CHAPTER 5

Planning principles and methods in the frequency bands 174-230 MHz and 470-862 MHz

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5.1 Planning principles

5.1.1 Scope of the agreement

5.1.1.1 Planning area

The definition of the planning area is provided in Chapter 1, § 1.1.3.

5.1.1.2 Plans associated with the new agreement

The new Agreement should contain the following frequency plans:

i) A digital plan comprising two parts:

– Part 1, for digital broadcasting in Band III (174-230 MHz), with provisions for T-DAB and DVB-T;

– Part 2, for digital broadcasting in Bands IV and V (470-862 MHz), with provisions for DVB-T.

The digital plan would contain existing and planned assignments and allotments, as defined in § 1.7 of this report, in addition to the assignments and allotments proposed by administrations and approved by the conference at its second session.

ii) An analogue plan comprising two parts:

– Part 1, for analogue broadcasting in Band III (174-230 MHz);

– Part 2, for analogue broadcasting in Bands IV and V (470-862 MHz).

The analogue plan would contain existing and planned analogue assignments as defined in § 1.7 of this report.

5.1.2 Equitable access

The planning process shall be based on the principle of "equitable access" to frequency resources in accordance with No. 196 of Article 44 of the ITU Constitution. In this connection, during the establishment of the plan, the analogue and digital requirements, as well as assignments of other primary services, need to be taken into account according to their respective definitions as contained in § 1.7.

Planning exercises should be carried out to indicate the possibilities in different parts of the planning area, taking account of the requirements for digital terrestrial broadcasting and the data for other primary services submitted by administrations.

Planning exercises also need to be based on equitable access with respect to, but not limited to, the following criteria:

– coverage, in terms of area to be covered;

– quality of reception (C/I, C/N, protection ratio, power flux-density/minimum field strength to be protected);

– percentage of locations and percentage of the time for which a given quality of reception is to be achieved and for which the interference analysis is to be performed;

– type of reception: fixed, portable (indoor/outdoor), mobile;

– bandwidth available for planning;

– other criteria, which will be used for the establishment of the plan(s).

The new Agreement will need to provide a framework in which individual countries can continue to develop their individual and different requirements on an equitable access basis.

In cases where an administration requires assignments of primary services other than broadcasting to be taken into account in the establishment of the plan, its access to the frequency band used by these assignments in the geographical area concerned, might be reduced for digital broadcasting services, based on the results of the planning exercise.

However, the methods and criteria for the implementation of the principle of equitable access mentioned above need to be further studied and reported to the second session of RRC for its consideration.

5.1.3 Flexibility regarding possible future developments

5.1.3.1 T-DAB and DVB-T in Band III

The whole of Band III (174 - 230 MHz) should be available for both DVB-T and T-DAB planning. Taking into account equitable access, due care should be taken in the planning of digital broadcasting, DVB-T and T-DAB, to ensure cross-border compatibility. This can be ensured by bilateral and multilateral agreements between the administrations concerned. There should not be a rigid splitting of Band III between DVB-T and T-DAB unless it is proposed on a national basis and only depending on national requirements.

5.1.3.2 Transmitter networks and reception modes

Subject to the conditions described in § 5.1.2, the planning should be able to deal with:

a) different network structures, namely, multifrequency networks (MFN), single frequency networks (SFN) and a mixture of both configurations, using the appropriate system variants and location probabilities;

b) different reception modes, namely, fixed reception, portable (outdoor and indoor) reception and mobile reception, using a limited number of appropriate system variants and location probabilities.

5.1.3.3 Possible future developments

The new plans, to be adopted at the second session, will need to provide a framework in which each country can continue to satisfy its own individual requirements on an equitable access basis.

The new plans must be sufficiently forward-looking and sufficiently flexible to cover developments in digital technology in future years.

In addition to video and audio signal distribution, digital terrestrial broadcasting may serve as a data platform for innovative telecommunication applications (e.g. e-health, e-government, e-learning) to effectively help to bridge the digital divide, in particular in the developing world.

5.1.4 Efficient use of frequency bands

A minimum number of channels should be used to satisfy the requirements.

5.1.5 Approach to the production of a plan, including protection of existing and planned stations

5.1.5.1 Attributes of the planning process

– The planning process shall deal with the two bands (VHF Band III and UHF Band IV/V) separately.

– In order to expedite the planning exercises, requirements for assignments to low power digital stations[1] or small allotment areas[2] in the planning process shall be ignored. Once the plan is adopted, low power digital stations and small allotments may be entered in the plan in accordance with the plan modification procedures established by the second session of the conference.

– Input requirements for digital broadcasting assignments of more than 200 kW e.r.p. should not be considered in the planning process.

– In order to facilitate the planning process, administrations are encouraged to state which of their existing and planned assignments defined in § 1.7 they would like to be protected in the establishment of the plans and/or during the implementation of the plans in the transition period.

– Bilateral and multilateral discussions will aid the planning process. Administrations are encouraged, as part of the planning process, to agree, on a bilateral and multilateral basis, the mutual compatibility between the input requirements of digital terrestrial broadcasting services and the compatibility between those input requirements and other assignments and services. Such agreements need to be notified to the ITU Radiocommunication Bureau in order to assist the planning process.

– The planning process will use the inventory of requirements communicated by administrations to the ITU Radiocommunication Bureau in accordance with the process and data format described in Chapter 6.

5.1.5.2 Compatibility in the planning process – Protection of existing and planned stations

Compatibility between the digital assignments/allotments contained in the new digital plan and existing and planned[3] analogue assignments should, as far as possible, be ensured in the design of the plan, without the need for the application of supplementary procedures.

Compatibility between the digital assignments/allotments contained in the new digital plan should, as far as possible, be ensured in the design of the plan, without the need for the application of supplementary procedures.

5.1.5.3 Approaches to the production of the plan

RRC is to establish a new plan for digital terrestrial broadcasting, while protecting, during the transition period, existing and planned assignments/allotments as defined in § 1.7 of this report. The transition period is defined in Chapter 7, § 7.4.

In this process, spectrum efficiency needs to be taken into account.

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[1] See definition of low power station in § 1.6.17.3.

[2] See definition of small allotment area in § 1.6.16.

[3] See definition of existing and planned analogue assignments in § 1.7

One approach is to ensure compatibility between the new digital plan and existing and planned assignments/allotments in the design of the new plan, without the need for any procedures at the stage of implementation of the new plan. This approach, however, results in non-optimum use of spectrum, hence less capacity available per country for satisfying its future digital requirements.

Another approach, by which spectrum efficiency may be maximized, is not to take into account existing and planned assignments/allotments in the design of the plan, but to ensure compatibility between them and the new plan at the stage of implementation of the new plan by the application of appropriate procedures (see Chapter 7). In this approach, it is likely that many assignments in the new plan could not be brought into service without restrictions before the end of the transition period.

It is likely that most administrations will tend to include, as part of their digital requirements, some degree of compatibility with existing and planned assignments/allotments, for example by converting analogue assignments into digital. In practice, the two above approaches will therefore tend to converge, i.e. a large proportion of the existing and planned assignments/allotments will be taken into account in the planning process, and only a small proportion of the assignments in the new digital plan could not be brought into service without restrictions before the end of the transition period.

It is expected that the iterations of the draft plan(s) considered could establish the proper balance between the above contradictory objectives in order to satisfy all administrations.

