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Security Information

APPENDIX A

The Radio Medium as a World Resource

World-wide Resource.

The radio medium is a world-wide natural resource.

The radio medium (it used to be popularly known as the "ether") is a harnessable means of transport for the conveyance of ideas, information, and remote control signals. Its speed of conveyance is that of light--186,000 miles per second.

With suitable investment of equipment, manpower, and technology, the radio medium is capable of use by all nations of the world for the provision of a variety of economic and other services, domestic and foreign. Because it exists everywhere, it is not subject to world monopoly by one country as are some physical resources. It is expoloited to create thought values in time and place.

The Radio Spectrum.

The radio medium is measurable in numerous ways. The commonest dimension is expressed in the popular numerical unit called "frequency" (formerly in wave-length). The numerical range of frequencies capable of conveying usable energy in the form of radio-frequency waves in the radio medium may be called the "radio spectrum".

The range, or width, of the usable radio spectrum in use has been increasing over the years. At about the turn of the twentieth century, when practical radio was first realized, only a small band of frequencies was used. Subsequent research and development greatly enlarged the range of frequencies in use, as well as the variety of uses. By 1947, for the purposes of regulation and organization, international agreement had established the practical range of the radio spectrum as 10 kilocycles to 10,500,000 kilocycles. 1/ At the same time, however, the agreement recognized scientific evidence that the radio spectrum extends to the order of 3,000,000,000 kilocycles. 2/ Since 1947 research and development effort has been pushing the practical range well beyond the 10,500,000 kilocycles mark.

For economic purposes it is the workable radio spectrum which represents the world "supply" of the radio medium as a natural resource. It is from this single, free, supply that the various users of the world select frequencies and, with the employment of appropriate apparatus, create radio facilities to meet their needs for communication, radar, radio-navigation, missile guidance, and other services.

Technological Requirements.

Besides frequencies, efficient and expanding employment of radio today calls for the application of a thorough-going fund of technological know-how. Useful radio frequencies do not exist in nature. Apparatus must be provided to generate and to receive them. Know-how is indispensable for

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1/ "Radio Regulations", Final Acts of the International Telecommunication and Radio Conferences, Atlantic City, N. J., International Telecommunications Union, 1947, p. 58 E.

2/ Ibid., p. 1-E.

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the development, production, operation, and maintenance of radio apparatus. Likewise indispensable is a sound technical knowledge of the behavior of the radio medium itself and of the radio-frequency waves sent through it. This know-how means trained manpower. Paradoxically such trained manpower is a potential source for the discovery of techniques to conserve manpower through the replacement of manual radio functions by automatic functions.

Though accumulated with great labor and cost for over fifty years, the present massive, world fund of radio knowledge, as in any field one would care to name, continues incomplete. Today great economic and political pressures are at work to increase that fund. New discoveries in radio are always a potential attraction for capital and labor investment. Further, world tension has set off an international race in scientific research and development for discoveries which might well give far-reaching economic and strategic advantages to those nations making them.

Technology is the key to new developments in radio.

Characteristics of the Medium.

The major characteristic of the radio medium is v riability. It does not treat all frequencies in the same way. It is not of uniform quality at all places nor at all times at any given place. It is susceptible to uncontrollable influences.

A brief, non-technical explanation of these variables will help to define the capabilities of the medium.

As to the unequal treatment of the various frequencies by the radio medium, three major, somewhat arbitrary divisions of the radio spectrum may be identified. In general the radio waves (ground waves) of frequencies below about 3,000 kilocycles tend to travel along the surface of the earth and thus, if strong enough, to follow its curvature. They may be used for long-distance purposes, especially where coverage in the intervening area is required. For these, distance is a direct function of power put into the waves. Radio waves of frequencies between about 3,000 kilocycles and about 30,000 kilocycles do not travel very far along the earth's surface, but instead generally reach out to longer distances by angular reflection from ionized layers in the upper atmosphere, often skipping over the intervening areas. For such operations, choice of frequency as well as power are important factors in distance coverage. Today they comprise the group of frequencies in greatest demand for direct, long-distance purposes especially where coverage of the intervening areas is unnecessary. Radio waves of frequencies above 30,000 kilocycles act somewhat as do light rays, that is, they tend to travel in a straight line and for relatively short distances. Of the three arbitrary divisions, the highest frequency group furnishes by far the largest supply of frequencies, because their number is largest and because their short-distance characteristic permits reuse within small areas.

As to the non-uniform quality of the radio medium, its transmissibility by ground wave on the lower order of frequencies varies through differing kinds of soil and differing soil conditions, through waters of differing salinity, through differing atmospheric conditions, among others.

