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Christian A. Herter Jr.

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CHRISTIAN A. HERTER, JR.*

The Electromagnetic Spectrum: A Critical Natural Resource

INTRODUCTION

Much has been written in recent years about the use, development, and conservation of natural resources, those parts of the natural environment that serve a useful purpose and which include land, water, forests, air, minerals, and energy sources. Some are renewable, such as forests; some are depletable through use, for example, minerals; and some are degradable through various forms of pollution or mismanagement. Degradable natural resources include land, water, and the atmosphere.

Relatively little, however, has been written about a very different natural resource, the electromagnetic spectrum.¹ Although most people are unfamiliar with the electromagnetic spectrum, it is the natural resource which makes modern communication and communications development possible. The electromagnetic spectrum and frequency of radio wave propagation in particular permit radio and television transmission communication with moving vehicles on land, at sea, in the air, and in outer space. No other natural resource has such an immediate and extensive impact on modern civilization as the electromagnetic spectrum.

This article will explore the nature of the electromagnetic spectrum as a natural and common property resource; elaborate on some uses of the electromagnetic spectrum, particularly in conjunction with the geostationary orbit; examine the institutional frameworks that have been developed to manage the resource; and discuss some of the emerging political and legal problems that have arisen in connection with the use of the electromagnetic spectrum.

WHAT IS THE SPECTRUM?

Electromagnetic radiation is "a form of oscillating electrical and magnetic energy capable of traversing space without benefit of physical interconnections. Radiant heat and light are forms of electromagnetic radiation, as are radio signals".²

*School of Advanced International Studies, the Johns Hopkins University, Washington, D.C. 20036.

1. The twenty-year index of the *Natural Resources Journal*, NAT. RES. J. INDEX 1-20 (1981), for instance, makes no reference in its list of titles to the electromagnetic spectrum, perhaps because there has been some lingering doubt as to whether it should be identified as a natural resource.

2. Final Report: President's Task Force on Communications Policy (1968).

Heinrich Hertz, in the late 1880s, first characterized and demonstrated that electromagnetic waves move outward from an electrical stimulus at the speed of light.³ Ten years later Guglielmo Marconi, an Italian physicist, used this natural phenomenon as an effective vehicle for human communication. By creating a series of electrical impulses from an electrical spark, he transmitted information by Morse Code to a receiver without the benefit of the physical connection required for earlier telephone and telegraph. Then in 1901, on a hill in Newfoundland, Marconi's copper wire antenna, suspended by a kite 400 feet in the air, picked up a telegraphic signal sent by a powerful transmitter in Cornwall, England.⁴ Thus began the age of wireless communication. Technological innovation progressed rapidly and, during World War I, electromagnetic waves were used for voice transmission with radio broadcasting soon following.

The electromagnetic spectrum comprises the complete range of rates at which electrical waves fluctuate as they pass through space. Waves produced by an oscillator are transmitted into space through an antenna which vibrates at the particular frequency of those waves.⁵ The waves travel in a continuing sequence of peaks and troughs, like ripples that are produced when one drops a stone in a pond. Waves may be characterized by wavelength or frequency.⁶ That part of the electromagnetic spectrum which has a frequency range of from 30 Hz to 300 GHz is called the radio spectrum.⁷

Information, whether audio, video, or digital, can be superposed or "transported" on radio waves and therein lies their enormous utility. The higher the frequency, the more information a radio wave will carry.⁸ The

3. The speed of light is 186,000 miles or 300,000 kilometers per second.

4. For useful background, see International Institute of Communications, *Telecommunications: National Policy and International Agreement: A Briefing Paper in Preparation for the World Administrative Radio Conference in 1979* (Sept. 1977) [hereinafter cited as Briefing Paper].

5. An oscillator, in its simplest form, is like a tuning fork, which vibrates and emits electrical impulses. Electric coils and capacitors (condensers), interacting with each other, can produce and receive almost any predetermined frequency.

