XVII A.P.
DÜSSELDORF
21.5-1.6 1990
CCIR

XVIIth PLENARY ASSEMBLY
DÜSSELDORF, 1990

INTERNATIONAL TELECOMMUNICATION UNION

RECOMMENDATIONS OF THE CCIR, 1990

(ALSO RESOLUTIONS AND OPINIONS)

VOLUME IV – PART 1

FIXED-SATELLITE SERVICE

CCIR INTERNATIONAL RADIO CONSULTATIVE COMMITTEE

Geneva, 1990

CCIR

1. The International Radio Consultative Committee (CCIR) is the permanent organ of the International Telecommunication Union responsible under the International Telecommunication Convention "... to study technical and operating questions relating specifically to radiocommunications without limit of frequency range, and to issue recommendations on them..." (International Telecommunication Convention, Nairobi 1982, First Part, Chapter I, Art. 11, No. 83).*

2. The objectives of the CCIR are in particular:

a) to provide the technical bases for use by administrative radio conferences and radiocommunication services for efficient utilization of the radio-frequency spectrum and the geostationary-satellite orbit, bearing in mind the needs of the various radio services;

b) to recommend performance standards for radio systems and technical arrangements which assure their effective and compatible interworking in international telecommunications;

c) to collect, exchange, analyze and disseminate technical information resulting from studies by the CCIR, and other information available, for the development, planning and operation of radio systems, including any necessary special measures required to facilitate the use of such information in developing countries.

* *See also the Constitution of the ITU, Nice, 1989, Chapter 1, Art. 11, No. 84.*

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92-61-04191-4

Geneva, 1990

PLAN OF VOLUMES I TO XV
XVIIth PLENARY ASSEMBLY OF THE CCIR

(Düsseldorf, 1990)

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All references within the texts to CCIR Recommendations, Reports, Resolutions, Opinions, Decisions and Questions refer to the 1990 edition, unless otherwise noted; i.e., only the basic number is shown.

1990
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DISTRIBUTION OF TEXTS OF THE XVIIth PLENARY ASSEMBLY OF THE CCIR IN VOLUMES I TO XV

Volumes and Annexes I to XV, XVIIth Plenary Assembly, contain all the valid texts of the CCIR and succeed those of the XVIth Plenary Assembly, Dubrovnik, 1986.

1. Recommendations, Resolutions, Opinions are given in Volumes I-XIV and Reports, Decisions in the Annexes to Volumes I-XII.

1.1 *Numbering of texts*

When a Recommendation, Report, Resolution or Opinion is modified, it retains its number to which is added a dash and a figure indicating how many revisions have been made. Within the text of Recommendations, Reports, Resolutions, Opinions and Decisions, however, reference is made only to the basic number (for example Recommendation 253). Such a reference should be interpreted as a reference to the latest version of the text, unless otherwise indicated.

The tables which follow show only the original numbering of the current texts, without any indication of successive modifications that may have occurred. For further information about this numbering scheme, please refer to Volume XIV.

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* Not reprinted, see Dubrovnik, 1986.

(1) Published separately.

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* Not reprinted, see Dubrovnik, 1986.

(1) Published separately.

1.3.1 *Note concerning Reports*

The individual footnote "Adopted unanimously" has been dropped from each Report. Reports in Annexes to Volumes have been adopted unanimously except in cases where reservations have been made which will appear as individual footnotes.

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2. **Questions** (Vols. XV-1, XV-2, XV-3, XV-4)

2.1 *Numbering of texts*

Questions are numbered in a different series for each Study Group: where applicable a dash and a figure added after the number of the Question indicate successive modifications. The number of a Question is completed by an *Arabic figure indicating the relevant Study Group.* For example:

- Question 1/10 would indicate a Question of Study Group 10 with its text in the original state;
- Question 1-1/10 would indicate a Question of Study Group 10, whose text has been once modified from the original; Question 1-2/10 would be a Question of Study Group 10, whose text has had two successive modifications.

Note – The numbers of the Questions of Study Groups 7, 9 and 12 start from 101. In the case of Study Groups 7 and 9, this was caused by the need to merge the Questions of former Study Groups 2 and 7 and Study Groups 3 and 9, respectively. In the case of Study Group 12, the renumbering was due to the requirement to transfer Questions from other Study Groups.

2.2 *Assignment of Questions*

In the plan shown on page II, the relevant Volume XV in which Questions of each Study Group can be found is indicated. A summary table of all Questions, with their titles, former and new numbers is to be found in Volume XIV.

2.3 *References to Questions*

As detailed in Resolution 109, the Plenary Assembly approved the Questions and assigned them to the Study Groups for consideration. The Plenary Assembly also decided to discontinue Study Programmes. Resolution 109 therefore identifies those Study Programmes which were approved for conversion into new Questions or for amalgamation with existing Questions. It should be noted that references to Questions and Study Programmes contained in the texts of Recommendations and Reports of Volumes I to XIII are still those which were in force during the study period 1986-1990.

Where appropriate, the Questions give references to the former Study Programmes or Questions from which they have been derived. New numbers have been given to those Questions which have been derived from Study Programmes or transferred to a different Study Group.

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VOLUME IV

FIXED-SATELLITE SERVICE

(Study Group 4)

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FIXED-SATELLITE SERVICE

Terms of reference:

To study questions relating to systems for the fixed-satellite service and inter-satellite links in the fixed-satellite service (including the associated tracking, telemetry, and telecommand functions).

1986-1990	*Chairman:*	E. R. HAUCK (Switzerland)
	Vice-Chairmen:	F. S. LEITE (Brazil) T. MURATANI (Japan) P. REMEDI (Indonesia)

As from the next study period, in conformity with Resolution 61 adopted at the XVIIth Plenary Assembly, Düsseldorf (May-June 1990), the scope of the work which will be undertaken and the names of the Chairman and Vice-Chairmen concerned are given below:

STUDY GROUP 4

FIXED-SATELLITE SERVICE

Scope:

Systems and networks for the fixed-satellite service and inter-satellite links in the fixed-satellite service, including associated tracking, telemetry and telecommand functions.

1990-1994	*Chairman:*	E. R. HAUCK (Switzerland)
	Vice-Chairmen:	J. M. P. FORTES (Brazil) T. MURATANI (Japan) P. REMEDI (Indonesia)

INTRODUCTION BY THE CHAIRMAN, STUDY GROUP 4

1. Introduction

The Interim Meeting was held from 17 November to 3 December 1987 in Geneva. Forty-eight administrations, recognized private organizations and international organizations attended this meeting. The workload during this meeting was considerably greater than usual, since in addition to the normal ongoing work, a report to the JIWP/ORB(2), the technical preparatory meeting to the WARC ORB-88, had to be prepared. An Ad Hoc Group collected contributions from the Working Groups and produced a consolidated Report from CCIR Study Group 4 to the JIWP/ORB(2). This document was an important input to the JIWP/ORB(2) to draft the CCIR Report to WARC ORB-88.

The Final Meeting was held from 20 September to 6 October 1989 in Geneva. One hundred eighty-nine participants from 47 administrations, recognized private organizations and international organizations attended this meeting, during which 139 input documents were considered. Dr. J. M. P. Fortes (Brazil) was elected as Vice-Chairman in place of Mr. F. S. Leite (Brazil) who took a position in the IFRB. Four new Recommendations were approved by Study Group 4 and two by the Joint Study Groups 4 and 9. Eight new Reports were adopted for Volume IV and two for Volume IV/IX.

Our Vice Chairman, Dr. T. Muratani, organized a presentation for Study Group 4 at the Meeting of the Plan Committee for Asia and Oceania in Bali, October 1986: "The Role of Digital Satellite Systems in the ISDN Era", by Mr. K. Inagaki, KDD.

At the First Meeting of the CITEL Permanent Technical Committee III: Radiocommunications in Buenos Aires (Argentina) (11-15 July, 1988) Dr. J. M. Fortes of Brazil gave a presentation on "The Intersessional Activities of CCIR which are related to the Allotment Planning and to Improved Procedures".

I presented papers on "The Work in Progress in CCIR Study Group 4 on the Intersessional Work of the CCIR for WARC ORB-88" at the Meeting of the Plan Committee for Africa in Yaoundé, March 1987; on "CCIR Study Group 4 Work on the Digitalization of Satellite Systems" during the World Plan Committee Meeting (3-10 February, 1988) in Estoril, Portugal, and one during the ICC Conference in Philadelphia (12-15 June, 1988) on "Technical Parameters for Planning the Fixed-Satellite Service".

In the following some organizational aspects and major results are presented.

2. Organizational aspects

2.1 *Interim Working Party 4/1*

During the study period IWP 4/1 held three meetings under the chairmanship of Mr. A. G. Reed (United Kingdom). The first in June 1986 in London, the second in May 1987 in Rio de Janeiro and the third in June 1989 in Stockholm. A great deal of the work of the first and second meetings was directed to the preparation of material for the JIWP/ORB(2).

Since the third meeting took place after the WARC ORB-88, all the Reports on Orbit/Spectrum Efficiency, in the light of the results of WARC ORB-88 Coordination and Interference Calculations such as Reports 453, 454, 455 and 870 had to be revised and obsolete material was deleted. Much time was spent on a draft new Recommendation for satellite antenna pattern.

Owing primarily to the effects of the change in the terms of reference occasioned by the WARC ORB intersessional requirements, the workload of the IWP 4/1 grew to the point where it got unusually large. Now that the WARC ORB conferences are over, consideration was given to whether the IWP should continue, and if so, what its new terms of reference should be. IWP 4/1 discussed this matter and made recommendations to the Final Meeting of Study Group 4. After further discussions during the Final Meeting of Study Group 4 Decision 2 was revised as shown in Document 4/1062.

2.2 *Interim Working Party 4/2*

IWP 4/2 held two meetings under the chairmanship of Mr. J. Potts (United States of America): in April 1987 in Tokyo, and in March 1989 in Bali.

The existence of IWP 4/2 has always proven a valuable resource of Study Group 4 in providing prompt responses to CCITT Study Groups. Some of the results of IWP 4/2 are summarized under § 3.2 of this report. The mandate of IWP 4/2 has been reconsidered during the Final Meeting of Study Group 4 and is reflected in Decision 70 (see Document 4/1064).

2.3 *JIWP CMTT 4-10-11/1*

The JIWP held its 3rd meeting in Paris during the week of June 26, 1989. The focus of its work was to revise the Report 1237 Satellite News Gathering, and its associated Recommendation 722, "Uniform Technical Standards and Uniform Operational Procedure for Satellite News Gathering (SNG)".

The revised draft Recommendation requests the preparation of user guides by satellite space segment providers and host administrations. The report describes the content of these guides and discusses all aspects of Satellite News Gathering.

The JIWP also agreed to modifications to Decision 76, and to a draft new Study Programme, "Use of Portable and Transportable Satellite Earth Stations for the transmission of HDTV" assigned to the CMTT.

2.4 *Ad Hoc Group for the drafting of the Fixed-Satellite Service Handbook*

During the Final Meeting in 1985, Decision 64 was drafted and a Group to update the CCIR Handbook on Satellite Communications was established with Mr. J. Salomon of France as its Chairman. The Group held its first meeting in Paris from 2 to 6 March, 1987, at the invitation of the French PTT Administration. At this meeting the group decided that the updating should be done in the form of a new edition, rather than an addition to the existing Handbook.

The Final Meeting took place in April 1988 in Geneva. It was well attended and members from the Federal Republic of Germany, Brazil, Canada, People's Republic of China, United States of America, France, India, Italy, Japan, United Kingdom, Switzerland, USSR, EUTELSAT and INTELSAT helped to draft an excellent second edition of the Handbook. With the effective support of the Director of the CCIR and his Secretariat it was possible to produce both an attractive and reasonably priced Handbook. The English edition became available in March 1989 and the French and Spanish versions have been available since August 1989.

Some delegates, particularly from developing countries, asked for the insertion of computer programmes in the Handbook which could assist them for calculations and training in the field of satellite communications. Therefore, the "Handbook Group" decided, during its Final Meeting, to set up a Sub-Group with the task of preparing a supplement on this point.

The Director of the CCIR, recognizing the fact that, due to scheduling reasons, the decisions of the WARC ORB-88 Conference could not be included in the Second Edition, recently suggested to include in the supplement another part dealing with the relevant decisions of the WARC ORB-88 and with the consequences of these decisions on the content of the Handbook.

To start the preparation of this supplement, a meeting of the Group was held on the 18th and 19th of September 1989 in Geneva, just before the SG 4 Final Meeting.

2.5 *Rapporteurs*

Mr. A. A. Sophianopoulos (Canada) is the Rapporteur of Study Group 4 to the CMV and the Joint Coordination Group (JCG) of the CCIs and IEC. His important work assures that the terms and definitions relating to space radiocommunications in Recommendation 673 are up to date and well coordinated with these two groups.

The Rapporteur of Study Group 4 to the CCITT Study Groups II and XVIII for Availability and Quality matters was Mr. K. Lum of Canada. He participated in several CCITT Meetings and his reports to the IWP 4/2 Meetings were important inputs to these meetings.

Due to changes in his function within his administration he will no longer be able to continue his work as Rapporteur. I would like to take this opportunity to express my thanks to him and his administration for the strong and continuous support to Study Group 4 in this important and difficult task.

Mr. D. Weinreich (United States of America) was appointed as the new Rapporteur to CCITT Study Group XVIII. It was agreed that the mandate of CCITT Study Group II did not require a rapporteurship from Study Group 4. On the other hand a need for a Rapporteur to CCITT Study Group IV seemed necessary. As a consequence Mr. R. Southworth (United Kingdom) was appointed as Rapporteur to this Study Group. Mr. P. Amadesi (EUTELSAT) was appointed as a Liaison Rapporteur to CCITT to generally follow other work within CCITT that is of interest to Study Group 4.

2.6 *World-wide activities for standardization in telecommunication*

The work within IEC which is of most interest to Study Group 4 is done in the IEC Subcommittee 12E (Radio-Relay and Fixed Satellite Communications Systems). The Subcommittee met at Prague, Czechoslovakia, on April 14, 1989 under the chairmanship of Mr. A. A. Sophianopoulos from Telecom Canada, who was recently appointed as its new Chairman. After discussions with the Director of the CCIR, I asked Mr. Sophianopoulos to accept in addition the task of liaison officer of SC 12E to CCIR SG 4 for the time being, subject to approval by the Study Group during the Final Meeting. During the Final Meeting the appointment of Mr. Sophianopoulos as SG 4 Rapporteur to IEC Subcommittee 12E was approved.

During its 3rd meeting (Nice, 29-30 March 1989), the ETSI Technical Assembly decided to set up a new Technical Committee in charge of "Satellite Earth Stations (SES TC)" and appointed Mr. J. Salomon (ALCATEL, France) as the Chairman of this Committee.

The basic purpose of the SES TC is to prepare – in the area defined by its terms of reference – drafts of European Telecommunication Standards (ETSs or I-ETSs at the interim stage) to be submitted to the Technical Assembly for approval.

According to its terms of reference, the SES TC is also the Primary Committee for coordinating the position of ETSI, in the field of its area of competence, vis-à-vis the standardization activity of outside bodies, in particular of international standardization organizations (CCIR, CCITT, IEC, etc.) and of international satellite organizations (EUTELSAT, INTELSAT, INMARSAT). Therefore it will be an important concern of the SES TC to establish proper liaison with the CCIR Satellite Communications activities.

In view of all the activities going on world-wide in setting up standards for telecommunications, and also considering the conclusions of the last ITU Plenipotentiary Conference (i.e.: Article 11 of the Constitution of the Final Acts) it seems to me timely and important to consider how Study Group 4 could issue recommendations with a view to standardizing telecommunications on a world-wide basis.

3. Major topics

During the last study period most of the work was carried out in the areas of orbit/spectrum utilization, systems performance and availability aspects and earth-station antenna aspects. For the new Volume IV, Part 1, the sections have been structured accordingly. In addition a separate section on definitions has been prepared. The most important results referring to the different Sections are presented in the following.

3.1 *Definitions* (Section 4A)

During the Final Meeting it was agreed unanimously that Report 204 on terms and definitions relating to space radiocommunications should be converted into the Recommendation 673. It was not necessary to change the content, since the Report had already the structure and the value of a Recommendation.

3.2 *Systems aspects – performance and availability*

3.2.1 *Systems aspects* (Section 4B1)

In this Section two new Reports are introduced, to a great extent based on material produced by IWP 4/2.

Because of the growing amount of material contained in Report 997 this material was split into two parts. The part which remains in Report 997 is supporting text to Recommendation 614. The other part which includes matters related to ISDN but not currently essential material for Recommendation 614 is presented as Report 1139. This new Report contains material such as broadband-ISDN (B-ISDN), the Synchronous Digital Hierarchy (SDH), the Asynchronous Transfer Mode (ATM) and aspects of interference on quality and availability. A proposal for the text of a new Recommendation on maximum permissible levels of interference into digital satellite transmissions, which form part of an Integrated Service Digital Network, is annexed to this Report.

Report 1134 presents the advantages of satellite communication systems to digital services in user dedicated networks. It describes how satellite systems, due to their flexibility and multi-access capabilities using small earth stations, are the ideal means for dedicated digital business networks. In particular the relevant quality aspects in view of error performance are covered.

New material on 30/20 GHz satellite systems has been added to Report 552 as well as information on fade countermeasures for time-division-multiple-access systems during severe rain attenuation.

The titles of Recommendation 722 and Report 1237 on Satellite News Gathering drafted by JIWP 4-10-11-CMTT/1 are referenced. The texts will be printed in Volume XII.

3.2.2 *Performance and availability aspects* (Section 4B2)

This Section contains Recommendations and Reports on Hypothetical Reference Circuits and Hypothetical Reference Digital Paths including the relevant recommended quality and availability standards.

The availability objectives were not modified during the last study period.

To Recommendation 614 a new Note 12 was added to point out that RECOMMENDS 1 was developed for the "high grade" section of the Hypothetical Reference Connection in CCITT Recommendation G.821, and that error performance objectives can be adjusted to other applications of the HRDP.

