

EXTRACTS FROM THE
REPORT OF
CANADIAN DELEGATION
TO THE
INTERNATIONAL TELECOMMUNICATION UNION
EXTRAORDINARY ADMINISTRATIVE RADIO CONFERENCE
ON
SPACE RADIOCOMMUNICATION AND RADIO ASTRONOMY
— GENEVA
OCTOBER 7 - NOVEMBER 8, 1963.

BACKGROUND

Radio is involved and is essential in practically all uses of outer space. It is of great importance in the operation of all types of space vehicles and in the exploration and study of celestial bodies. At the same time, space vehicles and systems will provide new telecommunication facilities to supplement existing terrestrial systems, new meteorological data to be used in improved weather forecasting, and new navigational aid facilities for use by ships and aircraft.

The Administrative Radio Conference, Geneva, 1959, recognizing that the use of telecommunications in space would expand, recommended that the Administrative Council might review developments at its sessions in 1962 and 1963 and consider the convening of a conference in 1963 to decide on the allocation of frequency bands essential for the various categories of space radiocommunication. This was done and the Administrative Council received approval of the majority of the members of the I.T.U. to convene an E.A.R.C. in Geneva commencing October 7, 1963, for a period of five weeks with the following agenda:-

- (i) to examine the technical progress in the use of radio-communications in the space, earth-space and radio astronomy services and to examine the results of the technical studies made by the C.C.I.R. and other organizations and the proposals of Administrations concerning these services;
- (ii) in the light of this examination:-
 - (a) to decide on the allocation of frequency bands essential for the various categories of space radiocommunications and for radio astronomy;
 - (b) to consider whether there is a continuing need for the allocation of each of the bands designated for space research and take appropriate action in this regard;
- (iii) in accordance with Nos. 61 and 249 of the International Telecommunication Convention, Geneva, 1959, to revise only such provisions of the Radio Regulations, Geneva, 1959, as are essential for the effective implementation of the decisions of the Conference relating to the allocation, notification, recording and use of frequencies for space, earth-space, and radio astronomy services;
- (iv) in accordance with Nos. 61 and 249 of the International Telecommunication Convention, Geneva, 1959, to adopt such provisions additional to those contained in the Radio Regulations, Geneva, 1959, as are essential for the effective implementation of the decisions of the Conference concerning the technical characteristics of the space, earth-space and radio astronomy services;
- (v) to make such recommendations and to adopt such resolutions related to the foregoing as may be necessary.

CANADIAN PREPARATION

In the fall of 1961 the Frequency Planning and Co-ordination Committee (F.P.C.C.), a joint D.O.T./D.N.D. radio committee established a working group to prepare Canadian proposals for presentation to the E.A.R.C. Canadian industry was also brought into active participation in the technical aspects of space radio spectrum management through the International Consultative Committee on Radio (C.C.I.R.) by the formation of a Canadian National C.C.I.R. Committee and

associated Study Groups in Canada to participate in its work. This organ of the I.T.U. which deals with the technical problems of spectrum management had the task of resolving the problems at an international level envisaged by the introduction of space techniques and space radio services in the spectrum.

Canada participated in the 1962 interim meetings of those Study Groups of the C.C.I.R. where the first steps were taken toward resolving the technical problems which included those related to sharing the radio spectrum between space and terrestrial radiocommunication systems. In addition, two meetings were held in Europe with NATO countries in April and July, 1962, where Canada had the opportunity of co-ordinating space radio frequency plans with these Administrations.

In November, 1962, meetings were held in Washington with representatives of the U.S.A., U.K., France, Italy and the Federal Republic of Germany to discuss frequency allocation problems in preparation for the E.A.R.C. A further meeting was held in London in March, 1963, to discuss consequential changes to the Radio Regulations (Geneva, 1959).

Many answers to technical problems faced by the Space E.A.R.C. were provided by the C.C.I.R. at its Xth Plenary Assembly held in Geneva from January 14 - February 16, 1963, where the Canadian Administration assisted by Canadian industry participated actively.

The third and final meeting with NATO countries to discuss frequency allocations for space radio purposes was held in Paris in March, 1963. The 1963 session of the I.T.U. Administrative Council in confirming the Space E.A.R.C. agenda, added Radio Astronomy because of its close relationship and importance in the uses of outer space.

When Canada undertook its preparatory work for this conference it did so with the view that the amount of adjustment by existing terrestrial services should be held to a minimum while ensuring Canada's full participation in all activities involving the use of Space radio. In other words, Canada should be able to take advantage of space radio techniques in all fields without detriment to existing terrestrial radio services or the expansion of her terrestrial radio systems.

During the 18-month period when proposals were being prepared, Canada benefited considerably from active participation in discussions with other countries mentioned above and Canadian allocation proposals were generally similar to those made by these countries. The proposals of Canada respecting notification of frequency assignments to the I.T.U., sharing and co-ordination of frequency usage, and the consequential amendments to the regulations reflected our desire to protect the terrestrial use of our microwave spectrum. The technical aspects of this last group of proposals benefited considerably from industry participation.

The preparatory working group, which eventually became the Delegation, completed work on Canadian proposals and, after co-ordinating discussions with representatives of the CRTPB on June 13, 1963, forwarded them to the I.T.U. on June 21, 1963 (see Conference Document 10).

Whereas in previous I.T.U. conferences our views were in written form and well known to our Delegation, this time we went one step further and made our views known, by means of a comprehensive set of proposals, to all members of the I.T.U. Our position in the work of the conference was thereby considerably strengthened.

CANADIAN PARTICIPATION

The Canadian Delegation was made up as follows:-

Head

Mr. William A. Caton,

Controller,
Radio Regulations Division,
Department of Transport.

