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The Broadcasting-satellite Conference*

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1. Introduction

In the field of broadcasting new telecommunication techniques have always been welcomed because of the ever-increasing demand for programme channels. Satellite broadcasting has now been added to the list of technical possibilities, and the International Telecommunication Union (ITU) has again proved its importance in the development of world telecommunication policy by preparing the necessary plan and procedures for the implementation of satellite broadcasting in an orderly fashion and on a world-wide basis.

It still remains to be seen what role this new possibility will play in the future of broadcasting, but it seems a fair guess that it will be a supplement to existing forms rather than a substitution. As the Secretary-General of the ITU stated at the opening of the World Broadcasting-satellite Conference on 10 January 1977: " I would not give the impression that satellite broadcasting is about to supersede all other forms. Experience in telecommunications shows that a system rarely supersedes another system entirely, but that it supplements it by adding fresh transmission or broadcasting capabilities. However, particular countries or groups of countries will in all likelihood find it convenient at a given stage in their development to focus their efforts on this new mode of broadcasting which will offer the advantage of providing total or virtually total coverage of their territory in a short space of time. "

* World Administrative Radio Conference for the planning of the broadcasting-satellite service in the 11.7-12.2 GHz band (12.5 GHz in Region 1) (Geneva, 1977).

2. Background and preparations

Frequency bands for radiocommunications were originally allocated by the Extraordinary Administrative Radio Conference, Geneva (1963). The same conference recommended that the Administrative Council of the ITU should commend to administrations the convening of an Administrative Conference to work out further agreements for the international regulation of radio frequency bands allocated for space radiocommunications.

Such a Conference was held in Geneva in 1971 (WARC-ST). And a Resolution (Spa2-2) was adopted requesting the Administrative Council to examine the question of convening a World Administrative Conference and/or Regional Administrative Conferences to draw up agreements and associated plans for the broadcasting-satellite service.

After the Plenipotentiary Conference of Malaga-Torremolinos, 1973, had decided (Resolution No. 27) that a World Administrative Radio Conference for the planning of the broadcasting-satellite service in the 12 GHz band should be convened not later than April 1977, the Administrative Council finally resolved that the Conference should take place in Geneva, starting on 10 January 1977 and lasting five weeks.

The agenda for the Conference was in broad terms:

- to establish the sharing criteria for the various services in the 12 GHz band;
- to plan for the broadcasting-satellite service;
- to establish procedures to govern the use of the 12 GHz band by the various services;
- to consider the result of the work of the Group of Experts on the possible rearrangement of the Radio Regulations.

The last item had of course little connection with the others but was necessary as part of the preparations for the World Administrative Conference in 1979.

The technical preparations for the Conference were entrusted to the International Radio Consultative Committee (CCIR) to be carried out during its Interim Meeting in 1976. Thanks to the amount of technical preparations already made and compiled by the CCIR Study Groups during recent years, it was possible to produce a report with almost full documentation for the main topics:

- terminology;
- propagation;
- systems technology;
- planning;
- sharing.

It should be recognized that the fundamentals for the construction of channel/orbit-position plans have been virgin ground, and credit should be given to the very few persons round the world who have developed the necessary algorithms, synthesis and analysis programs, without which no planning of such a complicated nature is possible.

It was recognized that although the Conference was foreseen five years ago satellite broadcasting was still a new technical field. Therefore a special effort was appropriate in order to give administrations the possibility of familiarizing themselves with the various aspects of the problems involved in such a planning conference. To serve the purpose three seminars were held—in Rio de Janeiro, Kyoto and Khartoum—where lecturers from various countries outlined their ideas of possible solutions to the problems.

The International Frequency Registration Board (IFRB) was, of course, also involved in the preparations and gathered what was called the foreseeable requirements of administrations. The information, i.e. the number of channels wanted and service area (defined by an ellipse specified by its centre, its major and minor axes and orientation), was arranged in a form suitable for planning exercises and comparative studies and sent to all administrations in good time before the Conference.

3. Structure of the Conference

The traditional structure of an administrative conference was adopted; eight committees were set up and their terms of reference given as follows:

Committee 1—Steering Committee

(consisting of the Chairman and Vice-Chairmen of the Conference and the Chairmen and Vice-Chairmen of the other Committees)

□ To co-ordinate the work of the Committees, fix the timetables of meetings, etc.