6. Frequency is the number of wavecrests that pass a particular point in one second. Wavelength is the distance between successive crests. Radio wavelength multiplied by the frequency always equals the speed of light. Frequency is denominated in Hertz (Hz). One Hertz is one wavelength per second; a kilohertz (KHz) is a thousand wavelengths per second 1×10^3 Hz; a Megahertz (MHz) a million wavelengths per second, 1×10^6 Hz; and a Gigahertz (GHz) is a billion wavelengths per second, 1×10^9 Hz. Wavelengths are denominated in meters.

7. As a practical matter, usable radio frequencies currently do not exceed about 40 GHz, although the radio spectrum abuts the infrared. The frequency of the visible light spectrum varies from 4×10^{14} Hz to 7×10^{14} Hz. Technology has now made it possible to transmit information on light waves, through the medium of fiber optics. Above visible light on the electromagnetic spectrum lie the ultra violet, x-ray, and gamma wave frequencies. The frequency of x-rays, for example, is 1×10^{18} Hz.

8. To transmit information it was necessary to "modulate" the fundamental frequency of the "carrier wave" of the transmitter. The output signal of the transmitter will contain many frequency components other than the "carrier" which are carried on "sidebands." It is on the "sidebands" that

propagation characteristic of radio waves is also a function of frequency. Low frequency waves have very long wavelengths and can travel great distances close to the ground. They are, however, subject to physical and electrical interference, and carry little information. Low frequency waves are used extensively by the military. Very high frequency waves (VHF), generally line-of-sight, penetrate the earth's atmosphere and reach orbiting satellites, but run the risk of being diffracted or absorbed by atmospheric particles and rain drops. Between AM radio waves with medium frequency carrier and FM radio with a very high frequency carrier are *short waves* in the high frequency (HF) band. Short waves repeatedly bounce between the ionosphere and the earth and because of this reflection process short waves are able to travel very long distances around the curvature of the earth, particularly at night. As a result of this propagation characteristic, the HF band of frequencies is extremely crowded and much in demand.

For each use of the radio spectrum—whether for radio or television broadcasting, mobile land and/or air communication, radio navigation, microwave relay,⁹ radar, radio astronomy or satellite communications—there is a portion of the spectrum that produces optimal results. Conversely, because of physical-natural constraints, there are portions of the spectrum that simply cannot be used for some purposes, although they may be ideal for others. The radio spectrum is divided, therefore, into bands of varying frequencies and their typical use and physical characteristics are best determined by its frequency band.

THE ELECTROMAGNETIC SPECTRUM'S CHARACTERISTICS AS A NATURAL RESOURCE

As a natural resource, the electromagnetic spectrum is a part of the natural environment of the earth and the space around it. Unlike hard minerals or petroleum, the electromagnetic spectrum is not depletable; it is always available in infinite abundance except for that portion which is being used. When that portion of the electromagnetic spectrum is not in use, it is instantly renewable. Soils or forests are also renewable but frequently at a price. Perhaps the closest analogy is a river, which can be used for a variety of purposes, but is never used up. The electromagnetic spectrum can be compared to the other natural resources of the earth in that it can be wasted or abused. In this sense, it can be "polluted" as water and air are polluted. Even though the spectrum cannot be used up,

information is "transported." The "carrier" plus the "sidebands" constitute spectrum "bandwidth." Various uses of the spectrum require significantly different bandwidths. For example, television requires three hundred times the bandwidth of very low frequency (VLF) point-to-point communications.