Report 997 was revised extensively by IWP 4/2 and much material was transferred to the Report 1139 as explained above. In particular in view of Recommendation 614, Annex IV of Report 997 was revised to take account of the effects of the bursty nature of errors that might be caused by the use of coding.

3.3 *Earth station aspects* (Section 4C)

This Section covers earth station and baseband characteristics, earth-station antennas and maintenance of earth stations.

The Recommendation and Reports on maintenance of earth stations and on earth station and baseband characteristics were changed very little during the last study period. On the other hand Reports 391 and 998 on the radiation diagrams of earth-station antennas received many contributions and could be updated accordingly.

They show that antennas developed during the last few years can meet the design objectives of Recommendation 580. In particular Note 7 of this Recommendation points out the possibility to extend the specification of antennas for D/λ between 100 and 150 also to antennas with D/λ below 100. This would be beneficial in view of the efficient use of the geostationary-satellite orbit.

Other additions to Recommendations 465 and 580 refer to requirements of very closely spaced satellites where information on the main lobe and/or the first side lobe is needed (Note 3 of Recommendation 465) and to cases for off-axis angles greater than the limits specified in Recommendation 580 (see RECOMMENDS 4).

3.4 *Frequency sharing between networks of the fixed-satellite service — use of the geostationary-satellite orbit*

3.4.1 *Permissible levels of interference* (Section 4D1)

This Section contains material on permissible levels of interference and interference aspects. Recommendations 466, 483, 523 and 671 give limits for permissible interference levels. A new Note 11 to Recommendation 523 suggests that the percentages of total noise power given in RECOMMENDS 1.1, 1.2 and 2 may provisionally be used for digital satellite transmissions which form part of an Integrated Service Digital Network. The proposal for a text of a new Recommendation on this subject is annexed to Report 1139 (see § 3.2.1 above). Recommendation 671 is an important addition to this set of interference recommendations since it provides the necessary protection ratios for the critical situation where narrow-band single-channel-per-carrier transmissions are interfered with by analogue television carriers. Additional information on interference in single-channel-per-carrier is given in Report 867 which has been extended to include information on IDR (Intermediate Digital Rate) transmissions.

To Recommendation 524 RECOMMENDS 3 was added to take account of the 14 GHz frequency band in addition to the previously covered 6 GHz band. In respect of FM/TV emissions in the 14 GHz band (see Note 11) two reservations were stated and concerning the date shown in RECOMMENDS 2 one reservation was made. Additional information on off-axis e.i.r.p. density limits is given in Report 1001.

In addition to Report 555 on dual polarization operation Report 1141 has been drafted. It contains information to produce design objectives for the cross-polar patterns of earth station and satellite antennas. These objectives should facilitate interference calculations for system design and coordination purposes.

In light of revising and restructuring all reports on orbit/spectrum utilization, Report 455 was modified. Further details are given in the next section.

3.4.2 *Efficient orbit/spectrum utilization, coordination methods* (Section 4D2)

Based on intensive work during the last IWP 4/1 meeting and final work in Working Group 4C during the Final Study Group Meeting, Reports 453, 454, 455, 870 and 1135 were modified and restructured to take account of the results of WARC ORB-88 and to give each Report a specific emphasis. The Chairman of Working Group 4C Mr. A. G. Reed drafted an overview to show the functions of the different Reports (see Appendix I to this report). Administrations are encouraged to take this outline into account in their preparations for the meetings of the next study period. The different steps which were taken for these rearrangements are listed in Appendix II to this report.

Some sections and tables in Reports 454 and 1135 have to be adjusted to the newly recommended interference limits in Recommendation 671.

Report 1137 demonstrates that significant benefits in the utilization of the geostationary-satellite orbit could be achieved by statistical approaches as compared to deterministic and most often worst-case assumptions currently used in computing interference between satellite networks.

Based on the Question put forward by the IFRB during the JIWP/ORB(2) and Annex V of Report 453, the IWP 4/1 received much material on "slightly inclined geostationary orbit" aspects. This material was collected and is now presented as Report 1138. Discussions showed that other CCIR Study Groups might be even more affected than Study Group 4 by the possible impacts of slightly inclined orbit operations.

In view of results of WARC ORB-88, texts on "satellite networks for more than one service in one or more frequency bands" were contributed to IWP 4/1 and discussed. The material is collected in Report 1140.

As the number of satellites in the geostationary orbit increases, it will become common that two or more satellites are placed and operated at the same longitudinal position of the orbit. Accordingly the situation that an operational satellite encounters physical interference with another operational satellite will also be possible in future. Additional text to Report 1004 takes account of this situation and provides new information.

3.4.3 *Spacecraft aspects* (Section 4D3)

This Section covers aspects of spacecraft positioning and station-keeping as well as satellite antenna matters.

Recommendation 670 gives design objectives for satellites to improve the flexibility in the positioning of satellites to increase the efficiency of the geostationary orbit. Report 1002 contains supporting material on this subject.

Information in Recommendation 484 and Report 556 on station-keeping of geostationary satellites was kept unchanged in essence during the last study period.

On satellite antennas a new Recommendation and a new Report were drafted.

Report 558 on satellite antennas now has enough supporting material and measurements of practical examples, so that the Final Meeting could approve the Recommendation 672 on satellite antenna radiation pattern for use as a design objective.

Report 1136 summarizes the achievable performance of satellite antenna beam pointing and its effect on the efficient utilization of the geostationary-satellite orbit. It might be useful to transform material of this nature into a Recommendation soon.

3.5 *Frequency sharing between networks of the fixed-satellite service and those of other space radiocommunication systems* (Section 4E)

The seven Reports in this Section were hardly modified during the last study period. To Report 873 information on criteria for the determination of the need to coordinate fixed-satellite space stations in Region 2 with BSS assignments of the Region 1 and 3 plan were added.

3.6 *Frequency sharing between systems in the fixed-satellite service and terrestrial radio services*

Recommendations and Reports on this topic are reproduced in Volume IV/IX, Part 2.

3.6.1 *Sharing conditions* (Section 4/9A)

To facilitate the application of Article 14 of the Radio Regulations to the sharing situation in Region 2 in the frequency band 11.7-12.2 GHz, Recommendation 674 provides power-flux density values. Additional explanatory text on this subject is given in Report 1143.

Report 1142 describes the sharing situation when satellites go into slightly inclined orbit. The impact on terrestrial networks due to both the space and earth stations is shown. Similarly, satellite networks will be affected by interference into space and earth stations.

3.6.2 *Co-ordination and interference calculations* (Section 4/9B)

Recommendation 675 provides a method of calculating the power level in the worst 4 kHz band to prepare information required in Appendices 3 and 4 of the Radio Regulations for coordination and notification purposes. Report 792 was modified in reference to Recommendation 675.

Decision 87 was drafted to set up and formulate the mandate of a Joint Interim Working Party 2-4-5-8-9-10-11/1 to undertake a comprehensive revision of CCIR texts relevant to Appendix 28 of the Radio Regulations.*

4. Conclusion

The last study period was a very busy one especially because of the preparatory work for the Second Session of the World Administrative Radio Conference on Orbit/Spectrum Utilization.

The forthcoming Volume IV will offer a set of new Recommendations and Reports in addition to important material added to the existing Recommendations and Reports.

During the next study period the Study Group should concentrate its efforts to identify and improve existing material in Reports with the goal of transforming it into Recommendations.

In view of the world-wide activities on standardization the Study Group should consider to produce recommendations in this field.

It will also play an active part in the new JIWP for the revision of Appendix 28 as mandated in Decision 87.*

Depending on the agenda and the Decision on WARC-92 Study Group 4 and IWP 4/1 will have to make relevant contributions.

These examples show that another busy study period lies ahead of us. I would like to take this opportunity to thank all delegates of Study Group 4, in particular the SG 4 Vice-Chairmen, the Chairman of the IWP's and the Rapporteurs, for their efforts to achieve the good results of the last study period and I am looking forward to an active and successful study period in good spirit.

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* *Note by Secretariat* – The Chairmen and Vice-Chairmen of CCIR Study Groups, in consultation with the Director in their meeting held 4-6 July 1990, approved a provisional structure of Working Parties and Task Groups, and assigned Questions for study, pending approval at the earliest Study Group meetings (Study Period 1990-1994). The task of New JIWP 2-4-5-8-9-10-11/1 for the revision of Appendix 28 of the Radio Regulations now is under the responsibility of CCIR Study Group 12.

APPENDIX I

PURPOSES OF VOLUME IV-1
REPORTS ON INTERFERENCE AND COORDINATION

Report 454

This Report is to investigate current and new methods of determining whether coordination is required between fixed-satellite networks, as distinct from how to coordinate once it has been established that coordination is necessary. This Report provides CCIR information relating to Appendix 29 of the Radio Regulations.

Report 870

This Report describes the technical basis for tools that may be used in the actual coordination process, once it has been established that coordination is necessary. It concentrates on frequency and traffic coordination rather than orbit selection as such (this last topic is discussed in more detail in Report 1135).

Report 1135

This Report discusses tools that may be used in the selection of an orbit position for a new satellite network or the replacement of an old space station, to avoid the need to coordinate if possible and if not to minimize the difficulty and the complexity of that coordination.

Report 455

This Report is to provide the technical basis for consideration of changes to Recommendations 466, 523 and 483, the Recommendations dealing with the maximum permissible interference into fixed-satellite networks carrying specific types of traffic. Note that it should not deal with the coordination between networks *per se*; that subject is considered in Report 870.

Report 453

This Report describes new concepts to be used in the sharing of the spectrum and the GSO between fixed-satellite networks. If such a new idea withstands the test of time, it should result in a new Recommendation, or should be included in the text of one of the above four Reports, or should be the basis for a new Report. It is not expected that Report 453 should be the permanent home for a new idea or concept.

APPENDIX II

REORGANIZATION OF TEXTS IN
REPORTS 453, 454, 455, 870 AND 1135

- Normalized $\Delta T/T$ texts – Text currently associated with Report 453 to be moved to become Annex III to Report 454.
- $\Delta T/T$ relationship with C/I – Text currently associated Report 455 to be moved to become Annex V to Report 454.
- ABCD parameter sets – Texts on sets other than A′, B′, C′, D′ to be deleted from Report 453, and a reference to their existence in the 1986 Green Book substituted. A′, B′, C′, D′ texts to remain as Annex II to Report 453.
- Power density averaging bandwidth – Text to be moved from association with Report 870 to become Annex IV with Report 454.
- COS, isolation and link isolation – To be moved from association with Report 453, to Annex II and Annex I to Report 1135 (texts on isolation and link isolation currently in Report 870 to remain).
- C/I – Texts to remain associated with Reports 870, 455 and 453.
- Impact of new entrants – To be associated with Report 453 (Annex I).
- Orbit management techniques – To be associated with Report 870 (Annex I).
- Total orbit capacity – To be deleted from Report 453.
- Optimization methods to identify satellite orbital positions – Subject reference in Report 453 to remain; new text to be included in association with Report 1135.
- Interference calculation presentation (currently in Annex II to Report 453) – To be moved to become Annex II to Report 455.
- Frequency sharing in the FSS – To remain as Annex I to Report 455.

SECTION 4A: DEFINITIONS

RECOMMENDATION 673

TERMS AND DEFINITIONS RELATING TO SPACE RADIOCOMMUNICATIONS

(1990)

The CCIR,

CONSIDERING

(a) that terms and definitions concerning space systems, services and stations are included in the Radio Regulations;

(b) that it is necessary to establish definitions for additional terms relating to space radiocommunications in order to facilitate studies in the CCIR,

UNANIMOUSLY RECOMMENDS

that terms listed in the Annex below should be used as far as possible with the meaning ascribed to them in the corresponding definition.

ANNEX

TERMS AND DEFINITIONS RELATING TO SPACE RADIOCOMMUNICATIONS

Terms and definitions concerning space systems, services and stations are included in the Radio Regulations and are not reproduced in this Annex.

Spacecraft

A man-made vehicle which is intended to go beyond the major part of the Earth's atmosphere.

Space probe

A spacecraft designed for making observations or measurements in space.

Satellite

A body which revolves around another body of preponderant mass and which has a motion primarily and permanently determined by the force of attraction of that other body.

Note – A body so defined which revolves around the Sun is called a planet or planetoid.

Active satellite

A satellite carrying a station intended to transmit or retransmit radiocommunication signals.

Reflecting satellite

A satellite intended to transmit radiocommunication signals by reflection.

Primary body (in relation to a satellite)

The attracting body which primarily determines the motion of a satellite.

Orbit

The path, relative to a specified frame of reference, described by the centre of mass of a satellite or other body in space, subjected solely to forces of natural origin, mainly the force of gravity; by extension, the path described by the centre of mass of a body in space subjected to forces of natural origin and occasional low-energy corrective forces exerted by a propulsive device in order to achieve and maintain a desired path.

Unperturbed orbit (of a satellite)

The orbit of a satellite in the idealized condition in which the satellite is subjected only to the attraction of the primary body, effectively concentrated at its centre of mass.

Note – In a frame of reference whose centre is the centre of mass of the primary body, and whose axes have fixed directions in relation to the stars, the unperturbed orbit is a conic section.

Orbital elements (of a satellite or other body in space)

The parameters by which the shape, dimensions and position of the orbit in space and the period of the body can be defined in relation to a specified frame of reference.

Note 1 – In order to determine the position of a body in space, at any instant it is necessary to know, in addition to its orbital elements, the position of its centre of gravity in its orbit at one given instant.

Note 2 – The frame of reference used is a direct rectangular co-ordinate system OXYZ, in which the origin is at the centre of mass of the primary body and the third axis OZ is perpendicular to the principal reference plane, also called the basic reference plane, or simply the reference plane.

Note 3 – For an artificial earth satellite, the reference plane is the Earth's equatorial plane and the third axis OZ has a South to North orientation.

Visible arc

The common part of the arc of the geostationary satellite orbit over which the space station is visible above the local horizon from each associated earth station in the service area.

Service arc

The arc of the geostationary satellite orbit within which the space station could provide the required service (the required service depends upon the system characteristics and user requirements) to all of its associated earth stations in the service area.

Orbital plane (of a satellite)

The plane containing the centre of mass of the primary body and the velocity vector of a satellite, the frame of reference being that specified for defining the orbital elements.

Ascending (descending) node

The point at which the orbit of a satellite or planet intersects the principal reference plane, the third co-ordinate of the satellite or planet being increasing (decreasing) on passing through that point.

Direct (retrograde) orbit (of a satellite)

A satellite orbit such that the projection of the centre of mass of the satellite onto the principal reference plane revolves about the axis of the primary body in the same (reverse) direction as (to) that in which the primary body rotates.

Inclination (of a satellite orbit)

The angle between the plane of the orbit of a satellite and the principal reference plane.

Note – By convention, the inclination of a direct orbit of a satellite is an acute angle and the inclination of a retrograde orbit is an obtuse angle.

Circular orbit (of a satellite)

A satellite orbit in which the distance between the centres of mass of the satellite and of the primary body is constant.

Elliptical orbit (of a satellite)

A satellite orbit in which the distance between the centres of mass of the satellite and of the primary body is not constant but remains finite.

Note – The unperturbed orbit is an ellipse within a frame of reference, the origin of which is the centre of gravity of the main body and the axes of which have fixed direction with reference to the stars.

Equatorial orbit (of a satellite)

A satellite orbit, the plane of which coincides with that of the equator of the primary body.

Polar orbit (of a satellite)

A satellite orbit, the plane of which contains the polar axis of the primary body.

Inclined orbit (of a satellite)

A satellite orbit which is neither equatorial nor polar.

Apoapsis

The point in the orbit of a satellite or planet which is situated at the maximum distance from the centre of mass of the primary body.

Periapsis

The point in the orbit of a satellite or planet which is situated at the minimum distance from the centre of mass of the primary body.

Apogee

The point in the orbit of an earth satellite which is situated at the maximum distance from the centre of the Earth.

Note – The apogee is the apoapsis of an earth satellite.

Perigee

The point in the orbit of an earth satellite which is situated at the minimum distance from the centre of the Earth.

Note – The perigee is the periapsis of an earth satellite.

Altitude of the apogee (perigee)

The altitude of the apogee (perigee) above a specified hypothetical reference surface serving to represent the surface of the Earth.

Period of revolution (of a satellite)
Orbital period (of a satellite)

The time elapsing between two consecutive passages of a satellite through a characteristic point on its orbit.

Note – If the characteristic point on the orbit is not specified, the period of the revolution considered is, by convention, the anomalistic period.

Anomalistic period

The time elapsing between two successive passages of a satellite through its periapsis.

Nodal period

The time elapsing between two consecutive passages of a satellite through the ascending node of its orbit.

Sidereal period of revolution (of a satellite)

The time elapsing between two consecutive intersections of the projection of a satellite onto a reference plane which passes through the centre of mass of the primary body with a line in that plane extending from the centre of mass to infinity, both the normal to the reference plane and the direction of the line, being fixed in relation to the stars.

Sidereal period of rotation (of a body in space)

Period of rotation, around its own axis, of a body in space in a frame of reference fixed in relation to the stars.

Station-keeping satellite

A satellite, the position of the centre of mass of which is controlled to follow a specified law, either in relation to the positions of other satellites belonging to the same space system or in relation to a point on Earth which is fixed or moves in a specified way.

Synchronized satellite
Phased satellite (deprecated)

A satellite controlled so as to have an anomalistic period or a nodal period equal to that of another satellite or planet, or to the period of a given phenomenon, and to pass a characteristic point in its orbit at specified instants.

Attitude-stabilized satellite

A satellite with at least one axis maintained in a specified direction, e.g. toward the centre of the Earth, the Sun or a specified point in space.

Synchronous satellite

A satellite for which the mean sidereal period of revolution is equal to the sidereal period of rotation of the primary body about its own axis; by extension, a satellite for which the mean sidereal period of revolution is approximately equal to the sidereal period of rotation of the primary body.

Geosynchronous satellite

Synchronous earth satellite.