Where an administration chooses to base its digital input requirements on existing and planned analogue assignments, the expression “digital conversion” is sometimes used. Such digital conversions may be submitted to the ITU Radiocommunication Bureau as input requirements and be subject to the same compatibility analysis and synthesis as other input requirements. The concept of a digital conversion may be understood as one or more digital assignments or a digital allotment that replace an analogue assignment on the same frequency as the existing analogue assignment.

A requirement which is a digital conversion could be identified as such in the output of the planning process. This would facilitate the implementation of the digital plan.

During the transition period, some digital assignments in the plan may need to be operated with some restrictions, for example a reduction of radiated power, in order to protect analogue assignments. In such cases, the administrations concerned may agree on a date before the end of the transition period at which such restrictions may be removed. This date will be recorded in the plan.

5.1.6 Treatment of digital broadcasting requirements

5.1.6.1 Scope of digital broadcasting requirements

The following types of digital broadcasting notices are accepted:

– allotments;

– assignments.

Notices for individual assignments can be linked together to form a single frequency network. See § 6.2 for the definition of the data elements of digital broadcasting requirements.

Receiving antenna polarization discrimination should not be taken into account in the planning process except in the case of fixed reception where this is requested by an administration in its input digital requirement. Thus, in the planning process, receiving antenna polarization discrimination will only be applied in considering interference to and from assignments or allotments for which both requirements have indicated a specific polarization.

T-DAB planning should be able to deal with mobile reception and with portable indoor reception. Planning of digital television broadcasting should make provision for all three reception modes, i.e. fixed, portable and mobile.

5.1.6.2 Bilateral and multilateral agreements

On the basis of planning exercises between the sessions, every effort is to be made to reduce incompatibilities and, where they occur, to resolve them by bilateral or multilateral discussions, preferably before the second session of the conference. During the planning process, all proposed digital broadcasting allotments and assignments are open to discussion through bilateral or multilateral negotiation among the administrations concerned, which may be conducted either directly or with the assistance of the ITU Radiocommunication Bureau within their available resources, on the understanding that those administrations may be requested to modify the characteristics of their allotments or assignments. These bilateral or multilateral agreements need to be taken into account in the planning process when administrations declare incompatible digital broadcasting requirements as compatible, providing this does not affect other administrations concerned. See § 6.2 for the format in which such agreements are recorded.

5.1.7 Treatment of other primary services

5.1.7.1 General

The definition of existing and planned assignments of other primary services to be protected by digital broadcasting assignments and allotments in the new plan is found in § 1.7. Before the start of the second session of RRC, the ITU Radiocommunication Bureau will draw up and post on the RRC section of the ITU website (www.itu.int) a list of such assignments of other primary services that need to be taken into account. Existing and planned assignments to other primary services should only be taken into account during the planning process at the request of administrations concerned and as defined in § 1.7 of this report. Potential incompatibilities between digital broadcasting requirements and assignments of other primary services could be resolved by bilateral or multilateral negotiations.

5.1.7.2 Protection of assignments of other primary services during the establishment of the new plan

Compatibility between the digital broadcasting assignments/allotments contained in this new digital plan and the existing and planned assignments of other primary services that are to be protected in the new plan should be ensured in the design of the plan.

See also § 1.7 including footnotes 5, 6 and 7.

5.1.8 Preparation of requirements

The preparation of requirements is the responsibility of administrations.

5.1.8.1 Generating digital broadcasting requirements when none are submitted

In order to preserve the rights of all administrations and facilitate subsequent coordination, those countries covered by the planning area, but not present at the second session of the conference, and which have not submitted their digital broadcasting requirements, should be provided with a reasonable number of allotments and/or assignments.

5.2 Planning methods

5.2.1 General aspects of the planning structure

The following aspects need to be considered in relation to the broadcasting planning structure:

5.2.1.1 Planning approach and methods

– The planning methods should be able to deal with different planning approaches being adopted for different geographical areas. Since different planning methods and approaches may be used, special measures and procedures should be elaborated to ensure the compatibility of plans;

– different planning methods may be used for different portions of the bands being considered;

– both lattice-based and non-lattice-based planning methods should be accommodated during the planning process.

5.2.1.2 Allotments and assignments

– T-DAB planning should be based on allotment planning, if appropriate;

– DVB-T planning should be based either on allotment or assignment planning or a combination of both;

– the planning process should be able to deal with both allotments and assignments;

– planning should be based on the protection of the service area for assignments and allotments. Administrations should be free to specify their input requirements as either assignments and/or allotments. (See also § 5.1.7 “Treatment of other primary services”.)

5.2.1.3 Network configuration, receiving modes and system variants

– T-DAB planning should as far as practicable be based on SFNs;

– for DVB-T, the planning process should be able to deal with MFN, SFN or a combination of both;

– for both T-DAB and DVB-T, the planning methods shall enable plans to be developed for RPCs and different reference networks as given in § 3.6.2 and 3.6.3, respectively;

– the number of system variants to be considered in the planning process should be limited as far as possible, as described in Annex 3.4.

5.2.2 Allotments and assignments

5.2.2.1 Introduction

The planning process can be considered as a multiple-step process which includes a "compatibility analysis" and a "synthesis". The analysis step is intended to identify incompatibilities among the input requirements to determine which requirements may not share any given channel, while the synthesis step is intended to identify different possible frequency distributions.

5.2.2.2 Assignment planning

The term "assignment planning" is defined in Chapter 1, § 1.6.2.

In the past, terrestrial television planning has been implemented by way of assignment conferences. In assignment planning, a significant amount of individual station planning is needed to prepare for a planning conference.

Assignment planning, based on a lattice structure, for terrestrial digital television is appropriate where all the transmitter sites can be assumed to have the same characteristics. This is not to say that station characteristics are fixed for all time.

An assignment plan provides a frequency for each station and at the completion of the assignment planning process the locations and characteristics of the transmitters in the planning area are known. The transmitters can be brought into service without further coordination.

For practical reasons, a lower limit for the radiated power is normally defined for stations to be dealt with in the planning process. Stations with a radiated power below the limit are then included in the plan subsequently.

5.2.2.3 Allotment planning

The term "allotment planning" is defined in Chapter 1, § 1.6.1.

The possibility of obtaining allotments at a terrestrial broadcasting conference has received attention in recent years, particularly because of the opportunities offered by SFNs. Allotments may also be applicable for MFN planning where a country has no plans to use specific transmitter sites and wishes to retain some flexibility for the future.

Thus, in order to carry out the planning it is necessary to define some reasonably realistic reference transmission conditions which represent the potential interference which could be caused, so that any necessary compatibility calculations can be made.

The resulting allotment plan provides the frequencies to be used in particular areas without specifying the stations to which the frequencies are assigned.

5.2.2.4 Mixed planning

It is not necessary to use exclusively allotment planning or exclusively assignment planning to produce a plan. A mixed plan can be produced, provided that at least the following are specified:

a) the intended service area;

b) the interference potential of the assignment or allotment.

Such a mixed plan, containing both assignments and allotments, gives equal priority to both.

5.2.2.5 Specification of service area

Service areas are specified by boundary test points. The service area of an allotment is explicitly given in the allotment area requirement (see Chapter 6). In the case of an assignment, the service area is calculated from the characteristics of the assignment as part of the planning procedure (a method for this is given in § A.5.2.2.1).

5.2.2.6 Characterization of interference potential

For an assignment the interference potential can be calculated from the characteristics of the assignment supplied by the requesting administration.

