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I. PROBLEM OVERVIEW

Not long after the initiation of our nation's space activity, a program in space communications became significant. This program has resulted in a series of satellites involved in communications, including passive reflectors of energy and active relay satellites.

Among the uses realized and projected for communications satellites are: relaying telephone conversations; relaying data in digital or coded form; closed circuit television; and relaying broadcast material.

Broadcast material may be of an educational nature, a commercial nature (*i.e.*, advertising products or services for sale), a political nature (*e.g.*, position statements by candidates for office), or an entertainment nature. While uses in each of these areas may be very beneficial to those concerned, certain uses could be subverted to the accomplishment of undesirable ends. Herein lies the major problem with direct broadcast application.

The purpose of this article is to examine certain problems arising from the technical aspects of direct broadcasting satellites (D.B.S.) and to inquire into their legal implications.

II. TECHNICAL FACTORS

A. The Satellite System

In typical application, the communications system comprises a ground-based transmitter, a space-borne satellite to relay information, and a ground-based receiver, or set of receivers. A signal, sent continuously over the broadcast frequency, emanates from the transmitting antenna and is directed toward the satellite. The satellite, having an antenna system of its own, receives the signal, performs certain operations thereupon (typically, an amplification and conversion to a retransmission frequency), and retransmits the signal in the direction of the ground-based receiver.

For maximum user utility, the relay satellite should be in geo-stationary orbit; that is, in an orbit remaining over a given location of the Earth's surface for a usefully long time. Such orbits are of large diameter and thus the satellite is more than 22,000 miles

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from the Earth's surface.¹ This long retransmission distance places stringent demands upon the satellite's required radiated power so that a considerable amount of power is needed to provide a useful signal level at the receiver site.²

The primary advantage of using a direct broadcasting satellite system lies in the fact that at television frequencies (30-300 MHz for VHF), propagation occurs in nearly straight-line paths. Therefore, the earthbound range of ordinary television signals is severely limited by the Earth's curvature. To send a television signal over the face of the Earth would require having relay stations located every 75 miles or so. Obviously, this is not easily done over oceans, but the satellite effectively bridges these distances.

By using a geo-stationary orbit, one satellite can provide coverage to locations within nearly an entire hemisphere. Of course, if the satellite's radiated signal were spread out over the entire hemisphere, the signal strength received at any location in the hemisphere would be very small. Therefore, it is useful to confine the radiated signal to geographically limited regions on the Earth's surface. The techniques for confining radiated signal beams rely on having proper transmission antennas. The simplest antenna is a dipole antenna. The radiation pattern of such an antenna is almost unconfined; the amplitude of radiation along or near the direction of the dipole axis is small, but in all other directions the signal strength is almost uniformly large. Arrays of dipoles, however, can be structured to provide reinforcement of the radiated signal in selected directions and diminution of the signal in other directions. Parabolic antennas are one configuration useful in this context. In principle, a dipole array can be designed to produce any reasonable beam pattern desired, but in practice, certain arrays or structures are preferred; chief among these is the parabolic dish.

With properly designed antennas, the power demand of the radiating satellite can be efficiently matched to the requirement for adequate signal strength on the Earth's surface. However, other considerations enter into the "power equation". For example, more power is required to transmit a color television program than a black and white program. This requirement is related to the increased frequency band width required for color television. Power required by the transmitter is also linked to the sensitivity of the receiver. Thus, if it is necessary to provide a substantially increased receiver sensitivity to utilize the satellite signal, the economics involved may affect the choice between reception by centralized ground relay stations and reception by end users.

¹The requirements for a geo-stationary orbit are: (1) the period of satellite rotation about the Earth must be the same as the period of rotation of the Earth on its axis, (2) the satellite's orbital plane must very nearly coincide with the Earth's equatorial plane, and (3) the satellite must be in a circular or near-circular orbit. The period of a circular orbit is related to the orbit altitude above the Earth. A satellite in a geo-stationary orbit will keep station approximately 22,500 miles above the equator.

²Signal strength varies inversely with the square of the distance from the source. Thus a transmitter broadcasting from an altitude of 200 miles would produce a signal strength at the Earth's surface approximately 10,000 times greater than the signal strength produced by the same transmitter broadcasting from geo-stationary orbit.

B. The Technical Problems

The first technical problem to be considered is that of frequency allocation; that is, what frequencies of operation are to be used for direct broadcast? The radio frequency spectrum has become so extensively used that in certain situations it is on the verge of overcrowding. Effective operation of a satellite communication system requires that an operating frequency be chosen which minimizes the detrimental effects of the following factors: a) atmospheric absorption, b) background noise, c) interference, and d) radiation pattern. Such minimization suggests an operating frequency in the range of 1-10 GHz (a GHz is 1000 MHz).³ Prior to 1971, the only available band was a 500 MHz band about 4 GHz and 6 GHz. In 1971 the World Administrative Radio Conference approved the following frequency bands for communications satellite systems: 10.95 to 11.2 GHz; 11.45 to 11.7 GHz; 14.0 to 14.5 GHz; 17.7 to 19.7 GHz; 19.7 to 21.2 GHz; 27.5 to 29.5 GHz; 29.5 GHz to 31.0 GHz.⁴ All of these bands are outside the most desirable spectral region, but the bands near 12 and 14 GHz have been of the most interest so far.