Note – The sidereal period of rotation of the Earth is about 23 hours 56 minutes.

Sub-synchronous (super-synchronous) satellite

A satellite for which the mean sidereal period of revolution about the primary body is a sub-multiple (an integral multiple) of the sidereal period of rotation of the primary body about its own axis.

Stationary satellite

A satellite which remains fixed in relation to the surface of the primary body; by extension, a satellite which remains approximately fixed in relation to the surface of the primary body.

Note – A stationary satellite is a synchronous satellite with an orbit which is equatorial, circular and direct.

Geostationary satellite

A stationary satellite having the Earth as its primary body.

Geostationary satellite orbit

The unique orbit of all geostationary satellites.

Frequency re-use satellite network

A satellite network in which the satellite utilizes the same frequency band more than once, by means of antenna polarization discrimination, or by multiple antenna beams, or both.

Geocentric angle

The angle formed by imaginary straight lines that join any two points with the centre of the Earth.

Topocentric angle

The angle formed by imaginary straight lines that join any two points in space with a specific point of the surface of the Earth.

Exocentric angle

The angle formed by imaginary straight lines that join any two points with a specific point in space.

SECTION 4B: SYSTEMS ASPECTS – PERFORMANCE AND AVAILABILITY – SUSCEPTIBILITY TO INTERFERENCE

4B1: *Systems aspects*

RECOMMENDATION 722

UNIFORM TECHNICAL STANDARDS AND UNIFORM OPERATIONAL PROCEDURES FOR SATELLITE NEWS GATHERING (SNG)

(Question 13/CMTT and Study Programme 13H/CMTT)

(1990)

The text of this Recommendation is published in Volume XII.

4B2: *Performance and availability*

RECOMMENDATION 352-4

HYPOTHETICAL REFERENCE CIRCUIT FOR SYSTEMS USING ANALOGUE TRANSMISSION IN THE FIXED-SATELLITE SERVICE

(Question 2/4)

(1963–1970–1974–1978–1982)

The CCIR,

CONSIDERING

(a) that it is desirable to establish a hypothetical reference circuit for active fixed-satellite systems to afford guidance to designers of equipment and systems for use in telephone and television networks;

(b) that only high-altitude satellites are being used or planned;

(c) that with such satellites it will become possible for most connections to be made with one satellite link, with occasional need for two links in tandem, particularly for television;

(d) that the overall performance of each satellite link depends only to a small extent on the great circle distance between the earth stations;

(e) that, to overcome fading, earth stations may operate in site diversity configurations, requiring terrestrial interconnection links between pairs of antennas;

(f) that satellite-to-satellite links are likely to be used in the fixed-satellite service,

UNANIMOUSLY RECOMMENDS

1. that a hypothetical reference circuit for systems in the fixed-satellite service using analogue transmission should consist of one Earth-space-Earth link in which the space portion may contain one or more satellite-to-satellite links.

2. that for earth stations not connected in site diversity the input to this circuit should correspond to the input of the modulator carrying out the translation from the baseband to the radio-frequency carrier and the output should correspond to the output of the demodulator carrying out the reverse operation;

3. that links between these earth stations and their associated switching centres should not be included in this hypothetical reference circuit;

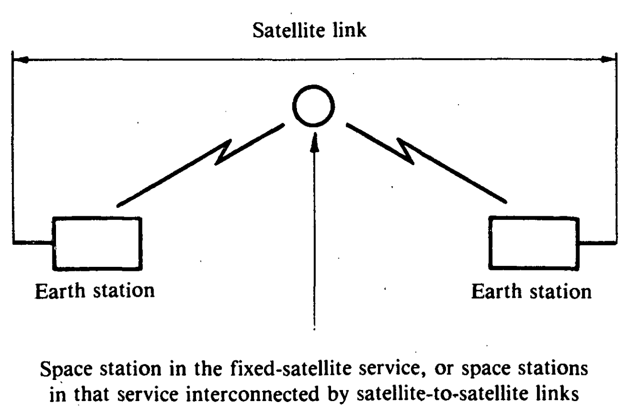

FIGURE 1 – *Hypothetical reference circuit for analogue transmission*

4. that, for site diversity earth stations, the hypothetical reference circuit shall also include the necessary terrestrial links and where appropriate additional modulation and/or demodulation equipment; the terrestrial/ satellite system interface should then be assumed to be situated at the baseband, after the diversity switching point;

5. that terrestrial links between the site diversity switching points of such earth stations and the associated switching centres, should not be included in the hypothetical reference circuit.

RECOMMENDATION 353-6

ALLOWABLE NOISE POWER IN THE HYPOTHETICAL REFERENCE CIRCUIT FOR FREQUENCY-DIVISION MULTIPLEX TELEPHONY IN THE FIXED-SATELLITE SERVICE

(Question 27/4)

(1963-1966-1970-1978-1982-1986-1990)

The CCIR,

CONSIDERING

(a) that the hypothetical reference circuit is intended as a guide to the design and construction of actual systems;

(b) that the cost of establishing and maintaining systems in the fixed-satellite service are critically dependent on the overall signal-to-noise performance requirements;

(c) that the total noise power in the hypothetical reference circuit should not be such, as would affect appreciably conversation in most telephone calls or the transmission of telephone signalling;

(d) that it may be necessary to take account of fading due to meteorological events, particularly rain;

(e) specifications of circuit availability are contained in Recommendation 579;

(f) that there may be other sources of noise of short duration,

UNANIMOUSLY RECOMMENDS

1. that the noise power, at a point of zero relative level in any telephone channel in the hypothetical reference circuit as defined in Recommendation 352 should not exceed the provisional values given below:

1.1 10 000 pW0p psophometrically-weighted one-minute mean power for more than 20% of any month;

1.2 50 000 pW0p psophometrically-weighted one-minute mean power for more than 0.3% of any month;

1.3 1 000 000 pW0 unweighted (with an integrating time of 5 ms), for more than 0.01% of any year;

2. that the following Notes should be regarded as part of the Recommendation:

Note 1 – Noise in the multiplex equipment is excluded from the above. For frequency-division multiplex telephony, noise additional to the above values is introduced by the equipment necessary to translate the satellite baseband to and from the multiplex level required for interconnection to a terrestrial link. In considering the performance of an overall connection, the noise introduced by such equipment should be added to the values given in RECOMMENDS 1. The noise allowed by CCITT for multiplex equipment is given in CCITT Recommendation G.222, § 4.

Note 2 – It is assumed that noise surges and clicks from power supply systems and from switching apparatus (including switching from satellite to satellite) are reduced to negligible proportions and therefore will not be taken into account when calculating the noise power.

Note 3 – In applying the hypothetical reference circuit and the allowable circuit noise to the design of satellite and earth-station equipment for a given overall signal-to-noise performance, the system characteristics preferred by the CCIR, as found in its Recommendations, should be used where appropriate; where more than one value is recommended, the designer should indicate the value chosen; in the absence of preferred values, the designer should indicate the assumptions used.

Note 4 – For frequency-division multiplex telephony, it will be assumed that, during the busy hour, the baseband signal can be represented by a uniform-spectrum signal, the mean absolute power-level of which, at a point of zero relative level is equal to $(-15 + 10 \log N)$ dBm for 240 channels or more, and $(-1 + 4 \log N)$ dBm* for number of channels between 12 and 240, N being the number of channels. These formulae apply only to baseband signals without pre-emphasis and using independent amplifiers or repeaters for the two directions of transmission. Further information on the conventional load, in particular in the case of a repeater which is common to both directions of transmission, is given in CCITT Recommendation G.223.

Note 5 – Compandors are sometimes used in achieving a performance considered equivalent to that of RECOMMENDS 1.1 with typical compandor gain values of approximately 10 dB for speech-like signals.

Note 6 – The noise power indicated in RECOMMENDS 1 above should include interference noise (see Recommendations 356 and 466) and noise resulting from atmospheric absorption and increased noise temperature due to rain. In certain cases, such as extremely long links and low elevation angles where margins must be higher, additional noise may cause limits of the general objectives to be slightly exceeded. This should not cause serious concern, provided that the provisions of CCITT Recommendation G.222, § 2.6, are met.

Note 7 – The value given in § 1.3 may on occasions be exceeded due to solar interference in the beam of the antenna but this noise is assumed to result in unavailability of the circuit. Detailed information is given in Annex II of Report 390.

Note 8 – The objectives set out in this Recommendation are performance objectives, as distinct from availability objectives.

Note 9 – It may be necessary to make special provision regarding the performance of inter-satellite links. The extent of this provision is a matter requiring further study.

Note 10 – Short interruptions (less than 10 s) shall be treated as equivalent to the case where noise power of a circuit is more than 10^6 pW0 unweighted.

Note 11 – It is desirable that systems be planned on the basis of propagation data covering a period of at least four years. The performance recommended to be met in "any year" should be based on the cumulative propagation statistics for all the complete years for which reliable data are available. The performance recommended to be met for "any month" should be based on the propagation data corresponding to the "worst month of the year taken from the monthly statistics for all the years for which reliable data are available". The "worst month" should be calculated in accordance with Recommendation 581.

Note 12 – This Recommendation applies only when the system is considered available in accordance with Recommendation 579.

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* It is considered that these formulae give a good approximation in calculating intermodulation noise when $N \geqslant 60$. For small number of channels, however, tests with uniform-spectrum random noise are less realistic, due to the wide difference in the nature of actual and test signals.

RECOMMENDATION 354-2

VIDEO BANDWIDTH AND PERMISSIBLE NOISE LEVEL IN THE HYPOTHETICAL REFERENCE CIRCUIT FOR THE FIXED-SATELLITE SERVICE*

(Question 2/4)

(1963-1970-1974)

The CCIR,

CONSIDERING

(a) that the hypothetical reference circuit is intended as a guide to designers and constructors of actual systems;

(b) that the costs of establishing and maintaining systems in the fixed-satellite service are critically dependent on the video bandwidth and the overall signal-to-noise ratio to be provided and these should, therefore, not be greater than is strictly necessary for acceptable transmission;

(c) that it is desirable for the noise level in satellite transmission not to exceed the permissible level for international terrestrial transmissions (see Recommendation 567);

(d) that it is desirable for international television programmes via space stations in the fixed-satellite service to be transmitted according to the television standards and system of origin, so as to ensure the best quality of service in conformity with Opinion 38,

UNANIMOUSLY RECOMMENDS

1. that, in the hypothetical reference circuit for systems in the fixed-satellite service, as defined in Recommendation 352, the nominal upper limit of the video bandwidth should be compatible with the necessary bandwidth for the television system or systems to be transmitted (see Recommendation 567);

2. that the signal-to-weighted noise ratios for continuous random noise at the end of the hypothetical reference circuit, defined in Recommendation 352, should provisionally be equal to the ratios recommended for the 2500 km terrestrial reference circuit in Recommendation 567 for the appropriate television standard.

Note 1 – The CMTT intends to study the definitions and characteristics of auxiliary circuits to be associated with picture and sound programme circuits (see Study Programme 17C/CMTT).

Note 2 – In the application of RECOMMENDS 2 of this Recommendation, special note should be taken of Note 2** of § 1.2 of Recommendation 421-3 (Geneva, 1974) with regard to noise in the hypothetical reference circuit.

Note 3 – The noise specified above should include the interference noise in Recommendation 483.

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* These requirements are provisional. In Question 13/CMTT and Study Programme 13D/CMTT, the CMTT invites Administrations to study the characteristics of a hypothetical reference circuit for the transmission of television by satellite.

** *Note by the Secretariat:* this Note has been deleted in Recommendation 567 which replaces Recommendation 421-3.

RECOMMENDATION 521-2

HYPOTHETICAL REFERENCE DIGITAL PATH FOR SYSTEMS USING DIGITAL TRANSMISSION IN THE FIXED-SATELLITE SERVICE

(Study Programme 29A/4)

(1978–1982–1986)

The CCIR,

CONSIDERING

(a) that it is desirable to establish a hypothetical reference digital path for active fixed-satellite systems to afford guidance to designers of equipment and systems for use in networks employing digital transmission techniques;

(b) that it will become possible for most connections to be made with one satellite link, with occasional need for two links in tandem;

(c) that satellite-to-satellite links may be used in the fixed-satellite service;

(d) that the transmission delay variation introduced by satellite movement relative to the Earth is of particular significance in a plesiochronous network and facilities to compensate for it may be located at earth stations;

(e) that a number of techniques such as time division multiple access (TDMA), digital speech interpolation (DSI) and low rate encoding (LRE) are being used in digital satellite links;

(f) that single channel and time division multiplexed digital signals may be transmitted on digital satellite links;

(g) that a fixed-satellite service hypothetical reference digital path (HRDP) may form part of an integrated services digital network (ISDN) hypothetical reference connection (HRX) as defined by the CCITT,

UNANIMOUSLY RECOMMENDS

1. that a hypothetical reference digital path for systems using digital transmission in the fixed-satellite service should consist of one Earth-space-Earth link, whose space portion may comprise one or more satellite-to-satellite links;

2. that this hypothetical reference digital path should include the equipment indicated in Fig. 1 and should interface with the terrestrial network at a suitable digital distribution frame (DDF) at the lowest bit rate appropriate to that HRDP;

3. that the bit rate at the terrestrial network interface may be any value depending upon the application;

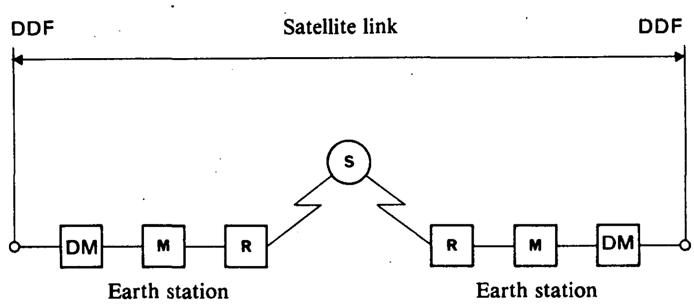

FIGURE 1 – *Hypothetical reference digital path*

S : space stations in the fixed-satellite service, or space station in that service interconnected by satellite-to-satellite links

DM: digital multiplex equipment (including TDMA, DSI and LRE equipment if used)

M: modem equipment

R: IF/RF equipment

4. that the digital multiplex equipment should include TDMA, DSI and LRE equipment if used at the earth station and should also include any equipment required for the purpose of compensating for the effects of satellite link transmission time variation when it is used at an earth station;

5. that links between these earth stations and their associated digital switching centres should be considered as part of the terrestrial network and should not be included in this hypothetical reference digital path;

6. that for site diversity earth stations, the hypothetical reference digital path should also include the terrestrial links and any associated equipment necessary for connecting the diversity earth stations to the diversity switching point;

Note 1 – This Recommendation may not apply to satellites providing on-board baseband signal processing. This subject requires further study.

Note 2 – If transmultiplexers are used at an earth station, they are not considered as part of the HRDP defined in this Recommendation.

RECOMMENDATION 522-3

ALLOWABLE BIT ERROR RATIOS AT THE OUTPUT OF THE HYPOTHETICAL REFERENCE DIGITAL PATH FOR SYSTEMS IN THE FIXED-SATELLITE SERVICE USING PULSE-CODE MODULATION FOR TELEPHONY

(Study Programme 29A/4)

(1978-1982-1986-1990)

The CCIR,

CONSIDERING

(a) that the hypothetical reference digital path is intended as a guide to the design and construction of actual systems;

(b) that the costs of establishing and maintaining digital communication-satellite systems are critically dependent on the overall bit error ratio performance;

(c) that the bit error ratio in the hypothetical reference digital path should not be such as to appreciably affect conversation in most telephone calls, or the transmission of telephone signalling;

(d) that the bit error ratio may vary with time due to the effect of varying propagation conditions;

(e) that high bit error ratios may occur for short periods due to other sources of noise, such as interference,

UNANIMOUSLY RECOMMENDS

1. that the bit error ratio at the output of the hypothetical reference digital path, as defined in Recommendation 521, should not exceed the provisional values given below:

1.1 one part in 10^6, 10-minute mean value for more than 20% of any month;

1.2 one part in 10^4, 1-minute mean value for more than 0.3% of any month;

1.3 one part in 10^3, 1-second mean value for more than 0.05% of any month;

2. that the following Notes should be regarded as part of the Recommendation:

Note 1 – The performance of a digital satellite system is generally much more sensitive to a variation in performance in the radio-frequency part of the network than is the case with analogue systems. It is therefore particularly important for designers to allow adequate margins for degradations which may occur during the life of the system if the recommended performance is to be maintained.

Note 2 – The objectives for bit error ratio indicated in RECOMMENDS 1 above, include the effects due to interference noise, and noise due to atmospheric absorption and rain, but exclude the unavailable time due to equipment (see Recommendation 579).

Note 3 – It is assumed that no framing information other than that required for the adequate operation of the satellite system, would be transmitted over the satellite. If PCM multiplex framing information is to be transferred unmodified via the satellite link, note should be taken of the possible effect of the higher error ratios in RECOMMENDS 1.2 and 1.3 on the alarm indication system of the terrestrial systems.

Note 4 – The objectives for bit error ratio indicated in RECOMMENDS 1 above, apply only to the transmission of PCM-telephony (see CCITT Recommendation G.711). Further study by CCIR Study Group 4 is required regarding the performance objectives appropriate to other digital services.

Note 5 – Fixed satellite systems operating below 10 GHz would not generally be limited by the short-term 10^{-3} bit error ratio performance objective and system designers should assume this short-term objective is in terms of total time.

Note 6 – For systems operating above 10 GHz the performance objectives in RECOMMENDS 1 would apply during the available time. For such systems, effects of rain attenuation for small percentages of time could degrade the system to less than 10^{-3} bit error ratio. For these percentages of the time the circuit should be considered unavailable in accordance with the definition of unavailability as given in Recommendation 579, i.e. periods of high bit error ratio which persist for 10 consecutive seconds duration or longer are considered unavailable. Short interruptions (less than 10 s) shall be treated as available time and are equivalent to the case in which the bit error ratio of a link exceeds 10^{-3}. Therefore the overall design objective for the 10^{-3} criteria (total time) would comprise those periods of time from RECOMMENDS 1.3 plus those periods of unavailable time from Recommendation 579 (RECOMMENDS 3.1).

