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Broadcasting-Satellite and Fixed-Satellite Service Considerations After the 1979 World Administrative Radio Conference

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LIST OF SYMBOLS AND ABBREVIATIONS

BS	broadcasting service (terrestrial)
BSS	broadcasting-satellite service
CCIR	International Radio Consultative Committee
CIR	carrier-to-interference ratio
CNR	carrier-to-noise ratio
Comsat	Communications Satellite Corporation
CONUS	contiguous 48 states of the United States
dB	decibel(s)
dBW	decibel(s) relative to 1 W (one watt)
EIRP	equivalent isotropically radiated power
FCC	Federal Communications Commission
FM	frequency modulation
FS	fixed service (terrestrial)
FSS	fixed-satellite service
GHz	gigahertz
Hz	hertz
IFRB	International Frequency Registration Board
INTELSAT	International Telecommunications Satellite Consortium
ITFS	instructional television fixed service
ITU	International Telecommunication Union
K	kelvin(s)
m	meter(s)
MDS	multiple distribution service
MHz	megahertz
MS	mobile service (terrestrial)
MSS	mobile-satellite service
NF	noise figure
NTIA	National Telecommunications and Information Administration
OFS	operational fixed service
PFD	power flux density
PSK	phase-shift keying
RARC	Regional Administrative Radio Conference
RR	Radio Regulation

SBS	Satellite Business Systems
SCPC	single channel per carrier
TV	television
W	watt(s)
WARC	World Administrative Radio Conference
WARC-BS	World Administrative Radio Conference for the Planning of the Broadcasting-Satellite Service

BROADCASTING-SATELLITE AND FIXED-SATELLITE SERVICE CONSIDERATIONS AFTER THE 1979 WORLD ADMINISTRATIVE RADIO CONFERENCE

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The 1979 WARC (World Administrative Radio Conference) revised the international Radio Regulations of the ITU (International Telecommunication Union) including the international table of frequency allocations. The revised Radio Regulations will govern internationally the use of the radiofrequency spectrum and the geostationary satellite orbit for the rest of this century. Restricting its scope to the topics related to the broadcasting-satellite and fixed-satellite services in ITU Region 2, this report reviews the outcome of the 1979 WARC and considers possible technical issues to be dealt with in the future.

Key words: 1979 WARC (World Administrative Radio Conference), BSS (broadcasting-satellite service), FSS (fixed-satellite service), frequency allocation, satellite communication

1. INTRODUCTION

1.1 Background and Scope of This Report

The 1979 WARC (World Administrative Radio Conference) convened in Geneva, Switzerland, from September to December 1979 was the first general conference since 1959 that was tasked to review, and authorized to revise, the international Radio Regulations of the ITU (International Telecommunication Union). In fact, the 1979 WARC substantially revised the Radio Regulations including the international table of frequency allocations (ITU, 1979). The WARC also adopted provisions for several future world and regional conferences that would supplement the decisions made by the WARC. The revised Radio Regulations and the decisions to be made in these future conferences will govern internationally the use of the radiofrequency spectrum and the geostationary satellite orbit for the rest of this century.

Restricting its scope to the topics related to the BSS (broadcasting-satellite service) and the FSS (fixed-satellite service) in ITU Region 2 (i.e., North, Central, and South America), this report reviews the outcome of the 1979 WARC and considers possible technical issues to be dealt with in the future. More specifically, this report reviews the changes made in frequency allocations to the two services and new provisions for the two services in Section 2. The report discusses technical issues regarding the new allocations in Sections 3 and 4; the discussions in these sections are based on the new international

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table of frequency allocations only. The report identifies technical issues relative to national provisions in Section 5. The report examines user requirements for these services including those of public service users in Section 6. Finally, the report discusses various options for the future conferences as to their respective advantages and disadvantages in Sections 7 and 8.

1.2 Some Conventions Used in the Radio Regulations

This report makes extensive references to the Radio Regulations. This subsection describes some conventions and general terms used in the Radio Regulations. Marginal numbers are added to the Radio Regulations for ease of reference; RR numbers in this report refer to the marginal numbers in the Radio Regulations. Many footnotes are added to the table of frequency allocations in the Radio Regulations; each footnote has a footnote number, which is also a marginal number in the Radio Regulations.

For the allocation of frequency bands in the Radio Regulations, the world has been divided into three Regions. The 1979 WARC retained the division of the world into three Regions. Region 1 includes Europe, Africa, and the territories of the Union of Soviet Socialist Republics and the Mongolian People's Republic. Region 2 includes North, Central, and South America; it also includes Greenland. Region 3 includes Asia and Oceania but excludes the territories of the countries mentioned in Region 1. More precise and detailed definitions of the Regions are given in the Radio Regulations (RR Nos. 3415 to 3426) but they are not of particular significance to this report.

In the Radio Regulations, each service in each band has been categorized into one of three categories of services, i.e., primary service, permitted service, and secondary service. These categories were not changed by the 1979 WARC (RR Nos. 3427 to 3430). Primary and permitted services have equal rights, except that, in the preparation of frequency plans, the primary service shall have prior choice of frequencies. (In the frequency bands described in this report, however, no service is allocated as a permitted service.) Stations of a secondary service shall not cause harmful interference to stations of primary or permitted services to which frequencies are already assigned or to which frequencies may be assigned at a later date; stations of a secondary service cannot claim protection from harmful interference from stations of a primary or permitted service to which frequencies are already assigned or may be assigned at a later date.

In the Radio Regulations, all bands are designated by their frequencies such as the band 3700-4200 MHz, the band 10.7-11.7 GHz, etc. In the Radio Regulations

and in communication with administrations, the ITU neither has used nor will use letter designations of microwave bands such as X Band, Ku Band, etc.; these letter designations are commonly used particularly in reference to radar equipment but have no official international standing.

2. MAJOR DECISIONS MADE BY THE 1979 WARC

2.1 Introduction

The 1979 WARC revised the international table of frequency allocations extensively. (The table which was in Article 5 of the old Radio Regulations, is now in Article N7 of the revised Radio Regulations.) In this revision, the WARC allocated more frequency bands to the space services as a whole in the revised table than in the old table. Insofar as the space services are concerned, the revised table well reflects the U. S. proposals (FCC (Federal Communications Commission), 1978). The 1979 WARC incorporated the final acts of the 1977 WARC-BS (World Administrative Radio Conference for the Planning of the Broadcasting-Satellite Service) (ITU, 1977) into the revised Radio Regulations as Appendix 29A and adopted several resolutions and recommendations concerning the RARC (Regional Administrative Radio Conference) of Region 2 for the planning of the BSS to be convened in 1983 and another WARC for the space services to be convened in 1984. The 1979 WARC further adopted other provisions including addition of new terminology to improve the descriptions of the Radio Regulations.

2.2 Frequency Allocations to the BSS and FSS for Region 2

Frequency band allocations to the BSS and FSS (both downlink and uplink) for Region 2 adopted by the 1979 WARC are listed in Table 1. (In addition, the BSS is permitted to operate in the band 620-790 MHz by Footnote 3661, but no FSS uplink band to be paired with the band cannot be identified in its neighborhood. We will not further discuss this band in this report.) Most of the bands listed in Table 1 are shared with other services, i.e., they are allocated also to other services. The relation to the old allocation, other services that share the same band as primary services with the space services, and applicable provisions will be described for each band. Unless otherwise noted, all services in the following descriptions are primary services.

The band 2500-2690 MHz. The allocations of the band 2500-2690 MHz to the BSS and the band 2655-2690 MHz to the FSS uplink were retained. The allocation to the FSS downlink was expanded from 2500-2535 MHz to 2500-2690 MHz. The use

Table 1. Frequency Allocations to the BSS and FSS for Region 2, Adopted by the 1979 WARC.

Bands Allocated to the Services and Their Widths in Parentheses. (Frequencies in the first seven lines are in megahertz, and the remaining frequencies are in gigahertz.)		
BSS	FSS (downlink)	FSS (uplink)
2500-2690 (190)	2500-2690 (190) 3400-4200 (800) 4500-4800 (300) 7250-7750 (500)	2655-2690 (35) 5850-7075 (1225) 7900-8400 (500)
12.1-12.7 (0.6)	10.7-11.7 (1.0) 11.7-12.3 (0.6)	12.7-13.25 (0.55) 14.0-14.8 (0.8)* 17.3-18.1 (0.8)*
22.5-23.0 (0.5) 40.5-42.5 (2.0) 84.0-86.0 (2.0)	17.7-21.2 (3.5) 37.5-40.5 (3.0) 81.0-84.0 (3.0) 102.0-105.0 (3.0) 149.0-164.0 (15.0) 231.0-241.0 (10.0)	27.0-31.0 (4.0) 42.5-43.5 (1.0) 47.2-50.2 (3.0)* 50.4-51.4 (1.0) 71.0-75.5 (4.5) 92.0-95.0 (3.0) 202.0-217.0 (15.0) 265.0-275.0 (10.0)

*Use of the band or a part thereof is limited to feeder links for broadcasting satellites.

of the band 2500-2690 MHz by the BSS and FSS is limited to national and regional systems, and to systems for community reception in the use by the BSS (Footnotes 3715 and 3723). The allocations of this band to the terrestrial FS (fixed service) and MS (mobile service) except aeronautical mobile were retained. The PFD (power flux density) limits for the BSS and FSS downlink were unchanged (RR Nos. 6059 to 6062). The EIRP (equivalent isotropically radiated power) limit on the FSS earth station in the band 2655-2690 MHz (old RR Nos. 470G and 470J) was deleted.

The band 3400-4200 MHz. The allocation of this band to the FSS downlink remains unchanged. A new allocation of the band 3400-3500 MHz to the FS was made, and the allocation of the band 3500-4200 MHz to the FS was unchanged; therefore, the FSS downlink is to share the whole band 3400-4200 MHz with the FS. The old allocation of the band 3400-3700 MHz to the radiolocation service as a primary service was downgraded to the secondary-service category in the allocation table. In Regions 2 and 3, however, the primary allocation of the band 3400-3600 MHz to the radiolocation service was retained by Footnote 3736A on the condition that "all administrations operating radiolocation systems in this band are urged to cease operations by 1985." The old allocation of the band 3500-4200 MHz to the MS is now restricted to the MS except aeronautical mobile. The PFD limits on the FSS downlink were unchanged (RR Nos. 6063 to 6066).

The band 4400-4700 MHz (not included in Table 1). The old allocation of this band to the FSS uplink was deleted.

The band 4500-4800 MHz. A new allocation of this band to the FSS downlink shared with the FS and MS was made. The same PFD limits on the FSS downlink as in the band 3400-4200 MHz apply (RR Nos. 6063 to 6066).

The band 5850-7075 MHz. The allocation of the band 5925-6425 MHz to the FSS uplink was expanded to the band 5850-7075 MHz. The old allocation of the band 5850-5925 MHz to the radiolocation service was downgraded to the secondary-service category, and the allocations of this band to the FS and MS were added. Therefore, the whole band 5850-7075 MHz is to be shared by the FSS uplink, FS, and MS. The EIRP limits on the FSS earth station were unchanged, i.e., the old limits for the band 5925-6425 MHz now apply to the whole band 5850-7075 MHz (RR Nos. 6039 and 6045).

