CHAPTER EIGHT

THE USE AND MANAGEMENT OF THE ELECTROMAGNETIC SPECTRUM

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CHAPTER EIGHT

THE USE AND MANAGEMENT OF THE ELECTROMAGNETIC SPECTRUM

In this chapter, we address the question posed to us by the President: "Are we making the best use of the electromagnetic frequency spectrum?" This is not a new topic for policy review. It has been a source of great concern to a number of agencies, committees, and commissions in recent years.*/ Their studies have clearly shown that the nation is not achieving the best use of the spectrum in the face of growing demand and increasing shortage. Although many basic recommendations for improvement have been made, few have been implemented. Generally, those infrequent remedial measures taken in the past have proved inadequate.

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*/ Among the major previous studies are: Joint Technical Advisory Committee (JTAC) of the Institute of Electrical and Electronics Engineers and Electronics Industries Association, Radio Spectrum Conservation (1952), Radio Spectrum Utilization (1963), and Spectrum Engineering, the Key to Progress (1968); Director of Telecommunications Management, A Report of Frequency Management Within the Executive Branch of the Government (1966); Commerce Technical Advisory Board (CTAB), U.S. Department of Commerce, Electromagnetic Spectrum Utilization -- The Silent Crisis (1966); Federal Communications Commission, Final Report of the Advisory Committee for the Land Mobile Radio Services (1967).

Our own studies confirm many of the conclusions reached in earlier investigations. Spectrum resources are now being utilized wastefully and inefficiently. In some locations serious shortage prevails. And those problems will become increasingly severe in the face of clearly increasing demand for radio communications. Technological and economic change will increasingly generate stresses beyond the capacity of existing policies and institutions to cope with them.

I. THE ELECTROMAGNETIC SPECTRUM IS A VALUABLE NATURAL RESOURCE

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. So are radio signals. The rate (in cycles per second) at which the energy oscillates is termed its frequency, and the complete range of frequencies is encompassed by the electromagnetic spectrum. That portion of the spectrum usable for radio communication ranges from about 10,000 cycles per second to 40 billion cycles per second.

Aircraft, ships, motor vehicles and other mobile units are critically dependent on radio for rapid communications. Radio is also the dominant technique for providing such disparate services as television broadcasting, long-distance telephony, navigation, radar, and some scientific research. In short, the spectrum is a natural resource vital to the functioning of modern society.

In many respects the spectrum is a plentiful resource since it is not depleted through use (unlike, say, coal and oil), and discrete portions can in general be used simultaneously by many separate radio services. But, as a consequence of their propagation characteristics, some portions of the spectrum can be used only for certain kinds of services; and extensive simultaneous use of identical portions <u>can</u> result in troublesome or intolerable interference. These problems become increasingly severe as the demand for radio communication grows. For example, very low-frequency radio signals are especially useful for worldwide services because they can propagate thousands of miles around the curvature of the earth. In contrast, some signals of much higher frequency travel only over line-of-sight paths and are ordinarily useful only for short distance terrestrial services and satellite services. Limitations of frequency range adaptable or available to particular services, combined with increasing demands for those services, has caused an increasing scarcity of usable spectrum in some areas. As this occurs, entry of new spectrum-using services must be restricted or more stringent and costly operating standards must be imposed upon established services.

While the role of spectrum management embraces the entire usable range of frequencies, we are especially concerned with the ranges above 100 MHz.*/ For it is in that portion of the spectrum that we face pressing problems of shortage. It is there that the needs of such services as

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*/ The term MHz refers to "megahertz" or millions of cycles per second; similarly, kHz and GHz refer respectively to kiloHertz (thousands of cycles per second) and gigaHertz (billions of cycles per second).

mobile radio, broadcast television, communication satellites, and terrestrial microwave relay must be satisfied.*/

II. WE ARE NOT NOW MAKING BEST USE OF THE SPECTRUM

A. Growth in Radio Services in the Past Decade Has Been Remarkable

Within the United States over the past decade, the number of radio transmitters has grown at an average rate of over 17% per year. Total authorized non-government transmitters increased from about 1.2 million in 1957 to over 6 million in 1967. An average of less than three transmitters per 1000 persons in 1950 had grown to over 30 per 1000 persons in 1967.

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*/ While we have examined a wide variety of spectrum uses throughout the entire range of frequencies now in use or potentially useful for radio services, a major portion of our specific analyses and recommendations deals with the broad category termed "Safety and Special Services" by the Federal Communications Commission. The reasons for this emphasis are: (a) this category encompasses roughly 98% of all stations and well over 99% of all transmitters licensed by the FCC; (b) with a few exceptions (e.g., communication satellites) these services pose the major problem for spectrum management, both now and in the foreseeable future; and (c) the responsible management and user agencies consider that Federal Government spectrum needs, comprising the major requirements outside the Safety and Special Services category, can generally be handled under existing allocations through the application of improved frequency management capabilities.