For an allotment, the interference potential may either be calculated as:

a) the aggregate interference from the known assignments, i.e. one transmitter or a group of transmitters (forming an SFN) whose precise site location(s) and other technical characteristics are known at the time when the plan is made; or as

b) the interference potential from the relevant reference network specified by the administration in its input requirements. (See § 3.6.3 on reference networks.)

5.2.2.7 Methods for the conversion of analogue assignments into digital allotment or assignment requirements

Administrations may wish to establish a frequency plan for digital broadcasting which is based on existing analogue frequency plans. It can be advantageous to convert entries of existing analogue frequency plans (which are lattice based) to digital assignment or allotment requirements. Two such methods are described in § A.5.2.2.2.

5.2.3 Procedure for the production of a plan

5.2.3.1 Lattice and non-lattice-based planning

Traditionally, two methods have been employed for the preparation of a frequency plan. These are:

– lattice-based – a systematic and geographically regular distribution of frequency resources over an area;

– non-lattice-based – an irregular, but spectrum-utilization-efficient distribution of frequency resources over a geographical area.

Either of the two methods is suitable for assignment/allotment planning, and either is capable of use in the presence of pre-existing constraints.

With regard to the choice of a planning method or methods, lattice-based methods have successfully provided the basis for most of the past frequency plans and would be appropriate for use in digital broadcasting planning in areas of relative uniformity of requirement characteristics. This method essentially applies in areas where existing or planned assignments are converted to digital assignments and will form part of the digital plan.

However, in areas where there are non-uniform requirements for digital broadcasting (e.g. very different sizes of service area and various reception conditions), or in areas where there is a requirement for digital broadcasting stations and there are already networks of analogue stations, non-lattice-based planning will provide an optimum means to achieve both the desired coverage and the most efficient use of the available spectrum. This method permits the addition of assignments which are not distributed across the total area in any regular way and which may not have equal-sized service areas.

5.2.3.2 "Compatibility analysis" and "synthesis" process

The planning process can be split into "compatibility analysis" and "synthesis" stages. The analysis stage would enable incompatibilities to be identified and appropriate responses to these incompatibilities to be considered by the second session of the conference.

The planning process may be summarized by the following steps:

Step 1: submission of the input requirements for digital broadcasting;

Step 2: identification of the analogue broadcasting stations and of other services that need to be taken into account;

Step 3: performance of compatibility analyses;

Step 4: assessment of the results from Step 3;

Step 5: allowance for administrative input concerning compatibility between requirements, with a return to Step 3 if necessary;

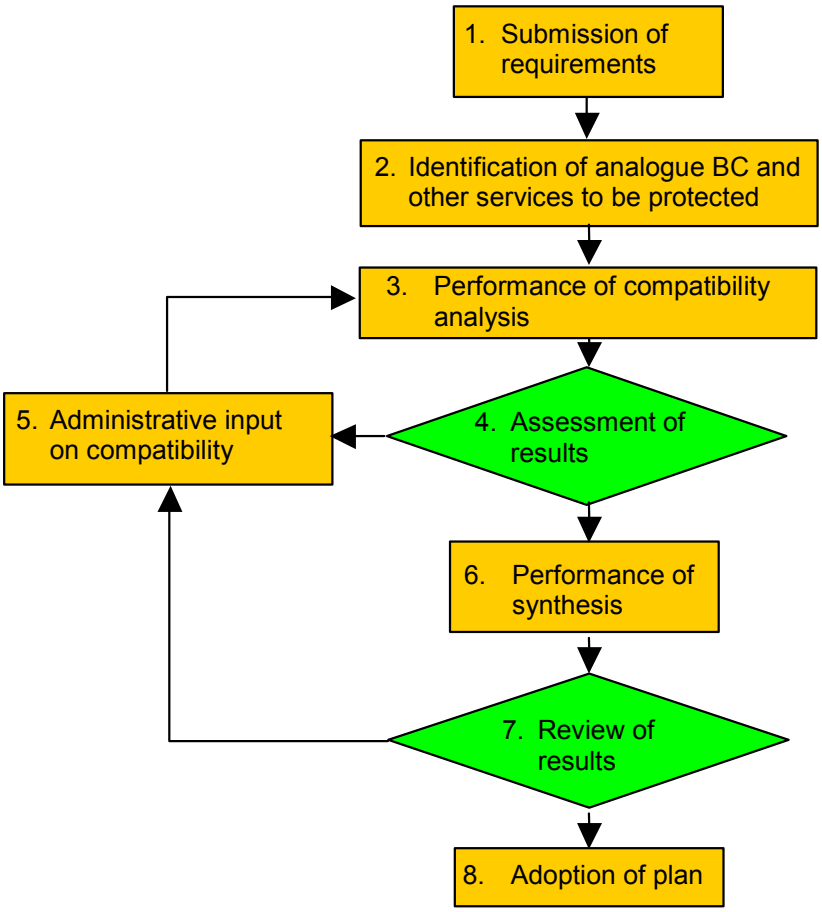
Step 6: performance of synthesis, the output of which is a plan;

Step 7: review of the results, with a loop back to Step 5 and then to Step 3 if the desired result is not achieved;

Step 8: adoption of the final plan.

FIGURE 5.2.3-1

Steps in the "compatibility analysis" and "synthesis" process



A detailed description of the compatibility analysis is given in § 5.3.1.

A detailed description of the synthesis process is given in § 5.3.2.

5.3 Planning tools

5.3.1 Compatibility analysis

5.3.1.1 Planning methods

5.3.1.1.1 Identification of incompatibilities between requirements

5.3.1.1.1.1 General

In order to produce a frequency plan it is necessary to know which requirements may not share any given channel. This is done by identifying all of the requirements which are incompatible with a given requirement. It is only necessary to consider two requirements at a time in order to establish a complete set of incompatibilities. For this purpose it is not necessary to know which channels any given requirement may use.

From the protection ratio values for digital broadcasting systems it is apparent that only co-channel or overlapping channel interference need be taken into account and that adjacent channel and image channel interference may be neglected.

The more general case of requirements using channels in Bands IV or V is dealt with first. The additional information needed for the case of requirements using channels in Band III is dealt with at the end of this section.

In order to be able to deal with a set of requirements which may be specified as assignments or allotments or as a mixture of these two, it is necessary to assume that the area to be covered by any given requirement is specified in some way. The following text assumes that this is done by means of a series of geographic locations, referred to as test points, situated around the boundary of that area. These test points are specified by their geographic coordinates.

The service within the area of the requirement may be provided either by a single assignment or by a set of assignments operating as a single frequency network (SFN). The following text assumes that the outgoing interference from any point on the boundary of an SFN is represented as a "reference source" situated on a specified location on a reference network. The implication of this is that it is not necessary to specify the site locations of the individual assignments within the SFN.

The interference potential of an individual requirement using an SFN may be determined by considering that the reference source, relevant to the reference network specified by the concerned administration for the requirement, is situated at each of the test points in turn. It is to be noted that this does not imply that the reference network needs to be implemented physically in order to provide coverage within the area of the requirement, nor does it imply that an interference source will exist physically at any test point when the requirement is implemented.

5.3.1.1.1.2 Calculation methods

In order to identify requirements which are incompatible, two sets of calculations are needed. The first set identifies requirements which have a service overlap, and the second set identifies requirements which would produce excessive interference if operating on the same channel.