Committee 2—Credentials Committee

Chairman: Mr. A. Dione (Senegal)
Vice-Chairman: Mr. A. W. Gamal (Sudan)

□ To verify the credentials of delegations and to report on its conclusions to the Plenary Meeting within the time specified by the latter.

Committee 3—Budget Control Committee

Chairman: Mr. V. A. D. Rayalu (India)
Vice-Chairman: Mr. J. Székely (Hungarian People's Republic)

□ To determine the organization and the facilities available to the delegates and to examine and approve the accounts for expenditure incurred throughout the duration of the Conference.

Committee 4—Technical Committee

Chairman: Mr. F. Kralik (Czechoslovakia)
Vice-Chairman: Mr. C. A. Siocos (Canada)

□ To establish the basic technical characteristics for the broadcasting-satelilte service and the sharing criteria between the broadcasting-satellite service and the other services concerned for planning the use of the bands 11.7-12.2 GHz (in Regions 2 and 3) and 11.7-12.5 GHz (in Region 1) for the broadcasting-satellite service taking into account the reports of the CCIR (May/June 1976).

Committee 5—Planning Committee

Chairman: Mr. A. Petti (Italy)
Vice-Chairman: Mr. M. Zubair (Pakistan)

□ To establish the principles on which planning should be based for the broadcasting-satellite service in the bands 11.7-12.2 GHz (Regions 2 and 3) and 11.7-12.5 GHz (Region 1) taking into account sharing criteria with other services and other basic technical parameters.

□ To plan for the broadcasting-satellite service and to determine the data to be included in the Plan.

Committee 6—Procedures Committee

Chairman: Mr. R. J. Bundle (New Zealand)
Vice-Chairman: Mr. M. Lô (Mauritania)

□ To establish procedures to govern the use of the bands 11.7-12.2 GHz (Regions 2 and 3) and 11.7-12.5 (Region 1) by the broadcasting-satellite service and the other services to which these bands are allocated, to the extent considered necessary by the Conference.

Committee 7—Rearrangement of the Radio Regulations

Chairman: Mr. J. J. Hernández (Mexico)
Vice-Chairman: Mr. S. Odunga (Tanzania)

□ To consider the results of the work of the Group of Experts on the possible rearrangement of the Radio Regulations and make recommendations to administrations on the use of the proposed structure in the presentation of their proposals to the World Administrative Radio Conference, in 1979.

Committee 8—Editorial Committee

Chairman: Miss M. Huet (France)
Vice-Chairmen: Mr. V. Quintas (Spain), Mr. D. E. Baptiste (United Kingdom)

□ To perfect the form of the texts of the Final Acts without altering the sense.

Five Vice-Chairmen were elected: Messrs. N. Bouhired (Algeria), R. E. Lee (United States), Y. Maki (Japan), A. L. Badalov (USSR) and A. Fadami (Iran).

Because of the difficult interface problems between Committees 4, 5, and 6 Mr. A. Fadami, as a special Vice-Chairman, was given the following tasks:

— to co-ordinate and appraise the activities of Committees 4, 5 and 6 and to ensure that the progress of the work resulted in equitable planning;
— to chair a special committee composed of the Chairmen and Vice-Chairmen of these Committees in order to achieve the above-mentioned goal.

Of course, the main committees had to split up in numerous working groups and sub-groups in order to prepare the necessary documents. Working Group 5A, chaired by Mr. S. R. Temple (United Kingdom), which established the plan for Regions 1 and 3, deserves to be specially mentioned because of its most difficult task and successful result.

4. Basic technical characteristics

In many cases it was possible for the Conference without hesitation to adopt the characteristics contained in the report of the Joint Working Party of the CCIR. However, in some cases values were agreed upon only after lengthy discussions. The sharing criteria between the broadcasting-satellite service of Regions 1 and 3 and the satellite services (fixed and broadcasting) of Region 2 presented an especially difficult problem to which a solution was found only at the very end of the Conference.

