GE06 — overview of the second session (RRC-06) and the main features for broadcasters

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The Geneva 2006 frequency plan (GE06) is set to replace the Stockholm plan of 1961 (ST61) – providing for T-DAB and DVB-T digital services in the VHF and UHF broadcasing bands (Bands III and IV/V) throughout the European Broadcasting Area and beyond. The EBU contributed actively and efficiently to the success of the planning process, by developing the calculation software that was used by the ITU at RRC-06.

This article describes the planning process and its outcome which should ensure that spectrum is available for digital terrestrial broadcasting over the next few decades, covering a large area including 118 countries.

1. Background

The Stockholm '61 Agreement (**ST61**), a frequency plan for analogue broadcasting assignments, has provided the basis for all terrestrial television broadcasting in the European Broadcasting Area (EBA) for the last 45 years.

In the meantime, digital technology has made enormous strides, especially in the last two decades. Digital broadcasting (DVB and DAB, for example) holds the promise of providing more television and radio programmes with improved quality, as well as a more efficient use of the available broadcasting spectrum. Unfortunately, assignments using the new digital technology are not easily fitted into the structure of the ST61 plan and, to fully exploit its potential, a new frequency plan was deemed to be required.

After many discussions during numerous ITU meetings over the period 2001 - 2003, the ITU Council (Resolution 1224, 2003) decided to convene a relevant Regional Radiocommunication Conference (RRC) for the *"planning of the digital terrestrial broadcasting service in Region 1 (parts of Region 1 to the west of meridian 170°E and to the north of parallel 40°S) and in the Islamic Republic of Iran, in the bands 174 - 230 MHz and 470 - 862 MHz, in two sessions"*.

The first Session, **RRC-04** (held in Geneva in May 2004), established the technical basis (planning criteria and parameters) for the new Plan, i.e. for T-DAB and DVB-T in Band III and for DVB-T in Bands IV/V. (See [1] for a detailed review of the results of RRC-04.) The second Session, **RRC-06** (held in Geneva from 15 May to 16 June, 2006), adopted a New Agreement and associated Frequency Plans.

RRC-04 was only a prelude to the "real" planning work to be completed at RRC-06. During the two year interim period (the "intersessional period"), much work within the ITU, EBU and CEPT was carried out.

The ITU established “working groups” to deal with the multitude of tasks in preparation for RRC-06. In particular:

- An “Intersessional Planning Group” (IPG), to develop draft plans during the intersessional period, taking account of bi- and multi-lateral negotiations carried out by the Administrations (Resolution COM 5/1);
- A “Planning eXercise Team” (PXT), to carry out planning exercises (Resolution COM 5/1);
- A “Regulatory / Procedural Group” (RPG), to deal with the regulatory / procedural matters relating to the relevant parts of the RRC-06 agenda (Resolution PLEN 1).

The development of the calculation software was undertaken by the EBU Technical Department (TD), as specified in the Report from the RRC-04 to the second Session. The data-entry and data-validation software, and the software to display the results of the calculations, were undertaken by the ITU.

To meet the resulting demands (explicit and implicit) of the results of the first Session, the EBU established two Project Groups (B/BCP and B/EPS) which:

- evaluated the planning software (primarily for EBU Members);
- conducted the planning exercises (for EBU and ASBU Members);
- updated the existing technical planning criteria and proposed the revised criteria for use during the intersessional period and at RRC-06.

CEPT also carried out intersessional planning work very actively, in particular with respect to bi- and multi-lateral coordination between its Member Administrations, as well as establishing correct data for existing / planned broadcasting and relevant non-broadcasting services. CEPT focused its intersessional work within its Working Group RRC-06.

The EBU and CEPT cooperated closely in this work.

2. The unfolding of RRC-06

RRC-06 was held in Geneva from the 15th of May to the 16th of June 2006. More than 1000 participants, representing 104 countries, attended. The Chairman of the conference, Mr Kavouss Arasteh of the Islamic Republic of Iran, was unanimously elected the first day of the conference.

The work of the conference was undertaken by the following committees:

- Committee 1 – Steering Committee chaired by Mr K. Arasteh (Islamic Republic of Iran);
- Committee 2 – Credentials Committee chaired by Ms L. Hamdallah (Egypt);
- Committee 3 – Budget Control Committee chaired by Mr. E. Owusu-Adansi (Ghana);
- Committee 4 – Planning Committee chaired by Mr. D. Sauvet-Goichon (France);
- Committee 5 – Regulatory Committee chaired by Mr. S. Djematene (Algeria);
- Committee 6 – Editorial Committee chaired by Mr. F. Sillard (France).
- and the Working Group of the Plenary chaired by Mr. S. Perpar (Slovenia).

Committee 4 conducted the required planning activities and established the frequency plans for terrestrial digital broadcasting in the frequency bands 174 - 230 MHz and 470 - 862 MHz, and the associated analogue plan. Due to the large physical extent of the planning area and the different frequency-planning needs between the regions, the work was divided between five Coordination and Negotiation Groups (CNGs) [1]:

- CNG1: “Europe and the North Eastern part of the Planning Area”;
- CNG2: “Western/Central Africa”;

1. As defined by the RRC-06 (Document 47 Rev 1).

Abbreviations

ASBU	Arab States Broadcasting Union
CEPT	*Conférence Européenne des Postes et Télé-communications* (European Conference of Postal and Telecommunications Administrations)
CNG	(ITU) Coordination and Negotiation Group
DAB	Digital Audio Broadcasting (Eureka-147) http://www.worlddab.org/
DMB	Digital Multimedia Broadcasting http://www.t-dmb.org/
DVB	Digital Video Broadcasting http://www.dvb.org/
DVB-H	DVB - Handheld
DVB-T	DVB - Terrestrial
EBA	European Broadcasting Area
EBU-TD	EBU Technical Department
ERP	Effective Radiated Power
GE06	Geneva Frequency Plan of 2006
IFRB	(ITU) International Frequency Registration Board
IMT-2000	International Mobile Telecommunications - 2000
IPG	(ITU) Intersessional Planning Group
ITU	International Telecommunication Union
ITU-R	ITU - Radiocommunication Sector
MIG	Mutually Incompatible Group
PXT	(ITU) Planning eXercise Team
RN	Reference Network
RPC	Reference Planning Configuration
RPG	(ITU) Regulatory / Procedural Group
RR	(ITU) Radio Regulations
RRC	(ITU) Regional Radiocommunication Conference
SFN	Single-Frequency Network
ST61	Stockholm Frequency Plan of 1961
T-DAB	Terrestrial - DAB
T-DMB	Terrestrial - DMB
UHF	Ultra High Frequency
UMTS	Universal Mobile Telecommunication System
VHF	Very High Frequency
WRC	(ITU) World Radiocommunication Conference

- CNG3: “Eastern/Southern Africa”;
- CNG4: “Red Sea area (area with extreme propagation conditions) and other States”;
- CNG5: “Mediterranean”.

Committee 5 dealt with the regulatory, procedural and technical aspects relating to the use of the bands 174 - 230 MHz and 470 - 862 MHz by the Broadcasting Service and the sharing of these bands between the Broadcasting Service and the other primary services [2].

The working group of the Plenary established the planning parameters / criteria for digital broadcasting, taking into account the results of RRC-04 and the results of the intersessional work.

The result of the work undertaken during the five weeks of RRC-06 is the Geneva 2006 Agreement (**GE06**) which includes 12 articles, 5 technical annexes (including, in particular, the frequency plans) and 2 resolutions.

3. Software development

There were four main areas in the development of the required software during the intersessional period (extending into RRC-06):

- data capture and validation;
- compatibility analysis;
- plan synthesis, and
- display.

EBU-TD was tasked with the analysis and synthesis software development and the ITU was tasked with the data capture and display software development.

2. “Other primary services” are those services other than terrestrial broadcasting, which have Primary status in parts or all of the planning area, and that share the bands under consideration with the terrestrial broadcasting service. A few examples are: some aeronautical services, the radio astronomy service, the fixed service, the land mobile service, etc.