The band 7250-7750 MHz. The allocation of this band to the FSS downlink was unchanged. Allocations of the band 7250-7300 MHz to the FS and MS were added in the allocation table. An allocation of the band 7250-7375 MHz to the MSS (mobile-satellite service) (downlink) was also added by Footnote 3764B. The allocations of the band 7300-7750 MHz to the FS and the band 7450-7550 MHz to the meteorological-satellite service downlink were unchanged. The old allocation of the band

7300-7750 MHz to the MS is now restricted to the MS except aeronautical mobile. Therefore, the FSS downlink is to share with the FS and MS (with or without aeronautical mobile) in the whole band, and with the meteorological-satellite service downlink in a small portion of the band. The PFD limits on the FSS downlink were unchanged (RR Nos. 6063 to 6066).

The band 7900-8400 MHz. The allocation of this band to the FSS uplink was unchanged. The allocations of the bands 7900-7975 MHz and 8025-8400 MHz to the FS and MS remain unchanged, and new allocations of the band 7975-8025 MHz to the FS and MS were added. An allocation of the band 7900-8025 MHz to the MSS (uplink) was also added by Footnote 3764B. The allocations of the band 8025-8400 MHz to the earth-exploration satellite service downlink and the band 8175-8215 MHz to the meteorological-satellite service uplink were also unchanged. Therefore, the FSS uplink is to share the whole band 7900-8400 MHz with the FS and MS and, in addition, a portion of the band with some other services. The EIRP limits on the FSS earth station were unchanged (RR Nos. 6039 and 6045).

The band 10.7-11.7 GHz. New allocations to the FSS downlink of the bands 10.7-10.95 GHz and 11.2-11.45 GHz were added to the old allocations of the bands 10.95-11.2 GHz and 11.45-11.7 GHz. Therefore, the whole 1-GHz wide band 10.7-11.7 GHz is now allocated to the FSS downlink. The allocation of the band 10.7-11.7 GHz to the FS was unchanged, and the allocation to the MS is now restricted to the MS except aeronautical mobile. The PFD limits on the FSS downlink were unchanged (RR Nos. 6067 to 6070).

The band 11.7-12.7 GHz. The 1979 WARC adopted several resolutions concerning the use of this band by the FSS downlink and BSS. The WARC tentatively allocated the band 11.7-12.3 GHz to the FSS downlink and the band 12.1-12.7 GHz to the BSS. The old allocation of the band 12.5-12.7 GHz to the FSS uplink was deleted. The 1983 RARC for Region 2 will divide the overlapping portion (i.e., the band 12.1-12.3 GHz) into two subbands, will allocate the lower subband to the FSS downlink and the upper subband to the BSS, and will draw up a detailed frequency allotments and orbital positions plan for the BSS for Region 2 in the band 12.3-12.7 GHz and the upper subband of the band 12.1-12.3 GHz. (Footnote 3787B and Resolution CH). Regardless of the uncertainty in the dividing frequency, the 1979 WARC doubled the band allocated to the two space services and adopted spectrum division in preference to orbit division. Therefore, arc segmentation is no longer applicable in the band 11.7-12.1 GHz and will not be applicable in the band 12.1-12.2 GHz following the 1983 RARC (Resolution CK). The use of the band 11.7-12.7 GHz by the FSS and BSS is limited to national and sub-regional systems (Footnote 3787). In the

band 11.7-12.1 GHz and the lower subband of the band 12.1-12.3 GHz, transponders in the FSS may be used additionally for transmissions in the BSS under certain conditions, although this combined band shall be used principally for the FSS downlink insofar as the space services are concerned (Footnote 3787A). Similarly, in the band 12.3-12.7 GHz and the upper subband of the band 12.1-12.3 GHz, stations of the BSS may also be used for transmissions in the FSS downlink under certain conditions, although this combined band shall be used principally for the BSS insofar as the space services are concerned (Footnote 3787F). Although the FS allocation in the band 11.7-12.7 GHz remains unchanged in the table of frequency allocations, the FS in the band 11.7-12.2 GHz in Canada, Mexico, and the United States was downgraded to a secondary service (Footnote 3878G). The old allocation of the band 11.7-12.1 GHz to the MS except aeronautical mobile was downgraded to a secondary-service category, and the allocation of the band 12.1-12.7 GHz to the same service was unchanged. The terrestrial BS (broadcasting service) allocation was moved from the band 11.7-12.2 GHz to the band 12.1-12.7 GHz. Since the 1983 RARC will allocate the lower subband of the band 12.1-12.3 GHz only to the FSS downlink (Footnote 3787B), allocations of the lower subband to these terrestrial services (i.e., the FS, MS except aeronautical mobile, and the BS) will be suppressed following the 1983 RARC. PFD limits on the FSS downlink and the BSS in the band 11.7-12.7 GHz remain nonexistent. The WARC provides that, in the band 12.3-12.7 GHz and the upper subband of the band 12.1-12.3 GHz, existing and future terrestrial radiocommunication services shall not cause harmful interference to the space services operating in accordance with the BSS plan to be prepared at the 1983 RARC for Region 2, and shall not impose restrictions on the elaboration of such a plan (Footnote 3787D). The WARC also provides that, in the same combined band, the Region 2 space services, existing or planned before the 1983 RARC, shall not impose restrictions on the elaboration of the BSS plan for Region 2 (Footnote 3787E).

The band 12.7-13.25 GHz. The allocation of the band 12.7-12.75 GHz to the FSS uplink was retained, and a new allocation of the band 12.75-13.25 GHz to the FSS uplink was made. The allocations of the band 12.7-13.25 GHz to the FS, the band 12.7-12.75 GHz to the MS except aeronautical mobile, and the band 12.75-13.25 GHz to the MS were unchanged. The same EIRP limits on the FSS earth station as applicable to the bands 5850-7075 MHz and 7900-8400 MHz apply to this band (RR Nos. 6039 and 6045).

The band 14.0-14.8 GHz. The allocation of this band to the FSS uplink is an expansion from the band 14.0-14.5 GHz. The band 14.0-14.5 GHz may be used for feeder links for the BSS (Footnote 3793B), and the use of the band 14.5-14.8 GHz

by the FSS uplink is limited to feeder links for the BSS (Footnote 3796A). The allocation of the band 14.0-14.3 GHz to the radio-navigation service was retained, and the provision that use of this band by this service shall provide sufficient protection to space stations of the FSS (Footnote 3795) was also retained. The allocation of the band 14.3-14.4 GHz to the radionavigation-satellite service was downgraded to the secondary-service category. The allocations of the band 14.4-14.8 GHz to the FS and the band 14.5-14.8 GHz to the MS were unchanged. The old allocation of the band 14.4-14.5 GHz to the MS is now restricted to the MS except aeronautical mobile. The EIRP of the FSS earth station is not limited in the band 14.0-14.4 GHz but is limited in the band 14.4-14.8 GHz in the same way as it was previously limited in the band 14.4-14.5 GHz (RR Nos. 6039 and 6045).

The band 17.3-18.1 GHz. The allocation of this band to the FSS uplink is a new allocation made by the 1979 WARC. The use of this band by the FSS uplink is limited to feeder links for the BSS (Footnote 3794H). The old allocation of the band 17.3-17.7 GHz to the radiolocation service was downgraded to the secondary-service category. The allocations of the band 17.7-18.1 GHz to the FS, MS, and FSS downlink were retained. The EIRP of the FSS earth station is not limited in the band 17.3-17.7 GHz but is limited in the band 17.7-18.1 GHz (RR Nos. 6040 and 6046).

The band 17.7-21.2 GHz. The allocation of this band to the FSS downlink was unchanged. A new allocation of the band 17.7-18.1 GHz to the FSS uplink to be used as feeder links for the BSS was added. The allocations of the band 17.7-19.7 GHz to the FS and MS were retained with an exception that the aeronautical mobile service was excluded from the MS allocation in the band 18.6-18.8 GHz. New allocations of the band 18.6-18.8 GHz to the earth exploration-satellite service (passive) and the space research service (passive) and of the band 20.2-21.2 GHz to the MSS (mobile-satellite service) downlink were added. The PFD limits on the FSS downlink in the band 17.7-19.7 GHz were unchanged (RR Nos. 6075 to 6078), and the PFD remains unlimited in the band 19.7-21.2 GHz.

The band 22.5-23.0 GHz. The allocation of this band to the BSS is a new allocation. The allocations of this band to the FS and MS were unchanged, and a new allocation of the band 22.55-23.0 GHz to the inter-satellite service was made. Although PFD limits on the BSS do not exist, authorization of the service is subject to agreement of any other administration, whose services may be affected, obtained under the procedure set forth in Article N13A (Footnote 3802).

The band 27.0-31.0 GHz. The allocation of this band to the FSS uplink is an expansion of the old allocation to the lower frequency side by 500 MHz. The allocations of the band 27.0-29.5 GHz to the FS and MS were retained, and new

allocations of the bands 29.5-30.0 GHz and 30.0-31.0 GHz to the MSS uplink were made on secondary and primary bases, respectively. The EIRP limits on the FSS uplink that were applicable to the old allocation in the band 27.5-29.5 GHz are now applicable in the band 27.0-29.5 GHz (RR Nos. 6040 and 6046), and the EIRP of an FSS earth station remains unlimited in the band 29.5-31.0 GHz.

The band 37.5-40.5 GHz. The allocation of this band to the FSS downlink is an expanded replacement of the old allocation of the band 40-41 GHz. The allocations of the band 37.5-40.0 GHz to the FS and MS were retained and new allocations of the band 40.0-40.5 GHz to these two services were added. In addition, a new allocation of the band 39.5-40.5 GHz was made to the MSS downlink. The PFD limits on the FSS downlink in this band 37.5-40.5 GHz were tentatively set to be the same as in the band 17.7-19.7 GHz (RR Nos. 6076, 6079A to 6079E); this provision shall apply until such time as the CCIR (International Radio Consultative Committee) has made a Recommendation on this matter (RR No. 6079B.1).

The band 40.5-42.5 GHz. The allocation of this band to the BSS is a shift-down in frequency of the old allocation in the band 41.0-43.0 GHz. Although some new allocations of this band to other services were added, none of them is on a primary basis. As before, no PFD limits on the BSS exist.

The band 42.5-43.5 GHz. The allocation of this band to the FSS uplink is a new allocation. New allocations of this band were also made to the FS, MS except aeronautical mobile, and radio astronomy service. All old allocations in the band 43.0-43.5 GHz were deleted. No EIRP limit exists on the FSS earth stations in the entire band 42.5-43.5 GHz.

