Chapter 4

WARC-79 Overview, Actions, and Impacts

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From the point of view of a developing country burdened with poverty, illiteracy, and disease, access to modern telecommunications is every bit as vital as it is to the United States. Conversely, whether the Department of Defense (DOD) can communicate with a missile submarine at sea or a high-flying jet bomber over Alaska is of much less consequence to the leader of a Third World country than whether he can send a simple radio message to a doctor or village administrator 100 miles outside his capital city.

The gap between the modern “information society" —with its computers, microprocessors, and multichannel satellite systems— and the developing nations struggling to harness basic, unsophisticated radio systems to the task of economic development is growing wider. At today's pace, a villager in central Africa is likely to watch an American film on a community television set long before he has an opportunity to use a telephone.

The gap in priorities is equally wide. It is difficult, for example, to persuade a representative of a developing country to give up certain radiofrequencies that provide him with a rudimentary telephone system in order that the Voice of America can broadcast more clearly. The task of persuasion is made no easier by suggesting that a satellite or a microwave system would provide the developing country with better phone service with more efficient use of the spectrum when, in fact, such systems may be too costly for many developing countries.

When the technically advanced, industrial nations get together with Third World countries to discuss telecommunications and spectrum management, their needs and priorities are so different that their negotiating goals and objectives are far apart. Viewed against this background, and the mounting frustrations of the developing countries, U.S. delegates to the World Administrative Radio Conference (WARC-79) that convened in Geneva in September 1979, had reason to be wary. It was the first general administrative radio conference in 20 years and was unquestionably the largest and most significant intergovernmental meeting on radio communications in more than a decade.

There had been tremendous advances in telecommunications since the last WARC, held in 1959. Worldwide demand for improved communications had greatly increased, together with a sharp rise in the demand to use the radio spectrum. Inconsistencies had developed in the general regulations having to do with more than one of the individual radio services. A number of specialized radio conferences had taken place since 1959 resulting in decisions that were inconsistent with one another, thus adding to the urgency of convening a general conference.

The U.S. Role

As the largest and most technically advanced user of the radio spectrum on a worldwide basis, the United States approached WARC-79 with the greatest stake in reaching agreement on a new table of frequency allocations and a revised set of related technical and administrative regulations. At previous WARCs, the United

States had been a strong advocate of compromise and had tried to set an example by not taking reservations that would indicate refusal to abide by a particular decision of the conference.

A determination to avoid needless controversy and to arrive at mutually acceptable compromises continued to guide the U.S. delegation at Geneva in 1979. The goal of the United States was to ensure that whatever changes were made in International Telecommunication Union (ITU) regulations governing the allocation and use of radio spectrum were made in light of current U.S. economic, social, and technical requirements. The United States would support incremental change, but not wholesale shifts in spectrum allocations or in ITU procedures. Because of the rapid and frequently unforeseen changes in communications technology, the United States was committed to the general principle of flexibility so that any decisions made at WARC-79 would permit future accommodation to new circumstances.

The United States was on record as supporting, in principle, changes in international spectrum allocations and related frequency management procedures that would accommodate the needs of other nations, consistent with its own interests and with the essential requirements and sound principles of international spectrum utilization.

How WARC-79 Differed From WARC-59

WARC-79 was vastly different from any previous ITU administrative radio conference, both in size and complexity. Membership in ITU stood at 154. Almost half the nations eligible to attend WARC-79 did not even exist in 1959.

These new nations brought rising expectations that increased demand for telecommunication services worldwide. New communication technologies that made increasing use of different forms of telecommunications had come into being including satellites. Other techniques made it possible for radiofrequencies to carry more information than ever before. Coordination and avoidance of interference procedures were more highly developed.

While the countries of the developed world introduced these improvements as a matter of choice, developing nations often could not afford to abandon less expensive and less sophisticated equipment and procedures even though these were not technically efficient in their use of spectrum. They had to be content with older, less sophisticated telecommunication systems while the industrialized nations pursued new technologies and services vital to their growing information economies. * The developed countries, for example, could seriously consider shifting some broadcasting services out of the radio spectrum entirely and onto cable to make room in the ultrahigh frequency (UHF) and very high frequency (VHF) bands for new mobile services. Most Third World countries could not conceive of such a move.

WARC-79 differed from WARC-59 in that demands on the radio spectrum had significantly increased; more countries were making greater use of spectrum for a greater variety of purposes. Moreover, the conference sessions, while still highly technical in nature, were influenced to a greater extent than in the past by political and economic considerations that can best be understood within the context of a confrontational North-South relationship and the so-called "New World economic order. " This new relationship is characterized by more sharply defined demands of the less developed nations for a redistribution of the world's

*It should be recognized that technically inefficient uses of spectrum may nonetheless be economically most efficient at a particular stage of development for a developing country.

wealth and resources, and for an end to what they regard as exploitation by the industrialized nations. It is also marked by a growing awareness among developing countries that in many international fora where the "one-nation, one-vote" principle prevails they enjoy an advantage in numbers.

There is a long history of international cooperation in radiofrequency matters, but there were forces at work that made agreements difficult to reach at Geneva in 1979. The developing countries were guided by a set of general principles aimed at gaining preferential treatment for themselves (e.g., an Algerian proposal to give priority to developing countries in the use of 70 percent of the high frequency (HF) fixed bands). They demanded guaranteed access to certain congested frequency bands and to the geostationary satellite orbit. They refused to accept the vital importance for national security and financial investment of some advanced U.S. communications systems. Moreover, there was an unwillingness on the part of many developing countries to accept package deals in which a U.S. concession in one area was linked to a developing country concession in another.

WARC-79 also differed in that there were recognizable ideologies in spectrum matters that were associated with particular countries or groups of countries. For example, those countries that already had extensive telecommunication systems were most interested in pursuing expensive efforts to get the most out of spectrum and to identify those frequencies that were not being fully utilized. Countries that were still developing their telecommunication services were anxious to prevent the more sophisticated users from preempting their potential use of large portions of the radio spectrum and geostationary satellite orbit space before they, themselves, could determine their own future needs.

This is not to say that there was unanimity among the Third World nations. They differed sharply in their goals and interests. For example, Brazil was anxious to develop its own satellite communications system and disputed the claims of Colombia and other equatorial nations to sovereignty over the space above their territories where geosynchronous satellites could be parked.

Nor did the developed countries always share the same sense of priority. Other North Atlantic Treaty Organization (NATO) members gave only lukewarm support for certain U.S. military requirements for spectrum and the United States and Canada split over some important issues.

The United States has found it necessary in the past to take reservations and other actions at ITU conferences to protect its interests. The United States took a substantive reservation at the 1937 WARC, refused to sign the Final Acts of the 1950 Mexico City WARC, and did not become a party to the additional radio regulations. However, as noted earlier, the United States has been a strong advocate of compromise and has for the most part refrained from using the accepted practice of taking a reservation on a particular clause or section of the Final Acts of a conference to indicate that the provision would not be considered binding. The only substantive reservation dealing with radio communication taken by the United States in recent years was at the 1974 maritime WARC.

At WARC-79, the U.S. delegation found it necessary to deviate from this policy of setting an example for resolving differences within the conference. The United States ultimately took six reservations, helping to bring the total to 83. Two of the six were directed at political issues but the remaining four have a direct impact on U.S. telecommunication operations. In one of these, the United States rejected the terms of a footnote to the ITU radio regulations that could jeopardize the continuing use of U.S. military mobile satellite systems in the UHF band.

The Impacts of WARC-79

Finding a meaningful way to measure success and evaluate results of an administrative radio conference is not as simple as comparing specific U.S. proposals submitted to the conference with the Final Acts of the conference. While such a comparison is important, it does not reflect the underlying reasons and motives for particular decisions, the problems encountered, or any apparent trends important in evaluating results of an administrative radio conference. It is important to understand the intervening events that underlie decisions, not only to evaluate the results of WARC-79, but to prepare for the many future conferences important to U.S. interests.

The specific consequences of WARC-79 decisions on U.S. interests regarding particular services can best be treated in terms of how the conference dealt with specific technical issues created by some significant trends in telecommunications. These trends include the following:

- A reduction in the use of HF (3 to 30 MHz) by international fixed point-to-point operations as satellite and cable use expands, coupled with the increasing demand for HF spectrum by the more developed countries to meet maritime and international broadcasting needs, conflicts with the desires of the less developed countries to use HF for inexpensive domestic communications.
- The rapid growth in VHF (30 to 300 MHz) and UHF (300 to 3000 MHz) land-mobile operations in the face of continuing vital military requirements and the heavy use of these bands for TV broadcasting now necessitates greater sharing of frequencies, for example, by radiolocation sharing with radionavigation and with other services, and by land-mobile sharing with TV broadcasting.
- There has been rapid growth of both domestic and international fixed-satellite requirements in the super high frequency (SHF) (3 to 30 GHz) spectrum coupled with growth in microwave radio relay, space research, and Earth-exploration satellite services, and the continuing need to protect important radio-astronomy operations.

These requirements are being pressured by new demands to accommodate mobile, navigation, and broadcasting satellites (and their feeder links) in increasingly crowded orbits. Most of these satellite spectrum uses have military as well as civil applications. In addition, there is the continuing use of the SHF spectrum for terrestrial systems.

The actions of WARC-79 with respect to these operational trends and the technical issues they raised either closely reflected U.S. proposals or were acceptable to the United States with certain important exceptions. However, this judgment hardly does justice to the overall results of WARC-79, particularly the future implications for the United States. The long-term trends may be running against the United States in the sense that more problems without apparent solutions are foreseen. The United States finds itself increasingly in a defensive mode, trying to minimize losses rather than seeking significant changes to improve the long-term posture of the United States.

For example, significant amounts of spectrum were added to the allocations for the fixed-satellite service (FSS) in general accordance with U.S. objectives. The technical rules that affect the design and operation, and hence the cost, of satellite systems were generally in agreement with U.S. positions. Where U.S. desires were not precisely met, no significantly adverse repercussions resulted. No immediate or significant changes in the structure or operation of U.S. fixed-satellite telecommunication services will result from conference decisions. No operational or economic dislocation was imposed

on any existing FSS system, and no major burden appears to be placed on the Government, or private operating entities, in order to comply with the decisions of WARC-79 regarding FSS.

However, the conference also adopted a resolution that calls for a space planning conference to be held in two sessions to plan space services using the geostationary satellite orbit. The first session, to be held in 1985, will define the type of planning and determine which services and which frequency bands should be planned. The second session, scheduled for 1987, will do the actual planning. The space conference, as well as the previously scheduled broadcasting satellite conference set for June 1983 to plan broadcasting satellite service in region 2 (the Americas) in the 12-GHz band, are of vital importance and concern to the United States. The ability to implement new technologies and offer new services via satellite in the years ahead depend in part on the decisions taken at these future conferences.

There is a significant difference between the approach advocated by the United States for using the geostationary satellite orbit and any rigid a priori allotment and planning approach advocated primarily by some developing nations. The United States, as well as other countries, has consistently favored a flexible approach that assigns orbit locations and satellite frequencies on a case-by-case basis, often referred to as "first-come, first-served. " The U.S. approach seeks to accommodate needs as required and relies, at least in part, on technological advancements and good engineering practices to "engineer in" the next satellite and accommodate all users. Such an approach is consistent with existing practice under ITU procedures for the notification, coordination, and assignment of radiofrequencies generally.

Many developing countries, on the other hand, see a negotiated plan that assigns specific frequency channels and orbital positions to each country under a rigid a priori allotment plan as a means to guarantee future access. This approach does not depend upon advances in technology or new engineering technologies to assure accommodation of newcomers, but neither does it provide for technological improvements that might be necessary to accommodate growing requirements. The developed countries already have the economic and technological means of launching and utilizing domestic satellite systems; most developing countries do not, even though many do make use of joint user systems like the International Telecommunications Satellite Organization (INTELSAT) global satellite system. The developing nations are concerned that as "late comers" (hence later served) there will be little or no way to accommodate their domestic requirements.

Both a posteriori (the case-by-case approach usually relying on a notice and recordation procedure) and a priori (the collective subdivision approach usually relying on a negotiated plan) have won past acceptance at conferences of ITU. Over the last 75 years one or the other approach has been advocated and used by nearly all nations to allocate spectrum, both internally and internationally. On a domestic level, the a posteriori approach is often coupled with an adjudication procedure for deciding among competing applicants, as is the case in the United States. On the international level, adjudication is almost impossible because of sovereignty claims. Most nations have been unwilling to allow an international body to determine whether they can or cannot use a radio channel or satellite position. Where channels become limited, the recourse in the recent past has been to adopt an a priori method. However, for the allocation of radio bands and services like FSS, which are affected by rapidly changing technology, or which are fraught with political controversy, a priori methods tend to promote too rigid technical specifications or exaggerated claims for channels. Much of the controversy at WARC-79 and that likely to emerge at future conferences, arises from the question

of the appropriate administrative arrangements to determine rights to the use of frequencies free from harmful interference.

Several countries made planning proposals at WARC-79, ranging in scope from planning all services in all frequency bands to allocated space services, planning only FSS in bands newly allocated to that service below 10 GHz. However, it is clear that FSS was the main target of these proposals. Developing a plan of this nature is an enormous undertaking and would not have been possible at WARC-79; however, acceptance of the principle of "planning" was a major goal of the developing countries.