Deputy Heads

Mr. William J. Wilson,

Superintendent,
Radio Regulations Engineering,
Department of Transport.

Group Captain Robert E. Mooney,

Frequency Co-ordinator,
Joint Staff,
Department of Defence.

Delegates

Mr. Richard O. Hewitt,

Technical Officer,
Radio Regulations,
International Agreements,
Department of Transport.

Mr. F. Gerard Perrin,

Technical Officer,
Radio Regulations,
International Agreements,
Department of Transport.

Mr. John E. Wilson,

Engineer,
Radio Regulations,
Department of Transport.

Dr. Richard S. Rettie,

Principal Research Officer,
National Research Council.

Dr. Bertram Ch. Blevis,

Scientific Officer,
Defence Research Board.

Mr. J. Raymond Marchand,

Assistant Space Communications
Engineer,
Radio Regulations Engineering,
Department of Transport.

Mr. Werner A. Ch. Schultz,

Engineer I.C. Systems Analysis,
Department of Transport.

Sqn. Ldr. John F.L. Cartwright,

RCAF Frequency Management,
Department of Defence.

Lt. Cdr. John W. Jewers,

RCN Frequency Management,
Department of Defence.

Captain Stephen T. Chisholm,

Canadian Army Frequency Management,
Department of Defence.

Mr. William E. Bauer,

First Secretary,
Permanent Mission to U.N.

Credentials and signing powers were arranged for the Delegation by the Department of External Affairs in accordance with Nos. 529 to 532 inclusive of the I.T.U. Convention.

This Conference was preceded by a two-day Commonwealth meeting in London attended by Messrs. W.A. Caton and W.J. Wilson. The meeting was held with the object of briefing the less well-informed Commonwealth delegates, as well as exchanging views with the countries concerned and consolidating support where possible. During the conference the Commonwealth countries met weekly for an hour or two to discuss the work of the Conference. These meetings were well worthwhile because the small delegations appreciated being kept in the picture by those with larger delegations who could cover the many simultaneous meetings and because in the end when the proposals that we supported went to the vote we got Commonwealth support.

It would be interesting to note the scope of participation by other delegations in the various committees, working groups, and sub-working groups. A few of the 70 Administrations sent delegations of 1 or 2 while many countries were represented by 4 or 5 persons. Those 10 or 15 countries with a major interest in the use of radio sent from 10 to 30 delegates. All delegations were represented at the main committee meetings and they varied from 1 person for small delegations to 20 persons. The Frequency Allocation Committee always drew the largest attendance because of its impact. This was also the case in frequency allocation working groups where up to 60 delegations took part and sent from 1 to 7 persons and in sub-working groups where up to 50 delegations sent from 1 to 3 or 4 persons. While the technical working groups were attended by about 25 delegations sending from 1 to 4 persons, the sub-working groups were represented by 9 to 14 delegations, each sending from 2 to 4 persons. The 2 working groups on Notification Procedures and related regulations were the busiest working groups and about 8 delegations sent their specialists, which varied from 2 to 14 persons. In fact these two groups were 2 of the more important and their work was accepted by the Conference with the least comment.

CONFERENCE STRUCTURE

At the first Plenary Assembly, Mr. Gunnar Pedersen (Denmark) was elected Chairman of the Conference, while Mr. A. Badalov (U.S.S.R.) and Ambassador J.H. McConnell (U.S.A.) were elected Vice-Chairmen, all by acclamation.

In order to handle the agenda in a period of five weeks, the Plenary Assembly decided on the following committees, together with their Chairmen and Vice-Chairmen:-

COMMITTEE 1 : Steering Committee

Chairman : Mr. Gunnar Pedersen (Denmark)
Vice-Chairmen : Mr. Ashot Badalov (U.S.S.R.)
Ambassador J.H. McConnell (U.S.A.)

COMMITTEE 2 : Credentials Committee

Chairman : Dr. F. Nicotera (Italy)
Vice-Chairman : Mr. L.M. Harris (Australia)

COMMITTEE 3 : Budget Control Committee

Chairman : Mr. M. Marin Grigore (Roumanian P.R.)
Vice-Chairman : Mr. S.H. Butler (Liberia)

COMMITTEE 4 : Technical Committee

Chairman : Mr. Erik Esping (Sweden)
Vice-Chairman : Mr. M. Zahradnicek (Czechoslovak S.R.)

COMMITTEE 5 : Allocation Committee

Chairman : Mr. W. Klein (Switzerland)
Vice-Chairman : Mr. S. Fujiki (Japan)

COMMITTEE 6 : Regulations

Chairman : Mr. Juan A. Autelli (Argentine)
Vice-Chairman : Mr. A.B. Eid (United Arab Republic)

COMMITTEE 7 : Editorial

Chairman : Mr. Yves Place (France)
Vice-Chairmen : Capt. Charles Booth (U.K.)
Mr. J. Garrido Moreno (Spain)

The terms of reference for Committees 2, 3 and 7 are contained in Chapters 5 and 9 of the General Regulations annexed to the I.T.U. Convention as these committees are common for all conferences.

In general, Committee 4 was responsible for examination of technical progress in the field of space radiocommunication and radio astronomy, and for the establishment of appropriate technical criteria. Committee 5 had the task of examining proposed amendments to the Table of Frequency Allocations and to make appropriate revisions of the Table for all classes of space radiocommunications, space research and radio astronomy. Committee 6 was instructed to prepare only such revised texts of the Radio Regulations as were essential for the effective implementation of the decisions of the Conference relating to the allocation, notification, recording and use of frequencies for the Space and Radio Astronomy services.

