (RLS2 Type 1) should be considered. However it should be noted that occupation of the frequency band 645-862 MHz by typical ARNS systems is given in Fig. 31.
The ARNS stations operating in other carriers in the frequency band 694-790 MHz are notified in MIFR. It is confirmed by the information given in Appendix 5 of Section 2 “Summary of assignments of ARNS stations recorded in the MIFR”. Therefore it is required to take into account all types of ARNS stations given in Table 11.

FIGURE 31

Typical systems of ARNS and possible MS frequency utilisation



Based on the calculations above the coordination distances between MS and ARNS shown in Table 61 below can be concluded.

TABLE 61

Coordination distance required between MS and ARNS in 694-790 MHz

ARNS station	System type code	Coordination distances for the receiving MS base stations (km)[3]	Coordination distances for the transmitting MS base stations (km)
RSBN (ground receiver)	AA8	441[1]	455[2]/480[2]*
RLS 2 (type 1) (airborne receiver)	BD	130[1]/165[1]*	441[2]
RLS 2 (type 1) (ground receiver)	BA	441[1]	400[2]/425[2]*
RLS 2 (type 2) (airborne receiver)	BC	405[1]/445[1]*	441[2]
RLS 2 (type 2) (ground receiver)	AA2	441[1]	530[2]/550[2]*
RLS 1 (types 1 and 2) (ground receiver)	AB	405[1]/445[1]*	545[2]/565[2]*
Other ARNS ground stations	Not applied	405[1]/445[1]*	545[2]/565[2]*
Other ARNS airborne stations	Not applied	405[1]/445[1]*	441[2]
* 50% ≤ land path ≤ 100% / 0% ≤ land path < 50%.			
Note 1: Result based on conditions that MS base stations operate with antenna height 50 m. No downtilt of the MS base stationantennas has been applied. Antenna pattern only in horizontal plane from Recommendation ITU-R F.1336 has been used.			
Note 2: Result based on conditions that MS base stations operate with antenna height 50 m, cell radius is 8 km for rural area, 2 km for suburban area (S=300 km^2) and 0.5 km (S=100 km^2) for urban area, power of MS base stations is 55 dBm in 5 MHz due orientation of main beam antenna pattern towards ARNS station. No downtilt of the MS base station antennas has been applied. Antenna pattern only in horizontal plane from Recommendation ITU-R F.1336 has been used.			
Note 3: The figures given are based on the estimated distance to protect the IMT from ARNS.			

Views from some administrations regarding Study #B.3 are presented in Appendix 7.

5 Summary

In the studies two different interference impact scenario from MS to ARNS were considered:

1) Interference from MS to ARNS without interference from the broadcasting service.

2) Interference from MS to ARNS with interference from the broadcasting service

5.1 Results of compatibility studies of MS with ARNS without interference from BS

Based on study A1 the coordination distances between MS and ARNS shown in Table 62 below can be concluded. The study was based on application of field strength thresholds as the protection criteria for ARNS.

TABLE 62

Coordination threshold values of MS stations with ARNS

ARNS station	System type code	Coordination distances for the receiving MS base stations (km)[3]	Coordination distances for the transmitting MS base stations (km)[1]
RSBN	AA8	Rural: <1 Suburban: <1 Urban: N/A[5]	Rural: 15/19*[2] Suburban: 17/25*[2] Urban: 5/7*[2] Mixed: 15/20*[2]
RLS 2 (type 1) (airborne receiver)	BD	Rural: <1 Suburban:<1 Urban: <1	Rural: >RH[4] Suburban/urban: >RH[4] Mixed: >RH[4]
RLS 2 (type 1) (ground receiver)	BA	Rural: <1 Suburban:<1 Urban: N/A[5]	Rural: 31/42* Suburban: 70/112* Urban: 13/18* Mixed: 40/61*
RLS 2 (type 2) (airborne receiver)	BC	Rural: <1 Suburban:<1 Urban: <1	Rural: 251 Suburban/urban: 403 Mixed: 373
RLS 2 (type 2) (ground receiver)	AA2	Rural: <1 Suburban: <1 Urban: N/A[5]	Rural: 45/65* Suburban: 124/167* Urban: 18/29* Mixed: 69/111*
RLS 1 (types 1 and 2) (ground receiver)	AB	Rural: <1 Suburban: <1 Urban: N/A[5]	Rural: 112/163* Suburban: 230/274* Urban: 53/97* Mixed: 171/212*
Other ARNS ground stations	Not applied	Rural: <1 Suburban: <1 Urban: N/A[5]	Rural: 112/163* Suburban: 230/274* Urban: 53/97* Mixed: 171/212*
Other ARNS airborne stations	Not applied	Rural: <1 Suburban:<1 Urban: <1	Rural: >RH[4] Suburban/urban: >RH[4] Mixed: >RH[4]

* 50% ≤ land path ≤ 100% / 0% ≤ land path < 50%.

Note 1: Result based on condition that MS base station operate with antenna height 30 m, cell radius is 8 km for rural area, 2 km for suburban and urban area. MS base station e.i.r.p. in direction towards the country hosting the ARNS is not more than 55 dBm in 5 MHz and 3 degrees down tilt of antenna pattern in accordance with Rec. ITU-R F.1336.

Note 2: Result based on condition that MS base stations operate with antenna height 30 m, cell radius is 8 km for rural area, 2 km for suburban and urban area

Note 3: All terminals with antenna height 1.5 m use average transmit power of 2 dBm for macro rural scenario, –9 dBm for macro urban/suburban scenario and densities of terminals in active mode are: rural: 0.17 UE per km^2/5 MHz, suburban/urban: 2.16 UE per km^2/5 MHz, as specified by ITU-R. Typical body loss of 4 dB was taken into account.

Note 4: RH= radio horizon (The radio horizon for 30m and 10000 m antenna heights are 431 km)

Note 5: Rec. ITU-R P.1546 is not applicable for the urban case sinceboth transmitter and receiver antenna heights are below the clutter height

Note 6: Base stations density in the mixed scenario: 0.0274 base station/km^2/5 MHz, which is made up from: 70% rural (density of 0,7x0.0050 base station/km^2/5MHz = 0,0035), 20% suburban (density of 0,2x0.0796 base station/km^2/5MHz = 0,0159), 10% urban (density of 0,1x0.0796 base station/km^2/5MHz = 0,0080).

Note 7: Propagation environment between MS base station and ARNS receiver, in the same environment (rural/suburban/urban) corresponds to the deployment scenario of MS base station, that means MS base station transmitter and ARNS receiver are placed in the same type of area (rural/suburban/urban).

Note 8: Tropospheric scattering effect in propagation model from Rec. ITU-R P.1546 was not taken into account.

It can be concluded that only the coordination distances between MS base stations and ARNS needs to be considered, since the coordination distances between MS UE and ARNS in all cases are considerably smaller than the coordination distances between MS base stations and ARNS.

Further analysing which frequencies the different ARNS systems use, it can also be concluded that only the ground stations of the RSBN system and the ground station of the RLS2 type 2 needs to be taken into account and it could be concluded that the coordination distance between MS base station and ground ARNS receivers in the 694-790 MHz band vary from 15 to 111 kilometres, depending on scenario.

TABLE 63

Coordination distance required between MS and ARNS in 694-790 MHz if only RLS 2 (type 2) ground and RSBN receivers of the ARNS system are concerned

Scenario	Propagation type	Required coordination distance – Mixed environment	Required coordination distance – Rural environment	Required coordination distance – Sub-urban environment	Required coordination distance – Urban environment
MS base station to RLS 2 (Type 2)	Land path	69 km	45 km	124 km	18 km
MS base station to RLS 2 (Type 2)	Mixed: 50 % sea/50 % land path	111 km	65 km	167 km	29 km
MS base station to RSBN	Land path	15 km	15 km	17 km	5 km
MS base station to RSBN	Mixed: 50% sea/50 %land path	20 km	19 km	25 km	7 km

General note: all below notes applies to all of the values in this table.

Note 1: Result based on condition that MS base station operate with antenna height 30 m, cell radius is 8 km for rural area, 2 km for suburban and urban area, MS base station e.i.r.p. in direction towards the country hosting the ARNS is not more than 55 dBm in 5 MHz and 3 degrees down tilt of antenna pattern in accordance with Rec. ITU-R F.1336.

Note 2: Base station density in the mixed scenario: 0.0274 BS/km^2/5 MHz, which is made up from: 70% rural (density of 0,7x0.0050 BS/km^2/5MHz = 0,0035), 20% suburban (density of 0,2x0.0796 BS/km^2/5MHz = 0,0159), 10% urban (density of 0,1x0.0796 BS/km^2/5MHz = 0,0080).

Note 3: Propagation environment between MS base stations and ARNS receiver, in the same environment (rural/suburban/urban) corresponds to the deployment scenario of MS base stations, that means MS base station transmitter and ARNS receiver are placed in the same type of area (rural/suburban/urban).

Note 4: Tropospheric scattering effect in propagation model from ITU-R Rec. P.1546 was not taken into account.

For the case that only RSBN ground receivers are concerned (e.g. if lower duplex pair of frequency arrangement A5 of Recommendation ITU-R M.1036-4 is used for the MS implementation) the distances shown in Table 64 below applies.

TABLE 64

Coordination distance required between MS and ARNS in 694-790 MHz if only RSBN ground receivers of the ARNS system are concerned

Scenario	Propagation type	Required coordination distance – Mixed environment	Required coordination distance – Rural environment	Required coordination distance – Sub-urban environment	Required coordination distance – Urban environment
MS base station to RSBN	Land path	15 km	15 km	17 km	5 km
MS base station to RSBN	Mixed: 50% sea/50 %land path	20 km	19 km	25 km	7 km

General note: all below notes applies to all of the valuesUE in this table.

Note 1: Result based on condition that MS base station operate with antenna height 30 m, cell radius is 8 km for rural area, 2 km for suburban and urban area, MS base station e.i.r.p. in direction towards the country hosting the ARNS is not more than 55 dBm in 5 MHz and 3 degrees down tilt of antenna pattern in accordance with Rec. ITU-R F.1336If lower duplex pair of frequency arrangement A5 of Rec. ITU-R M.1036-4 is used for the MS implementation.

Note 2: Base station density in the mixed scenario: 0.0274 base station/km^2/5 MHz, which is made up from: 70% rural (density of 0,7x0.0050 base station/km^2/5MHz = 0,0035), 20% suburban (density of 0,2x0.0796 base stations /km^2/5MHz = 0,0159), 10% urban (density of 0,1x0.0796 base stations /km^2/5MHz = 0,0080).

Note 3: Propagation environment between MS base stations and ARNS receiver, in the same environment (rural/suburban/urban) corresponds to the deployment scenario of MS base stations, that means MS base station transmitter and ARNS receiver are placed in the same type of area (rural/suburban/urban).

Note 4: Tropospheric scattering effect in propagation model from Rec. ITU-R P.1546 was not taken into account.

In Study A.2 and Study A.3 the interference scenario from MS to ARNS in absence of interference caused by the broadcasting service is feasible when the BS stations operate in the frequency band 694-790 MHz at a large distance (more than 450 kilometres) from ARNS stations and in this case they will not cause interference to ARNS stations. The studies were based on application of field strength thresholds as the protection criteria for ARNS.

Under the considered scenario two studies were conducted. The results of the Study A.2 are given in Table 65.

TABLE 65

Compatibility conditions of MS stations with ARNS stations

ARNS station	System type code	Coordination distances for the receiving MS base stations (km)[3]	Coordination distances for the transmitting MS base stations (km)
RSBN (ground receiver)	AA8	441[1]	75[2] / 90[2]*
RLS 2 (type 1) (airborne receiver)	BD	130[1]/165[1]*	441[2]
RLS 2 (type 1) (ground receiver)	BA	441[1]	185[2] / 200[2]*
RLS 2 (type 2) (airborne receiver)	BC	405[1]/445[1]*	400[2]
RLS 2 (type 2) (ground receiver)	AA2	441[1]	250[2] / 275[2]*
RLS 1 (types 1 and 2) (ground receiver)	AB	405[1]/445[1]*	350[2] / 375[2]*
Other ARNS ground stations	Not applied	405[1]/445[1]*	350[2] / 375[2]*
Other ARNS airborne stations	Not applied	405[1]/445[1]*	441[2]

* 50% ≤ land path ≤ 100% / 0% ≤ land path < 50%.

Note 1: Result based on conditions that MS base stations operate with antenna height 50 m. No downtilt of the MS base station antennas has been applied. Antenna pattern only in horizontal plane from Recommendation ITU-R F.1336 has been used.

Note 2: Result based on conditions that MS base stations operate with antenna height 50 m, cell radius is 8 km for rural area, 2 km for suburban area (S=300 km2) and 0.5 km (S=100 km2) for urban area, power of MS base stations is 55 dBm in 5 MHz due orientation of main beam antenna pattern towards ARNS station. No downtilt of the MS base station antennas has been applied. Antenna pattern only in horizontal plane from Recommendation ITU-R F.1336 has been used.

Note 3: The figures given are based on the estimated distance to protect the IMT base stations from ARNS with the protection criteria of I/N= -6dB.

Note 4: Propagation environment between MS base stations and ARNS receiver is rural for all deployment areas (rural, suburban, urban) in mixed scenario.

Note 5: Tropospheric scattering effect in propagation model from Rec. ITU-R P.1546 was taken into account. Due to the lack of terrain information, terrain clearance angles of 0 degrees was used.

The results of the Study A.3 are given in Table 66.

The conducted studies showed that the ARNS systems the same that were considered in the frequency band 790-862 MHz under the studies on WRC-12 agenda item 1.17 operate in the frequency band 694-790 MHz. The MS system characteristics in the frequency band 694-790 MHz are also close to the MS systems characteristics which were used in the studies on WRC-12 agenda item 1.17.

Therefore in the frequency band 694-790 MHz in absence of interference from BS the results previously obtained (at WRC-12) for the frequency band 790-862 MHz reflected in Resolution **749 (Rev. WRC-12)** and given in Table 65 can be applied for protection of ARNS from MS.

TABLE 66

Compatibility conditions of MS stations with ARNS stations

ARNS station	System type code	Minimum separation distance between receiving MS base stations and ARNS stations (km)	Minimum separation distance between transmitting MS base stations and ARNS stations (km)
RSBN	AA8	50	125/175*
RLS 2 (type 1) (airborne receiver)	BD	410	432
RLS 2 (type 1) (ground receiver)	BA	50	250/275*
RLS 2 (type 2) (airborne receiver)	BC	150	432
RLS 2 (type 2) (ground receiver)	AA2	50/75*	300/325*
RLS 1 (types 1 and 2) (ground receiver)	AB	125/175*	400/450*
Other ARNS ground stations	Not applied	125/175*	400/450*
Other ARNS airborne stations	Not applied	410	432

* 50% ≤ land path ≤ 100% / 0% ≤ land path < 50%.

Note 1: Result based on conditions that MS base stations operate with antenna height 60 m, cell radius is 8 km for rural area, 2 km for suburban area (S=1470 km2) and 0.5 km (S=490 km2) for urban area, power of MS base stations is 55 dBm in 5 MHz due orientation of main beam antenna pattern towards ARNS station. The results are not based on the updated IMT parameters specified by ITU-R, but used the results in Res 749 (rev. WRC-12).

Note 2: Tropospheric scattering effect in propagation model from Rec. ITU-R P.1546 was taken into account. Due to the lack of terrain information, terrain clearance angles of 0 degree was used.

The difference of the obtained results in Table 65 and Table 66 is explained mainly by the fact that the Study A.2 option addresses the base stations with antenna height of 50 metres and urban area of 30 sq. km and suburban area of 90 sq.km. The Study A.3 option addresses base stations with antenna height from 30 metres to 60 metres and urban area of 490 sq. km and suburban area of 1 470 sq.km. For example Moscow area is 1081 sq.km, Berlin area is 900 sq.km, Helsinki area is 680 sq.km and Prague is 500 sq.km.

5.2 Results of compatibility studies of MS with ARNS with interference from BS

Currently the frequency band 694-790 MHz is widely used by the broadcasting service. Therefore interference to ARNS stations from the MS stations was considered taking into account interference caused by the existing and future stations of the broadcasting service.

In practice in the frequency band 694-790 MHz the most likely is interference scenario from MS to ARNS with interference caused by broadcasting service when the broadcasting stations operate at the distance of less than 450 kilometres from ANRS stations. It is confirmed by a large number of BS assignments implemented in the frequency band 694-790 MHz.