9. Microwaves are in that part of the spectrum above 1 GHz.

THE RADIO SPECTRUM

Wavelength	Frequency	Band Number	Band Designation	Metric Subdivision	Typical Uses
100 km	3 kHz	4	VLF very low frequency	Myriametric waves	Very long-range point-point communications (over 1,000 nautical miles)
10 km	30 kHz	5	LF low frequency	Kilometric waves	Long- and medium-range point-point communications; radionavigation aids; aeronautical mobile
1 km	300 kHz	6	MF medium frequency	Hectometric waves	Medium- and short-range communication, AM broadcasting; aeronautical mobile, radionavigation, marine radiophone, Loran; international distress, disaster, amateur
100 m	3 MHz (3000 kHz)	7	HF high frequency	Decametric waves	Medium- and long-range communication, International broadcasting; international point-point; air-ground; ship-shore; space research; amateur; radio astronomy
10 m	300 MHz	8	VHF very high frequency	Metric waves	Short-range line-of-sight communication; over-horizon 'scatter' communication, VHF television, FM broadcasting; space tracking and telemetry; satellites; aeronautical distress; worldwide radio-navigation; land mobile; amateur; radio astronomy
1 m	300 MHz	9	UHF ultra high frequency	Decimetric waves	Short-range communications; microwave relay; over-horizon 'scatter' communication, UHF television, instructional TV; land mobile, weather satellites, meteorological aids; space tracking and telemetry; radar; worldwide aeronautical radionavigation; amateur; radio astronomy
10 cm	3 GHz (3000 MHz)	10	SHF super high frequency	Centimetric waves	Microwave relay; deep space; space research, telemetry, communications satellites; radar; aeronautical radio-navigation; meteorological aids; amateur; citizens; radio astronomy
1 cm	30 GHz	11	EHF extra high frequency	Millimetric waves	Microwave relay; space research, radar, radionavigation; amateur; radio astronomy; broadcast satellites
1 mm	300 GHz				

The vertical scale has been compressed so that each horizontal strip represents a frequency range ten times wider than the one above.

1 hertz (Hz)
1 kilohertz (kHz)
1 megahertz (MHz)
1 gigahertz (GHz)

— one cycle per second
— 1,000 Hz
— 1,000 kHz
— 1,000 MHz

there are times when overcrowding or egregious interference prevent it from being used at all. The spectrum has been called a "limited" natural resource because, given present technology, there is only a finite portion available for beneficial uses at any one time. The word "scarce" is appropriate.

Generally speaking, natural resources contained within the geographic boundaries of a nation are owned by that nation; if the nation has a coast line, "ownership" extends to the outer limit of the territorial sea, now generally accepted as 12 miles. Equally, a nation has complete sovereignty over the air space above its territory. Other natural resources, such as rivers or lakes, form the boundaries between two nations or traverse them and constitute "shared" natural resources, the uses of which, under current law, are enjoyed by each on an "equitable" basis. Then there are "common property" resources, the principle characteristic of which is that they are *res communis*, accessible to all but not subject to appropriation by any one nation or person.¹⁰ The high seas and outer space are common property. The electromagnetic spectrum has many of the attributes of a "common property" resource. It is freely accessible to all, although, as is noted later, the first user of a radio frequency, provided he meets certain regulatory requirements, has a *de facto* lock on the frequency, and has virtually "appropriated" it.

The radio spectrum, as part of the electromagnetic spectrum, has the interrelated physical dimensions of space, time and frequency. The same frequency can be used in different geographical areas, depending on its propagation characteristics; or the same frequency can be used in the same area, but at different times. Or two different frequencies can be used in the same area at the same time. Radio signals occupy a volume of physical space depending on the intensity of the power that generates the signals. "Extreme power intensity will so saturate the volume of physical space as to preclude any other signal from being received intelligibly within it."¹¹ Thus, the cardinal constraint on the use of the radio spectrum is interference—interference with someone else's use by communicating on the same frequency at the same time and the same place. Normally, radio waves move out evenly from the source of electrical disturbance that created them. They keep travelling and expanding into larger areas of space as their energy per unit area gets smaller. Eventually, the radio signal cannot be heard against natural electromagnetic "noise and static," or against a stronger local radio signal which interferes with it at some location. Directional antennas focus the waves to minimize their dissipation. "Virtually all radio frequencies are potentially inter-