3.1. Compatibility analysis

Compatibility analysis was required during the planning process (intersessional as well as during RRC-06) in order to identify the required protection, i.e. in order to determine which digital requirements may or may not share any given channel and which may or may not use any given channel. This involved pair-wise calculations between digital requirements, as well as between the digital requirements and other primary services to be protected by the new Plan.

The first version of the compatibility software was presented to the ITU by EBU-TD at the end of August 2004. Thereafter the software was under continuous development and modification by EBU-TD in order to adjust to the revisions of technical parameters as decided by IPG, and even during RRC-06 itself. This included the updating / correction of data / services decided at RRC-04 as well as the inclusion of some parameters and other primary services not foreseen at RRC-04. Finally, additional analysis software was also developed by EBU-TD to enable an evaluation of the compatibility between the final digital Plan and the analogue television assignments.

3.2. Plan synthesis

The synthesis of a frequency plan is the process of determining a suitable frequency for each requirement so that no harmful interference arises, either to existing or planned stations or to the requirements themselves. Thus the results of the compatibility analysis must be taken into account as regards:

- the channels which are available to each requirement;
- the incompatibilities between requirements.

The first versions of the synthesis software (for VHF Band III, and UHF Band IV/V, respectively) were presented to the ITU by EBU-TD at the end of August 2004.

Due to the expected size of the planning scenario (about 100'000 or more requirements were predicted at the beginning), EBU-TD first developed several hundred "fast" synthesis algorithms to ensure that frequency plans could be developed rapidly (i.e. overnight) during RRC-06. But because it became obvious that the speed of the computers to be used would be sufficiently high, it was possible, during the intersessional period, for EBU-TD to develop further synthesis algorithms which were more efficient and, although slower, were still able to provide improved results within the desired timeframes. In addition, IPG made requests for certain planning studies, related to equitable access, which required further extensions of the synthesis software.

3.3. Data capture and display

During the intersessional period (continuing, as needed, through RRC-06), the ITU developed the necessary software for data entry, validation and correction. In addition, the ITU developed a display system enabling Administrations to view, pictorially, their data as well as the results of the calculations.

3.4. Software verification

During the intersessional period,

- EBU Project Group B/EPS had the task of checking, testing and verifying the analysis and synthesis software developed by EBU-TD.
- the ITU PXT group had the task, among others, of checking, testing and verifying all the relevant software which was produced for RRC-06. B/EPS reported the results of its work to PXT and PXT reported the results of its work (and that of other groups and Administrations submitting evaluation results) to IPG and RRC at the beginning of RRC-06.

4. Results of the RRC-06 planning process

4.1. The planning area

118 Administrations submitted their digital requirements (initially 120 Administrations were concerned but two – The Seychelles and Iceland – later requested not to be considered in the Planning process).

The Planning Area, as defined in Resolution 1224 is shown in *Fig. 1*.

Figure 1
RRC-06 Planning Area (truncated at the east but extends to 170° E)

4.2. The frequencies

The frequency band 174 - 230 MHz (Band III) is subdivided, depending on the country, into seven or eight DVB-T channels with 8 or 7 MHz bandwidth respectively. The same band is subdivided into 32 T-DAB blocks with 1.75 MHz bandwidth.

The frequency band 470 - 862 MHz (Bands IV/V) is subdivided into 49 channels with 8 MHz bandwidth.

4.3. The planning process

The planning process continued during the entire intersessional period and was accelerated during the five weeks of RRC-06. It consisted of successive planning iterations: two iterations were performed during the two-year intersessional period and four iterations were performed during the five weeks of RRC-06.

For each iteration, the Administrations submitted their digital requirements, and calculations were performed with the planning software in order to satisfy the maximum number of these requirements. In addition to the digital requirements, the bi- or multi-lateral agreements made between the Administrations were submitted in the form of “Administrative Declarations” (these are the declarations made during the planning process and are not related to any declarations made in relation to the Final Acts). These declarations often indicated that the concerned Administrations agree that two or more digital requirements can use the same channel even though the compatibility analysis may show that interference would occur between them.

In some cases, this approach was used to take into consideration the presence of terrain shielding, which could not be considered by the propagation-prediction method agreed at RRC-04 and used in the planning software. In other cases, the Administrative declarations were used to indicate that the concerned requirements could use the same channel subject to some restrictions, for example ERP reductions in specific directions. The latter Administrative declarations were called “Conditional”, which refers implicitly to the need for further detailed separate agreements already made or still to be made later by the concerned Administrations, before bringing into operation the Plan entries in question.

The resulting digital Plan notes the cases where a digital entry was agreed subject to conditional administrative declaration(s). It should be noted that the detailed conditions for implementing these digital entries are not intended to be made available, for example through the ITU. Broadcasters will therefore have to request this information from their respective Administrations, in order to design their networks.

During RRC-06, an additional means of reducing the planning constraints was used: this consisted of mutual declarations between Administrations stating that they accept a higher level of interference than the one based on the planning parameters agreed initially at RRC-04. An increase of up to 5 dB in the acceptable interference level was agreed between some Administrations. These mutual declarations occurred mainly in regions where Administrations had not coordinated their requirements during the intersessional period and were not able to make detailed coordination in the relatively short time of the Conference.

Assignments to analogue television, and to the other terrestrial primary services for which the protection was required by the concerned Administrations, were also provided as input to the planning software. However, near the beginning of the Conference, the Administrations agreed to ignore the protection of analogue television in the planning process, but to ensure this protection during the implementation phase. This decision was based, in part, on consideration of the impact of providing protection of analogue television assignments during the planning process which could be seen from the results of analyses carried out during the intersessional period.

An additional compatibility analysis between the final Digital Plan and the Analogue Plan was carried out after the last iteration. This allowed the identification of the digital entries which are subject to coordination with some neighbouring Administrations, in order to ensure the protection of their analogue television assignments.

The Data flow and the interaction between the software main functions are illustrated in *Fig. 2*.

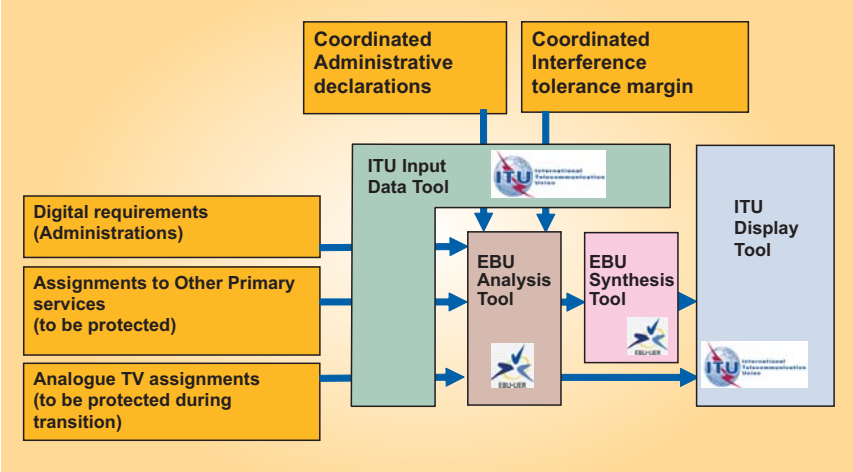

Figure 2
Data flow and main functions of the planning software

4.4. The resulting Frequency Plan

The results of each iteration were evaluated with regard to the proportion of the assigned requirements relative to the submitted ones.

The tables below show the evolution of the results from the first to the fourth iteration performed during RRC-06.

4.4.1. Band III

	Fourth Iteration			Third Iteration			Second Iteration			First Iteration		
	T-DAB	DVB-T	Total	T-DAB	DVB-T	Total	T-DAB	DVB-T	Total	T-DAB	DVB-T	Total
Total	8817	7411	16228	9061	7309	16370	10446	8402	18848	10755	8341	19096
Assigned	8379	6703	15082	8037	5745	13782	8151	5599	13750	7502	4831	12333
%Assigned	95.0	90.4	92.9	88.7	78.6	84.2	78.0	66.6	73.0	69.8	57.9	64.6

4.4.2. Bands IV/V

DVB-T	Fourth Iteration	Third iteration	Second Iteration	First Iteration
Total	56533	55876	60227	62692
Assigned	55409	52229	51222	46333
% assigned	98.0	93.5	85.0	73.9

The improvement through successive iterations was due to the combination of several actions:

1) Reduction by 15% of the input requirements in Band III and by about 10% in Bands IV/V, between the first and the fourth iteration;
2) Increase and generalization of the Administrative declarations as a result of the coordination activities carried out during RRC-06;
3) Tolerance of higher interference levels between some Administrations, as explained earlier.