These Committees formed working groups and sub-working groups as required to deal with the various tasks in their terms of reference. In all there were 9 working groups and 8 sub-working groups.

CONFERENCE ATTENDANCE

Out of a total of 122 Administrations in the I.T.U., 70 were represented at the Conference. Four United Nations agencies were also represented as follows:-

International Civil Aviation Organization (I.C.A.O.)
United Nations Educational, Scientific and Cultural Organization
(U.N.E.S.C.O.)
Intergovernmental Maritime Consultative Organization (I.M.C.O.)
The World Meteorological Organization (W.M.O.).

The United Nations Organization itself sent observers and eleven international organizations participated as follows:-

International Air Transport Association (I.A.T.A.)
International Radio Maritime Committee (C.I.R.M.)
Inter-Union Committee for Frequency Allocations for Radio
Astronomy and Space Science (I.U.C.A.F.)
Committee on Space Research (C.O.S.P.A.R.)
International Council of Scientific Unions (C.I.U.S.)
Federation Internationale des Editeurs de Journaux et
Publications (F.I.E.J.)
International Broadcasting and Television Organization (I.B.T.O.)
European Broadcasting Union (E.B.U.)
International Amateur Radio-Union (I.A.R.U.)
International Scientific Radio Union (U.R.S.I.)
International Chamber of Shipping.

Six private telecommunications operating agencies sent observers.

FREQUENCY ALLOCATIONS

The Frequency Allocation Committee (5) under the Chairmanship of Mr. W. Klein of Switzerland agreed that three working groups be set up as follows:-

- 5A - Communication Satellite Service and Telemetry and Telecommand.
- 5B - Space Research and Radio Astronomy Services.
- 5C - All other Space Radio Services.

The most difficult problems were encountered in the Communication Satellite Service and the resolution of this matter was accomplished through private discussions between the U.S., U.K., France and the U.S.S.R., with Canada being consulted by the U.S. and U.K. It was considered desirable to locate the Communication Satellite Service entirely within bands allocated to the Fixed and Mobile services, however,

this was not possible as the development of Fixed and Mobile services has not been carried out on a world-wide basis entirely in the same bands. The result of these discussions was the partial accommodation of the Communication Satellite Service in some bands other than those allocated to the Fixed and Mobile services.

After some discussion on the frequency proposals for the other radio services a large measure of agreement was reached, however, informal and formal voting was necessary to conclude discussion on certain bands in the Space Research and Radio Astronomy services and in several bands in the Meteorological Service. As a result of these different points of view and in order to recognize the rights of individual Administrations, it was necessary to permit the inclusion of footnotes for the countries concerned. In this connection it should be pointed out that the majority of these footnotes relate to countries associated with the Soviet Union.

The main points of discussion relating to proposals for the Space Research and Radio Astronomy services concerned the raising of the status of existing allocations to a primary or exclusive category or providing new allocations for the use of these radio services. The principal argument centered around the question of sharing with other radio services. While Canada and the U.S. considered that it was not possible to provide the necessary protection to Space Research and Radio Astronomy on a shared basis, other delegations, such as the Soviet Union, considered allocations to these services on a shared basis was adequate to provide for their requirements. The majority of delegations were quite satisfied with the allocations to these services.

The intended use by the proposers of the bands for the Meteorological Satellite Service and the reasons for choosing the frequencies in question were explained in detail by the respective delegations. There was a large measure of agreement concerning the Canadian and U.S. proposals which were similar, however, the U.S.S.R. proposals for this service were strongly opposed. With a view to providing a compromise to resolve this divergence of opinion it was agreed to accept the U.S.S.R. proposals on a secondary basis. The majority of delegates including the W.M.O. representative were pleased with the outcome of these discussions.

There was unanimous agreement in principle concerning the need for the Radionavigation Service to have access to space techniques. However, considerable opposition was raised in relation to the frequency proposals for the Navigation Satellite Service especially in the 150 Mc/s band and to a lesser degree in the 400 Mc/s and 14 Gc/s bands. Canada did not submit proposals for this service and supported the position of the U.S. who were satisfied with the results obtained.

The U.S.S.R. submitted proposals for supplementary HF and VHF distress frequencies for detection and recovery of cosmonauts and spacecraft. Following some very lengthy discussions it was concluded that there was no need for supplementary VHF frequencies in view of the existing allocation of 121.5 Mc/s and 243 Mc/s for this purpose. It was agreed that the frequency 20,007 kc/s could be used in an emergency to satisfy the HF requirement, however, it was pointed out that this is not considered to be a distress frequency in the true sense of the phrase. The U.S.S.R. insisted on further discussion of the VHF requirement in Committee and finally a resolution was adopted which resolves that until such time as the Regulations may be revised the provisions of the Regulations concerning distress and emergency will apply to spacemen and space vehicles.

The United Kingdom introduced a proposal to include a footnote in the band 144 - 146 Mc/s to permit the use of space stations and space techniques by the Amateur Radio Service. This proposal was discussed at great length and as a result of an agreement reached by an ad hoc working group in which Canada participated, a footnote which provides that "In the band 144 - 146 Mc/s artificial satellites may be used by the amateur service" was adopted by the Committee. A draft resolution inviting the C.C.I.R. to study this question was discussed and finally defeated by a vote in Committee.

Generally speaking all of the Canadian frequency allocation proposals which were much the same as those of the U.S. and to a lesser extent those of the U.K. were adopted by the Conference with some modifications concerning associated footnotes. In several bands it was necessary to compromise with allocations on a regional basis.

In order to keep this report as short as possible a summary of the frequency bands allocated to each Space Radio Service is contained in Annex 1 to this report.