10. See O. SCHACHTER, SHARING THE WORLD'S RESOURCES 38 (1977).

11. H. LEVIN, THE INVISIBLE RESOURCE: USE & REGULATION OF THE RADIO SPECTRUM 18 (1971).

national and for most countries it is extremely difficult to avoid transborder 'spillover'.¹²

The nations of the Eastern Communist Bloc regularly jam unwanted transborder signals. A major political controversy at the United Nations concerns whether prior consent on program content is required for a television signal originating in one state to be received in another via direct broadcast satellite. A state may prevent radio waves from entering the country, but "a state is precluded from making constructive use within its borders of the frequencies over which the transboundary signals are being transmitted."¹³

THE ORBIT-SPECTRUM RESOURCE

A major step toward enlarging the information carrying capacity of the radio spectrum was the discovery that very high radio frequencies emitted from one location on the earth's surface are received by a satellite, and can be sent back to a different location on the earth. It was determined that a satellite located approximately 22,300 miles above the surface of the earth travels at a velocity that takes it around the earth once every twenty-four hours. If the satellite is on an equatorial path in the direction of the earth's rotation, it will remain above the same location on the surface of the planet and from that location will appear to be stationary. Satellites traveling this course are said to be in geosynchronous, or geostationary, orbit.

The great advantage of this orbit for communication purposes is that one satellite can see roughly 40 percent of the surface of the planet, and thus only three are needed for global coverage. No one is sure how many satellites can occupy the geostationary orbit, and estimates of the number of satellites vary from 180 to 1800, depending on a variety of factors which include the size of the satellite, stability of orbit, degree of interference, and the state of technology.¹⁴ The limiting factor on the number of satellites in the geostationary orbit is not physical space; rather it is a matter of electromagnetic interference between satellites using the same frequency band. Military systems control a substantial share of communication satellites, while the major civilian contributor to the international satellite communication service is INTELSAT, a global consortium of 108 member countries which provides direct services for nearly 150 countries. INTERSPUTNIK is the Soviet Block equivalent.

12. Robinson, *Regulating International Airwaves: The 1979 WARC*, 21 VA. J. INT'L L. 1, 2 (1980).

13. Sordos, *The Commons in the Sky: the radio spectrum and geosynchronous orbit as issues in global policy*, 36 INT'L ORGANIZATION 665, 668-69 (1982).

14. See Gorove, *The Geostationary Orbit: Issues of Law and Policy*, 73 AM. J. INT'L L. 444, 445-46 (1979).

Like the radio spectrum, the geostationary orbit is a limited natural resource that cannot be used by everyone for every purpose at the same time. The "orbit-spectrum" resource includes the geostationary orbit and the radio spectrum. The "orbit-spectrum" is not depleted in the same fashion as some other natural resources; but it can become crowded, and communications satellites must stay a respectful distance from each other (the distance decreases as technological innovation increases) to avoid harmful interference between satellite networks.¹⁵ Thus, this resource is the product of two "limited" natural resources, physically distinct, yet interacting with each other and mutually dependent for the optimum use of space communication services.¹⁶

MANAGEMENT OF THE RADIO SPECTRUM

The Formal Structure

In a world where the availability of virtually all natural resources is subject to the pressures of increased use, the careful and equitable management of that resource is crucially important. "Two general factors have a major impact on the use of the spectrum: first, a continually escalating demand for communication services, and second, technological advances which permit the same amount of bandwidth to be used more efficiently and effectively, much as the value of an ore deposit can be increased by various means."¹⁷

The earliest efforts to develop international cooperative use of the radio spectrum were born out the necessity for enhancing safety at sea. Marconi had a virtual monopoly on the personnel and wireless equipment used on the British and Canadian fleets and no one could communicate with these ships or Marconi's shore installations without using his equipment. It became apparent that "there was an urgent need for all maritime nations to agree on which frequencies ships were to operate both to encourage communication and avoid interference."¹⁸ National sovereignty or per-

15. See Rothblatt, *The Impact of International Satellite Communication Law upon Access to the Geostationary Orbit and the Electromagnetic Spectrum*, 16 TEX. INT'L L.J. 207, 207-11 (1981).