This pattern of growth is due to many factors. Most significantly, requirements for higher levels of mobility have combined with technological advances to greatly enlarge the benefits of using radio. America is a nation on the move. People want communication services to match this mobility, and radio is increasingly being called on to provide those services. The ability to dispense with wires which constrain mobility is a powerful incentive to radio use. Moreover, while radio services have always offered mobility, only in recent years has advancing technology permitted widespread use of these services. The advent of low-cost transistorized circuitry has been a major, though by no means exclusive, factor. With the projected development and application of integrated electronic circuits, the trend toward complex yet low-cost radio systems can be expected to continue.

Thus, the two-way radio is a matter of sound economics, whether for police protection, fire prevention, diaper delivery, TV repair, taxi service, cement delivery, or utility service and maintenance. As one example, for certain kinds of services it has been estimated that three radio-equipped service vehicles can carry the same workload as four vehicles without radio,*/ meaning savings of perhaps $50,000 to $100,000 per year.

The general public has also begun to realize the potential benefits of two-way radio. Thus far, a principal user has been the busy executive, who can use radio service effectively en route between business activities. But the rapid growth of "Citizens Radio" (a special classification which includes all two-way radio uses by the general public) is evidence of additional important demand by the public for spectrum use.

B. Spectrum Scarcities are Inhibiting This Growth Under Existing Allocation and Usage Procedures

Despite the growth in demand for radio services, certain potentially beneficial services are being denied satisfactory use of the spectrum. During the period 1959-64, growth in authorized spectrum uses averaged about 22% per year, both

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*/ FCC Land Mobile Advisory Committee, Final Report, Vol. 2, Pt. 2, Section 9.

in number of users (from 652,000 to 1.42 million) and number of transmitters (from 2.18 million to 4.92 million). From 1964 to 1967, however, the annual growth rate was only about 7%, while applications for spectrum use (which had grown steadily throughout the earlier period) leveled off and in many services began to decline. Statistics for 1967 indicate a significant decline in applications for virtually every category except marine and amateur radio services.

Although other factors may have contributed to diminished growth, there is reason to believe that spectrum scarcity and congestion, with resultant service degradation, are significant contributing factors. In 1958 the condition in land mobile services (a category encompassing nearly 50% of all authorized transmitters) was described by the FCC as spectrum "congestion," by 1962 as "extreme congestion," and by 1964 as "acute frequency shortage." In March 1964 an FCC Land Mobile Frequency Advisory Committee was appointed to explore steps which might be taken to alleviate these problems "without involving the allocation of additional spectrum space to land mobile service." This committee reported in November 1967 that "no major long-term relief ... can be achieved in the major metropolitan areas ... by further changes in operating techniques and procedures ..."; and further that "additional frequency spectrum must be allocated for this use."

Many land mobile users operate on a "party-line" basis, with numerous users sharing the same spectrum assignment. As demand for the service grows, and as the FCC continues to grant additional licenses to qualified applicants, over-crowding and interference rise to progressively higher levels -- thereby reducing the utility of the service to all users. Moreover, the situation tends to discourage further applications even though additional mobile services might be valuable.

On the basis of various studies we have reviewed, it is reasonable to conclude that over the past decade land mobile services have been unable to obtain sufficient spectrum resources to avoid harmful interference and service degradation in major metropolitan areas. These services have undergone three major equipment conversions since 1950 to reduce the amount of spectrum (bandwidth) required per voice channel, as a way to accommodate more users; but further steps in this direction do not appear economically feasible, nor technically adequate.

Aside from the general problems of land mobile services, there is a specific area of particular concern. The vital communications requirements of state and local entities providing police, fire, ambulance, and related public safety services have become increasingly dependent upon radio. Yet, in the face of a rising crime rate, violence and civil disorder in our urban centers, those services have experienced spectrum scarcity and congestion comparable to that experienced by land mobile users generally.

Finally, some contend that spectrum scarcity has inhibited development of communications satellites. This more recent spectrum claimant has been required to share spectrum bands previously allocated exclusively to microwave radio relay service since exclusive bands for satellites are not available. Concern over the possibility of mutual interference between radio relay services and an extensive nationwide network of satellite earth stations has been cited as a major reason for delay in implementing a fully-operational domestic satellite service (although lack of a comprehensive national program for domestic use of satellites has also been a major contributing factor).