The U. S. delegation worked to prevent any decision to convene a "planning" conference. When it became clear that such a conference would be approved, the United States argued successfully to keep the terms of reference rather broad. The first session of the "WARC on the Use of the Geostationary Satellite Orbit and the Planning of Space Services Utilizing It," scheduled for July 1985, will consider which services and which frequency bands to "plan." Further, the meaning of "plan" will be decided, and will not necessarily be a rigid "a priori" type. The operative thought in determining the type of planning is to provide "in practice equitable access" to the geostationary orbit. The second session of the conference, scheduled for September 1987, will meet to enact the decisions of the first.

It has been the official position of the United States, shared by a number of other countries, that a rigid a priori plan for FSS is bad planning and bad engineering; that it is likely to inhibit technological innovation, result in inefficient use of the orbit and spectrum and have a major adverse impact on U.S. telecommunication systems. Thus, the United States faces a significant challenge over the next few years to develop compelling arguments against a rigid a priori approach and to carry that message convincingly to all parts of the world well before these conferences convene; or to find alternatives acceptable to all parties. Examples of such alternatives are discussed in chapter 5.

The adoption of the space planning conference resolution is a vigorous reminder that the effective management of orbit and spectrum utilization on both a worldwide and a regional basis is a continuing process that is becoming increasingly more difficult and complex. The achievement of U.S. objectives at ITU conferences is no longer a matter of reaching painstaking agreement on technical solutions to problems of coordination and multiple usage of spectrum. It will require sophisticated, political negotiations; imaginative, innovative approaches; and long, hard bargaining.

Perhaps an acceptable compromise will be found regarding the satellite orbit planning issue prior to the 1983 region 2 conference. Nevertheless, the mechanism to develop and test a possible solution before the meeting is not now apparent, and the task of shaping a compromise during the meeting may prove too difficult. While there is no certainty that the majority of the region 2 countries will favor a rigid orbital and frequency allotment plan like the one adopted for regions 1 and 3 at WARC-77 for broadcasting satellite service (BSS), the United States must be prepared for such a prospect nevertheless. According to the OTA survey cited in chapter 3, only 8 percent of the respondents believe that a compromise between the United States and the Third World positions on a priori allotment is impossible; an additional 15 percent believe that a compromise is possible, but undesirable. A majority of the respondents, 68 percent, believe that a practical compromise is possible and desirable, although relatively few have any specific concept of the form such compromise could take. The remaining 9 percent expressed no opinion.

Key Conference Decisions and Their Consequences

The Fixed-Satellite Service

FSS is defined as "a radio communication service between Earth stations at specified fixed points when one or more satellites are used; in some cases this service includes satellite-to-satellite links, which may also be effected in the intersatellite service; FSS may also include feeder links for other space radio communications services."

This definition fails to convey fully both the diversity of applications that already exist, and those that are expected to be accommodated in FSS in the future. The emergence of the wide variety of applications for fixed-satellite service stems in a major way from the properties of a natural phenomenon known as the geostationary satellite orbit. This orbit is circular, some 165,000 miles in circumference, and in the plane of the Equator approximately 22,300 miles above the Earth's surface. At this altitude, a satellite in orbit rotates about the Earth's axis at the same rate as the Earth (one revolution per day) and appears to be stationary when viewed from a point on the Earth. This special characteristic of the geostationary orbit allows an Earth station antenna to point at a geostationary satellite without the need for expensive antenna-tracking equipment. Earth stations in the intended coverage area and a geostationary satellite are continuously visible to each other in contrast to a satellite in any other orbit. These unique characteristics have caused the member nations of ITU to view the geostationary orbit as a "natural resource." The ITU convention recognizes the geostationary satellite orbit as a limited natural resource.

With consideration only for avoidance of physical collisions between satellites, the number of satellites that can be placed in the geostationary orbit is nearly unlimited. However, the current ITU convention recognizes that satellites operating in a common-frequency band must be sufficiently separated to avoid harmful interference. For example, U.S. communication satellites currently operating in the 4- to 6-GHz frequency bands and serving the same or adjacent coverage areas are presently required by the Federal Communications Commission (FCC) to be separated by 4°. It is important to note that the required separation between satellites operating in the same frequency band could be greatly reduced if the coverage areas are separated geographically. For example, satellites operating in FSS with proper antennas could be essentially colocated in the geostationary orbit when one satellite serves the United States while the second satellite serves a South American country.

A second limitation to the capacity of the geostationary orbit occurs as a consequence of geometric considerations. Only a portion of the geostationary orbit is visible from a particular coverage area on Earth. To illustrate, table 2 shows the portions of the geostationary orbit "available" to the various countries in region 2.

Sharing of the geostationary orbit in a particular frequency band is principally a problem of sharing between adjacent countries. For the United States, the sharing problem is largely with Canada and Mexico. The dimensions and capacity of the geostationary orbit available to the United States, assuming an appropriate international coordination approach, is essentially independent of the use of the orbit by countries in regions 1

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Table 2.—Service Arc of Geostationary Orbit

World region	Coverage range	**Visibility arc** for minimum elevation angle of 100 (degrees in west longitude)
North America	Canada, including Yukon and Northwest Territories	**114-116**
	Canada, Vancouver to Halifax.	61-128
	USA, including Hawaii, Alaska, and Puerto Rico.	133-134
	USA, CONUS only.	61-134
	USA, CONUS and Hawaii. .	91-134
Latin America	Brazil	0-109
	Columbia.	10-143
	Chile/Argentina.	10-130
	Total regional coverage . . .	10-109
	Mexico/Caribbean	46-143

SOURCE: Telecommunications Systems Inc.

or 3, or in South America. Conversely, the use of the geostationary orbit by countries in North America should not significantly limit the availability of the orbit for countries in the other regions or in South America. Again, this assumes an appropriate international coordination approach.

In summary of the points made above, the capacity of the geostationary orbit for a particular country operating in a given frequency band is determined primarily by four factors. These are:

1. the dimensions of the available arc as determined by geometric considerations;
2. the characteristics of individual satellites at each orbital position;
3. the separation between satellites operating in that band as required to avoid harmful interference; and
4. the number of adjacent countries planning to operate in the same frequency band.

The usable capacity of the geostationary orbit available to a particular nation may be increased under three of the limiting factors enumerated above. First, the capacity at each orbital position may be increased through application of technology improvements. Frequency reuse, higher satellite power, more efficient and higher gain antennas, and lower noise receivers are examples. The required separation between satellites is a second category of improvement possible through improvements in technology. Interference-resistant modulation methods and improved antenna sidelobe performance are examples. In the third category, the dimensions of the available orbit arc may be extended through the application of intersatellite links. As a first approximation, the available arc may be increased by the latitude extent of the service area. For the United States, the use of intersatellite links might more than double the available arc.

The ability of a country to make these improvements depends on its own level of technological advancement, ability to pay for such improvements, and the sociopolitical needs and trends within the country. Also, the extent to which a country can take advantage of these improvements is determined in part by the actions of other countries. Again, appropriate international coordination and cooperation are required. Chapter 5 discusses alternative approaches for coordinating use of the geostationary satellite orbit.

During the last decade many countries have taken advantage of the telecommunication capabilities offered by the orbit/spectrum resource. As a result there are many domestic satellite systems in operation and being planned, as well as international systems (e.g., INTELSAT) shared by many countries throughout the world. These systems support a variety of services, including broadcasting and maritime-mobile. The specific functions rendered by these established services, and those being planned or foreseen, include:

- Domestic and international point-to-point connections for trunk telephony and television distribution.
- “Thin-route” telephony and instructional television to remote areas.
- Data transmission and computer-to-computer communication.

- Facsimile, teletext, videotext (viewdata), and electronic mail.
- Interoffice connections for teleconferencing, inventory control, and the like, for large organizations.

Central to the utility and the economic attractiveness of satellite systems is their almost unlimited "connectivity" or flexibility; i.e., the possibility of mutually connecting a large number of Earth terminals through a single satellite. Thus, many nations believe that many of their future telecommunication needs can be satisfied by geostationary satellite systems, whether wholly owned or jointly operated by regional entities. This is true for both advanced and developing countries but particularly the latter who hope through the use of satellites to leapfrog many of the problems and much of the time and expense required to install conventional terrestrial communication systems.

At WARC-79, the United States sought to expand the allocations to FSS for both domestic and international use. There was a particular need for frequencies below 10 GHz and this requirement gave rise to considerable controversy throughout the conference. The United States was determined to preserve the status of the radiolocation service in the 3400- to 3600-MHz band, now used by important military radar systems. The band has long been shared with FSS, and in order to facilitate use of FSS systems, particularly INTELSAT, some delegations proposed to downgrade radar to secondary status. A compromise was ultimately worked out that restored primary status for radars subject to a footnote provision urging, but not mandating, ITU members to phase out of the band and to take practicable steps to protect FSS. The United States and several other countries formally declared their intention to accommodate FSS when it is feasible to do so. (This topic is covered in greater detail in a later section.) Allocations to FSS were also made in the 4- and 6-GHz bands.

In other actions, WARC made additional uplink allocations acceptable to the United States, including those at 6425 to 7175 MHz and 17.3 to 18.1 GHz. The former band was allocated to provide the uplink for fixed satellite service in the bands 3400 to 3700 and 4500 to 4800 MHz. Both bands (6425 to 7175 MHz and 19.3 to 18.1 GHz) were needed for feeder links to satellites in other services such as broadcasting and maritime-mobile satellites. Still other downlink frequencies were allocated to FSS in the band 10.7 to 11.7 GHz as the United States had proposed. These frequencies will also be used for the increasing requirements of INTELSAT.

A major objective of the United States was to resolve the difficult sharing situation in region 2 between FSS and BSS in the 1000-MHZ bandwidth at 12 GHz. The conference agreed with the U.S. proposal to separate the two services by allocating the 12.1- to 12.7-GHz segment to the BSS and the 11.7- to 12.3-GHz segment to the FSS. Although the frequency-sharing between the space services was thus largely eliminated (12.1 to 12.3 GHz remains a shared band, but sharing may be completely eliminated by the 1983 regional conference), BSS must now share with the *terrestrial* fixed service including private microwave systems widely used in the United States. This sharing could result in interference to BSS Earth station receivers operating in the same area as private microwave fixed-station transmitters. The private microwave users are concerned that sharing with direct-broadcasting satellites is not feasible and oppose sharing in the 12-GHz band. The concern is that home receivers for direct-broadcasting satellites would receive interference from terrestrial microwave transmitters. As a practical matter, the microwave users anticipate the burden to resolve any resulting interference problems will be placed on them. This concern is reinforced by footnote 3787D of the Final Acts of WARC-79, which places terrestrial services on a noninterference basis to BSS operating in accordance with a plan to

be prepared at the 1983 region 2 broadcasting satellite conference. How this conflict will be resolved within the United States is a current matter before FCC.

Existing FSS allocations at higher frequencies were maintained. In general, all U.S. objectives were met in the bands above 40 GHz (to 275 GHz). These bands will be used in future years as advanced technology is developed and as communication requirements continue to grow.

Apart from the decision to convene a space WARC to "plan" use of the geostationary orbit and related spectrum, WARC-79 will have some longer range impacts on FSS. For example, new allocations to FSS are likely to motivate system designers to exploit these frequencies, especially in the 4- to 6- and 11- to 14-GHz bands where bandwidth was more than doubled. In order to take advantage of this increased capacity, a spacecraft payload built on current technology would have to double in size, weight, and power requirements. To keep these at a minimum we may see renewed efforts at material development, to build, for example, lighter weight filters, more efficient solar cells and space-qualified solid-state amplifiers. The availability of the U.S. Space Transportation System (Shuttle) will have increasing impact on the capacity and costs of satellite systems, particularly when the shuttle attains full capability to locate spacecraft in geostationary orbit. The large bandwidth available may also create opportunities in traffic routing flexibility not possible with smaller bandwidths. This may stimulate spacecraft switching technology and the associated satellite-switch logic, as well as the development of shaped spot beams.

Generally speaking, the impact of WARC-79 on the availability and cost of FSS systems was favorable because substantial increases were granted in the "lower" frequency bands where technology is well developed and relatively economical. WARC also reaffirmed the FSS allocations near 20 and 30 GHz where the next generation of domestic communication satellites is now under development. When this new generation of satellite systems becomes operational, in a decade or more, there are likely to be lower costs and higher availability both in new types of services and in number of users, particularly those in remote areas.

U.S. operating practices for planning, allocating, managing, and using the spectrum allocated to FSS have not been altered as a result of WARC-79 decisions. The expansion of allocations would seem to mitigate some policy conflicts that might have existed before. For example, the guiding U.S. policy for commercial FSS systems has been to permit any financially and technically qualified entity to compete in the marketplace. The decision to allocate separate bands to FSS and BSS about 12 GHz serves to alleviate, at least temporarily, a potential problem area.

The results of WARC-79, insofar as FSS is concerned, do not impose any hardships on the Government to comply with the demands contained in the Final Acts. Some effort will be required to amend the existing documentation, manuals, and computer programs to reflect the new regulations and modifications to the old ones, but this is a one-time effort.