The RRC-06 planning process produced three sets of results:

1) a Digital Plan consisting of:
   - T-DAB Plan assignments;
   - T-DAB Plan allotments;
   - DVB-T Plan assignments;
   - DVB-T Plan allotments.
2) a Frequency Assignment Plan for Analogue Television Broadcasting in the concerned Frequency Bands in the transition period;
3) a list of assignments to other primary terrestrial services in the concerned Frequency Bands.

The planned allotments and assignments in the part of the planning area centred on Europe are shown in *Fig. 3* for all Bands.

According to rough estimations, the majority of the European countries within CEPT obtained seven nationwide coverages for DVB-T in Bands IV/V and one DVB-T coverage in Band III. In some parts of their national territories, some countries obtained a certain number of additional local coverages.

For T-DAB in Band III, the majority of the European countries obtained an estimated three nationwide coverages, and some of them obtained additional coverages in parts of their territories.

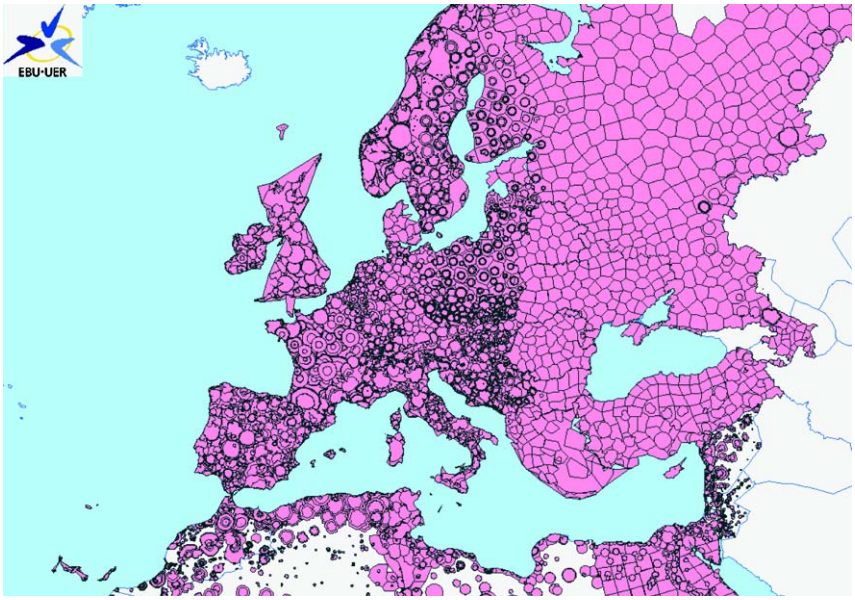

Figure 3
General view of the planned allotments / assignments for Bands III and IV/V in Europe and neighbouring countries

4.5. Channel usage

The level of individual channel usage can be represented by the number of requirements which have been assigned a given channel, as shown in *Figs 4, 5 and 6*. This is a first

indication as some Plan entries are actually linked (an allotment with one or several linked assignments), but the information about the link between allotments and assignments has been deleted by many Administrations from their input requirements. A more accurate calculation requires a

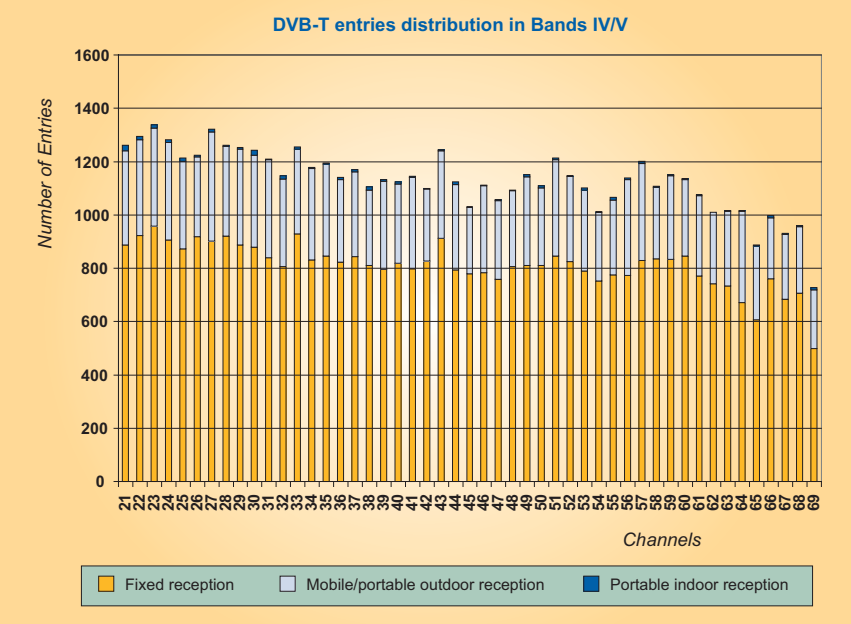

Figure 4
Indication of the channel usage in Bands IV/V for DVB-T and for the different reception modes, in the whole planning area

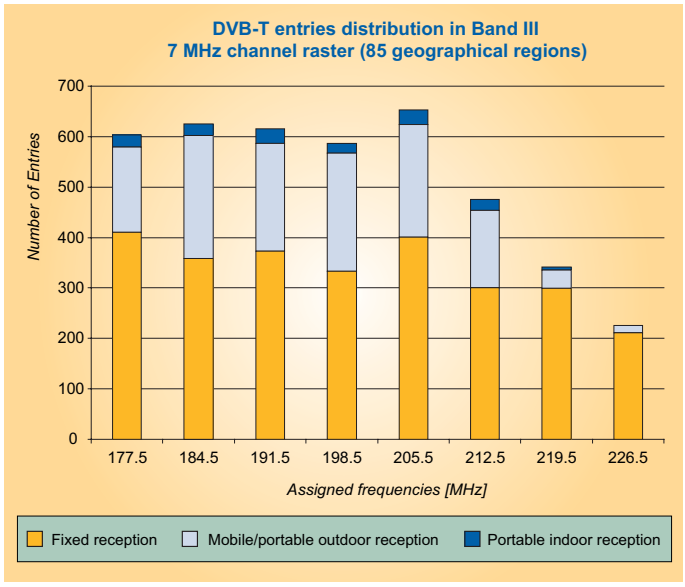

Figure 5
Indication of the channel usage in Band III for DVB-T in countries using a 7 MHz channel raster and for the different reception modes, in the whole planning area

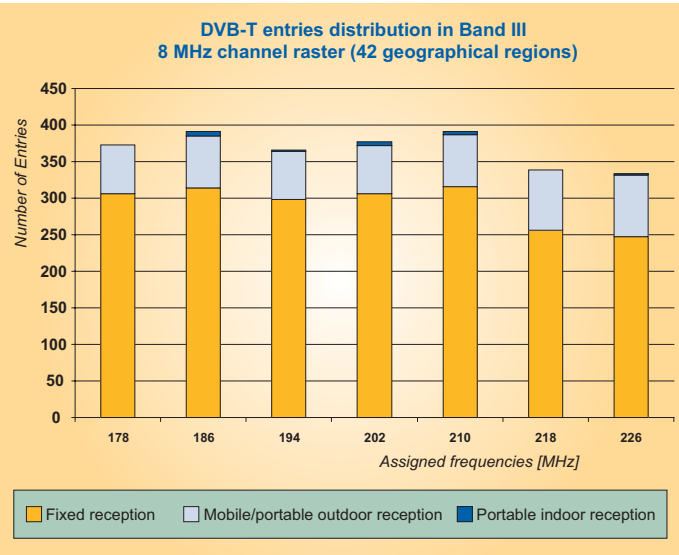

Figure 6
Indication of the channel usage in Band III for DVB-T in countries using an 8 MHz channel raster and for the different reception modes, in the whole planning area

geographical analysis of the coverage areas of the allotments and assignments using the same channel, which is not made here. The words "Plan Entry" in the scope of this document refer to each individual record (Assignment or Allotment) in the Plan, without consideration of the link between some of these Allotments and Assignments.