C. Growing Demand for Spectrum Use Will Intensify the Problem

Technological advances will continue to drive the cost of radio communication services down, and demand for radio services is expected to grow rapidly. However, lack of adequate spectrum resources could be a major inhibiting factor unless remedial measures are begun.

Land Mobile Radio Services -- In the past 18 years, the number of transmitters in this service has grown from 180,000 to 2.6 million; by 1975 this number might well double, given adequate spectrum resources. The amount of spectrum now available for this service is about 42 MHz. To handle expected growth, assuming present operating practices, a minimum of 42 additional MHz will be needed in the major metropolitan areas. */ Moreover, in view of the probable need to reassign some present users to reduce excessive interference in existing services, even more spectrum could be required.

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*/ FCC Land Mobile Frequency Relief Committee, op. cit.

Public Radio Services -- Although few studies have been made of the potential demand for radio services by the general public, growth in the Citizens Radio Service provides some general information. The number of transmitters in this service has grown from about 20,000 to 2.7 million since the mid-1950's, and conservative estimates place this figure at close to 7 million by 1975. */ With future technology, these radios need not be significantly higher in cost than conventional AM auto radio. It seems likely, therefore, that a major segment of the driving public might find this two-way radio service desirable -- adding significantly to the demand for spectrum use.

Spectrum allocations now available for public use in the Citizens Radio category total 4.1 MHz, or 10% as much as the congested land mobile service. Yet Citizens Radio transmitters outnumber mobile radio transmitters. To be sure, these users do not require the same quality of service as, for example, a metropolitan police cruiser. Nevertheless, a large potential demand exists for public radio service,

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*/ Director of Telecommunications Management, The Radio Frequency Spectrum, U.S. Use and Management, September 1968, p. D-27.

and in some geographic areas congestion within the Citizens Radio Service is already intolerably high. If existing rules permitting this use remain in effect, significant increases in usable spectrum must be made available to accommodate the most conservative estimates of growth. If public radio services developed to meet demand, their spectrum requirement might well dwarf even that of land mobile radio services.

Microwave Radio Relay -- This service provides the bulk of the long-haul transmission capability of the common carrier network as well as of numerous private services. Its annual growth rate, which ran to over 15% throughout the 1950-60 period, has declined in recent years to 7% in 1967. This decline is due to several factors, including spectrum scarcity near major urban areas where routes converge, and the declining cost of coaxial cable facilities which provide an alternative to radio services. The future is somewhat uncertain. The Bell System expects that by 1980 only 10% of its bulk transmission requirements will be met by radio relay, with the remaining 90% met by cable or other non-radiating alternatives.

Were adequate spectrum resources available to permit full exploitation of microwave economies of scale, the future pattern of development might be substantially different.

Communication Satellite Services -- In our chapter on domestic satellites, we discussed the technical feasibility and economic viability of satellites vis-a-vis various terrestrial alternatives. Satellite systems require a relatively high initial fixed investment regardless of the level of system capacity, while the additional cost to increase capacity is low in comparison to fixed costs. Therefore, the bandwidth available to each satellite, the location of this bandwidth within the overall spectrum range (e.g., above or below 10 GHz) and the nature of sharing constraints imposed, as functional limitation upon total capacity, have a marked effect on system economies. Prospects for such services are therefore quite dependent on the spectrum sharing and/or allocation approach that is adopted.

The pervasive general problem in the above areas is that -- with some exceptions -- the demand and technology for economical radio services requiring spectrum use are growing at a very fast rate, while new spectrum resources are not becoming available nearly so rapidly. As noted earlier, authorized non-government radio transmitters of all types in the United States already exceed 6 million -- a threefold increase since 1960. By 1980, assuming that demand can be accommodated, this number is conservatively projected to reach 17 million. */ Should usage by the general public grow as rapidly as we believe possible, the number could easily reach 50 million or more. Since spectrum use has been termed a "silent crisis" **/ and "spectrum congestion" and "spectrum saturation" have become everyday words in the telecommunications vocabulary, even conservative estimates of future demand will pose a serious challenge for spectrum management.

III. PRESENT-DAY MANAGEMENT APPROACHES AND CAPABILITIES ARE NOT ADEQUATE TO ACHIEVE OPTIMUM USE OF THE SPECTRUM

Existing capability for spectrum management is based on administrative simplicity and the needs of an earlier era.