Note 7 – In RECOMMENDS 1.3, the 10^{-3} bit error ratio is specified over a period of any month which has been assumed to correspond to a period of any year* by a conversion factor of 5, i.e. 0.05% of any month would correspond to 0.01% of any year*. This conversion factor is discussed in more detail in Report 997, Annex II.

Note 8 – It may be necessary to make special provision regarding the performance of satellite-to-satellite links. The extent of this provision is a matter requiring further study.

Note 9 – The performance to be met for "any month" should be based on the propagation data corresponding to the "worst month" of the year taken from the monthly statistics covering a period of at least four years for which reliable data are available. The "worst month" should be calculated in accordance with Recommendation 581.

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* Referring to the term of "any year", see Note 11 of Recommendation 353.

RECOMMENDATION 614-1

ALLOWABLE ERROR PERFORMANCE FOR A HYPOTHETICAL REFERENCE DIGITAL PATH IN THE FIXED-SATELLITE SERVICE OPERATING BELOW 15 GHz WHEN FORMING PART OF AN INTERNATIONAL CONNECTION IN AN INTEGRATED SERVICES DIGITAL NETWORK

(Study Programme 29A/4)

(1986-1990)

The CCIR,

CONSIDERING

(a) that the concept of an integrated services digital network (ISDN) has been defined by the CCITT;

(b) that satellites operating in the fixed-satellite service will have an important role to play in extending the concept of the ISDN to international connections;

(c) that satisfactory error performance is an essential feature of any digital transmission system;

(d) that the error performance of an international digital connection forming part of an ISDN has been specified by the CCITT in Recommendation G.821 at 64 kbit/s;

(e) that the costs of establishing and maintaining digital communication satellite systems are critically dependent on overall error performance;

(f) that in defining error performance criteria, it is necessary to take account of all foreseeable error-inducing mechanisms, especially time-varying propagation conditions and interference,

UNANIMOUSLY RECOMMENDS

1. that the bit error ratio (see Note 2) at the output (i.e. at either end of a two-way connection) of a satellite hypothetical reference digital path (HRDP) operating below 15 GHz and forming part of a 64 kbit/s ISDN connection should not exceed during the available time the values given below:

1.1 1×10^{-7} for more than 10% of any month;

1.2 1×10^{-6} for more than 2% of any month;

1.3 1×10^{-3} for more than 0.03% of any month (see Note 5);

2. that the following Notes should be regarded as part of the Recommendation:

Note 1 – RECOMMENDS 1 was established utilizing the method outlined in Report 997. It is based on, and sufficient to meet, the required fixed-satellite HRDP error performance objectives given in CCITT Recommendation G.821 under all envisaged operating conditions. The CCITT allocations for an FSS HRDP, which are considered to apply to the available time over a period of the order of any one month, can be stated as:

– fewer than 2% of the 1 min intervals to have a bit error ratio worse than 1×10^{-6};
– fewer than 0.03% of 1 s intervals to have a bit error ratio worse than 1×10^{-3};
– fewer than 1.6% of 1 s intervals to have errors.

Note 2 – The bit error ratios in RECOMMENDS 1 should be measured over a sufficiently long period of time in order to ensure that they provide a good estimate of the bit error probability (see Report 997). An exact measurement period may vary depending on the situation and specific measurement period that would suit all situations should be studied further.

Note 3 – The bit error ratios given in this Recommendation have been based on the assumption that contributions to severely errored seconds can be produced by two different error mechanisms: those occurring randomly and those occurring in bursts. For the major portion of the time, the errors are random and are constrained by RECOMMENDS 1.1 and 1.2. Severely errored seconds are excluded from the random error measurements made to verify RECOMMENDS 1.1 and 1.2, but are included in RECOMMENDS 1.3 (see Report 997).

Note 4 – The bit error ratios in RECOMMENDS 1 provide a margin for some burst errors that could arise from sources identified in Report 997.

Note 5 – The value 0.03% of any month relates to the measured BER during the available time. This objective could be met, for example, by designing the satellite system to an unavailability objective of 0.2% of the worst month (total time). By using a 10% availability factor (ratio of available to total time while the BER is worse than 10^{-3}), this would correspond to 0.02% of the available time of any month. Further, it is necessary to include an allowance to accommodate contributions to those severely errored seconds which occur when the BER is better than 10^{-3}. Taking in our example 0.01% of the worst month for this allowance, the total performance objective would be 0.03% of the available time of the worst month (see Report 997).

Note 6 – The hypothetical reference digital path (HRDP) referred to in this Recommendation is specified in Recommendation 521.

Note 7 – It may be necessary to make special provision regarding the performance of satellite-to-satellite links. The extent of this provision is a matter requiring further study.

Note 8 – The Recommendation applies only when the system is considered available in accordance with Recommendation 579 and includes periods of high bit error ratio exceeding 10^{-3} which persist for periods of less than 10 consecutive seconds. Short interruptions (less than 10 s) shall be treated as equivalent to the case in which the bit error ratio exceeds 10^{-3}.

Note 9 – The error performance objectives given in this Recommendation are designed to meet the specified end-to-end performance of a 64 kbit/s circuit switched, ISDN connection regardless of the service carried on that connection. Performance objectives for satellite systems carrying PCM encoded telephony in a non-ISDN connection are given in Recommendation 522. Performance objectives for satellite systems carrying any other type of digital connection, such as low rate encoded speech or voice band data, would be a subject of further study when the requirements of such connections become known to the CCIR.

Note 10 – The objectives for bit error ratios indicated in RECOMMENDS 1 are not unique in meeting the required performance objectives given in CCITT Recommendation G.821. Other masks for the bit error ratios may be used by the designer where appropriate as long as these masks satisfy CCITT Recommendation G.821. Examples of alternative masks are shown in Report 997.

Note 11 – It is desirable that systems be planned on the basis of propagation data covering a period of at least four years. The performance recommended to be met for "any month" should be based on the propagation data corresponding to the median "worst month of the year" taken from the monthly statistics of all the years for which reliable data are available.

Note 12 – The error performance described in RECOMMENDS 1 was developed based on the use of the HRDP in the "high grade" section of the Hypothetical Reference Connection (see CCITT Recommendation G.821). Other applications of the HRDP in the Hypothetical Reference Connection are possible and the error performance objectives can be adjusted accordingly.

RECOMMENDATION 579-1

AVAILABILITY OBJECTIVES FOR A HYPOTHETICAL REFERENCE CIRCUIT AND A HYPOTHETICAL REFERENCE DIGITAL PATH WHEN USED FOR TELEPHONY USING PULSE-CODE MODULATION, OR AS PART OF AN INTEGRATED SERVICES DIGITAL NETWORK HYPOTHETICAL REFERENCE CONNECTION, IN THE FIXED-SATELLITE SERVICE

(Question 24/4)

(1982–1986)

The CCIR,

CONSIDERING

(a) that the hypothetical reference circuit and the hypothetical reference digital path in the fixed-satellite service are intended as a guide to designers and planners;

(b) that it is desirable to be compliant with concepts, terms and definitions related to availability as given in CCITT Recommendation G.106;

(c) that the equipment availability (including the space station) is dependent on reliability performance, maintainability performance and maintenance support performance;

(d) that the availability of a hypothetical reference circuit or digital path is determined by the combined effects of equipment and propagation availability;

(e) that it is desirable to apply similar availability objectives to cable, radio-relay and fixed-satellite systems,

UNANIMOUSLY RECOMMENDS

1. that the availability of a hypothetical reference circuit or digital path in the fixed-satellite service should be defined by the following formula:

$$\text{Availability} = (100 - \text{unavailability}) \quad (\%)$$

where:

$$\text{Unavailability} = \frac{\text{unavailable time}}{\text{required time}} \times 100\ (\%) \tag{1}$$

where the required time is defined as the period of time during which the user requires the circuit or digital path to be in a condition to perform a required function, and unavailable time is the cumulative time of circuit or digital path interruptions within the required time;

2. that the unavailability of a hypothetical reference circuit or digital path in the fixed-satellite service due to equipment should provisionally be not more than 0.2% of a year (see Note 7);

3. that the unavailability due to propagation (see Note 7) should provisionally be not more than:

3.1 0.2% of any month for a hypothetical reference digital path in the fixed-satellite service (see Note 8);

3.2 X% of any year* for a hypothetical reference circuit in the fixed-satellite service (see Note 3);

4. that a link in the fixed-satellite service defined between the ends of the hypothetical reference circuit or digital path in Recommendations 352 and 521 should be considered unavailable if one or more of the conditions in RECOMMENDS 4.1 and 4.4 below exist at either of the receiving ends of the link for 10 consecutive seconds or more (see Note 6) (A period of unavailable time begins when one of the conditions in RECOMMENDS 4.1 to 4.4 persists for a period of 10 consecutive seconds. These 10 s are considered to be unavailable time. The period of unavailable time terminates when the same condition ceases for a period of 10 consecutive seconds. These 10 s are considered to be available time.):

4.1 for analogue transmission the wanted signal is received at the far end at a level 10 dB or more below its expected level;

* Referring to the term of "any year", see Note 11 of Recommendation 353.

4.2 for digital transmission the digital signal is interrupted (i.e. alignment or timing is lost);

4.3 for analogue transmission, the unweighted noise power in a telephone channel at a point of zero relative level, with 5 ms integration time is higher than 10^6 pW0;

4.4 for digital transmission, the bit error ratio, averaged over 1 s, exceeds 10^{-3};

5. that the following Notes should be regarded as part of this text.

Note 1 – The unavailability of analogue multiplexing equipment is not taken into account in the foregoing. The unavailability of digital multiplexing equipment is included in RECOMMENDS 2 above.

Note 2 – The unavailability value of the circuit or digital path is a planning objective for fixed-satellite systems; it should neither be included in system specifications nor used for acceptance tests.

Note 3 – The value of X is under study and a value of 0.1 has been suggested.

Note 4 – Periods of less than 10 consecutive seconds, during which conditions in RECOMMENDS 4.1 to 4.4 exist, are considered available time and should be taken into account in applying the Recommendations.

Note 5 – All outages due to solar eclipses and interference from the sun are included as part of the unavailable time in RECOMMENDS 2.

Note 6 – Availability calculations should explicitly take into account mean time between failures, mean time for resumption of service, precautions taken against interruptions and impairment of satellite performance (especially use of reserve channels and back-up systems).

Note 7 – The unavailability of a circuit or digital path in the fixed-satellite service for national portions with alternative transmission systems may be excluded from RECOMMENDS 2 and 3 and can be determined by administrations in accordance with local conditions (i.e., propagation, geographical size, population distribution, organization of maintenance, etc.).

Note 8 – In RECOMMENDS 3.1 the value of 0.2% of any month is assumed to correspond to a period of any year* by a conversion factor of 5, i.e. 0.2% of any month would correspond to 0.04% of any year*. This conversion factor is discussed in more detail in Report 997.

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* Referring to the term of "any year", see Note 11 of Recommendation 353.

SECTION 4C: EARTH STATION AND BASEBAND CHARACTERISTICS – EARTH STATION ANTENNAS – MAINTENANCE OF EARTH STATIONS

RECOMMENDATION 465-3

REFERENCE EARTH-STATION RADIATION PATTERN FOR USE IN COORDINATION AND INTERFERENCE ASSESSMENT IN THE FREQUENCY RANGE FROM 2 TO ABOUT 30 GHz

(Study Programme 1A/4)

(1970–1974–1986–1990)

The CCIR,

CONSIDERING

(a) that, for coordination studies and for the assessment of mutual interference between radiocommunication-satellite systems and between earth stations of such systems and stations of other services sharing the same frequency band, it may be necessary to use a single radiation pattern for the earth-station antenna;

(b) that, for the determination of coordination distance and for the assessment of interference between earth and terrestrial stations, a radiation pattern based on the level exceeded by a small percentage of the side-lobe peaks may be appropriate;

(c) that, for coordination studies and for the assessment of interference between earth stations and space stations, a radiation pattern for the region near the main beam based on the envelope of the peak power of the side lobes in this region may be appropriate;

(d) that, at angles relative to the axis of the main beam where effects peculiar to the particular feed system used do not contribute appreciably to the power in the side lobes, the radiation patterns for numerous existing earth-station antennas show only moderate scatter about a simple generalized radiation pattern, at least within the frequency range 2-30 GHz;

(e) that, for systems of the Cassegrain type over the range of angles relative to the axis of the main beam where contributions to the side-lobe power occur primarily as a result of spill-over, the patterns of a number of existing antennas also show reasonable agreement;

(f) that, at large angles, the likelihood of local ground reflections must be considered;

(g) that the use of antennas with the best achievable radiation patterns will lead to the most efficient use of the radio-frequency spectrum and the geostationary-satellite orbit,

UNANIMOUSLY RECOMMENDS

1. that, in the absence of particular information concerning the radiation pattern of the antenna for the earth station involved, a single reference radiation pattern should be used for:

1.1 coordination studies and interference assessment between earth stations in the fixed satellite service and stations of other services sharing the same frequency band;

1.2 coordination studies and interference assessment between systems in the fixed-satellite service;

2. that the following reference radiation patterns should be adopted for angles between the direction considered and the axis of the main beam at least for frequencies in the range 2-30 GHz:

2.1 antenna diameter/wavelength ratio (D/λ) greater than 100:

$$\begin{aligned} G &= 32 - 25 \log \varphi \quad \text{dBi} && \text{for} \quad 1° \leqslant \varphi < 48° \\ &= -10 \quad \text{dBi} && \text{for} \quad 48° \leqslant \varphi \leqslant 180° \end{aligned}$$

2.2 D/λ less than, or equal to, 100:

$$
\begin{aligned}
G &= 52 - 10 \log (D/\lambda) - 25 \log \varphi \quad \text{dBi} && \text{for} \quad (100\,\lambda/D)^\circ \leqslant \varphi < 48^\circ \\
&= 10 - 10 \log (D/\lambda) \quad \text{dBi} && \text{for} \quad 48^\circ \leqslant \varphi \leqslant 180^\circ
\end{aligned}
$$

Note 1 – The reference radiation pattern should be assumed to be rotationally symmetrical.

Note 2 – The reference radiation pattern should be used with caution over the range of angles for which the particular feed system may give rise to relatively high levels of spill-over.

Note 3 – In cases where coordination or interference assessment between two closely spaced satellites requires information on the main-lobe and/or the first side-lobe characteristics of an antenna, the relevant information given in Annex I of Report 391 could be used.

RECOMMENDATION 580-2

RADIATION DIAGRAMS FOR USE AS DESIGN OBJECTIVES FOR ANTENNAS OF EARTH STATIONS OPERATING WITH GEOSTATIONARY SATELLITES

(Question 1/4 and Study Programme 1A/4)

(1982-1986-1990)

The CCIR,

CONSIDERING

(a) that efficient utilization of the radio spectrum is a primary factor in the management of the geostationary-satellite orbit;

(b) that the side-lobe characteristic of earth station antennas is one of the main factors in determining the minimum spacing between satellites and therefore the extent to which the radio spectrum can be efficiently employed;

(c) that the radiation diagram of antennas directly affects both the e.i.r.p. outside the main radiation axis and the power received by the side lobes;

(d) that the construction of antennas with improved side-lobe characteristics may be envisaged using current design techniques but that their practical applications may involve increase in cost;

(e) that data relating to diagrams of earth station antennas with improved side-lobe characteristics are set out in Report 391;

(f) that the CCIR is studying the potential advantages of using antennas with improved side-lobe characteristics for a better utilization of the geostationary orbit;

(g) that a design objective 3 dB better than the reference patterns given in Report 391 may be practical in the long term,

UNANIMOUSLY RECOMMENDS

1. With regard to antennas having a D/λ exceeding 150:

that new antennas of an earth station installed after 1988 operating with a geostationary satellite should have a design objective such that the gain, G, of at least 90% of the side-lobe peaks does not exceed:

$$G = 29 - 25 \log \varphi \qquad \text{dBi}$$

(G being the gain relative to an isotropic antenna and φ being the off-axis angle in the direction of the geostationary-satellite orbit referred to the main-lobe axis).

This requirement should be met for any off-axis direction which is within 3° of the geostationary-satellite orbit and for which $1° \leqslant \varphi \leqslant 20°$ as illustrated in Fig. 1.

2. With regard to antennas having a D/λ between 100 and 150:

- that antennas should have a design objective such that the gain, G, of at least 90% of the side-lobe peaks does not exceed:

$$G = 32 - 25 \log \varphi \qquad \text{dBi}$$

- that antennas installed after 1995 (this date takes into account the needs of developing countries and every effort should be made to achieve the design objective at an earlier date) should have a design objective such that the gain, G, of at least 90% of the side-lobe peaks does not exceed:

$$G = 29 - 25 \log \varphi \qquad \text{dBi}$$

These requirements should be met for φ between 1° and 20° for any off-axis direction which is within 3° of the geostationary-satellite orbit.