To identify requirements which overlap, it is necessary to examine each of the test points for one requirement to determine if it lies inside the area of a second requirement. Because there can be anomalies in the case where there are large separation distances between adjacent test points, it is also necessary to repeat the examination to determine if any of the test points of the second requirement lies inside the area of the first requirement.

To identify requirements which are incompatible because of potential interference, it is necessary to consider three cases:

– where both of the requirements are specified as assignments;

– where one of the requirements is specified as an assignment and the other is specified as an allotment;

– where both requirements are specified as allotments.

In all three of the above cases, the assessment of the protection margin is made separately using the method of § 5.3.1.2.1 for each of the test points which define the area to be served.

When applying the method of § 5.3.1.2.1, the wanted field strength is:

– in the case of an assignment, the reference field strength for 50% of the time and 50% of locations or the wanted field strength for 50% of the time and 50% of locations provided by the assignment calculated using the method of § 5.3.1.2.2;

– in the case of an allotment, the reference field strength for 50% of the time and 50% of locations specified for use with the specified reference network.

The nuisance field strength is calculated for 50% of locations and for 1% of the time (thus providing protection against interference for 99% of the time) except where a value greater than 1% is agreed between the concerned administrations.

The wanted field strength and the reference field strength are dependent on the service conditions. These service conditions include:

– reception mode: (fixed, portable, mobile);

– type of service: (television or sound radio);

– system variant: (64-QAM, 16-QAM or QPSK) together with the code rate to be used;

– reference planning configuration;

– target percentage of locations to be achieved.

The calculations described above are needed for the case of the first requirement considered as the source of potential interference to the second requirement, and for the case of the second requirement considered as the source of potential interference to the first requirement.

If the protection margin is negative at any test point of either requirement, the two requirements are theoretically incompatible.

5.3.1.1.1.3 Special consideration for requirements in Band III

In the case of Band III, it is also necessary to consider the impact of the possible overlapping channel situations which might occur. This involves an extension to the process described in § 5.3.1.1.1.1 and § 5.3.1.1.1.2. In addition to the calculations described there, it is also necessary to calculate the amount of any permitted frequency overlap between two requirements and also to obtain information about the particular set of channels which each requirement might occupy. The latter information is available from knowledge of the channel alignment in use by any given administration.

5.3.1.1.1.4 Sets of incompatible requirements

For each requirement, the process described in § 5.3.1.1.1.2, when applied to all other requirements in turn, permits the establishment of the set of incompatible requirements. If applicable, this information may need to be supplemented as described in § 5.3.1.1.1.3. This set of incompatible requirements forms one element of the planning process.

5.3.1.1.1.5 Administrative declarations

If it so wishes, an administration may declare that two of its requirements are compatible, without adversely affecting other administrations, even though the calculations using the methods of § 5.3.1.1.1.2 indicate that the requirements are incompatible. This is equivalent to declaring that the requirements may share a channel if that makes the planning process easier.

It is possible for two administrations to declare that two requirements, one for each administration, are compatible, without adversely affecting other administrations, even though the calculations using the methods of § 5.3.1.1.1.2 indicate that the requirements are incompatible. This is equivalent to declaring that the requirements may share a channel if that makes the planning process easier.

It is possible for one administrations to declare that two of its requirements are incompatible even though the calculations using the methods of § 5.3.1.1.1.2 indicate that the requirements are compatible. This is equivalent to declaring that the requirements may not share a channel.

It is also possible for two administrations to declare that two requirements, one for each administration, are incompatible even though the calculations using the methods of § 5.3.1.1.1.2 indicate that the requirements are compatible. This is equivalent to declaring that the requirements may not share a channel.

5.3.1.1.2 Identification of channels available for use by a requirement

5.3.1.1.2.1 General

In order to identify which channels might be available for use by a given requirement, it is necessary to take into account any indications provided by the concerned administration and to calculate any potential interference from or to all existing or planned broadcasting stations and all other primary service stations, as appropriate. However, in the case where an administration allows for a choice to be made between multiple channels, it is not necessary to know which requirements are compatible with any other requirements, all that is established here is which channels a given requirement might be able to use.

5.3.1.1.2.2 Calculation methods

As was already noted in § 5.3.1.1.1.1, digital broadcasting requirements have their service area defined by a set of test points. Analogue broadcasting service stations, mobile service stations and stations of the aeronautical radionavigation service are considered in the same way, although it is necessary to calculate the locations of the test points by the method of § 5.3.1.1.3 if the service area is not specified by the concerned administration. Reception locations for fixed service stations will need to be specified by the concerned administration. Radio astronomy service station sites will need to be specified by the concerned administration.

All calculations for a given requirement take account of any potential interference which it might cause and what potential interference it might suffer (except in the case of possible interaction with a station of the radio astronomy service) if it were to use any individual channel.

In the case of potential interference to the requirement, the protection margin is calculated as in § 5.3.1.2.1:

– for each channel;

– for each broadcasting or other primary service station which might cause interference to the requirement;

– for each of the test points defining the boundary of the area of the requirement.

In the assessment of the protection margin:

– 50% of the time and 50% of location values will be used for the wanted signal;

– 1% of the time (except in the case of a specific request by individual administrations to use a higher value) and 50% of location values will be used for the nuisance signal, calculated as in § 5.3.1.2.3.

The reference reception values for the wanted signal depend on the service conditions.

In the case of potential interference from the requirement, the protection margin is calculated as in § 5.3.1.2.1:

– for each channel;

– for each broadcasting or other primary service station which might suffer interference from the requirement;

– for each of the fixed test points or the test points defining the boundary of the service area of the other service.

In the assessment of the protection margin:

– 50% of the time and 50% of location values will be used for the other primary service wanted signal;

– the percentage time and location values used for the nuisance signal, calculated as in § 5.3.1.2.3, are given in Chapter 4.

The reference emission values for the signal from the requirement depend on the service conditions.

If the lowest protection margin for any test point and for any channel is less than –0.5 dB, that channel is not available for the requirement.

5.3.1.1.2.3 Channel availability lists

At the end of the calculations described in § 5.3.1.1.2.2, the set of available channels is known for a given requirement.

5.3.1.1.2.4 Administrative declarations

If it so wishes, an administration may declare that a requirement may use a given channel even though the calculations using the methods of § 5.3.1.1.2.2 indicate that the use of that channel is not possible. This is equivalent to declaring that the requirement may use a particular channel if that makes the planning process easier. However, this declaration is only possible if there are no potential incompatibilities with services of some other administration. If there are incompatibilities which involve more than one administration, then it will be necessary for both administrations to declare that a given channel may be used by a given requirement.

It is also possible for an administration to declare that a requirement may not use a given channel even though the calculations using the methods of § 5.3.1.1.2.2 indicate that the channel may be used.

The declarations identified in the previous paragraphs may only be made if they do not adversely impact the planning process.

5.3.1.1.3 Calculation of the position of the test points delineating the service area

The method of § 5.3.1.2.4 is used to calculate the position of the test points delineating a service area in the case that the service is provided by an assignment and not by an allotment. While the emission and reception conditions are service-dependent, the same process is used for all services. In order to use the method of § 5.3.1.2.4, it is necessary to specify the bearings for which the service radius is to be determined.

In the form given in § 5.3.1.2.4, the method calculates the coverage area in the absence of interference. However, by calculating the protection margin instead of the wanted field strength, the effect of interference is taken into account and the service area is then defined.