Under the considered scenario three studies were conducted:

– First study (study B.1) is based on application of protection criteria for ARNS as the permissible aggregate threshold field strength;

– Second study (study B.2) is based on application of protection criteria for ARNS as the permissible interference-to-noise ratio I/N=-6 dB;

– Third study (study B.3) is based on application of protection criteria for ARNS as the permissible interference-to-noise ratio I/N=-6 dB to obtain coordination protection distances.

In the first study (B.1) the permissible aggregate threshold field strength given in Table 67 is used as protection criteria for ARNS. It was assumed that in the territory of neighbouring countries different services can operate (in one country –BS, in other –MS and in the third –ARNS).

TABLE 67

Protection criteria for ARNS stations

ARNS type	Predetermined aggregate trigger field-strength values (dB(μV/m))
RSBN	42 at 10 m in a 3 MHz reference bandwidth
RLS 2 (Type 1) (aircraft receiver)	52[1] at 10 000 m in a 4 MHz reference bandwidth
RLS 2 (Type 1) (ground receiver)	29[1] at 10 m in a 4 MHz reference bandwidth
RLS 2 (Type 2)	73 at 10 000 m in a 3 MHz reference bandwidth
RLS 2 (Type 2) (ground receiver)	24[1,2] at 10 m in a 8 MHz reference bandwidth
RLS 1 (Type 1 and 2)	13 at 10 m in a 6 MHz reference bandwidth
Other type ARNS ground stations	13 at 10 m in a 6 MHz reference bandwidth
Other type ARNS airborne stations	52 at 10 000 m in a 4 MHz reference bandwidth

NOTE 1 – The values provided in this table refer to the permissible aggregate co-channel interference field strength values provided for the necessary emission bandwidth (from all services).

The performed studies showed that compatibility of MS stations of one country with ARNS stations of another country with BS in the third country is feasible. With this restrictions to MS stations from ARNS are not so significant as it was expected. In practice the minimum distance between MS stations and the country border operating ARNS does not exceed several tens km. These restrictions mostly depend on implementation features of BS stations and MS networks in the neighbouring countries.

In the second study (B.2) interference-to-noise I/N = –6 dB given in the Table 68 was used as protection criteria for ARNS. It was assumed that in the territory of neighbouring countries different services can operate (in one country –BS, in other country- MS and in the third country –ARNS). However unlike the first study the protection criterion for ARNS as interference-to-noise ratio allows to estimate interference to ARNS stations from MS station not accounting for interference from broadcasting service even notwithstanding their real existence.

TABLE 68

Protection criteria for ARNS stations

ARNS system type	Permissible ratio «interference-to-noise»*, *I/N* (dB)
RSBN	–6 at 10 m in a 3 MHz reference bandwidth
RLS 1 (types 1 and 2)(ground receiver)	–6 at 10 m in a 6 MHz reference bandwidth
RLS 2 (type 1) (aircraft receiver)	–6 at 10 000 m in a 4 MHz reference bandwidth
RLS 2 (type 1) (ground receiver)	–6 at 10 m in a 4 MHz reference bandwidth
RLS 2 (type 2) (aircraft receiver)	–6 at 10 000 m in a 3 MHz reference bandwidth
RLS 2 (type 2) (ground receiver)	–6 at 10 m in a 8 MHz reference bandwidth
Other type ARNS ground stations	–6 at 10 m in a 6 MHz reference bandwidth
Other type ARNS airborne stations	–6 at 10 000 m in a 4 MHz reference bandwidth
*) Values of «interference-to-noise», presented in the table relate to the total permissible level of «interference-to-noise» (from mobile service) in a common frequency band. For the earth stations the propagation model is used in accordance with Recommendation ITU-R P.1546-4 for 10% of time and 50% of places.	

The conducted studies showed that compatibility of MS stations in one country with ARNS stations in the other country with operation of BS in the third country is feasible.

The third study (B.3) is based on application of protection criteria for ARNS as the permissible interference-to-noise ratio I/N=-6 dB to obtain coordination protection distances. The approach indicated in this study allows to estimate interference to ARNS stations from MS stations not accounting for interference from the broadcasting service even notwithstanding their real existence.

The conducted studies showed that compatibility of MS stations in one country with ARNS stations in the other country with operation of BS in the third country is feasible. The obtained separation distances between the transmitting MS BS and ARNS stations in the frequency band 694-790 MHz are given in Table 69.

TABLE 69

Compatibility conditions of MS stations with ARNS stations

ARNS station	System type code	Coordination distances for the receiving MS base stations (km)[3]	Coordination distances for the transmitting MS base stations (km)
RSBN (ground receiver)	AA8	441[1]	455[2]/480[2]*
RLS 2 (type 1) (airborne receiver)	BD	130[1]/165[1]*	441[2]
RLS 2 (type 1) (ground receiver)	BA	441[1]	400[2]/425[2]*
RLS 2 (type 2) (airborne receiver)	BC	405[1]/445[1]*	441[2]
RLS 2 (type 2) (ground receiver)	AA2	441[1]	530[2]/550[2]*
RLS 1 (types 1 and 2) (ground receiver)	AB	405[1]/445[1]*	545[2]/565[2]*
Other ARNS ground stations	Not applied	405[1]/445[1]*	545[2]/565[2]*
Other ARNS airborne stations	Not applied	405[1]/445[1]*	441[2]
* 50% ≤ land path ≤ 100% / 0% ≤ land path < 50%.			

Note 1: Result based on conditions that MS base stations operate with antenna height 50 m. No downtilt of the MS base station antennas has been applied. Antenna pattern only in horizontal plane from Recommendation ITU-R F.1336 has been used.

Note 2: Result based on conditions that MS base stations operate with antenna height 50 m, cell radius is 8 km for rural area, 2 km for suburban area (S=300 km2) and 0.5 km (S=100 km2) for urban area, power of MS base stations is 55 dBm in 5 MHz due orientation of main beam antenna pattern towards ARNS station. No downtilt of the MS base station antennas has been applied. Antenna pattern only in horizontal plane from Recommendation ITU-R F.1336 has been used.

Note 3: The figures given are based on the estimated distance to protect the IMT base stations from ARNS,with the protection criteria of I/N= -6dB.

Note 4: Tropospheric scattering effect in propagation model from Rec. ITU-R P.1546 was taken into account.

Due to the lack of terrain information, terrain clearance angles of 0 degree was used.

6 Recommendations

The obtained study results can be used under RR No.**9.21** for MS stations in relation to ARNS used under RR No. **5.312** by inclusion in relevant ITU-R documentation (e.g. Resolution **232 (WRC-15))**.

APPENDIX 2

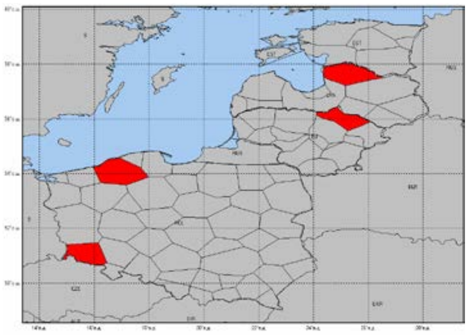
Explanations for interference scenario from MS to ARNS when there is additional interference to ARNS from BS

In Figure 1 GE06 Plan Broadcasting service in TV channels (TVC) 54 and 55 in different countries is given as an example. Figure 1 shows that there are no allotments to the broadcasting service in TVC 54 and 55 in Kaliningrad region, north-western part of Russian boundary and also in adjacent regions.

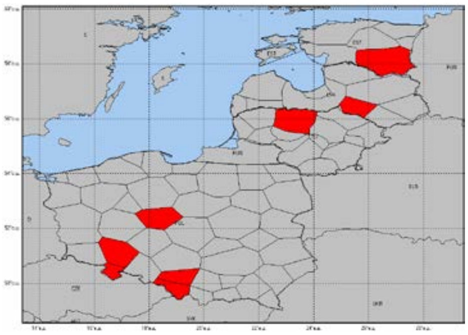
This situation is due to the fact that ARNS systems are located in the above-mentioned regions which were taken into account while developing GE06 Plan broadcasting service.

FIGURE 1

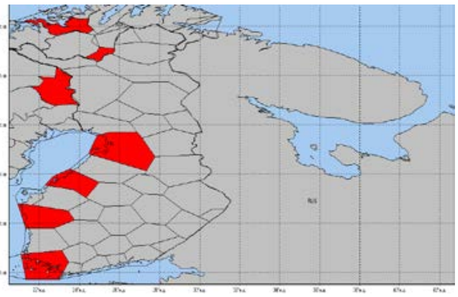
The example of TVC 54 and 55 usage in the adjacent regions to Russian Federation under GE06 Plan



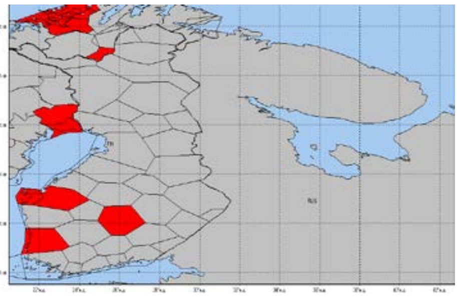
54 TVC



55 TVC



54 TVC



55 TVC

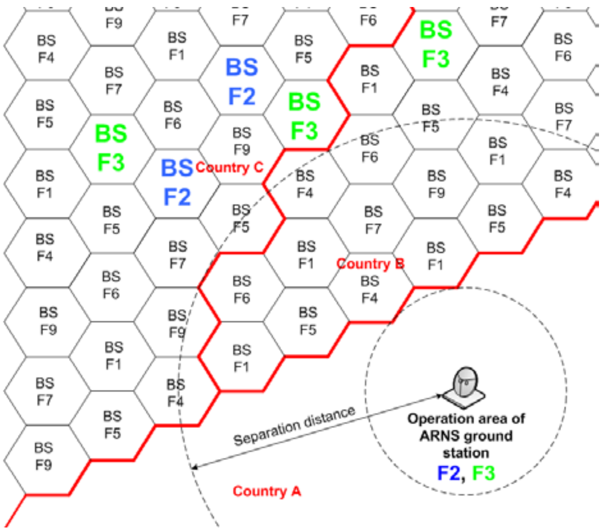
Currently operation in the frequency band 694-790 MHz between the broadcasting service and ARNS is regulated by GE06. GE06 Plan for the broadcasting service was developed taken into account the requirement of providing compatibility with ARNS systems. Interference from specific allotment/assignment of the Plan was estimated taken into account interference impact from other allotments/assignments.

This approach allowed provision of protection for the ARNS taken into account the aggregate interference influence from different BS transmitters.

Figure 2 shows sharing scenario of ARNS and the Plan of the adjacent countries. In general it illustrates the co-channel usage of ARNS with planned allotments at a specific separation distance from the service area of ARNS.

FIGURE 2

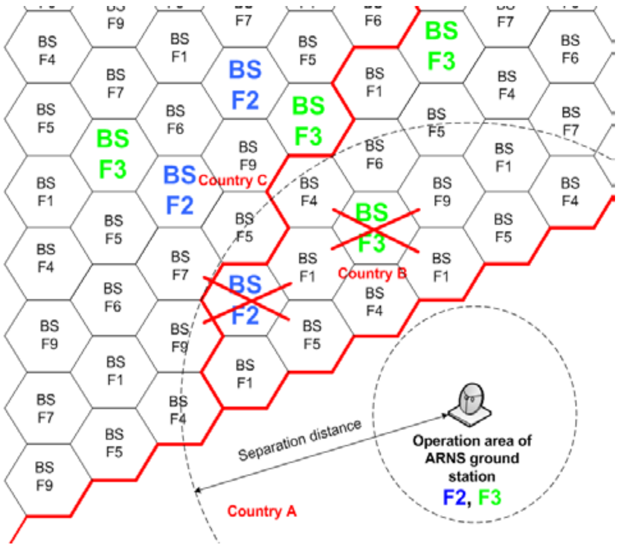
Scenario of shared operation ARNS and BS



Upon modification of the Plan, account of impact of aggregate interference from BS does not allow to include to the Plan additional sources of interference from allotments/assignments which will lead to the excess of the protection threshold of ARNS as it is shown in Figure 3.

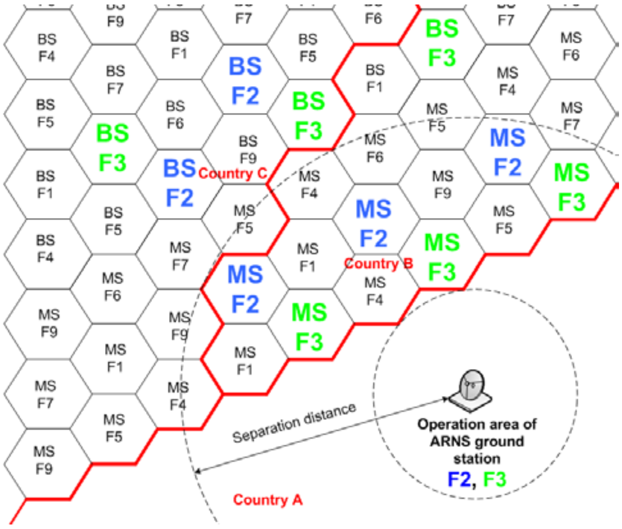
FIGURE 3

Plan modification



Since there is no decision so far whether the broadcasting service will operate or not in the frequency band 694-790 MHz the situation can occur when Country B decides not to operate the broadcasting service in the frequency band 694-790 MHz and Country C continues to operate the broadcasting service. This case is shown in Figure 4.

FIGURE 4



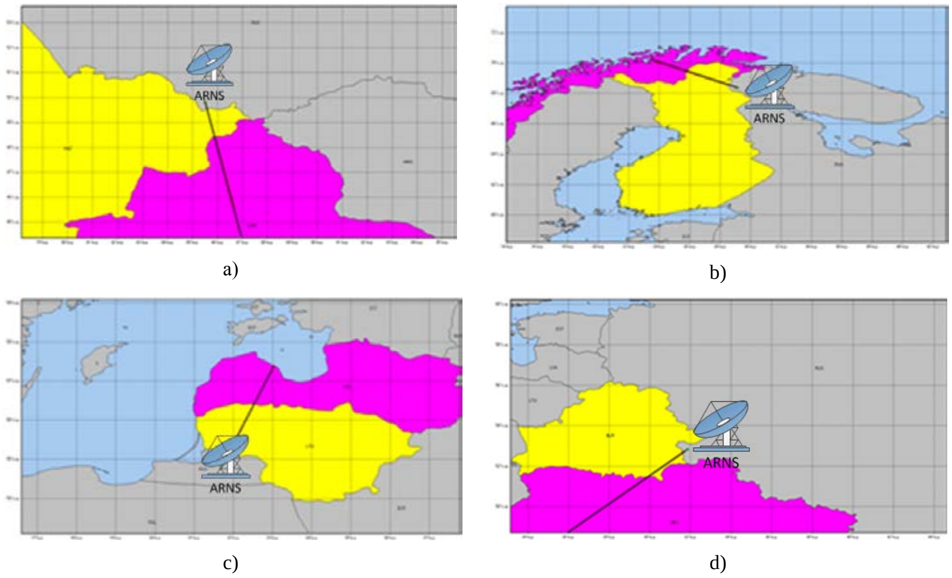
In this case interference is possible to ARNS stations of Administration A caused by not only assignments/allotments to the broadcasting service of Administration C and also by assignments to the mobile service of Administration B. In practice many such examples can occur in particular if possible interference to ARNS airborne receiver is taken into account.

In addition some countries may wish to operate BS and MS simultaneously in the frequency band 694-790 MHz (at least during some transition period) and it is particular case of the scenario shown in Figure 4.

The examples of such scenario at the boundary of the Russian Federation are given in Figure 5.