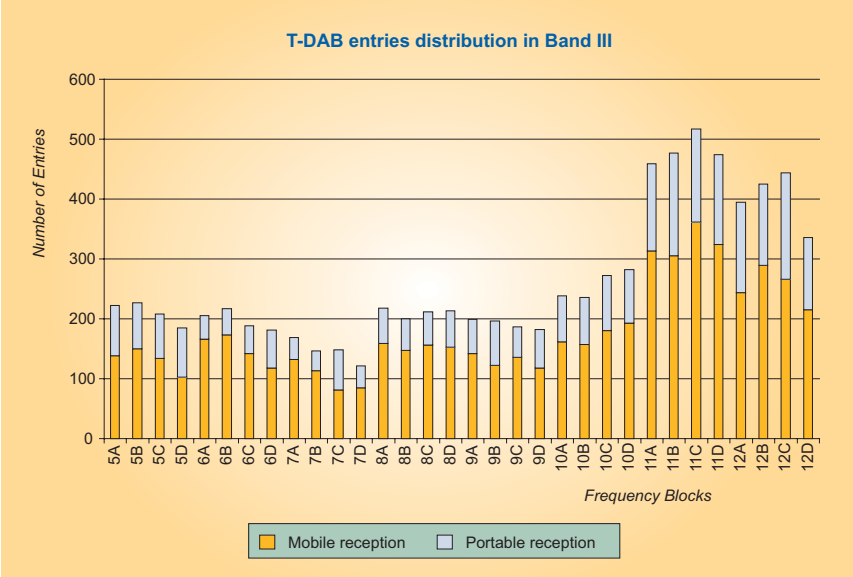

Figure 7
Indication of the channel usage in Band III for T-DAB and for the different reception modes, in the whole planning area

Figs 4 to 7 show that:

- Fixed reception represents the major proportion of the DVB-T requirements in all the considered bands.
- Portable indoor reception represents a very small proportion of the requirements, almost negligible compared with the two other modes.
- Mobile reception of T-DAB represents the major proportion of the T-DAB requirements.
- Channel usage in Bands IV/V is higher in the lower frequencies. A noticeable decrease in channel usage starts from channel 61. This could be explained by the fact that the band 790 - 862 MHz is allocated to other primary services (mobile, fixed, etc.) in several countries.
- Usage of Band III for DVB-T in the countries using the 7 MHz channel raster is lower in the last three channels than in the other channels. This corresponds especially to the 46 CEPT countries. In these countries, the upper part of Band III is mainly used for T-DAB (blocks 11A to 12D as shown in *Fig. 7*).

The channel usage can also be represented using maps of allotment / assignment areas. As examples, *Figs 8 and 9* show the maps for the two following cases:

- In Band III, channel 5 (or 6 in Russia and neighbouring countries) and Blocks 5A to 5D *(Fig. 8)*;
- In Bands IV/V, channel 21 *(Fig. 9)*.

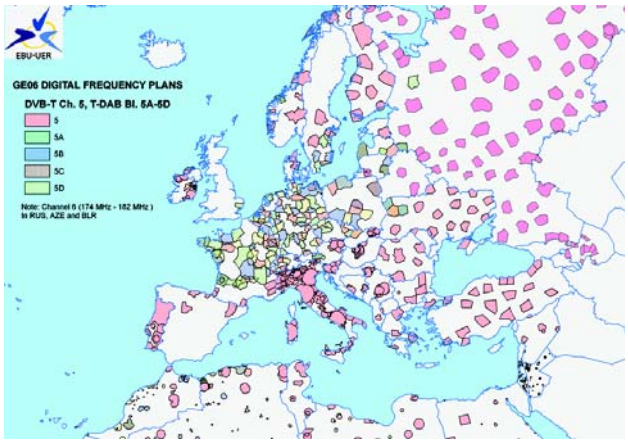

Figure 8
Map of T-DAB plan entries using blocks 5A to 5D and DVB-T plan entries in the frequency range 174 - 182 MHz (channel 5 in the 7 MHz raster and channel 6 in the 8 MHz raster) in Europe and neighbouring countries

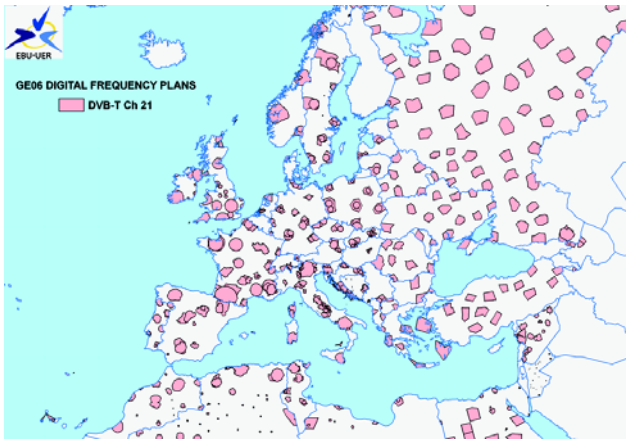

Figure 9
Map of DVB-T plan entries in UHF channel 21 in Europe and neighbouring countries.

5. Considerations of implementation

5.1. Restrictions

For the first official planning exercise, carried out during the intersessional period by the PXT/IPG, it was found that an inadequate percentage (about 39%) of digital broadcast requirements could be satisfied during the synthesis process. Initial investigations into why a complete plan could not be synthesised showed that the number of coverages requested by Administrations in many areas far exceeded the theoretical spectrum capacity, in particular as calculated within the EBU planning groups.

Because of the controversy which occurred in this matter [3], and as an independent check, the EBU developed new methods for estimating the number of channels needed to satisfy any given set of requirements. Thus arose the concept of "Mutually Incompatible Group" (MIG). This new EBU-TD MIG software allowed precise calculations to be carried out, the results of which indicated the minimum amount of spectrum (the minimum number of channels) needed to satisfy any given set of requirements [4]. With these tools, and additional MIG display software provided by the ITU, it was possible to convince Administrations that, in fact, too many requirements were being put forward: The approximately 82'000 requirements submitted at the beginning of RRC-06 was eventually reduced to about 72'000 by the end of the Conference.

In order to attempt to satisfy the very large numbers of digital broadcasting requirements submitted to RRC-06, it was necessary to make many compromises during the conference. For example:

- Interference between analogue and digital broadcasting was not taken into account during the planning process: this potential breach of protection will have to be taken care of during the "transition period" (see section 6 below).
- Many satisfied requirements are subject to coordination and / or time constraints, a consequence of the extremely large number of "administrative declarations" needed during the four iterations of the planning process, in order to overcome calculated incompatibilities; the coordination and constraints involve both digital requirements and other primary services.

In other words, many of the digital broadcasting requirements will need to be coordinated before they can be implemented fully, and many cannot be implemented at all in the near future, perhaps not until the end of the transition period, or perhaps even beyond.

In the Digital Plan, three types of Remarks can appear for each entry:

Remark 1: indicates that the entry should be coordinated with regard to the protection of analogue TV in some Administrations before its implementation;

Remark 2: indicates that the entry is subject to conditional Administrative declaration by some Administrations with respect to their digital entries, and therefore may have to be coordinated with these Administrations before its implementation;

Remark 3: indicates that the entry is subject to conditional Administrative declaration by some Administrations with respect to their Other Primary Services, and therefore may have to be coordinated with these Administrations before its implementation.