The amount of spectrum allocated to the Space Radio Services between 10 kc/s and 40 Gc/s is summarized below:-

<u>SERVICE</u>	<u>EXCLUSIVE</u>	<u>PRIMARY</u>	<u>SECONDARY</u>	<u>SUBJECT TO</u>	<u>TOTAL</u>
	<u>Mc/s</u>	<u>Mc/s</u>	<u>Mc/s</u>	<u>AGREEMENT</u>	<u>Mc/s</u>
				<u>Mc/s</u>	
		<u>BELOW 10 Gc/s</u>			
Communication-Satellite	100.0	2700.0			2800.0
Space Research		123.005	121.050		244.055
Radio Astronomy	43.0	20.550	4.5		68.050
Meteorological Satellite		121.950	80.0		201.950
Radionavigation Satellite	0.300				0.300
Telemetering/Tracking	5.0	1313.0	5.0		1323.0
Telecommand		1502.0		20.560	1522.560
Aeronautical Mobile (R)				388.025	388.025
Aeronautical Radionavigation		570.0			570.0
Satellite Identification		0.005			0.005
Emergency Use			0.006		0.006
Amateur Use			2.0		2.0
Sub-Total	148.3	6350.510	212.556	408.585	7119.951 Mc/s
		<u>ABOVE 10 Gc/s</u>			
Communication-Satellite					Nil
Space Research	400.0		1800.0		2200.0
Radio Astronomy	370.0	400.0			770.0
Meteorological Satellite			100.0		100.0
Radionavigation Satellite	100.0				100.0
Telemetering/Tracking					Nil
Telecommand					Nil
Aeronautical Mobile (R)				300.0	300.0
Aeronautical Radionavigation		300.0			300.0
Satellite Identification					Nil
Emergency Use					Nil
Amateur Use					Nil
Sub-Total	870.0	700.0	1900.0	300.0	3770.0 Mc/s
GRAND TOTAL	1018.300	7050.510	2112.556	708.585	10889.951 Mc/s

There are several frequency bands in which future assignments to the Fixed and Mobile services will have to be curtailed and in a few narrow bands the Fixed and Mobile services will have to cease operations by January 1, 1969. These factors were considered in the drafting of the Canadian proposals and while certain adjustments will be necessary, generally speaking these revisions to the Frequency Allocation Table will not have a great impact on existing users of radio in Canada. The frequency bands where adjustments are necessary, together with suggested action, will be found outlined in Annex 2 of this report and will also be the subject of separate correspondence to those concerned with the assignment of frequencies.

In addition to the foregoing and with a view of providing the Space services with greater protection from other radio services, several resolutions and recommendations were adopted by the Conference. Where these resolutions or recommendations make reference to a specific frequency band, the purpose is summarized in the comments pertaining to that band as contained in Annex 1.

REGULATIONS RELATING TO NOTIFICATION

Committee 6 (Regulations) met on October 9 and immediately set up Working Group 6A (Chairman, Mr. J.M. Power - New Zealand) responsible for the revision of Article 9 (Notification and Recording of Frequencies) and Appendix 1 (Basic Characteristics to be Furnished and General Instructions Relating to Notification of Frequencies) of the Geneva Radio Regulations, and Working Group 6B (Chairman, Mr. P.E. Willems - Netherlands) responsible for other Articles or Appendices not dealt with by Committees 4 and 5. Because pre-Conference talks had shown it to be unacceptable to the majority, Canada withdrew a proposal which would prohibit out-of-band assignments in bands allocated to Space and Radio Astronomy Services.

At the initial meetings it was decided that existing Article 9 and Appendix 1 would be revised to apply only to stations in Terrestrial Services, while a new Article 9A, and a new Appendix 1A, closely parallel to the existing Article 9 and existing Appendix 1 would be prepared for the Space Services and Radio Astronomy. In this regard, the Canadian proposals were based on a single Article 9, but they were in such a form that the principles could be readily incorporated in two separate Articles, one for Terrestrial Services and one for Space Services.

Our proposal requiring the notification of frequency assignments to space stations by the Administration having operational control was opposed as a Regulation, but appeared acceptable as a Recommendation. It was decided, therefore, to retain this proposal in recommendation form until such time as alternative proposals with the same intent were accepted by the Conference. In Appendix 1A it was made obligatory to specify the Administration to be contacted in cases of interference. Also, in Resolution 1A there is an obligation for any Administration planning to establish an international satellite system to provide the I.F.R.B. with a general description thereof, as early as possible during the co-ordination process, for publication in the weekly circular to all Administrations. Since these provisions cover the Canadian viewpoint, with the higher status of a Regulation and Resolution, there was no need to press for acceptance of our draft Recommendation on the subject.

As a consequence of withdrawing our proposal relating to out-of-band assignments, it was necessary to drop several proposals in Article 9 (9A). However, our active participation in every working group meeting enabled us to influence preparation of the regulations in such a way as to provide adequate safeguards for terrestrial services sharing frequency bands with space services. In particular, the co-ordination procedure for earth stations and fixed stations sharing frequency bands was carefully examined, in consultation with the Technical Committee, to ensure that each service enjoys equal priority of treatment for existing assignments, and assignments to be brought into use within a two year planning period. A procedure for Calculating the Co-ordination Distance is contained in Recommendation 1A.

The co-ordination principles in Article 9A apply to any transmitting or receiving assignment to an earth station in a particular band between 1 and 10 Gc/s allocated with equal rights to the Fixed or Mobile Service. In the case of new assignments or changes in assignments to Fixed or Mobile stations within co-ordination distance of an earth station, Article 9 (amended), co-ordination is required only where the necessary bandwidths of the Fixed/Mobile assignment on the one hand, and the earth station on the other, are separated by less than 6 Mc/s. In effect, this would encourage Administrations to plan their microwave systems to avoid conflict with earth station assignments, thus avoiding the necessity of carrying out the co-ordination procedure.