As to the sensitiveness of the radio medium to uncontrollable influences, there are a number of phenomena which alter the carrying capacity of the medium for better or for worse. Some of these are atmospheric noise (static), sun-spot activity, seasonal changes, day-night conditions, magnetic and other storms, and fading.

These variants of the radio medium complicate the employment of radio. Employment is further complicated by the behavior of the radio-frequency waves propagated into it.

Radio-frequency waves are subject to influence and partial human controls. They may be strengthened or weakened in several ways. They may be directed, somewhat as a beam of light. And as a beam of light, they may be reflected, deflected, and diffused. They may be shielded by metallic materials, obstructed by terrain, by snow, rain, and other physical matter in the atmosphere. Peculiarly, radio-frequency waves do not interfere with each other in traversing the medium even though the waves may be of the same frequency. Two or more such waves entering the same receivers would, however, produce reception interference. Channelization by apparatus is the key to control.

The Radio Channel

The establishment of a radio facility involves the provision of suitable radio-wave generating (transmitting) equipment and of receiving equipment capable of being tuned to the frequencies of the waves transmitted from the other end of the circuit or channel. The transmission consists of complex waves comprising a cluster of radio frequencies. The width of this cluster varies with the nature of the desired signals. It may vary from a few hundred cycles for the old-fashioned, manual Morse telegraph, to 10 kilocycles for ordinary broadcasting, to 6,000 kilocycles for television and to 40,000 kilocycles or more for the new multiplexed micro-wave and other systems. These clusters are known as radio channels or circuits and when placed in a specific place in the radio spectrum, they become frequency assignments. The radio channel may be said to be an exploited piece of the spectrum.

The Inefficiency of the Channel.

The generation of radio waves and their reception in most cases requires electricity as a source of power. The equipment used to propagate and to receive radio waves does not handle this power very efficiently. Besides, much of the energy transferred to the waves, in most applications, is wasted. Unless the waves are concentrated and focused as a beam in the wanted direction, the energy radiated in the other directions serves no other purpose than to create potential interference to other stations. Even the energy that passes by the wanted receiving point is in the same category. On the other hand, in non-directional services, such as broadcasting and mobile, some energy is necessarily radiated in all directions. For practical purposes, receivers do not consume any measurable amount of the radiated energy, so that an unlimited number of scattered receivers may pick up a given wave without affecting the amount of wave energy available to other receivers.

From the preceding descriptions of the more salient features of the radio medium as annatural resource and of the waves of frequencies of the radio spectrum which pass in it, some notion may be gotten of the investment in technology, material, and manpower needed to employ radio in a progressive, modern nation.

The Present State of the Art.

But the problems inherent in the development and use of radio, though fraught with economic, political, and social involvements, as well as technical complexities, have by no means seriously impeded the progress made in many countries in this field, particularly since the beginning of the First World War. Radio has accelerated economic activity wherever it is employed. It serves as a means of rapid communications and as a means to provide special services which cannot be made available in any other way. Radio has become an industry on the one hand and a utility service on the other. Radio and radar have become tools of war and have profoundly influenced the conduct of war. It offers the only efficient means of

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communication for moving vehicles. Radio broadcasting has become the great mass informer, the cunning mass propagandist, and the enlightened mass educator. Television appears destined to achieve these ends through the eye as well as through the ear.

A few available world figures will give some idea of the extent to which radio has been exploited in a few fields. As of October, 1951, there were over 214,000,000 broadcasting and television sets 1/ and over 10,000 broadcasting stations were listed in July, 1950. 2/ At the end of 1950, 43,000,000 U.S. public telephones could be potentially connected to almost all of the 32,000,000 public telephones in the rest of the world, principally by radio link. 3/ Listed in September, 1951, were over 110,000 ships equipped with radio and served b over 3,000 listed coast stations. 4/ In December, 1950, there were over 2,500 larger, non-military and principally commercial, listed radio-equipped aircraft served by over 5,500 listed aeronautical (ground) stations 5/ though nearly all aircraft are radio-equipped for safety, if for no other purpose. As of March, 1951, the list of frequencies for which radio service has been notified by the world amounts to almost 100,000 entries for the band of frequencies between 14 kilocycles and 27,500 kilocycles alone, though many frequencies show numerous entries. 6/ These figures by no means complete the picture of the depth or scope of the military, governmental, or commercial utilization of the radio medium.