For television purposes, frequencies already allocated may be useful. For example, the NASA/India Satellite Instructional Television Experiment (SITE) will utilize an 860 MHz (UHF) spacecraft transponder aboard the ATTS-F satellite.⁵

Technological solutions to the spectrum crowding problem may be based on any of several techniques under active investigation at various laboratories. Such techniques as controlled polarization and advanced forms of modulation hold promise.

The second major technical problem associated with broadcasting from space is that of "spillover". From a satellite in geo-stationary orbit, even a narrowly confined radiation pattern of 3 degrees beam width produces a beam cross-section width at the Earth's distance of approximately 1100 miles. Because the beam is not generally pointed straight down at the center of the earth, the surface area intercepted by the beam will be oblong and of characteristic dimensions greater than 1100 miles.⁶ Many countries are less than 1100 miles across. Furthermore, there are many regions of the Earth's surface in which vast political and cultural differences exist within a range of 1100 miles. Of course, the radiated signal does not change from full strength to zero strength at the "beam edge", but actually declines gradually. Using the ATTS-F/SITE experiment as an example, from the center of the beam at Nagpur, India, the signal strength declines in the North-South dimension by 1 decibel (db) at 260 miles, 3 db at 650 miles, and 10 db at 1050 miles. A

³See, e.g., Jaffe, *Communication by Satellite*, in *Modern Science and Technology* 543 (R. Colborn ed. 1965); Pritchard & Bargellini, *Trends in Technology for Communications Satellites*, 10 *Astronautics and Aeronautics* 36 (1972).

⁴Partial Revision of the Radio Regulations, Geneva, 1971 and Final Protocol: Space Telecommunications, July 17, 1971, [1972] 23 U.S.T. 1527, T.I.A.S. No. 7435 (effective Jan. 1, 1973).

⁵Hearings on S. 2955 Before the Senate Comm. on Aeronautical and Space Sciences, 93rd Cong., 2nd Sess., pt. 2, at 670-71 (1974).

⁶The surface pattern will be generally egg-shaped with a minimum pattern dimension of 1100 miles.

signal strong enough for use in most of India will also be strong enough to be used in Pakistan, Burma, parts of China and the Soviet Union, and in other nearby countries.⁷

Assuming that spillover program reception is to be prevented, the principal techniques available involve either shaping the beam so that the resultant signal strength outside the intended reception area is too weak to use, or producing a signal which is unusable except by those possessing the necessary technology and equipment. In fact, the signal strength outside the intended area will never be exactly zero no matter how well the beam is shaped. Also, there is cause to question the viability of an exclusionary technique which relies on special receiving technology and/or equipment.

The third major technical problem concerns the possibility of interference with the satellite broadcast by a State intending to counteract the broadcast. Several techniques could be called into play. Jamming by sending out strong distracting signals on the broadcast frequency would produce a noisy reception. A State might be able to broadcast improper satellite control commands and interfere with the operation of the satellite or its orientation, and thus reduce the utility of the broadcast. A State having substantial space capabilities could produce interference by positioning its own space vehicle or other space object so as to alter the characteristics of the signal received by the direct broadcasting satellite or the signal retransmitted by it.

Finally, the fourth major technical problem involves unintentional interference in the utilization of space. Geo-stationary orbits are immensely useful, but there is a limited availability of "orbit space". All such orbits must be approximately 22,500 miles above the Earth. If all geo-stationary orbit positions were to be used by communications satellites, then to avoid interference between them, they would have to be separated by some minimum amount, perhaps as much as 5 degrees.⁸ The problem here is not physical interference but radiation interference.

There are several regions over which geo-stationary orbit placement is particularly attractive. The uses to which such positions could be put include surveillance for national security purposes, monitoring associated with treaty verification, Earth observation, navigation, and all types of communications. There is a possibility of demand for geo-stationary orbit positions greatly in excess of the supply. This question of interference needs to be examined in more technical detail.

⁷Hearings, *supra* note 5, at 671.

⁸*Id.*

III. LEGAL IMPLICATIONS

A. Frequency Allocation

This problem is one of the most difficult and urgent technical problems relating to direct broadcasting satellites. However, there already exists a substantial institutional mechanism for dealing with the legal aspects of the problem. Within the United States, the Federal Communications Commission, and internationally, the International Telecommunication Union, arrange the allocation of the frequency spectrum.