The band 47.2-50.2 GHz. The allocation of this band to the FSS uplink is a new allocation. New allocations of this band were also made to the FS and MS. All old allocations in the band 47.2-48.0 GHz were deleted. No EIRP limit was imposed on the FSS earth stations in the entire band 47.2-50.2 GHz. The use of the band 47.2-49.2 GHz by the FSS uplink is intended for feeder links for the BSS in the band 40.5-42.5 GHz (Footnote 3814B).

The band 50.4-51.4 GHz. The allocation of this band to the FSS uplink is a shift-up in frequency of the old allocation in the band 50.0-51.0 GHz. New allocations of this band were also made to the FS and MS. As before, no EIRP limit on the FSS earth stations exists.

The band 71.0-75.5 GHz. The allocation of this band to the FSS uplink is a new allocation. New allocations of this band were also made to the FS and MS, and a new allocation of the band 71.0-74.0 GHz was made to the MSS uplink. No EIRP limit was imposed on the FSS earth stations in the entire band 71.0-75.5 GHz.

The band 81.0-84.0 GHz. The allocation of this band to the FSS downlink is a new allocation. New allocations of this band were also made to the FS, MS, and MSS downlink. No PFD limit was imposed on the FSS downlink.

The band 84.0-86.0 GHz. The allocation of this band to the BSS was retained. New allocations of this band were made to the FS, MS, and BS with the provision that stations in these services should not cause harmful interference to the BSS (Footnote 3815F). PFD limits on the BSS remain unimposed in this band.

The band 92.0-95.0 GHz. The allocation of this band to the FSS uplink was retained. New allocations of this band were made to the FS, MS, and radiolocation service. EIRP limits on the FSS earth stations remain unimposed.

The band 102.0-105.0 GHz. The allocation of this band to the FSS downlink was retained. New allocations of this band were made to the FS and MS. PFD limits on the FSS downlink remain unimposed.

The band 149.0-164.0 GHz. The allocation of this band to the FSS downlink is an expanded replacement for the old allocation of the band 150-152 GHz to the same service. New allocations of this band were made to the FS and MS, and new allocations of the band 150-151 GHz were made to the earth exploration-satellite service (passive) and space research service (passive). PFD limits remain unimposed on the FSS downlink in the entire band 149-164 GHz.

The band 202.0-217.0 GHz. The allocation of this band to the FSS uplink is an expanded replacement for the old allocation of the band 140-142 GHz to the same service. New allocations of this band were made to the FS and MS. EIRP limits remain unimposed on the FSS earth stations.

The band 231.0-241.0 GHz. The allocation of this band to the FSS downlink is a replacement of the old allocation of the band 220-230 GHz to the FSS with the direction indicator newly added. This band is also allocated to the FS and MS, and the band 235-238 GHz is also allocated to the earth exploration-satellite service (passive) and space research service (passive). No PFD limits are imposed on the FSS downlink in the entire band 231-241 GHz.

The band 265.0-275.0 GHz. The allocation of this band to the FSS uplink is a modification of the old allocation with the direction indicator newly added. New allocations of this band were made to the FS, MS, and radio astronomy service. EIRP limits remain unimposed on the FSS earth station.

2.3 Appendix 29A

In accordance with the request by the 1977 WARC-BS, the 1979 WARC incorporated into the Radio Regulations, as Appendix 29A, the provisions and associated Plan contained in the Final Acts of the 1977 WARC-BS (RR No. 9358). Since the frequency

allocations to the FSS and BSS in the 12 GHz band in Region 2 have been expanded and modified by the 1979 WARC, however, some provisions in the Final Acts of the 1977 WARC-BS are irrelevant. In this regard, the 1979 WARC adopted two resolutions, i.e., Resolutions CI and CK, to effect necessary modifications instead of changing those provisions.

In Resolution CI, the 1979 WARC resolves in effect that the provisions in Appendix 29A concerning the sharing among the BSS and FSS in the band 11.7-12.2 GHz in Region 2, the BSS in Regions 1 and 3, and terrestrial services shall be applicable to the bands newly allocated to the BSS and FSS in Region 2. In Resolution CK, the 1979 WARC suppressed in effect the provisions relating to arc segmentation in Region 2. In the same resolution, the WARC also resolves that the remaining interim provisions relating solely to Region 2 in Appendix 29A shall continue to apply pending the decision of the 1983 RARC of Region 2.

2.4 The 1983 RARC of Region 2

One of the major decisions made by the 1979 WARC that affect the use of the space services in Region 2 is the adoption of Resolution CH, "Relating to the convening of a Regional Administrative Radio Conference for the detailed planning of the broadcasting-satellite service in the 12 GHz band and associated feeder links in Region 2." This resolution replaces the provisions for convening the RARC of Region 2 set forth in Article 12 of Appendix 29A with several additional provisions. It also replaces Resolutions No. Sat-8 and No. Sat-9 of the 1977 WARC-BS.

The RARC of Region 2 will be held no later than 1983. It is tasked (1) to divide the band 12.1-12.3 GHz into two subbands and to allocate the lower subband to the FSS and the upper subband to the BSS, BS, MS (except aeronautical mobile), and FS, (2) to draw up a detailed frequency allotments and orbital positions plan for the BSS for Region 2 in the band 12.3-12.7 GHz and in the upper subband of the band 12.1-12.3 GHz, and (3) to plan feeder links in a part of the band 17.3-18.1 GHz, of a bandwidth equal to the total bandwidth allocated to the BSS. Tasks (1) and (3) are new additions made by the 1979 WARC.

The planning must take into account the pertinent provisions of Appendix 29A as well as the latest CCIR Recommendations and technical advances. The planning must be based on individual reception. Each administration must be guaranteed at least four channels for the operation of the BSS by the Plan. It is required that all administrations in Region 2 submit their BSS requirement to the IFRB (International Frequency Registration Board) not later than one year before the start of the RARC of Region 2, and the IFRB will remind administrations of the need to

submit the requirements. These provisions remain essentially unchanged by the 1979 WARC.

Since neither the band 11.7-12.1 GHz nor the band 12.3-12.7 GHz is shared between the BSS and FSS in the new table of frequency allocations, and since the band 12.1-12.3 GHz will not be shared between the two services after the 1983 RARC, the provisions of Article 12 of Appendix 29A relating to arc segmentation in Region 2 are no longer applicable. In planning the BSS at the 1983 RARC, broadcasting satellites can be placed at any position on the geostationary-satellite orbit.

2.5 The 1984 WARC for Space Services

One of the major decisions made by the 1979 WARC concerning the space services is the adoption of Resolution BP, "Relating to the use of the geostationary-satellite orbit and to the planning of space services utilizing it." This resolution calls for convening of another WARC "to guarantee in practice for all countries equitable access to the geostationary-satellite orbit and the frequency bands allocated to the space services." This WARC will be held in two sessions; the first session will be held not later than 1984, and the second session not sooner than 12 months and not later than 18 months after the first session. The first session is tasked to decide which space services and frequency bands should be planned, and the second session is tasked to implement the decisions taken at the first session.

In addition to the task of deciding space services and frequency bands to be planned, the first session is also tasked to establish the principles, technical parameters, and criteria for the planning. The first session is also expected to consider other possible approaches that could meet the objective of equitable access.

2.6 Other Provisions

The 1979 WARC added and modified definitions of many terms. Some important ones closely related to the space services will be described here.

Definitions of three terms "allocation" (RR No. 3023B), "allotment" (RR No. 3023C), and "assignment" (RR No. 3023D) were added to the Radio Regulations. Allocation refers to a frequency band, while the other two refer to a radio frequency or a radio frequency channel. An allocation of a frequency band means an entry in the table of frequency allocations of a given band for the purpose of its use by one or more services. Allotment is a new term; an allotment of a radio frequency or a radio frequency channel means an entry of a frequency or a channel in an agreed

plan adopted by a competent conference, for use by one or more administrations for a service in one or more countries or geographical areas. An assignment of a radio frequency or radio frequency channel means an authorization (or a license) given by an administration for a radio station to use a frequency or a channel. In short, a WARC allocates a frequency band to a service in the table of frequency allocations (which, rigorously speaking, should be called the table of frequency band allocations); a WARC or RARC allots a frequency or a channel to an administration in a plan; and an administration assigns a frequency or a channel to a station. Until the 1977 WARC-BS, assignment encompassed both allotment and assignment.

The WARC introduced a new term "feeder link" (RR No. 3094A). A feeder link is defined as a "radio link from an earth station at a specified fixed point to a space station, or vice versa, conveying information for a space radiocommunication service other than for the fixed-satellite service." According to this definition, a feeder link can be either an uplink or a downlink.

With regard to inclusion of feeder links, definitions of several services were modified by the 1979 WARC. In the old Radio Regulations (i.e., before the 1979 WARC), the FSS included all feeder links. Also in the old Radio Regulations, the MSS was allowed to include its feeder links if the system so required. According to these old definitions, therefore, a feeder link for the MSS can be in the MSS and, at the same time, it must be in the FSS. The 1979 WARC changed the definition of the FSS and corrected this inconsistency. The new definition of the FSS reads, in part, that "the fixed-satellite service may also include feeder links for other space radiocommunication services" (RR No. 3102). Therefore, a feeder link for the MSS can be now either in the MSS (RR No. 3115) or in the FSS (RR No. 3102). The definitions of the radionavigation-satellite service, earth exploration-satellite service, and standard frequency and time signal-satellite service were also modified in such a way that each service "may also include feeder links necessary for its operation" (RR Nos. 3112, 3106, 3109).

The definition of the BSS remains essentially unchanged (RR No. 3103). Therefore, uplinks for broadcasting satellites are still in the FSS.

The definitions of individual reception and community reception in the BSS also remain unchanged. Therefore, transmission of TV (television) programs from a satellite to a distribution system such as a cable TV operator can be, as before, either in the FSS or in the BSS.

3. UPLINK AND DOWNLINK PAIRING

3.1 Services to be Considered

According to the definitions of the BSS and FSS (RR Nos. 3103 and 3102), only the downlink (i.e., the link in the space-to-earth direction) from the broadcasting satellite to the general public in a satellite-broadcasting system is in the BSS, and any feeder link that transmits programs to the broadcasting satellite is in the FSS. This is in a parallel relation with a terrestrial broadcasting system where only the link from the broadcasting transmitter to the general public is in the BS and any radio link from the studio to the broadcasting transmitter is in the FS if such a radio link is used. Therefore, the BSS must be treated together with the FSS downlink when the uplink and downlink pairing of the FSS is considered.

In the case of the MSS, the situation is different. When two mobile earth stations are communicating with each other via a satellite operating in the MSS, all four links are in the MSS. When a mobile earth station is communicating with a base station via a satellite operating in the MSS, the links between the mobile earth station and the satellite are in the MSS, and the feeder links in both directions between the satellite and the base station are either in the MSS or in the FSS (RR Nos. 3115 and 3102). Contrary to the case of the BSS, two feeder links in both directions are involved in this case, and these feeder links should be balanced either within the MSS or within the FSS. Insofar as the uplink and downlink pairing is concerned, pairing of the feeder links for the MSS is a matter within the MSS or the FSS and requires no separate considerations.