FIGURE 5

Examples of scenarios for aggregate interference to ARNS from BS and MS

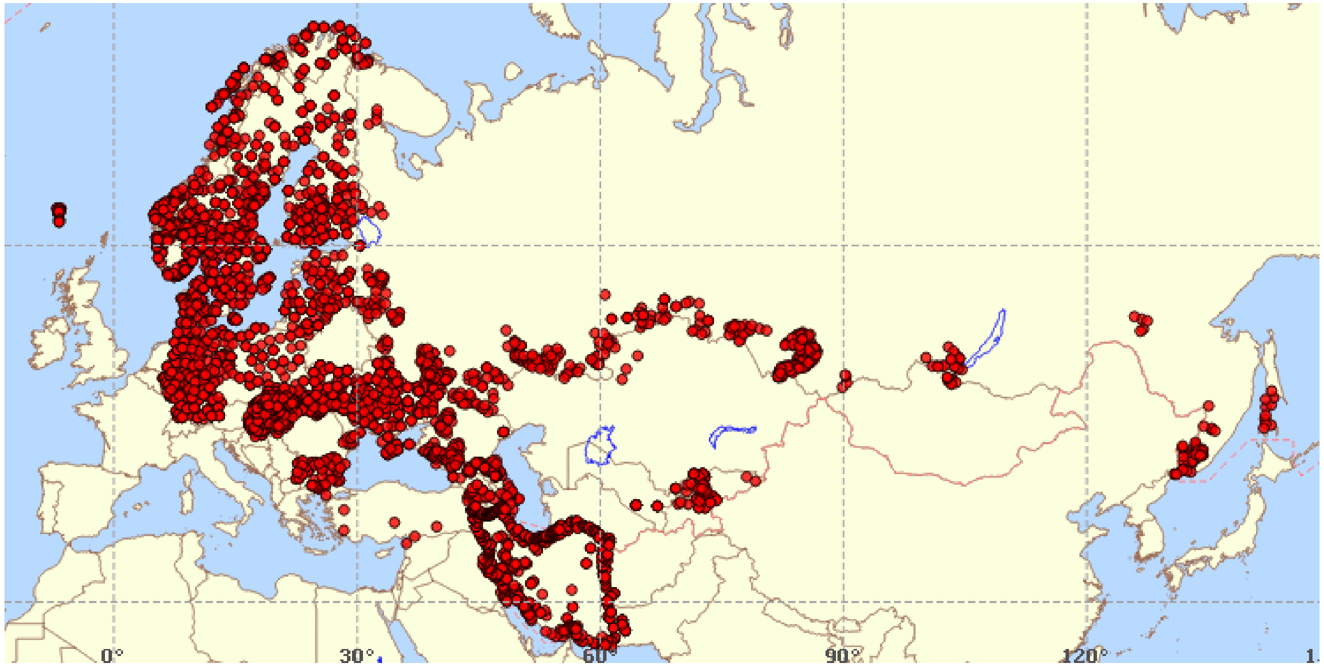


In Figure 5, as an example, a country which operates the BS is highlighted by purple colour and a country which plans to operate the MS in the ARNS frequency bands 694-790 MHz is highlighted by yellow colour. The direction of the aggregate interference caused by two services to ARNS receiver is indicated by the line. In practice, there can be much more such examples especially in case possible interference to the ARNS airborne receiver are taken into account.

In addition some countries may wish to operate the BS and the MS simultaneously in the frequency band 694-790 MHz (at least during some transition period) which is the particular case of the scenario described above.

Therefore, the permissible interference level to ARNS must be considered as a requirement to the aggregate interference level caused by several broadcasting and mobile base stations.

Assignments of DVB-T in the frequency band 694-790 MHz around countries that are used ARNS under RR No. 5.312



Adm	ARM	AZE	BUL	D	DNK	EST	FIN	GEO	HNG	IRN	KAZ	KGZ	LTU	LVA	NOR	POL	RUS	S	SVK	TKM	TUR	UKR	UZB	Total
All band 694-790 MHz	12	38	80	430	236	19	216	22	127	633	5	53	51	35	456	83	821	419	109	0	7	510	17	**4249**
Typical ANRS bands 734-750 MHz 766-790 MHz	0	17	21	167	46	8	77	4	55	272	0	4	25	13	234	29	307	175	43	0	2	186	8	**1693**

APPENDIX 3

Additional study, supporting Study#A.1

1 Background

WRC-12 developed and agreed upon Resolution **232 (WRC-12)** which now constitutes agenda item 1.2. Resolution **232 (WRC-12)** invites ITU-R *inter alia* “to study the compatibility between the mobile service and other services currently allocated in the frequency band 694-790 MHz and develop ITU-R Recommendations or Reports”.

This document focuses on compatibility between the mobile service and the aeronautical radionavigation service. It also contains elements of compatibility between the mobile service and broadcasting services.

The frequency band 694-790 MHz is widely used for digital and analogue TV broadcasting. In countries mentioned in RR footnote No. **5.312** this band or its sub bands are also allocated to the aeronautical radionavigation service. Introducing the mobile service and IMT to this band can potentially cause interference to ARNS. Some proposals [to JTG 4-5-6-7] also raise the issue of a potential aggregation of interferences from more than one service, so called multiservice interference, into ARNS.

2 Technical characteristics

All assumptions were derived [from Annex 2 and Annex 6 of the JTG Chairman’s Report (Document 4-5-6-7/113)]. For comparison, the bandwidth is normalized to 1 MHz.

Detailed characteristic of RSBN and RLS2 Type 2 systems are provided in Recommendation ITU-R M.1830. [JTG 4-5-6-7] should not extend its deliverables beyond the scope of technical characteristics provided by ITU WGs.

Appendix [1] presents a general description of the RSBN system. It may be concluded that the RSBN system has not been designed to provide any kind of ground-to-air communication in the band 694-790 MHz. On the basis of information given in Appendix [2] and MIFR records it may also be concluded, that the stations of the aeronautical radionavigation service is deployed in such manner that the RSBN system would actually cause harmful interference to itself.

As shown in Appendix [2], the number of stations of other ARNS systems (other than RSBN and RLS 2 Type 2) is very low, these systems are deployed in a few Region 1 countries only. There is no need to develop regulatory provisions for local usage of spectrum.

2.1 Interference scenarios

The extract of ARNS systems characteristics of, operating in the frequency band 694-790 MHz, from Recommendation ITU-R M.1830 is presented in Table 1.

TABLE 1

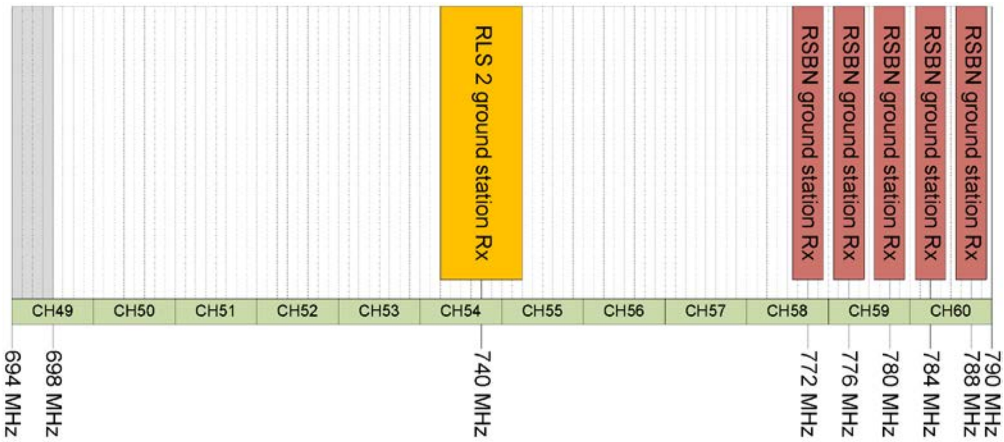
Basic characteristics of the ARNS system operating in the 694-790 MHz frequency band

ARNS system type	Transmitting station	Receiving station	Operating frequencies, MHz	Bandwidth, MHz	Receiver antenna height, m
RSBN	Aircraft transmitter	Ground radar receiver	772, 776, 780, 784, 788	3 or 0.7	10
RLS 2 Type 2	Aircraft transponder transmitter	Ground radar receiver	740	8	10

As shown in the Table 1 systems (systems' segments) operating in the 694-790 MHz frequency band operate in "air-to-ground" direction.

FIGURE 1

Channel arrangement of the ARNS in the 694-790 MHz frequency band



Depending on the applied channel arrangement of the mobile service, different scenarios of interferences can occur. If a conventional duplex direction, where the UE transmits within the lower band and the base station transmits within the upper band, is chosen, the RSBN receiving ground stations will be interfered with by the base stations of the mobile service. It has to be noted that if such channel arrangement applies, the RLS 2 receiver will likely be operating in the duplex gap of channel arrangement applying the lower duplex pair of frequency arrangement A5 of Recommendation ITU-R M.1036-4 (APT band plan); or in the uplink of the mobile service for a 2 × 40 MHz channel arrangement.

Regardless the channel arrangement and duplex type used in the mobile service, the base station to ARNS receiving ground station interference scenario corresponds to the worst coexistence case.

Two different cases are considered:

– Case 1: RSBN ground station is receiving at 780 MHz
FDD mobile service base station interferes with ARNS
DTT (channel 59) interferes with ARNS

– Case 2: RLS2 Type 2 ground station is receiving at 740 MHz
FDD mobile service UE interferes with ARNS
DTT (channel 54) interferes with ARNS

In order to account for the multiservice interference the following co-channel sharing scenario between MS base stations and DTT station should be also analysed:

− interference from DTT station to MS UE for case 1;

− interference from DTT station to MS base stations for case 2.

When analysing the multiservice interference to ARNS it is assumed that both DTT and MS stations are within the ARNS receiver station antenna sector. It is also assumed that the antennas of both interfering and victim systems are directed “face to face” (direction of maximum gain).

2.2 Summary of parameters

Mobile service (MS) base station, broadcasting service (DTT) station and aeronautical radionavigation services (ARNS) station parameters used to derive the respective interference power threshold and required path loss are summarized in Table 2.

TABLE 2

Mobile, broadcasting and ARNS ground station receivers (RSBN/RLS2 Type 2) parameters

Parameter	MS base station	MS UE	DTT station	ARNS station
Frequency, MHz	780/740	740	780/740	780/740
Transmitter power (maximum), dBm/MHz	36	16	76	–
Rx noise figure, dB	5	9	5	5
Rx antenna gain (incl. feeder loss), dBi	12	–3	9	22/28.4
Tx antenna gain (incl. feeder loss), dBi	12	–3	0	–
Antenna height, m	30	1.5	300	10
Antenna tilt, degree	3	–	–	–

2.3 Methodology

The calculations are performed using Minimum Coupling Loss (MCL).

2.4 Interference criteria

For the protection of MS the Interference-to-Noise ratio (I/N) is used in Table 3. For calculation of interference to ARNS caused by MS, the Interference-to-Noise ratio (I/N) is used in Table 3 as well as the protected field-strength values corresponding to Recommendation ITU-R M.1830, Annex 2 (see Table 4).

For interference to ARNS caused by DTTB, the field-strength levels are used as defined in the Final Acts of RRC-06 in Annex 4.2 (see Table 4). The permissible aggregate interference field strength from all services as provided by ITU-R is contained in Table 5.

TABLE 3

Interference-to-Noise ratio for mobile and aeronautical radionavigation services

System	I/N, dB	Reference
Mobile service	–6	JTG4-5-6-7 Chairman's Report (Annex 2 to Document 4-5-6-7/113)
ARNS service	–6	Liaison Statement of WP 5B (Document 4-5-6-7/134)

TABLE 4

DTTB interference: protection criteria for (RSBN and RLS2 Type 2 (Ground reception)

System	Protected field strength, (dB(μV/m))	Reference
RSBN	42	Final Acts of RRC-06 in Annex 4.2 Recommendation ITU-R M.1830 Annex 2
RLS2 Type 2	24 – single interferer 28 – aggregate interference	

TABLE 5

Permissible aggregate interference field-strength level for RSBN and RLS2 Type 2 (Ground reception)

System	Aggregate protected field strength (from all service), (dB(μV/m))	Reference
RSBN	42	Liaison Statement of WP5 B (Document 4-5-6-7/134)
RLS2 Type 2	24	

3 Analysis

3.1 Receiver noise

According to Recommendation ITU-R V.573, the thermal noise threshold of a receiver can be determined by:

$$P_n = 10\log(kT_0) + 10\log\left(10^{\frac{NF}{10}} - 1\right) + 10logB$$

where:

- k: Boltzmann's constant (1.3806488 × 10^{-23} J K^{-1});
- T_0: Reference temperature (290 K);
- B: noise equivalent bandwidth of receiver (Hz);
- NF: receiver noise figure (dB).

The thermal noise power for the receiver of 1 MHz bandwidth:

$$P_n = -114 \text{ dBm} + 10\log\left(10^{\frac{NF}{10}} - 1\right)$$

Then the noise power at the MS base station receiver (index: BS), ARNS receiver (index: ARNS) and MS UE receiver (index: UE) are given by:

$$P_{n\_BS} = -114 \text{ dBm} + 3.4 \text{ dB} = -110.6 \text{ dBm}$$

$$P_{n\_ARNS} = -114 \text{ dBm} + 3.4 \text{ dB} = -110.6 \text{ dBm}$$

$$P_{n\_UE} = -114 \text{ dBm} + 8.4 \text{ dB} = -105.6 \text{ dBm}$$

3.2 Conversion of field-strength criteria used for ARNS protection into I/N

The field-strength protection values for the ARNS receivers in the Tables 4 and 5 can be converted into I/N by the following equations.

According to Recommendation ITU-R P.525-2 the received power can be expressed in terms of field strength given as

$$P_r = E - 20\log f - 167.2$$

where:

- P_r: isotropically received power (dBW);
- E: electric field strength (dBμV/m);
- f: frequency (GHz).

The *I/N* is then given as:

$$\frac{I}{N} = P_r - 10 log B_{ARNS} + G_r - L_f - P_{n\_ARNS}$$

where:

- P_r: isotropically received power (dBm);
- P_{n_ARNS}: noise power at the ARNS receiver in dBm;
- G_r: receiver antenna gain (dB);
- L_f: feeder loss (dB);
- B_{ARNS}: reference bandwidth of the ARNS receiver (MHz), which is 3 MHz for RSBN and 8 MHz for RLS2 Type 2.

The received power for RSBN and RLS 2 (Type 2) normalized to 1 MHz is given then by:

$$P_{r\_RSBN} = 42 - 4.7 - 20\log 0.78 - 167.2 = -127.8 \text{ dBW} = -97.8 \text{ dBm}$$

$$P_{r\_RLS2} = 24 - 9 - 20\log 0.74 - 167.2 = -149.6 \text{ dBW} = -119.6 \text{ dBm}$$

Due to lack of information on radar feeder losses, $L_f = 0$ dB is chosen. Then interference-to-noise ratio is given by

$$I/N_{RSBN} = -97.8 + 22 - 0 - (-110.6) = 34.8 \text{ dB}$$

$$I/N_{RLS2} = -119.6 + 28.4 - 0 - (-110.6) = 19.4 \text{ dB}$$

3.3 Case 1: RSBN at 780 MHz

3.3.1 Path loss or isolation between DTT transmitter and MS UE

For a given target interference to noise ratio *I*/*N*, the target interference level is given by:

$$P_I = P_n + I/N$$

The interference level at the MS UE receiver is given by:

$$P_{I\_UE} = -105.6 \text{ dBm} + (-6 \text{ dB}) = -111.6 \text{ dBm}$$

The total maximum equivalent isotropically radiated power (e.i.r.p.) of the transmitter is given by:

$$P_{e.i.r.p.} = P_{Tx} + G_{Tx}$$

where:

P_{Tx}: transmit power of the antenna;

G_{Tx}: transmitter antenna gain including cable losses.

The total maximum equivalent isotropically radiated power (e.i.r.p.) of the DTT transmitter is given by:

$$P_{e.i.r.p.\_DTT} = 76 \text{ dBm} + 0 \text{ dBi} = 76 \text{ dBm}$$

The isolation required between interferer and victim to ensure that there is no interference is given by:

$$\text{Isolation} = P_{e.i.r.p.} + G_{Rx} - P_{I\_UE}$$

where:

G_{Rx}: the receiver antenna gain including cable losses.

Isolation required for the MS receiving UE from the DTT transmitter in-band transmission is given by:

$$\text{Isolation}_{DTT-UE} = 76 \text{ dBm} + (-3) \text{ dBi} - (-111.6 \text{ dBm}) = 184.6 \text{ dB}$$

The isolation is then converted to separation distance using the Recommendation ITU-R P.1546-4 propagation model[11] for path loss calculation (for 10% of time and 50% of location).

The required protection distance between MS UE and the DTT station is:

$$\text{d}_{req\_DTT-UE} = 86 \text{ km for 780 MHz.}$$

3.3.2 Path loss or isolation between DTT transmitter and ARNS ground stations

The required protection of ARNS against DTT, especially DVB-T, is given in the GE06 Agreement and listed in Table 4. The converted values into I/N protection criteria are provided in section 3.2 for RSBN by 34.8 dB.