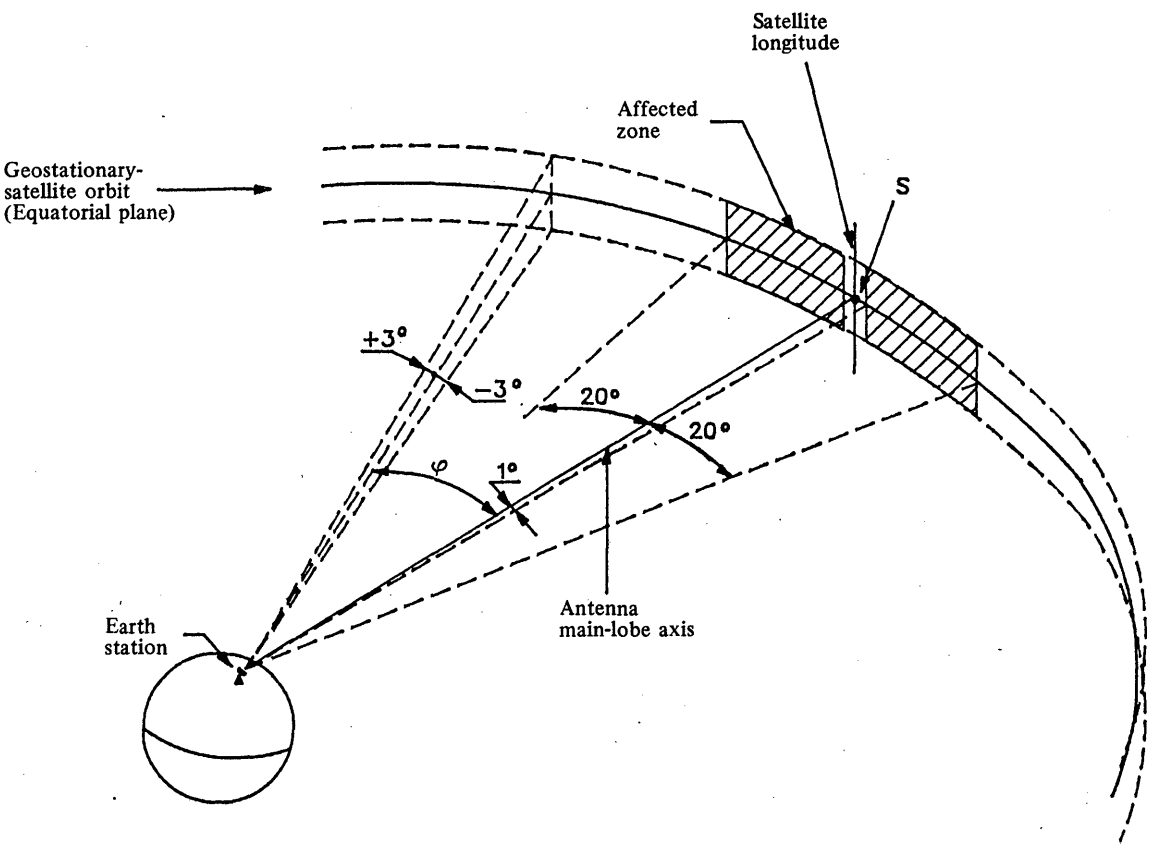


FIGURE 1 – *Example of a zone around the geostationary-satellite orbit to which the design objective for earth-station antennas applies*

3. With regard to antennas having a D/λ between 35 and 100:

– that new antennas installed after 1989 should have a design objective such that the gain, G, of at least 90% of the side-lobe peaks does not exceed:

$$G = 52 - 10 \log (D/\lambda) - 25 \log \varphi \qquad \text{dBi}$$

– that antennas installed after 1995 (this date takes into account the needs of developing countries and every effort should be made to achieve the design objective at an earlier date) should have a design objective such that the gain, G, of at least 90% of the side-lobe peaks does not exceed:

$$G = 49 - 10 \log (D/\lambda) - 25 \log \varphi \qquad \text{dBi}$$

These requirements should be met for φ between $(100\ \lambda/D)$ degrees and $(D/5\lambda)$ degrees with $(D/5\lambda)$ not less than 7°, which is equivalent to an antenna lower size limit of $D/\lambda = 35$. These requirements apply to any off-axis direction which is within 3° of the geostationary-satellite orbit.

4. For an off-axis angle, φ, greater than the limits specified above, Recommendation 465 should be used as a reference (see Note 6).

Note 1 – This Recommendation does not apply to existing antennas.

Note 2 – This Recommendation primarily addresses the geostationary orbit sharing criteria. However, it must be emphasized that the application of this Recommendation should not prejudice the antenna characteristics concerned with frequency coordination between the fixed-satellite service and terrestrial services (see Recommendation 465).

Note 3 – When elliptical beam antennas are used, the side-lobe radiation in the direction of the geostationary-satellite orbit can be reduced if the minor axis of the beam is adjusted parallel to the geostationary-satellite orbit. Further study is required on the application of this Recommendation in the case of the minor axis of the antenna which would correspond with a $D/\lambda < 35$.

Note 4 – The method of statistical processing of side-lobe peaks is dealt with in Annex II of Report 391.

Note 5 – This Recommendation may need modification in the light of further decisions made by future WARCs, especially in the orbital arcs and frequency bands where recognition is given to the special needs of developing countries.

Note 6 – In those cases where there is discontinuity between this design objective Recommendation and the reference radiation patterns of Recommendation 465, the gain G of at least 90% of the side-lobe peaks is defined as follows:

For antennas having a D/λ equal to or exceeding 100:

$$G = -3.5 \text{ dBi} \qquad \text{for} \qquad 20° < \varphi \leq 26.3°$$

For antennas having a D/λ between 35 and 100:

$$G = 49 - 10 \log (D/\lambda) - 25 \log (D/5\lambda) \text{ dBi} \qquad \text{for} \qquad (D/5\lambda)° < \varphi \leq 1.3\,(D/5\lambda)°$$

Note 7 – Small earth-station antennas with improved side-lobe characteristics have been developed during the last few years and are in operation in many parts of the world. It is indicated that the efficient use of the GSO may necessitate reflecting these improved characteristics in the CCIR texts and Recommendations. There is increasing evidence that the 29 – 25 log φ side-lobe antenna pattern is also applicable to antennas with D/λ less than 100.

RECOMMENDATION 464-1

PRE-EMPHASIS CHARACTERISTICS FOR FREQUENCY-MODULATION SYSTEMS FOR FREQUENCY-DIVISION MULTIPLEX TELEPHONY IN THE FIXED-SATELLITE SERVICE

(Study Programme 2D/4)

(1970-1982)

The CCIR,

CONSIDERING

(a) that the pre-emphasis characteristic should preferably be such that the r.m.s. deviation due to the frequency-division multiplex telephony signal is the same with and without pre-emphasis;

(b) that in a frequency-modulation system for frequency-division multiplex telephony operating well above threshold the thermal noise is highest in the top channel and decreases with decreasing baseband frequency;

(c) that in a phase-modulation system, or in a frequency-modulation system with pre-emphasis at 20 dB per decade, operating well above threshold the thermal noise is constant over the whole baseband;

(d) that the thermal noise in the highest channel of a phase-modulation system is approximately 4.8 dB lower than the corresponding channel of a frequency-modulation system, assuming that both systems operate well above threshold and are adjusted to have the same multi-channel r.m.s. frequency deviation;

(e) that the reduction in frequency deviation with decreasing baseband frequency in a phase-modulation system makes such a system more sensitive to low frequency noise, especially that arising in threshold extension demodulators operating near to threshold;

(f) that for earth stations normally operated above threshold the efficiency of use of satellite transmitter power is practically unaffected by changes in the range of pre-emphasis characteristic from below 6 dB to about 8 dB, but the efficiency of use of radio-frequency bandwidth increases slightly with an increase in pre-emphasis range;

(g) that there is insufficient information at the present time to assess the optimum pre-emphasis characteristic for systems using radio-frequency carriers with capacities of less than 12 telephone channels,

UNANIMOUSLY RECOMMENDS

1. that in systems in the fixed-satellite service employing frequency modulation, radio-frequency carriers with capacities of 12 or more telephone channels should be used with pre-emphasis and should use the same normalized pre-emphasis characteristic;

2. that the pre-emphasis characteristic for numbers of telephone channels less than 12 should be the subject of further study;

3. that the preferred pre-emphasis characteristic is given by the expression:

$$\text{Relative frequency deviation of the test tone at the frequency } f = 5 - 10 \log \left[1 + \frac{6.90}{1 + \dfrac{5.25}{\left(\dfrac{f_r}{f} - \dfrac{f}{f_r}\right)^2}} \right] \quad \text{dB}$$

where $f_r = 1.25\, f_{max}$ is the resonant frequency of the network, f_{max} is the highest telephone channel baseband frequency of the system and f is the baseband frequency. The variation of deviation with frequency is shown in Fig. 1;

4. that the tolerance on the frequency response of the pre-emphasis characteristic, and also on the de-emphasis characteristic should be such that, within the nominal upper and lower limits of the baseband, the departure of the characteristic of a practical network from the theoretical characteristic should be confined within a variation of $\pm (0.1 + 0.05 \, f/f_{max})$ dB, f being the baseband frequency and f_{max} the nominal maximum frequency of baseband. This corresponds to component tolerances of about ± 1% for resistors and about ± 0.5% for capacitors and inductors. Further, the magnitude of the departure should exhibit no rapid variations within this frequency range.

Note 1 – It is recognized that it may be desirable to achieve the pre-emphasis characteristic by inserting a network at different places in various types of equipment. An example of pre-emphasis and de-emphasis network, to work between a constant-voltage source and an open-circuit load, is shown in Figs. 2a) and 2b), respectively. An example to work between matched resistive input and output impedances is shown in Figs. 3a) and b), respectively.

Note 2 – In the expression for the relative deviation as indicated in § 3, it should be noted that the frequency at which the deviation with pre-emphasis corresponds to that without pre-emphasis is $0.61320 \, f_{max}$. It may be convenient to adopt this frequency for testing the loss between-baseband terminal points of systems when these are not in service.

Note 3. – It is recognized that it may sometimes be desirable to use a different pre-emphasis characteristic by agreement between the administrations concerned.

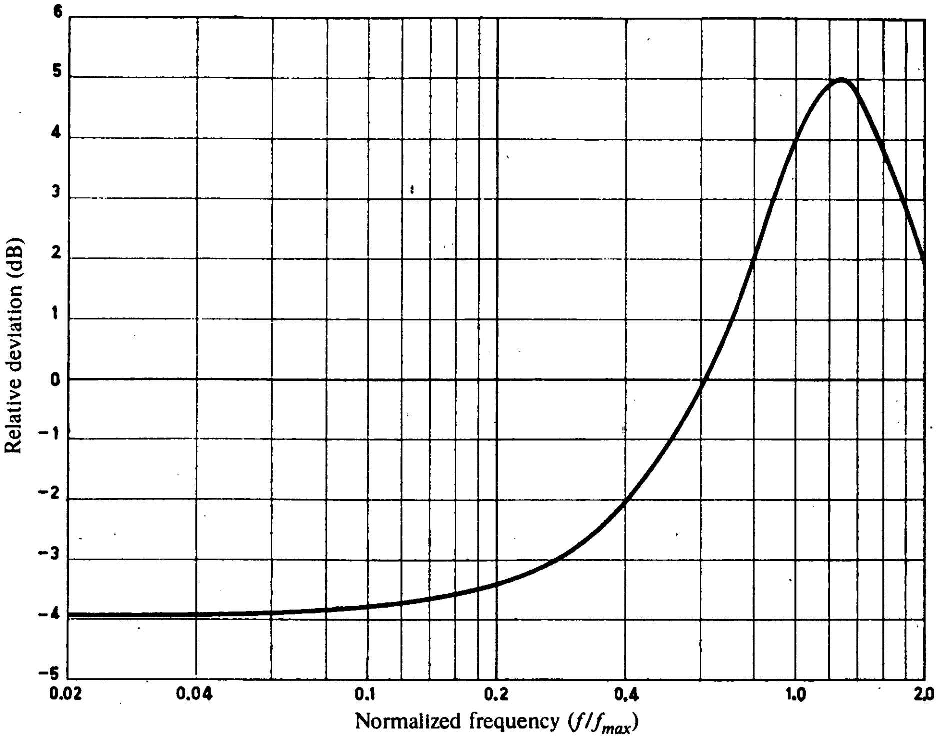
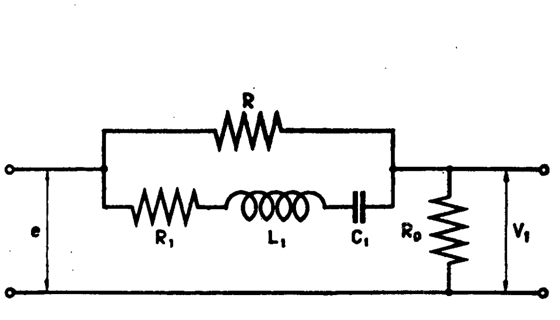


FIGURE 1 — *Pre-emphasis characteristic for telephony*



$R = 1{\cdot}81\ R_0$

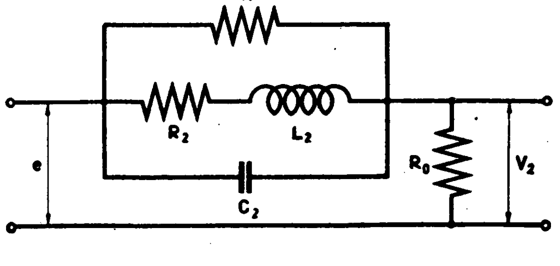
$R_1 < 0{\cdot}01\ R_0$ at f_r

$\sqrt{\frac{L_1}{C_1}} = 0{\cdot}79\ R_0$

$f_r = 1{\cdot}25\ f_{max} = \frac{1}{2\pi}\sqrt{\frac{1}{L_1C_1}}$

Where f_{max} is the highest baseband frequency

(a) Pre-emphasis network



$R = 1{\cdot}81\ R_0$

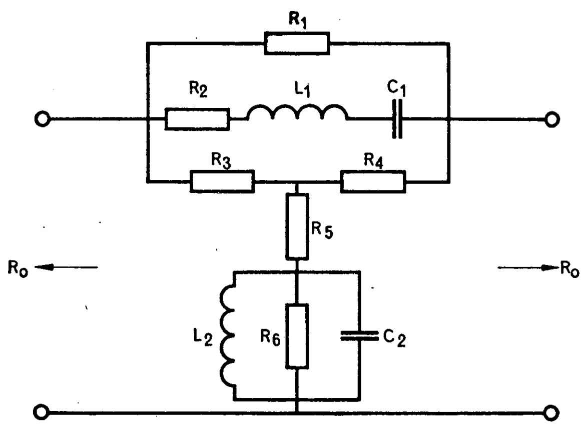
$R_2 < 0{\cdot}02\ R_0$ at f_r

$\sqrt{\frac{L_2}{C_2}} = 1{\cdot}47\ R_0$

$f_r = 1{\cdot}25\ f_{max} = \frac{1}{2\pi}\sqrt{\frac{1}{L_2C_2}}$

(b) De-emphasis network

FIGURE 2 — *Pre-emphasis and de-emphasis networks to work between a constant-voltage source and an open-circuited load*



$R_1 = 1{\cdot}81\ R_0$

$R_2 < 0{\cdot}01\ R_0$

$R_3 = R_4 = R_0$

$R_5 = \dfrac{R_0}{1{\cdot}81}$

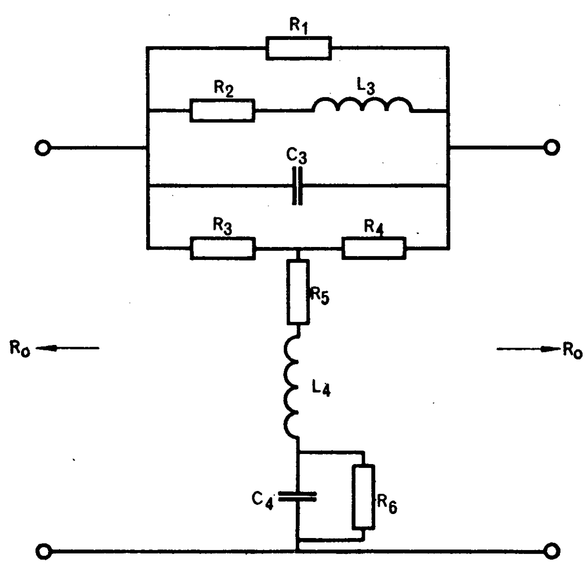
$R_6 > 100\ R_0$

$$f_r = 1{\cdot}25\ f_{max} = \frac{1}{2\pi}\sqrt{\frac{1}{L_1C_1}} = \frac{1}{2\pi}\sqrt{\frac{1}{L_2C_2}}$$

$$\sqrt{\frac{L_1}{C_1}} = 0{\cdot}79\ R_0$$

$$\sqrt{\frac{L_2}{C_2}} = \frac{R_0}{0{\cdot}79}$$

(a) Pre-emphasis network



$R_1 = 1{\cdot}81\ R_0$

$R_2 < 0{\cdot}01\ R_0$

$R_3 = R_4 = R_0$

$R_5 = \dfrac{R_0}{1{\cdot}81}$

$R_6 > 100\ R_0$

$$f_r = 1{\cdot}25\ f_{max} = \frac{1}{2\pi}\sqrt{\frac{1}{L_3C_3}} = \frac{1}{2\pi}\sqrt{\frac{1}{L_4C_4}}$$

$$\sqrt{\frac{L_3}{C_3}} = 1{\cdot}47\ R_0$$

$$\sqrt{\frac{L_4}{C_4}} = \frac{R_0}{1{\cdot}47}$$

(b) De-emphasis network

FIGURE 3 — *Pre-emphasis and de-emphasis networks to work between matched resistive input and output impedances*

RECOMMENDATION 446-2

CARRIER ENERGY DISPERSAL FOR SYSTEMS EMPLOYING ANGLE MODULATION BY ANALOGUE SIGNALS OR DIGITAL MODULATION IN THE FIXED-SATELLITE SERVICE

(Study Programme 2D/4)

(1966–1974–1978)

The CCIR,

CONSIDERING

(a) that use of carrier energy dispersal techniques in systems in the fixed-satellite service can result in a substantial reduction of interference to stations of a terrestrial service operating in the same frequency bands;

(b) that in many cases the use of such techniques can result in a moderate to substantial reduction in the level of interference between systems in the fixed-satellite service operating in the same frequency bands, although in other cases the use of such techniques may not reduce the level of interference between such systems;

(c) that such techniques are being regularly and successfully employed in systems in the fixed-satellite service without noticeable deterioration of the quality of operation;

(d) that a Recommendation, (Spa2 – 11),* relating to carrier energy dispersal in systems in the fixed-satellite service, was adopted by the World Administrative Radio Conference for Space Telecommunications, Geneva, 1971,

UNANIMOUSLY RECOMMENDS

1. that systems in the fixed-satellite service should use carrier energy dispersal techniques, as far as is practicable and in a manner consistent with satisfactory operation of the systems (see Report 384, § 2 and 3), with a view to spreading energy such that the interference to stations of a terrestrial service operating in the same frequency bands is maintained within specified tolerable limits at all times;

2. that the capability for carrier energy dispersal up to the maximum degree practicable (see Report 384) should be included in the design of satellite systems to be available for implementation when necessary to maintain a reduced level of interference between systems in the fixed-satellite service operating in the same frequency bands.