3.2 Technical Pairs

Except for certain uplink bands designated for the feeder links for the BSS, the table of frequency allocations does not specify for each uplink band that it is to be paired with a particular downlink band. This report will examine technical uplink and downlink pairings on the assumption of an equal bandwidth for both links in a pair. When various types of signal processing on board the satellite

become practicable in the future, there will be a possibility of using a narrow-band modulation such as low modulation index FM (frequency modulation) or multi-phase PSK (phase-shift keying) in one link with an excessive CNR (carrier-to-noise ratio). Use of inter-satellite links and/or new technologies such as multiple access with scanning beams, SCPC (single channel per carrier), etc., may also require unequal bandwidths for both links. Just for simplicity, however, this report assumes an equal bandwidth for both links. As will be seen below, the table of frequency allocations seems to be based generally on the same assumption.

The pair to be discussed first is relative to the band 2500-2690 MHz. Since the FSS uplink allocation of the band 2655-2690 MHz is only 35 MHz wide, it is not sufficient to match the BSS and FSS downlink allocations of the band 2500-2690 MHz, which is 190 MHz wide. In addition, the FSS allocation of this band is bi-directional; the same band is also allocated to the BSS and FSS downlink. A part of the FSS uplink allocation of the band 5850-7075 MHz may be used to supplement any deficiency but, as described in the next paragraph, this resource amounts to 125 MHz at most, resulting in a total uplink bandwidth of 160 MHz, which can be paired with the downlink allocations only in the band 2500-2660 MHz. Moreover, the pairing of a part of the band 5800-7075 MHz with the band 2500-2690 MHz, or a part thereof, represents a big difference in frequency, exceeding a two-to-one ratio, and may impose severe operational restrictions on the systems operating in these bands. The uplink pairing with the downlink band 2500-2690 MHz is one of the unsettled areas in the outcome of the 1979 WARC.

The FSS downlink allocations of the bands 3400-4200 MHz and 4500-4800 MHz can be paired with the FSS uplink allocation of the band 5850-7075 MHz. Here, the total downlink band is 1100 MHz wide, while the uplink band is 1225 MHz wide. This pair is one of the very few pairs in the entire table of frequency allocations in which the uplink band allocation exceeds the downlink allocation. As described in the preceding paragraph, the excess in the uplink band may be used for the downlink band 2500-2690 MHz. In order that the uplink-to-downlink frequency ratio does not vary unnecessarily over a wide range, it is technically desirable to pair the band 5850-5975 MHz with the band 2500-2690 MHz or a part thereof, the band 5975-6775 MHz with the band 3400-4200 MHz, and the band 6775-7075 MHz with the band 4500-4800 MHz. Since the pair of bands 5925-6425 MHz and 3700-4200 MHz has been extensively used, however, rearrangement of the pairing would be very costly and will likely not be considered useful.

The next pair consists of the downlink band 7250-7750 MHz and the uplink band 7900-8400 MHz. Both bands are 500 MHz wide, and they are well matched.

The uplink pairing with the FSS downlink allocation of the band 10.7-12.3 GHz and the BSS allocation of the band 12.1-12.7 GHz seems to be another problem. (As described earlier, the band 12.1-12.3 GHz will be divided into two subbands and the lower and upper subbands will be allocated by the 1983 RARC of Region 2 to the FSS downlink and BSS, respectively.) There is a general consensus that these FSS downlink and BSS allocations are paired with the FSS uplink allocations of the bands 12.7-13.25 GHz, 14.0-14.8 GHz, and 17.3-18.1 GHz. The total downlink bands are 2.0 GHz wide, and the total uplink bands are 2.15 GHz wide. It appears that sufficient uplink bands are allocated. In pairing these bands, however, there are some technical issues, which will be discussed in the next subsection.

The next pair consists of the downlink allocations of the bands 17.7-21.2 GHz and 22.5-23.0 GHz to the FSS downlink and BSS, respectively, and the FSS uplink allocation of the band 27.0-31.0 GHz. The total band in each direction is 4.0 GHz wide. The uplink band and the downlink bands are reasonably separated. There seems to exist no technical problem in the use of these bands by the space services insofar as the uplink and downlink pairing is concerned.

The next pair consists of the downlink allocations of the bands 37.5-40.5 GHz and 40.5-42.5 GHz to the FSS downlink and BSS, respectively, and the FSS uplink allocations of the three bands 42.5-43.5 GHz, 47.2-50.2 GHz, and 50.4-51.4 GHz. The total band in each direction is 5.0 GHz wide. Among the uplink bands, the band 47.2-49.2 GHz is reserved for feeder links to broadcasting satellites operating in the band 40.5-42.5 GHz (Footnote 3814B), and the remaining bands can be paired with the FSS downlink band. There seems to exist no technical problem in pairing these bands.

The next pair consists of the downlink allocations of the bands 81.0-84.0 GHz and 84.0-86.0 GHz to the FSS downlink and BSS, respectively, and the FSS uplink allocation of the band 71.0-75.5 GHz. The total downlink band is 5 GHz wide, while the total uplink band is 4.5 GHz wide. Therefore, there is an imbalance of 0.5 GHz. This pair is one of only two pairs where the uplink band is located below the downlink band in the frequency spectrum.

The next pair consists of the FSS downlink band 102-105 GHz and the FSS uplink band 92-95 GHz. The band is 3 GHz wide in each direction. There should be no technical problem in the use of these bands insofar as the uplink and downlink pairing is concerned. This pair is also one of the two pairs where the uplink band is lower than the downlink band in frequency.

The next pair is between the FSS downlink band 149-164 GHz and the FSS uplink band 202-217 GHz. The band is 15 GHz wide in each direction. There should be no technical problem in pairing these bands.

The last pair is between the FSS downlink band 231-241 GHz and the FSS uplink band 265-275 GHz. The band is 10 GHz wide in each direction. There should be no technical problem in pairing these bands.

3.3 Problem Areas

As described in the preceding subsection, there are several technical problem areas in the uplink and downlink pairing. In this subsection, possible solutions for each problem area will be considered. The discussions in this subsection are based on the new international table of frequency allocations only, and problems relevant to the U.S. national provisions will be discussed in Section 5. (In the following description, each frequency value in parentheses represents the width of the band.)

Uplink bands for the downlink band 2500-2690 MHz. The band 2500-2690 MHz (190 MHz) is allocated to the BSS and FSS downlink, and the highest part of this band, i.e., the band 2655-2690 MHz (35 MHz), is also allocated to the FSS uplink. This uplink band should be paired with the lowest part of the downlink band, i.e., the band 2500-2535 MHz (35 MHz), since the uplink and downlink bands used by a satellite must be reasonably separated in frequency. The remaining downlink band 2535-2690 MHz (155 MHz) needs its uplink band of the same width, but there is no FSS uplink allocation in its vicinity, i.e., with an uplink-to-downlink frequency ratio of 1.5 or less. The FSS uplink band closest to this band is the band 5850-7075 MHz (1225 MHz), which seems to be allocated to make a pair with the downlink bands 3400-4200 MHz (800 MHz) and 4500-4800 MHz (300 MHz), with an excess uplink allocation of 125 MHz. This excess uplink allocation seems to be the only resource to be paired with the downlink allocation of the band 2535-2690 MHz (155 MHz) or a part thereof. There is still an uplink shortage of 30 MHz, and a large uplink-to-downlink frequency ratio (greater than a two-to-one ratio) may cause operational difficulties in the use of this pair of bands. Moreover, there is another problem concerning the portion of the band 5850-7075 MHz that can be spared for this pairing, as discussed in the following paragraph.

Uplink bands for the downlink bands 3400-4200 MHz and 4500-4800 MHz. The bands 3400-4200 MHz (800 MHz) and 4500-4800 MHz (300 MHz) are allocated to the FSS downlink, and the band 5850-7075 MHz (1225 MHz) allocated to the FSS uplink is supposedly to be paired with the downlink bands. The downlink bands are 1100 MHz

wide, while the uplink band is 1225 MHz wide, with an excess uplink allocation of 125 MHz. From the current use of some parts of these bands, however, use of this possible pair of bands is not as straightforward as it looks.

The downlink band 3700-4200 MHz (500 MHz) is currently used very extensively. Although the FSS downlink allocation of the band 3400-3700 MHz (300 MHz) already existed in the old table of frequency allocations, this band was also allocated to the radiolocation service on a primary basis. In the new allocation table adopted by the 1979 WARC, the radiolocation service in the band 3400-3700 MHz is a secondary service although the same service in the band 3400-3600 MHz is a primary service in Regions 2 and 3 (Footnote 3736A), and a new FSS downlink band 4500-4800 MHz (300 MHz) is added. Effectively, therefore, the currently used FSS downlink band 3700-4200 MHz has been expanded by 300 MHz each on both of its sides. On the other hand, the FSS uplink band has been expanded from the band 5925-6425 MHz (500 MHz), currently used very extensively as a companion uplink band of the downlink band 3700-4200 MHz (500 MHz), to the band 5850-7075 MHz (1225 MHz), i.e., expanded downward by 75 MHz and upward by 650 MHz. If the current pairing between the bands 3700-4200 MHz and 5925-6425 MHz is maintained, the two downlink bands 3400-3700 MHz and 4500-4800 MHz should be paired with the uplink band 6425-7075 MHz leaving a 50-MHz wide excess uplink band. This excess uplink band coupled with the new uplink band 5850-5925 MHz (75 MHz) may be used for the downlink band 2500-2690 MHz, but these two widely separated and relatively narrow uplink bands are not convenient for many purposes. Moreover, the pairing of the band 3400-3700 MHz with a part of the band 6425-7075 MHz would impose technical constraints if the entire 800-MHz wide downlink band 3400-4200 MHz were used by a single satellite in the future, or if the same band were divided in a manner other than the 300 and 500 MHz division.

Uplink bands for the downlink band 10.7-12.7 GHz. The bands 10.7-11.7 GHz and 11.7-12.1 GHz are allocated to the FSS downlink, and the band 12.3-12.7 GHz is allocated to the BSS. In addition, following the 1983 RARC of Region 2, the lower and upper subbands of the band 12.1-12.3 GHz will be allocated to the FSS downlink and BSS, respectively. The use of the band 10.7-11.7 GHz by the FSS downlink is intended, at least in the United States, for international use, and the use of the band 11.7-12.7 GHz by the space services is limited to national and sub-regional systems. Corresponding to these downlink bands, there are three uplink bands, i.e., the bands 12.7-13.25 GHz (0.55 GHz), 14.0-14.8 GHz (0.8 GHz), and 17.3-18.1 GHz (0.8 GHz). The total downlink bands are 2.0-GHz wide, while the total uplink bands are 2.15-GHz wide. The total uplink bands are wider than the total downlink bands. As described earlier, however, the uplink band 14.0-14.5 GHz may be used

for feeder links for the BSS (Footnote 3793B), and the use of the bands 14.5-14.8 GHz and 17.3-18.1 GHz by the FSS uplink is limited to feeder links for the BSS (Footnotes 3796A and 3794H). In contrast to these provisions, Resolution CH directs that the 1983 RARC of Region 2 should plan feeder links in a part of the band 17.3-18.1 GHz, of a bandwidth equal to the total bandwidth allocated to the BSS. As a consequence, the band 14.5-14.8 GHz and the unused part of the band 17.3-18.1 GHz for the feeder links for the BSS can never be used by any space service, and only the FSS uplink bands that are 1.05-GHz wide will be available for the FSS downlink bands that are 1.4-GHz wide at least. To secure necessary uplink bands to be paired with the FSS downlink bands, the provisions of Footnotes 3796A and 3794H may need to be re-examined at some future time.