The isolation could be recalculated:

$$\text{Isolation}_{DTT-RSBN} = 76 \text{ dBm} + 22 \text{ dBi} - (-110.6 \text{ dBm} + 34.8 \text{ dB}) = 173.8 \text{ dB}$$

The required protection distance between ARNS station and the DTT station is:

$$\text{d}_{req\_DTT-ARNS} = 110 \text{ km for RSBN at 780 MHz.}$$

---

[11] Recommendation ITU-R P.1546-4 is under revision for short paths longer than 1 km when there is a large required correction (happening with large difference in antenna heights) $C_{ds} = 20\log(d/d_{slope})\ dB$. This is not the case here since $|C_{ds}| \leq 10^{-1}$.

3.3.3 Path loss or isolation between MS base station and ARNS ground stations using I/N = −6 dB

The interference level at the ARNS ground station due to the mobile service is given by:

$$P_{I\_ARNS} = -110.6 \text{ dBm} + (-6 \text{ dB}) = -116.6 \text{ dBm}$$

The total maximum equivalent isotropically radiated power (e.i.r.p.) of the MS base station transmitter is given by:

$$P_{e.i.r.p.\_BS} = 36 \text{ dBm} + 12 \text{ dBi} = 48 \text{ dBm}$$

The isolation required between interferer and victim to ensure that there is no interference is given by:

$$\text{Isolation} = P_{e.i.r.p.} + G_{Rx} - P_{I\_ARNS}$$

where:

G_{Rx}: the receiver antenna gain including cable losses.

Isolation required for the MS base station transmitter and ARNS receivers are given by:

RSBN:

$$\text{Isolation}_{BS-ARNS} = 48 \text{ dBm} + 22 \text{ dBi} - (-116.6 \text{ dBm}) = 186.6 \text{ dB}$$

The required protection distances between ARNS stations and the MS base stations are:

$$\text{d}_{req\_BS-ARNS} = 132 \text{ km} \qquad \text{for RSBN at 780 MHz}$$

3.3.4 Path loss or isolation between MS base station and ARNS ground stations using aggregate field-strength values in Table 3

Using the I/N values derived in section 3.2, the isolation between the base station and ARNS receiver in the ground station can be determined by:

$$\text{Isolation}_{BS-RSBN} = 48 \text{ dBm} + 22 \text{ dBi} - (-110.6 \text{ dBm} + 34.8 \text{ dB}) = 145.8 \text{ dB}$$

The required protection distance between ARNS station and the MS base station results then in:

$$\text{d}_{req\_BS-ARNS} = 15 \text{ km for RSBN at 780 MHz.}$$

3.4 Case 2: RLS2 Type 2 at 740 MHz

3.4.1 Path loss or isolation between DTT transmitter and MS base station

For a given target interference to noise ratio *I*/*N*, the target interference level is given by:

$$P_I = P_n + I/N$$

The interference level at the MS base station receiver is given by:

$$P_{I\_BS} = -110.6 \text{ dBm} + (-6 \text{ dB}) = -116.6 \text{ dBm}$$

The total maximum equivalent isotropically radiated power (e.i.r.p.) of the transmitter is given by:

$$P_{e.i.r.p.} = P_{Tx} + G_{Tx}$$

where:

P_{Tx}: transmit power of the antenna;

G_{Tx}: transmitter antenna gain including cable losses.

The total maximum equivalent isotropically radiated power (e.i.r.p.) of the DTT transmitter is given by:

$$P_{e.i.r.p.\_DTT} = 76 \text{ dBm} + 0 \text{ dBi} = 76 \text{ dBm}$$

The isolation required between interferer and victim to ensure that there is no interference is given by:

$$\text{Isolation} = P_{e.i.r.p.} + G_{Rx} - P_{I\_BS}$$

where:

G_{Rx}: the receiver antenna gain including cable losses.

Isolation required for the receiving MS UE from the DTT transmitter in-band transmission is given by:

$$\text{Isolation}_{DTT-UE} = 76 \text{ dBm} + 12 \text{ dBi} - (-116.6 \text{ dBm}) = 204.6 \text{ dB}$$

The isolation is then converted to separation distance using the Recommendation ITU-R P.1546-4 propagation model[12] for path loss calculation (for 10% of time and 50% of location).

The required protection distance between MS UE and the DTT station is:

$$\text{d}_{req\_DTT-UE} = 422 \text{ km for 740 MHz.}$$

3.4.2 Path loss or isolation between DTT transmitter and ARNS ground stations

The required protection of ARNS against DTT, especially DVB-T, is given in the GE06 Agreement and listed in Table 4. The converted values into I/N protection criteria are provided in section 3.2 for RLS2 Type 2 by 19.4 dB.

The isolation could be recalculated:

$$\text{Isolation}_{DTT-RLS2} = 76 \text{ dBm} + 28.4 \text{ dBi} - (-110.6 \text{ dBm} + 19.4 \text{ dB}) = 195.6 \text{ dB}$$

The required protection distance between ARNS station and the DTT station is:

$$\text{d}_{req\_DTT-ARNS} = 252 \text{ km for RLS2 Type 2 at 740 MHz.}$$

3.4.3 Path loss or isolation between MS UE and ARNS ground stations using I/N = −6 dB

The interference level at the ARNS ground station due to the mobile service is given by:

$$P_{I\_ARNS} = -110.6 \text{ dBm} + (-6 \text{ dB}) = -116.6 \text{ dBm}$$

The total maximum equivalent isotropically radiated power (e.i.r.p.) of the transmitting MS UE is given by:

$$P_{e.i.r.p.\_UE} = 16 \text{ dBm} + (-3) \text{ dBi} = 13 \text{ dBm}$$

The isolation required between interferer and victim to ensure that there is no interference is given by:

$$\text{Isolation} = P_{e.i.r.p.} + G_{Rx} - P_{I\_ARNS}$$

where:

G_{Rx}: the receiver antenna gain including cable losses.

Isolation required for the transmitting MS UE and ARNS receivers are given by:

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[12] Recommendation ITU-R P.1546-4 is under revision for short paths longer than 1 km when there is a large required correction (happening with large difference in antenna heights) $C_{ds} = 20\log(d/d_{slope})\ dB$. This is not the case here since $|C_{ds}| \leq 10^{-1}$.

RLS2 Type 2 :

$$\text{Isolation}_{UE-ARNS} = 13\text{ dBm} + 28.4\text{ dBi} - (-116.6\text{ dBm}) = 158.0\text{ dB}$$

The required protection distance between ARNS stations and the MS UE is:

$$\text{d}_{req\_UE-ARNS} = 8\text{ km for RLS2 Type 2 at 740 MHz}$$

3.4.4 Path loss or isolation between MS UE and ARNS ground stations using aggregate field-strength values in Table 5

Using the I/N values derived in section 3.2, the isolation between the MS UE and ARNS receiver in the ground station can be determined by:

$$\text{Isolation}_{UE-RLS2} = 13\text{ dBm} + 28.4\text{ dBi} - (-110.6\text{ dBm} + 19.4\text{ dB}) = 132.6\text{ dB}$$

The required protection distance between MS UE and ARNS station results then in:

$$\text{d}_{req\_UE-ARNS} = 2\text{ km for RLS2 Type 2 at 740 MHz}$$

4 Summary

- For the protection of ARNS against DTT interference the protection criteria as given in the GE06 Agreement is applied.
- According to the provided information from ITU-R, only ground based ARNS receiver are considered: RSBN operating at 780 MHz and RLS2 Type 2 operating at 740 MHz.
- RSBN at 780 MHz (extracted from section 3.3)

TABLE 6

Required separation distance between

DTT and ARNS	**DTT and MS UE**	**MS base station and ARNS**
$d_{DTT\text{-}ARNS}$ in km	$d_{DTT\text{-}UE}$ in km	$d_{BS\text{-}ARNS}$ in km
110	86	132 for I/N=-6 dB 15 for F=42 dB(µV/m)

For ARNS interference criteria of I/N = −6 dB: $d_{DTT\text{-}UE} + d_{BS\text{-}ARNS} > d_{DTT\text{-}ARNS}$

For ARNS interference criteria of F = 42 dB(µV/m): $d_{DTT\text{-}UE} + d_{BS\text{-}ARNS} \approx d_{DTT\text{-}ARNS}$

Because the required separation distance of the sum of DTT-MS UE plus MS base station and ARNS is approximately in the same range or larger than the distance DTT-ARNS depending on the interference criteria , the operation of mobile service between DTT transmitter and RSBN receiver is not possible.

- RLS2 Type 2 at 740 MHz (extracted from section 3.4)

TABLE 7

Required separation distance between

DTT and ARNS	**DTT and MS base station**	**MS UE and ARNS**
$d_{DTT\text{-}ARNS}$ in km	$d_{DTT\text{-}BS}$ in km	$D_{UE\text{-}ARNS}$ in km

252	422	8 for I/N=-6 dB 2 for F=24 dB(µV/m)

$d_{DTT-BS} > d_{DTT-ARNS}$

Even if the uplink of the MS (FDD) is located in a band where ARNS is operated, i.e. ARNS is not using the duplex gap; the required distance to protect the MS base station is considerable larger than for the protection distance required for ARNS Type 2. The mobile service cannot be operated between DTT and RLS2 Type 2.

– The analysis has shown that the consideration of multiservice, here the mobile service and the broadcasting service, interfering with the RSBN and RLS2 Type 2 receiving ground station do not needed to be taken into account.

– In the GE06 Agreement the protection of ARNS against DVB-T is defined and it ensures sufficient protection of ARNS. For a balanced approach, similar protection against interference of mobile service should be considered due to the similarity of the signals.

5 Recommendation

For ARNS operating in the band 694-790 MHz, consideration of interference from only the mobile service is sufficient when deriving the appropriate protection for ARNS. Protection against DTT is ensured through the GE06 Agreement. This analysis has shown that the combined impact of mobile service and broadcasting (multiservice interference) does not need to be taken into account.

APPENDIX 4

Detailed characteristics of RSBN system

Note: This document is based on the official technical and tactical description of the RSBN-4N system. It describes basics of the RSBN operation and provides some details concerning ground component of the system. It has to be noted that RSBN system has a backward compatibility, and the basic principle of operation is common for all generations of the system.

1 Overall description

The RSBN system is the non-directional, two way radionavigation aid capable to determine the azimuth and distance of the aircraft from the point where RSBN is installed. Together with on-board part of RSBN system, it is capable to:

– provide information on distance and azimuth;
– provide automatic correction of the on-board odometer;
– identify all the aircrafts within the range of RSBN;
– cooperate with up to 100 aircraft in the distance mode, and with unlimited number of aircrafts in azimuth mode.

The typical deployment consists of one RSBN unit per airfield, with possibility to deploy two units, with second unit working as a backup. It has to be noted that the system has been designed as fail-safe, and only one RSBN channel is associated with one airfield (ground RSBN unit). Channels are selected manually by the pilot on an on-board RSBN unit control panel. This panel is equipped with two selectors – on for navigation mode, second for landing mode. By selecting the channel in navigation mode, the frequency of desired RSBN ground station is chosen.

RSBN on-board device is also capable to work with PRMG system, intended to provide approach and landing for an aircraft. Channel selection for approach and landing mode is also done manually by landing channel selector.

2 Operation principle

The distance between aircraft and ground RSBN system is determined by measuring (on-board) time between transmission of interrogation signal from the aircraft to the ground station and reception of response from the ground station. This information is also used to provide automatic correction of the odometer, within the range of ground transmitter.

Azimuth is also determined by measuring the time shift between the two signals transmitted by ground RSBN antennas. Ground RSBN system is equipped with two antennas for providing the azimuth information. First, directional with narrow two-sidelobe characteristic rotates with stabilized speed of 100 rev/min. Second antenna is a non-directional beacon. When minimum characteristic of the directional antenna is lined-up with North, the non-directional beacon transmits signal named “North Convergence”, common to all aircrafts within the range of ground RSBN transmitter. Second signal, called "Azimuth" is received by aircraft when the minimum of characteristics of the directional antenna is aligned with the direction of the aircraft. The time interval between receiving those two signals provides the azimuth.

3 Technical characteristics

TABLE 1

General characteristic of RSBN ground component

Frequency range	Transmitter – Rangefinder: 939.6 – 1 000.5 MHz – Azimuth: 873.6-903.7 MHz, 905.1 – 935.2 MHz Receiver – 770-812.8 MHz
Number of channels	88
Output power	Rangefinder – > 20 kW nominal – > 30 kW maximum Azimuth – > 80 W for continuous transmitter – > 30 kW for pulse transmitter

Figures from 1 to 3 presents the so called observation zones for the transmitting antennas of RSBN ground system. Figure 4 presents observation zone of receiving ground antennas, both for low and high elevation angles. In every case the vertical axis shows altitude of aircraft and elevation angle, horizontal axis presents the distance from ground RSBN (in kilometres).

FIGURE 1

Radiation pattern of the azimuth signal (non-directional beacon)

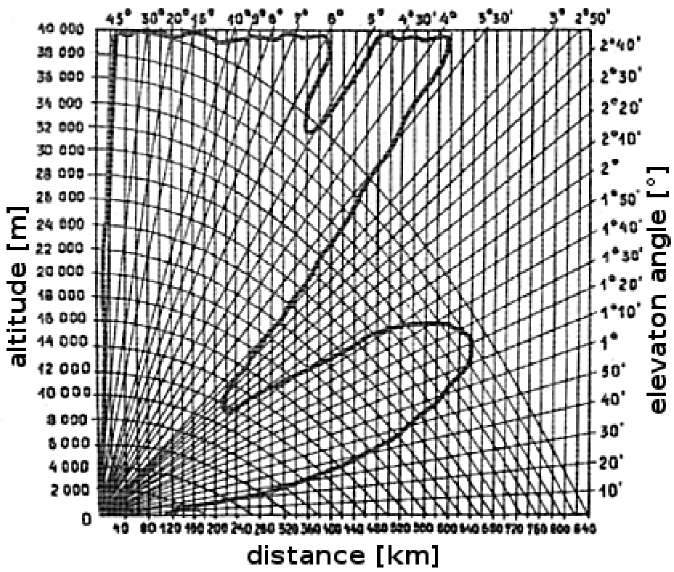


FIGURE 2

Radiation pattern of the azimuth signal (directional)

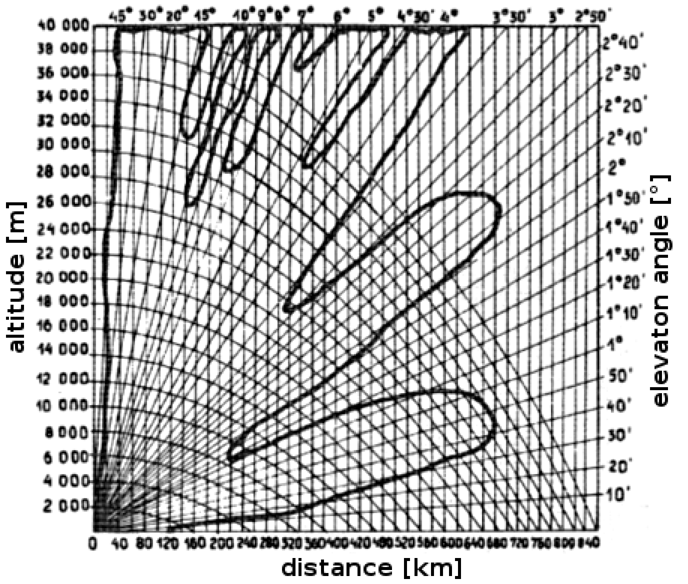


FIGURE 3

Radiation pattern of the distance signal (response)

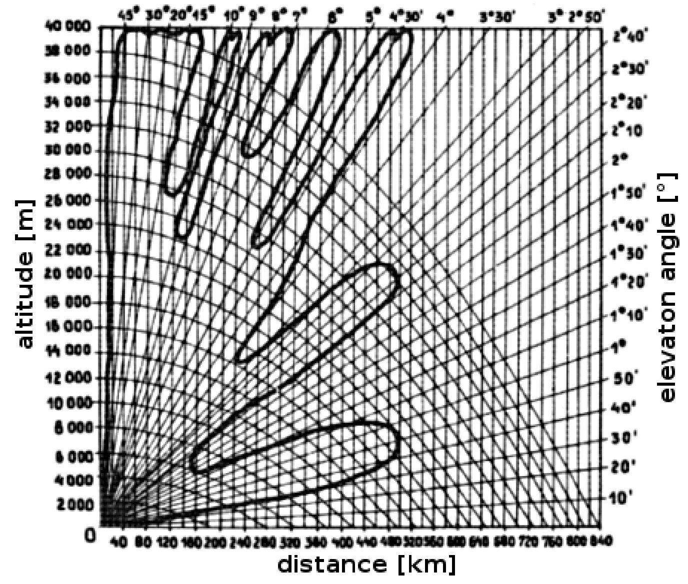
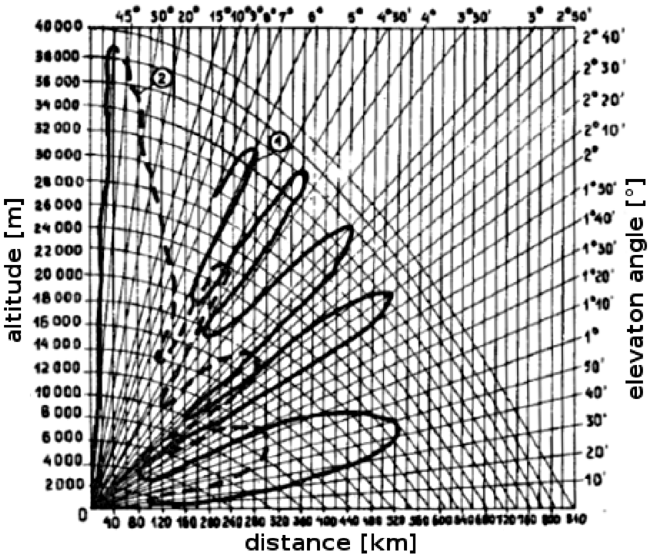


FIGURE 4

Receiving antenna characteristic (observation zone, distance signal)



According to characteristic provided in Table 1 and RSBN characteristic from Recommendation ITU-R M.1830, RSBN system itself provides passive (continuous) information on azimuth, common to all aircraft being within the range of the system, and active (interrogation – response) information on the distance from the RSBN ground station. Frequency bands for transmitters (distance, azimuth) and receivers (distance) do not overlap, in order to avoid interferences and are common to all RSBN systems to ensure the reverse compatibility. It has to be noted that ground transmitters of the rangefinder operates with output power exceeding 30 kW and omnidirectional antennas. Therefore, in order to avoid harmful interferences, frequency separation between ground RSBN rangefinder transmitter and RSBN ground rangefinder receiver exceeds 166 MHz.