4.1 Terms and definitions

In order to be able to be quite precise when speaking of "coverage" it was found necessary to give new definitions in relation to a broadcasting-satellite plan. The following were adopted:

Service area

The area on the surface of the Earth in which the administration responsible for the service has the right to demand that the agreed protection conditions be provided.

Note: In the definition of service area, it is made clear that within the service area the agreed protection conditions can be demanded. This is the area where there should be at least the wanted power flux density and protection against interference based on the agreed protection ratio for the agreed percentage of time should be achieved.

Coverage area

The area on the surface of the Earth delineated by a contour of a constant given value of power flux density which would permit the wanted quality of reception in the absence of interference.

Note 1: In accordance with the provisions of No. 428A of the Radio Regulations, the coverage area must be the smallest area which encompasses the service area.

Note 2: The coverage area, which will normally encompass the entire service area, will result from the intersection of the antenna beam (elliptical or circular) with the surface of the Earth, and will be defined by a given value of power flux density. For example, in the case of a Region 1 or 3 country with a service planned for individual reception, it would be the area delineated by the contour corresponding to a level of -103 dBW/m² for 99% of the worst month. There will usually be an area outside the service area but within the coverage area in which the power flux density will be at least equivalent to the minimum specified value; however, protection against interference will not be provided in this area.

Beam area

The area delineated by the intersection of the half-power beam of the satellite transmitting antenna with the surface of the Earth.

Note: The beam area is simply that area on the Earth's surface corresponding to the -3 dB points on the satellite antenna radiation pattern. In many cases the beam area would almost coincide with the coverage area, the discrepancy being accounted for by the permanent difference in path lengths from the satellite throughout the beam area, and also by the permanent variations, if any, in propagation factors across the area. However, for a service area where the maximum dimension as seen from the satellite position is less than 0.6° (the agreed minimum practicable satellite antenna half-power beamwidth), there could be a significant difference between the beam area and the coverage area.

A further definition adopted was:

Nominal orbital position

The longitude of a position in the geostationary satellite orbit associated with a frequency assignment to a space station in a space radiocommunication service. The position is given in degrees from the Greenwich meridian.

4.2 Modulation, chanelling and protection ratio

It was agreed that planning should be based on the use of a video signal with a baseband carrier, frequency modulated by a sound signal, both frequency modulating a carrier in the 12 GHz band.

A value of 27 MHz was fixed as channel width and 19.18 MHz as the spacing between channels so as to give a good balance between co-channel and adjacent channel interference.

However, other types of modulation may be used, provided they do not cause greater interference.

By dividing the band 11.7-12.5 GHz for Region 1 into 40 such channels (giving 25 channels in the band 11.7-12.2 GHz for Region 3) a guard band of 14 MHz at the lower end and of 11 MHz at the upper end of the band was obtained. Such guard bands should give the necessary protection to the services in the adjadent bands.

For planning purposes a carrier-to-noise level of 14 dB for 99% of the worst month was chosen and the following protection ratios adopted:

— 31 dB for co-channel signals,

— 15 dB for adjacent channel signals.

The two latter values were adopted for the purpose of calculating the so-called equivalent protection margin* used to evaluate the Plan.

In each service area the responsible administration defined six test points where the equivalent protection margin was calculated.

4.3 Antennae, polarization and power flux density

In order to cope with the very difficult sharing problems between the Regions it was agreed to specify a side-lobe pattern for the broadcasting-satellite antenna 5 dB better than the one proposed by the CCIR. It was stated by experts that such improvement could be made without special effort in development.

So far as the use of either linear or circular polarization was concerned no recommendation was made by the CCIR.

A choice was made in favour of circular polarization, which at least eliminates the problem of the exact alignment of the directions of polarization, on transmission as well as reception. The United States expressed concern with regard to this choice, because of the sharing problems when the fixed-satellite service uses linear polarization, and Iran expressed a reservation.

A most important decision was of course the choice for planning purposes of the values of power flux density at the edge of coverage because of its impact on receiver design and price.

As is well known, the receiver price in any broadcasting system is of paramount importance and in systems planning due respect has always been given to this aspect. A power flux density value of -101 dBW/m² was indicated by the CCIR as a representative figure for individual reception leading to a value of G/T = 4 dB for the receiving installation, but recent studies in Europe had indicated that a value of 6 dB could be obtained without excessive increase in receiver cost.