16. International Telecommunication Convention, Oct. 12, 1973, Malaga-Torremolinos, 28 U.S.T. 2497, T.I.A.S. No. 8572. Article 33(2) of that treaty states:

In using frequency bands for space radio services, Members shall bear in mind that radio frequencies and the geostationary orbit are limited natural resources, that they must be used efficiently and economically so that countries or groups of countries may have equitable access to both in conformity with the provisions of the Radio Regulations according to their needs and the technical facilities at their disposal.

28 U.S.T. 2497, 2529. Christol agrees they "are limited" in the sense that their use can be expanded regularly over time as the result of scientific and technological innovations. *But see* Christol, *The Geostationary Orbital Position as a Natural Resource of the Space Environment*, 26 NETHERLANDS INT'L L. (1979) (citing A. CHAYES, *SATELLITE BROADCASTING* 17 (1973)).

17. LEIVE, *INTERNATIONAL TELECOMMUNICATIONS AND INTERNATIONAL LAW: THE REGULATION OF THE RADIO SPECTRUM* (1970).

18. Briefing Paper, *supra* note 4, at 6.

sonal monopolies over radio communications were no longer possible.

A series of international conferences were held in Berlin, London, and Washington during the early part of this century to negotiate agreements on frequencies that could be used by all nations for ships in distress, for weather and storm signals at sea, and to establish a network of coastal stations. All frequencies agreed upon were recorded with the International Telegraph Union, now the International Telecommunications Union (ITU). The Washington Conference in 1927 created the Table of Frequency Allocations, where frequencies were recorded for various services and for various countries. Use of a particular frequency was not mandatory, and interference disputes were settled by arbitration.

Nonetheless a principal goal in the management of the radio spectrum has always been to avoid interference. As public and private use of the spectrum grew exponentially, specific frequencies were registered by their user with the ITU and a system of "squatter's rights" or "first come, first served" became the basic method of international regulation. Once a frequency was registered to a particular user, it was recognized internationally. The ITU has no regulatory power to prevent the use of a particular frequency. The ITU can, however, deny the formal legal protection provided by the Radio Regulations, which have the force of treaty law, to any station that engages in "harmful interference" with the functioning of other radio services. Harmful interference by a later station with a frequency assigned to an earlier one is proscribed.

Periodically a World Administrative Radio Conference (WARC), convenes under the auspices of the ITU, reviews the entire use of the spectrum and revises its Radio Regulations to reflect technological change and accommodate new users and services. Specialized WARC's for particular services such as Space, Maritime, Aeronautical, Broadcast Satellites, and for particular Regions¹⁹ convene in the years between the general WARC's. At the specialized WARC's, an overall "plan" is devised for the use of the specific service, the major criterion again being non-interference. The allocation of frequencies when the effects are principally within the region, for example, AM radio frequencies, and the assignment of geostationary satellite slots is discussed at regional conferences.

The ITU, the oldest international organization in existence, has 157 members, of whom 142 attended the 1979 General WARC. Since it would be administratively impossible for the ITU to distribute specific frequencies to all its members, it *allocates* usable portions of the spectrum to the different communication services. "[T]he *assignment* of frequencies to specific stations takes place on the national level, consistent with

19. Region 1 covers Europe, Africa, and the U.S.S.R.; Region 2, the Americas and Greenland; Region 3, Asia, Australia, and the Western Pacific.

international allocations and other applicable rules.”²⁰ Individual countries select frequencies and can insist that those frequencies be recorded with the International Frequency Registration Board (IFRB), an organ of the ITU. An assignment recorded with IFRB is normally given priority over subsequent notices if it is in conformity with international law provided in the Convention and Radio Regulations. The International Telecommunications Convention and the annexed Radio Regulations have the force of Treaty Law when ratified by a member country.