When referring to the figures 1 to 4 it may be assumed, that gain of the RSBN antenna in both Tx/Rx distance mode as well as Tx azimuth mode varies depending on the elevation angle. Therefore is may be not appropriate to use the maximum gain given in Recommendation ITU-R M.1830 at low elevation angles, when conducting the compatibility studies between ARNS (RSBN) and mobile service. This may lead to vast overprotection of ARNS.

APPENDIX 5

Distribution of ARNS stations in Region 1 countries

Note: For purpose of this document all assignments overlapping the 694-790 MHz band were considered as stations operating in this band.

1 Summary of ARNS systems operating in (overlapping) the 694-790 MHz band

In accordance with the Recommendation ITU-R M.1830 (Technical characteristics and protection criteria of aeronautical radionavigation service systems in the 645-862 MHz frequency band) the 694-790 MHz band is used only by two ARNS systems – see Table 1. Both systems use air-to-ground link (direction) in this band.

TABLE 1

ARNS systems operating in the 690-790 MHz band in accordance with Recommendation ITU-R M.1830

ARNS system type	System type code	Terrestrial station type	Operating frequencies, MHz	Bandwidth, MHz
RSBN	AA8	Receiver	772, 776, 780, 784, 788	3 or 0.7
RLS 2 Type 2	AA2	Receiver	740	8

However, [Document 4-5-6-7/23 (Russian Federation) extends] the list of ARNS systems operating in the 694-790 MHz band and provides details which allow to distinguish specific systems registered in the MIFR – see Table 2.

TABLE 2

List of ARNS systems [provided in Document 4-5-6-7/23 (Russian Federation)]

ARNS system type	System type code	Station class	Terrestrial station type	Compliance with Rec. ITU-R M. 1830
RSBN	AA8	AL	Transmitter	no
RSBN	AA8	AM	Receiver	yes
RLS 1 Types 1,2	AB	AL	Transmitter	no
RLS 2 Type 1	BA	AM	Receiver	no
RLS 2 Type 1	BD	AL	Transmitter	no
RLS 2 Type 2	BC	AL	Transmitter	no
RLS 2 Type 2	AA2	AM	Receiver	yes
Other(ARNS transmitting station)	-	AL	Transmitter	no
Other(ARNS receiving station)	-	AM	Receiver	no

2 Summary of assignments of ARNS stations recorded in the MIFR

Table 3 below provides statistics concerning ARNS assignments recorded in the MIFR, it shows total number of ARNS stations recorded in the register and number of specific system stations recorded by administrations in Region 1.

Presented information is based on BR IFIC No. 2749 issued on 23 July 2013. [Identification of ARNS systems and their components was done in accordance with Document 4-5-6-7/23 (Russian Federation) *Note cannot be referred to like this in a DNR*].

TABLE 3

Number of ARNS systems in the 694-790 MHz band in Region 1 countries

ARNS system type	Transmitting station	Receiving station	Administration	Number of assignments	Remarks
RLS 2 Type 2	airborne	ground station	RUS	223	
			UKR	37	
			UZB	28	
			KAZ	18	
			BLR	17	
			AZE	9	
			KGZ	8	
			TJK	1	
			Total	**341**	
	ground station	airborne	AZE	5	
			Total	**5**	
	Total			**346**	
RSBN	airborne	ground station	RUS	182	
			BLR	4	
			UKR	4	
			Total	**190**	
	ground station	airborne	RUS	154	
			Total	**154**	
	Total			**344**	
Other	airborne	ground station	UKR	47	
			KAZ	12	
			HNG	8	
			BLR	4	
			ARM	2	
			Total	**73**	
	ground station	airborne	D	20	assignments unused since 1990 – administration is going to withdraw the MIFR records
			BLR	10	

<table>
<tr><th>ARNS system type</th><th>Transmitting station</th><th>Receiving station</th><th>Administration</th><th>Number of assignments</th><th>Remarks</th></tr>
<tr><td rowspan="3"></td><td rowspan="2"></td><td rowspan="2"></td><td>POL</td><td>5</td><td>geographical coordinates not provided, assignments not in operation – administration is going to withdraw the MIFR records</td></tr>
<tr><td>Total</td><td>35</td><td></td></tr>
<tr><td colspan="3">Total</td><td>108</td><td></td></tr>
<tr><td rowspan="3">RLS 2 Type 1</td><td rowspan="2">airborne</td><td rowspan="2">ground station</td><td>AZE</td><td>4</td><td></td></tr>
<tr><td>Total</td><td>4</td><td></td></tr>
<tr><td colspan="3">Total</td><td>4</td><td></td></tr>
<tr><td rowspan="4">RLS 1 Types 1, 2</td><td rowspan="3">ground station</td><td rowspan="3">–
(primary radar)</td><td>GEO</td><td>2</td><td></td></tr>
<tr><td>AZE</td><td>1</td><td></td></tr>
<tr><td>Total</td><td>3</td><td></td></tr>
<tr><td colspan="3">Total</td><td>3</td><td></td></tr>
<tr><td colspan="4">Total</td><td>805</td><td></td></tr>
</table>

3 RLS 2 Type 2

RLS 2 Type 2 system is one of two ARNS systems mentioned in the Recommendation ITU-R M.1830 as system operating in the 694-790 MHz band. According to the Recommendation RLS 2 Type 2 system uses frequency of 740 MHz to transmit from aircraft to ground station. 336 of 346 assignments recorded in the MIFR are fully compliant with the Recommendation, 10 stations transmits from ground station to airborne receiver and/or use different frequencies than given in the Recommendation.

Table 4 provides details concerning frequencies used by the system, Figure 1 shows locations of the stations registered in the MIFR.

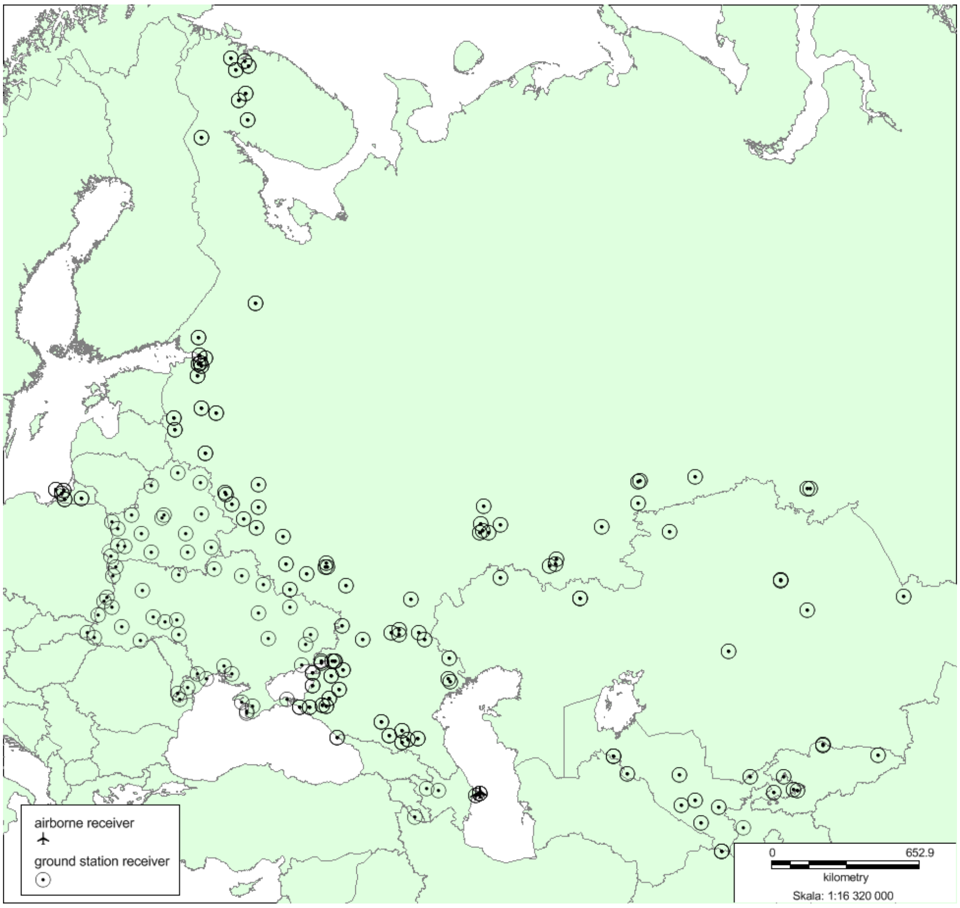
TABLE 4

Frequencies assigned to RLS 2 Type 2 system and number of stations

<table>
<tr><th>ARNS system type</th><th>Transmitting station</th><th>Receiving station</th><th>Assigned frequency, MHz</th><th>Number of assignments</th><th>Remarks</th></tr>
<tr><td rowspan="6">RLS 2 Type 2</td><td rowspan="4">airborne</td><td rowspan="4">ground station</td><td>691</td><td>1</td><td rowspan="3">assigned frequency not compliant with Rec. ITU-R M.1830</td></tr>
<tr><td>694</td><td>2</td></tr>
<tr><td>697</td><td>2</td></tr>
<tr><td>740</td><td>336</td><td></td></tr>
<tr><td rowspan="2">ground station</td><td rowspan="2">airborne</td><td>694</td><td>2</td><td rowspan="2">direction of operation and/or assigned frequency not compliant with Rec. ITU-R M.1830</td></tr>
<tr><td>697</td><td>3</td></tr>
</table>

FIGURE 1

Locations of RLS 2 Type 2 stations



4 RSBN

According to the Recommendation ITU-R M.1830 RSBN system can use five radio channels (772, 776, 780, 784 and 788 MHz) for transmission from aircraft to ground station. The MIFR contains 190 records of RSBN ground radar receivers – all of them operate using frequency defined in the abovementioned Recommendation. Additionally 154 stations in the Register can be identified as RSBN stations operating in ground-to-air direction. 150 of these stations use five standard (defined in Recommendation) radio channels, two stations use frequency of 722 MHz and two use frequency of 778 MHz.

Table 5 below lists frequencies assigned to the RSBN stations and provides information concerning number of stations for each assigned frequency. The following Figures (2 to 8) show geographical locations of stations for specified radio channels.

TABLE 5

Frequencies assigned to RSBN system and number of stations

ARNS system type	Transmitting station	Receiving station	Assigned frequency, MHz	Number of assignments	Remarks
RSBN	airborne	ground station	772	44	
			776	35	
			780	30	
			784	37	
			788	44	
	ground station	airborne	722	2	direction of operation and/or assigned frequency not compliant with Rec. ITU-R M.1830
			772	30	
			776	30	
			778	2	
			780	26	
			784	22	
			788	42	

FIGURE 2

RSBN stations using frequency of 722 MHz

FIGURE 3

RSBN stations using frequency of 772 MHz

FIGURE 4

RSBN stations using frequency of 776 MHz

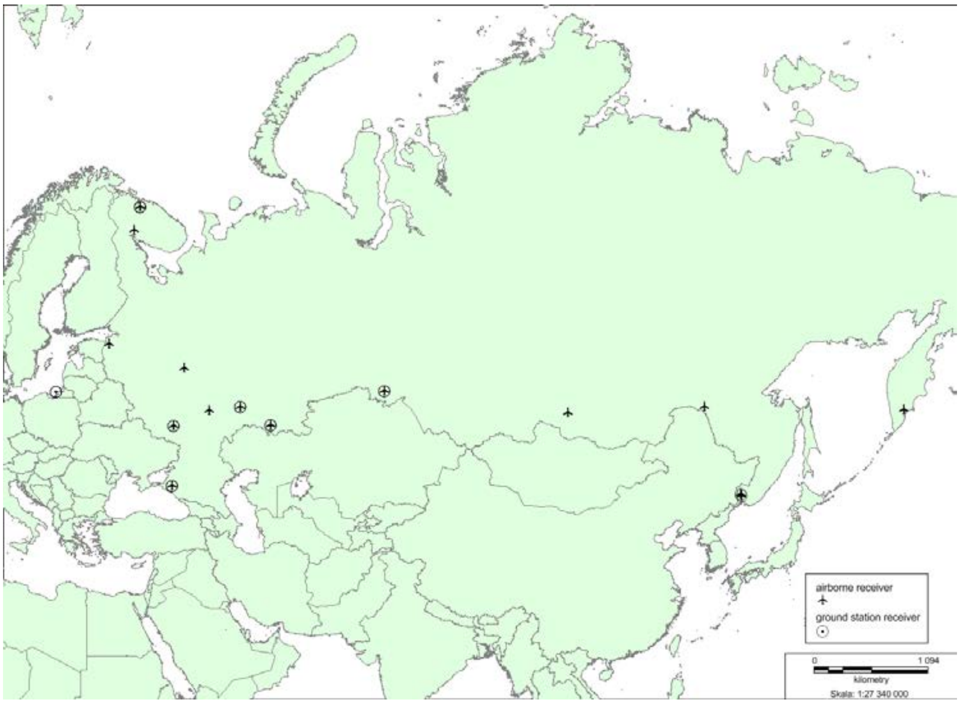


FIGURE 5

RSBN stations using frequency of 778 MHz

FIGURE 6

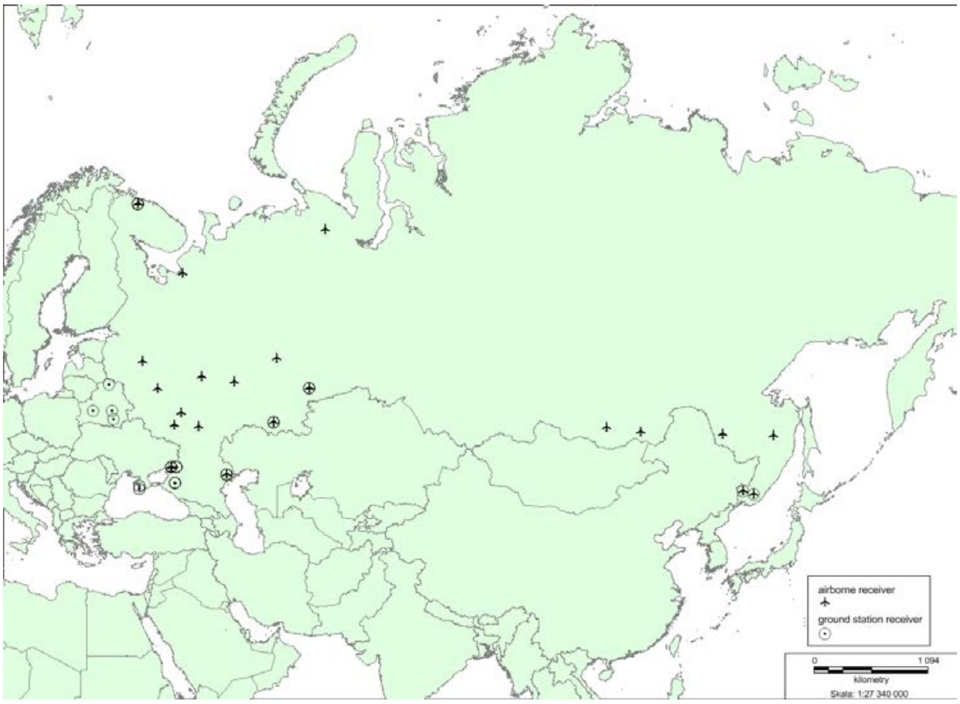
RSBN stations using frequency of 780 MHz

FIGURE 7

RSBN stations using frequency of 784 MHz

FIGURE 8

RSBN stations using frequency of 788 MHz



5 Other ARNS systems

There are 108 assignments in the MIFR which can be identified as "Other" stations. 61 of these stations operate in air-to-ground direction using frequency of 740 MHz – it can suggest that some of these stations could be RLS 2 Type 2 stations erroneously recorded in the MIFR without system type code indication. Additionally 20 assignments in Germany and 5 in Poland are not in operation and these administrations are going to withdraw the MIFR records.