The provisions of Articles 9 and 9A, as adopted by the Conference, are sufficiently complete with respect to co-ordination, notification and recording of frequency assignments to stations in the terrestrial and space services. This view was not shared by the U.S.S.R. Delegation which sought to introduce additional regulations in Article 9A to require world-wide co-ordination of space systems of different countries. Opposition to this concept was based on the fact that no technical parameters are available for such co-ordination, nor are they foreseen. This matter was resolved in Resolution 1A, which calls for advance publication by the I.F.R.B. of technical data on international satellite systems, and provides opportunity for any Administration to comment.

There was initially a tendency to neglect Radio Astronomy in the new Article 9A, but at our insistence amendments were made to permit Administrations to notify the frequencies or frequency bands used by particular radio astronomy stations if they desire such information should be published in the International Frequency List and receive the international recognition necessary to receive protection. By definition, radio astronomy is not a bona-fide communication service, therefore, it was necessary to insert an additional paragraph 116A in Article 3 to provide that the radio astronomy service shall be treated as a radio-communication service for the purpose of resolving cases of harmful interference. This means that radio astronomy now enjoys the same protection against interference as is applied to any radiocommunication service having equal status in the same band.

Working Group 6B chaired by Mr. P.E. Willems (Netherlands) considered proposed Regulations other than those for Article 9 and those handled by Committees 4 and 5. In Document No. 10, Canada had proposed that space stations shall be identified by specifying the orbital characteristics (rather than by call sign), whereas France had introduced a method of forming call signs. Provision is made for the use of such call signs, but on a permissive basis allowing for identification by means of orbital characteristics where the use of call signs is not practicable. Canada had also proposed that in cases of harmful interference caused by a space station, the Administration having jurisdiction must, upon request, furnish precise orbital data to permit identification. This proposal (with minor amendments) was accepted by the Conference.

The remaining task of Working Group 6B was to consider French proposals and I.F.R.B. recommendations relating to Service Documents and Service Document Symbols. The Canadian Delegation participated in the drafting group to ensure that the information required in the Service Documents could be readily obtained by the I.T.U. Secretary-General from data supplied by Administrations under Articles 9 and 9A. A new list, comprising 9 sections, was drawn up to cover all classes of stations in the Space and Radio Astronomy Services.

Further mention should be made of Resolution 1A. The U.S.S.R. had a series of proposed Regulations for Article 9A which would require co-ordination of one space system vs another, that is, space station vs space station and earth station vs earth station. There was solid opposition to the setting up of Regulations to this effect because a technical basis for such co-ordination has not been developed. Eventually agreement was reached on a Resolution which provides that any Administration establishing an international satellite system has an obligation to provide the I.F.R.B. with details of the system as early as possible during the co-ordination process. Provision is made for Administrations to comment on the interference aspects of the proposed system, and for the responsible Administration to find a satisfactory solution to any problem. In difficult cases, the I.F.R.B. may be asked to make suitable suggestions. In our opinion, this Resolution will help to ensure that space systems are adequately publicized and that adequate co-ordination of frequency allocations is carried out. This will go a long way toward protecting other services sharing frequency bands with the Space Service.

Article 9 relating to Terrestrial Services is completed by Appendix 1 concerning the submission of frequency assignment notices to the International Frequency Registration Board (I.F.R.B.). This Appendix was amended to delete references to the Space Services, which is now covered in Appendix 1A.

In view of the Canadian proposals for amendment of Appendix 1, including a consolidated form of notice for the Space Service, it was necessary for our delegation to take an active part in the development of the new Appendix 1A for Space Services and Radio Astronomy. At the outset it was decided to adopt four separate notice forms for the Space Service (space station transmitting and receiving, earth station transmitting and receiving), also one notice form for the Radio Astronomy Service. Considerable liaison was necessary to ensure that all pertinent data was included in the forms of notice. In the case of space stations Canada obtained inclusion of the name of the Administration to be contacted in cases of harmful interference as a basic characteristic to be furnished in all cases involving space stations or earth stations. This had the effect of fixing responsibility for the station, and was an alternate means of achieving the thought behind our proposal calling, in part, for the notification of assignments to space stations by the Administration having primary operational control of the vehicle.

SHARING CRITERIA

Technical provisions for the use of frequency bands shared between the Terrestrial and Space radio services were derived from recommendations of the C.C.I.R. as developed through the March, 1962, Study Group IV interim meeting at Washington and the Xth Plenary Assembly at Geneva, January-February, 1963. It was also considered feasible to extend these technical provisions to meteorological satellite systems sharing bands with the terrestrial systems. These provisions were adopted by the Conference and incorporated in the revision to Article 7 of the Radio Regulations, Annex 4, of the Final Acts of the E.A.R.C. as follows:-

- Section VII Terrestrial Services sharing Frequency Bands with Space Services between 1 Gc/s and 10 Gc/s.
- Section VIII Space Services sharing Frequency Bands with Terrestrial Services between 1 Gc/s and 10 Gc/s.
- Section IX Space Services.

Sections VII and VIII require Administrations to give attention to relevant C.C.I.R. recommendations in selecting sites and frequencies for terrestrial stations operating in frequency bands shared with equal rights between terrestrial and space services.

The following is a brief description of other significant provisions contained in these new sections:-

Section VII

The maximum effective radiated power (E.R.P.) and antenna input power of stations in the fixed and mobile services are respectively 55 dbW and 13 dbW. The relevant shared bands are listed therein.