Even if the feeder links for the BSS are restricted in a subband having the same width as the BSS band, pairing the uplink bands with the FSS downlink bands is not easy because of unequal widths of the bands. Since no uplink band is 1.0-GHz wide, the FSS downlink band 10.7-11.7 GHz must be paired with two or more separated bands. If the BSS band is paired with the top subband of the band 17.3-18.1 GHz, each FSS downlink band must be paired with two separated uplink bands. If the domestic FSS downlink band is paired with a single uplink band, then the BSS band must be paired with two uplink bands. At the same time, no uplink band except the band 12.7-13.25 GHz can be paired with a single downlink band or a part thereof. All these facts will impose operational restrictions on both the BSS and FSS systems operating in these bands.

Uplink bands for the downlink bands 81.0-84.0 GHz and 84.0-86.0 GHz. The bands 81.0-84.0 GHz (3.0 GHz) and 84.0-86.0 GHz (2.0 GHz) are allocated to the FSS downlink and BSS, respectively, while the band 71.0-75.5 GHz (4.5 GHz) is allocated to the FSS uplink. Since the widths of downlink and uplink allocations are 5.0 GHz and 4.5 GHz, there is a shortage of uplink band, or an imbalance, of 0.5 GHz. Since both pairs right below and above the pair in question are well balanced, use of a part of an uplink band other than the band 71.0-75.5 GHz to make up this uplink shortage would merely transfer the imbalance to another pair. Expansion of the band 71.0-75.5 GHz may not be easy on either of its sides. Since actual use of these bands is expected to be rather distant in the future (say, 10 years from now or even later), this imbalance will not cause any trouble in practice, at least for the time being.

4. SHARING WITH OTHER SERVICES

4.1 Overall Review

In the new table of frequency allocations adopted by the 1979 WARC, most bands allocated to the BSS or FSS are shared with other services. Some bands exclusively allocated to the BSS or FSS in the old table of frequency allocations are now allocated also to other services, particularly to the terrestrial FS and MS (with or without aeronautical mobile). Some radiodetermination services, such as the radiolocation service and the radionavigation-satellite service, that were primary services and shared the bands with the FSS, are now secondary services in several bands. As a whole, sharing among the BSS, FSS, and other services is now more uniform than it was in the old table. The listing of the primary services that share each band with the BSS or FSS will follow. Only primary services will be listed here, and the remark "except aeronautical mobile" on the MS will be disregarded just for simplicity.

The band 2500-2690 MHz (BSS and FSS downlink). The entire band is allocated also to the FS and MS. The subband 2655-2690 MHz is allocated also to the FSS uplink.

The band 2655-2690 MHz (FSS uplink). This band is allocated also to the BSS, FSS downlink, FS, and MS.

The band 3400-4200 MHz (FSS downlink). The entire band is allocated also to the FS. In Regions 2 and 3, the subband 3400-3600 MHz is allocated also to the radiolocation service (Footnote 3736A). The subband 3500-4200 MHz is allocated also to the MS.

The band 4500-4800 MHz (FSS downlink). This band is allocated also to the FS and MS.

The band 5850-7075 MHz (FSS uplink). This band is allocated also to the FS and MS.

The band 7250-7750 MHz (FSS downlink). The entire band is allocated also to the FS and MS. The subband 7250-7375 MHz is allocated also to the MSS (mobile-satellite service) downlink (Footnote 3764B). The subband 7450-7550 MHz is allocated also to the meteorological-satellite service downlink.

The band 7900-8400 MHz (FSS uplink). The entire band is allocated also to the FS and MS. The subband 7900-8025 MHz is allocated also to the MSS uplink (Footnote 3764B). The subband 8025-8400 MHz is allocated also to the earth exploration-satellite service downlink, and the subband 8175-8215 MHz, to the meteorological-satellite service uplink.

The band 10.7-11.7 GHz (FSS downlink). This band is allocated also to the the FS and MS.

The band 11.7-12.3 GHz (FSS downlink). The subband 11.7-12.1 GHz is allocated also to the FS, but the FS in this subband is a secondary service in Canada, Mexico, and the United States.

The band 12.1-12.7 GHz (BSS). The subband 12.3-12.7 GHz is allocated also to the BS, FS, and MS. The upper subband of the band 12.1-12.3 GHz will be allocated also to the same services by the 1983 RARC of Region 2.

The band 12.7-13.25 GHz (FSS uplink). This band is allocated also to the the FS and MS.

The band 14.0-14.8 GHz (FSS uplink). The subband 14.0-14.3 GHz is allocated also to the radionavigation service, but this service is similar to a secondary service by Footnote 3795. The subband 14.4-14.8 GHz is allocated to the FS and MS.

The band 17.3-18.1 GHz (FSS uplink). The subband 17.7-18.1 GHz is allocated also to the FS, MS, and FSS downlink.

The band 17.7-21.2 GHz (FSS downlink). The subband 17.7-18.1 GHz is allocated also to the FSS uplink. The subband 17.7-19.7 GHz is allocated also to the FS and MS. The subband 18.6-18.8 GHz is allocated also to the earth exploration-satellite service (passive) and the space research service (passive). The subband 20.2-21.2 GHz is allocated also to the MSS downlink.

The band 22.5-23.0 GHz (BSS). The entire band is allocated also to the FS and MS. The subband 22.55-23.0 GHz is allocated also to the inter-satellite service.

The band 27.0-31.0 GHz (FSS uplink). The subband 27.0-29.5 GHz is allocated also to the FS and MS. The subband 30.0-31.0 GHz is allocated also to the MSS uplink.

The band 37.5-40.5 GHz (FSS downlink). The entire band is allocated also to the FS and MS. The subband 39.5-40.5 GHz is allocated also to the MSS downlink.

The band 40.5-42.5 GHz (BSS). The entire band is not allocated to any other service on a primary basis.

The band 42.5-43.5 GHz (FSS uplink). This band is allocated also to the FS, MS, and radio astronomy service.

The band 47.2-50.2 GHz (FSS uplink). This band is allocated also to the FS and MS.

The band 50.4-51.4 GHz (FSS uplink). This band is allocated also to the FS and MS.

The band 71.0-75.5 GHz (FSS uplink). The entire band is allocated also to the FS and MS. The subband 71.0-74.0 GHz is allocated also to the MSS uplink.

The band 81.0-84.0 GHz (FSS downlink). This band is allocated also to the FS, MS, and MSS downlink.

The band 84.0-86.0 GHz (BSS). This band is allocated also to the FS, MS, and BS. The BSS is protected against harmful interference from the other services in this band (Footnote 3815F).

The band 92.0-95.0 GHz (FSS uplink). This band is allocated also to the FS, MS, and radiolocation service.

The band 102.0-105.0 GHz (FSS downlink). This band is allocated also to the FS and MS.

The band 149.0-164.0 GHz (FSS downlink). The entire band is allocated also to the FS and MS. The subband 150-151 GHz is allocated also to the earth exploration-satellite service (passive) and space research service (passive).

The band 202.0-217.0 GHz (FSS uplink). This band is allocated also to the FS and MS.

The band 231.0-241.0 GHz (FSS downlink). The entire band is allocated also to the FS and MS. The subband 235-238 GHz is allocated also to the earth exploration-satellite service (passive) and space research service (passive).

The band 265.0-275.0 GHz (FSS uplink). This band is allocated also to the FS, MS, and radio astronomy service.

4.2 Sharing Problem Areas

In general, sharing the same band between the downlink space services with many receiving earth stations and the terrestrial services with many transmitters is difficult. The BSS falls in this category of space services and so do the FSS systems that deliver messages directly to and from earth stations on customer premises. We will discuss some frequency bands that are considered to have potential sharing problems. The discussions in this subsection are based on the new international table of frequency allocations only, and problems relevant to the U.S. national provisions will be discussed in Section 5.

The band 2500-2690 MHz. The entire band is allocated to the BSS, FSS downlink, FS, and MS, and the subband 2655-2690 MHz is also allocated to the FSS uplink. The principal use of the band by the terrestrial FS in the United States is by the ITFS (instructional television fixed service). This use is quite extensive in some large metropolitan areas. The FCC may open up this band to the MDS (multipoint distribution service) and OFS (operational fixed service) as well. With this extensive terrestrial use, coordination of sharing will be very important.

However, the current ITFS users are also the most likely candidates to utilize this band first with the space service system having small-antenna earth stations and a large-antenna satellite.

Bidirectional use of the subband 2655-2690 MHz will make the sharing with terrestrial services more difficult. Since it is difficult to find a sufficient uplink band for the entire band 2500-2690 MHz, the use of the subband 2655-2690 MHz by the BSS and FSS downlink might not be technically feasible.

The band 12.1-12.7 GHz. The 1979 WARC that allocated the band 12.3-12.7 GHz to the BSS allocated the same band also to the terrestrial FS, MS except aeronautical mobile, and BS. The WARC also provided that the 1983 RARC of Region 2 divide the band 12.1-12.3 GHz into two subbands and allocate the upper subband to the BSS and the same terrestrial services. In making these allocations, the WARC established a higher priority for the BSS over the terrestrial services and placed the following restrictions on operation and planning of the terrestrial services. The revised Radio Regulations provide that "in Region 2, in the band 12.1-12.7 GHz, existing and future terrestrial radiocommunication services shall not cause harmful interference to the space services operating in accordance with the broadcasting-satellite plan to be prepared at the 1983 Regional Administrative Radio Conference for Region 2, and shall not impose restrictions on the elaboration of such a plan" (Footnote 3787D). Insofar as future conformity with the international Radio Regulations is concerned, therefore, the BSS in the upper subband of the band 12.1-12.3 GHz and the band 12.3-12.7 GHz in Region 2 can be planned without regard to existing and future terrestrial services.

In the United States, however, more than 1500 FS systems are currently operating in the band 12.2-12.7 GHz. If the existing FS systems are ignored in the BSS planning as provided by Radio Regulations, serious domestic problems may be raised in the United States. It is very unlikely that the 1983 RARC of Region 2 will establish a frequency allotments and orbital positions plan in such a way that all the existing FS systems in the United States can remain in operation without interfering with or being interfered with by the BSS systems after the implementation of the plan. If the plan to be established is such that at least one-half of the band is unused by the BSS in a BSS service area, then the FS systems in the same area may remain in the same band with their frequencies reassigned (SBS (Satellite Business Systems), 1978). (In this statement, the channels immediately adjacent to an assigned BSS channel must be considered occupied by the BSS, because such channels cannot be used by an FS system in the same geographical area.) If more

than one-half of the band is used by the BSS, the FS systems may need to be moved to another band, the availability of which may be a problem.