Such a value of G/T would lead to a power flux density value of -103 dBW/m².

From other considerations—mainly sharing with terrestrial services—an even lower value was wanted.

As a compromise the following values at the edge of the coverage area for 99% of the worst month were adopted:

a) -103 dBW/m² for individual reception in Regions 1 and 3;

b) -105 dBW/m² for individual reception in Region 2;

c) -111 dBW/m² for community reception in all Regions.

It was agreed that planning be based on individual reception and that the receiving antennae for that purpose have the following half-power beamwidth:

Regions 1 and 3: 2° (i.e. a minimum diameter of about 90 cm).

Region 2: 1.8° (i.e. a minimum diameter of about 100 cm).

Furthermore, for planning, it was agreed that the absolute value of the difference between the equivalent isotropic radiated power (e.i.r.p.) directed towards the edge of the coverage area and that on the axis of the beam (called ΔG) should be 3 dB. And, most important for very small countries, if the beam area is larger than the coverage area, the value will be less than 3 dB. In other words, everything is done to keep the unavoidable overspill to an absolute minimum.

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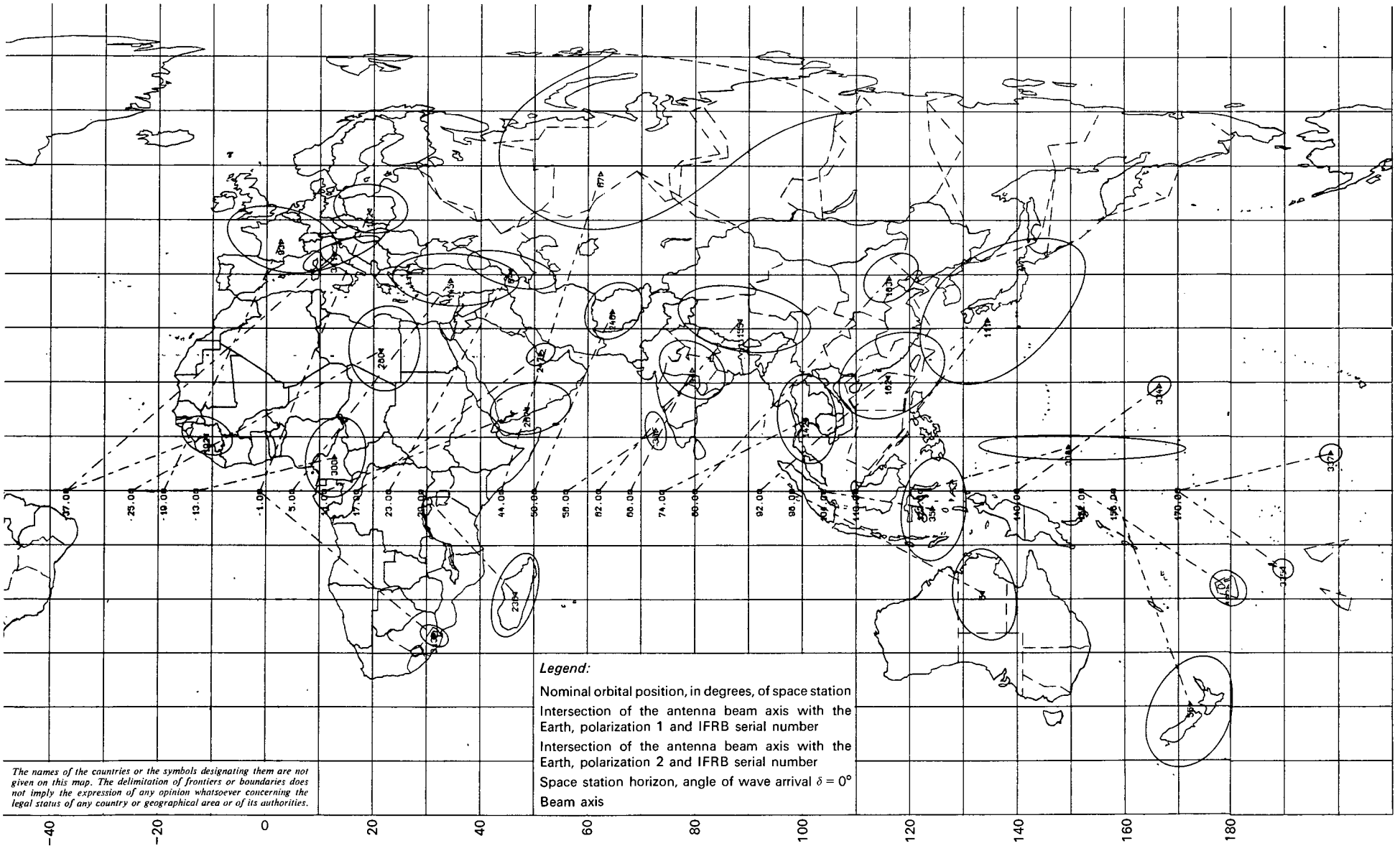
* The equivalent protection margin is defined as:

$$M = -10 \log [10^{-M_1/10} + 10^{-M_2/10} + 10^{-M_3/10}]$$

where M_1, M_2 and M_3 are the protection margins (in dB) for the same channel, the upper and the lower channels respectively.

$$M_1 = \frac{\text{wanted power}}{\text{sum of the co-channel interfering power}} \text{ (dB)} - \text{co-channel protection ratio (dB)}$$



Example of graphical presentation of assignments contained in the frequency assignment plan adopted by the Broadcasting-satellite Conference. There are separate maps for each of the 40 channels

4.4 Propagation

The CCIR atmospheric models for five rain-climatic zones, giving atmospheric attenuation as a function of elevation angles, were adopted for planning as the best possible models available.

However, because of their somewhat theoretical nature, the Conference requested the CCIR to make an urgent study of the problem. The African countries especially expressed the need for experimental data on propagation in Africa in the 12 GHz band.

To take account of the depolarization effect it was decided for planning that the level of the depolarized component relative to the level of the co-polar component for circular polarization should be taken as:

a) −27 dB for rain-climatic zones 1 and 2;

b) −30 dB for rain-climatic zones 3, 4 and 5.

4.5 Energy dispersal

As is well known, sharing with other services sensitive to interference in a narrow bandwidth (for example, 4 kHz) is facilitated if artificial energy dispersal is applied to satellite broadcasting emissions.

Of course, the use of energy dispersal gives an unwanted complication on the receiver side, but recent studies have shown that a small degree of energy dispersal would not lead to an unacceptable increase in receiver cost. It could be shown that the necessary protection of the services in question could in fact only be met if energy dispersal were used in satellite broadcasting. It was therefore accepted to use a peak-to-peak deviation of the carrier of 600 kHz, which reduces the power flux density over a 4 kHz bandwidth with respect to the value in a 27 MHz bandwidth by 22 dB.

5. Requirements and planning

Planning studies made before the Conference for certain parts of the world had shown that it might be possible to assign as many as five channels per country in Region 1 and four channels in Region 3. It was also shown that the most difficult part to plan for was Europe—Africa because of the high number of countries sharing a minor part of the orbital arc.

The information distributed before the Conference by the IFRB showed—not surprisingly—that the foreseeable requirements of most countries were four or five channels either per country or per region for larger countries. But it could also be seen that excessive requirements were presented, especially in some parts of Region 1.

As far as Region 2 was concerned it was made clear, during the time of preparation in the CCIR and later in the seminars, that in general the countries of Region 2 did not favour the establishment of a fixed plan—at least not at the present time. The United States had been the spokesman for the so-called evolutionary approach, where system design and deployment are constrained by a number of sharing principles together with prior consultation with other concerned administrations. During the Conference the countries of Region 2 did set up (Annexes 6 and 7 of the Final Acts) certain general planning principles confirming, for example, the equality of countries, the equal rights for services of the various Regions and equitable rights of access to the geostationary orbit. Also, certain techniques such as satellite clustering, meaning that satellites of similar characteristics should be grouped in the same part of the orbit, and crossed-beam geometry, meaning that adjacent satellites should not serve adjacent service areas, were identified.