3. The word "excessive" was a highly emotive expression and became a "non-word" for a while; during a large part of the intersessional period, "excessive" was not allowed to be used officially during ITU proceedings nor to be included in ITU texts. The reason given was that, to paraphrase, "Administrations have requirements and, by definition, these cannot be considered excessive". Well into the intersessional period, Administrations and the ITU were prepared to face reality. It was accepted that "the number of requirements was in excess of the spectrum capacity" and the term "excessive requirements" began to be widely used.
4. Just as one example: in the first planning exercise, a MIG was found having 357 mutually incompatible requirements, which would have been impossible to satisfy with only 49 channels!

In addition to entries with Remarks, a large number of entries which bear no Remarks in the Plan are subject to bilateral agreements between neighbouring countries. Such agreements may contain conditions for the implementation, e.g. limitations to outgoing interference from the real network or acceptance of higher incoming interference. Before broadcasters and network operators start planning the real networks, it is therefore important to get access to all bilateral agreements that may be relevant in order to assess the implications of the agreements.

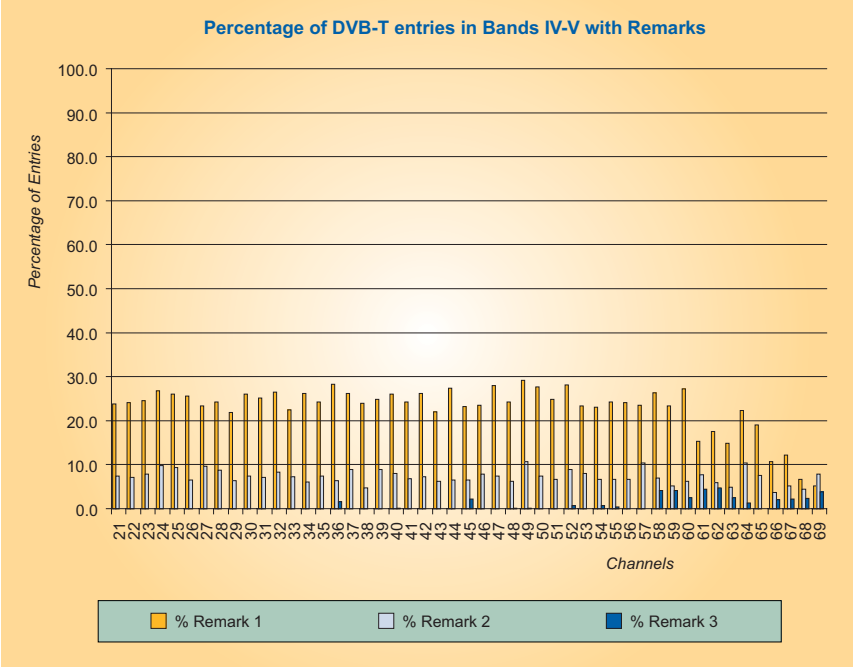

Figure 10
Percentage of DVB-T Plan entries in Bands IV/V having Remarks, in the whole planning area.

Figs 10, 11 and 12 show the percentage of DVB-T entries in Bands IV/V and III (for the 7 and 8 MHz channel rasters) having each of these Remarks, relative to the total number of entries in each channel. As explained in the previous paragraph, a certain number of entries represented in the charts as having no Remarks may also be subject to bilateral agreements made between Administrations but not included in the GE06 Agreement.

On average, depending on the frequency band, between 23% and 30% of the entries in each channel should be coordinated with analogue in neighbouring countries before implementation (entries with Remark 1) and between 4 and 8% should be coordinated with digital (entries with Remark 2). On the other hand, coordination with Other Primary Services will be necessary only for a small percentage of entries in each channel (entries with Remark 3). These latter are mainly located in channels around and above channel 60, as these channels are known to be the most frequently used by Other Services throughout the planning area. The corresponding entries have a lower number of Remark 1s relative to the protection of analogue TV and a higher number of Remark 3s relative to the protection of Other Primary Services, compared to entries in other channels in Bands IV/V.

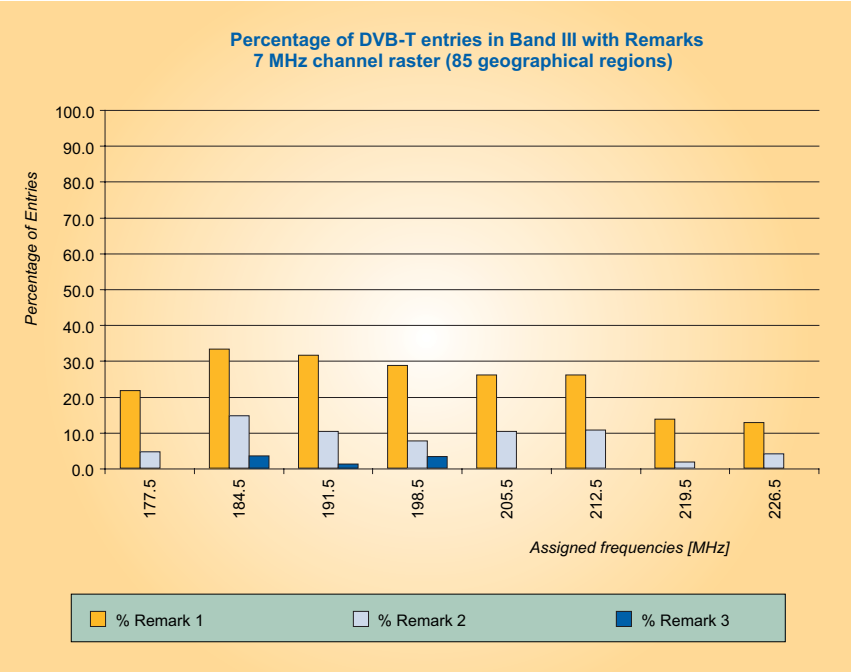

Figure 11
Percentage of DVB-T Plan entries in Band III (in countries using a 7 MHz channel raster) having Remarks, in the whole planning area.

Fig. 13 shows the percentage of T-DAB entries having Remarks relative to the total number of Plan entries in each channel.

The average percentage of entries with Remark 1 (protection of analogue TV) is around 24%, and with Remark 2 (protection of digital TV) is around 7%. A very small percentage (2.5%) of entries in one Block (7D) has Remark 3 (protection of Other Primary Services).

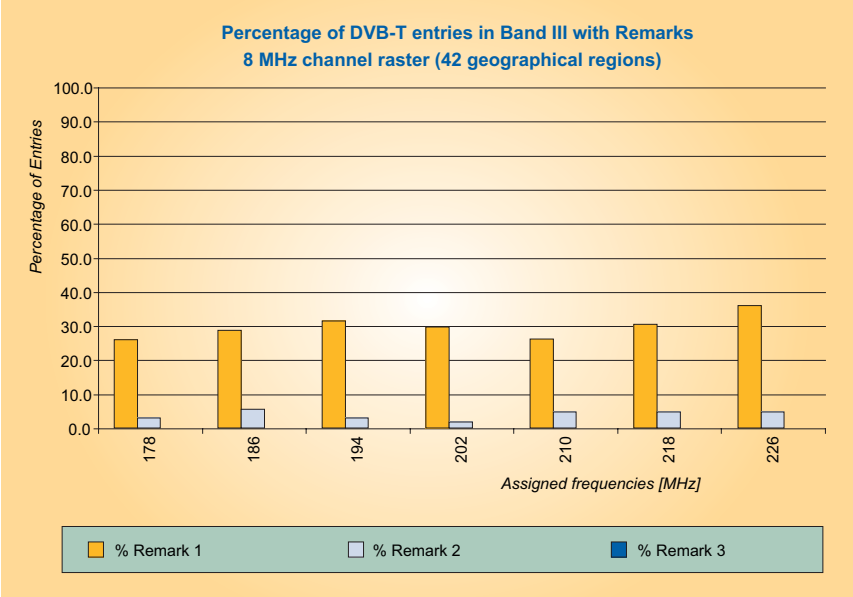

Figure 12
Percentage of DVB-T Plan entries in Band III (in countries using 8 MHz channel raster) having Remarks, in the whole planning area.