5. RELEVANCE TO NATIONAL TABLE OF FREQUENCY ALLOCATIONS

In the United States, frequencies used by the U. S. Government agencies are managed by the NTIA (National Telecommunications and Information Administration) and frequencies used by non-Government users are managed by the FCC (Federal Communications Commission). The frequency management by the NTIA and FCC is based on the national table of frequency allocations (NTIA, 1980). Services in a band in the national table of frequency allocations have not necessarily been the same as those in the international table of frequency allocations and, although it is desirable that they be the same, they will not be the same in every band. Nonetheless, since the international table was revised extensively in the 1979 WARC, revisions of the national table jointly by the NTIA and FCC are also expected. In revising the national table to implement the revisions made in the international table by the 1979 WARC, proper considerations should be given to the allocations in the existing national table and to the systems operating in compliance with the existing national table.

In the national table of frequency allocations, each band has a national provision that the band is allocated either for Government users or for non-Government users, or for both. Table 2 lists, for the Region 2 BSS and FSS bands in the international table or the subbands thereof, the U. S. national provisions concerning the Government or non-Government use. This table also indicates for each band or subband whether the band is allocated to the BSS or FSS. Since almost every band above 40 GHz is allocated to identical services for both Government and non-Government users, this table does not elaborate on them.

Table 3 lists the BSS and FSS bands (also below about 40 GHz) that the United States proposed for the 1979 WARC (FCC, 1978). The U. S. proposal was prepared by a joint effort by the FCC and NTIA through lengthy proceedings consisting of a series of FCC notices of inquiry. The proposal not only takes into account various requests by many parties but it reflects well the national provisions. We will review some technical issues concerning the national provisions. (In the following description, each frequency value in parentheses represents the width of the band.)

The bands 3400-3700 MHz and 4500-4800 MHz. In the revised international table of frequency allocations, these two bands are allocated to the FSS downlink and some terrestrial services. Coupled with the band 3700-4200 MHz, these bands are supposed to be paired with the FSS uplink band 5850-7075 MHz. In the national

Table 2. Current National Provisions for the Region 2 BSS and FSS Bands and Their Government and Non-Government Allocations to the BSS or FSS below About 40 GHz.
(Symbols G, NG, and ng are for Government use (primary service), non-Government use (primary service), and non-Government use (secondary service), respectively.)

Region 2 BSS & FSS Bands	Subbands	National Provisions	Government Alloc. to BSS or FSS	Non-Govt. Alloc. to BSS or FSS
2500-2690 MHz		NG	---	yes
2655-2690		NG	---	yes
3400-4200	3400-3700	G,ng	no	no
	3700-4200	NG	---	yes
4500-4800		G	no	---
5850-7075	5850-5925	G,ng	no	no
	5925-6425	NG	---	yes
	6425-6625	NG	---	no
	6625-7075	NG	---	yes
7250-7750		G	yes	---
7900-8400		G	yes	---
10.7-11.7 GHz	10.7-10.95	NG	---	no
	10.95-11.2	NG	---	yes
	11.2-11.45	NG	---	no
	11.45-11.7	NG	---	yes
11.7-12.3	11.7-12.2	NG	---	yes
	12.2-12.3	NG	---	no
12.1-12.7	12.1-12.2	NG	---	yes
	12.2-12.5	NG	---	no
	12.5-12.7	NG	---	yes
12.7-13.25	12.7-12.75	NG	---	yes
	12.75-13.25	NG	---	no
14.0-14.8	14.0-14.5	G,NG	no	yes
	14.5-14.8	G	no	---
17.3-18.1	17.3-17.7	G,ng	no	no
	17.7-18.1	NG	---	yes
17.7-21.1	17.7-20.2	NG	---	yes
	20.2-21.2	G	yes	---
22.5-23.0		G,NG	no	no
27.0-31.0	27.0-27.5	G	no	---
	27.5-30.0	NG	---	yes
	30.0-31.0	G	yes	---
37.5-40.5	37.5-38.6	G	no	---
	38.6-40.0	NG	---	no
	40.0-40.5	G,NG	yes	yes

Table 3. Frequency Allocations to the BSS and FSS for Region 2 below About 40 GHz, Proposed by the United States for the 1979 WARC. (Underlining indicates new text, and dashes through the text indicate deletion.)

Frequency Bands	Services
1850-2200 MHz	FSS (downlink)
2500-2535	BSS, FSS (downlink)
2535-2655	BSS, FSS (downlink)
2655-2900	BSS, FSS (uplink)
3400-4200	FSS (downlink)
4400-4700	FSS (uplink)
5925-6425	FSS (uplink)
6425-7115	FSS (uplink)
7250-7750	FSS (downlink)
7900-8400	FSS (uplink)
10.70-10.95 GHz	FSS (downlink)
10.95-11.20	FSS (downlink)
11.20-11.45	FSS (downlink)
11.45-11.70	FSS (downlink)
11.7-12.2	~~BSS~~, FSS (downlink)
12.2-12.5	BSS
12.5-12.7	BSS, ~~FSS (uplink)~~
12.70-12.75	FSS (uplink)
12.75-13.25	FSS (uplink)
14.0-14.5	FSS (uplink)
17.1-17.6	FSS (uplink)
17.7-21.2	FSS (downlink)
22.5-23.0	BSS
27.5-31.0	FSS (uplink)
40.0-41.0	FSS (downlink)

table, however, these downlink bands are divided into Government and non-Government bands about evenly, while the major portion of the uplink band is a non-Government band. Specifically, the downlink bands 3400-3700 MHz (300 MHz) and 4500-4800 MHz (300 MHz) are essentially Government bands, with a secondary allocation of the former to non-Government users, and the downlink band 3700-4200 MHz (500 MHz) is a non-Government band. The uplink band 5850-5925 MHz (75 MHz) is essentially a Government band, with a secondary allocation to non-Government users, and the uplink band 5925-7075 MHz (1150 MHz) is a non-Government band. If the international allocations of the bands 3400-3700 MHz and 4500-4800 MHz to the FSS downlink were to be implemented in the United States, either some portion of these bands would have to be changed to non-Government bands or some portions of the band 5850-7075 MHz would have to be changed to Government bands in the national table of frequency allocations.

The band 5850-7075 MHz. In the revised international table, this band is allocated to the FSS uplink and some terrestrial services. In the national table, this band is divided into four subbands. The subband 5850-5925 MHz is a Government band allocated to a terrestrial service, but the remaining three subbands are non-Government bands. The subband 5925-6425 MHz is allocated to the FSS uplink, but the subband 6425-6625 MHz is not allocated to the FSS, and the subband 6625-7075 MHz is allocated to the FSS downlink in the national table. If the international allocation of the band 5850-7075 MHz to the FSS uplink were to be implemented in the United States, some exchanges between Government bands and non-Government bands would be necessary, as described in the preceding paragraph.

The bands 7250-7750 MHz and 7900-8400 MHz. This pair of bands is one of the two Government band pairs that are allocated to the FSS in the national table. (As described later, another pair is the pair of bands 20.2-21.2 GHz and 30.0-31.0 GHz.) Since the allocation of this pair of bands to the FSS was retained in the international table, the FSS allocation of this pair of bands can be retained also in the national table.

The band 14.0-14.8 GHz. In the revised international table, this band is allocated to the FSS uplink and some terrestrial services. Together with the bands 12.7-13.25 GHz and 17.3-18.1 GHz, this band is an essential band that provides feeder links for satellites operating in the BSS and FSS downlink band 10.7-12.7 GHz. In the national table, the band 14.0-14.5 GHz is a shared band by Government and non-Government users, and only non-Government operations are authorized in the FSS in this band by Footnote No. US207 to the national table of frequency allocations. Also in the national table, the band 14.5-14.8 GHz is a Government band

allocated to terrestrial services. Note that this band is not included in the U. S. proposal, as shown in Table 3.

The band 17.3-17.7 GHz. In the revised international table, this band is allocated to the FSS uplink and some terrestrial services. In the national table, although this band is a shared band and allocated to the radiolocation service for both Government and non-Government users, the allocation to non-Government users is as a secondary service. Retaining the priority for Government users in the use of this band may again result in a shortage of uplink band.

The bands 20.2-21.2 GHz and 30.0-31.0 GHz. This pair of bands is one of the two Government band pairs that are allocated to the FSS in the national table. (As described earlier, another pair is the pair of bands 7250-7750 MHz and 7900-8400 MHz.) Since the allocation of this pair of bands to the FSS was retained in the international table, the same allocation can be retained also in the national table.

The band 22.5-23.0 GHz. This band is allocated to the BSS in the international table, while it is allocated to the FS and MS for both Government and non-Government users in the national table. Operation of BSS systems might be difficult in a band shared equally between Government and non-Government users.

The bands 27.0-27.5 GHz and 37.5-38.6 GHz. These bands are Government bands in the national table. This fact may be a potential problem in implementing the international allocations of the band 27.0-31.0 GHz to the FSS uplink and the band 37.5-40.5 GHz to the FSS downlink.

6. PUBLIC SERVICE SATELLITE COMMUNICATIONS

There are emerging public-service communication requirements that include the delivery of health care and education to rural and dispersed users, emergency communications related to natural disaster, etc. Technically, such requirements may include transmission of voice, data, and TV signals in a single telecommunication system. Satellite communication systems are prime candidates for fulfilling many of these requirements.

The controlling factor in the possible implementation of such integrated services seems to be the cost of providing the TV (television) channel. It appears that the cost of the TV channel would need to be on the order of $50 to $100 per TV channel-hour for the combined earth station and space segments (Akima et al., 1978). These cost goals cannot, of course, be met by the current generation of geostationary satellites. To meet these cost requirements, small-antenna earth stations must be used.

Service classification of such integrated communication systems is unclear. Some segments of the systems may be best classified as the FSS, some as the BSS, and some as either FSS or BSS. Service classification of the systems seems to be a matter of expediency and should be determined by various factors including, but not limited to, the nature of the systems.

One of the candidate downlink bands for these uses is the band 2500-2690 MHz which is allocated to the BSS and FSS downlink in Region 2. The use of this band by the BSS and FSS is limited to national and regional systems, and the use by the BSS is further limited to systems for community reception (Footnotes 3715 and 3723). This band, however, is rather narrow, only 190-MHz wide, and there is serious doubt that the use of this band would be cost-effective if present satellite and earth-station technology is used. Any frequency reuse may be attractive by providing a large traffic base over which fixed costs can be distributed. The economic analysis is yet to be done since the technology is in the early developmental stage. A study suggests the future feasibility of satellites with large aperture multibeam antennas (Kelley et al., 1977). Since large-aperture satellite antennas have not yet been used commercially, there is some uncertainty associated with the development, launch, and deployment of such antennas.