A related obligation concerns technical assistance to developing countries. WARC-79 adopted a series of resolutions and recommendations that call on the industrialized nations to give additional help to the Third World in telecommunciations. FSS is the service that developing countries look to for satisfying many of their needs. These resolutions and recommendations are basically in line with the U.S. approach to technical assistance since they regard the United Nations Development Program (UNDP) as the primary source of financing. They do not call for the establishment of either mandatory or voluntary funds for technical cooperation. But the question arises as to whether, and to what extent, it is desirable or necessary, as an extension of U.S. foreign policy, to offer unilateral assistance to developing countries

with a view to influencing their attitudes on FSS "planning" and other issues. The potential benefits of using U.S. technology and expertise to provide assistance and develop closer coordination and planning activities with developing countries are discussed in chapter 5.

The Fixed Service

The fixed service above 1 GHz supports communication systems that are more commonly known as microwave, radio-relay systems and widely used in the United States by common carriers, Government agencies, and business.

Substantial frequency allocations between 1 and 40 GHz were made to the fixed service by the 1959 WARC. Those allocations (particularly those between 1 and 15 GHz) have been used extensively and considerable effort has been expended on the design of radio-relay equipment and field engineering methods. As a result, the available allocations have been used very efficiently. Increasingly large volumes of communication have been squeezed into each radio channel and there has been careful planning of adjacent systems to avoid excessive interference.

Because of the highly efficient use of existing allocations, there were few proposals at WARC-79 for changes. Those changes that were adopted by the conference consisted mainly of attempts to aline the allocations among the three regions and, by means of footnotes, to accommodate the specific needs of individual countries.

More significant for the fixed service were new allocations made to the space services that will permit additional use by those services, on a coequal basis, of bands already allocated to the fixed service. Such sharing was first included, on a limited basis, in the allocation table of 1963 as a means of accommodating the new concept of communication satellites. At that time technical criteria were introduced to control the amount of interference each service might impose on the other.

Sharing is not without cost, but these penalties have been felt to be in the interest of overall efficient use of the spectrum by all services in order to permit additional use of the frequency bands. There is a price paid in the practical use of radio-relay systems in the shared environment because of the need to shorten repeater spacings and to undertake complex route engineering to avoid interference to or from satellite Earth stations. This can result in the need to build more expensive repeater sites or even the addition of extra repeater stations to bypass a problem; it can also require a shift in frequency bands or, in extreme cases, switching to cable for some route segments.

With new provisions for sharing in additional bands, and with additional types of space services, the pressure on radio relay system design will be increased. The conference recognized this as a complex problem and identified several aspects of sharing on which further consideration and refinement are needed and asked the International Radio Consultative Committee (CCIR) to undertake appropriate studies.

The decisions of WARC-79 affecting the use of microwave radio relay systems do not mandate any drastic reconsideration of U.S. practices in allocating and managing the spectrum. The principal new allocations are those between 40 and 275 GHz, which open up a number of new, wide bands for the fixed service that are shared with several other services. There will be decisions to be made on whether any of these bands is to be limited domestically to an individual service instead of being shared broadly as provided in the international table, and whether any should be identified exclusively for U.S. Government or nongovernment use.

In order to simplify the administrative process for certain countries which otherwise might need to coordinate with a number of neighboring states, the radio regulations were revised and simplified at the risk of creating future interference problems. The changes were opposed by the United States, Canada, and others as counterproductive.

Potential policy conflicts involving the fixed service arise from WARC decisions on the shared use of frequency bands with space services. Such sharing requires accommodation or even sacrifices on the part of each service. How much sharing will be allowed, and the degree to which one service will be affected in order to facilitate the other, become policy determinations that are little appreciated at present.

The most conspicuous case that will require action in the near future is the treatment of the 12.1- to 12.7-GHz band. There, BSS will now share with private microwave systems. The use of sensitive receiving installations in BSS coupled with the necessity to locate them at any place within the service area of the satellite, essentially precludes radio-relay operation within the coverage area of a broadcasting satellite on any radio-frequency channel to be used for satellite broadcasting. Hence, the extent to which channels and areas are reserved for broadcasting, to the exclusion of private microwave systems, is under study in the United States and will be a major policy determination.

Another area of potential conflict is the sharing of frequency bands by the mobile-satellite service (MSS) and FSS. MSS is a different category of service than the discrete services like maritime MSS or land MSS. It was developed primarily for military satellite communications use, wherein the Earth station may be located from time to time anywhere within a defined area (and even operated in moving vehicles such as aircraft and ships), rather than being limited to a fixed, predetermined location. So far there has been little practical experience of this type, but the idea that a small essential area around the radio-relay station would be protected, while a large area would be reserved for the convenience of the mobile-satellite Earth station is a concept not fully understood or accepted. Because of these concerns, the conference made only very limited allocations to MSS.

As noted earlier, the provisions for space systems to share frequency bands with the fixed service tend to complicate, make more expensive, and even inhibit the growth of radio-relay systems, but in the past this has not resulted in the dislocation of existing services or systems.

The new allocations for broadcasting satellites to share in the 12.2- to 12.7-GHz band may well cause dislocations to private microwave systems. Frequency sharing will be quite a different problem from that in other "shared" bands. In fact, licenses being issued now for private microwave stations bear a warning to the effect that continued operation is not assured.

Distribution of television by terrestrial radio-relay systems may also suffer dislocations, depending on the ultimate decisions on sharing conditions. The 6.425- to 6.525-GHz band, which is the principal band used by common carriers for service to broadcasters and for closed-circuit uses such as medical demonstrations and sporting events, and the band 6.875 to 7.075 GHz, which is heavily used by the broadcasters, are now to be shared with satellites.

The Land-Mobile Service

For the past 20 years, land-mobile has been one of the fastest growing radio services. Not only has use of land-mobile radio systems increased for local governments, businesses and for other specialized uses, but land-mobile use as part of the terrestrial telephone network has increased greatly. Further growth can be expected with the advent of cellular public telephone systems and the increase of private radio requirements.

The United States has already added land-mobile to portions of the UHF television band 470 to 890 MHz in the U.S. domestic table of allocations, an action permitted under the ITU's radio regulations, provided no interference is caused to stations of other countries operating in those frequencies. The

United States proposed at WARC-79 that most of the band 470 to 960 MHz be allocated to the land-mobile service, sharing on a primary basis with broadcasting in the lower part, and with fixed and radiolocation services in the upper part. This would permit each country in region 2 to determine which of the internationally allocated primary services would be implemented in their own areas.

WARC only partially accepted these proposals. The mobile service was added to the bands 806 to 902 MHz on a primary basis, but on a secondary basis in the bands 470 to 512 MHz and 614 to 806 MHz. A footnote raises mobile to primary status in the United States, with the provision that such use is subject to the coordination procedures of article 14 of the radio regulations. The United States submitted a protocol statement rejecting the article 14 procedure, however, the requirement for coordination, coupled with the continued use of 470 to 512 MHz in Canada for broadcasting, and the use of band 614 to 806 MHz in both Canada and Mexico for the same purpose, makes our use of these bands for the mobile service problematic. A similar situation prevails regarding U.S. proposals for the 902- to 960-MHz band where the United States, Canada, and Mexico use the same segments for competing services and where coordination in border regions may be difficult.

The United States must determine its policies and means to follow through on this declaration. There are no FSS Earth stations currently operating in the 3.4- to 3.6-GHz band. In its declaration, the United States agreed not to withhold support if INTELSAT decided to undertake FSS in that band. If such a decision was implemented, the United States would be under strong pressure to restrain radar operations that might interfere with international satellite operations.

The HF Broadcasting Service

In recent decades, growing numbers of countries have turned to HF (shortwave) broadcasting to carry news, entertainment, comment, and propaganda to audiences beyond their own borders. The potential effectiveness of these broadcasts has been hampered by two factors: 1) the congestion of the shortwave frequency bands by more and more stations with ever-higher transmitter power, resulting in unintentional interference; and 2) jamming—the deliberate interference with broadcast signals.

WARC-79 offered the first opportunity since 1959 for the international community to attempt to alleviate the present congestion in HF broadcasting and the United States went to the conference seeking a substantial expansion of spectrum allocated to this service. The United States did not win approval for all its proposals but the overall outcome was satisfactory from both the technical and political standpoints. As a result of WARC-79, congestion and interference should be reduced considerably by the end of the 1980's and reception of HF broadcasts should be clearer. For the United States, this will benefit the Voice of America, Radio Free Europe/Radio Liberty (RFE/RL), the Armed Forces Radio and Television Service, and several private organizations engaged in HF broadcasting.

To reduce interference and congestion, the conference agreed to an increase of 850 kHz in the HF broadcasting bands between 9 and 21 MHz, including the creation of a new 13-MHz band. This represents an overall increase of 33 percent in the allocation for HF broadcasting. The United States had proposed a 46 percent increase, while the Soviet Union asked for no increase at all. The compromise was the result of an initiative by nonalined countries and it was especially welcomed because the allocation will ulti-

mately become exclusive, although it remains shared until the fixed service operations now using it can be reaccommodated. Despite appeals by the United States and other countries, proposals to expand the important 6- and 7-MHz bands failed by very narrow margins, largely because many developing countries claimed a continued need for these bands for other forms of communication.

WARC-79 also agreed to convene a specialized HF broadcasting conference in the mid-1980's to plan for the more efficient and equitable use of the broadcasting bands, and it tied the bringing into force of the new allocations to the effectiveness of this conference. The United States initially opposed this follow-on conference but switched to support the idea when it became apparent that WARC was running behind schedule and that U.S. interests might suffer substantial damage in the atmosphere of frustration that prevailed.

The United States achieved one goal by keeping open the scope and character of the follow-on conference; the agenda will be open and the meeting does not constitute an assignment or allocation conference. Nevertheless, there are potential problems with this follow-on conference. Political issues, such as "prior consent," could prove troublesome. Also, as noted above, the increased allocations to HF are dependent upon success in accommodating the fixed services that were ousted from the spectrum given to international broadcasting. For this reason, the United States, together with the United Kingdom, Spain, Greece, Saudi Arabia, Cyprus, Sri Lanka, and Zambia in a multinational protocol statement, reserved the right—in the absence of an adequate plan—to take the necessary steps to meet the needs of the HF broadcasting services. Similar independent reservations were made by 17 other countries. (Three host countries for RFE/RL transmitters–West Germany, Spain, and Portugal–were among those taking reservations.)

In an effort to deal with the continued problem of deliberate jamming by the Soviet Union and other Communist bloc countries, the United States made the following protocol statement at the conclusion of the conference:

> Administration of the United States of America, calling attention to the fact that some of its broadcasting in the high frequency bands allocated to the broadcasting service are subject to willful, harmful interference by administrations that are signatory to these Final Acts, and that such interference is incompatible with the rational and equitable use of these bands, declares that for as long as this interference exists, it reserves the right with respect to such interference to take necessary and appropriate actions to protect its broadcasting interests. In so doing, however, it intends to respect the rights, to the extent practicable, of administrations operating in accordance with these Final Acts.

Other smaller countries, like Iran, also complained of Soviet jamming which, although not directed at them, interfered with their broadcasting. Neither the Soviet Union nor any of the other Eastern bloc nations that currently jam U.S. broadcasts submitted an official statement to answer the U.S. complaint.

U.S. delegation representatives who dealt with HF broadcasting issues reported that the nonalined movement countries generally supported or opposed U.S. positions on the basis of their own interests and not for ulterior political motives. Some of the strongest opposition to U.S. proposals came from Latin America, especially on the issue of fixed services v. broadcasting. Brazil and Costa Rica proved to be more influential than Cuba in controlling the Latin American delegations.

The Soviet Union, which often operates HF broadcasting stations "out of band," i.e., using frequencies allotted to some other service, did not request additional HF broadcasting frequencies. However, this

may be explained by the fact that the Soviet Union entered a protocol statement in the Final Acts of the 1959 General Administrative Radio Conference regarding HF frequency bands and thus the Soviet Union does not consider their operations "out of band."

National Security Systems

This report deals at length with the consequences to U.S. national security of decisions reached at WARC-79. The extensive treatment is not intended to disparage the importance of WARC for other U.S. interests. It arises, rather, from the peculiar nature of DOD communications requirements and their broad-ranging use of satellites and radiofrequency spectrum.

The Final Acts of WARC-79 represent a generally acceptable compromise that satisfied most U.S. national security needs but will require some significant changes in the coming years. Greater numbers of different operations will have to make use of the same frequency bands; systems will need greater frequency flexibility to cope with competing users of the spectrum. The magnitude and cost of these changes cannot be known for some time; they will be determined in part by the manner in which the new radio regulations agreed on at WARC-79 are actually implemented worldwide.

Without being pessimistic, it should be noted that most of the major reservations that the U.S. delegation took at WARC-79 involved national security considerations. This fact by itself justifies a thorough look at the short- and long-term consequences for U.S. security of decisions reached at the conference.

Military systems must be prepared to operate anywhere in the world, and geographical restrictions on some bands generate additional requirements for frequency flexibility—sometimes demanding costly increased design and operational complexity.

The problem of "universality" is partly solvable through bilateral and multilateral agreements, but there is still a significant impact on system planning and operation. Some military systems are fielded in a less advanced state of development than their civil counterparts. As a result, they must be adjusted more. They are also used in field tests and exercises, and the frequency coordination is an important component of the planning. Nevertheless, advanced technology developments can provide some solutions.