In the United States, management of the spectrum is divided between two federal bodies. The National Telecommunications Information Agency (NTIA) is an executive agency and assigns frequencies to all Federal agencies, while the Federal Communications Commission (FCC) assigns frequencies to all private users.

Legal and Political Considerations

As the demand for the use of the spectrum increased from all corners of the globe, it was inevitable that disputes would arise concerning priority rights to the use of certain bands and frequencies.²¹ The basic method of “first come, first served” international regulation became insufficient to allocate the spectrum as it became a “scarce” resource. It became necessary to accord priority to mobile, navigation, rural broadcasting, and satellite services that *must* use the spectrum and cannot rely on material supports, such as wire or cable. Nonetheless, frequencies registered with the IFRB prior to the subsequent notification and used in conformity with applicable international law of the Convention and Radio Regulations still have a priority status.

The ITU has no coercive means of enforcement. The IFRB cannot order stations to stop transmission and cannot even refuse to record frequency assignments. The Convention and Radio Regulations, however, have the force of law and, for the most part, are observed. Self-interest provides an important sanction against interference. Interference can invite retaliation and the original party guilty of interference may later be estopped from asserting a priority claim.

The most difficult legal and political problems have arisen in the use of the orbit-spectrum resource for satellites. The allocation of frequency bands for maritime services at the beginning of this century grew out of

20. For a detailed description of the basic features of the ITU regulatory regime, see LEIVE, *supra* note 17, at 19-28.

21. The high-frequency (HF) or “short-wave” band, because of its great usefulness for long distance communications became very congested early on. Careful planning, including moving some users to terrestrial transmission, has been required to avoid constant interference. The military, the developing countries, and such broadcast services as the Voice of America, Radio Free Europe, BBC, and Radio Moscow are the principal users of high-frequency communications.

a shared international concern for safety at sea. Similarly, the rapid proliferation of space services—communication, radio navigation and meteorological—necessitated the international allocation of bands in which these services could operate. “The two basic principles which guide international regulation of space telecommunications are efficient use and equitable sharing of space service frequencies and the geostationary orbit . . . and are based on the valid premise that both are infinite and *res communis*.”²²

Two basic factors, one technical and one political, have influenced the use of the orbit-spectrum resource; first, the actual ability of the space powers, primarily the United States and the USSR, to use the spectrum and establish orbital slots; and second, the strong desire of the Third World to have guaranteed access *now* to the radio spectrum and the orbit lest there be no room left when they have the resources and the technological expertise to use them. The issues raised by these considerations are increasingly being discussed in ITU forums such as the Broadcast Satellite WARC in 1977, and the General WARC in 1979. The considerations of the Conferences reflect the Third World’s campaign to obtain a more equitable share of the world’s resources and communication capacity under the principles propounded by the New World Economic Order and the New World Information Order. “Developing countries will continue to seek changes in the existing mechanism for vesting rights in the use frequencies and access to the geostationary orbit. They seek a shift away from the current notification and coordination procedure on a ‘first come, first served’ basis, toward a negotiated plan developed on an *a priori* basis.”²³

The growing awareness of the enormous commercial, political and strategic value of the orbit-spectrum resource has strongly influenced the need for a legal regime to govern its use. Two legal instruments are of primary importance: The 1973 International Telecommunications Convention, particularly Article 33(2)²⁴ and the Outer Space Treaty.²⁵

22. Rothblatt, *ITU Regulation of Satellite Communication*, 18 STAN. J. INT’L STUD. 10 (1982).

23. For the text of this provision, see *supra* note 16.

24. Treaty on Principles Governing the Activities of States in the Use of Outer Space, including the Moon and Other Celestial Bodies, Jan. 27, 1967, 18 U.S.T. 2410, T.I.A.S. No. 6347, 610 U.N.T.S. 205. Article I of that treaty provides:

The exploration and use of outer space, including the moon and other celestial bodies, shall be carried out for the benefit and interests of all countries, irrespective of their degree of economic and scientific development, and shall be the province of all mankind.