* This Recommendation become Recommendation No. 103 of WARC, Geneva, 1979.

RECOMMENDATION 481-2

MEASUREMENT OF NOISE IN ACTUAL TRAFFIC FOR SYSTEMS IN THE FIXED-SATELLITE SERVICE FOR TELEPHONY USING FREQUENCY-DIVISION MULTIPLEX

(Question 20/4)

(1974–1978–1986)

The CCIR,

CONSIDERING

(a) that measurements by means of a generator producing white noise (Recommendation 482) are only possible when the radio-frequency channel is not carrying traffic;

(b) that systems carrying multi-channel telephony cannot be withdrawn from service for measurement at will;

(c) that protection channels, similar to those used in terrestrial radio-relay systems, are not available for maintenance purposes;

(d) that maintenance measurements of the total noise (thermal and intermodulation noise) are useful for determining the quality of a system and must be made while the system is carrying traffic;

(e) that it is convenient to place the channels used for this kind of measurement outside the total bandwidth of the multiplex signal;

(f) that, when these measuring channels are located outside the total multiplex signal band, they should be positioned as near the limits of the total signal band as possible, to measure the intermodulation products due to the non-linearity of the system;

(g) that, on the other hand, to facilitate and to minimize the cost of filter construction, the measuring channels should not be positioned too near these limits;

(h) that measurements in channels about 10% above the upper limit of the total multiplex signal band are generally sensitive to changes of thermal and intermodulation noise in the radio-frequency and intermediate-frequency circuits of the equipment;

(j) that it is usually necessary to use band-stop filters at the input of the system to minimize noise on the incoming circuit in the bands occupied by the measuring channels, and that it will be necessary to specify the minimum performance of these filters, both in the stopband of these filters and at the edges of the total multiplex signal band,

UNANIMOUSLY RECOMMENDS

1. that noise occurring in links in the fixed-satellite service while actual traffic is being carried should be measured at the output of the system in relatively narrow bands situated above the total multiplex signal band;

2. that the centre frequencies of these measuring bands should be those listed in Table I;

3. that the attenuation of the band-stop filters at the input of the system should exceed 50 dB over a minimum frequency band of $\pm$ $(0.005\, f + 2)$ kHz (f being the centre frequency in kHz of the measuring channel). The additional attenuation caused by the insertion of the band-stop filters at the upper edge of the total multiplex signal band shall not exceed 0.3 dB referred to the additional attenuation caused in the centre of the multiplex signal band;

4. that the effective bandwidth of the bandpass filters in the receiving equipment should be small enough for use with the input band-stop filter mentioned above;

5. that, in all cases where different frequency bands are used, or where there are differences between the measurement techniques, special agreements should be made between the administrations which use the same space systems of the fixed-satellite service.

TABLE I

System capacity (number of channels)	Limits of band occupied by telephone channels (kHz)	Centre frequencies, f of noise-measuring channels (kHz)
12	12- 60	66
24	12- 108	116
36	12- 156	172
48	12- 204	224
60	12- 252	277
72	12- 300	331
96	12- 408	448
132	12- 552	607
192	12- 804	884
252	12-1 052	1 157
312	12-1 300	1 499
372	12-1 548	1 730
432	12-1 796	1 976
492	12-2 044	2 248
552	12-2 292	2 438
612	12-2 540	2 794
792	12-3 284	3 612
972	12-4 028	4 430
1 092	12-4 892	5 381
1 200	12-5 340	5 874
1 332	12-5 884	6 300
1 872	12-8 120	8 932

RECOMMENDATION 482-2

MEASUREMENT OF PERFORMANCE BY MEANS OF A SIGNAL OF A UNIFORM SPECTRUM FOR SYSTEMS USING FREQUENCY-DIVISION MULTIPLEX TELEPHONY IN THE FIXED-SATELLITE SERVICE

(Question 20/4)

(1974-1978-1986)

The CCIR,

CONSIDERING

(a) that it is desirable to measure the performance of satellite links in the fixed-satellite service for frequency-division multiplex telephony under conditions closely approaching those of actual operation;

(b) that a signal with a continuous uniform spectrum (white noise) has statistical properties similar to those of a multiplex signal when the number of channels is not too small;

(c) that the use of a signal with a continuous uniform spectrum to measure the performance of such links is already widespread;

(d) that it is necessary to standardize the frequencies and bandwidths of the measuring channels to be used for such measurements;

(e) that for reasons of international compatibility it is necessary to standardize the minimum attenuation and the bandwidth of the stop filters which may have to be used in the white-noise generator;

(f) that the CCITT has indicated, for the planning of telephone circuits, a mean value of speech power in the baseband of a multiplex telephone system to be taken into consideration during the busy hour (CCITT Recommendation G.223, Vol. III-2),

UNANIMOUSLY RECOMMENDS

1. that the performance of frequency-division multiplex satellite links in the fixed-satellite service should be measured by means of a signal with a continuous uniform spectrum in the frequency band used for the telephone channels;

2. that the nominal power level of the uniform spectrum test signal should be in accordance with the conventional load, specified in CCITT Recommendation G.223 *;

2.1 that the sending equipment should be capable of providing, at the output of an inserted band-stop filter, a loading level of at least up to +10 dB, relative to the nominal power level defined above;

2.2 that, within the bandwidth corresponding to the baseband of the system under test, the r.m.s. voltage of the white noise spectrum measured in a band of about 2 kHz should not vary by more than ± 0.5 dB. This degree of spectrum uniformity should be met in the level range of up to +6 dB, relative to the nominal power level;

2.3 that the white noise test signal should be available at the output of the sending equipment with a peak factor of about 12 dB with respect to the r.m.s. value;

3. that the nominal effective cut-off frequencies (the cut-off frequencies of hypothetical filters having ideal square cut-off characteristics and transmitting the same power as the real filters) and tolerances, for the band-limiting filters proposed for the various bandwidths of systems to be tested, should be as specified in Table I. (To reduce the number of filters required, compromises have been made between the nominal effective cut-off frequency and the system bandwidth-limiting frequency in some cases. The tolerances ensure that consequent calibration errors do not exceed ± 0.1 dB and errors in measurement of intermodulation noise do not exceed ± 0.2 dB assuming system pre-emphasis conforming to Recommendation 464);

3.1 that the discrimination of a low-pass filter should be at least 20 dB at a frequency of more than 10% above nominal cut-off and at least 25 dB at frequencies of more than 20% above nominal cut-off. The discrimination of a high-pass filter should be at least 25 dB at frequencies of more than 20% below nominal cut-off;

* The level of the conventional load in dBm0 is given by:

$-1 + 4 \log N$, for $N < 240$ channels

$-15 + 10 \log N$, for $N \geqslant 240$ channels.

3.2 that to limit discrimination against measuring channels, the spread of losses introduced by any pair of high-pass and low-pass filters should not exceed 0.2 dB over a range of frequencies which includes the upper and lower measuring channels;

4. that values of the characteristics for the discrimination in each stopband at the output of a sending equipment are given in Table II. The passband of each band-stop filter shall be designed to cover at least the largest baseband frequency range with which it is to be used, as indicated in the column entitled "Limits of band . . ." in Table I. These characteristics are intended to apply over a temperature range from 10° to 40 °C;

5. that, when the receiving equipment is connected directly to a sending equipment provided with band-stop filters which only just meet the requirements of item 4, the ratio of the noise power indicated by the receiving equipment when the band-stop filter is by-passed, to that indicated when the filter is in circuit, should be a minimum of 67 dB; this requirement applies when a conventional load is applied. The minimum effective bandwidth of the receiver should be 1.7 kHz. The maximum reading of absolute noise power arising from leakage given by a receiver of 1.74 kHz effective bandwidth and which just meets the foregoing leakage requirement is −85.6 dBm0p;

6. that additional measuring channels may be provided by agreement between the administrations concerned;

6.1 that for the selection and technical characteristics of any new measuring or band-limiting filters the technical details indicated in the Annex I to Report 553 should be taken into account.

Note – An overall accuracy of ± 2 dB and better, is assumed for systems in operation in the fixed-satellite service. Attention is also drawn to CCITT Recommendation G.228, Annex 1 and Annex 2 which discuss the method of measurement and the measuring accuracy.

TABLE I

Capacity (channels)	Limits of band occupied by telephone channels (kHz)	Effective cut-off frequencies of band-limiting filters (kHz)		Frequencies of recommended measuring channels (1) (kHz)
		High pass	Low pass	
12	12- 60	12 ± 0.5	60 ± 0.5	16 56
24	12- 108	12 ± 0.5	108 ± 1.0	16 98
36	12- 156	12 ± 0.5	156 ± 1.0	16 140
48	12- 204	12 ± 0.5	204 ± 1.5	16 185
60	12- 252	12 ± 0.5	252 ± 2.0	16 240
72	12- 300	12 ± 0.5	300 ± 2.0	16 270
96	12- 408	12 ± 0.5	408 ± 3.0	16 240 394
132	12- 552	12 ± 0.5	552 ± 4.0	16 240 534
192	12- 804	12 ± 0.5	804 ± 6.0	16 394 770
252	12-1 052	12 ± 0.5	1 052 ± 8.0	16 534 1 002
312	12-1 300	12 ± 0.5	1 296 ± 8.0	16 534 1 248
372	12-1 548	12 ± 0.5	1 548 ± 10	16 534 1 002 1 490
432	12-1 796	12 ± 0.5	1 796 ± 12	16 534 1 002 1 730
492	12-2 044	12 ± 0.5	2 044 ± 14	16 534 1 248 1 940
552	12-2 292	12 ± 0.5	2 292 ± 17	16 770 1 730 2 150
612	12-2 540	12 ± 0.5	2 600 ± 20	16 770 1 730 2 438
792	12-3 284	12 ± 0.5	3 284 ± 25	16 1 002 2 438 3 150
972	12-4 028	12 ± 0.5	4 100 ± 30	16 1 002 2 438 3 886
1 092	12-4 892	12 ± 0.5	4 892 ± 40	70 1 002 2 438 4 650
1 200	12-5 340	12 ± 0.5	5 340 ± 45	70 1 002 3 150 4 650
1 332	12-5 884	12 ± 0.5	5 884 ± 50	70 1 002 3 150 4 650 5 340
1 872	12-8 120	12 ± 0.5	8 160 ± 75	70 1 002 3 150 5 340 7 600

(1) See also Recommends 6.1 of this Recommendation.

TABLE II

Centre frequency f_c (kHz)	Bandwidth (kHz) in relation to f_c, over which the discrimination should be at least: (1)				Bandwidth (kHz) in relation to f_c outside of which the discrimination should not exceed:	
	70 dB	55 dB	30 dB	3 dB (2)	3 dB	0.5 dB
16	± 1.5	± 2.1	± 2.7	–	± 5	± 7
56	± 1.5	± 1.8 (3)	± 2.1 (3)	–	± 5	± 10
70	± 1.5	± 2.2	± 3.5	–	± 12	± 18
70 (4)	± 1.5	± 1.7	± 2.0	–	± 5	± 10
98	± 1.5	± 1.8	± 2.1	–	± 4	± 9
140	± 1.5	± 1.8	± 2.2	–	± 5	± 14
185	± 1.5	± 1.8	± 2.2	–	± 5	± 17
240	± 1.5	± 1.8	± 2.2	–	± 5	± 21
270	± 1.5	± 2.3	± 2.9	–	± 8	± 24
394	± 1.5	± 3.0	± 4.5	–	± 11	± 35
534	± 1.5	± 3.5	± 7.0	–	± 15	± 48
770	± 1.5	± 3.8	± 8.0	–	± 21	± 70
1 002	± 1.5	± 4.0	± 9.0	–	± 27	± 90
1 248	± 1.5	± 4.0	± 11.0	–	± 35	± 110
1 490	± 1.5	± 4.1	± 12.0	–	± 42	± 135
1 730	± 1.5	± 4.2	± 14.0	–	± 48	± 155
1 940	± 1.5	± 4.3	± 15.0	–	± 52	± 175
2 150	± 1.5	± 4.4	± 17.0	–	± 55	± 195
2 438	± 1.5	± 4.5	± 19.0	–	± 60	± 220
3 150	± 1.5	± 9.0	± 22.0	–	± 85	± 285
3 886 (5)	± 1.5	± 15.0	± 30.0	–	± 110	± 350
		± 1.8	± 3.5	± 8.0	± 12	± 100
4 650	± 1.5	± 2.0	± 3.8	± 8.5	± 13	± 120
5 340	± 1.5	± 2.2	± 4.0	± 8.5	± 14	± 150
7 600	± 1.5	± 2.4	± 4.6	± 9.5	± 16	± 200

(1) The discrimination values quoted are relative referred to the minimum attenuation of band-stop filters within the baseband frequency range defined by high-pass and low-pass filters in Table I.

(2) New 3 dB-column from CCITT Recommendation G.228.

(3) The values accepted at the Final Meeting of Study Group 4 were: ± 2.0 (55 dB) and ± 2.5 (30 dB).

(4) New band-stop filter from CCITT Recommendation G.230.

(5) The characteristics recommended for the filters 16 kHz to 3150 kHz inclusive are based on inductor-capacitor type filters. Those characteristics recommended for the filters at 4650 kHz and above are based on crystal-type filters. Optional characteristics are recommended for the 3886 kHz filter to permit a choice of design between a coil-capacitor type (upper line in table) or crystal-type filter (lower line in table).
The design of the receiver selectivity of 3886 kHz should be matched to the characteristic of the crystal-type band-stop filter. It is suggested that in the range from 3150 kHz to 7600 kHz the receiver selectivity should be related to the characteristics of crystal-type band-stop filters.

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SECTION 4D: FREQUENCY SHARING BETWEEN NETWORKS OF THE FIXED-SATELLITE SERVICE – EFFICIENT USE OF THE SPECTRUM AND GEOSTATIONARY-SATELLITE ORBIT

4D1: *Permissible levels of interference*

RECOMMENDATION 466-5

MAXIMUM PERMISSIBLE LEVEL OF INTERFERENCE IN A TELEPHONE CHANNEL OF A GEOSTATIONARY-SATELLITE NETWORK IN THE FIXED-SATELLITE SERVICE EMPLOYING FREQUENCY MODULATION WITH FREQUENCY-DIVISION MULTIPLEX, CAUSED BY OTHER NETWORKS OF THIS SERVICE

(Study Programme 28A/4)

(1970-1974-1978-1982-1986-1990)

The CCIR,

CONSIDERING

(a) that geostationary satellite networks in the fixed-satellite service operate in the same frequency bands;

(b) that interference between networks in the fixed-satellite service contributes to the noise in the network;

(c) that it is desirable that the interference noise in the telephone channels of networks in the fixed-satellite service caused by transmitters of different networks in that service should be such as to give a reasonable orbit utilization efficiency;

(d) that the overall performance of a network should essentially be under the control of the system designer;

(e) that it is necessary to protect a network in the fixed-satellite service from interference by other such networks;

(f) that it is necessary to specify the maximum permissible interference power in a telephone channel, to determine space station and earth station characteristics;

(g) that the value selected for the maximum permissible single entry of interference noise should not result in too wide a minimum orbital spacing;

(h) that for co-ordination between two satellite networks, it is necessary to know the maximum permissible level of interference in a telephone channel of the wanted network caused by transmitters of the other network;

(j) that networks in the fixed-satellite service may receive interference both into the space station receiver and into the earth station receiver;

(k) that the mean interference noise power should be an appropriate fraction of the total noise power permitted in the hypothetical reference circuit;

(l) that in many cases the largest interference contributions to a geostationary satellite network will be from the networks using geostationary satellites in orbit nearby and serving an overlapping coverage area. The value of interference from any other network will generally be less;

(m) that the accumulation of interference from many entries from other satellite networks and from terrestrial stations is not likely to be equal to the arithmetic sum of the individual interference entries at their maximum value across the band, and the total interference noise level in any single channel may be significantly less;

(n) that the levels of interference between geostationary satellite networks in the fixed-satellite service operating in frequency bands below 10 GHz are not expected to undergo a large variation with time;

(o) that in frequency bands between 10 and 15 GHz where very high propagation attenuation may occur for short periods of time, it would generally be desirable for systems to make use of adaptive up-path power control or earth-station site diversity or other techniques to counteract signal fading and that under these circumstances the levels of interference from other satellite systems would also not undergo a large variation with time;

p) that the use of syllabic companding may be useful in reducing transmitter power requirements or increasing transmission capacity, but that companded transmissions have a sensitivity to interference which is different from that of uncompanded transmissions,

UNANIMOUSLY RECOMMENDS

1. that different geostationary-satellite networks in the fixed-satellite service operating in the same frequency bands, below 15 GHz, be designed in such a manner that the interference noise power at a point of zero relative level in any telephone channel of a hypothetical reference circuit of a network in the fixed-satellite service, employing frequency modulation, caused by the aggregate of the earth station and space station transmitters of other fixed satellite networks, should not exceed:

1.1 in frequency bands in which the network does not practise frequency re-use: 2500 pW0p, psophometrically weighted one minute mean power for more than 20% of any month;

1.2 in frequency bands in which the network practises frequency re-use; 2000 pW0p, psophometrically weighted one minute mean power for more than 20% of any month;

2. that the maximum level of the interference noise power at a point of zero relative level in any telephone channel of the hypothetical reference circuit of a geostationary satellite network in the fixed-satellite service employing frequency modulation, caused by the transmitters of another fixed satellite network, should not exceed 800 pW0p, psophometrically weighted one minute mean power, for more than 20% of any month;

3. that the maximum level of interference noise power caused to that network should be calculated on the basis of the following values for the receiving earth station antenna gain, in a direction at an angle φ (in degrees) referred to the main beam direction:

$$G = 32 - 25 \log \varphi \quad \text{dBi} \quad \text{for} \quad 1° \leqslant \varphi < 48°$$
$$G = -10 \quad \text{dBi} \quad \text{for} \quad 48° \leqslant \varphi \leqslant 180°$$

except when the actual gain is known and is less than the above value, in which case the actual value should be used.