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*/ DTM, op. cit. p. D-27

**/ Department of Commerce Technical Advisory Board, Electromagnetic Spectrum Utilization -- The Silent Crisis, 1966.

It is designed primarily to accommodate those radio services inherently worldwide in scope (e.g., services using frequencies below about 100 MHz); to deal with broad classes of spectrum use rather than with individual uses; and to minimize the expense of spectrum management. Thus, spectrum resources are apportioned among potential users according to a single nationwide "block" allocation plan. Priorities for spectrum access are established by this plan on the basis of the user category in which a given claimant falls. Spectrum resources are also divided between government and non-government uses on a nationwide block basis, largely irrespective of geographic variations in relative need. The amount of spectrum allocated to a particular service is controlled primarily by broad nationwide standards rather than the dynamics of spectrum demand in particular areas.

Until recently, this approach has by and large accommodated essential spectrum needs of the nation, and perhaps minimized government expenditures for spectrum management. But it has serious deficiencies for the immediate future and beyond:

-- Police and other public safety radio services in major metropolitan areas may be unable to obtain vital spectrum resources, while those resources allocated to other user categories go unused in the same area (e.g., frequencies reserved for forestry services were only recently made available to the New York City Police Department).

-- The business community and the general public throughout the nation may be denied access to otherwise unused spectrum bands, simply because these bands are used for other services in a few metropolitan centers (e.g., land mobile services are unable to use spectrum allocated to television in areas where these allocations are unusable for TV).

-- One class of users may be forced to adopt costly equipment modifications to meet growing demand, while another class, favored with an abundance of similar spectrum resources, may use them wastefully (e.g., private land mobile users have undertaken three major equipment revisions since 1950 to conserve spectrum, while certain other mobile services continue to use wider bandwidths than required by existing technology.

-- New spectrum dependent services, irrespective of potential social or economic benefit, may be denied allocations or forced to adopt uneconomic design and operating practices to protect established services, without even the option to indemnify existing users against harmful interference (e.g., satellite services are forced to locate earth terminals in remote areas and to adopt sub-optimum system trade-offs and operating constraints to ensure absolute interference protection for microwave relay systems).

Within the limitations of staff and funding -- and the dual system of management under which they must operate -- the FCC and DTM have attempted in recent years to coordinate efforts and eliminate these deficiencies.*/ Certain steps recently begun, if carried to fruition, will

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*/ DTM, op. cit., pp. E 1-29

afford temporary relief from some of the most urgent of these problems.*/ However lauditory, these efforts serve only to highlight the need for an improved spectrum management capability which will, systematically and expeditiously, make spectrum resources available to meet growth in demand and variations in social, geographic and economic benefits.

A. National "Block" Allocation Procedures Lack Adequate Flexibility.

The opportunity to use spectrum has historically been allocated among various groups and types of service according to a uniform national plan in which particular spectrum bands are earmarked for use by a particular category of user and/or service. The spectrum band allocated for the petroleum industry is the same in New York City as in the Texas oil fields, as are those allocated for taxicabs,

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*/ FCC Dockets 18261 and 18262 seek to determine whether certain unused UHF television channels (i.e., the lower 7) could be shared by land mobile services in selected geographic areas, and whether other channels at the upper end of the UHF television allocations might be reallocated to land mobile service in a separate action. The DTM released 26 MHz of spectrum formerly allocated to government use to enable the FCC to meet urgent needs.

maritime radio, police forces, etc. Similarly, spectrum allocated to television broadcasting bands, as distinguished from discrete channel assignments, is uniform in all areas of the country. Yet, in every area of the country portions of these bands lie idle and unassignable to discrete television channels because of existing intra-service interference standards. In New York City alone, the FCC Land Mobile Frequency Relief Committee reports that some 84 MHz */ of spectrum lies fallow and unused for this reason. While unusable for TV, many of these frequencies would be quite suitable for other services without jeopardizing television reception. Meanwhile, spectrum available to land mobile users, including critical public safety services, is experiencing intolerable congestion in that city.

When spectrum resources were abundant, advantages of nationwide block allocations, such as administrative

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*/ This is twice as much spectrum as is now allocated to land mobile services in the City.

simplicity and equipment standardization, may have outweighed the disadvantages. However, the sharp rise in demand for spectrum use combined with finite limits upon usable spectrum clearly requires that local variations in demand among various user and service categories be considered in apportioning spectrum resources. To be sure, the existing spectrum management structure has occasionally responded to such needs on an *ad hoc* basis in selective geographic areas. But those steps have usually involved lengthy administrative negotiation and coordination. Flexibility must become the rule rather than the exception if we are to achieve effective use of the spectrum. Of course, we must be mindful of imbedded capital investment in existing equipment. Before any changes invoking equipment obsolescence, reasonable periods of amortization should be afforded.