5.3.1.1.4 Method for producing a plan

The method given in § 5.3.2 is to be used to produce a plan.

5.3.1.1.5 Analysis of final plan(s)

The approach given in § 5.3.1.2.4 will be used to calculate the position of the test points delineating the service area of all assignments in the final plan(s), noting that it is necessary to calculate protection margins instead of wanted field strength in order to take interference into account. For allotments, the analysis will consist of calculating the protection margins for the test point locations specified by the administration concerned.

5.3.1.2 Elements of planning methods

The elements given below apply to calculations involving digital and analogue transmitting and receiving stations in the broadcasting service and in other primary services. It is to be noted that the terms “base” and “mobile” are used in the mobile service. In this section, the terms “transmitting station” and “receiving station” are used to describe the functionality of stations in general and are thus not confined to stations of the broadcasting service.

5.3.1.2.1 Protection margin

The protection margin is calculated as:

wanted field strength – nuisance field strength – combined location correction factor

In this expression, the wanted and nuisance field strengths refer to 50% of location values of those field strengths. The purpose of the combined location correction factor is to convert the protection margin to the percentage location value needed for the wanted service.

Calculate the wanted field strength as in § 5.3.1.2.2.

Calculate the nuisance field strength as in § 5.3.1.2.3.

Calculate the combined location correction margin as in § 5.3.1.3.4.

The test point location at which the wanted field strength is to be determined will be determined as part of the planning process. These test point locations may be calculated or may be defined by the concerned administration.

Test point locations:

– in the case of an assignment or allotment with a single defined service area, the test point location may be at any point on the periphery of that service area in order to ensure that worst-case conditions are taken into account;
– in the case of an allotment whose service area is made up of a number of discrete areas taken together, the test point location may be at any point on the composite boundary of these areas taken together;
– in the case of an assignment or allotment whose service area is an entire country, the test point location may be at any point on the boundary of the country.

In any of these cases, the test point locations may be defined by the concerned administration, although it will be necessary to verify by means of calculations that such test points are technically valid.

In any case where the test point is intended to represent the edge of the service area, the wanted field strength indicated in the expression in the first two lines of the this section will be the minimum median field strength. This value is derived from the minimum field strength as in § 5.3.1.3.5.

In the case that there are several nuisance signals, it is necessary to combine them, using the information in § 5.3.1.2.6, and substitute the results for 50% of location value of nuisance field strength and σ_n in the expressions given above and in § 5.3.1.3.4. An additional signal will be included in the summation; this is the minimum median field strength and it is added to represent the noise level.

Similarly, if the wanted signals come from multiple sources, it will be necessary to combine them, using for example the information in § 5.3.1.2.5, and substitute the results for 50% of location value of wanted field strength and σ_w in the expressions given above and in § 5.3.1.3.4.

5.3.1.2.2 Wanted field strength at a receiving location

Identify the receiving location in terms of its geographic coordinates.

Identify the frequency, percentage of time and percentage of locations for which the result is needed. All of these elements enter into the detailed calculations carried out in subsequent steps.

Identify the source of the wanted signal and its geographic coordinates.

Calculate two field strengths (one for each polarization) at the destination given by the receiving location coordinates as in § 5.3.1.3.1.

If the reception mode is fixed:

– Calculate 50% of location field strength as the value obtained from § 5.3.1.3.1 for the polarization of the receiving antenna. In the case of a transmitted signal which has mixed polarization, the polarization of the receiving antenna is that of the larger received component, otherwise, the polarization of the receiving antenna is that of the wanted transmission.

If the reception mode is portable or mobile:

– Calculate 50% of location field strength as the larger of the values for the two planes of polarization obtained from § 5.3.1.3.1.

In the case where the polarization of the wanted signal is not specified, the receiving antenna is also assumed to have no polarization discrimination.

5.3.1.2.3 Nuisance field strength at a receiving location

Identify the receiving location in terms of its geographic coordinates.

Identify the frequency, percentage of time and percentage of locations for which the result is needed. All of these elements enter into the detailed calculations carried out in subsequent steps.

Identify the source of the interfering signal and its geographic coordinates.

Calculate two field strengths (one for each polarization) at the destination given by the receiving location coordinates as in § 5.3.1.3.1.

If the receiving antenna has directional or polarization characteristics:

– Calculate the bearing from the receiving location to the source location.

– Calculate the receiving antenna discriminations against vertically and horizontally polarized signals as in § 5.3.1.3.2.

– Calculate 50% of location field strength at the receiving location as the power sum of the relevant field strengths and receiving antenna discriminations for the two planes of polarization.

If the receiving antenna has no directional or polarization characteristics:

– Calculate 50% of location interfering field strength at the receiving location as the power sum of the two field strengths.

Calculate the relevant protection ratio value as in § 5.3.1.3.3.

Calculate the sum of the protection ratio and the interfering field strength at the receiving location.

5.3.1.2.4 Receiving location at which a target field strength is reached

Identify the frequency, percentage of time and percentage of locations for which the result is needed. All of these elements enter into the detailed calculations carried out in subsequent steps.

Obtain the bearing for which the receiving location is needed.

Set the "current distance" to an initial value of, say, 1 km.

5.3.1.2.4.1 Calculate a "current receiving location" on the given bearing at the "current distance".

5.3.1.2.4.2 Calculate the "current field strength" for the destination given by the "current receiving location" as in § 5.3.1.3.1.

5.3.1.2.4.3 If the absolute difference between the "current field strength" and the target field strength is smaller than a defined margin, the required receiving location has been found.

5.3.1.2.4.4 If the field strength from § 5.3.1.2.4.1 is larger than the target field strength, increase the current distance.

5.3.1.2.4.5 If the field strength from § 5.3.1.2.4.1 is smaller than the target field strength, reduce the current distance.

5.3.1.2.4.6 Return to § 5.3.1.2.4.1.

5.3.1.2.5 Wanted signal summation

In the case of digital broadcasting, it is possible to operate a set of transmitting stations as an SFN, and it is then necessary to use a statistical method for signal summation. The *k*-LNM (see § 5.3.1.3.7) will be used to calculate the mean and standard deviation of the field strength distribution test points.

5.3.1.2.6 Unwanted signal summation

If the wanted signal is analogue or digital:

– the power sum method as given in § 5.3.1.3.6 is used.

5.3.1.3 Details of calculation methods

5.3.1.3.1 Field strengths at a destination

Calculate the length of the path from source to destination using great circle geometry.

Calculate the relative proportions of land and sea for the path.

If the source is a transmitter:

– calculate the bearing from the source to the destination using great circle geometry;

– calculate the effective height of the transmitting antenna as a function of the bearing;

– calculate the field strength value at the destination for an effective radiated power (e.r.p.) of 1 kW using the propagation prediction method given in Chapter 2.

In the case where the transmitted signal has mixed polarization:

– obtain the maximum e.r.p. for the horizontally and vertically polarized components of the radiated signal;

– calculate the reduction in e.r.p. for each plane of polarization as a function of the bearing;

– calculate the field strengths at the destination taking account of the maximum e.r.p. and the reductions in each plane of polarization.

In the case where the transmitted signal has either vertical or horizontal polarization:

– obtain the maximum e.r.p. for the relevant polarized component of the radiated signal;

– calculate the reduction in e.r.p. for the relevant plane of polarization as a function of the bearing;

– calculate the field strength at the destination taking account of the maximum e.r.p. and the reduction in the relevant plane of polarization;

– set the field strength in the other plane of polarization to a low value, say –99.9 dB(μV/m).