Section VIII

In the case of earth station transmissions, the mean E.R.P. in a 4 kc/s band, when reduced by the site shielding factor (determined per Section 5 of Annex to Recommendation No. 1A) shall not exceed 55 dbW in any direction in the horizontal plane, except that it may be increased at 2 db per 100 km to a maximum of 65 dbW in any such direction if the distance between the earth terminal and the territory of another Administration exceeds 400 km. The 55 dbW/4 kc/s limitation may also be exceeded by agreement between administrations interested and affected.

Earth station antennae shall not be employed at elevation angles of less than 3 degrees except by agreement with administrations concerned or affected. The power flux density produced by communication

and meteorological satellites using wide-deviation FM, whether by emission or reflection, shall not exceed -130 dBW/m^2 for all angles of arrival as recommended by the C.C.I.R. The bands to which such limits apply are listed therein. Proposals to apply these power flux density limits also to space research satellite stations were not supported.

Section IX

Space Services. Satellites are required to be capable of definite cessation of emission. This provision produced a discussion at almost every stage from ad-hoc group to the final plenary. The point of disagreement here was the wish of certain countries, without immediate prospects for launching satellites, for a clear clause providing for immediate cessation of emission if interference were to occur, as opposed by those launching satellites who wanted a rather nebulous clause leaving the greatest possible freedom to achieve the expected useful life.

CO-ORDINATION DISTANCE CALCULATION

When co-ordination of frequency assignments is required under Article 9A, the Administration proposing to establish an earth station is required to calculate a "co-ordination distance" from the earth station for both transmission and reception and to send to any other administration whose territory lies within such distance a diagram showing all pertinent technical details. Recommendation No. 1A of the Final Acts describes a procedure for calculating co-ordination distance, based on a U.K. proposal but using propagation data based on losses exceeded for all but 0.1% of the time instead of 0.01% of the time. The choice of 0.1% propagation data was based on the larger volume of data available and its greater accuracy. Curves giving loss vs distance for mixed paths over land and tropical sea show that over a path consisting of about 900 km over land plus distances of 0 to 600 km over tropical sea, the 0.1% loss decreases as the total distance increases. To avoid this anomaly, which is most serious with paths of total length greater than 1000 km, it was agreed that the mixed path diagrams would be so altered as to present loss against distance only up to 1000 km total distance. Anomalous effects are observed only for losses greater than 220 db in the special case of a propagation path partly over land and partly over tropical sea. Such combinations will be uncommon and the anomaly will produce little difficulty. This problem has been referred to C.C.I.R. under Recommendation No. 3A.

Procedures are given for determination of co-ordination distance for interference from an earth station transmitter to a terrestrial station receiver and from terrestrial station transmitters to earth station receivers, for the co-channel case only.

Knowing the gain and output power of the transmitter, and site shielding factor, equations are given for calculating the minimum basic transmission loss for which a possibility of harmful interference will exist. Site shielding factor varying from 0 db to 15 db shall apply for obstacles not less than 5 km away, subtending angles of up to 5° . Curves are given for determining the path length over land, or sea, temperate and tropical, or partly over both land and sea. Generally, losses of up to 195 db can be correlated with path lengths of up to 1000 km for the worst case (tropical oversea paths). In other cases, greater losses can be correlated with distance. Examples of path calculations are given in Recommendation 1A. The procedure outlined in this Recommendation is regarded as provisional and the C.C.I.R. is requested to make recommendations for a more suitable procedure.

FUTURE TASKS OF THE C.C.I.R. ARISING OUT OF THE CONFERENCE

Growing problems of frequency congestion have given rise to several new spectrum sharing situations, many of them not previously studied by the C.C.I.R. As a result some C.C.I.R. Questions and Study Programmes must be examined with a change of emphasis or expansion of scope.

On several occasions during the Conference, existing C.C.I.R. documentation was found inadequate because the problems of the E.A.R.C. were somewhat different from those to which the C.C.I.R. had found solutions. Recommendations 2A, 3A, 4A and 5A, especially No. 3A, list a number of problems, most of them referred to the C.C.I.R. as extensions to existing Questions or Study Programmes.

The following problems, arising from the E.A.R.C. Final Acts will be referred to the appropriate study groups of the Canadian C.C.I.R. Committee. Recommendation No. 2A invites:-

- (a) administrations to submit, during the period preceding the C.C.I.R. XIth Plenary Assembly, contributions concerning procedures for calculating the probability of harmful interference between terrestrial and space services and typical values of the governing factors.
- (b) the C.C.I.R., during the XIth Plenary Assembly to decide on the most appropriate manner to publish the material adopted.

This Recommendation was proposed on the grounds that many of the less advanced countries do not have personnel capable of determining the effect on their line-of-sight radio relay systems of projected construction of an earth terminal station in a neighbouring country within co-ordination distance. Since Canada has an interest in obtaining a technical solution we propose to ask the Canadian C.C.I.R. Committee, Study Group IV, to produce documents describing a procedure for Calculation of the Probability of Interference between Stations within Co-ordination Distance.

Recommendation No. 3A lists a number of C.C.I.R. Questions and Study Programmes for which change in emphasis, widening of scope or further information is considered necessary.

Question 235 (IV), 4 concerns the feasibility of frequency sharing between communication satellite systems and terrestrial radio services.

Emphasis is placed on:-

- (a) need for and application of maximum limits of power to earth stations and terrestrial stations in shared bands; and,
- (b) need for and application of escalation clauses on such power limits where the stations are remote from international boundaries.

In particular, the case for power limits of line-of-sight radio relay transmitters in bands allocated to transmission by communication satellites should be developed.