5.2. Real vs. theoretical

The planning process was based in large part on assignments and also on allotments, whereby "reference networks" (RNs) and "reference planning configurations" (RPCs) were used as planning guides during the Conference. Each of these allotments will eventually be converted into a set of one or more assignments, usually operating as a single-frequency network (SFN). The problems facing planners after the conference will involve the matching of the "real world" (i.e. the networks to be established) with the theoretical (and thus artificial) world of RNs and RPCs. The Conference addressed the part of the problem involving the avoidance of interference to other Plan entries by establishing a complicated set of implementation checks (see *section 7.3* below).

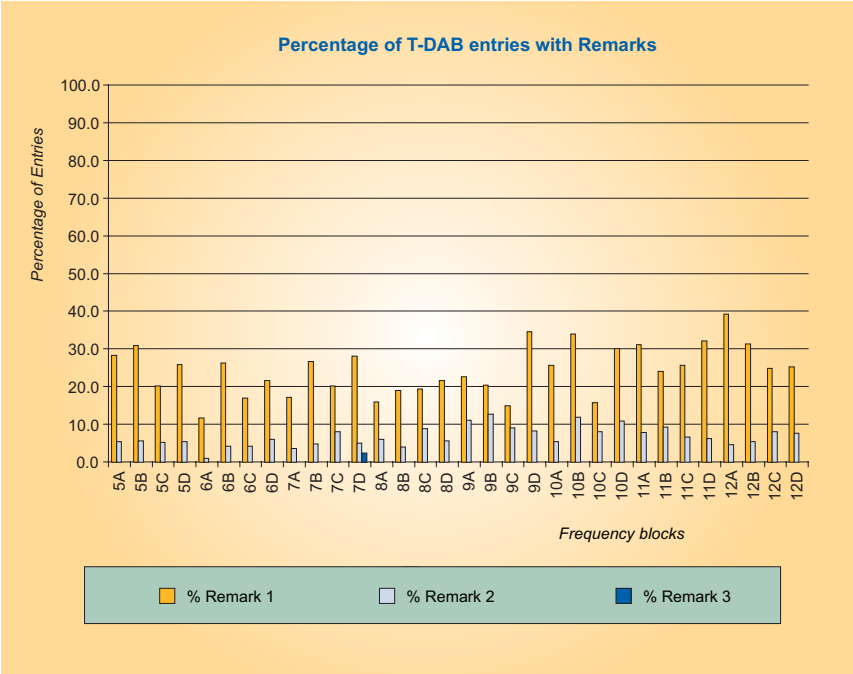

Figure 13
Percentage of T-DAB Plan entries having Remarks, in the whole planning area.

5.3. Broadcast continuity

In the long run, digital broadcasting will undoubtedly completely replace analogue broadcasting. RRC-06 was intended to accelerate this movement as rapidly as possible in Bands III and IV/V. Nevertheless, for practical reasons, the switchover cannot be instantaneous, even in the presence of the GE06 Plan, because of the difficulties identified in *section 5.1.*

As digital stations are gradually introduced and digital networks are gradually developed, additional broadcast programmes and services may also be launched. But certainly, the digital stations which are gradually introduced may have less coverage than the corresponding analogue stations because of the required protection of analogue during the transition period. When analogue services are terminated, the digital stations may have their coverage increased by implementing their characteristics in full according to the plan, or else by switching to frequencies made available by the cessation of the analogue services. The general aim would be, at least, to achieve if not exceed the existing global analogue coverage.

6. The transition period

The GE06 Plan foresees the eventual introduction of a complete digital broadcasting future in Bands III and IV/V. But planning at RRC-06 was carried out in large part by ignoring interference between analogue and digital services: the needed analogue protection would nevertheless be provided during the transition period; potential interference to digital networks from analogue services is also a risk.

In order to achieve the goal of an all-digital future, it will be necessary to reduce the number of, and finally to cease altogether, existing analogue broadcast transmissions. This replacement of analogue transmissions by digital will entail a process which will take time. During this time, called the "transition period", it will be necessary to protect assignments remaining in the analogue Plan, until they cease operation, or until the end of the transition period (June 2015 [5]), whichever comes first.

As long as analogue broadcasting networks and transmitters continue in operation, and thus need to be protected, it will be difficult for many digital networks to start operation, or to be implemented to their full potential. Part of the difficulty in carrying out a rapid transition concerns the extensive presence of analogue receiving equipments and the difficulty in pre-equipping the viewers with digital set-top boxes on a large scale before starting the digital transmissions.

The case where a rapid transition is possible in a given area is when the number of analogue terrestrial receivers in that area is sufficiently low and when there are enough frequency resources to start a simultaneous digital transmission with sufficiently large coverage. Then it is possible to set a short period (in terms of months) during which the viewers could buy their digital receivers / set-top boxes, provided these are available on the market.

The cases where there is extensive analogue terrestrial reception or there is a lack of frequency resources to start simultaneous digital transmissions with large coverage, are not convenient for rapid transition. The main costs related to this "conversion" to digital must be bourne by the public, who are not going to buy any new equipment significantly long before the start of the corresponding service. And the broadcasters will not usually be willing to force the situation by simply turning off the analogue transmissions, which would likely lead to significant losses in the audience, at least in the short run.

During the transition period, it may be possible to introduce digital transmissions "gradually":

- Those digital assignments and allotments which are not incompatible with any analogue assignments could be implemented as soon as the Administration desires.
- Those digital allotments / assignments which are incompatible with any analogue assignments could be implemented "in part" as soon as the Administration desires. For an allotment, this could mean implementing less assignments than needed for full coverage, and for the concerned assignments this could mean using a reduced ERP, or effective transmitter antenna height, or a restrictive radiation pattern, etc. in order to reduce the interference to analogue, or other primary services, to an acceptable level.

5. 2020 for some non-European countries in Band III.

- As more and more digital transmissions are introduced, the need for analogue transmissions will be reduced, thus enabling the shutdown of analogue, step by step, during the transition period; this in turn will allow for the implementation of more and more digital networks, at least in part.

At the end of the transition period, analogue services will no longer be protected, even should they continue operation; furthermore, they would be required to reduce their emissions to ensure non-interference to digital networks, if continued analogue operation were foreseen. On the other hand, other primary services should still be protected after the transition period.

An Administration which desires to make the digital switchover very rapidly, or immediately, can do so – but with some restrictions in border areas. For example, an Administration deciding to turn off analogue television services immediately and turn on digital television and radio services simultaneously, would presumably have little or no internal interference difficulties. However, to the extent that its neighbours maintain analogue services, requiring protection, digital services may still have to be restricted in the border areas.

Although interference between digital and other primary services can also impede digital implementation, many Agreements were reached between Administrations to reduce or avoid these problems altogether; some of these Agreements involved restrictions with respect to digital implementation dates. This type of restriction is not covered in the framework of the transition period.

7. Flexibility

The flexibility that the GE06 Agreement allows for future innovation of digital broadcasting technology is one of the major achievements of RRC-06.

Part of such flexibility was already introduced at the First Session by taking into account the different DVB-T system variants and the different reception modes which are possible with digital broadcasting technology (fixed, portable and mobile reception). Hundreds of combinations are possible but not all of them would provide the types of coverage normally required. A limited number of Reference Planning Configurations (RPCs) was defined to represent, in an approximate way, most of the types of coverage normally desired (for more detailed background information see [1] and [2]). In the implementation phase, broadcasters will have the freedom to decide the system variant that best fits the RPC of the corresponding digital entry in the Plan. However, Administrations had also the freedom to choose any other particular planning configuration if the ones pre-defined could not satisfy the needs in their country. Of course, some 25% of the Plan entries identify a specific system variant and reception; even for these entries, significant implementation flexibility exists.

Allotment planning is another tool that gives flexibility to the GE06 Agreement. Allotment sizes can vary from relatively small to very large. In order to accommodate the wide range of possible allotment sizes, a limited number of Reference Networks (RNs) was also defined. In allotment planning, only the RN, the RPC, the frequency channel assigned and the service area are included in the Plan. In contrast to assignment planning, the actual location of the transmitter site and the specific transmission characteristics to be used are not defined in the Plan, but in the implementation phase.