Radio has altered the demand for raw and processed materials. Pole lines of wood and copper wires are beginning to give way in some countries to concrete and steel towers: submarine cables are beginning to give way to complex apparatus for high-capacity radio circuits. The vacuum tube, first introduced in radio, has opened up the more recent, fast growing field of electronics. Vacuum tubes are at the heart of techniques for multiplying the channel capacity of wire lines without the need for additional pole or underground lines or the addition of wires to existing lines. Vacuum tubes make possible the insertion of submerged booster repeaters in long, deepwater submarine cables to increase their capacity, thus avoiding the expense otherwise entailed in making and laying additional cables.

Radio has come a long way, but seems to have a long way yet to go.

International Interference

In this discussion the radio medium is viewed as a world-wide natural resource. But, in the strictest sense, it cannot be viewed as a national resource in which individual nations enjoy full and sovereign control over the whole or a divisible part of it. It is essentially a world community resource. As has been seen, radio-frequency waves are no respecters of political boundaries. This is especially true of waves of frequencies below 30,000 kilocycles which can travel long distances. It is also true of those above 30,000 kilocycles which, though generally limited to line-of-sight ranges, do propagate at times to much greater distances where reception or interference to reception can take place.

1/ The World Almanac and Book of Facts, New York, New York World-Telegram and the Sun, 1952, p. 505.
2/ List of Broadcasting Stations. Geneva, The General Secretariat of the International Telecommunications Union, 1950.
3/ Telephone Statistics of the World, New York, American Telephone and Telegraph Company, 1951, p. 1.
4/ List of Coast and Ship Stations, Geneva, The General Secretariat of International Telecommunications Union, 1951.
5/ List of Aeronautical and Aircraft Stations, Geneva, The General Secretariat of the International Telecommunications Union, 1951.
6/ List of Frequencies, Geneva, The General Secretariat of the International Telecommunications Union, 1951.

Even on a line-of-sight basis, when they are used close to political borders, they can, if not otherwise directed, pass across those borders where they may produce interference to existing radio services there.

There can be no world monopoly by any given country of the radio resource either by possession or control. Its use cannot be reserved to one nation in one area and denied to other nations in other areas. Pre-emptive occupancy of a channel by one nation tends to preclude occupancy of the same channel by another nation only within interference range, although where long-distance sky waves are involved, this range may be thousands of miles. Jamming, or interference intentionally created to deny the use of a channel, is effective at the receiver only where the jamming signals can over-ride the desired signal. This may be a limited area, near the jamming transmitter, if ground-waves are depended on for propagation, or it may be a very extensive area where the receivers are receiving sky-waves from both the desired and the jamming station.

This inherent "across the border" feature of radio is at once a help and a hindrance. It is a help in that it permits inter-communication within and between all nations of the world, though some nations consider this a hindrance because they neither stop nor censor all foreign radio signals at their borders. It is a hindrance in that effort must be put forth to avoid interference from unwanted signals. These realities gave early rise to complex problems.

Supply and Demand

The economics of supply and demand applies to radio. In some portions of the spectrum supply has not kept up with world demand. The current shortage of channels, especially below 30,000 kilocycles, where long-distance propagation is obtained, persists in spite of rapid technological and operational advancements which have contributed greatly to effect economy in spectrum occupancy. On the demand side, the commercial needs of expanding aviation and maritime services for communication and navigation, the political needs for broadcasting services, the commercial and political needs for over seas communication services, growing military needs, are tending to "saturate" that portion of the spectrum. On the supply side, reluctance to write-off older equipment for the new and the poor post war economic conditions prevailing in many countries have retarded investment in apparatus for the employment of modern spectrum-saving techniques. The unwillingness of some countries to provide wire lines or short range radio systems for their domestic communications detract from the available supply of frequencies for services which cannot be performed by any other means.

The forces of supply and demand are inevitably exerted in a truly world market where they give rise to world problems.

Need for International Regulation

The essential nature of the problems inherent in the exploitation of the radio medium was recognized in the early days of radio. It was seen that, if the world was to obtain the fullest benefit from the radio spectrum, the nations of the world must agree upon a set of international regulations for the avoidance of interference between stations of the various countries operating on the same frequencies and to serve as a base for national regulation. Such international regulations were to cover technical standards and operating procedures. It was also seen that the then useful frequencies must be systematized and organized in such a way that universally common frequencies would be used for common services. This makes it possible, for example, for a radio equipped ship or aircraft of one country to voyage to the area of another country and experience no difficulty whatever in establishing and maintaining communication with stations of that country. Again, it was seen that a need existed for the establishment of minimum conditions which transmitting and receiving apparatus should meet, in order that transmitted intelligence could be intelligibly received. Still again, a need was seen for a mechanism to facilitate the international exchange of new ideas on radio and for the compilation of data on the radio facilities of the world.