In the case where the polarization of the transmitted signal is not specified, the polarization must be regarded as being the same as that of the receiving antenna in order to ensure that worst-case conditions are taken into account.

If the source is a reference source:

– calculate the field strength at the destination from the characteristics of the reference source taking account of the distance and the propagation path and also taking account of the polarization of the reference source (as specified above for the case of a transmitter). In the case where the reception location is specified to be significantly above the surface of the earth and where a line of sight condition applies, the field strength is obtained using a free space calculation and taking account of the total power of the transmitters in the reference network.

5.3.1.3.2 Receiving antenna discrimination values

If the receiving antenna has neither directivity discrimination nor polarization discrimination:

– set the discrimination against horizontally polarized signals to zero;

– set the discrimination against vertically polarized signals to zero.

If the receiving antenna has directivity or polarization discrimination:

– Calculate the directivity discrimination of the receiving antenna as a function of the frequency and the absolute difference between the bearing of the interfering signal and the bearing of the wanted signal.

– Calculate the polarization discrimination, this may be a function of the frequency in the case of some other primary services.

– Determine the polarization of the receiving antenna:

  – If the antenna is vertically polarized, set the discrimination against vertically polarized signals to the value of the directivity discrimination and set the discrimination against horizontally polarized signals to the value of the polarization discrimination.

  – If the antenna is horizontally polarized, set the discrimination against horizontally polarized signals to the value of the directivity discrimination and set the discrimination against vertically polarized signals to the value of the polarization discrimination.

5.3.1.3.3 Protection ratio value

Calculate the protection ratio from the information in Chapters 3 and 4.

The planning exercise team will need to select the relevant protection ratios where no information has been provided by administrations, and seek the approval of the administrations concerned. The IPG need to be informed in this regard.

5.3.1.3.4 Combined location correction factor

Calculate the combined location correction factor as:

$$\mu\sqrt{(\sigma_w^2+\sigma_n^2)}$$

where:

μ = $Q_i(1 - x/100)$

Q_i: multiplying factor given in § 12 of Annex 2.1 to Chapter 2

x: percentage of location for which protection is required

σ_w: standard deviation of location variation for the wanted signal

σ_n: standard deviation of location variation for the nuisance signal.

5.3.1.3.5 Minimum median field strength

The minimum median field strength is the field strength required at 50% of locations in order to ensure that the minimum field strength can be achieved for the wanted service at the required percentage of locations. This is expressed as:

$$\text{minimum median field strength} = \text{minimum field strength} + \mu\,\sigma_w$$

where the symbols have the same meaning as in § 5.3.1.3.4.

5.3.1.3.6 Power sum method

The power sum is the logarithmic value of the sum of the individual field strengths expressed as arithmetic powers:

$$\text{sum} = 10 \log\left(\sum 10^{\frac{E_i}{10}}\right)$$

where E_i represents the individual field strengths (dB(μV/m)).

5.3.1.3.7 Statistical summation method

The *k*-LNM method is described in detail in Annex 5.3.1

5.3.1.3.8 Derivation of intermediate radiation pattern values

Where an antenna is directional, horizontal radiation patterns may have been given as part of the input data for bearings at intervals of 10°, linear interpolation being used to obtain radiation reduction values for intermediate bearings. Alternatively, the transmitting antenna pattern may be calculated, where the relevant information has been provided as part of the input data, using Recommendation ITU-R BS.1195 for broadcasting services and Recommendation ITU-R F.699 for fixed service.

5.3.1.3.9 Derivation of intermediate values of effective height

Where the terrain around a transmitter site is not uniform, an array of effective height values may have been given as part of the input data for bearings at intervals of 10°, linear interpolation being used to obtain effective height values for intermediate bearings.

5.3.2 Plan synthesis

5.3.2.1 General

The synthesis of a frequency plan is the process of determining a suitable channel (frequency) for each requirement (assignment or allotment) so that no harmful interference is caused to the existing and planned stations by the requirements, and that no harmful interference is caused to the requirements, either due to the existing and planned stations or due to the requirements amongst themselves, in their respective channels. The situation concerning requirement compatibility/incompatibility and channel availability is calculated during the compatibility analysis (see § 5.3.1) and is thus a predetermined input to a synthesis process.

5.3.2.2 Synthesis: algorithms

A synthesis procedure involves the attribution of channels (frequencies) to requirements, taking into account the results of the compatibility analysis as regards:

– the channels which are available to meet the requirements;

– the incompatibilities between requirements.

At any point during the synthesis process there are generally many possible channels available for each particular requirement. The selection of a channel for a requirement at any juncture will influence the development of the synthesis thereafter. Each individual choice is determined by the rules of the particular algorithm. The number of channel choices available for requirements treated

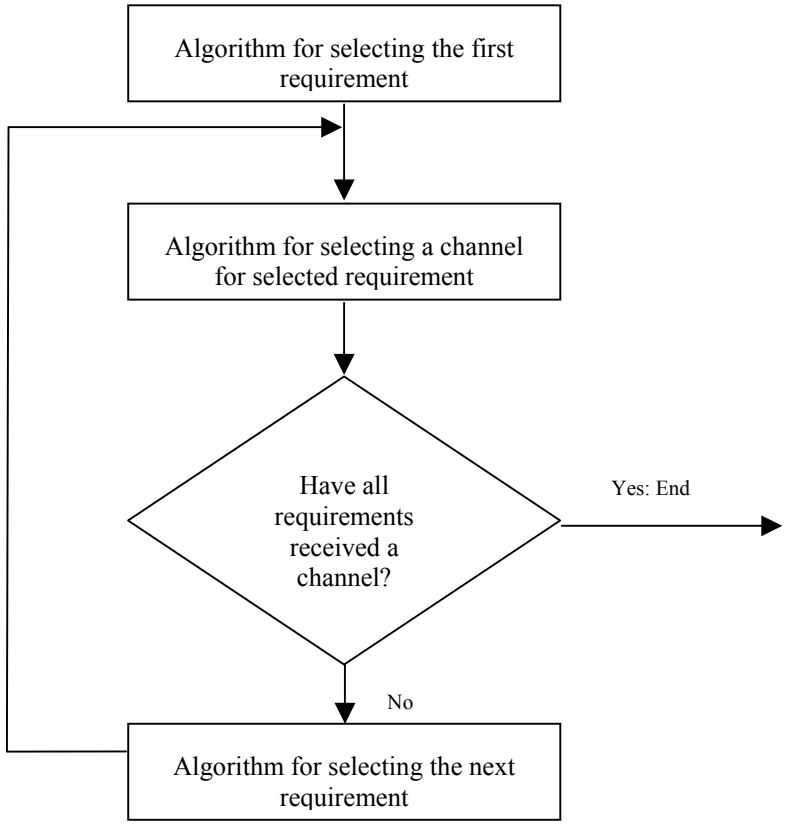
towards the end of the process will generally decrease as the synthesis continues. In the worst case, no channels will be available for one or more requirements towards the end of the synthesis procedure. Thus, it is important to make assignment choices at the beginning of a synthesis process that do not too significantly reduce the possibilities in the synthesis process at a later point.