Military-Related Issues and Objectives

The security of the United States depends on economic health as well as defense posture. The following discussion, however, focuses on the major military-related issues and objectives that were identified going into WARC-79:

- Radiolocation (radar)
  - – Minimize encroachment of radar bands, below 1000 MHz, especially in the 400- and 800-MHz bands, and at 3.4 and 5 GHz.
- Satellites (radionavigation)
  - – Provide for NAVSTAR Global Positioning Satellite (GPS) at 1,227 and 1,575 MHz.
- Satellites (communications)
  - – Recognize and provide for MSS.
  - – Obtain reasonable sharing criteria for MSS.
  - – Avoid any a priori plans that would allocate or preposition geostationary orbit spacing.
- High frequency (HF)
  - — Insure adequate HF allocations for non-line-of-sight (NLOS) nonsatellite strategic communications, beyond line-of-sight (LOS) tactical communications.
  - – Avoid regulatory limitations that would inhibit over-the-horizon (OTH) radars.
- . Fixed and mobile (terrestrial)
  - – Maintain status quo in the 4400- to

4900-MHz band, pertinent to NATO requirements.
  - Retain the 14.5- to 15.35-GHz bands for fixed and mobile systems pertinent to NATO requirements, and minimize the growth of the space services in these bands.
- Intelligence
  - Avoid any regulations that limit or reduce flexibility of operation.

One part of the U.S. preparation strategy was to participate in and strengthen the International Radio Consultative Committee (CCIR) of ITU as a technical forum. Toward that end, DOD participated actively in the work of CCIR study groups, the CCIR XIV Plenary held in Kyoto, Japan (June 1978), and in the CCIR special preparatory meeting (SPM) for WARC-79 held in Geneva in October 1978. DOD prepared substantial documentation for SPM in the following technical areas:

- G P S
- Mobile-satellite systems
  - Sharing criteria
  - Coordination areas
- Radiolocation
  - Sharing
  - Signal characteristics
- Mobile sharing with fixed service (HF band)
- Spread-spectrum techniques
- Techniques above 50 GHz.

The documents prepared for the CCIR plenary and SPM by DOD were in most cases adequate technically to support the DOD positions at WARC; however, the decisions ultimately taken at WARC-79 did not necessarily turn on technical data. It should be recognized that CCIR work is a continuing program and future active U.S. and DOD participation is essential.

The results of WARC-79 are provided in the Final Acts, and the overall results as they pertain to the United States have been summarized by Ambassador Robinson and the members of the delegation. The national security impacts have been considered in a report to the Air Force, and DOD has provided a national security assessment to the Senate that will consider the Final Acts for ratification as a treaty. The DOD consensus is that with some exceptions, the WARC-79 outcome did not degrade the national security of the United States. However, it is recognized that costs must increase in the future. Some of the results and an estimate of their impact on national security were apparent immediately after the conference. For example, our national security posture was improved when the United States:

- Obtained provisions in the allocation table that accommodate the NAVSTAR-GPS on a worldwide basis; and
- Obtained provisions for the operation of mobile-satellite terminals at 7 and 8 GHz (although the specific frequency bands are not consistent with the current design and channelization plans for the DSCS [Defense Satellite Communications System] III).

While the United States as an entity minimized its losses due to conference actions, DOD (as a major U.S. international user of the radio spectrum) did bear the brunt of the loss of flexibility for use of the spectrum (e.g., radiolocation). The United States took six reservations, four of which dealt directly and one of which dealt peripherally with decisions that could adversely affect national security.

It should be recognized that the total impact of WARC-79 will take some time to assess due to the interdependence with implementing actions of other nations, particularly those with whom the United States is allied militarily.

Spectrum Availability for National Security

Major national security questions are: "What portions of the radiofrequency spectrum are available for DOD use, and what was the effect of WARC-79 allocation actions on DOD's capability to perform its mission?" There is no simple, single answer to

these questions. However, one method of gaining some perspective is to examine the status of the major radio bands and services employed by DOD in the revised table of allocations developed by WARC-79 and compare it with the existing table. The bands below 27.5 MHz and above 15 GHz are treated on a *band* basis; whereas, between 27.5 MHz and 15 GHz the changes are treated on a *service* basis for the fixed, mobile, radiolocation and fixed-satellite and mobile-satellite services. All of these bands and services are vital to U.S. national security. They are used: for example, for command, control, and intelligence systems; for radionavigation; for military weapon systems that use radiosignals for guidance and targeting; for early warning and all forms of communication. Moreover, they must operate in all parts of the world under various conditions of competing spectrum use.

Bands Below 4 MHz

The following changes were made in the bands below 4 MHz:

- The radionavigation service in the very low frequency (VLF) and low frequency (LF) bands was expanded. This was a U.S. proposal for protection of nongovernment and military operations.
- The medium frequency (M F) spectrum for AM broadcasting was expanded to 1605 to 1705 kHz.
- Fixed and mobile operations between 2 and 4 MHz were maintained; however, footnotes and power limitations were specified in an attempt to reduce interference.

The HF Band (4 to 27.5 MHz)

The United States proposed to reduce allocations to the fixed service by 18 percent and reallocate these frequencies to the maritime-mobile, broadcasting, radio astronomy, amateur, and mobile (except aeronautical-mobile) services. While there was only a 14-percent reduction in HF spectrum available to DOD, the exclusive bands were reduced by over 65 percent. The shared use of bands by service was greatly increased. The conference made significant reallocations to maritime (including several new bands above 10 MHz) and to international broadcasting operations. This led, in part, to U.S. reservations. The aeronautical-mobile service bands were not changed. A detailed reaccommodation procedure, whereby services displaced would be provided for elsewhere in the spectrum, was a part of the revised HF allocation agreement. The conference action lessened the number of assignments that may be affected. The time frame for completion of the changeover as specified by the conference further reduces the overall impact on DOD and other HF users. The immediate procedure is for each administration to review all the HF fixed service listings in the international frequency list as furnished by the International Frequency Registration Board (IFRB). This review will:

- Delete entries not required.
- Identify remainder by category, regular operational use, standby, occasional use on a reserve basis.
- Determine hours of operation.

IFRB was to be advised by March 1981 of the administrations' findings. Then, beginning in July 1984, administrations will be required to effect the changeover from the old assignment to a new assignment. For bands above 10 MHz the changeover will be completed by July 1, 1989, and for bands below 10 MHz by July 1, 1994. (Tables 3 and 4 show the distribution of the HF band before and after WARC-79.)

The 20-, 30-, 40-GHz Bands

In the bands at 20, 30, and 40 GHz, virtually all U.S. requirements for FSS and MSS were met, though in certain instances the sharing with other services as agreed by the conference may not prove to be feasible. The MSS proposals in these bands were companion to MSS proposals in the 7- to 8-GHz bands. The successes achieved will strengthen military communications by satellite.

Table 3.–Distribution of the HF Band (4000 to 27,500 kHz) Before WARC-79

Service	Exclusive		Shared		Total	
	kHz	Percent	kHz	Percent	kHz	Percent
Fixed service	10,157	43.2%	4,348	18.5%	14,505	61.7%
Maritime mobile	3,850	16.4	2,202	9.4	6,052	25.8
Land mobile	—	—	4,177	17.7	4,177	17.7
Broadcasting	2,350	10.0	300	1.3	2,650	11.3
Aeronautical fixed and mobile	1,795	7.6	50	0.2	1,845	7.8
Amateur	900	3.8	–	–	900	3.8
Others	116	0.5	–	–	116	0.5

SOURCE. H A. Feigleson, "High Frequency in the Future," IEEE *Trans. EMC,* vol. *23, No. 3,* August 1981, draft

Table 4.–Distribution of the HF Band (4000 to 27,500 kHz) After WARC-79

Service	Exclusive		Shared		Total	
	kHz	Percent	kHz	Percent	kHz	Percent
Fixed service	3,704	15.8%	8,191	34.9%	11,895	50.7%
Maritime mobile	4,650	19.8	158	0.6	4,808	20.5
Land mobile	—	—	2,120	9.0	2,129	9.0
Other mobile	—	—	6,442	27.4	6,442	27.4
Broadcasting	2,930	12.5	250	0.1	3,180	12.6
Aeronautical	1,815	7.7	80	0.3	1,895	8.0
Amateur	1,300	5.5	50	0.2	1,350	5.7
Others	200	0.8	66	0.2	266	1.0

SOURCE: H. A. Feigleson, "High Frequency in the Future," IEEE *Trans. EMC,* vol. *23, No, 3,* August 1981, draft.

Fixed Service

Table 5 is a summary of WARC-79 gains and changes in status on fixed allocations between 27.5 MHz and 15 GHz as reflected in the allocation tables. Between 15 to 40 GHz there were no changes to the fixed service allocation tables; and, above 40 GHz, the gains were extensive—virtually assuring frequency support for DOD fixed requirements above 40 GHz. The table does not show those fixed bands that were unchanged, but does give a measure of the gains made by the fixed service. However, between 1 and 15 GHz, the fixed service gains were made by sharing with the radiolocation and FSS.

Some gains in spectrum allocations for the fixed service are not in DOD's best interests, though the results were expected at the conference. The 420- to 430-MHz and 440- to 450-MHz bands contain important DOD radiolocation systems that are expected to have a long lifetime. These systems will now have to share with the fixed service. The allocation changes imposed by WARC will have a significant effect on the operation of these systems. The allocation of the fixed service on a primary basis to the 7250- to 7300- and 7975- to 8025-MHz bands was also expected (but not welcomed) by DOD. DSCS operates uplinks in the 7900- to 8400-MHz band and downlinks in the 7250- to 7750-MHz band. Airborne satellite communication operations are planned for the 7975- to 8025-MHz band, which was an exclusively allocated satellite band in most of the world prior to WARC-79, although this "exclusivity" was already diluted significantly by footnotes. Coordination of airborne satellite operations in a band with existing fixed systems within the United States has been very difficult. The proliferation of fixed communication systems will exacerbate this problem.

The band 4400 to 4990 MHz, is in heavy use by the military service for tactical communications, including tropospheric scatter operations; and in NATO Europe it has been designated a military band. In 1963, a

Table 5.—Summary of WARC Gains and Changes in Status on Fixed Allocations Between 27.5 MHz and 15 GHz

Frequency band (MHz or GHz)	Region(s)	Bandwidth MHz (nearest tenth) Primary	Secondary	Change MHz	Prior major use of the band
27.5-28 MHz	1	0.5		+ 0.5	Met aids
41.015-47	1	6		6	BC
54-68	2		14	14	BC
68-72	2		4	4	BC
74.6 -74.8	2 and 3	0.2		+ 0.2	Aero nav
75.2 -75.4	2 and 3	0.2		+ 0.2	Aero nav
76-88	2		12	12	BC
136-138	All		2	+ 2	Space research
146-148	3	2		+ 2	AM
174-216	2		42	42	FX MO BC
220-225	2	5		+ 5	AM RL
230-235	1	5		5	Aero nav
420-430	2 and 3	10		+ 10	RL
440-450	2 and 3	10		+ 10	RL
470-512	2		42	+42	BC
470-610	3	140		+ 140	BC and Rnav
614-890	2	84	192	+ 276	BC
1435-1525	2	90		90	MO
1530-1535	1 and 3		10	10	Space OPS
1660.5-1670	All	1.6	7.9	+ 9.5	Met aids
2300-2450	2 and 3	150		150	RL
3300-3400	2		100	+ 100	RL
3400-3500	2 and 3	100		+ 100	RL and FX satellites
4990-5000	2	10		+ 10	Radio astronomy
5850-5925	2	75		+ 75	RL
7250-7300	All	50		+50	FX satellite
7975-8025	All	50		+50	FX satellite
10-10.45 GHz	1 and 3	450		+ 450	RL
10.5-10.55 GHz	2 and 3	50		+50	RL
14.3 -14.4 GHz	1 and 3	100		+ 100	FX satellite and nav satellite

SOURCE Systematics General Corp., "The World Administrative Radio Conference 1979," final report

U.S.S.R. proposal for the inclusion of FSS, Earth-to-space on a primary basis in the band 4400 to 4700 MHz was accepted as part of a conference compromise among the United States, United Kingdom, and the Union of Soviet Socialists Republics. To date there is no known satellite use of this band; however, the INTELSAT intentions to use this band became apparent at WARC-79. This desired use became coupled to negotiations related to the band 3400 to 3700 MHz. In order best to protect current known operations in the band, FSS was shifted to 4500 to 4800 MHz (sharing with the fixed and mobile services), and its direction was changed to space-to-Earth. The bands 4400 to 4500 MHz and 4800 to 4990 MHz remain primarily fixed and mobile, except that in the subbands 4825 to 4835 MHz and 4950 to 4990 MHz the aeronautical-mobile service is excluded.

Mobile Service

The summary of WARC-79 gains, losses, and changes in status on mobile allocations between 27.5 MHz and 15 GHz is given in table 6. As can be noted, the differences between tables 5 and 6 are minor, and many of the comments concerning the fixed service changes apply to the mobile service. While the mobile service has several reductions in the status of the service, it suffered no loss of a band.