In the band 2500-2690 MHz, the PFD at the surface of the earth must not exceed -137 dBW/m^2 in any 4 kHz band in both the BSS and FSS (RR No. 6060). (This PFD limit was unchanged by the 1979 WARC.) If one assumes 14 dB for the minimum CNR, 100 K for the antenna noise temperature, 20 MHz for the receiver bandwidth, 55% for the antenna efficiency, and 600 kHz for energy dispersal of the transmitted signal (i.e., the same peak-to-peak deviation value as adopted by the 1977 WARC-BS), the receiving antenna diameter of the earth station required for successful reception of an FM TV signal equals approximately 2 m and 1.5 m for a receiver NF (noise figure) of 5 dB and 3 dB, respectively. (A receiver NF of 3 dB in this band is now available at a reasonable cost.) These antenna diameter values may be suitable for some applications but not for others.

None of the bands in the frequency range between 3400 MHz and 11.7 GHz can be considered ideal for the public service uses with small earth stations, since even tighter PFD limits are imposed on the bands in this frequency range. In addition, the band 3700-4200 MHz is currently used extensively, and the expanded band 3400-4200 MHz is considered to be used for the same purposes with more capacity and higher flexibility in introducing a new technology. The downlink band 7250-7750 MHz has been used exclusively by U. S. Government agencies in the United States.

The downlink band 10.7-11.7 GHz is intended for use by the international systems such as the INTELSAT (International Telecommunications Satellite Consortium) system.

The downlink band 11.7-12.7 GHz is another candidate band that has a high potential of accommodating the public service communication systems. As described earlier, the band 11.7-12.1 GHz is allocated to the FSS downlink, and the band 12.3-12.7 GHz is allocated to the BSS. The 1983 RARC of Region 2 will divide the band 12.1-12.3 GHz into two subbands and allocate the lower and upper subbands to the FSS downlink and BSS, respectively. No PFD limit exists in the band 11.7-12.7 GHz in Region 2.

Although the band 11.7-12.7 GHz has not yet been used very extensively, there are proposals and plans of FSS and BSS systems that will use this band. It is not expected that the public service systems can use the entire spectrum-orbit resources in this band. The public service systems must share the resources with other systems including the ones already proposed or being planned. Since technical characteristics of the public service systems are expected to differ widely from those of other systems, sharing among these systems must be considered in the same manner as sharing between different services even if these systems may be in the same service.

Basically, there are two approaches in accommodating the public service communication systems, i.e., orbit division and spectrum division. In the orbit-division approach, a portion of the geostationary-satellite orbit arc is set apart for use by the public service systems. An advantage of this approach is that the public service systems can use the entire band. A disadvantage is that no other satellite can operate in the same frequency band in the vicinity of the public service satellite because of the small earth-station antennas of the public service systems. In the spectrum-division approach, a portion of the frequency spectrum is set apart for use by the public service systems. An example is to allocate the bands 11.7-12.3 GHZ and 12.3-12.7 GHz to the FSS downlink and BSS, respectively, and to limit the use of the band 12.1-12.3 GHz by the FSS downlink to the public service systems. An advantage of the spectrum-division approach is that the public service systems can use the entire orbital arc. A disadvantage is that only a relatively narrow band is available for the public service systems because of

their relatively light traffic compared with the traffic of other systems that include common-carrier systems.

Of course there are several variations and combinations of these approaches. It is possible to use orbit division only in the band allocated to the FSS or BSS. An example of such variations is that the public service systems and other systems in the FSS share the band 11.7-12.3 GHz by orbit division and the BSS use the entire orbital arc in the band 12.3-12.7 GHz. This example, however, has the same disadvantage as the orbit-division approach in the entire band 11.7-12.7 GHz, viz., the orbital utilization is rather low.

Regardless of which approach will be taken, the relative traffic amounts of the public service and other systems in the band 11.7-12.7 GHz will have to be estimated before the 1983 RARC of Region 2. It is also highly desirable that various options of allocating the orbit-spectrum resources to the public service systems are established and their respective advantages and disadvantages are studied in detail by that time. In addition, since the public service systems involve various types of information signals and modulation techniques, developing a uniform channel allotment plan for the public service systems in this band is inappropriate and should be avoided.

There are future possibilities of using higher frequency bands. There are wider downlink bands allocated to the space services around 20 GHz, 40 GHz, etc., and their respective uplink bands. In these bands, however, radio signals suffer severe attenuation due to rain absorption, and space-qualified technology has not yet been developed. Therefore, it is not anticipated that any use of those higher frequency bands will be proposed before the 4-GHz and 12-GHz bands become congested.

7. VARIOUS OPTIONS FOR THE 1983 RARC OF REGION 2

7.1 Introduction

In Resolution CH, the 1979 WARC calls for convening of a RARC of Region 2 no later than 1983. This RARC is tasked (1) to divide the band 12.1-12.3 GHz into two subbands and to allocate the lower subband to the FSS and the upper subband to the BSS, BS, MS except aeronautical mobile, and FS, (2) to draw up a detailed frequency allotments and orbital positions plan for the BSS for Region 2 in the band 12.3-12.7 GHz and in the upper subband of the band 12.1-12.3 GHz, and (3) to plan feeder links in a part of the band 17.3-18.1 GHz. There are various options the United States can pursue for each task of the RARC.

7.2 Division of the Band 12.1-12.3 GHz

Selection of the dividing frequency of the band 12.1-12.3 GHz depends on the requirements for use of the band by the FSS and BSS. In the United States, several wideband FSS systems that would use the entire 500-MHz wide band have been planned in the 11.7-12.2 GHz band by SBS, Western Union (Advanced Westar), and others. (As planned, some of these systems would be based on digital modulation and would use a transponder bandwidth of 200 MHz or wider.) On the other hand, although a BSS system plan has been announced by Comsat (Communications Satellite Corporation), the total band requirement for the BSS has not yet been made final.

As discussed earlier, some of the public service systems may be classified technically as either the FSS or the BSS, and their service classification is not clear. There are at least three factors to consider in classifying the public service systems in the 12-GHz band. First, technical sharing of a common band between the public service systems and terrestrial systems is considered difficult. Second, the BSS must share the band with the terrestrial BS, MS, and FS, while the FSS does not have to. Third, the BSS must be planned in the 1983 RARC, while the FSS will not be planned; the question as to whether or not the FSS in a particular band should be planned is a subject of discussion for the 1984 WARC.

Dividing the band at a frequency lower than 12.2 GHz (e.g., 12.1 GHz or 12.15 GHz) is an option, but this option is considered inappropriate. Under this option, the width of the band allocated to the FSS would be less than 500 MHz, and there would not be sufficient room to accommodate both the wideband systems and the public service systems operating in the FSS. There seems to be no support for this option from the BSS either, i.e., no evidence has been presented that the BSS would require a total band wider than 500 MHz.

Dividing the band at 12.2 GHz is another option. If the public service systems did not have to be accommodated in the 12-GHz band at all, this option would be the best choice. Currently, there seems to be no convincing reasoning that either the wideband FSS systems or the BSS systems require a band wider than 500 MHz. For accommodating the public service systems, however, this option is not considered appropriate. This option does not provide sufficient flexibility for setting apart a portion of the band for public service systems. It seems that this option would yield at most a 400-MHz wide band to the wideband FSS systems and a 100-MHz wide band to the public service systems if

spectrum division between the wideband systems and the public service systems is used.

Dividing the band at a frequency higher than 12.2 GHz (e.g., 12.25 GHz or 12.3 GHz) is another option. This option would place a burden on the BSS and FS but provide greater flexibility to the FSS in accommodating the public service systems. If spectrum division between the wideband systems and the public service systems is used in this option, the FSS band 11.7-12.25 GHz or 11.7-12.3 GHz can be subdivided in several ways depending on the requirements by the wideband systems and the public service systems. As a possible suboption, the band 12.1-12.3 GHz can be divided at 12.3 GHz (i.e., the entire band 12.1-12.3 GHz could be allocated to the FSS) and the band 12.1-12.3 GHz can be set apart for use by the public service systems. This suboption would place a burden on the wideband FSS systems, BSS, and FS. Combined with the use of the band 2500-2690 MHz, this suboption might yield sufficient bands for operation of public service communication systems; however, this form of spectrum division creates considerable inflexibility.

7.3 Frequency Allotments and Orbital Positions Plan

The overall approach to the 1983 RARC of Region 2 is considered rather important to the United States. Items to be discussed include the life of the plan, review and revision of the plan, retuning and repositioning capabilities of the satellites, the extent to which the spectrum and orbit resources are allotted in the plan, provisional use by an administration of a frequency and orbital position not allotted to the administration in the current plan, planning capability, technological development, etc.

The 1977 WARC-BS plan for Regions 1 and 3 was prepared to cover a period of at least 15 years from January 1, 1979, and will remain in force until its revision by a competent administrative radio conference (RR, Appendix 29A, Article 16). Since no provision has been made on its review and revision, the life of the plan can be even longer than 15 years. An approach parallel to this plan is a possible option in the 1983 RARC for Region 2. A 15-year lifespan for the plan, however, is considered by many to be too long, compared with the fast development of the current satellite technology. It would very likely freeze technological development of the BSS. The life of the plan should be much shorter than 15 years, e.g., 5 or 7 years. In addition, the 1983 RARC should provide that a RARC be convened periodically (e.g., every 5 or 7 years) to review the plan and revise it if necessary.

Since the life of the plan and the life of a satellite do not necessarily match, revision of the plan may take place during the lifetime of the satellite. Although these currently operating satellites must be taken into account when the plan is reviewed and revised, retuning and/or repositioning the satellite may still become necessary to improve the overall spectrum and orbit utilization. Since the plan is not expected to be revised more than once in the lifetime of a satellite (which presently is nominally 7 years), retuning and repositioning may not be required more than once. Therefore, requiring the one-time retuning and repositioning capability to each satellite is a valuable option.

To what extent the plan will allot the spectrum and orbit resources is another problem. If the life of the plan is very long (e.g., 15 years or longer), all the resources might have to be distributed (or allotted) to the administrations. On the other hand, if the life of the plan is relatively short (e.g., 5 or 7 years) and the plan is subject to periodic review and revision, the initial plan to be adopted by the 1983 RARC must satisfy only the initial minimum requirements of all administrations, and portions of the spectrum and orbit resources may be reserved for the future revision of the plan. Together with the technological development, the reserved portions of the resources will provide flexibility for high utilization of the overall spectrum and orbit resources and capacity for accommodating possible future systems of novel types. Therefore, a sparing use of the spectrum and orbit resources in the 1983 RARC of Region 2 is highly desirable.

Provisional (or temporary) use by an administration of a frequency and orbital position not allotted to the administration should be a subject of discussion. This frequency and orbital position can be either unallotted to any administration or allotted to another administration. For higher utility of the resources, allowing such provisional use is desirable. The provision must, however, be given that such a provisional use shall not be considered a de facto allotment when the plan is reviewed at the next RARC or when any administration holding an allotment wants to use it.