Variations in the planning situation between Band III and Band IV/V will necessitate different synthesis approaches, and therefore different computer synthesis implementations, to reflect the distinctions. For example, in Band III, the plan will be synthesized with respect to T-DAB with a 1.75 MHz bandwidth (32 frequency blocks) and DVB-T with a 7 or 8 MHz bandwidth (7 or 8 channels) and multiple channel spacings and alignments; in Band IV/V, the plan will be synthesized with respect to DVB-T with a 8 MHz bandwidth (49 channels) and a single channel spacing and alignment.

Specific synthesis methods to be used include sequential assignment procedures whereby frequencies are assigned to requirements one by one (see Fig. 5.3.2-1 for a general approach). These methods are rapid when carried out with a computer, and many algorithms are known. A large number of such algorithms form the basis of a single synthesis approach, with the results of the best algorithm being retained as the overall result.

FIGURE 5.3.2-1

General flowchart of sequential frequency-synthesis planning



5.3.2.3 Synthesis planning

Synthesis is generally not an “all at once” event, but starts with no requirements having been assigned a channel, and proceeds to the finish, where all requirements have been assigned a channel.

During the synthesis stage of planning, a satisfactory solution (i.e. all requirements assigned a frequency) is not expected to be achieved on the first synthesis attempt. It is thus necessary to adopt an iterative procedure, as shown in § 5.2.3.2.

ANNEX 5.2.2

A.5.2.2.1 Proposed method for establishing the service area of assignments

A.5.2.2.1.1 Existing or planned assignments

To calculate the service area of an existing or planned assignment, two elements are necessary:

– the parameters specific to an individual transmitting station (coordinates, effective height of the antenna, radiated power, etc.) which are used to calculate the wanted signal. These parameters are needed for the individual station under consideration and for all potentially interfering stations;

– the system parameters such as the minimum median field strength and the protection ratios which are used to calculate the individual nuisance field strengths and the usable field strength.

Because a certain amount of iteration is involved, the service areas are determined in three stages, and reference should be made to Fig. A.5.2.2.1-1 for clarification of the following texts:

Stage 1 – Calculation of noise-limited coverage area

Using the agreed propagation prediction model, the locations of the noise-limited test points are found, which represent the area that could be served if there were no interference. This area may be approximated on the basis of up to 36 radials, using the e.r.p. and the effective antenna height. For each radial, that location is determined where the field strength of the wanted transmitter equals the minimum median field strength.

Stage 2 – Identification of interferers

The impact of co-channel (and, in Band III, overlapping channel) interference from other transmitters and allotments is calculated for each wanted station and each noise-limited test point from Stage 1. First, the subset of possible interferers is established. This consists of the stations and allotments which can produce a nuisance field which is no more than 12 dB below the minimum median field strength at any of the noise-limited test points from Stage 1.

Stage 3 – Calculation of the test points for the interference-limited coverage

The individual nuisance field strength caused by each of the interfering stations or allotments in this subset of interferers is calculated at each of the noise-limited test points from Stage 1 (see Fig. A.5.2.2.1-1). The usable field strength is calculated for each of these test points.

In the case of no interferers, the usable field strength at a test point is equal to the minimum median field strength, no further calculation is required, and the coverage radius is that of Stage 1 above (see also Fig. A.5.2.2.1-1).

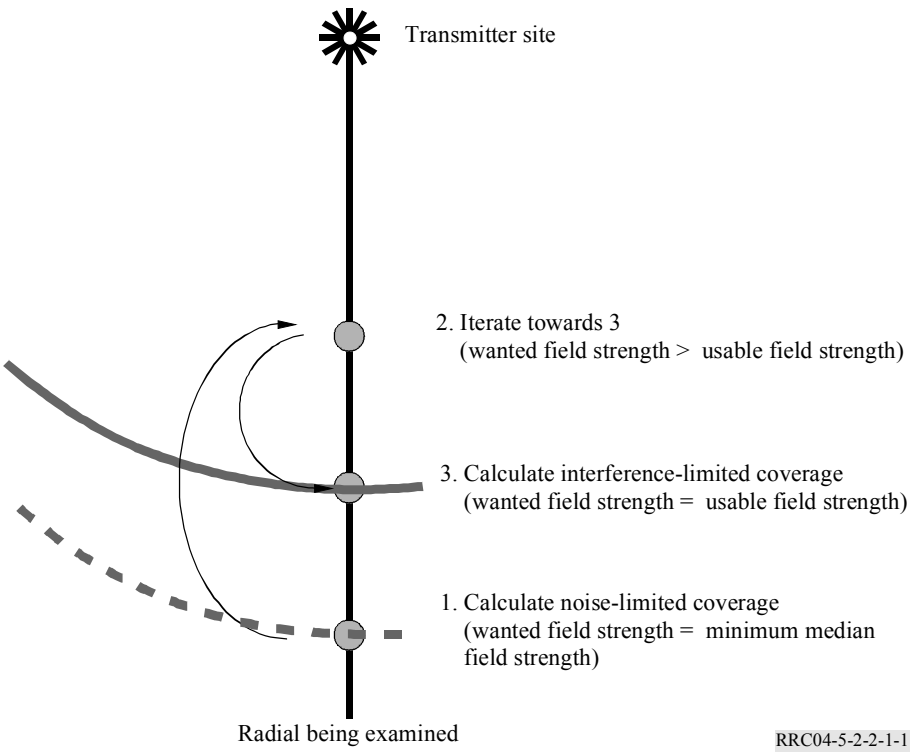
If the usable field strength at a test point is greater than the minimum median field strength, it is then necessary to find the new coverage radius on this bearing at which the field strength from the wanted station equals the usable field strength.

In general, the coverage radius thus calculated will not equal the radius previously calculated for the same bearing and thus the nuisance field strengths will change; hence, the process of the previous paragraph is repeated to obtain a close approximation to the required coverage radius on each of the bearings.

If the coverage radius crosses a country boundary, the test points in this area are located at the crossing points between a radial and the boundary unless otherwise agreed by the concerned administrations.

FIGURE A.5.2.2.1-1

Illustration of the calculation of location of test points for the interference-limited coverage



A.5.2.2.1.2 New digital assignment requirements

The method to calculate the service area of a digital assignment also refers to the calculation of a noise-limited coverage area, but, taking into account a required minimum median field strength which is augmented by a margin of 3 dB. This margin is added in order to allow a limited amount of interference to be introduced during the planning stage. Apart from this modification, the calculation of the service area is based on the same two elements as in § A.5.2.2.1.1. Furthermore, it follows the same procedure as given in § A.5.2.2.1.1, except that only the first stage of the calculation is needed. In this case also, the test points must not be outside the territory of the administration responsible for the assignment.

A.5.2.2.2 Two possible methods for the conversion of analogue assignments into digital allotment or assignment requirements

A.5.2.2.2.1 MFN conversion

A possible method to prepare assignment requirements for an all-digital plan is the conversion of analogue assignments into digital, while retaining the original MFN configuration. In this context, a conversion is one digital assignment that replaces one analogue assignment on the same frequency channel without increasing the usable field strength of other administrations' assignments and allotments. This is achieved by a suitable reduction of the e.r.p. of the digital assignment relative to that of the analogue assignment being converted, while maintaining the other transmission parameters (such as transmitting antenna height and radiation pattern) unchanged. The coverage of the converted digital assignments can closely match the service area of the original analogue stations. Low-power stations could form a part of such a plan and may be included in the conversion process.