Outer space, including the moon and other celestial bodies, shall be free for exploration and use by all states without discrimination of any kind, on a basis of equality and in accordance with international law, and there shall be free access to all areas of celestial bodies.

18 U.S.T. 1412. Article II further provides that “[o]uter space . . . is not subject to national

Developing countries have claimed that occupying an orbital slot is an "appropriation" proscribed by Article II of the Space Treaty.²⁶ The developing countries assert that space occupied by a satellite in geostationary orbit over an equatorial state is national space subject to national sovereignty.²⁷ Given the language of both Article 33(2) of the 1973 Convention²⁸ and Article I of the Outer Space Treaty,²⁹ all states have a valid claim to an orbital slot as a matter of "equity" and "fairness." Because outer space is the "province of all mankind," some international body should, therefore, allocate orbital slots in advance to those countries that desire them.

Two claims of the developing countries can be easily dismissed. "Appropriation" requires an intent to appropriate, and no such intention has ever been demonstrated by developed countries. The space powers assert only a "temporary occupancy," and in any case, under present international law, the space environment is considered *res communis*, available to everyone and not subject to ownership. As to the second claim, it has been generally agreed upon that the term "outer space," as used in the Outer Space Treaty, includes "all space at and above the lowest perigee achieved by 27 January 1967, when the Treaty was opened for signature, by any satellite put into orbit, without prejudice to the question whether it may or may not later be determined to include any part of space below that perigee."³⁰ The lower boundary of space is at about 100—110 kilometers (63—70 miles) above the surface of the earth,³¹ whereas a geostationary satellite in orbit is at 22,300 miles from the earth's surface. Thus the geostationary orbit is in "outer space" and, therefore, is governed by the Outer Space Treaty.

The claim of "fairness" and "equity" in allocating orbit slots to the developing countries, however, is valid. As a practical matter, many of

appropriation by claim of sovereignty, by means of use or occupation, or by any other means." *Id.* at 2413.

25. OFFICE OF TECHNOLOGY ASSESSMENT, UNITED STATES CONGRESS, RADIOFREQUENCY USE AND MANAGEMENT: IMPACTS FROM THE WORLD ADMINISTRATIVE RADIO CONFERENCE OF 1979 (1982) [hereinafter cited as RADIOFREQUENCY].

26. *Id.*

27. The claim of eight equatorial states, embodied in the Bogota Declaration, is based on the assumption that since "outer space" has never been defined, the Outer Space Treaty does not apply, and "segments of the geostationary orbit (a natural resource) lying above their territories are an integral part of the territory over which the equatorial countries exercise complete and exclusive sovereignty." Gorove, *supra* note 14, at 450. It should be noted that Colombia, Congo, and Kenya never signed the Outer Space Treaty, and therefore do not think it relevant to the "equatorial claim."

28. See *supra* note 16.

29. See RADIOFREQUENCY, *supra* note 25.

30. Williams, *The Geostationary Orbit: A Limited Natural Resource from Outer Space*, 6 INT'L REL. 662, 663 (1979).

31. 58th Conference of the International Law Association, in Manila, August 1978 cited in Williams, *supra* note 30, at 663.

the developing countries, particularly those with large geographical areas and long distances between communities, don't have the resources to establish an expensive ground-based communication system, and it is only with a satellite that they can get adequate coverage.

The developing countries would like to eliminate the "first come, first served" rule, and obtain agreement on *a priori* planning of the orbit-spectrum resource, whereby they are guaranteed a position in the orbit. Part of this objective was achieved at the 1977 Broadcast Satellite WARC, where the IFRB was authorized to furnish advice relating to the "equitable, effective, and economical use of the geostationary satellite orbit."³² This language lent strong support to the demand by the developing countries for *a priori* assignment of the space geostationary orbit.³³ The issue of *a priori* assignment of the spectrum will be fully discussed at the upcoming two-part specialized WARC on the "Geostationary Satellite Orbit and the Planning of Space Service Utilizing it," scheduled for 1985 and 1987.