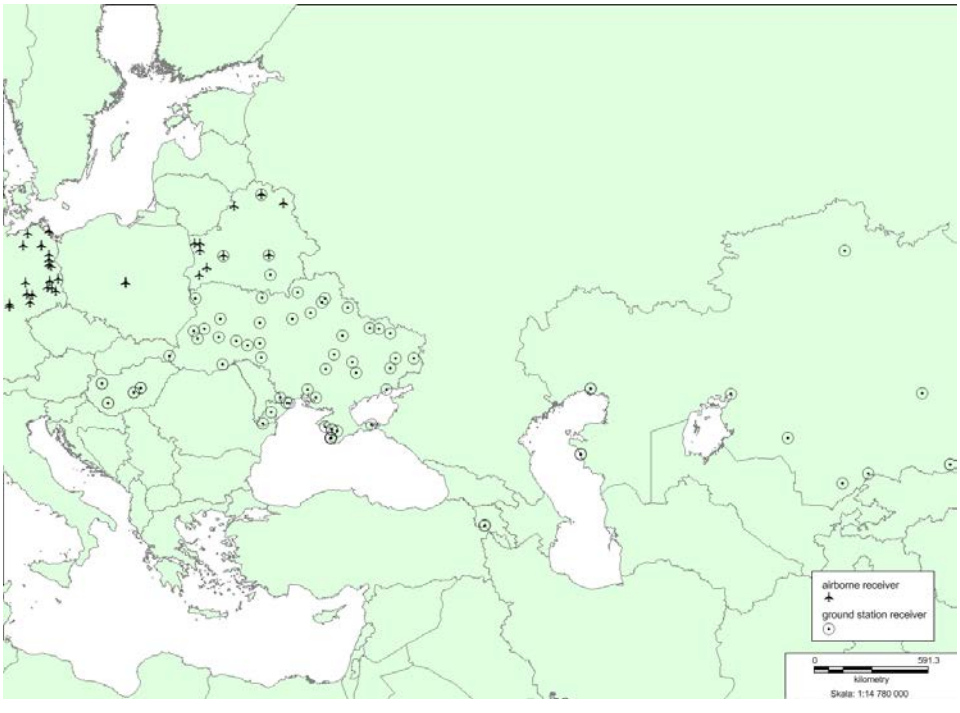
TABLE 6

Frequencies and number of stations of systems which can be identified as "other ARNS"

ARNS system type	Transmitting station	Receiving station	Assigned frequency, MHz	Number of assignments	Remarks
Other	airborne	ground station	740	61	
			750	4	
			788	8	
	ground station	airborne	770	1	
			772	6	
			776	8	
			778	1	
			780	4	
			784	6	
			788	9	

FIGURE 9

Locations of other ARNS system stations



6 RLS 2 Type 1

Four assignments in the MIFR can be identified as RLS 2 Type 1 system. All of them use the same radio channel and direction of transmission as RLS 2 Type 2 system described in Recommendation ITU-R M.1830.

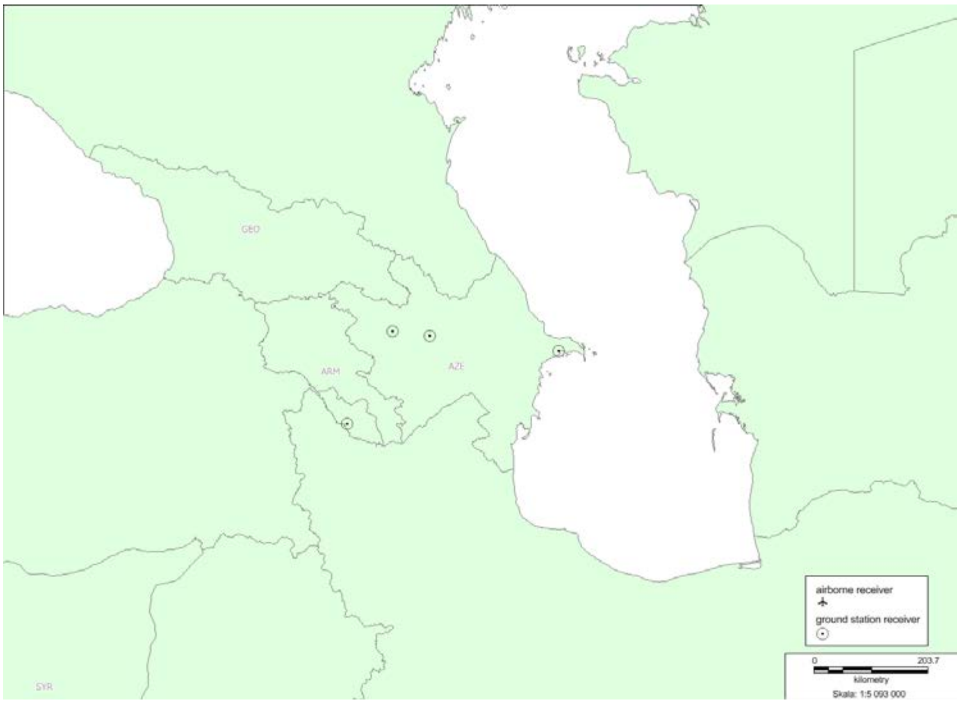
TABLE 7

Frequencies assigned to RLS 2 Type 1 system and number of stations

ARNS system type	Transmitting station	Receiving station	Assigned frequency, MHz	Number of assignments	Remarks
RLS 2 Type 1	airborne	ground station	740	4	

FIGURE 10

Locations of RLS 2 Type 1 stations



7 RLS 1 Types 1, 2

Three assignments recorded in the MIFR can be identified as RLS 1 Types 1, 2 stations. Two of them operate using the same frequency and transmission direction as RLS 2 Type 2 systems.

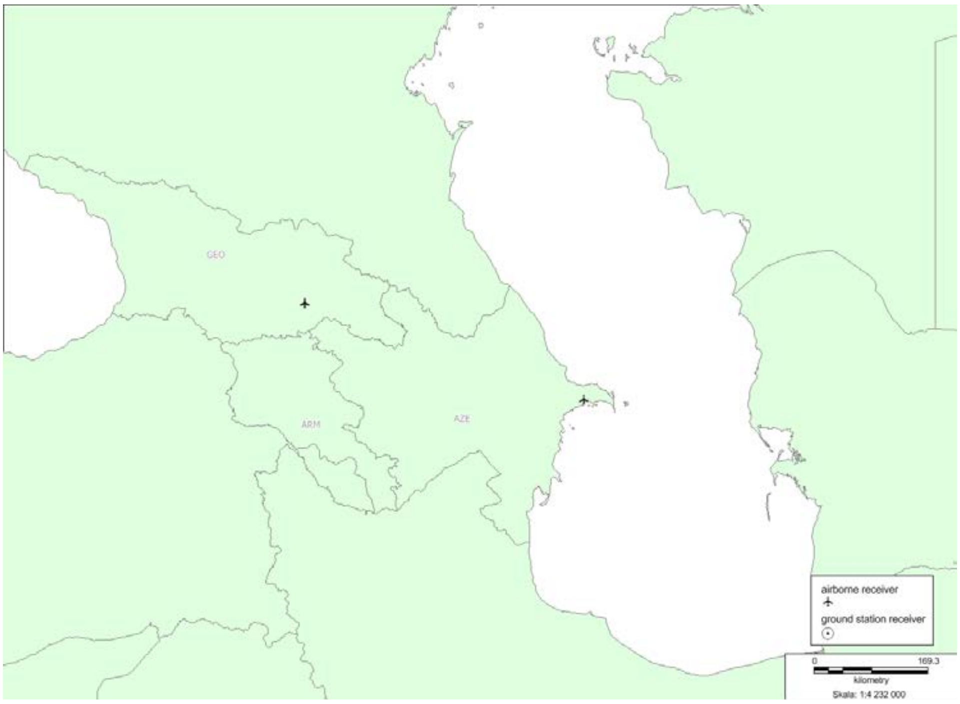
TABLE 8

Frequencies assigned to RLS 1 Types 1 and 2 systems and number of stations

ARNS system type	Transmitting station	Receiving station	Assigned frequency, MHz	Number of assignments	Remarks
RLS 1 Types 1, 2	ground station	_[13]	694	1	
			740	2	

FIGURE 11

Locations of RLS 1 Types 1, 2 stations



[13] RLS 1 Types 1 and 2 are primary radars.

Additional study, supporting Study#B.1 and Study#B.2

1 Introduction

The document presents material regarding the compatibility between MS with ARNS taking into account interference caused by BS in the frequency band 694-790 MHz.

The compatibility was analysed to determine whether the protection distances required to ensure sharing between MS and ARNS are sufficient for preventing BS from causing interference in a given direction.

To attain this goal the required protection distances between MS and BS, between ARNS and MS, between ARNS and BS were estimated.

2 Interference scenario

Assuming that MS systems operate in FDD mode the document analysed the following interference scenarios:

Scenario 1: Interference from a transmitting BS station towards a receiving ARNS ground station.

Scenario 2: Interference from a MS base station towards a receiving ARNS ground station.

Scenario 3: Interference from a transmitting BS station towards a receiving MS UE.

The estimation assumed that transmitting and receiving antennas of stations under consideration were pointed at one to another with their maximum gains.

For simplification in the indicated above scenarios single interference source approach was considered.

3 Technical characteristics

3.1 Parameters of MS, BS and ARNS systems

Parameters of MS, BS and ARNS systems are shown in Tables 1 and 2.

TABLE 1

Parameters of MS, BS and ARNS systems

Parameter	MS base station (transmitter)	MS UE (receiver)	BS station (transmitter)	RSBN station (receiver)
Carrier, MHz	770	770	770	770
Antenna fed power, dBm/MHz	36	–	76	–
Noise figure, dB	–	9	–	5
Receiving antenna gain (including feeder loss), dBi	–	–3	–	22
Transmitting antenna gain (including feeder loss), dBi	12	–	0	–
Antenna altitude, m	30	1.5	300	10

TABLE 2

Parameters of MS, BS and RLS systems

Parameter	MS base station (transmitter)	MS UE (receiver)	BS station (transmitter)	RLS station (receiver)
Carrier, MHz	740	740	740	740
Antenna fed power, dBm/MHz	36	–	76	–
Noise figure, dB	–	9	–	5
Receiving antenna gain (including feeder loss), dBi	–	–3	–	28.4
Transmitting antenna gain (including feeder loss), dBi	12	-	0	–
Antenna altitude, m	30	1.5	300	10

3.2 Protection criteria for MS and ARNS stations

In this document conducted studies deals with criteria of two types:

– the first type is based on I/N protection criterion;

– the second type is based on field strength level.

I/N protection criterion for the first case

Protection criterion for MS UE and for receiving ARNS stations was assumed to be equal to I/N = –6 dB.

Field strength protection criterion for the second case

The field strength protection criterion for RSBN system operating on the 770 MHz carrier frequency is 42 dB(µV/m) in 3 MHz band. The field strength protection criterion for RLS system operating on the 740 MHz carrier frequency is 24 dB(µV/m) in 8 MHz band. Recalculation of the above criteria for 1 MHz band results in 37.2 dB(µV/m) for RSBN system and 15 dB (µV/m) for RLS system.

Determination of the MS system field strength protection criterion was based on Recommendation T/R 25-08 which is used for terrestrial mobile service in the frequency band 29.7-921 MHz. Thus the field strength protection criterion for MS systems operating in the frequency band 606-921 MHz would be 35.6 dB (µV/m) in any 1 MHz.

4 Results of estimations based on I/N protection criterion

Estimation of acceptable interference level

Receiver noise power is estimated using the following equation:

$$P_n = 10\log kT + 10 * \log(10^{\frac{NF_{\text{dB}}}{10}} - 1) + 10\log B_{\text{Hz}}$$

$$= -204\text{ dBm} + 10 * \log\left(10^{\frac{NF_{\text{dB}}}{10}} - 1\right) + 10\log B_{\text{Hz}} =$$

$$= -174\text{ dBm} + 10 * \log(10^{\frac{NF_{\text{dB}}}{10}} - 1) + 10\log B_{\text{Hz}}$$

where:

k – Boltzmann constant (1.3806488×10^{-23} J K^{-1});

T – temperature (290 K);

B – reception pass band (Hz);

NF – noise figure (dB).

Then receiver noise power in 1 MHz bandwidth would be:

$$P_n = -174\ \text{dBm} + 10\log 1 \times 10^6 = -114\ \text{dBm}$$

The resulting noise power in MS UE receiver and in ARNS station receiver would be:

$$P_{n\_UT} = -114\ \text{dBm} + 8{,}3\ \text{dB} = -105.7\ \text{dBm}$$

$$P_{n\_ARNS} = -114\ \text{dBm} + 3{,}3\ \text{dB} = -110.7\ \text{dBm}$$

Having known receiver noise power and acceptable interference-to-noise ratio I/N the acceptable interference level could be determined as:

$$P_I = P_n + I/N$$

As a result, the acceptable interference level for a MS UE receiver and for an ARNS station receiver could be estimated as:

$$P_{I\_UT} = -105.7\ \text{dBm} + (-6\ \text{dB}) = -111.7\ \text{dBm}$$

$$P_{I\_ARNS} = -110.7\ \text{dBm} + (-6\ \text{dB}) = -116.7\ \text{dBm}$$

Transmitter e.i.r.p. is estimated using the following equation:

$$P_{e.i.r.p.} = P_{Tx} + G_{Tx}$$

where:

P_{Tx} – transmitting power (dBW);

G_{Tx} – transmitting antenna gain (including feeder loss) (dBi).

As a result e.i.r.p. of transmitting MS base station and that of transmitting BS station could be estimated as:

$$P_{e.i.r.p\_BSMS} = 36\ \text{dBm} + 12\ \text{dBi} = 48\ \text{dBm}$$

$$P_{e.i.r.p.\_DTT} = 76\ \text{dBm} + 0\ \text{dBi} = 76\ \text{dBm}$$

Estimation of required separation distances

Estimation of separation distances is based on required attenuation between an interfering transmitter and a victim receiver using a propagation model described in Recommendation ITU-R P.1546-4 (for 10% of time and 50% of locations).

Required attenuation between an interferer and an affected station with the aim of protecting the affected station could be estimated as:

$$\text{Isolation} = P_{e.i.r.p.} + G_{Rx} - P_I$$

where:

G_{Rx} – receiving antenna gain (including feeder loss) (dBi).

Scenario 1

Required attenuation between a BS station transmitter and a MS UE receiver is estimated in the following way:

$$\text{Isolation}_{DTT-UTMS} = 76\text{ dBm} + (-3\text{ dBi}) - (-111.7\text{ dBm}) = 184.7\text{ dB}$$

Then the required separation distance between a BS station transmitter and a MS UE receiver would be as $\text{d}_{req\_DTT-UTMS} = 93$ km.