This method might be suitable for countries that rely on fixed terrestrial antennas for a large proportion of their television reception.

With the correct e.r.p. reduction relative to the original analogue assignment, it retains compatibility with the current analogue entries in the ST61 or GE89 Plans, or with fully coordinated assignments in other countries outside the areas of these plans.

A.5.2.2.2.2 The channel potential method

The channel potential method provides information on how analogue assignments could be converted into digital allotment requirements, while facilitating compatibility with existing analogue or digital services.

The conversion of analogue assignments into digital allotments is a twofold process, in the sense that it involves two independent stages. The first stage consists in the construction of so-called channel potential areas for each channel under consideration.

The step-wise procedure to calculate the channel potential area is given below and illustrated in Fig. A.5.2.2.2-1:

Step 1: Define the minimum power limit of analogue assignments to be taken into account.

Step 2: Select all analogue assignments using a particular channel, according to the power limit.

Step 3: Calculate interference-limited contour for each selected assignment.

Step 4: Choose an assignment for which the channel potential area is to be calculated.

Step 5: Draw a line between the chosen assignment and any other adjacent assignment.

Step 6: Draw a normal at the midpoint between the intersections of the line with the interference contours.

Step 7: Define the value of the channel re-use distance *R*. This depends on the required transmitting parameters, the reception conditions and the propagation conditions between the two areas under consideration.

Step 8: On either side of the normal, at a distance of *R*/2, draw a line parallel to the normal.

Step 9: Repeat Steps 5 to 8 for each assignment adjacent to the chosen one.

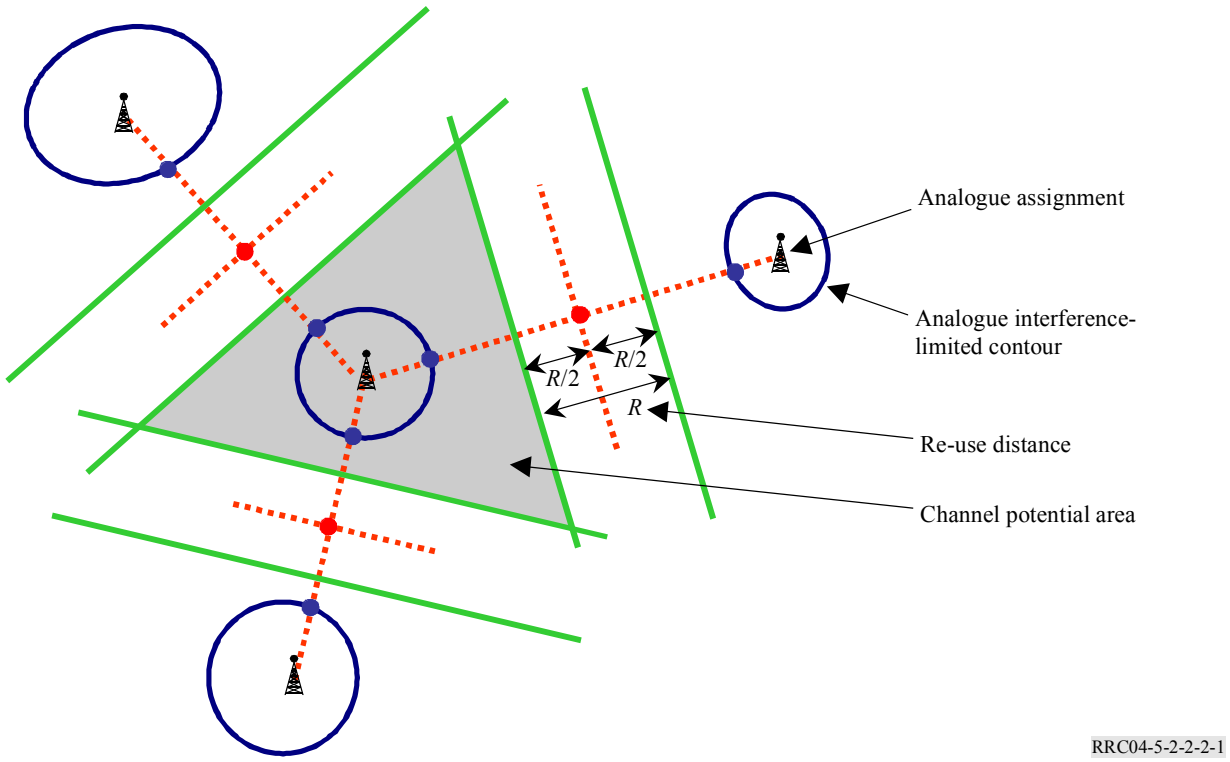
Step 10: Construct the channel potential area by connecting the intersection points of the individual borderlines.

In the second stage, the channel potential areas constructed in the manner described above are mapped onto the required service areas so that the allotment requirements are created. It should be also noted that channel potential areas constructed from the assignments belonging to one administration could be combined in order to provide more flexibility in defining allotment areas.

This method might be suitable for countries that wish to cooperate in the production of mutually compatible allotment plans.

FIGURE A.5.2.2.2-1

Construction of the channel potential area from analogue assignments



ANNEX 5.3.1

Mathematical treatment for combining multiple field strengths

A.5.3.1.1 *k*-LNM method

A value of 0.6 is used for *k*, and this can be expected to provide an accuracy within a few dB over 70% to 99% of location range.

Suppose there are given *n* logarithmic fields, F_i, with Gaussian distribution (parameters $\overline{F}_i, \sigma_i, i=1...n$), i.e. the corresponding powers are log-normally distributed.

The task is to determine the approximate log-normal distribution of the power sum, or, equivalently, to find the parameters of the Gaussian distribution of the corresponding logarithmic sum field:

Step 1: Transform $\overline{F}_i, \sigma_i, i=1...n$, from dB scale to Neper scale:

$$X_{\text{Neper}} = \frac{1}{10\log_{10}(\text{e})} \cdot X_{\text{dB}}$$

Step 2: Evaluate the mean values, M_i, and the variances, S_i^2, of the *n* power distributions:

$$M_i = \text{e}^{\overline{F}_i + \frac{\sigma_i^2}{2}}, \quad S_i^2 = \text{e}^{2\overline{F}_i + \sigma_i^2} \cdot \left(\text{e}^{\sigma_i^2} - 1\right), \quad i=1...n \qquad \text{(Neper scale)}$$

Step 3: Determine mean value, *M*, and variance, S^2, of the sum power distribution:

$$M = \sum_{i=1}^{n} M_i, \quad S^2 = \sum_{i=1}^{n} S_i^2 \qquad \text{(Neper scale)}$$

Step 4: Determine the distribution parameters $\overline{F}_\Sigma$ and σ_Σ of the approximate log-normal sum distribution:

$$\sigma_\Sigma^2 = \log_{\text{e}}\left(k\frac{S^2}{M^2} + 1\right), \quad \overline{F}_\Sigma = \log_{\text{e}}(M) - \frac{\sigma_\Sigma^2}{2} \qquad \text{(Neper scale)}$$

Step 5: Transform $\overline{F}_\Sigma$ and σ_Σ from Neper scale to dB scale:

$$X_{\text{dB}} = 10\ \log_{10}(\text{e}) \cdot X_{\text{Neper}}$$

$\overline{F}_\Sigma$ and σ_Σ are the mean value and the standard deviation, respectively, of the approximate log-normal distribution of the true sum field.