7.1. Procedures for modification of the Plan

As in other agreements, GE06 has its corresponding Article 4 with procedures for modifications to the Plans. Those procedures are essential for future modifications of existing entries in the Plan and also for additions of new entries. Just to give an indication of the importance, the Article 4 procedures in the ST61 Agreement allowed the number of stations included in the plan to increase from the original 5300 stations in Bands III and IV/V to more than 50,000 stations which are operating now.

As expected, the discussions during RRC-06 on such a crucial item were long and difficult! Two main different positions arose. On the one hand, the European countries favoured quick and short procedures, requiring the least possible involvement of ITU-R. On the other hand, most of the other countries in the planning area favoured slower and longer procedures where ITU-R would play the main role. The agreed Article 4 of GE06 reflects a compromise between the two positions where the procedures are quicker and shorter than in other Agreements but they still give enough time for Administrations to complete all the necessary steps [6]. Such compromise was part of the "compromise package" agreed between the Heads of Regional Groups at the end of the conference.

An important part of the procedures for modifications to the Plans defines the limits and a methodology for determining when agreement with another Administration is required. Here, once again, the discussions were very long. In the ST61 Agreement, the methodology is based on coordination distances given for each type of service. In GE06, the methodology is based on coordination trigger field strengths which were used to define an area within which a trigger field-strength value is reached. Specific coordination trigger field-strength values were defined for each type of service but, for some aeronautical radionavigation services, a "safety margin" (of 6 dB) was added, which gives higher protection to some other services. In total, over 70 different values and several formulas (each involving many parameters) were needed to define a complete set of trigger field strengths.

7.2. The "envelope concept"

Taking into account the rapid evolution of technology, CEPT wanted to introduce additional flexibility to the GE06 Agreement. The CEPT proposal was the so-called "envelope concept". The idea was to use a digital entry in the Plan for other terrestrial applications, provided that:

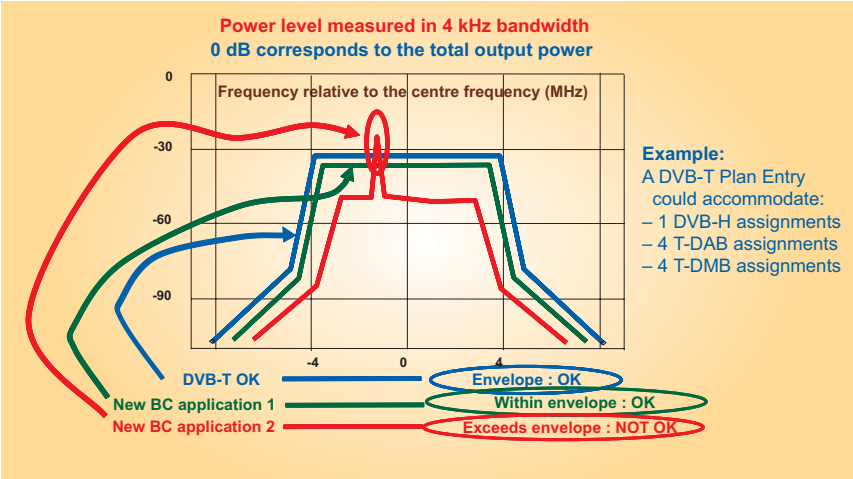

Figure 14
The "envelope concept"

1) such use does not cause more interference than would be caused by the digital entry in the Plan (i.e. the new terrestrial application must not exceed the power spectral density of the digital entry);
2) it does not demand greater protection than the digital entry in the Plan would need *(see Fig. 14)*.

However, there might be cases where the strict application of this concept may not necessarily be sufficient to ensure the protection of other digital entries in the Plan [7].

The proposal was intended to open the GE06 Plan to future broadcasting applications (such as DVB-H or T-DMB) but also to non-broadcasting applications (for example, UMTS technology). Also in this matter, the discussions during the conference were tense because the non-European countries were not in favour of opening the GE06 Plan to non-broadcasting services.

6. For example if, after a certain period (a little more than two years), not all agreements to a proposed modification to the Plan have been reached, then the modification request lapses.
7. For example, services using pulse-like signals, operating within the envelope, may still be harmful to a DVB-T or a T-DAB signal because higher protection ratios may be required.

The final text adopted was also part of the "compromise package" agreed between the Heads of Regional Groups at the end of the conference. Paragraph 5.1.3 of Article 5 "Notification of frequency assignments" reads as follows:

> *"A digital entry in the Plan may also be notified with characteristics different from those appearing in the Plan, for transmissions in the broadcasting service or in* ***other primary terrestrial services operating in conformity with the Radio Regulations****, provided that the peak power density in any 4 kHz of the above-mentioned notified assignments shall not exceed the spectral power density in the same 4 kHz of the digital entry in the Plan. Such use shall not claim more protection than that afforded to the above-mentioned digital entry."*

Broadcasters were less unhappy with that text as it is more restrictive than the initial proposal from CEPT. Before using a digital entry in the Plan for a non-broadcasting terrestrial application, the corresponding service must be allocated as a primary service in the relevant frequency band in the ITU Radio Regulations (RR). The frequency allocations can only be modified by an ITU World Radiocommunications Conference (WRC).

It is therefore to be expected that a strong effort will be made at WRC07 and WRC10 to introduce new primary allocations for UMTS/IMT2000 and other non-broadcasting applications in Bands III and IV/V.

However, not content with the explicit restrictions in Paragraph 5.1.3, some 52 Administrations, mostly from CEPT countries, effectively emasculated the compromise with an additional declaration at the end of the conference. In that declaration they stated that use of a digital entry in the Plan may be allowed for a non-broadcasting application, irrespective of whether its corresponding service is a primary allocation in the RR, or not, and that those Administrations will grant protection to these other services between themselves.

For broadcasters, the threat is enormous. If the digital entries in the Plan are not notified quickly for digital broadcasting, they may very likely be expropriated for non-broadcasting applications, preventing the future development of terrestrial broadcasting applications such as HDTV services, and mobile and portable indoor reception.

7.3. Examination of conformity with the digital Plan entry

One of the consequences of introducing as much flexibility into the Plan as possible is the additional need for a methodology to determine the conformity of the notified assignment with the digital Plan entry. The conformity check is needed to ensure that the interference levels remain below the ones calculated in the Plan. Instead of a method whereby interference would be calculated directly at each potentially interfered-with Plan entry or other service assignment, CEPT opted for a "self-contained" method. CEPT was successful in convincing the other participating Administrations that this method should be adopted at RRC-06.

The main part of this method, as adopted in GE06, consists of the comparison of the interference arising from the digital Plan entry with the actual interference that would arise from the proposed implementation of that entry, using the following steps [8]:

- For any given potentially-interfered-with Other Service, the comparison is made within an area limited by a corresponding cut-off field-strength contour. The cut-off field-strength values are based on the coordination trigger field-strength values *(see Paragraph 7.1)*.
- Once this area is defined, geometrical contours are constructed using seven constant control distances [9], respectively. In the case of assignments, these contours are concentric circles, with the control distances as radii, centred on the station transmitter site. In the case of allot-

8. This is a simplified description.
9. These seven distances range from 60 to 1000 km.

ments, the contours are “parallel” to, and separated by the control distances from, the allotment polygons.

- From a defined reference point, for assignments and/or for allotments, radials are developed at 1° steps; calculation points are defined where these radials cross the cut-off field-strength contour and the geometrical contours outside the national boundary.
- The comparison of the potential interference with the interference envelope is done at those calculation points.