Scenario 2

Required attenuation between a BS station transmitter and an ARNS station receiver is estimated in the following way:

$$\text{Isolation}_{DTT-RSBN} = 76\text{ dBm} + 22\text{ dBi} - (-116.7\text{ dBm}) = 214.7\text{ dB}$$

$$\text{Isolation}_{DTT-RLS} = 76\text{ dBm} + 28.4\text{ dBi} - (-116.7\text{ dBm}) = 221.1\text{ dB}$$

The required separation distance between a BS station transmitter and an ARNS station receiver would be as :

$$\text{d}_{req\_DTT-RSBN} = 445\text{ km}$$

$$\text{d}_{req\_DTT-RLS} = 525\text{ km}$$

Scenario 3

Required attenuation between a MS base station transmitter and an ARNS station receiver is estimated in the following way:

$$\text{Isolation}_{BSMS-RSBN} = 48\text{ dBm} + 22\text{ dBi} - (-116.7\text{ dBm}) = 186.7\text{ dB}$$

$$\text{Isolation}_{BSMS-RLS} = 48\text{ dBm} + 28.4\text{ dBi} - (-116.7\text{ dBm}) = 193.1\text{ dB}$$

The required separation distance between a MS base station transmitter and an ARNS station receiver would be as:

$$\text{d}_{req\_BSMS-RSBN} = 147\text{ km}$$

$$\text{d}_{req\_MS-RLS} = 202\text{ km}$$

The obtained result is shown graphically in Figures 1 and 2.

FIGURE 1

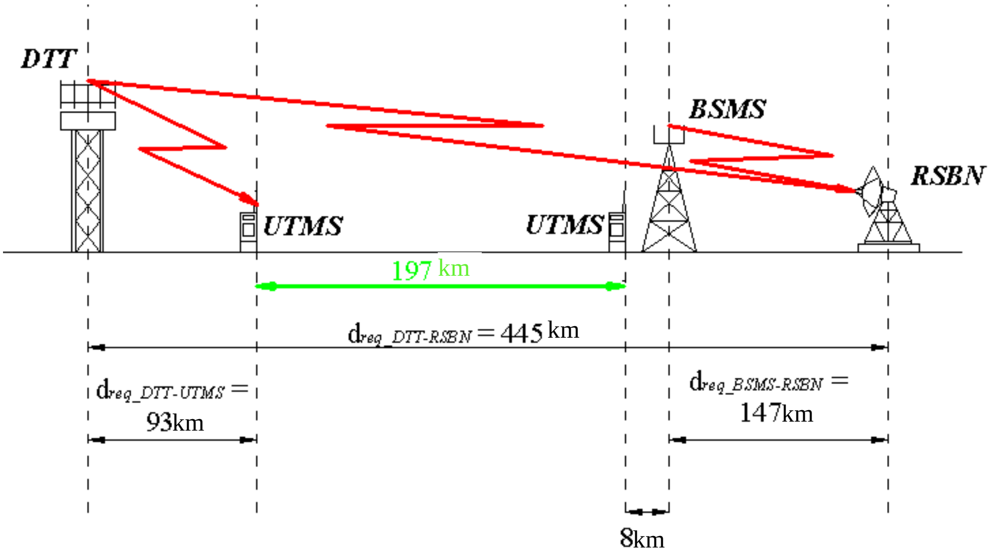
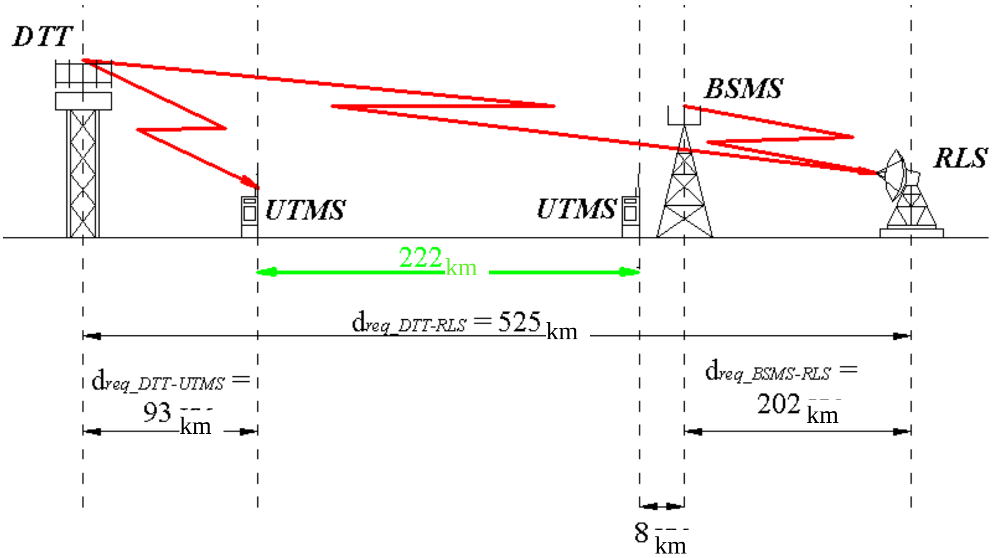


FIGURE 2



Thus it is obvious from the above estimation results that protection distance between a transmitting BS station and a receiving ARNS station would substantially exceed protection distance between a transmitting BS station and a receiving MS UE.

It is readily apparent from the obtained data that in case of interference effect to RSBN it could be feasible to deploy MS base stations in a geographical zone of 197 kilometres in width and in case of interference effect to RLS it could be feasible to deploy MS base stations in a geographical zone of 222 kilometres in width.

Finally a conclusion may be drawn that MS stations could operate between a BS station transmitter and an ARNS station receiver with interference to that ARNS station from both MS and BS stations hence it is necessary to consider issue of interference from MS to ARNS taking onto account interference caused by BS in the frequency band 694-790 MHz.

5 Results of estimations based on field strength protection criterion

Estimation of acceptable interference level

Based on Recommendation ITU-R P.525-2 power of received emission may be expressed as:

$$P = E \ + G_{Rx} - 20\log f - 167.2$$

where:

P – received power, dBW;

E – field strength level, dB(μV/m);

G_{Rx} – receiving antenna gain (including feeder loss) (dBi);

f – frequency, GHz.

Then received power for RSBN and RLS would be estimated as:

$$P_{RSBN} = 37.2 + 22 - 20\log 0.77 - 167.2 = -105.7 \text{ dBW} = -75.7\text{dBm}$$

$$P_{RLS} = 15 + 28.4 - 20\log 0.74 - 167.2 = -121.2 \text{ dBW} = -91.2\text{dBm}$$

Then received power for a MS system would be estimated as:

$$P_{UTMS} = 35.6 + (-3) - 20\log 0.74 - 167.2 = -\ 132 \text{ dBW} = -\ 102.0 \text{ dBm}$$

$$P_{UTMS} = 35.6 + (-3) - 20\log 0.77 - 167.2 = -\ 132.3 \text{ dBW} = -\ 102.3 \text{ dBm}$$

Transmitter e.i.r.p. is determined as:

$$P_{e.i.r.p.} = P_{Tx} + G_{Tx}$$

where:

P_{Tx} – transmitting power, dBW;

G_{Tx} – transmitting antenna gain (including feeder loss), dBi.

Therefore e.i.r.p. of a transmitting MS base station and a transmitting BS station is estimated as:

$$P_{e.i.r.p.\_BSMS} = 36 \text{ dBm} + 12 \text{ dBi} = 48 \text{ dBm}$$

$$\mathrm{P_{e.i.r.p.\_DTT}} = 76 \text{ dBm} + 0 \text{ dBi} = 76 \text{ dBm}$$

Estimation of required separation distance

Estimation of separation distances is based on required attenuation between an interfering transmitter and a victim receiver using a propagation model described in Recommendation ITU-R P.1546-4 (for 10% of time and 50% of locations).

Required attenuation between an interferer and an affected station with the aim of protecting the affected station could be estimated as:

$$\text{Isolation} = P_{e.i.r.p.} + G_{Rx} - P$$

where:

G_{Rx} – receiving antenna gain (including feeder loss) (dBi).

Scenario 1

Required attenuation between a BS station transmitter and a MS UE receiver at 740 MHz frequency is estimated in the following way:

$$\text{Isolation}_{DTT-UTMS} = 76\text{ dBm} + (-3\text{ dBi}) - (-102.0\text{ dBm}) = 175.0\text{ dB}$$

Required attenuation between a BS station transmitter and a MS UE receiver at 770 MHz frequency is estimated in the following way:

$$\text{Isolation}_{DTT-UTMS} = 76\text{ dBm} + (-3\text{ dBi}) - (-102.3\text{ dBm}) = 175.3\text{ dB}$$

Then the required separation distance between a BS station transmitter and a MS base station receiver would be $\text{d}_{req\_DTT-UTMS} = 68\text{ km}$ at carrier frequencies of 740 MHz and 770 MHz .

Scenario 2

Required attenuation between a BS station transmitter and an ARNS station receiver is estimated in the following way:

$$\text{Isolation}_{DTT-RSBN} = 76\text{ dBm} + 22\text{ dBi} - (-75.7\text{ dBm}) = 173.7\text{ dB}$$

$$\text{Isolation}_{DTT-RLS} = 76\text{ dBm} + 28.4\text{ dBi} - (-91.2\text{ dBm}) = 195.6\text{ dB}$$

The required separation distance between a BS station transmitter and an ARNS station receiver would be:

$$\text{d}_{req\_DTT-RSBN} = 120\text{ km}$$

$$\text{d}_{req\_DTT-RLS} = 268\text{ km}$$

Scenario 3

Required attenuation between a BS base station transmitter and an ARNS station receiver is estimated in the following way:

$$\text{Isolation}_{BSMS-RSBN} = 48\text{ dBm} + 22\text{ dBi} - (-75.7\text{ dBm}) = 145.7\text{ dB}$$

$$\text{Isolation}_{BSMS-RLS} = 48\text{ dBm} + 28.4\text{ dBi} - (-91.2\text{ dBm}) = 167.6\text{ dB}$$

The required separation distance between a BS station transmitter and an ARNS station receiver would be:

$$\text{d}_{req\_BSMS-RSBN} = 16.5\text{ km}$$

$$\text{d}_{req\_MS-RLS} = 49\text{ km}$$

The obtained results are shown graphically in Figures 3 and 4.

FIGURE 3

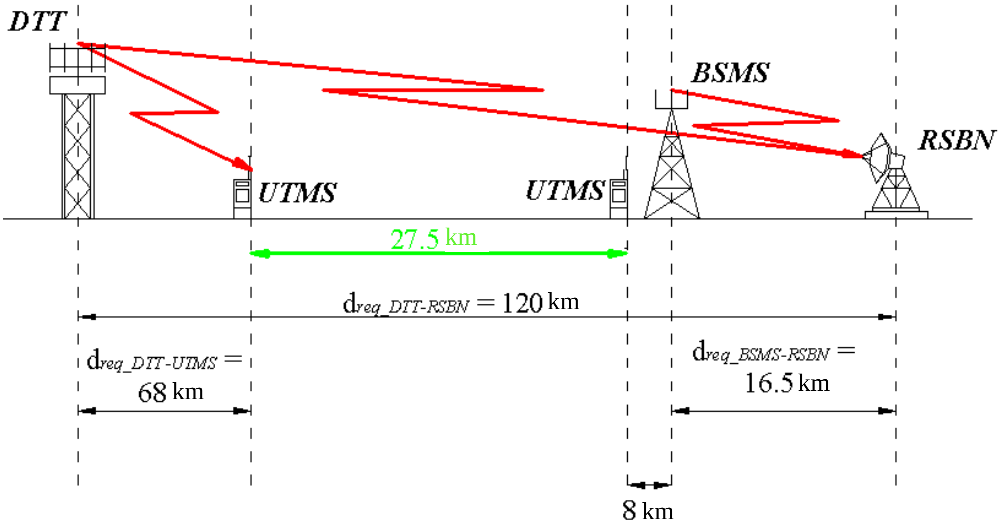
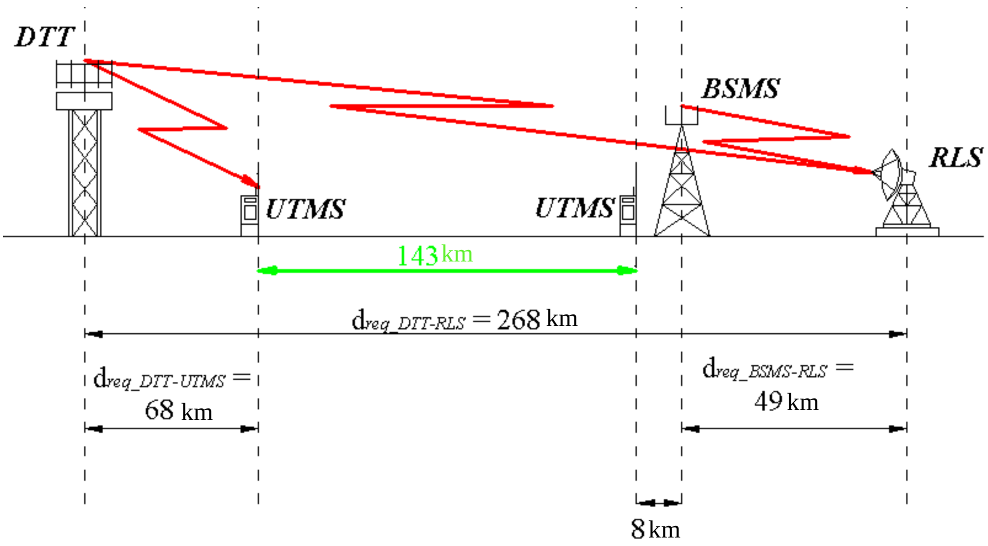


FIGURE 4



Thus it is obvious from the above estimation results that protection distance between a transmitting BS station and a receiving MS UE would be substantially less than that between a transmitting BS station and a receiving ARNS station.

It is readily apparent from the obtained data that in case of interference effect to RSBN it could be feasible to deploy MS base stations in a geographical zone of 27.5 kilometres in width and in case of interference effect to RLS it could be feasible to deploy MS base stations in a geographical zone of 143 kilometres in width.

Finally a conclusion may be drawn that MS stations could operate between a BS station transmitter and an ARNS station receiver hence it is necessary to consider issue of interference from MS to ARNS taking onto account interference caused by BS in the frequency band 694-790 MHz.

6 Conclusions

Thus it is obvious from conducted estimations that in current sharing conditions of interference effect from BS to ARNS a location of MS stations between a BS station and an ARNS station when a MS station would cause increasing interference to that ARNS station.

Hence it would be necessary to consider an issue of effect of MS on ARNS with interference caused by BS in the frequency band 694-790 MHz. The conclusion is valid for two protection criteria types based on I/N ratio and on field strength values.

Estimates of the first protection criteria option show that in case of interference effect to RSBN it could be feasible to deploy MS base stations in a geographical zone of 197 kilometres in width and in case of interference effect to RLS it could be feasible to deploy MS base stations in a geographical zone of 222 kilometres in width.

Estimates of the second protection criteria option show that in case of interference effect to RSBN it could be feasible to deploy MS base stations in a geographical zone of 27.5 kilometres in width and in case of interference effect to RLS it could be feasible to deploy MS base stations in a geographical zone of 143 kilometres in width.

It should be noted, that indicated above conclusion based on single interference source approach. So for multiple interference source approach the width of geographical zone for MS deployment will be higher.