Radiolocation (Radar)

In the United States, the radiolocation service provides the spectrum support for

Table 6.—Summary of WARC Gains, Losses, and Changes in Status on Mobile Allocations Between 27.5 MHz and 15 GHz

Frequency band (MHz or GHz)	Region(s)	Bandwidth MHz		Change MHz	Prior major use of the band
		Primary	Secondary		
27.5-28 MHz	1	0.5		+ 0.5	Met aids
41.015-47	1	6		6	BC
54-68	2		14	14	BC
68-72	2		4	4	BC
74.6 -74.8	2 and 3	0.2		+ 0.2	Aero nav
75.2 -75.4	2 and 3	0.2		+ 0.2	Aero nav
76-88	2		12	12	BC
100-108	1	8		–8	BC
136-138	All		2	+ 2	Space research
146-148	3	2		+ 2	AM
174-216	2		42	42	FX MO BC
220-225	2	5		+ 5	AM RL
230-235	1	5		5	Aero nav
420-430	2 and 3	10		+ 10	RL
440-450	2 and 3	10		+ 10	RL
470-512	2		42	+42	BC
470-610	3	140		+ 140	BC and Rnav
614-980	2	110	236	+ 346	BC FX RL
862-960	1	98		+ 98	BC FX
1660.5-1670	All	1.6	7.9	+9.5	Met aids
2300-2450	2 and 3	150		150	RL
3300-3400	2		100	+ 100	RL
3400-3500	2 and 3		100	+ 100	RL and FX satellites
3400-3600	1		200	200	FX and FX satellites
4990-5000	2	10		+ 10	Radio astronomy
5850-5925	2	75		+ 75	RL
7250-7300	All	50		+ 50	FX satellite
7975-8025	All	50		+ 50	FX satellite
10-10.45 GHz	1 and 3	450		+ 450	RL
10.5-10.55 GHz	2 and 3	50		+ 50	RL
11.7 -12.5 GHz	1		800	800	FX BC and BC satellites
11.7 -12.1 GHz	2		400	400	FX FX satellite BC satellite
14.3 -14.4 GHz	1 and 3	100		+ 100	FX satellite nav satellite

SOURCE Systematics General Corp., "The World Administrative Radio Conference 1979," final report,

certain Government operations—principally military radars. Frequency management for this service, including assignments, coordination, etc., is under the jurisdiction of the National Telecommunications and Information Administration (NTIA) but operational responsibility is with DOD and the Federal Aviation Administration. As such, radiolocation proposals and associated position papers were generated in DOD with the aims of national security in mind. It should be noted that radar systems for different purposes and with different technical characteristics and operational requirements are used by many other telecommunication services and are administered by other agencies. Thus, radionavigation radars generally fall under the operational purview of the Department of Transportation, meteorological radars under the Department of Commerce, and Earth exploration satellite radars with the National Aeronautics and Space Administration. Nongovernment radar users are regulated by FCC.

It should be noted further that not all systems in the radiolocation service are radar systems. These other systems include highly accurate, position-fixing systems similar in principle to the Loran and Omega hyperbolic radionavigation systems. Used for surveying purposes such as offshore oil exploration, these systems are technically navigation devices but have been traditionally operated in the radiolocation service, using its frequency allocations and subject to its technical

standards. The existing allocation for radiolocation (and the proposals to retain them) have a firm foundation in the technical aspects of radio wave propagation and radar system missions.

During the preparation for WARC, problems were foreseen in three major areas involving seven different bands. Problems in the UHF band were deemed particularly important because this is the frequency range best suited for the long-range, air-surveillance mission. Prior to WARC-79, a worldwide primary allocation existed for radiolocation in the band 430 to 440 MHz, while in regions 2 and 3 it extended from 420 to 450 MHz. It was known that there would be intensive pressure for allocation of these bands to the fixed and mobile services. The U.S. position, therefore, was to retain at least the existing worldwide primary allocation and acquiesce to secondary status in the adjoining bands, if necessary. WARC did, in fact, arrive at this result along with a reduction to secondary status in the 890- to 942-MHz band. By country footnote, the United States retained a primary allocation for itself in those bands where the status had been reduced. It is the position of DOD that the radar system using these bands have sufficient flexibility to perform their mission. All of the systems involved have some modes of operation that could create undesirable interference. However, the retention of primary status in the United States will provide sufficient training opportunities to maintain operator proficiency in these modes. The WARC results fell reasonably within the U.S. fall-back position in these bands until the fixed and mobile footnotes started mounting up. Unable to control the flood of countries participating in these footnotes, the United States entered the reservation contained in Protocol Statement No. 38.

Of the three bands noted as problem areas in the fixed-satellite and radar sharing area, only the 3.5-GHz band was a serious problem. The 17.5-GHz band will require further study but raises no immediate hardships, and the anticipated problems at 5.5 GHz never materialized. The U.S. proposal contained provisions to meet the well recognized need for additional bandwidth for FSS in the frequency bands below 10 GHz. At the same time, the United States was committed to retaining spectrum support for major military radar systems in the 3.4- to 3.6-GHz band. Predictions of pressures to turn this band over to FSS were indeed fulfilled at WARC. The intensive, and sometimes acrimonious, negotiations included at one time the submission of a proposed footnote by the United States that would exclude FSS in the United States from operating in the 3.4- to 3.7-GHz band. The final result was a compromise; a compromise achieved by the removal of any mandatory requirement to stop radar operations in the band. In addition to the allocation status defined in the table of allocations and the footnotes, a declaration was signed by several members of INTELSAT (the United States included) that says, in part, “they shall make reasonable effort to accommodate FSS.” Thus the status of radiolocation was retained, but with the foreknowledge that the pressure from the fixed-satellite community, both internal and external to the United States, would continue.

In the 17.3- to 17.7-GHz band, the secondary status for radiolocation was part of the U.S. fallback position because of the very limited current use of the band by radar systems. By footnote, WARC-79 decreed that the band could be used for broadcast satellite uplinks, and this action was acceptable to the United States. With such usage, further study may show that radiolocation operations are possible with an acceptably low probability of interference.

The United States was well aware of the spectrum crowding occurring in the radionavigation bands and had made several proposals to alleviate it. Proposals from other countries sought to temper the problem by combining radionavigation and radiolocation into a common service—radio-determination—or by adding radionavigation as a coequal sharing partner with the radiolocation service. In addition to adopting some of

the U.S. proposals for beacons, transponders and the like, WARC opted for making radionavigation an equal partner. However, WARC came painfully close to defining aeronautical and maritime radionavigation as safety services, an action that would have included these services in the regulation regarding harmful interference to safety services. This action may be interpreted to give preferential status to the radionavigation service and bodes ill for the equality of the partnership. The U.S. recognition of this state of affairs is contained in the reservations taken in the affected bands in Protocol No. 38.

The radiolocation portion of the U.S. proposals to the WARC sought the following four major items:

1. retain radiolocation allocations in all existing bands except 216 to 225 MHz;
2. provide adequate provision for radiolocation above 40 GHz;
3. include allocations for space radar; and
4. provide worldwide primary allocations for high-accuracy, position-fixing radiolocation systems between 1615 and 3400 kHz.

In a strictly literal sense, all four objectives were met. From a practical point of view, however, only items 2, 3, and 4 can be claimed as truly successful. Concerning the first point, the existing radiolocation allocations were indeed retained, but the addition of other services on a primary basis will have a significant effect on the design, development, performance and operations of radiolocation systems operating between 400 MHz and 40 GHz.

Item I.–Table 7 compares the status of the radiolocation allocations between the existing radio regulations and those created by the Final Acts of WARC-79, indicating in the final column the changes that were made in the table of allocations. It is seen that the status of radiolocation was reduced in six bands. In all of these bands, pre-WARC negotiations had indicated that pressure for reductions was likely to be heavy. Consequently, fallback positions were prepared and, with one exception, adhered to during WARC. The one exception was in the 890-to 942-MHz band where radiolocation was reduced to a secondary service in region 2. This reduction was mitigated by the addition of footnote 3669A, which provides primary status to this service in the United States. The footnote was weakened by Canada's insistence on making the footnote subject to the procedures of article N13A. This amendment was unacceptable to the United States and formed the basis for a portion of the bands covered by the reservation noted in paragraph 4 of Protocol Statement No. 38 (which deals with the larger band 890 to 960 MHz). Thus, the objective of retaining radiolocation allocations has been met and, as such, continues to make available the frequencies required for the development and operation of radiolocation systems in the United States.

Not apparent from table 7, however, is a host of key decisions with respect to four other services that will greatly affect the radiolocation service. These four services are the fixed and mobile services (which will be discussed as a pair), the radionavigation services (including the aeronautical and maritime radionavigation service), and FSS.

The decisions made for the fixed and mobile service involved inserting these services by footnote in virtually every radiolocation band (as well as in bands for other services) between 420 MHz and 36 GHz. The footnotes are the so-called "country footnotes" in which each country claims band usage for a service that is in addition to or alternative to the service stated in the table of allocations itself. On the average, about 25 percent of the member nations of ITU are involved in these footnotes; however, over 40 percent of the member countries are involved in the band 430 to 440 MHz. A precedent for these country footnotes did exist in the previous radio regulations but the number of countries involved was small, generally less than 10 in a given band. These few exceptions were quite manageable in terms of worldwide

Table 7.—Pre- and Post-WARC Radiolocation Allocations

	Frequency band	Region	Bandwidth - MHz Primary Old	Primary New	Secondary Old	Secondary New	Change
	216-225 MHz	1		—	—	—	NOC
		2	‘9	–	–	9	1 9
		3	—	—	9	7	- 2
†	420-450 MHz	1	10	10	20	20	NOC
		2	30	10	–	20	↓ 20
		3	30	10	– 20		↓ 20
†	890-942 MHz	1	—	—	52	52	NOC
		2	52	–	–	52	I 52
		3	—	—	52	52	NOC
	1215-1400 MHz	1	135	135	50	50	NOC
		2	135	135	50	50	NOC
		3	135	135	50	50	NOC
	2300-2500 MHz	1	—	—	200	200	NOC
		2	200	200	–	–	NOC
		3	200	200	–	–	NOC
	2700-3400 MHz	1	300	300	400	400	NOC
		2	300	300	400	400	NOC
		3	300	300	400	400	NOC
	3400-3700 MHz	1	—	—	200	200	NOC
		2	300	(200) + –	300	↓ 300	
		3	300	(200) +	–	300	I 300
t	5250-5925 MHz	1	300	300	300	300	NOC
		2	375	300	300	375	↓ 75
		3	300	300	375	375	NOC
†	8.5-10.0 GHz	1	1100	1100	400	400	NOC
		2	1100	1100	400	400	NOC
		3	1100	1100	400	400	NOC
t	10.0-10.68 GHz	1	500	500	180	180	NOC
		2	550	550	130	130	NOC
		3	550	550	130	130	NOC
t	13.4-14 GHz	1	600	600	–	–	NOC
		2	600	600	–	–	NOC
		3	600	600	–	–	NOC
t	15.7 -17.7 GHz	1	2000	1600	—	400	↓ 400
		2	2000	1600	–	400	↓ 400
		3	2000	1600	—	400	1 400
	24.05-24.25 GHz	1	200	200	–	–	NOC
		2	200	200	–	–	NOC
		3	200	200	–	–	NOC
t	33.4-36 GHz	1	2600	2600	–	–	NOC
		2	2600	2600	–	–	NOC
		3	2600	2600	–	–	NOC

t U S reservation
– Lost bandwidth
↓ Status reduced
+ See text
NOC No change

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operations. Now, however, the exceptions can become extremely difficult with the expected proliferation of the fixed and mobile services. The difficulty will be particularly severe for airborne radar operations because the large LOS distances these signals travel when aircraft are at high altitudes can cause interference over large areas extending into other countries.

Because of this incompatibility between the fixed and mobile services on the one hand and radiolocation service on the other, the United States entered reservations to the Final Acts in Protocol Statement No. 38 for the frequency bands 430 to 440 MHz, 5650 to 5850 MHz, 8500 to 8750 MHz, 10,000 to 10,500 MHz (where the fixed and mobile services were added as a primary service in the table of allocations rather than by footnote), 13.4 to 14 GHz, 15.7 to 17.3 GHz, and 33.4 to 36 GHz. Fixed and mobile footnotes were also included in the bands 1215 to 1300 MHz and 3300 to 3400 MHz, but some mitigating circumstances precluded the need for U.S. reservations.

In the band 1215 to 1300 MHz, one-third of the countries present in the fixed and mobile footnote are also represented in a radionavigation footnote for the same frequency band. It was felt that the fixed and mobile usage would not be so severe as to warrant a U.S. reservation. In the 3300- to 3400-MHz band a clause was inserted in the footnote that negates the primary status of the fixed and mobile services in the regions around the Mediterranean Sea. It was felt that this was sufficient to obviate a need for a reservation in this band.

A second key decision was made in connection with the radionavigation services. The decision here was to add maritime radionavigation as a primary service in the radiolocation bands 8850 to 9000 MHz and 9200 to 9300 MHz, and to add radionavigation as a primary service in the band 9500 to 9800 MHz.

The third key decision concerned FSS in the band 3400 to 3700 MHz. The existing radio regulations showed that the radiolocation and FSS would share this band equally at least in regions 2 and 3. In the U.S. national table of allocations, the band was alloted to (and in use by) the radiolocation service. Studies conducted in preparation for WARC showed that the specific systems being used by these services could not share the band. On the basis of the radar system usage, the U.S. position was to retain radiolocation as a primary service with the provision that a part of the band could be made available to support fixed-satellite communications.