By the 1983 RARC of Region 2, the United States must have developed a planning capability that can develop a plan when the requirements from all administrations are known. This planning capability must cover all technical features of the 1977 WARC-BS as well as recent developments of satellite technology such as the shaped-beam satellite antennas with low sidelobe levels.

In addition, the United States must have developed several examples of the frequency allotments and orbital positions plan for Region 2. An

example should be the minimum plan in which four channels are allotted to each time zone of each administration in the band 12.3-12.7 GHz. Various examples should have been developed that correspond to various conditions and restrictions on the usage of the satellites. For example, the CONUS (contiguous 48 states of the United States) can be served either from four orbital positions (with a satellite for each time zone) or from two orbital positions (with a satellite for two time zones), and an example plan should be developed for each case. Another restriction could be that each service area should be served from a single orbital position, and an example plan should be developed either with or without this restriction. Various service area configurations will also result in various plans. All service areas can be disjoint with each other, or some areas can overlap. A service area can be small and totally included in another service area, or it can even straddle the border of two other service areas. Channel spacing is still another parameter. It can be equal to 19.18 MHz, as in the 1977 WARC-BS plan for Regions 1 and 3, or unequal. More studies are needed for selecting the combinations of restrictions, conditions, and parameter values for which example plans should be developed before the 1983 RARC of Region 2.

7.4 Feeder Link Planning

In many satellite communication systems, good design practice for the CIR (carrier-to-interference ratio) and CNR (carrier-to-noise ratio) is to have these parameters about 10 dB higher for the uplink (feeder link) than for the downlink. It is considered reasonable for the BSS to follow this rather common practice.

Since a larger earth-station antenna is available for the uplink transmission than for the downlink reception, this uplink CIR objective can be considered achievable against both the cochannel and adjacent-channel interference without widening the channel spacing. Despite the higher uplink noise temperature of the satellite receiving system than the downlink noise temperature of the earth station, the higher CNR objective can also be considered achievable by using a higher uplink EIRP of the earth station than the downlink EIRP of the satellite.

It is possible theoretically that the uplink uses a wider band modulation than the downlink to take advantage of the wideband gain and to reduce the transmitter power. On the other hand, it is also possible theoretically that

the uplink uses a narrower band modulation than the downlink to reduce the necessary bandwidth at the expense of increased transmitter power. To use either a narrower or wider band modulation, however, demodulation and remodulation in the satellite transponder are necessary. Although such on board processings are believed feasible in the future, it is unlikely that they will become feasible in the initial phase of the 1983 RARC plan of Region 2, or even in the life of the plan if the life is limited to 5 or 7 years. Therefore, it is reasonable to assume that the total width of the uplink band is equal to that of the downlink band.

There are two FSS uplink bands, 14.5-14.8 GHz and 17.3-18.1 GHz, set apart for exclusive use by the feeder links for the BSS (Footnotes 3796A and 3794H), and another FSS uplink band, 14.0-14.5 GHz, may be used for feeder links for the BSS (Footnote 3793B). In contrast to these footnotes to the table of frequency allocations, Resolution CH directs that the 1983 RARC of Region 2 should plan feeder links in a part of the band 17.3-18.1 GHz. Several factors must be considered in selecting a band for the feeder links for the BSS band. The total width of the feeder link band can be equal to that of the BSS band which is equal to 600 MHz or less. The uplink bands mentioned in this paragraph must also serve for other FSS downlink bands near the BSS band. The BSS band is the highest in the frequency spectrum among the downlink bands in its neighborhood. The band 17.3-18.1 GHz is also the highest among the uplink bands in its neighborhood. It is, therefore, a convenient option to use for the feeder links for the BSS the highest frequency part of the band 17.3-18.1 GHz having the same width as the BSS band. This option, however, may not leave a solid uplink band to be paired with the domestic FSS downlink band. Since a contiguous 400 or 500 MHz wide band might be required by the FSS while not by the BSS, there is another option in which a lower subband of the band and an upper subband of the band 14.0-14.8 GHz are paired with the BSS. This requires more study.

The channel arrangement in the feeder link band can be the same as in the BSS band. This arrangement is equivalent to the frequency translation of the entire BSS band or two subbands of the BSS bands, depending on the uplink band options. It is the simplest arrangement in theory and also in the hardware design. Deviations from this arrangement may not only complicate the hardware design but may also introduce difficulties in rejecting adjacent-channel interference with no apparent benefit.

8. VARIOUS OPTIONS FOR THE 1984 WARC FOR SPACE SERVICES

8.1 Introduction

In Resolution BP, the 1979 WARC calls for convening of another WARC not later than 1984. The objective of the 1984 WARC is "to guarantee in practice for all countries equitable access to the geostationary-satellite orbit and the frequency bands allocated to space services."

The WARC shall be held in two sessions. The first session, expected to be held in 1984, shall (1) decide which space services and frequency bands should be planned; (2) establish the principles, technical parameters, and criteria for the planning; (3) provide guidelines for regulatory procedures; and (4) consider other approaches that could meet the objective of the WARC. The second session, to be held not sooner than 12 months and not later than 18 months after the first session, shall implement the decisions taken at the first session.

There are various options the United States can take for this WARC. Although this WARC will consider all space services, the following discussions are limited to the FSS and BSS.

8.2 Bands and Services to be Excluded

Use of the band has not been proposed and the type of the system has not been shaped for some bands. At present, the bands above 17.7 GHz fall in this category. Planning such bands is impossible at the present time. Therefore, the bands above 17.7 GHz should be excluded from consideration by the 1984 WARC.

The bands that will have been planned before the 1984 WARC (e.g., in the 1983 RARC of Region 2) should be excluded from consideration by the 1984 WARC. For example, the combined band consisting of the band 12.3-12.7 GHz and the upper subband of the band 12.1-12.3 GHz, allocated to the BSS, is expected to be planned by the 1983 RARC of Region 2. The FSS uplink band for the feeder links for the BSS in the combined band will also be planned by the same RARC. These bands should be excluded from this consideration.

Exclusion of the FSS downlink band 10.7-11.7 GHz from consideration by the 1984 WARC might be a valuable option. The reason behind this option is that a certain band must be set apart now for exclusive use by the international traffic for the future when the 6/4 GHz bands currently used become saturated, and that the band 10.7-11.7 GHz seems to be the most suitable band for this purpose. It is then more appropriate to let authorized international organizations such as

INTELSAT (International Telecommunications Satellite Consortium) plan and operate the systems in this band rather than to allot each segment of the band and orbital positions to each country in the 1984 WARC. In order for this option to be viable the uplink band to be paired with the downlink band 10.7-11.7 GHz must also be set apart for exclusive use by international traffic and must be excluded from consideration by the 1984 WARC. The most likely uplink bands are the bands 12.7-13.25 GHz and 14.0-14.5 GHz.

It might be possible to exclude more bands from consideration by the 1984 WARC. Additional studies are needed.

8.3 Options Concerning Principles

Since the advance of satellite communication technology is very rapid, setting the life of the plan relatively short might be a valuable option. Under this option, the plan for space services will be reviewed periodically (e.g., every 5 or 7 years) and revised if necessary. In current satellite technology the designed life of a satellite is usually 7 years, and revision of the plan may occur during the lifetime of a satellite. Therefore, requiring the one-time retuning and repositioning capability for a satellite whose expected life exceeds the life of the plan might also be a valuable option.

Planning only the downlink bands does not meet the objective of equitable access. If an FSS downlink band or a BSS band is to be planned, an FSS uplink band must be paired to the downlink band and also be planned. Pairing an appropriate uplink band with a downlink band is an important step. As discussed in Section 3, there are several problems and also various options in pairing FSS uplink bands with the FSS downlink and BSS bands. There are several options concerning the uplink pairing with the 12 GHz BSS band, but one should have been selected in the 1983 RARC of Region 2, before the 1984 WARC for space services.

There are several options for each band concerning the degree of planning. They range from no planning at all to a complete frequency allotments and orbital positions plan such as the 1977 WARC-BS plan for the BSS for Regions 1 and 3. Although the CCIR (International Radio Consultative Committee) is studying methods of reducing inhomogeneity of system parameters to improve the spectrum and orbit utilization, it is not expected for all bands that all systems in each band have homogeneous characteristics as in the BSS band. One valuable option is, for a given band, allocating a part of the band to a country or a group of countries. Here, countries should be grouped geographically rather than politically and in a smaller area than the current ITU Regions. Another option is, also for a band, allocating a segment of the orbital arc to a country or a group of countries,

or allotting orbital positions to a country. These two options may even be combined. Detailed studies are needed for each band.

9. CONCLUSIONS

Limiting our scope to the BSS and FSS, we have reviewed the outcome of the 1979 WARC. In general, the WARC acted favorably for the two space services. It allocated more bands to the space services. The uplink and downlink imbalance, or more specifically, the uplink shortage, has been improved significantly, although not all the problems have been resolved. Difficult situations regarding sharing with other services have been eased in many bands. There is now a better possibility of accommodating public service satellite communication systems with small-antenna earth stations.

Several options for various aspects of the 1983 RARC of Region 2 have been discussed. Since the treatment of the public service satellite communication systems is uncertain, there is also an uncertainty concerning the dividing frequency of the band 12.1-12.3 GHz. Despite this uncertainty, however, several reasons may support the option in which the public service systems are classified as the FSS and the band 12.1-12.3 GHz is divided at a frequency higher than 12.2 GHz. A relatively short life of the plan (e.g., 5 or 7 years) and periodic review of the plan are recommended for better utilization of the spectrum and orbit resources. A procedure of developing a plan based on recent technological advances should be established and, with this procedure, examples of plans should be developed with or without various restrictions and constraints and with various values of system parameters. There is an unsettled problem concerning selection of the FSS uplink band for the feeder links to the broadcasting satellites, and more studies are needed.

Several options have been discussed also for the 1984 WARC for space services. Reasons are given why some bands should be excluded from considerations by the WARC. Regardless of the type of plan, the life of the plan should be relatively short (e.g., 5 or 7 years), and the plan should be reviewed periodically and revised if necessary. Since downlink planning only does not guarantee access to the space-service bands and the geostationary orbit, the uplink and downlink pairing should be established. There are some problems concerning the pairing, however. Since all systems in a band are not expected to be of homogeneous characteristics, selection of the degree of

planning for each band is another problem. More studies are needed also concerning this problem.

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15. ABSTRACT *(A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here.)*

The 1979 WARC (World Administrative Radio Conference) revised the international Radio Regulations of the ITU (International Telecommunication Union) including the international table of frequency allocations. The revised Radio Regulations will govern internationally the use of the radiofrequency spectrum and the geostationary satellite orbit for the rest of this century. Restricting its scope to the topics related to the broadcasting-satellite and fixed-satellite services in ITU Region 2, this report reviews the outcome of the 1979 WARC and considers possible technical issues to be dealt with in the future.

16. Key Words *(Alphabetical order, separated by semicolons)*

1979 WARC (World Administrative Radio Conference), BSS (broadcasting-satellite service), FSS (fixed-satellite service), frequency allocation, satellite communication.

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