4. that the following Notes should be regarded as part of this Recommendation:

Note 1 – The values quoted in § 1.1, 1.2 and 2 are not intended to apply:

(a) to networks for which a complete advance publication was submitted to the IFRB by the time of the CCIR XIVth Plenary Assembly, 1978; for such networks the aggregate interference power in any telephone channel should not exceed 1000 pW0p psophometrically weighted one minute mean power for more than 20% of any month, and the single-entry interference noise power should not exceed 400 pW0p, psophometrically weighted one minute mean power, for more than 20% of any month;

(b) for networks which have submitted complete advance publication after the CCIR XIVth Plenary Assembly, 1978 and prior to the end of 1987, the aggregate interference power in any telephone channel should not exceed 2000 pW0p psophometrically weighted one minute mean power for more than 20% of any month for networks which do not practise frequency re-use and 1500 pW0p psophometrically weighted one minute mean power for more than 20% of any month for networks which practise frequency re-use, and the single-entry interference noise power should not exceed 600 pW0p, psophometrically weighted one minute mean power, for more than 20% of any month.

Note 2 – The pW0p values given in RECOMMENDS 1 and 2 apply to interfered with transmissions which do not use syllabic companding. When a transmission uses syllabic companding, the equivalent values to be used result from multiplication of the values from RECOMMENDS 1 and 2 with the numerical companding gain for which the transmissions have been characterized. This is predicated on an overall subjective channel performance objective of 10 000 pW0p.

Note 3 – Only a small fraction of the channels of a network will experience the maximum value of interference from any single network and therefore the aggregate level for many channels will be less than the totals contained in § 1. System designers may provide for a lower value in their noise budgets for a large portion of the spectrum. The way in which the aggregate values are to be taken into account in the general noise objectives for networks in the fixed-satellite service is defined in Note 6 of Recommendation 353.

Note 4 – In some cases it may be necessary to limit the single entry interference value to less than the value quoted in § 2 above in order that the total value recommended in § 1 may not be exceeded. In other cases, particularly in congested arcs of the geostationary satellite orbit, Administrations may agree bilaterally to use higher single entry interference values than those quoted in § 2 above, but any interference noise power in excess of the value recommended in § 2 should be disregarded in calculating whether the total value recommended in § 1 is exceeded.

Note 5 – There is a need for study to be given to means of increasing the single entry interference level quoted in § 2 above without causing the total interference noise level to exceed the values quoted in § 1; this study should include, for example, the feasibility of overcoming problems of interference which result from inhomogeneous network parameters.

Note 6 – There is a need for study of the acceptability of an increase in the maximum total interference noise values recommended in § 1.

Note 7 – In segments of the geostationary satellite orbit not likely to be crowded, an interference allowance less than that recommended in § 1 above, may be utilized, allowing a corresponding increase in other noise contributions within total acceptable noise limits.

Note 8 – Although this Recommendation has been extended to an upper frequency limit of 15 GHz, in the frequency range from 10 to 15 GHz short term propagation data are not available uniformly throughout the world and there is a continuing need to examine such data to confirm the appropriateness of the interference noise allowances.

Note 9 – There is a need for urgent study to be given to the interference noise allowances appropriate to systems operating at frequencies above 15 GHz.

RECOMMENDATION 483-1

MAXIMUM PERMISSIBLE LEVEL OF INTERFERENCE IN A TELEVISION CHANNEL OF A GEOSTATIONARY-SATELLITE NETWORK IN THE FIXED-SATELLITE SERVICE EMPLOYING FREQUENCY MODULATION, CAUSED BY OTHER NETWORKS OF THIS SERVICE

(Study Programme 2J/4)

(1974–1978)

The CCIR,

CONSIDERING

(a) that interference between networks in the fixed-satellite service contributes to the noise in the system;

(b) that it is desirable that the interference noise in television channels of networks in the fixed-satellite service caused by transmitters of different networks of this service should be such as to give a reasonable orbit utilization efficiency;

(c) that the overall performance of a network should essentially be under the control of the system designer;

(d) that it is necessary to protect a network in the fixed-satellite service from interference by other networks of this service;

(e) that it is necessary to specify the maximum permissible interference power in a television channel, in order to determine space station and earth station characteristics such as required protection ratios and minimum orbital spacing;

(f) that networks in the fixed-satellite service may receive interference both into the space station receiver and into the earth station receiver;

(g) that the interference noise power should be an appropriate fraction of total noise power permitted in the hypothetical reference circuit;

(h) that in many cases the largest interference contributions to a geostationary-satellite network will be from the networks using the adjacent geostationary satellites and the value of interference from any other network will generally be less,

UNANIMOUSLY RECOMMENDS

1. that different geostationary-satellite networks in the fixed-satellite service operating in the same frequency bands, be designed in such a manner that the interference noise power in a hypothetical reference circuit for television of a network in the fixed-satellite service employing frequency modulation caused by the aggregate of the earth station and space station transmitters of other networks, should not exceed 1/10 of the permissible video noise in the hypothetical reference circuit for more than 1% of any month;

2. that the maximum level of interference noise power caused by any one satellite network into another satellite network should not exceed 4/10 of the interference noise allowance recommended in § 1 but in some cases it may be necessary to limit the single entry value to less than 4/10 of the interference noise allowance quoted above;

3. that the maximum level of interference noise power caused to that network should be calculated on the basis of the following values for the receiving earth station antenna gain in a direction at an angle φ (in degrees) referred to the main beam direction:

$$G = 32 - 25 \log \varphi \text{ dB for } 1^\circ \leqslant \varphi < 48^\circ$$
$$G = -10 \text{ dB for } 48^\circ \leqslant \varphi \leqslant 180^\circ$$

except when the actual gain is known and is less than the above value, in which case the actual value should be used;

4. that the following Notes should be regarded as part of the Recommendation:

Note 1 – The above values of interference noise shall be included in the total noise allowances as defined in Recommendation 354.

Note 2 – In segments of the geostationary satellite orbit not likely to be crowded, interference allowances less than those recommended above may be utilized, allowing a corresponding increase in other noise contributions within total acceptable noise limits.

RECOMMENDATION 523-3

MAXIMUM PERMISSIBLE LEVELS OF INTERFERENCE IN A GEOSTATIONARY-SATELLITE NETWORK IN THE FIXED-SATELLITE SERVICE USING 8-BIT PCM ENCODED TELEPHONY, CAUSED BY OTHER NETWORKS OF THIS SERVICE

(Study Programme 28C/4)

(1978–1982–1986–1990)

The CCIR,

CONSIDERING

(a) that geostationary-satellite networks in the fixed-satellite service operate in the same frequency bands;

(b) that interference between networks in the fixed-satellite service degrades the bit error ratio performance relative to its value in the absence of frequency sharing;

(c) that it is desirable that the bit error ratio in networks in the fixed-satellite service caused by transmitters of different networks in that service should be such, as to give a reasonable orbit utilization efficiency;

(d) that the overall performance of a network should essentially be under the control of the system designer;

(e) that it is necessary to protect a network in the fixed-satellite service from interference by other such networks;

(f) that it is necessary to determine the maximum permissible interfering radio frequency power in a satellite system to establish space station and earth station characteristics such as required protection ratios and minimum orbital spacing;

(g) that networks in the fixed-satellite service may receive interference both into the space station receiver and into the earth station receiver;

(h) that it is desirable that the increase in bit error ratio due to interference from other satellite networks should be a controlled fraction of the total bit error ratio, as set out in Recommendation 522;

(j) that where adjacent satellites serve networks with similar characteristics the largest interference contributions to a geostationary satellite network will be from the networks using those adjacent satellites; but this may not be true where network characteristics are inhomogeneous;

(k) that the levels of interference between geostationary-satellite networks in the fixed-satellite service below 10 GHz are not expected to exhibit a large variation with time, and under these conditions it is preferable to define the permissible interference limit as a fraction of the pre-demodulator noise power, as this allows multiple interference entries to be superimposed on each other on the basis of RF power addition;

(l) that in frequency bands between 10 and 15 GHz where very high propagation attenuation may occur for short periods of time, it would generally be desirable for systems to make use of adaptive up-link power control or earth station site diversity or other techniques to counteract signal fading and that under these circumstances the levels of interference from other satellite systems would also not undergo a large variation with time,

UNANIMOUSLY RECOMMENDS

1. that networks in the fixed-satellite service operating in the same frequency bands below 15 GHz, and using geostationary satellites be designed and operated in such a manner that the total interference to an 8-bit PCM telephony system in the fixed-satellite service caused by the earth station and space station transmitters of all other networks, should conform provisionally to the following limits:

1.1 in frequency bands in which the network does not practise frequency re-use, the interference power level, averaged over any ten minutes, should not exceed, for more than 20% of any month, 25% of the total noise power level at the input to the demodulator which would give rise to a bit error ratio of 1 in 10^6;

1.2 in frequency bands in which the network practises frequency re-use, the interference power level, averaged over any ten minutes, should not exceed, for more than 20% of any month, 20% of the total noise power level at the input to the demodulator that would give rise to a bit error ratio of 1 in 10^6;

2. that the maximum level of interference power in any such 8-bit PCM telephony system caused by the transmitters of another fixed-satellite network, averaged over any ten minutes, should not exceed, for more than 20% of any month, 6% on a provisional basis of the total noise power level at the input to the demodulator which would give rise to a bit error ratio of 1 in 10^6;

3. that the maximum level of interference noise power caused to that network should be calculated on the basis of the following values for the receiving earth station antenna gain, in a direction at an angle φ (in degrees) referred to the main beam direction:

$$G = 32 - 25 \log \varphi \quad \text{dBi} \qquad \text{for} \quad 1° \leqslant \varphi < 48°$$
$$G = -10 \quad \text{dBi} \qquad \text{for} \quad 48° \leqslant \varphi \leqslant 180°$$

except when the actual gain is known and is less than the above value, in which case the actual value should be used;

4. that the following notes should be regarded as part of this Recommendation:

Note 1 – For the calculation of the limits quoted in § 1.1, 1.2 and 2 it should be assumed that the total noise power at the input to the demodulator is of thermal nature.

Note 2 – It is assumed in this Recommendation that the interference from other satellite networks is of a continuous nature; further study is required with respect to cases where interference is not of a continuous nature.

Note 3 – The values quoted in § 1 and 2 are not intended to apply:

(a) to networks for which a complete advance publication was submitted to the IFRB by the time of the CCIR XIVth Plenary Assembly, 1978: for such networks the aggregate interference power level, averaged over any ten minutes, should not exceed, for more than 20% of any month, 10% of the total noise power level at the input to the demodulator which would give rise to a bit error ratio of 1 in 10^6; and the single-entry interference power level, averaged over any ten minutes, should not exceed, for more than 20% of any month, 4% of the total noise power level at the input to the demodulator which would give rise to a bit error ratio of 1 in 10^6;

(b) to networks for which complete advance publication was submitted after the CCIR XIVth Plenary Assembly, 1978 and prior to the end of 1987: for such networks the aggregate interference power level, averaged over any ten minutes, should not exceed, for more than 20% of any month, 20% of the total noise power level at the input to the demodulator which would give rise to a bit error ratio of 1 in 10^6 for networks which do not practise frequency re-use, and 15% for those networks which do practise frequency re-use, and the single-entry interference power level, averaged over any ten minutes, should not exceed, for more than 20% of any month, 4% (see Note 5) of the total noise power level at the input to the demodulator which would give rise to a bit error ratio of 1 in 10^6.

Note 4 – In some cases it may be necessary to limit the single entry interference value to less than the value quoted in § 2 above in order that the total value recommended in § 1 may not be exceeded. In other cases, particularly in congested arcs of the geostationary-satellite orbit, administrations may agree bilaterally to use higher single entry interference values than those quoted in § 2 above, but any interference noise power in excess of the value recommended in § 2 should be disregarded in calculating whether the total value recommended in § 1 is exceeded.

Note 5 – The provisional single-entry value of 6% in § 2 has provisionally replaced the 4% value, pending the results of studies to determine the most appropriate value, taking into account the increase in the effective number of interferers contributing to the aggregate interference because of the increasing use of spot beam antennas at space stations. Study of the relationship between the single-entry interference value quoted in § 2 above and the aggregate interference values quoted in § 1 is required as a matter of urgency.

Note 6 – There is an urgent need for study of the acceptability of an increase in the maximum total interference noise values recommended in § 1 and more particularly those given in § 1.2 for satellite networks in which frequency re-use is practised.

Note 7 – In segments of the geostationary-satellite orbit not likely to be crowded, interference allowances less than those recommended in § 1 above, may be utilized, allowing a corresponding increase in other noise contributions within total acceptable noise limits. However, § 1.1 and 1.2 above should normally be evaluated with the assumption that the total power noise level present is that which produces the specified bit error ratio under unfaded conditions of the received signal.

Note 8 – Although this Recommendation has been extended to an upper frequency limit of 15 GHz, in the frequency range from 10 to 15 GHz short term propagation data are not available uniformly throughout the world and there is a continuing need to examine such data to confirm the appropriateness of the interference noise allowances.

Note 9 – There is a need for urgent study to be given to the interference noise allowances appropriate to systems operating at frequencies above 15 GHz.

Note 10 – The interference power levels indicated in § 1 and 2 above apply only to the transmission of PCM telephony (see CCIR Recommendation 522 and CCITT Recommendation G.711). Further study by CCIR Study Group 4 is required regarding the performance objectives appropriate to the transmission of digital services other than PCM telephony, as information on the performance requirements of such services becomes available to the CCIR.

Note 11 – The percentages of total noise power given in RECOMMENDS 1.1, 1.2 and 2 above (25%, 20% and 6%, respectively) may provisionally be used for a variety of digital satellite transmissions such as those which form part of an Integrated Services Digital Network connexion taking into account of its long-term performance objectives. Further study is necessary on the development of definitive interference Recommendations for other digital satellite systems.

RECOMMENDATION 671

NECESSARY PROTECTION RATIOS FOR NARROW-BAND SINGLE CHANNEL-PER-CARRIER TRANSMISSIONS INTERFERED WITH BY ANALOGUE TELEVISION CARRIERS

(Study Programme 28C/4)

(1990)

The CCIR,

CONSIDERING

(a) that narrow-band SCPC carriers are sensitive to the interference caused by analogue television carriers, especially when such carriers are only modulated with energy dispersal signals at the television frame rate;

(b) that interference from FM/TV into SCPC transmissions is generally a determining factor in the coordination of closely spaced satellites;

(c) that the calculation methods required for determining the level of permissible interference in such cases are unique to this class of signals;

(d) that the uniqueness of this situation is recognized in Appendix 4 of the Radio Regulations;

(e) that Report 867 contains methods for performing these calculations based on experimental results,

UNANIMOUSLY RECOMMENDS

1. for the purposes of calculating the permissible levels of interference between analogue television and narrow-band SCPC carriers, the protection ratio of SCPC carriers interfered with by analogue TV carriers modulated only by energy dispersal at the TV frame rate, be calculated from the following:

1.1 for 64 kbit/s SCPC, without forward error correction (FEC);

$$C/I = C/N + 6.4 + 3 \log \delta - 8 \log (i/10) \quad \text{dB}$$

1.2 for companded frequency modulation (CFM) SCPC;

$$C/I = 13.5 + 2 \log \delta - 3 \log (i/10) \quad \text{dB}$$

where:

- C/I: ratio of the interfered with SCPC carrier power to the total carrier power of the interfering dispersed TV signal;
- C/N: operating carrier-to-noise power ratio of the SCPC carrier which corresponds to a BER of 1×10^{-6};
- δ : ratio of the occupied bandwidth of the SCPC carrier to the TV peak-to-peak deviation due to dispersal;
- i: pre-demodulation interference power in the SCPC bandwidth expressed as a percentage of the total pre-demodulation noise power ($10 \leqslant i \leqslant 25$).

2. that the following Notes should be regarded as part of the Recommendation:

Note 1 – The interference criterion in § 1.1 and 1.2 are applicable for interfering TV signals with energy dispersal only. Report 867 contains information related to the interference with NTSC live programme material.

Note 2 – To protect 64 kbit/s SCPC carriers having forward error correction (FEC) coding at rates between 1/2 and 7/8 using soft decision Viterbi decoding, the following expression may be used:

$$C/I = C/N + 9.4 + 3.5 \log \delta - 6 \log (i/10) \quad \text{dB}$$

Note 3 – Interference criteria for TV signals into higher bit rate QPSK carriers are given in Report 867.

Note 4 – Significant additional protection for narrow-band SCPC carriers can be obtained if they are appropriately offset in frequency from the centre frequency of the TV carrier. This applies, in different degrees, both when the TV carrier is modulated with live programme material and otherwise.

Note 5 – Further study is needed where TV signals other than PAL, SECAM and NTSC are involved.