Question 235 (IV), 5 concerns the desirability of establishing channelling arrangements.

This question should also be studied in relation to co-ordination of frequency assignments for earth stations.

Study Programme 188 V 235 A(IV), 1 deals with the extent of electromagnetic shielding between earth stations and stations of other services obtainable by physical modification of terminal sites.

Up-to-date information is required on values allowable for site shielding in application of power limits and calculation of co-ordination distance.

Study Programme 235 A(IV), 3 relates to criteria for determining the minimum permissible antenna elevation angle.

The minimum permissible angle of elevation for earth station antennae, considering tropospheric effects on propagation of interference should be studied.

Study Programme 235 A(IV), 5 refers to criteria affecting choice of satellite power in shared bands.

Power flux density limits for communication satellites in bands shared with terrestrial services should be further developed.

Study Programme 235 A(IV), 6 pertains to criteria affecting minimum practicable separation between line-of-sight radio relay stations and communication satellite earth stations.

Technical data will be required for selection of sites and frequencies for terrestrial and earth stations in shared bands.

Question 236 (IV), 2 considers the feasibility of spectrum sharing for links between earth stations and spacecraft, between such links and other space systems, or between such links and terrestrial radio systems.

Sharing criteria will be required for all frequency bands shared between space and terrestrial services, including power flux density limits for meteorological, radionavigation and space research satellites. This would include bands below 1 Gc/s and above 10 Gc/s.

Question 235 (IV), 1, 2, 3, 4 concerns preferred technical characteristics and feasible system parameters to ensure maximum practical use of spectrum for telemetry, tracking, telecommand and data transmission earth-space links.

This question must be studied with emphasis on sharing between such links and terrestrial services with a view to the protection of terrestrial services.

Question 242 (IV), 3 which deals with technical characteristics of radio-navigation satellite systems, the feasibility of frequency sharing, and if so, with what services and under what conditions, will require further study.

Study Programme 243 A(IV), 3 relates to the radiocommunication aspects of meteorological satellite systems, including the feasibility of frequency sharing, and if so, with what services and under what conditions.

A study of the feasibility of such sharing and a report on the relevant sharing criteria is required with emphasis on protection of terrestrial services, but with recognition of our national interest in using information available from meteorological satellites.

Question 244 (IV), 2.1 requests study of threshold values for harmful interference to radio astronomy.

The information given in Report 224, Table I, covers only the frequency range 20 to 1280 Mc/s, stating tolerable levels of unwanted signal in terms of power flux, spectral power flux and field strength. It appears desirable that Table I of Report 224 be extended to the limits of the present Frequency Allocation Table.

Study Programme 190 (V) deals with tropospheric propagation factors affecting the sharing of frequencies between radio relay systems, including space and terrestrial telecommunications systems.

More precise data is required on the minimum transmission loss occurring under various regional climates for 0.1% and 0.01% of the time for overland, oversea and mixed land/sea paths and on the effects of reflection from precipitation or cloud in producing interference at long distances, especially when narrow beam antennae are in use. A programme of investigation would, however, be quite expensive; a year's operation on any one link would give only about 8.8 hours of 0.1% data over the 24 hours of a day. Diurnal and seasonal breakdown would reduce this figure considerably, therefore, no immediate action on this problem is planned.

C.C.I.R. Xth Plenary Assembly Recommendations 335, 356, 357, 358 and 406 must be reaffirmed or revised, because the majority of these Recommendations are of a provisional nature. In general, it will be necessary to obtain interference criteria for all cases where space services share spectrum in order to determine co-ordination distance and the probability of interference within co-ordination distance, necessary limits of earth's surface power flux density set up by satellites and limits to spurious emissions and frequency tolerance for all services in so far as they affect sharing.

Recommendation No. 4A of the E.A.R.C. calls upon the C.C.I.R. to study modulation methods (such as PCM with PM or FM), in particular, for line-of-sight radio relay systems in relation to sharing with communication satellite systems.

The sponsor of this recommendation expressed the opinion that PCM using FM or PM is relatively immune to thermal noise to such an extent as to permit operation of radio relay systems transmitting a wide baseband with transmitted power levels available with semi-conductor output amplifiers. A station using such equipment would require only a small fraction of the total power input required for existing stations transmitting the same baseband. The sponsor claimed that in his country this was a very great advantage. He was anxious that sharing criteria should limit earth's surface power flux induced by satellites to values compatible with PCM FM or PM line-of-sight radio relay systems.

CANADIAN PROTOCOL

Toward the end of the Conference it became apparent that the Cuban Delegation was systematically obtaining exceptions from Region 2 allocations for Space purposes, by means of footnotes to the Table of Frequency Allocations. This attitude caused the U.S.A. some concern and resulted in a U.S.A. Additional Protocol to the Radio Regulations, stating that they could not accept any obligation to observe the exceptions claimed by Cuba. Canada also presented an Additional Protocol, associating itself with the Protocol submitted by the U.S.A. in so far as the footnotes subscribed to by Cuba may be found now, or in the future, to be objectionable to Canada. These reservations also apply to the Final Protocol submitted by the Republic of Cuba. The Argentine, Columbia and Mexico submitted similar reservations in the form of protocols.

IMPACT ON CANADIAN SPECTRUM MANAGEMENT

The main result of the E.A.R.C. has been the allocation of frequency bands to the various space services and radio astronomy. It is fortunate that the requirements for these services have been met with a minimum of disturbance to, and restrictions on, allocations to existing services. However, account must be taken of the new allocations in assigning new frequencies and in planning the future utilization of the spectrum.

The greatest effect on existing and planned operations in the field of radio-relay systems will occur where portions of bands formerly allocated to fixed and mobile services are now exclusively allocated to a space service. Fortunately, such cases are a minority and are shown in Annex 2 of this Report.