This position was steadfastly maintained through a protracted period of intense negotiations at WARC. The final result did, indeed, reduce radiolocation to a secondary service in the table of allocations, but, by footnote, primary status was restored in regions 2 and 3 over the band 3400 to 3600 MHz. The footnote contains a directive for administrations to take all practical steps to protect FSS after 1985 along with a nonbinding plea for radiolocation systems to cease operations by the same year. As part of the compromise, a formal declaration was signed by the United States, Canada, the United Kingdom, the Netherlands, Australia, and Belgium vowing to make reasonable effort to accommodate FSS in the band. The national table of allocations, currently under development jointly by FCC and IRAC, will make limited allowance for FSS in the band 3600 to 3700 MHz with the remainder of the band being retained in the radiolocation service.

In the FCC's third notice of inquiry concerning implementation of the Final Acts of WARC-79 (Docket 80-739), the FSS allocations in the bands 3.7 to 3.7 GHz and 4.5 to 4.8 GHz are proposed to be limited to international satellite systems and excludes domestic satellite systems. According to the third notice of inquiry, the expectation is that no more than one Earth station on each U.S. coast can be successfully coordinated with stations operating in the radiolocation service.

Item 2.–WARC-79 presented the first opportunity to allocate the frequency bands above 40 GHz to terrestrial services. The U.S. radiolocation position in this frequency range was to obtain four primary bands and three secondary bands primarily in the regions of reduced atmospheric absorption, the so-called "propagation windows. " WARC allocated six primary bands and four secondary bands. A comparison of the U.S. proposals with the WARC action is shown in table 8. It is clear that there is adequate frequency support for radiolocation system development in these bands.

Item 3.—Prior to WARC-79 there was no provision for spaceborne radars in the radio regulations. The matter has been rectified by the WARC-79 action of permitting spaceborne radars in every radiolocation band between 1 and 36 GHz as well as the band 78 to 79 GHz. The U.S. proposal was to accommodate space radars on a secondary basis in the bands below 14 GHz and on a primary basis above 14 GHz regardless of the service that was employing the radar systems. The actual wording in the WARC-79 footnotes provides secondary status to space radiolocation systems in all the radiolocation bands from 1 to 14 GHz and in the band 35.5 to 35.6 GHz it has primary status. Radars used in the Earth-exploration satellite service have primary status in the bands 35.5 to 35.6 GHz and 78 to 79 GHz, with secondary status in all the radiolocation bands from 1 to 24.25 GHz. Thus, the status of spaceborne radiolocation systems is considerably enhanced from that which existed prior to WARC-79.

Table 8.—Comparison of WARC Radiolocation Allocations and U.S. Proposed Allocations Above 40 GHz

Bands in U.S. proposal (G Hz)	Bands allocated (GHz)
—	59-64 Primary
76-81 Primary	76-81 Primary
92-95 Primary	92-95 Primary
95-101 Secondary	95-101 Secondary
—	126-134 Primary
142-150 Secondary	134-142 Secondary
165-170 Primary	144-149 primary
221-229 Secondary	231-235, 238-241 Secondary
240-250 Primary	241-248 primary

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Item 4.–It was the U.S. objective to obtain more substantial frequency support for the accurate position-fixing systems in the MF band. While WARC did not provide a common, worldwide band for these nonradar radiolocation systems, it did provide primary status over 30 kHz in region 1, 245 kHz in region 2, and 193.5 kHz in region 3 coupled with secondary status over 80 kHz in region 2 and 200 kHz in region 3.

Reservations

The U.S. reservations on radiolocation matters, noted above, were contained in the initial set of reservations filed by various administrations in the Final Protocol of December 3, 1979. About 20 of the 51 reservations submitted contained a statement by the submitting government that it would take the steps necessary to protect its interests in the event of noncompliance with or reservations to the Final Acts by other administrations. The following day, 32 additional reservations were entered, 24 of which contained similar statements. Three of those twenty-four made specific mention of the U.S. Reservation No. 38.

The reservation by the United States contained in paragraph 4 of Protocol Statement No. 38, relating to the 890-to 960-MHz band will, in all probability, cause a problem along the U.S. borders primarily relating to nongovernment operations. The issue will become one of the many topics for discussion and negotiation in the future U.S. bilateral meetings on telecommunication matters with Canada, Mexico, and other nearby countries. The reservation merely places these countries on notice that the United States will coordinate its usage of the band but will not seek agreement prior to making assignments. Although radar users must protect nongovernment operations in this band, one reason agreements will not be sought is that U.S. radiolocation usage in-

volves the newest long-range surveillance radar in operation by the Navy, as well as another Navy surveillance radar now in the advanced development stage.

The reservations involving the bands where radionavigation was added as a primary service along with radiolocation (8500 to 9000, 9200 to 9300, and 9500 to 9800 MHz) can, if not forestalled, result in long-term, worldwide problems. Radar usage by the radiolocation service is extremely heavy in the radiolocation bands between 8500 and 10,000 MHz. The addition of the radionavigation service and the multicountry fixed and mobile footnotes in this band have taken 900 MHz of virtually exclusive radiolocation in the current radio regulations and added one or more primary services over the entire band. Technical and administrative solutions must be sought if radiolocation is to retain its effectiveness. Some effective technical solutions were proposed to the 1978 CCIR special preparatory meeting by the United States and the United Kingdom. Study of the technical solutions to radiolocation-radionavigation sharing needs to be pursued in CCIR. A more immediate solution, albeit partial, could be found administratively.

The U.S. International Radio Advisory Committee (IRAC) has shown no inclination to add radionavigation to the national table of allocations. IRAC might examine the matter more thoroughly and develop a set of recommendations for use by the State Department in discussions with other countries. The recommendations should propose an orderly introduction of radionavigation on an "as-needed" basis rather than throwing the bands open to any and all navigation use. The intent would be to buy time for the introduction of technical solutions. In the absence of such a planned introduction, the radiolocation service may soon find itself having a de facto secondary status because of the safety-of-life aspects of the radionavigation service.

The insertion of multiple country fixed and mobile footnotes into the table of allocations threatened chaos for many services. Through strenuous efforts by the United States, Brazil, and other countries, the situation was eased for some "passive" services (Earth-exploration satellite, space research, and radio astronomy) and the meteorological aids service. Radiolocation did not fare as well. Although many countries deplored these footnotes as being counter to the development of a rational table of allocations, the United States was the only country to act on them. The action noted in paragraph 3 of Protocol No. 38 indicated that the United States, in the operation of radiolocation stations, will not guarantee protection to, nor coordination with, other services. The action was necessary because the existence of the fixed and mobile footnotes in every radiolocation band between 1 and 40 GHz jeopardized all radars operating to serve national defense. Straightforward as it is with regard to the interference radars might cause to other services, the U.S. reservation contains the implicit statement that the radars can operate in the presence of interference from fixed and mobile emitters. All radars are designed to be operated in the presence of interference, either purposeful or accidental. The degree to which these interference rejection techniques will have to be improved and used depends on how extensively other countries introduce fixed and mobile services in these bands.

This implementation is not expected to occur equally in all the bands to which the footnotes have been added primarily due to economic considerations. However, early implementation is expected in the bands around 1 GHz and below where economical hardware already exists for fixed and mobile applications.

The U.S. reservations in Protocol No. 38 contain the only specific reference to the radiolocation service. Of the remaining protocol statements, a few are political, many deal

with specific bands and services, and the majority contain protective clauses indicating that the country or countries submitting the protocol will take necessary action in the event that other signatories abrogate the Final Acts. Only three protocol statements mention No. 38 and even in those cases the concern seems to be more with the 6- and 7-MHz bands than with radiolocation. Thailand, in Protocol No. 60, notes that it will allocate the band 435 to 438 MHz to the mobile, except aeronautical-mobile, service on a primary basis. Thus, while there is no specific threat to the radiolocation service, the mechanism is in place for electronic and political harassment should any country decide on this course of action.

Radar Spectrum Availability and Costs

The availability of spectrum for the radiolocation service had been significantly increased below 200 MHz and above 40 GHz and has remained virtually intact between these two frequencies. The principal benefit is that the new table of allocations (including the footnotes to the table) in the radio regulations continue to provide basic allocations for radiolocation service in all the currently used bands as well as some new bands.

Of equal importance is the retention in the United States of a primary status (by footnote) for radiolocation in the bands 420 to 430, 440 to 450, and 890 to 942 MHz. It is in these bands, which were reduced to secondary status in the table of allocations, that the United States has, and is developing, sophisticated surveillance radars. While these radars have operational modes suitable for worldwide use in a secondary status, the footnotes will provide the opportunity for exercising all modes of operation at U.S. training sites. The results of WARC have, therefore, done little to reduce the spectrum available for radar operations.

Adequacy of spectrum availability notwithstanding, the costs of radar development and operation must increase as a result of WARC-79. The increased costs will be associated with additional needs for operational frequency flexibility, development, and procurement of hardware for interference-free operation while retaining existing performance, and increased participation in international forums such as CCIR.

Frequency management is a continuing task, occupying staff people at the headquarters and unit level. Internationally, frequency managers ensure equitable allocations for various services as dictated by national needs; at the national level, they allot the allocated frequencies as appropriate to national usage; at the unit level, they assign frequencies in accordance with the local conditions. At all levels there is the need to deal with the incidence of interference. It is clear that all of these functions as applied to the radiolocation service will increase because of the additional services added by WARC to the radiolocation bands.

New coordinating activities must now take place between the radiolocation service and the fixed, mobile, Earth-exploration satellite, space research, radio astronomy, aeronautical radionaviagation, maritime radionavigation, radionavigation, and FSS. These activities are expected to be particularly heavy as the allowed usage in the fixed, mobile, and radionavigation bands are implemented. Significant numbers of interference incidents are also expected in these bands entailing the development of techniques to eliminate or reduce this interference.

As noted earlier, all military radars are designed to operate in the presence of intentional (jamming) and unintentional (interference) signals. Numerous electronic counter-countermeasure (ECCM) techniques are incorporated into systems to reduce the effects of unwanted electromagnetic emissions. However, ECCM is not a panacea for interference problems. In this regard, a few comments on radars, ECCM, and interference are in order.

First, radar performance is measured in terms of a clear radiofrequency environment

with no interference present. Most ECCM techniques involve some performance degradation. For this reason, a particular ECCM should be used only when it is needed. Of course, when interference is present, ECCM will improve system performance but will generally not bring it back to its clear environment performance. Second, ECCM techniques are largely signal-specific. Thus, a radar will have several techniques to be able to continue to operate in a changing radiofrequency environment. Not all techniques are compatible so that use of one may preclude the use of another. When multiple techniques are used, the performance degradation due to each is cumulative. And third, radar emissions, which generate interference into other services, are seldom considered as part of an ECCM package.

These factors when coupled with the expected proliferation of radiolocation band usage by other services means that radiolocation systems will spend more time with ECCM circuits operating and, through their radiofrequency emissions, be interfering with more systems in other services. In the short term, the need for extensive modifications to existing systems is not anticipated. However, planning should begin now for necessary modifications to radars operating in the frequency bands where the United States took a reservation. In the long term, development work on new and existing systems will have to be increased to ensure mission-fulfilling performance in the presence of increased interference. This additional development work should concentrate both on keeping unwanted signals out of the receiver and on reducing the level and direction of unnecessary ("spurious") emissions coming from the radar. This represents more than just an incremental increase in the ECCM budget of radar development, since performance in the presence of the "friendly" interference should equate to the current performance in a clear environment. The increase may range from 5 to 15 percent depending on the type of radar and the proliferation of the other services in the radar bands.

The third cost increase derives from a need for radar developers to expand their participation in CCIR. This expansion is extremely important in light of the many new sharing situations created by WARC. Prior to WARC, CCIR participation was considered relatively unimportant by radiolocation users since there was little sharing or interaction with other services. During preparations for WARC, it became apparent that the many exclusive bands employed by the radiolocation service would be reallocated or shared. Because of this likelihood, representatives of the radiolocation service participated in the IRAC preparing for the WARC-79 AD Hoc 144 and CCIR study group activities, served as members of the SPM delegation, and were part of the U.S. delegation to WARC.

This representation should continue at CCIR in order to establish a sound and consistent technical background for radar topics in the reports of CCIR plenary meetings (the CCIR Green Books). The absence of this technical basis may have been part of the reason that radiolocation received little support at WARC-79. The representation should consist of not only headquarters policy personnel but also scientists and engineers from Government laboratories and from Government contractors. Perhaps CCIR participation should become a "line item" in the budget of every radar system development. And CCIR should not be the only involvement. Future ITU conferences dealing with specific services and specific regions will continue to have an effect on radiolocation matters. It would be prudent to have radar expertise at these meetings as well.