RECOMMENDATION 524-3

MAXIMUM PERMISSIBLE LEVELS OF OFF-AXIS e.i.r.p. DENSITY FROM EARTH STATIONS IN THE FIXED-SATELLITE SERVICE TRANSMITTING IN THE 6 AND 14 GHz FREQUENCY BANDS*

(Study Programme 28A/4)

(1978-1982-1986-1990)

The CCIR,

CONSIDERING

(a) that geostationary-satellite networks in the fixed-satellite service operate in the same frequency bands;

(b) that interference between networks in the fixed-satellite service contributes to noise in the network;

(c) that it is necessary to protect a network in the fixed-satellite service from interference by other such networks;

(d) that it is necessary to specify the maximum permissible levels of off-axis e.i.r.p. density from earth stations, to promote harmonization between geostationary-satellite networks;

(e) that networks in the fixed-satellite service may receive interference into the space station receiver;

(f) that the use of antennas with the best off-axis performance will lead to the most efficient use of radio-frequency spectrum and the geostationary-satellite orbit;

(g) that progress in the development of reduced side-lobe antennas indicates that improved performance antennas will be widely available in the next few years;

(h) that off-axis e.i.r.p. density levels can be limited through the choice of antennas and/or transmission parameters,

UNANIMOUSLY RECOMMENDS

1. that networks in the fixed-satellite service operating in the 6 GHz frequency band be designed in such a manner that at any angle, φ, which is 2.5° or more off the main lobe axis of an earth-station antenna, the e.i.r.p. density in any direction within 3° of the geostationary-satellite orbit should not exceed the following values:

1.1 for emissions in systems other than those considered in § 1.2 and 1.3 below:

Angle off-axis	*Maximum e.i.r.p. per 4 kHz*
$2.5° \leq \varphi < 48°$	$(35 - 25 \log \varphi)$ dB(W/4 kHz)
$48° \leq \varphi \leq 180°$	-7 dB(W/4 kHz)

1.2 for emissions in voice-activated telephony SCPC/FM systems:

Angle off-axis	*Maximum e.i.r.p. per 40 kHz*
$2.5° \leq \varphi < 48°$	$(42 - 25 \log \varphi)$ dB(W/40 kHz)
$48° \leq \varphi \leq 180°$	0 dB(W/40 kHz)

1.3 for emissions in voice-activated telephony SCPC/PSK systems:

Angle off-axis	*Maximum e.i.r.p. per 40 kHz*
$2.5° \leq \varphi < 48°$	$(45 - 25 \log \varphi)$ dB(W/40 kHz)
$48° \leq \varphi \leq 180°$	3 dB(W/40 kHz)

2. For new antennas of an earth station using emissions other than those considered in § 1.2 and 1.3, after 1988 the e.i.r.p. density should not exceed the following values:

Angle off-axis	*Maximum e.i.r.p. per 4 kHz*
$2.5° \leq \varphi \leq 7°$	$(32 - 25 \log \varphi)$ dB(W/4 kHz)
$7° < \varphi \leq 9.2°$	11 dB(W/4 kHz)
$9.2° < \varphi \leq 48°$	$(35 - 25 \log \varphi)$ dB(W/4 kHz)
$48° < \varphi \leq 180°$	-7 dB(W/4 kHz)

* Except where providing feeder links to the broadcasting-satellite service in accordance with Appendix 30A of the Radio Regulations.

3. that earth stations operating in networks in the fixed-satellite service operating in the 14 GHz frequency band (which are not providing feeder links to the broadcasting-satellite service in accordance with Appendix 30A of the Radio Regulations) be designed in such a manner that at any angle, φ, which is 2.5° or more off the main-lobe axis of an earth-station antenna, the e.i.r.p. density in any direction within 3° of the geostationary-satellite orbit should not exceed the following values:

Angle off-axis	*Maximum e.i.r.p. per 40 kHz*
$2.5° \leq \varphi \leq 7°$	$(39 - 25 \log \varphi)$ dB(W/40 kHz)
$7° < \varphi \leq 9.2°$	18 dB(W/40 kHz)
$9.2° < \varphi \leq 48°$	$(42 - 25 \log \varphi)$ dB(W/40 kHz)
$48° < \varphi \leq 180°$	0 dB(W/40 kHz)

4. that the following Notes should be regarded as part of this Recommendation.

Note 1 – Values in § 1.2 above are based on a mean power noise analysis. Possible subjective effects of interference into an SCPC-FM carrier by a very narrow bandwidth emission have not been considered. Further studies are required on this matter.

Note 2 – Limits in § 1.2 above apply to normal operation of voice telephony in a 4 kHz baseband.

Note 3 – The values contained in § 1.1 above have been derived mainly from an analysis of FM systems used for analogue television or multi-channel telephony. It is not known at the present time whether telecommand and ranging systems operating in the emission band and some types of SCPC system different from those mentioned in § 1.2 and 1.3, comply with these provisions. Studies should be undertaken in order to determine how these systems could comply with the limits above.

Note 4 – Enhanced orbit utilization and easier coordination would be attained with lower side-lobe e.i.r.p. values, and therefore, administrations are encouraged to achieve lower values where practicable.

Note 5 – Wherever practicable, existing earth stations should comply with the values above.

Note 6 – The provisional values contained in § 2 have been derived from advanced, low side-lobe antenna patterns, taking into account the principles of Note 3. Further studies of earth-station antenna performance at angles close to the main beam, and particularly in respect of the validity of 7° as a value up to which it is reasonable to recommend this 3 dB tightening of the off-axis e.i.r.p. density limit, are urgently needed. These studies should also include consideration of the impact of the values in § 2 on antennas with operating bandwidths greater than 500 MHz.

Note 7 – It may be necessary, in frequency planning, to avoid situations where television transmissions in one network use the same frequencies as SCPC telephony transmissions in a network using a nearby satellite.

Note 8 – When uplink power control is used and rain fades make it necessary, the limiting values stated in § 3 may be exceeded for the duration of that period. In rain climates N and P in the case when uplink power control is not used, the limits given in § 3 may be exceeded by y dB. The value of y dB needs to be determined by further studies based on reliable propagation data to establish fade margins with adequate accuracy. Table II of Report 1001 provides further guidance on this subject.

Note 9 – Administrations operating earth-stations in the 14 GHz band are encouraged to reduce the off-axis e.i.r.p. density by increasing the required antenna diameter, employing improved antenna side-lobe performance or, in the case of FM/TV, to use an appropriate form of energy dispersal, if applicable.

Note 10 – The use of reduced satellite spacing will require further study of the e.i.r.p. limit for off-axis angles below 2.5°.

Note 11 – FM/TV emissions in the 14 GHz band may exceed the limits in § 3 by up to 3 dB in the case of earth stations which have been brought into service prior to 1993.

4D2: *Coordination methods*

There are no Recommendations in this Section.

4D3: *Spacecraft station-keeping – Satellite antenna radiation pattern – Pointing accuracy*

RECOMMENDATION 484-2

STATION-KEEPING IN LONGITUDE OF GEOSTATIONARY SATELLITES USING FREQUENCY BANDS ALLOCATED TO THE FIXED-SATELLITE SERVICE

(Study Programme 2J/4)

(1974-1978-1982)

The CCIR,

CONSIDERING

(a) that the geostationary-satellite orbit is of unique usefulness to telecommunication services;

(b) that the interference imposes a limit on the number of satellites which may operate in the same frequency band in the same part of the orbit but the number will tend to increase as the degree of accuracy of station-keeping is improved;

(c) that the number of satellites using this orbit for operational purposes is likely to grow significantly in the next few years;

(d) that it is technically feasible to maintain satellite position to within ± 0.1°; although this standard may not be achieved by some satellites designed before 1982,

UNANIMOUSLY RECOMMENDS

that space stations on geostationary satellites using frequency bands allocated to the fixed-satellite service:

1. should maintain their positions within ± 0.1° of longitude of their nominal positions irrespective of the cause of variation; but

2. need not comply with § 1 as long as the satellite network to which the space station belongs does not produce an unacceptable level of interference into any other satellite network whose space station complies with the limits of § 1;

3. that the following Note will be considered part of this Recommendation.

Note – For space stations on board geostationary satellites which are put into service prior to 1 January 1987, with the advance publication information for the network having been published before 1 January 1982, and for experimental stations on board geostationary satellites, the limits specified in § 1 may be replaced by ± 0.5°.

RECOMMENDATION 670

FLEXIBILITY IN THE POSITIONING OF SATELLITES AS A DESIGN OBJECTIVE

(Study Programme 28A/4)

(1990)

The CCIR,

CONSIDERING

(a) that flexibility in the positioning of satellites can increase the efficiency of the geostationary orbit;

(b) that flexible satellite positioning can, in some circumstances, increase the likelihood of successful frequency coordination;

(c) that repositioning can impact on the design of satellites as regards lifetime and the trade-off between coverage area and performance;

(d) that the repositioning of satellites will impact on earth segment operations and may require large numbers of non-tracking earth stations to be repointed;

(e) that the frequency of the repositioning should be limited so as to minimize disruption to the services being supported;

(f) that changing the order of satellites within a given arc of the geostationary-satellite orbit is likely to be more onerous than changing their spacings by a small amount,

UNANIMOUSLY RECOMMENDS

1. that satellites for new networks in the fixed-satellite service should be designed to have the flexibility to operate within ± 2° of their nominal orbital position, or to the extent of their service arc, whichever is less;

2. that Notes 1 and 2 be regarded as part of this Recommendation.

Note 1 – Administrations are encouraged to develop new satellite technology to permit satellites to operate within ± 5° of their nominal orbital position, or to extent of their service arc, whichever is less;

Note 2 – New networks are defined as networks for which the advance publication data is after 1990.

RECOMMENDATION 672

SATELLITE ANTENNA RADIATION PATTERN FOR USE AS A DESIGN OBJECTIVE IN THE FIXED-SATELLITE SERVICE

(Study Programme 1B/4)

(1990)

The CCIR,

CONSIDERING

(a) that the use of space-station antennas with the best available radiation patterns will lead to the most efficient use of the radio-frequency spectrum and the geostationary orbit;

(b) that both single feed elliptical (or circular) and multiple feed shaped beam antennas are used on operational space stations;

(c) that although improvements are being made in the design of space-station antennas, further information is still required before a reference radiation pattern can be adopted for coordination purposes;

(d) that the adoption of a design objective radiation pattern for space-station antennas will encourage the fabrication and use of orbit-efficient antennas;

(e) that it is only necessary to specify space-station antenna radiation characteristics in directions of potential interference for coordination purposes;

(f) that a considerable amount of theoretical and measured characteristics of space-station antennas has been available in Reports 558 and 810;

(g) that for wide applicability the mathematical expressions should be as simple as possible consistent with effective predictions;

(h) that nevertheless, the expressions should account for the characteristics of practical antenna systems and be adaptable to emerging technologies;

(j) that measurement difficulties lead to inaccuracies in the modelling of spacecraft antennas at large off-axis angles;

(k) that the size constraints of launch vehicles lead to limitations in the D/λ values of spacecraft antennas, particularly at lower frequencies such as the 6/4 GHz band;

(l) that space-station antenna pattern parameters such as reference point, coverage area, equivalent peak gain, that may be used to define a space-station reference antenna pattern, are found in Report 558;

(m) that further study is needed on the characterization of spacecraft antennas in the far side-lobe and back-lobe regions,

UNANIMOUSLY RECOMMENDS

1. that for single feed circular or elliptical beam spacecraft antennas in the fixed-satellite service, the following radiation pattern should be used as a design objective, outside of the coverage area:

$$G(\psi) = G_m - 3\,(\psi/\psi_b)^{\alpha} \qquad \text{dBi} \quad \text{for } \psi_b \leqslant \psi \leqslant a\psi_b \tag{1}$$

$$G(\psi) = G_m + L_N \qquad \text{dBi} \quad \text{for } a\psi_b \leqslant \psi \leqslant b\psi_b \tag{2}$$

where:

$G(\psi)$: gain at the angle (ψ) from the main beam direction (dBi)

G_m : maximum gain in the main lobe (dBi)

ψ_b : one-half the 3 dB beamwidth in the plane of interest (3 dB below G_m) (degrees)

L_N : required near-in side-lobe level relative to the peak gain (dB).

The numeric values of a, b and α for $L_N = -20$ dB and $L_N = -25$ dB side-lobe levels are given below. The values of a and α for $L_N = -30$ dB require further study.

L_N (dB)	a	b	α
−20	2.58	6.32	2
−25	2.88	6.32	2
−30	–	6.32	–

2. that for multiple-feed, shaped-beam, spacecraft antennas in the fixed-satellite service, the radiation pattern to be used as a design objective shall be selected from the following formulas depending upon the class of antenna and the range of the scan ratio.

Definition of class of antennas

– Definition of class A antennas:

Class A antennas are those with the boresight location within the coverage area.

– Definition of class B antennas:

Class B antennas are those with the boresight location outside the coverage areas for one or more of the beams.

Definition of scan ratio

The scan ratio δ in § 2.1 is defined as the angular distance between the centre of coverage (defined as the centre of the minimum area ellipse) and a point of the edge-of-coverage, divided by the beamwidths of the component beam. However, with regard to the scan ratio S used in § 2.2 this is defined as the angular distance between the antenna boresight and a point on the edge-of-coverage, divided by the beamwidth of the component beam.

In the initial determination of which RECOMMENDS is applicable to a specific class A antenna, the δ scan ratio definition should be used.

2.1 For class A antennas with scan ratio δ, values less than or equal to 3.5:

$$
\begin{aligned}
G_{\mathrm{dBi}}(\Delta\psi) &= G_{ep} + 0.256 - 13.065\left(\frac{\Delta\psi}{Q\psi_0} + 0.5\right)^2 && \text{for} \quad 0 \leqslant \frac{\Delta\psi}{\psi_0} \leqslant 0.8904\,Q \\
&= G_{ep} - 25 && \text{for} \quad 0.8904\,Q \leqslant \frac{\Delta\psi}{\psi_0} \leqslant 1.9244\,Q \\
&= G_{ep} - 25 + 20\log\left(\frac{1.9244\,Q\psi_0}{\Delta\psi}\right) && \text{for} \quad 1.9244\,Q \leqslant \frac{\Delta\psi}{\psi_0} \leqslant 18/\psi_0
\end{aligned}
$$

where:

$\Delta\psi$: angle (degrees) from the convex coverage contour to a point outside the coverage region in a direction normal to the sides of the contour,

G_{ep} : equivalent peak gain in dBi
$= G_e + 3.0$,

ψ_0 : the half-power diameter of component beam (degrees),
$= 72\ (\lambda/D)$,

λ : wavelength (m),

D : physical diameter of the reflector (m),

$$\frac{0.000075\ \delta^2}{[(F/D_p)^2 + 0.021]^2}$$

Q $= 10$,

δ : number of beamwidths scanned (scan ratio), as defined above in § 2,

F/D_p : ratio of the reflector focal length F to parent parabola diameter D_p.

2.2 That for class A antennas with scan ratio values $S \geqslant 5$:

$$
\begin{aligned}
G_{dBi}(\Delta\psi) &= G_e - B\left[\left(1 + \frac{\Delta\psi}{\psi_b}\right)^2 - 1\right] && \text{for} \quad 0° \leqslant \Delta\psi \leqslant C\psi_b \\
&= G_e - 22 && \text{for} \quad C\psi_b \leqslant \Delta\psi \leqslant (C + 4.5)\,\psi_b \\
&= G_e - 22 + 20 \log_{10}\left[\frac{(C + 4.5)\,\psi_b}{\Delta\psi}\right] && \text{for} \quad (C + 4.5)\,\psi_b \leqslant \Delta\psi \leqslant 18
\end{aligned}
$$

where:

$\Delta\psi$: the angle (degrees) from the convex coverage contour in a direction normal to the sides of the contour

G_e: gain at the edge-of-coverage (dBi)

$B \quad = B_0 - (S - 1.25)\,\Delta B \qquad S \geqslant 5$

$B_0 \quad = 2.05 + 0.5\,(F/D - 1) + 0.0025\,D/\lambda$

$\Delta B \quad = 1.65\,(D/\lambda)^{-0.55}$

ψ_b: beamlet radius
$= 36\,\lambda/D$

λ: wavelength (m)

D: physical diameter of the reflector (m)

$C \quad = \sqrt{1 + \frac{22}{B}} - 1$

S: number of beamwidths scanned (scan ratio), as defined above in § 2

F/D: ratio of focal length over the physical diameter of the antenna.

2.3 that for class B antennas with scan ratio values $S \geqslant 5$: RECOMMENDS 2.2 applies;

2.4 that for class A antennas with scan ratio values between $\delta > 3.5$ and $S < 5$, the design objective is still under study. In particular, studies are required on the extension of the equations given in § 2.1 and 2.2 into this region. For the definition of scan ratios δ and S and their application, see above;

2.5 that for class B antennas with scan ratio values of $S < 5$ no design objective is given. Further studies are required;

2.6 that the following notes shall be considered part of RECOMMENDS 2.1, 2.2 and 2.3:

Note 1 – The coverage area shall be defined as the contour constructed from the convex polygon points surrounding the service area, using the techniques given in Annex IV of Report 558 using the simplification to eliminate concave areas.

Note 2 – This Recommendation should be applied only in the direction of an interference sensitive system. That is, it need not be applied in directions where the potential for interference to other networks does not exist (e.g. off the edge-of-the Earth, unpopulated ocean regions). Consideration should also be given to permitting a small percentage of the side-lobe peaks exceeding the pattern in other directions. This Note also applies in respect of RECOMMENDS 1.

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SECTION 4E: FREQUENCY SHARING BETWEEN NETWORKS OF THE FIXED-SATELLITE SERVICE AND THOSE OF OTHER SPACE RADIOCOMMUNICATIONS SYSTEMS

There are no Recommendations in this Section.

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OPINIONS

OPINION 56-1*

LOCATION OF INTERFACE BETWEEN CCIR STUDY GROUP 4 AND CCITT RESPONSIBILITIES FOR DIGITAL NETWORK RECOMMENDATIONS

(1978-1986)

The CCIR,

CONSIDERING

(a) that the fixed-satellite service HRDP forms part of an overall HRX;

(b) that the CCITT has responsibilities for developing Recommendations for both the overall HRX and some of the constituent HRDPs;

(c) that CCIR Study Group 4 has responsibility for developing Recommendations relating to the satellite HRDP,

IS UNANIMOUSLY OF THE OPINION

that the interface point between the responsibilities of CCIR Study Group 4 and the CCITT should be the digital distribution frame at which the satellite HRDP interfaces with the terrestrial network (see Recommendation 521).

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* This Opinion should be brought to the attention of the CCITT.

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