However, during the Conference it was decided that a Regional Administrative Radio Conference for the detailed planning of the space services in the 12 GHz band in Region 2 should be held not later than 1982, and the necessary recommendation and resolutions were passed (Recommendation No. Sat-8 and Resolutions Nos. Sat-8 and Sat-9).

As the countries of Regions 1 and 3 were determined to construct a detailed plan, certain basic principles had to be agreed upon before any attempt could be made.

The most important principles adopted were those of individual reception and national coverage. In cases where the specified service area deliberately exceeded the national frontiers, the agreement of countries that were subject to spillover had to be obtained.

The basis for the definition of the antenna beam (circular or elliptical) was agreed to be a polygon, the vertices of which should lie within the national frontiers.

It should also be mentioned that the Conference decided to plan for countries or areas of Regions 1 and 3 not represented at the Conference on a basis equitable with other countries in the same part of the world.

To illustrate the problem of constructing a plan on the basis of the requirements presented two test plans were made, one based on the requirements and one on the principle of a " regular " plan giving four to five channels to each country (or specified regions of the large countries). It was thus shown that a satisfactory plan could not be constructed on the basis of the full requirements.

Consequently the painful procedure of " reducing requirements " had to be started, not only to reduce in certain cases the number of channels asked for but also to obtain some flexibility in the grouping of countries. It was also necessary to find solutions to the serious problems presented by some of the so-called " superbeams " (beams covering groups of countries).

To aid the necessary negotiations during the rest of the Conference, Mr. Fadami was asked to act as mediator in specially difficult cases.

Thanks to goodwill and a real spirit of co-operation it was possible to make the necessary reductions and adjustments and the list of requirements changed almost every day during the critical period when it could be seen that the Conference was running short of time.

Apart from the reduction of requirements in certain areas and the deletion of the most troublesome superbeams, adjustments in certain groupings of countries and their preferred orbital positions were made. In particular, the agreement upon the grouping of Austria, Belgium, France, the Federal Republic of Germany, Italy, Luxembourg, Netherlands and Switzerland at longitude 19°W and Bulgaria, the German Democratic Republic, the People's Republic of Poland, Roumania, Czechoslovakia, the Hungarian People's Republic at longitude 1°W solved many problems in that highly congested part of the orbit.

To facilitate the sharing problems with Region 2 it was agreed that only the portion of the orbital arc between 37°W and 146°E should be used in planning for Regions 1 and 3. It was also agreed that, whenever possible, channels between 12.2 and 12.5 GHz should be assigned to the countries in Region 1 most likely to cause interference in Region 2, because in that part of the band no sharing problems arise. On the other hand, Region 2 countries agreed to accept the power flux density values resulting from the Plan for Regions 1 and 3. The power flux density values for satellites on channels between 11.7 and 12.2 GHz and in positions between 37°W and 5°E are specified in Annex 11 of the Final Acts for a test point in eastern Brazil.

The planning work itself was carried out by very few individuals and was of course only made possible by the intensive use of computer facilities. It should be underlined that without the use of the program and computer of *Télédiffusion de France* generously put at the disposal of the Conference by the French delegation the planning would have failed.

Other programs also (from the European Broadcasting Union (EBU), the Federal Republic of Germany, Italy and Japan) were in use during the Conference. The formal updating of the list of requirements and the final analyses of the draft plans and " The Plan " were carried out successfully by the IFRB using ITU computing and printing facilities as well as other powerful installations in Geneva.

In spite of great difficulties it was possible to finalize a plan which met all the requirements in the final list, but only at the very last moment. In surprisingly few cases the prescribed limits of interference were not met.

Most countries—or regions of countries—were assigned the required four or five channels. In a limited number of cases—countries with many languages, with a special regional character or of isolated geographical position—it was found technically possible to assign more than the equitable number of channels.

Of the superbeams only a few were left, a Nordic one covering Denmark, Finland, Norway and Sweden, one with a single channel assigned to the Vatican City State covering most of Italy and one with a single channel assigned to Tunisia covering a large part of the Maghrib.

For the purpose of broadcasting an Islamic religious programme, an extra channel was assigned to some countries and a slight extension of the Syrian beam and a changed coverage of the Saudi Arabian beam for a single channel were accepted.

6. Procedures

As the agreement has the character of a treaty binding the signatory countries, Committee 6 had a most difficult task in setting up the necessary procedures.