Fixed-Satellite and Mobile-Satellite Services

Table 9 provides a summary of WARC-79 gains and changes in status on fixed and mobile satellite allocations above 27.5 MHz as reflected in the allocation tables. The data in the bandwidth and change columns illustrates that all the changes in the FSS and

Table 9.—Summary of WARC Gains and Changes in Status on Fixed- and Mobile. Satellite Allocations Above 27.5 MHz

Type of satellite	Frequency band (MHz or GHz)	Region(s)	Bandwidth MHz		Change MHz	Prior major use of the band
			Primary	Secondary		
MO	608-614 MHz	2		6	+6	BC
MO	1544-1545	All	1		+1	Aero mobile satellite
FX	5850-5925	2	75		+ 75	RL
FX	6425-7075	All	650		+ 650	FX MO
FX	10.7-10.95 GHz	All	250		+ 250	FX MO
FX	11.2-11.45	All	250		+ 250	FX MO
FX	12.1 -12.3	2	200		+ 200	FX MO and BC
FX	12,75-13.25	All	500		+ 500	FX MO
FX	14.5 -14,8	All	300		+ 300	FX MO
FX	17,3 -17.7	All	400		+ 400	RL
MO	19.7 -20.2	All		500	+ 500	FX satellite
FX	27-27.5	2 and 3	500		+ 500	FX and MO
MO	29.5-30	All		500	+ 500	FX satellite
FX	30-31	All	1000		+ 1000	FX satellite
FX	37.5 -39.5	All	2000		+ 2000	FX and MO
FX and MO	39.5 -40.5	All	2000		+ 2000	FX and MO
FX	42.5 -43,5	All	1000		+ 1000	BC satellite
MO	43.5-47	All	3500		+ 3500	Various MO satellites
FX	47.2 -50.2	All	3000		+ 3000	Not allocated
MO	50.4 -51.4	All		1000	+ 1000	FX satellite
MO	66-71	All	5000		+ 5000	Various MO satellites
FX and MO	71-74	All	3000		+ 3000	Not allocated
FX	74-75.5	All	1500		+ 1500	Not allocated
FX and MO	81-84	All	3000		+ 3000	Not allocated
MO	95-1oo	All	5000		+ 5000	Various MO satellites
MO	134-142	All	8000		+ 8000	Radio astronomy
FX	149-150	All	1000		+ 1000	Various MO satellites
FX	152-164	All	12000		+ 12000	Not allocated
MO	190-200	All	20000		+ 20000	Various satellites
FX	202-217	All	15000		+ 15000	Not allocated
FX	235-236	All	1000		+ 1000	Radio astronomy
FX	238-241	All	3000		+ 3000	Radio astronomy
MO	252-265	All	13000		+ 13000	Various satellites

SOURCE Systematics General Corp., "The World Administrative Radio Conference 1979, " final report, vols I and II

MSS allocations were positive and generally provided primary service status. The impression that everything went well for FSS and MSS (and for DOD satellite interests) does not reflect the full implications of WARC-79 decisions. There may be problems in satisfying the DSCS requirements in the 7- to 8-GHz band. DOD's WARC-79 initial goal for satellite operations was to increase the two partially exclusive 50-MHz FSS bands to 125 MHz for both fixed-satellite and mobile-satellite communications, and to add mobile-satellite as a secondary service in the two 500-MHz FSS bands 7250 to 7750 MHz and 7900 to 8400 MHz. Footnote 3764B was added to the table of allocations that authorized the bands 7250 to 7375 MHz (space-to-Earth) and 7900 to 8025 MHz (Earth-to-space) for use by MSS (subject to agreement obtained under the procedure set forth in article N13A)—a major gain. An additional footnote 3762B does not permit aircraft stations to operate in the 8025- to 8400-MHz band in region 2. So, although the goal of 125 MHz for up and downlinks for fixed-satellite and mobile-satellite communications was achieved, this meant that the partial exclusivity that existed for FSS was lost in the two 50-MHz bands (7250 to 7300 MHz and 7975 to 8025 MHz). The DOD plans for use of ground-mobile forces (transportable) and airborne satellite terminals in the United States, NATO countries, and in selected areas of the Pacific must take account of the WARC-79 decisions. Frequency support for these types of DSCS operations will require long lead times to coordinate with host administrations.

The coordination requirements for mobile-satellite use in the 235- to 399.9-MHz band have become more complex due to WARC-

79. Previously, under footnote 3618/308A, the use and development of this service was only subject to the agreement among the administrations concerned and those having services operating in accordance with the table, which may be affected. Now the modified 308A (3618) requires two conditions to be fulfilled:

. Agreement must be obtained under the procedure set forth in article N13A.
  – Under this article agreement among administrations now becomes more complex due to increased data to be furnished–and adding IFRB to the coordination process.
- Stations in MSS do not cause harmful interference to those of other services operating (or planned to be operating) in accordance with the table.

The United States and most NATO countries took a reservation in the final protocol against this second provision on the basis that this imposes a condition of noninterference that could lead to a request to cease operation of a previously coordinated satellite system in the case where an administration, despite having agreed to such a satellite system, puts into service (or merely plans) a system that might receive harmful interference.

Costs Pertinent to National Security

Costs have been discussed earlier in this report. Summarized here are the cost impacts of WARC-79 from the standpoint of national security. There is no major immediate cost impact of WARC-79 regarding national security systems. No heavily used equipment must be moved to another band or phased out and no expensive retrofits are required to existing DOD equipment because of WARC-79 actions. Three reasons explain this lack of immediate cost impact:

- frequency flexibility of existing U.S. equipment;
- success of the U.S. delegation at WARC-79; and
- reservations taken by the United States.

It should be emphasized that there will be future costs resulting from the actions at WARC-79. The nature of these costs are varied. The military, in particular, is affected by the number of footnotes (about 500) to the table of frequency allocations that make it impossible in some cases to know which countries will use which frequency bands for which services. Attempting to design military systems and plan operations on a worldwide basis with such uncertainty will increase system costs and decrease operational flexibility. This means, among other things, that system planners will need to design military systems that have the flexibility to operate in several different frequency bands. The extent of the changes and the magnitude of the costs associated with WARC-79 decisions will not become clear for some time. Discussions between the United States and other countries–particularly our NATO allies—about implementation plans will help clarify the future operating environment.

WARC-79 resulted in a large number of future conferences and DOD should actively participate in the preparation for national and international meetings pertinent to these conferences—including the activities of CCIR—to ensure that DOD spectrum needs are accommodated and that our national security interests are protected. DOD should also provide technically knowledgeable, experienced (and, to the extent possible, multilingual) members to the U.S. delegations. Of the three world conferences and seven regional conferences recommended in the Final Acts of WARC-79, the most important from a national security standpoint are:

- World Administrative Radio Conference on the Geostationary Orbit and the Planning of Space Services (1985 and 1987); and
- World Administrative Conference for Mobile Services (1983).

Mobile services were popular with the developing nations, and, with little regard for the technical aspects of sharing between different radio services, many additions were made to the table of frequency allocations in support of these services. The conference added many provisions impacting radar and weapon system frequency bands, both for terrestrial and satellite operations.

The overall DOD impact of these and other changes related to sharing will be a greater need for U.S. planners, managers, equipment suppliers, and operational forces to be aware of frequency band limitations, and a need to ensure better system development review to understand how U.S. systems can live with those of other countries. These changes add up to one thing for DOD—increased costs. These include: costs associated with additional needs for operational frequency management; costs associated with the development and procurement of the more sophisticated equipment (e.g., increased tunability) needed to permit interference-free operations with other services in the same band; and costs associated with proving the system is compatible, such as electromagnetic compatibility (EMC) studies. And there will be increased costs of coordination with our allies. Other costs may become apparent over time (e.g., as the HF reaccommodation takes effect in the coming years).

Summary of the National Security Impact of WARC-79

The major DOD-related issues and objectives were enumerated earlier. Here is a summary of the major impacts on those issues and objectives. Before beginning a more detailed summary, however, it should be reiterated that in general the national security interests of the U.S. were not endangered by WARC-79 actions. Nevertheless, continued active participation by DOD in the planning and conduct of future discussions and conferences will be required to ensure that follow-on actions to WARC-79 do not jeopardize national security. This will require adequate budget support.

Radiolocation (Radar) .-The service retained almost all of its allocations above 200 MHz; the only actual reduction of allocation to the radiolocation service occurred in the 216- to 230-MHz band in region 3. This occurred when 9 MHz of a secondary allocation (216 to 225 MHz) was reduced to 7 MHz (223 to 230 MHz). When considering the magnitude of spectrum allocated for radiolocation use, this reduction of 2 MHz is minor. Consistent with the U.S. proposals, radiolocation was reduced to a secondary service—except that in region 2 (the Americas) it will be on a primary basis until 1990 after which no new stations are to be authorized. However, significant loss in radiolocation status resulted from WARC-79 in certain radiolocation bands below 20 GHz. This loss of status plus the movement of other users into the bands combined to force the United States to take a reservation (No. 38) affecting certain radiolocation bands.

Although there was little actual loss of allocations, the provisions for radar were probably changed more by WARC-79 than for any other single radio operation. For example, in the band 3400 to 3600 MHz, there are provisions for radar to operate worldwide, but radar users must afford some measure of protection to satellite and radio relay operators. The United States operates the Airborne Warning and Control System (AWACS), the Navy's AEGIS, and several other systems of importance to DOD (e.g., missiles, air traffic control, air surveillance, etc.) in the band 2900 to 3700 MHz, and their operations may be affected through the need for added planning coordination. If there is extensive implementation of satellite communications in this band below 3600 MHz, then the problems mentioned above would be compounded–especially in Europe. The radiolocation service lost some exclusivity in the band 8500 to 10,000 MHz where DOD operates navigation, air search, fire control radars, and various airborne systems. When footnotes are considered, radiolocation effectively lost exclusivity over the whole band (8500 to 10,000 MHz). This could eventually

place constraints on radar operations and increase demands on system designers. Short-term relief is provided by Protocol Statement No. 38, and intermediate term relief can be negotiated with U.S. allies through bilateral and multilateral agreements outside of the radio regulations. Nevertheless, radar as it currently operates will become increasingly unwelcome in many parts of the world, and new design and operational strategies will be needed before the end of the century.

Radionavigation.–The U.S. objective of providing two bands (1215 to 1240 MHz and 1559 to 1610 MHz) for space-to-Earth navigation signals to accommodate the NAVSTAR/GPS was achieved. NAVSTAR/GPS is the cornerstone of future DOD high accuracy global navigation. It can also provide for improved civil navigation.

Satellite Communications.—The U.S. objective to maintain the status quo for MSS in the 235- to 399.9-MHz band used by the Naval Fleet Satellite Communication System (FLTSATCOM) was partially achieved; however, coordination provisions (article N13A) were added that included a condition that stations in MSS not cause harmful interference to those of other services operating, or planned to be operated, in accordance with the table of allocations. To forestall the potential negative impact, the United States and most of its NATO allies, took a reservation in the Final Protocol.

A major U.S. objective was achieved through the recognition of MSS. The bands 7250 to 7750 MHz and 7900 to 8400 MHz had been allocated to FSS (DSCS I, II, III, NATO SATCOM). Now, the MSS can operate on a primary basis in the bands 7250 to 7375 MHz and 7900 to 8025 MHz; however, there was a corollary loss of the partial exclusivity for FSS in two 50-MHz bands (7250 to 7300 MHz and 7975 to 8025 MHz). There was a net gain for national security objectives through these changes, although deployment of satellite systems without causing interference to radio relay systems in some areas will become increasingly difficult.

All U.S. objectives were met in the 20-,30-, and 40-GHz bands that may be used by future generation military satellite systems (e.g., DSCSs), including provisions for accommodating MSS.

The United States sought to avoid the possible future loss of system design flexibility and orbit locations associated with a rigid a priori allocation plan for satellites in the geostationary orbit. While no plan was adopted at WARC-79, plans were made for a future conference on space systems to be held no later than 1985–with a follow-on conference about 18 months later. These space conferences will probably result in some form of orbit spectrum planning that could inhibit technological development. The impact on all future DOD space systems is potentially very large. Proper preparation for these conferences is essential, including adequate budget allocations.

High Frequency.–The U.S. objectives of providing for the increasing requirements of international broadcasting (e.g., Radio Free Europe, Voice of America, etc.) and maritime operations (while limiting the loss of HF spectrum for DOD operations) were met, although the United States took reservations below 10 MHz for both of these services. The net reduction of only 14 percent in HF spectrum available to DOD should not adversely affect U.S. strategic networks, which rely increasingly on satellites, and the available spectrum should accommodate our tactical and other HF national security requirements.

Fixed and Mobile (Terrestrial) .-The U.S. objective of maintaining the status quo in the important NATO band of 4400 to 4990 -MHz was not met. The band is heavily used by the military for tactical communications (primarily radio relay and troposcatter systems). Although the present and past allocations provided for FSS in this band, there is no known satellite system operating as such.

In order to provide some protection, the fixed-satellite was changed from uplink to downlink and shifted from 4400 to 4700 MHz to 4500 to 4800 MHz, which is shared with fixed and mobile. (The aeronautical-mobile service is excluded from 4825 to 4836 MHz and 4950 to 4990 MHz by footnote.) The band 14.5 to 15.35 MHz was also designated by NATO as a primary military band for fixed and mobile services. WARC-79 included the FSS (Earth-to-space) in the band 14.5 to 14.8 MHz shared equally with fixed and mobile. By footnote, FSS would be limited to the broadcast feeder links and would be reserved for countries outside Europe. The effect is that, if satellite service is instituted, the military systems would have to be located and operated in a manner that would not cause interference. Analyses of potential interference might lead to the requirement for sharing sensitive military technical data with civil administrations. The impact of these changes cannot be fully determined until after discussions with our NATO allies.

Intelligence, –The impact of WARC-79 on U.S. intelligence systems is not discussed in this report.

Resolutions, Recommendations, Reservations, and Declaration

Many of the important consequences of WARC-79 derived from resolutions and recommendations approved by the conference and from reservations and declarations by individual countries indicating a refusal to be bound by a particular decision of the conference or agreeing to undertake certain actions in order to conform to a decision.