A world community resource needs world community management. Where world management is agreed, nations relinquish some national rights in the overall interest of all nations. Those rights which nations retain accrue to the governments of those nations. Some governments exercise those rights themselves as an internal monopoly, while others permit individuals and other legal entities to exercise those rights through grant of license.

The international management of radio as an economic resource has been cited as an outstanding example of effective world cooperation.

The Regulatory Mechanism.

Over the years numerous international and regional organs and conferences coped with all those problems as they arose and prepared international agreements on their solution. Ultimately the existing, permanent International Telecommunications Union was established, with its present headquarters at Geneva, Switzerland. Over eighty nations are currently Members.

Under the auspices of the Union, the most recent full international conferences were held at Atlantic City, N. J., in 1947, for the purposes of revamping the Union mechanisms and of bringing up to date the Convention and the Radio Regulations then in force, among other things. Approximately 1,000 delegates, aides, and others were engaged in this process at Atlantic City for a period of over five months. These conferences enlarged the scope of the Union, tightened regulations governing the use of the radio spectrum, revamped the table of frequency allocations to the various radio services, and laid the foundation of a mechanism for establishing a more orderly and efficient management and use of the radio spectrum and for requiring a more equitable assignment of priority or other rights to the various countries for use of specific frequencies.

The 1947 conference had anticipated that within two or three years the Member nations, through mechanisms created for the purpose, would have completed arrangements for the full implementation of the conference decisions, with particular regard to the assignment and use of frequencies below 30,000 kilocycles. At this time (early 1952) arrangements have been only partly completed and only partly brought into force. International difficulties in implementation create national difficulties in programming internal implementation, at least, among those nations which honor their international commitments. This contemporary five-year struggle gives some idea of the magnitude of the problem confronting the world and its nations in the orderly, efficient, management and use of the radio resources.

The International Situation Today.

Several reasons are advanced for this inordinate delay in achieving world agreement in the formulation and implementation of a new international frequency list. The deteriorating world political situation focused sharp attention upon security considerations and through them upon the strategic importance of certain radio facilities. Some nations did not wish to be caught in a war in the middle of a major frequency assignment reorganization. Further, to protect themselves against anticipated future shortages of frequencies, many nations allegedly submitted requirements for frequency assignments far in excess of current needs. These, when added to the World's needs for current radio services, could not be fitted -at least on paper- into the available spectrum space on a workable, engineered basis. This applied particularly to the so-called point-to-point telegraph and telephone service and to the broadcasting service.

In the present state of the World, the solution to World radio problems in the lower portion of the spectrum lies essentially in the areas of economics and technology, unhampered by supercharged political pressures. The alternative to solution is potential spectrum chaos and possible ultimate radio war.

The Soviet Union.

In the post World War II era, world effort toward spectrum management has been conditioned by the behaviour of the Soviet Bloc. At the international conference in 1947, the Soviet Bloc was thought to be comparatively reasonable and cooperative, but a change for the worse occurred soon after. At subsequent conferences, which considered ways and means for implementing the 1947 decisions, the political split between the East and the West entered the radio areas, and crept deeper as time went on. On the one hand, the Soviet Union, which invariably assumed the leadership of the Bloc, employed delaying, obstructive, and propagandistic tactics in conference negotiations under the guise of obscure technical objections to substantive matters. Few specific technical contributions or proposals were made by it. On the other hand, the solidarity of the Soviet Bloc tended to induce solidarity in the West, as the Western nations realized that the Bloc would otherwise attempt to create and exploit a Western split to the advantage of the Bloc.

Perhaps the most far-reaching proposal persistently made by the Soviet Union for over three years was, in effect, an attempt to press for adoption of the 1939 International List of Frequencies as notified by the nations to the Union as a base for the construction of a new list in conformity with the new Table of Frequency Allocations adopted in 1947. This proposal was in direct opposition to the directives adopted in 1947 for the preparation of a new frequency list on a basis of revised requirements to be engineered into the new list. This proposal was of course not adopted because it was known generally that the Soviet Union had by 1939 submitted frequency entries every few kilocycles almost throughout the spectrum below about 20,000 kilocycles, allegedly whether the frequencies were used by them or not. The adoption of such a proposal would obviously have given the Soviet Union a legalized lion's share of frequency usage priority rights, to the disadvantage of the rest of the World, in particular the "have-not" countries.

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