APPENDIX 6

Consideration of interference outside antenna main beam of ARNS ground station

Introduction

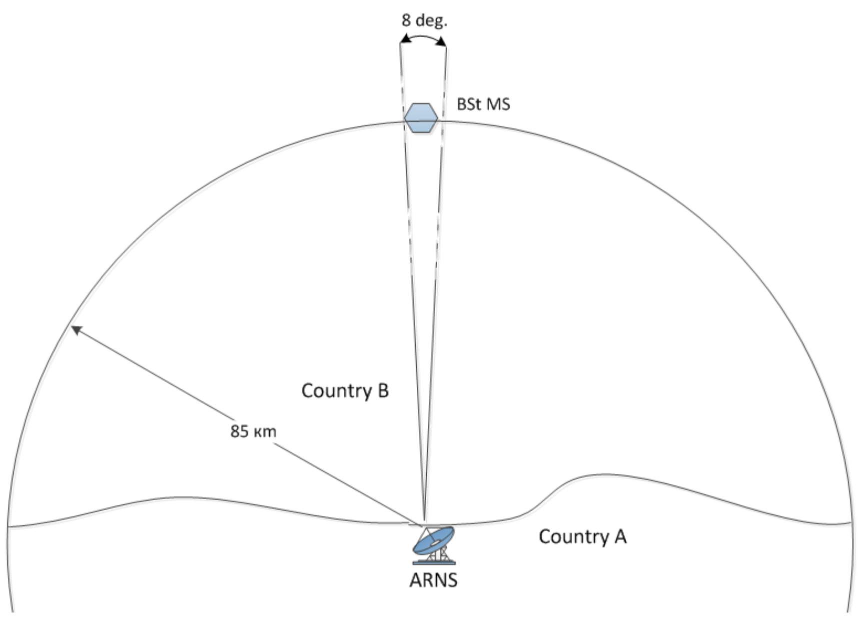
It should be noted that ARNS ground station antennas are directional. Therefore estimation of compatibility feasibility should consider primarily those interfering stations which emissions directly fall into main antenna beam of ARNS ground station. But it is also needed to account interference caused to ARNS stations by systems deployed outside of main beam a given ARNS antenna. For this purpose estimation of maximum potential effect of interference affecting a given ARNS antenna in angle sector outside its main lobe. The obtained estimates are used to determine a portion of interference received by a given antenna in angle sector outside its main beam (Δ) in relation to interference received by that antenna in angle sector of its main beam. The obtained value is then accounted in the estimation of interference sources emitting in the main lobe of that ARNS antenna pattern.

Assumptions

ARNS station –3 dB pattern width is taken to be of 8 degrees. For the simplification of analysis it is assumed that the pattern level in the rest part would be by 15 dB less than maximum gain.

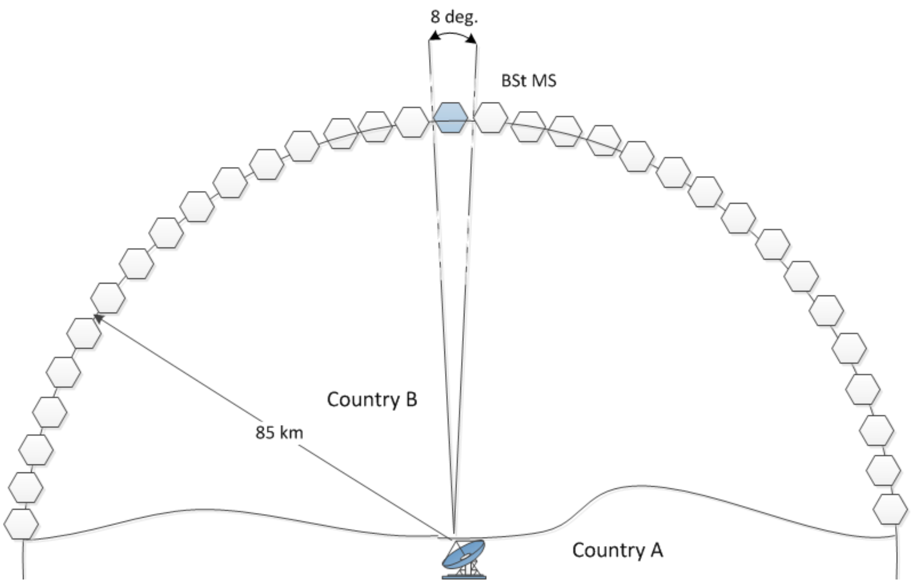
It is also assumed that a MS base station is deployed at a distance of 85 kilometres from an ARNS ground station and emissions by the base station fall into the ARNS ground station main lobe generating interference of 30 dBW in the ARNS ground station receiver band as shown in Figure 1 below.

FIGURE 1



Then it is assumed that MS base stations with the same power budget are deployed at a distance of 85 kilometres from a given ARNS ground station. Rural density of those MS base stations is assumed resulting in cell diameter of 8 kilometres. As shown in Figure 2, 32 MS base stations could be deployed additionally.

FIGURE 2



Results

Since emissions from those additional stations do not fall into the ARNS ground station antenna main lobe their level would be reduced by 15 dB in angle sector outside the ARNS ground station antenna main lobe. As a result, aggregate effect by addition MS base stations would be of 30.23 dBW in the ARNS ground station receiver band. It means that additional contribution from emissions by MS base stations deployed outside the ARNS ground station antenna main lobe would be of 3.13 dB in relation to a MS base station with emissions in the ARNS ground station antenna main lobe.

Conclusion

Thus in relation to the situation with the ARNS ground station a conclusion may be drawn that accounting for interference through side lobes would result in increasing the aggregate interference at least by 4 dB. Therefore interference by emission outside ARNS ground station antenna main lobe is accounted by adding 4 dB to interference estimated only in angle sector of a given ARNS ground station antenna main lobe.

APPENDIX 7

Views from some administrations regarding the studies

Study #A.1

Some administrations have pointed out that results in the Study A.1 are not correct for the following reasons:

– Under estimations of interference to ARNS from only MS it was used criterion which was not presented by ITU-R for considered scenarios. The difference between the recommended by ITU-R for considered scenarios I/N=–6 criteria and field strength trigger used in study A1 is greater than 30 dB.

– The height of antenna MS base station was restricted to a value of 30 m and case of antenna with height of 50m was not considered, that does not cover the possible real height of MS base stations presented by ITU-R.

– Interferences to ground-based ARNS stations caused by MS stations that received beyond from the main beam of antenna pattern ARNS stations were not taken into account.

– Additional losses of interference from MS stations were applied that are probabilistic by their nature and do not ensure protection of ARNS stations.

– Application of weight factors (10% - in urban area, 20% - in suburban area and 70% - in rural area) to reduce the aggregate interference from MS stations in each zone is not valid because it does not take into account the concentration of MS stations in the city and in the suburbs. Application of these weight factors actually means that low density of MS stations in 10 times for urban area and in 5 times for suburban area was used that does not correspond with data presented by ITU-R. Therefore, the method of calculating the aggregate interference applied in Study # A.1for mixed scenario, is not correct and leads to significant errors in calculations up to 10 dB.

– Propagation losses for urban and suburban that were used in the Study A.1 are not in line with real conditions of MS and ARNS placement because ARNS stations will never be placed in the same urban or suburban zone with MS stations and between them will be rural zone. It leads to the additional errors about 10 dB.

– In Study A.1 for urban case typical size of IMT BS cell (radius 2 km) does not take into account possible real situations when the size of the sell may be less (radius 0.5 km in accordance with data presented by ITU-R). It leads to additional calculation errors about 12 dB.

– Reduction of the ARNS receiver antenna gain (reflected in tables 4,5,6 and 7 but not in final results) in the horizon direction should not be taken into account in field strength value calculation, because this reduction has already been taken into account in determining of the permissible field strength level. In this case additional error about 10 dB has been made for RSBN receiver.

– In Study A.1 the tropospheric scattering effect was not taken into account from Recommendation ITU-R P.1546, therefore the obtained result couldn’t give assurance of protection for existing service.

– As a results, in Study A.1aggregate interference impact is less than impacts from single interfere because coordination distances, presented in Study A.1 for the case of aggregate interference for the urban scenario are less then distances in case of one source of interference for the rural scenario and do not provide protection for ARNS. That is why results obtained in Study A.1 are not correct and cannot be applied for decision of Issue C of WRC-15 AI 1.2.

Study #A.2

Regarding study # A.2 some administrations are of the view that:

– Some parameters used deviate from the agreed typical parameters given in Document 4-5-6-7/49 from ITU-R. Antenna down-tilt, vertical antenna pattern, and typical cell sizes are not applied. This results in overestimation of the required separation distance.

– The rural attenuation curves from Recommendation ITU-R P.1546 have been used for urban and sub-urban environments which lead to overestimation of the interference into ARNS from MS.

– The proposed coordination distances for the receiving base stations does not correspond to the distances needed to protect the ARNS systems, but are derived from the calculation of protection of MS from ARNS. Information on how these protection distances of MS are derived and which parameters that have been used are not presented. This is not the correct way to estimate the necessary protection of ARNS.

– In Recommendation ITU-R P.1546 the determination of the field strengths caused by tropospheric scattering requires the terrain database in order to determine the terrain clearance angle. Without using a terrain database, the received field strength is overestimated and is not correct.

– Given the comments above Study A.2 is not correct and cannot be applied for decision on Issue C of WRC-15 AI 1.2.

Study #A.3

Regarding study # A.3 some administrations are of the view that:

– the results not are based on the updated IMT parameters in Document 4-5-6-7/49 from ITU-R. This results in overestimation of the required separation distance.

– the coordination threshold values in Resolution 749 (Rev.WRC-12) were agreed upon only on the basis that all affected CEPT countries obtained coordination agreement with the relevant countries in RR No. 5.312.

– the methodology used should be further assessed and/or explained.

– In Recommendation ITU-R P.1546 the determination of the field strengths caused by tropospheric scattering requires the terrain database in order to determine the terrain clearance angle. Without using a terrain database, the received field strength is overestimated and is not correct.

Given the comments above Study A.3 is not correct and cannot be applied for decision on Issue C of WRC-15 AI 1.2.

Study #B.1

Some administrations are of the view that:

– The scenario where some countries would share usage of the frequency band 694-790 MHz between MS and BS is not necessary to consider when the required separation distances between BS transmitters and MS receiving base stations is larger than the required separation distance between BS and ARNS as shown in the additional study, supporting Study#A (Additional study, supporting Study#B.1 and Study#B.2).

– ECC Recommendation T/R 25-08 used for the derivation of MS system field strength protection criterion in the additional study supporting Study #B.1 is not applicable to IMT. Also, the protection field strength criteria derived from this Recommendation applies on a receiving antenna height of 10 metres, not 1.5 metres as used in this additional study.

– Some Administrations are of the view that this case should not be taken into account since protection against BS in ensured through the GE06 Agreement and that the operation of MS between a BS station and an ARNS station is not feasible (further details can be found in Appendix 3).

– The methodology in study #B.1 as described in 4.2.2.2.1.1 and 4.2.2.2.1.2 takes also into account the cumulative effect of broadcasting assignments, both in the country hosting ARNS as well as in countries within a certain radius from the ARNS station, regardless of the fact that these assignments may not be in operation. Thus, this method will highly overestimate the interference experienced by the ARNS station.

– The methodology proposed is impractical to use due to the dynamic development of a mobile network, and the coordination distances may have to be recalculated as soon as the deployment of the network changes.

– Given the comments above Study B.1 is not correct and cannot be applied for decision on Issue C of WRC-15 AI 1.2.

Study #B.2

Some administrations are of the view that:

– ECC Recommendation T/R 25-08 used for the derivation of MS system field strength protection criterion in the additional study supporting Study #B.2 is not applicable to IMT. Also, the protection field strength criteria derived from this Recommendation applies on a receiving antenna height of 10 m, not 1,5 m as used in this additional study.

– The methodology proposed is impractical to use due to the dynamic development of a mobile network, and the coordination distances may have to be recalculated as soon as the deployment of the network changes.

– The I/N=–6 dB leads to overprotection of ARNS stations in relation to the protection of the broadcasting interference as defined in Geneva-06 and Recommendation ITU-R M.1830. In Document 4-5-6-7/134 from ITU-R the field strength trigger used in study A1 and A2 are indicated as a possible alternative to the I/N=–6 criteria.
The difference between the I/N=-6 criteria and the recommended field strengths are greater than 30 dB.

– Given the comments above Study B.2 is not correct and cannot be applied for decision on Issue C of WRC-15 AI 1.2.

Study #B.3

Some administrations are of the view that:

– Some parameters used deviate from the agreed typical parameters given in Document 4-5-6-7/49 from ITU-R. Antenna downtilt, vertical antenna pattern, and typical cell sizes are not applied. This results in overestimation of the required separation distance.

– The rural attenuation curves from Recommendation ITU-R P.1546 have been used for urban and sub-urban environments which lead to overestimation of the interference into ARNS from MS.

– The proposed coordination distances for the receiving base stations does not correspond to the distances needed to protect the ARNS systems, but are derived from the calculation of protection of MS from ARNS. Information on how these protection distances of MS are derived and which parameters that have been used are not presented. This is not the correct way to estimate the necessary protection of ARNS.

– The I/N=-6 dB leads to overprotection of ARNS stations in relation to the protection of the broadcasting interference as defined in GE06 and Recommendation M.1830.
In Document 4-5-6-7/134 from ITU-R the field strength trigger used in study A1 and A2 are indicated as a possible alternative to the I/N=-6 criteria. The difference between the I/N=-6 criteria and the recommended field strengths are greater than 30 dB.

– In Recommendation ITU-R P.1546 the determination of the field strengths caused by tropospheric scattering requires the terrain database in order to determine the terrain clearance angle. Without using a terrain database, the received field strength is overestimated and is not correct.

– Given the comments above Study B.3 is not correct and cannot be applied for decision on Issue C of WRC-15 AI 1.2.

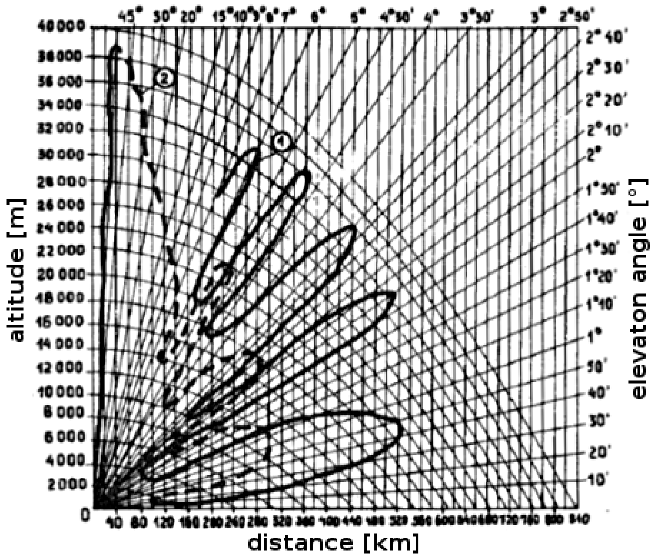
APPENDIX 8

Derivation of RSBN vertical antenna pattern

The antenna pattern for the receiver of the RSBN station is provided in Fig. 1.

FIGURE 1

Receiving antenna characteristic (observation zone, distance signal)



From this figure the following observation distances for given angles can be extracted as given in Table 1.

TABLE 1

Angle vs. observation distance for RSBN receiver

Angle, ϕ	**Observation distance (km)**
0° 00’	160
0° 10’	240
0° 20’	360
0° 30’	480
0° 40’	520
0° 45’	530
0° 50’	520
1° 00’	480
1° 10’	400
1° 20’	300
1° 30’	80
1° 40’	80
1° 50’	500
2° 00’	510
2° 10’	480
2° 20’	400
2° 30’	160
2° 40’	420
2° 50’	440
3° 00’	450
3° 30’	300
4° 00’	320
4° 30’	360
5° 00’	260
6° 00’	280
7° 00’	200

A reasonable assumption is that the observation distance corresponds to the distance when the signal transmitted from the aircraft is at the sensitivity level when received at the RSBN station. The equations giving the received power level at the RSBN station are:

$$P_s = e.i.r.p. - L_{fs} + G_{RSBN},$$

where P_s is the power received at the RSBN receiver input, e.i.r.p. is the aircraft transmission power plus antenna gain, L_{fs} is the free-space path loss, and G_{RSBN} is the antenna gain of the RSBN station, including any feeder losses. Inserting the expression for the free-space path loss and separating the RSBN into a maximum gain, G_{RSBN}^{max}, and an elevation angle-dependent offset, $\Delta(\phi)$, gives:

$$P_s = e.i.r.p. - 20\log_{10}(d_{km}) - 20\log_{10}(f_{MHz}) - 32.45 + G_{RSBN}^{max} + \Delta(\phi).$$

To calculate G_{RSBN}^{max}, it is observed from Fig. 1 that the strongest lobe is at $\varphi = 0° 45'$, and that $\Delta(\phi)$ is zero at this point. From Recommendation ITU-R M.1830, the e.i.r.p. of the aircraft is obtained as 30.5 dBW, and then $\Delta(\phi)$ can be calculated for all other angles in Table 1. Note that it is not necessary to know neither the sensitivity level P_s nor G_{RSBN}^{max}exactly since they are constant and only used to calculate $\Delta(\phi)$ for other angles than $\phi = 0° 45'$. The resulting plot of $\Delta(\phi)$ is shown in Figure 2. For angles less than 0°, –10 dB is used.

FIGURE 2

Normalized antenna gain vs. elevation angle for RSBN receiving ground station