A total of 87 resolutions and 90 recommendations were adopted by WARC-79. Many of the resolutions referred certain topics for study by CCIR or proposed the convening of world or regional administrative radio conferences. In addition, the developing countries introduced several resolutions seeking increased assistance in the following areas:

- technical cooperation in maritime telecommunications, especially by providing technical advice and by assisting in training personnel;
- technical cooperation in national radio propagation studies in tropical areas designed to improve and develop the developing countries' radiocommunications;
- development of national radio frequency management within the developing countries through such means as regional seminars and training;
- transfer of technology in telecommunications for the purpose of developing services and attaining social, economic, and cultural objectives of the developing countries; and
- use or role of telecommunications in rural development.

Those resolutions look to UNDP as the primary source of funding. However, the United States will be expected to participate directly or indirectly in the areas described. Some decisions must be made how the United States should respond to requests for assistance.

Many of the resolutions and recommendations relating to the CCIR study topics have to do with such highly controversial subjects as the use of the geostationary satellite orbit and the planning of space services utilizing it; the convening of a WARC for the planning of the HF bands allocated to the broadcasting service; and, the convening of a regional administrative radio conference for this detailed planning of the broadcasting-satellite service in the 12-GHz band and associated feeder links in region 2.

About 2 dozen specialized world or regional administrative radio conferences were proposed at WARC-79, many of which can affect U.S. interests. The conference recommended that three world conferences and seven regional conferences be held. (The recommended conferences and their projected dates are listed at the end of chapter 6.)

A reservation, as noted earlier, is a formal statement, as part of a protocol, wherein an ITU member indicates that it will not abide by a particular decision of a conference. These reservations are called protocol statements in the Final Acts of WARC-79 and this time the United States took a total of six. (Reservations generally provide a means by which countries can accept the majority of decisions reached by a WARC without being bound by a particular decision.)

Two of the six were rebuttal statements in which: 1) the United States rejected a Cuban complaint that U.S. use of radiofrequencies at our Guantanamo Naval Base was an impediment to Cuba's communication services and Cuban sovereignty; and 2) the United States joined with 22 other countries in noting that the claims of equatorial countries to sovereignty over segments of the geostationary orbit were not germane to the work of the conference. Such rebuttal statements are common in conferences such as WARC-79 to indicate that political rhetoric should not be confused with international agreements.

A third U.S. reservation called attention to the fact that our international broadcasting in the HF bands was being intentionally jammed by other ITU members and reserved the right to take "necessary and appropriate action" to protect U.S. broadcasting interest. The statement was included primarily to put the jamming problem on the record inasmuch as the subject was not mentioned during the course of the conference, although Israel made a reference to jamming in its statement for the final protocol.

None of these three reservations will impact on telecommunications operations directly; however, all three are likely to resurface at future conferences.

The remaining three U.S. reservations dealt directly with spectrum matters. In Protocol No. 32, the United States participated in a joint NATO statement rejecting the terms of a footnote affecting the operation of MSS in the bands 235 to 322 MHz and 335.4 to 399.9 MHz. The NATO countries agreed that they could meet the prescribed coordination procedures called for in the footnote. However, they rejected an additional provision of this footnote imposing a condition of noninterference. The concern was that this condition could lead to a request to cease operation of a previously coordinated satellite system when another country merely planned a system that might receive harmful interference from a MSS operating in the band. A separate reservation of Canada supported the U.S. view that future or planned terrestrial systems should not jeopardize existing MSS.

In Protocol No. 36, the United States joined the seven other countries in protesting the inadequate provision for HF broadcasting–particularly at 6 and 7 MHz. Fourteen other countries individually took reservations on this same matter. They all expressed concern that the forthcoming HF broadcasting conferences (1984 and 1986) will be hampered by the lack of adequate allocations, and reserved the right to take the necessary steps to meet the needs of their HF broadcasting services.

The United States took a major reservation in Protocol No. 38 that was submitted in five parts. The first two parts referred to Protocol Nos. 36 and 32. The third part stated that the United States could not guarantee protection to or coordination with other services that experienced interference from radars operated on a primary basis in a variety of specified bands. The fourth part stated that the United States reserves the right to operate fixed, mobile, and radiolocation services in the bands 470 to 806 MHz and 890 to 960 MHz without the required coordination procedures specified in footnotes pertaining to these bands. The United States agreed to coordinate its usage of such services with neighboring countries that are affected, but not with all the other countries that might, for no apparent good reason, request coordination under article 14.

Part five of the reservation addresses the failure of the conference to provide adequate

allocations for the maritime-mobile service below 12 MHz. In this reservation, the United States indicated that allocations to the mobile service below 10 MHz would be used to satisfy maritime mobile requirements.

The U.S. reservations contained in Protocol Statement 38 represent a conscious decision to take whatever steps are necessary to protect vital U.S. national interests. They cannot be regarded simply as a failure by the U.S. delegation to get what it wanted at WARC-79. This is no more valid than listing the hundreds of U.S. proposals that won approval and thereby claiming overall success.

Foreign Reservations

The remaining 77 reservations, some of which bear the names of several countries, can be grouped in three categories:

- general reservations;
- political reservations; and
- specific reservations.

Some 35 reservations can be categorized as "general" in that they were merely statements of a country's intent to do whatever is necessary to protect its radio-communication services should other ITU members fail to observe the radio regulations or take other detrimental measures.

Another 17 reservations are "political" in that they relate to territorial disputes (United States and Cuba over Guantanamo; Great Britain and Argentina over the Falkland Islands; Chile and Great Britain over the Antarctic). two others relate to sovereignty claims to the geostationary orbit.

Finally, 28 reservations address specific issues. Of these, 19 are concerned with the allocation of HF among the broadcasting, fixed, and mobile services. The majority of these were entered by developing countries and state that they may not be able to satisfy their fixed and mobile service requirements with the reduced allocations and they reserve the right to continue using these frequencies for those services. The large number of reservations on this single subject shows that the issue of HF allocations is far from settled. Continuing difficulties are likely, including actual interference with existing services, the inability of some countries to satisfy their requirements, and a troublesome time at future scheduled broadcasting conferences.

This leaves nine specific foreign reservations on all other subjects. Of these nine, four deal with the UHF band. All are related to localized problems, none of which greatly affect the United States. The remaining five are as follows:

- Belgium warned that it will use the band 100 to 104 MHz for a new network of broadcasting stations. Since the band is now, and has been, allocated for this service, the reservation addresses the question of allotments or assignments in a region 1 broadcasting plan, a subject outside the agenda of WARC-79.
- Japan said in another statement that it will continue to use the band 130 to 526.5 kHz for aeronautical radio-beacons. If region 1 broadcast stations continue to cause interference in the band 190 to 285 kHz, Japan will reallocate to protect itself.
- Nigeria claimed that the allocation of 14 to 14.8 GHz for feeder links to broadcasting satellites is not acceptable. This reservation is apparently intended to indicate that 14.0 to 14.5 GHz will be used for INTELSAT satellite services in Nigeria leaving only 300 MHz for feeder links to broadcasting satellites. However, sharing arrangements between those services should help assure adequate spectrum for feeder links.
- In a joint reservation, France and Switzerland objected to high-power broadcast stations below 5000 kHz and above 41 MHz. Brazil expressed opposition to a WARC resolution establishing the period of validity of frequency assignments to satellites prior to the 1985 and 1987 space planning conferences, arguing that the resolution would prevent

the planning conferences from deciding on other distributions of frequency and orbit allotments. However, the resolution specifically stated that its application should not prejudge decisions of the planning conferences.

. Finally, a Thailand reservation extended its allocation to the mobile service (except aeronautical-mobile) to the entire band 430 to 440 MHz. The effect is minimal because of the many other services and countries already included by footnotes.

Declaration

The United States signed a formal declaration of intent together with other countries at the WARC-79 conference as part of the effort to resolve the controversy surrounding use of the band 3.4 to 3.7 GHz.

In ITU regions 2 and 3 (the Americas, Oceania, and Asia) this band is allocated on an equal basis to both the fixed satellite and radiolocation services. Based on studies showing that it is not feasible for these two services to share the same band, the United States has not implemented FSS, but has carried on important military radar operations in this band. Commercial satellite systems—both the global INTELSAT system and U.S. domestic systems—operate in the adjacent band 3.7 to 4.2 GHz. The U.S. proposal to the WARC-79 was to maintain the status quo and retain radiolocation as a primary service in the 3.4 to 3.7 GHz band. While the United States was prepared to make some provision for FSS to use a part of the band, other countries, particularly from the developing world, insisted that the entire band be made available to expand satellite service.

From the viewpoint of the satellite operator, this proposal represents a logical and cost effective expansion into a band contiguous with existing operations. The problem for the United States, of course, is that it has large investments in radar equipment that is vital to national security and these radars would interfere with satellite operations in the same band.

Negotiations were intense and a compromise was found late in the conference. The final result did, indeed, reduce radiolocation to a secondary service in the International Table of Allocations. However, by a footnote to the table of allocations, primary status was restored to the radiolocation service in regions 2 and 3 for the bands 3.4 to 3.6 GHz. The footnote includes a directive for ITU members to take all practical steps to protect FSS after 1985 with a nonbinding appeal for radiolocation systems to cease operations by 1985. The compromise was made possible by the removal of any mandatory requirement to cease radar operations in the band. As part of the compromise, a declaration was signed by the United States, Canada, the United Kingdom, the Netherlands, Australia, and Belgium vowing to make reasonable effort to accommodate FSS in the band.

The United States will determine how to implement the intent of the declaration through its domestic processes. There are no FSS Earth stations currently operating in the 3.4- to 3.7-GHz band. However, the United States agreed not to withhold support if INTELSAT decided to undertake FSS operations in that band. If such a decision was made, the United States would be under strong pressure to restrain radar operations that might interfere with international satellite operations.

In the FCC's third notice of inquiry concerning implementation of the Final Acts of WARC-79 (General Docket 80-739) FCC proposed that only limited use be made of the FSS allocations in the 3.6- to 3.7-GHz and 4.5- to 4.8-GHz bands. The FCC's notice proposes a limitation on the use of these bands to international satellite systems (specifically the INTELSAT global system) and excludes domestic satellite systems. FCC expects, according to its third notice of in-

quiry, that no more than one Earth station on each coast of the United States can be successfully coordinated with stations operating in the radiolocation service.

The Impacts of WARC-77

The 1977 World Administrative Radio Conference for broadcasting satellites was convened to plan the use of the 11.7- to 12.2-GHz band that had been allocated in 1971 on a primary basis to the broadcasting satellite service, the fixed service, broadcasting service, and (in region 2 only) FSS. The decisions reached at WARC-77 are superseded by the Final Acts of WARC-79, but the manner in which these decisions were reached, and their longer term consequences, deserve some discussion.

Because the broadcasting satellite service was in an early stage of development, the United States produced elaborate technical arguments in advance against the adoption of a detailed geostationary orbit and channel allotment plan, believing that such a plan would waste orbit and spectrum and hinder technological advances. The United States proposed instead that the conference approve certain actions that would encourage planning that was evolutionary and flexible, rather than detailed and restrictive, and would make adequate provision for FSS in region 2 (the Americas).

The conference ignored the U.S. technical arguments and embraced the concept of detailed planning for two basic reasons:

- the majority of developing countries wanted to be assured of guaranteed access to specific orbital slots and channels and were convinced that a detailed a priori plan offered them that assurance; and
- a number of European countries believed that the adoption of an a priori plan would permit them to proceed with development of terrestrial services in the 11.7- to 12.2-GHz band.

Neither of these two goals would have been helped by adoption of an evolutionary plan that was subject to change. Moreover, the United States, Canada, and Brazil were the only countries planning use of the band for FSS and therefore concerned with problems of sharing between broadcasting satellites and FSS. Also, the United States and Canada had unilaterally ruled out primary domestic use of the band for terrestrial services.

The U.S. delegation made extensive efforts to find fallback positions, or supporting technical documentation, which, while encompassing U.S. views, would meet the concerns of other countries. These efforts were unsuccessful. The United States failed to forestall the adoption of a detailed plan for regions 1 and 3, but succeeded in putting off detailed planning for BSS in region 2 until 1983.

It can be argued that the United States prepared for the wrong conference in 1977. The delegation was thoroughly armed with technical arguments based on experimental operation of ATS-6 and CTS, satellites with broadcasting capabilities. The United States sent representatives to a series of regional ITU seminars and held bilateral discussions with a number of countries, including West Germany, Japan, the U. S. S. R., and the United Kingdom. Reports from these meetings made it clear that the U.S. position was shared by very few countries and was more than likely doomed to failure from the start.

Thus, in spite of a major U.S. effort, the principle of a “negotiated plan” for the space services was established and fully accepted by a large majority of ITU members at WARC-77, and the “planning” adopted was

detailed planning including specifications of national orbital positions, channel assignments, service areas, and a variety of detailed technical characteristics. There is no reason to assume that this approach will not be advocated for other space services, such as FSS, in future conferences.

A major challenge for the United States will be to develop alternate planning approaches that will satisfy renewed demands for "guaranteed access" for all countries and still permit the introduction of advanced technology to increase the capacity of the geostationary orbit and related spectrum to meet increasing requirements.