A principal problem was whether the Conference was competent to revise the Radio Regulations, thereby binding members not represented.

In the end the problem was solved by the adoption of Resolution No. Sat-4, in which the Conference request the 1979 World Administrative Radio Conference to " annex the provisions and associated Plan to the Radio Regulations, in the form and to the extent it deems most appropriate without thereby affecting their content or integrity ". By this procedure it is ensured that there will be full co-ordination between the Radio Regulations in general and the special provisions for the broadcasting-satellite service adopted at the 1977 Conference.

The provisions of the Final Acts of the Conference apply in principle both to the broadcasting-satellite service and to the other services to which the bands (11.7-12.5 GHz for Region 1 and 11.7-12.2 GHz for Regions 2 and 3) are also allocated as far as their relationship with the broadcasting-satellite service is concerned.

In Regions 1 and 3 space stations in the broadcasting-satellite service must conform to the characteristics specified in the Plan.

In Article 4 the necessary procedure for modifications to the Plan is outlined, and it can be said that there is virtually no room for departure from the characteristics laid down in the Plan without the agreement of other administrations.

The IFRB is of course responsible for keeping an updated master copy of the Plan, including agreed modifications.

Article 5 deals with the procedure to be followed when an administration intends to bring into use a broadcasting-satellite system.

It is worth mentioning that notification to the IFRB can be made at the earliest three years and at the latest 90 days before a frequency assignment is brought into use.

In Article 6 the rules for co-ordination between the satellite-broadcasting and the terrestrial services in the 12 GHz band are set out and the method of calculating the power flux density from the terrestrial service in the service area of the broadcasting satellite is given in an annex.

Articles 7, 9 and 10 concern the interface problems between Regions 1 and 3 on the one hand and Region 2 on the other hand.

Article 7 covers the fixed-satellite service of Region 2, Article 9 the broadcasting-satellite service of Region 2 and Article 10 the broadcasting-satellite service of Regions 1 and 3.

As there is still no plan for Region 2, provisions for the broadcasting-satellite service in that region are set out in Article 12 pending the establishment of a detailed plan.

Finally—in Articles 15 and 16—it is stated that the Final Acts shall enter into force on 1 January 1979 and that the provisions and the Plan have been prepared in order to meet the requirements of the broadcasting-satellite service for a period of at least 15 years.

7. Rearrangement of the Radio Regulations

This special task of the Conference was dealt with in a swift and expedient manner by Committee 7, thanks to the report drawn up before the Conference by the Group of Experts set up by the Administrative Council in 1975.

The proposals of the Group of Experts were adopted with only minor changes and the Conference instructed the Secretary-General to draw up and distribute the final text of the " Rearrangement of the Radio Regulations " by September 1977, the aim of course being that administrations in submitting their proposals for the WARC-1979 shall use this rearrangement as a basis, as is spelled out in a resolution contained in Part II of the Final Acts.

8. Special problems

Already from the start of the Conference a number of equatorial countries, i.e. the countries that are crossed by the equator, expressed the view that the portion of the geostationary orbit situated above their territory fell under their sovereignty and that they were entitled to apply their national legislation to it. Consequently, they argued, no satellite could be taken into service above an equatorial country without the agreement of that country.

However, it was stated from other quarters that as the Conference was governed by the ITU Convention it could only discuss items included in its agenda, and the question of the sovereignty of the geostationary orbit was not included; the matter could, therefore, not be discussed.

Furthermore, it was stated that the assignment of frequencies and orbital positions is fully in conformity with the generally recognized principles and rules of international law, including the International Telecommunication Convention.

The Conference took note of the various points of view but no discussion took place.

9. Conclusion

It is probably a fair statement that the Conference was a success thanks to the prevailing goodwill and hard work by all delegates.

The high level of co-operation may be judged by the fact that the Conference was brought to an end without a single vote being taken and with the signing of the Final Acts by all accredited delegations.

It is to be hoped that the technical foundation now laid down by the ITU for satellite broadcasting will serve its purpose in the evolution of this new service which has the possibility of bringing education and entertainment to many people, perhaps even some not yet served by broadcasting.

(Original language: English)