Large portions of the spectrum have been allocated for sharing with equal rights between the communication satellite service on the one hand and the fixed and mobile services on the other. However, where the communication satellite service is concerned, the direction of transmission, either earth-to-satellite or satellite-to-earth, is specified and subject to certain sharing criteria. For example, in those bands used for the downpath transmission, the power flux density limitations developed by the C.C.I.R. have been adopted as part of the Radio Regulations. Similarly, for the up-bands, the C.C.I.R. recommended power limitations on radio-relay stations have been adopted. Furthermore, to prevent earth station transmitters from monopolizing on the use of a given frequency over too large a geographical area, a minimum angle of elevation of 3° and a maximum value of effective radiated power towards the horizon (55 dbW in any 4 kc/s band) have been specified. Also for the shared bands, a method for determining the co-ordination area about an earth station has been prescribed. In so far as

future radio-relay stations are concerned, co-ordination will be required only if:-

- (a) the proposed radio-relay station is within the published co-ordination distance of an earth station; and,
- (b) if the necessary bandwidths of the emissions of the proposed radio-relay station fall within 6 Mc/s of the necessary bandwidths of the earth station.

It was recognized by the E.A.R.C. that co-ordination problems would be much alleviated if frequencies used for space services were interleaved with the frequencies used by terrestrial radio-relay systems. Although specific channelling plans for space services have not been adopted by the E.A.R.C., nor the C.C.I.R., there is every reason to expect that channelling will be recommended and specific arrangements adopted. Since such arrangements would be world-wide in scope, it would be desirable that frequencies proposed for radio-relay systems be chosen from the C.C.I.R. plans, which in many cases are of world-wide application. Fortunately, the users in Canada are already endeavouring to adhere to C.C.I.R. channelling arrangements whenever this is possible, and if our efforts continue in this direction, the greatest benefit will accrue from the expected interleaved channelling plans.

The results of the E.A.R.C. are of particular importance to the future utilization of the band 7125 to 8500 Mc/s. Several users have to date expressed much interest in this band. However, it was not possible to plan the orderly use of this band until allocations for space services had been determined. Noting that three exclusive bands have been allocated for space services in this part of the spectrum, it is now possible for the CRTPB and the D.O.T. to reconsider the future use of this band of frequencies, in the light of existing usage, existing C.C.I.R. Recommendations and, especially, in the light of our future requirements.

Article 9 of the Radio Regulations (Geneva, 1959) covered notification and recording in the Master International Frequency Register of transmitting frequency assignments for all classes of stations on land having fixed geographical locations, including earth stations, and of frequencies to be used for reception of mobile or space stations by land or earth stations. The allocations for the communication satellite service are based, in part, on sharing of certain microwave bands with fixed and mobile services, subject to sharing criteria and frequency co-ordination. The introduction of a single frequency co-ordination procedure into the existing Article 9 was considered inadvisable because it would apply fully to space services, but only to a limited segment of the terrestrial services. It was decided, therefore, to limit the present Article 9 to terrestrial services, including a co-ordination procedure for fixed and mobile services sharing bands between 1 and 10 Gc/s with the space communication service and to draw up a new Article 9A for the space services (and radio astronomy), including more complete co-ordination parameters than those of Article 9. This avoided undue complication of the existing Article 9, and permitted a "clean" presentation of the co-ordination procedure for space services.

The Final Acts of the Space E.A.R.C. will become effective on January 1, 1965. In the meantime there is a need to adjust certain spectrum management concepts in order that the revised procedures will have minimum impact on existing services. For example, our notification procedure for assignments above 28 Mc/s has been to notify a typical station on a province-wide basis (rather than notifying all stations using the frequency). In those bands shared with space services, future utilization should be strictly in accordance with the allocation table and technical limitations imposed by the Space E.A.R.C. This means that changes to existing services in shared bands, or the establishment of new services, must be carried out according to the Regulations so that incompatible fixed systems (such as tropospheric scatter) are required to operate elsewhere.

Regarding notification of frequency assignments above 28 Mc/s, it appears necessary to examine the bands to be shared with space/radio astronomy services, and to submit typical assignment notices to the I.F.R.B. where it appears necessary to establish a prior date in the International Frequency List. Such prior dates would become important in bands shared equally with the space services when cases of interference occur.

Heretofore the planning and establishment of microwave systems in Canada has taken account of other existing or planned systems in the area in order to permit a rational and equitable use of the spectrum. Also, it has been necessary to carry out frequency co-ordination with the U.S.A. to ensure no conflict with similar systems in that country. The Final Acts of the Space E.A.R.C. provide, in part, that any transmitting or receiving frequency assignment to an earth station in bands from 1 to 10 Gc/s shared with fixed and mobile services must be co-ordinated with any Administration whose territory lies within co-ordination distance of the earth station. In such co-ordination the Administrations with which co-ordination is sought are permitted to take into account, not only their existing microwave systems, but also those to be brought into use within the next two years. Similarly, when an Administration makes changes or additions to a microwave system co-ordination is required if the changes or additions occur within co-ordination distance of an earth station of a neighbouring country and the bandwidths of the respective emissions are separated by less than 6 Mc/s. In such cases the Administration having the earth station is permitted to take into account existing earth station frequency assignments and those to be brought into use within the next two years. Since the two year planning period applies equally to line-of-sight systems and space systems in shared bands, it is important that this Department be fully aware of such plans at least two years in advance of their implementation.



(W.A. Caton)

Controller, Radio Regulations Division.
Head of Canadian Delegation.

Ottawa, December 30, 1963.