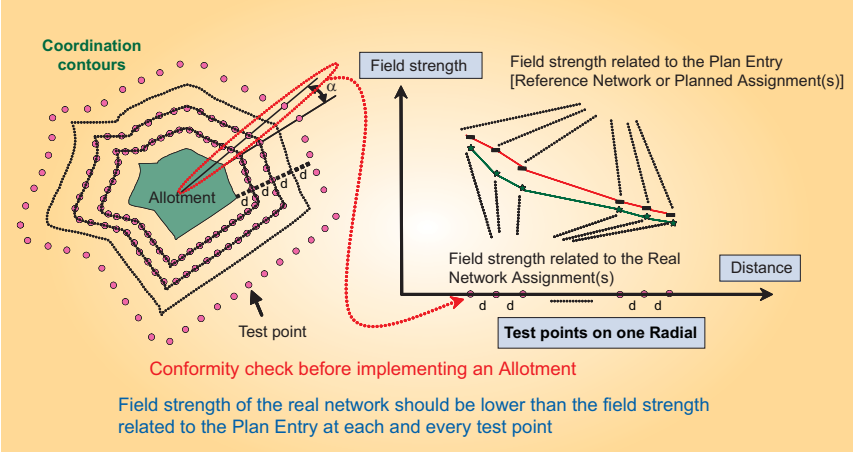

Figure 15
Simplified description of the conformity check

Fig. 15 illustrates, in a very simplified schematic manner, the three last steps given above.

At this stage, you are probably confused! Once the details of the method are studied, the common reaction is: what a complex method! Yes, the method is complex and will require many computations. The software to apply the method is under development at ITU-R. Broadcasters and network operators will certainly need some time to get familiar with it. Perhaps we can hope that the method will be simplified before any extensive use of it is needed.

8. The digital dividend

The “digital dividend” is a consequence of the efficiency of digital technologies as compared to analogue technologies. For example, it is possible to transmit four times as many programmes (and with better quality) per MHz with digital DVB-T as can be achieved with analogue techniques. Some of the advantages and spectral gains of the digital approach are mitigated, however, by the rapid degradation of digital quality in many situations.

In general, broadcasters interpret the digital dividend in the following ways:

- The same number of digital programme services as transmitted on the existing analogue networks can be transmitted in less spectrum than is presently used;
- More digital programme and associated services (including interactive multimedia ones) than the existing number of analogue programmes can be carried in the spectrum that is presently occupied by the analogue programme services.

For EBU Members, digitization of broadcasting creates opportunities to provide, within the present broadcasting spectrum, a new range of services such as HDTV, mobile reception, interactivity etc, in addition to the existing television programmes. Furthermore, digital television receivers are projected to become the most widespread means for the general public to access entertainment, education, news and E-commerce as well as digital TV programmes. For that, broadcasters need adequate and stable spectrum both now and in the future.

As was seen at RRC-06:

- The digital demands for broadcasting of almost all Member States far exceeded the spectrum available.
- The use of the broadcasting spectrum is critically dependent on national circumstances (such as topography, penetration of satellite/cable services and the requirements for regional services).

- Many of the digital requirements satisfied had pre-specified and pre-coordinated channels, scattered over the respective bands, which will make European "harmonisation" of spectrum bands for use by Other Services rather difficult in the future.
- Paragraph 5.1.3 of Article 5 of the Final Acts allows digital broadcasting entries in the Plan to be used for other primary services;
- Declaration 42 is a statement of intent of mainly European Administrations to use digital broadcasting entries in the Plan for **any** Other Service.

It may be that the excessive number of broadcasting requirements submitted by Administrations to RRC-06 was intended to cover their "real" broadcasting needs as well as to provide frequencies (within the digital plan) to be used for "new" services.

If parts of the broadcasting spectrum are to be used by Other Services, in-depth compatibility checks are needed to ensure that the Other Service does not create more interference than the digital entry in the Plan. Constraints on digital broadcasting which will limit its value to users are to be avoided. Digital broadcasting is characterised by a rapid transition from near-perfect reception to no reception at all and, thus, it is even more critical to limit interference than it is for analogue broadcasting.

9. Conclusions

RRC-06 has defined the use of 448 MHz of bandwidth (up to 57 channels for DVB-T in Bands III and IV/V, and up to 32 frequency blocks for T-DAB in Band III) for digital terrestrial broadcasting for the next decades over a large area including 118 countries.

As so often in the past with previous broadcast planning conferences, the EBU has contributed actively and efficiently to the success of the RRC-06 planning process. It is no exaggeration to say that, without the calculation software developed by the EBU and utilised by the ITU prior to, and during the RRC-06, no effective digital broadcasting plan could have been developed. It would not have been possible to carry out the vast and complex interference analyses, involving tens of thousands of digital requirements and Other Services assignments, nor the intricate synthesis process which actually assigned the 57 television channels and 32 audio frequency blocks to more than 70,000 digital broadcasting requirements throughout the planning area.

Although the smoke has not yet cleared from the final days of RRC-06, many conclusions can nevertheless already be drawn as to the future of digital broadcasting in Europe and beyond in the context of the GE06 plans.

It is true that the number of entries included in the Plans, and the number of coverages which could be provided by these Plans, are very large but, in general, these exceed the theoretical capacity of the frequency bands. This has been achieved at the expense of higher interference levels, and it will likely turn out that intended coverage in many areas will be severely reduced compared to Administrations' expectations and desires.

In addition, a considerable number of entries are subject to constraints to be satisfied before the assignments and/or allotments can be implemented (between 23 and 30% of the Plan entries). For example, during the transition period, protection of analogue TV imposes restrictions on digital broadcasting. Therefore coordination between neighbouring countries will often be necessary in order to implement the Plans. During the transition period, the switchover from analogue to digital should be carefully done to ensure that no overall loss of coverage of broadcast services occurs.

In any case, the full potential of the new Plan will not be available until the analogue switch-off. The RRC-06 decided to set the end of the transition period in 2015 (2020 in some countries for Band III).

Also important: the GE06 Agreement offers a great deal of flexibility for the future development of the digital Plan. This should allow it to accommodate recent technical developments, such as HDTV as well as "handheld television" (DVB-H) and also to easily adjust to "unforeseen" future

developments in broadcast technology. On the other hand, this flexibility, in conjunction with Article 5 of the Agreement, allows the introduction of other non-broadcasting services using the frequencies of the Plans and this may lead, in the long run, to a reduction of the broadcasting usage of the spectrum.

In spite of some limitations and some possible threats, broadcasters will nevertheless enjoy greater scope for improved quality, extended technology and new services when using GE06 to pass BC (BroadCasting) into the AD (Age of Digital)!

Terry O'Leary received a doctorate in Physics at the University of California. In 1975, he joined the Institut für Rundfunktechnik (IRT Munich) where he conducted research on a range of topics including propagation, antennas, and terrestrial network and satellite planning.

In 1979, Dr O'Leary joined the EBU Technical Department where he became involved in many projects within the framework of EBU Working Party R. From 1984 to 1990, the IFRB benefitted from his specialist knowledge of HF and television network planning. He returned to the EBU in 1990 and was involved in T-DAB planning, WARC'77 BSS replanning and other projects.

Terry O'Leary co-ordinates joint technical activities undertaken by EBU Members and represents the EBU in a number of international committees. He participated in the RRC-04 – the first Session of the Regional Radiocommunications Conference to review the ST61 and GE89 Plans, which agreed the planning parameters and criteria. He was one of the co-leaders who developed the EBU planning software used during the inter-sessional period and during the RRC-06 which led to a new Agreement and a new Plan (GE06) for the use of Band III and Bands IV/V for digital terrestrial broadcasting in 118 countries.

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In March 2000, Mrs Puigrefagut joined EBU Technical Department in Geneva where she currently works as a Senior Engineer, undertaking studies relating to frequency planning and spectrum management. She also co-ordinates the joint technical activities undertaken by EBU Members and represents the EBU in a number of international committees. She participated in the planning activities of the RRC-06 which led to a new Agreement and a new Plan (GE06) for the use of Band III and Bands IV/V for digital terrestrial broadcasting in 118 countries.

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In November 2006, Dr Sami joined the EBU Technical Department as a Senior Engineer, to undertake studies and co-ordinate the joint technical activities of EBU Members on subjects including frequency planning for Mobile TV and Digital Radio Mondiale (DRM), and on electromagnetic compatibility and spectrum-sharing issues. He represents the EBU in a number of international committees and participated in the planning activities of the RRC-06 which led to a new Agreement and a new Plan (GE06) for the use of Band III and Bands IV/V for digital terrestrial broadcasting in 118 countries.

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