The position of the advanced countries regarding allocation of the spectrum-orbit resource is essentially two-fold. First, the rule of "first come, first served," confers no proprietary or sovereign rights upon the earliest users, but only gives the right to exploit a frequency without harmful interference, based upon the priority of registration with the IFRB. Second, "when the LDCs have a present and practical need for access to and can make optimum use of such resources, such resources will be made available. Demonstrable need would require a sharing of use pursuant to the terms of Article 33 of the 1973 ITU Convention. This policy has been identified as the *a posteriori* doctrine."³⁴ The *a posteriori* doctrine embraces the strongly held view that *a priori* planning leads to wasteful and inefficient use of the spectrum. The *a priori* doctrine, moreover, does not take into account technical advances occurring between the time a frequency is allotted and the time it is actually used. Technological advances will increase the likelihood of equitable access.

The U.S. position, reflecting that of many advanced countries, asserts that guaranteed access deprives all nations of the fullest, most efficient utilization of the orbit-spectrum resource and cannot be considered equitable.³⁵

The fact remains that there is adequate spectrum for all nations at the present and that technology will very likely expand the effective

32. Christol, *National Claims for the Using/Sharing of the Orbit/Spectrum Resource*, in Proceedings of the 25th Colloquium on the Law of Outer Space 296 (1982) (emphasis added).

33. Rothblatt, *supra* note 22, at 10.

34. Christol, *supra* note 32, at 296.

35. Department of State, Office of International Communications Policy, Report of the Chairman of the United States Delegation to the World Administrative Radio Conference of the International Telecommunications Union (1979) (TD Serial No. 116).

utility of the available spectrum to satisfy future needs of all nations. The problem for the United States is to convince other nations, particularly the developing countries, that spectrum and orbit capacity will be available and that their needs for service can be satisfied. Technical assistance can be very useful in this regard, and economic assistance can help make the benefits of technology a reality. Creating a role for the developing countries in cooperative planning efforts is likely to make them more receptive to the positions and plans that are forthcoming, even though they benefit both the developed nations and themselves.³⁶

CONCLUSION

The electromagnetic spectrum *is* a natural resource because its physical characteristics make possible a major segment of modern communication, and it clearly serves a useful purpose. Even though its physical dimensions are infinite, and it can never be depleted, the constantly increased demands for use of the electromagnetic spectrum constrain the extent to which it can be exploited without unacceptable interference. That portion of the electromagnetic spectrum known as the radio spectrum is, however, a "limited" natural resource and, at least for the present, a "scarce" resource. Technological innovation expands the capacity of the orbit-spectrum resource to carry more information over greater distances and in new directions, but whether technology can keep up with the demand is by no means certain. Over-use and over-crowding cause interference and lead to situations where the use of the radio spectrum is severely impaired.

Equitable and careful management of the orbit-spectrum resource is crucial at the national and international levels. Legal regimes based on conventions, rules and regulations are in place, and institutional arrangements are functioning, albeit imperfectly. As would be expected, however, the interests of various countries in the use of the radio spectrum is not always harmonious. There simply isn't enough radio spectrum to go around to meet everybody's requirements whenever they need to be satisfied. The problem is further exacerbated by the technical and resource disparity between the developed and developing countries.

The competition for the use of the "high frequency" or short-wave band assumes strong political overtones. The issue of "equity" versus "efficiency," "guaranteed access" versus "technological innovation," is the same broad type of dichotomy that is at the core of the divergent views on so many so-called "North-South" issues. An accommodation to both views will inevitably have to be reached and may not be wholly satisfactory to either side. A less rigid, more elastic concept of "advance planning" will provide a basis for the necessary compromise.

36. RADIOFREQUENCY, *supra* note 25, at 120.