B. Spillover

This also is a very difficult technical problem. Here, however, the legal aspects of the question are of considerable concern.

Since the invention of the radio less than a century ago, mankind all over the Earth has been subjected to an increasingly intense bathing in electromagnetic signals. We are subject to radio waves from broadcast stations, short wave stations, "ham" radios, citizen's band radios, police, aircraft, marine and navigational radio, television, and from a host of other sources. Almost anywhere on the Earth we can, with ordinary equipment, receive information by radio from many nations around the world. There has never been recognized a right to be free from the infringement of such radiation, regardless of the points of origin or the purpose of the information carried. Can there be, therefore, any right to be free from such radiation coming from a satellite? There seems to be no basis for such an assertion.

It should be recognized, however, that there is a significant difference between radio-type information and television-type information. The experience in the United States is convincing that television has a far greater impact upon the individual than does radio. As noted above, surface-originated television signals are limited in their ability to carry great distances. Therefore, in most cases, there is little infringement of foreign television material on other countries except for those regions near the borders of the originating country. Perhaps this distinction between radio and television should be examined to see if a reasonable basis exists for asserting a right to be free from television infringement.

C. Intentional Interference

The legal implications of intentional interference are perhaps less important than the political or military implications because intentional interference connotes a hostile action on the part of the interfering state or person. We already have treaties, signed by many nations, which deal with the peaceful uses of outer space. An intentional interference propounded by a signatory State would raise questions of treaty violation. However,

suppose the interference arose from either a person or a non-signatory State. In what forum might the resulting legal questions be raised? What jurisdiction may cover such an act by a person who is not a citizen of a signatory State?

We discussed *supra* the fact that the signal from the satellite arriving at the Earth's surface will be weak. Intentional jamming at the receiver site could be easily accomplished. What is the legal situation regarding interference by a citizen of the receiving state? Does interference at the receiver site constitute interference with a space object?

D. Unintentional Interference

The question of allocation of orbital space is in need of resolution. There are many competing demands for such space and an uncontrolled race for occupation of usable positions will be detrimental to all intended users. The most reasonable approach to this problem seems to be one in which spacecraft would be assigned to specific positions for a certain time period. This approach, however, may create problems related to national security because many surveillance functions are now performed by military satellites in geo-stationary orbit.

Not every satellite mission poses the same stringent demands on vehicle separation that are made by communication satellites. Surveillance satellites, for example, need only an unobstructed view of the Earth (easily obtained even with satellite separations on the order of feet) and a clear communications channel to the command site. The quality of the communications channel is determined by parameters somewhat different for surveillance and alert missions from those required for direct broadcasting missions. An international registry of spacecraft would be helpful in planning missions so as to avoid interference. Mandatory registration and orbit allocation could eliminate the problem altogether.

IV. CONCLUSION

To summarize, direct broadcasting satellite technology leads to four major problem areas in the use of satellites for broadcasting: (a) further crowding of the frequency spectrum, (b) "spilling-over" of the signal onto nations not desirous of receiving it, (c) intentional interference with the system by a nation or a person, and (d) unintended interference caused by or with other space objects in geo-stationary orbit.

The solutions to these problems need individual attention because there are significant differences among them. Frequency allocation problems on the international scale are the concern of the International Telecommunications Union. The technological possibilities for solution include new methods of utilizing signals in shared bands and new methods of utilizing new bands.

"Spill-over" is a problem with very important legal aspects. The UNESCO "Declaration of Guiding Principles on the Use of Satellite Broadcasting", proclaimed on November 15, 1972,⁹ states that "[e]ach country has the right to decide on the content of the educational programs broadcast by satellite to its people. . . ."¹⁰ Is there any basis in law for such a principle? Associated with this problem are many basic questions of rights with regard to availability of information and with regard to our constant immersion in a bath of electromagnetic radiation.

The problem of intentional interference deals not only with measures which might be taken by a State, but, because of the ready technical feasibility, with actions of persons. A variety of motives for such actions can be imagined. As a deterrence to actions of persons, some suggest civil sanctions, while others propose criminal sanctions. A major question in this regard is the nature of the forum in which such matters may be heard.

Orbit allocation is a problem which should be dealt with by an international organization empowered to register spacecraft and control the use of such geo-stationary orbital positions as are in over-demand.

As with many applications of space, the technology to accomplish the primary goal in direct broadcasting satellites is here. The secondary matters of adjusting to the proper demands of the international community will require new technological developments and, granting a basic premise of goodwill among nations, these developments promise to provide the solutions needed.

⁹For a text of the Draft Declaration, see UNESCO Doc. 17 C/76, Part II (July 21, 1972). The Declaration is reproduced in 1 J. Space L. 161 (1973).

¹⁰*Id.*, IV (2).