B. Existing Criteria for Apportioning Spectrum Resources Among Competing Uses are Unsatisfactory

Under existing law and policy, the only criterion available to the spectrum manager for resolving conflicting claims is "the public interest, convenience or necessity." The product of an earlier era, that standard is neither sufficiently objective nor definitive to resolve the questions of spectrum access we now confront. In establishing the initial block allocations to user groups and services, the FCC relies primarily on the claims of competing interest groups and its own projections of potential need. Once established, the initial block allocations carry great weight; and thereafter integrity of the allocation, rather than flexibility to meet spectrum demand, tends to become the central concern.

When inflexible priorities are assigned on the basis of claims by institutional user groups, distortions are very likely to occur. Criteria for establishing priorities and comparing relative values are not likely to be applied consistently to differing claimants. Not forced to consider the value of spectrum to others, each group has every incentive to exaggerate its own needs. If one anticipates he will receive less than he asks for, he has all the more reason to inflate his demands. Accordingly, great latitude exists for sub-optimal allocation and use.

C. The Division of Spectrum Resources and Management Responsibilities between Government and Non-Government Uses is a Source of Inefficiency

Another characteristic of the national block allocation scheme is the division of spectrum resources between government and non-government uses. And, just as the resource is rigidly partitioned between government and non-government use, the responsibility for management of each portion is bifurcated. Under the 1934 Communications Act the FCC administers all non-federal government use of spectrum. Responsibility for assigning frequencies to federal government stations is vested in the President. By delegation of authority from the President, the Director of Telecommun.cations Management discharges that responsibility. The Interdepartment Radio Advisory Committee (IRAC), composed of representatives of the principal federal government users of radio frequencies, plays an important role in the actual determinations. While formally represented on only the Frequency Assignment Subcommittee of the IRAC, the FCC maintains close liaison with the IRAC.

Once spectrum is partitioned between government and non government uses, responsibility for allocating each portion is clearly defined. But, in prospective, there is no formal mechanism for resolving conflicting claims between government and non-government uses. By the same token, no formal mechanism exists for resolving ultimate differences between DTM, representing Executive Branch users, and the FCC, representing private users. The President and the FCC are, in effect, independent within their respective spheres.

To be sure, mechanisms have been developed to avoid interference between the two sectors, and to accommodate critical government needs. But the division of responsibility has inherent problems. For example, certain government spectrum resources go largely unused in those urban areas where civilian spectrum needs are greatest. The government may well need as much spectrum space as it has in some areas of the country -- indeed, in some areas it may need more. But more relevantly, what are the requirements for spectrum use by government agencies in specific urban areas? How much of this is contingency need, and how might the total spectrum resources of each area be better utilized if more flexible arrangements were established for government/non-government sharing at the local level? These are questions which no single agency can resolve under the present scheme of divided responsibility.

D. Spectrum Waste is a Significant Problem

By "spectrum waste" we refer to such factors as the use of broader bandwidths or higher power than required or antennas of less directivity than the service area would dictate; and to the use of receivers having less sensitivity and/or selectivity than current technology can economically provide. To avoid interference in such cases, greater separation (in geography and/or spectrum location) of spectrum uses must be maintained.

With present management procedures and resources, a major factor contributing to spectrum waste is the inability to engineer spectrum uses on an individual basis. The block allocation system is protected by nationwide standards dictating maximum bandwidth, power, antenna height, and other factors affecting each service. These standards are not adaptable to variations in need and location. Since the spectrum user faces no direct economic penalty for waste, it is often less expensive for him to comply with only the broadest standards than to tailor his equipment and operating practices more nearly to his specific requirements.

E. The Present Levels of Staff and Funding Devoted to Spectrum Management are Inadequate

The FCC's spectrum management responsibilities alone have reached staggering proportions. More than 800,000 license applications were received for processing in 1967. Unable to obtain necessary funds for enlarging its small technical staff, the FCC cannot adequately undertake the comprehensive planning needed to achieve greater efficiency in spectrum use. It has little alternative but (a) to rely on block allocations, (b) to establish simplified operating standards for use of frequencies, and (c) except for broadcasting, to issue licenses and renewals on a routine basis to qualified applicants.

Much of the technical work essential to the success of FCC licensing is done privately rather than by the FCC's engineering staff. Thus, within land mobile and other bands, the task of minimizing interference through coordinating new applications with existing assignments has been relegated to private user associations. Much of the monitoring activity necessary to trace harmful interference to its source must be done directly by the affected parties, rather than by FCC engineers. While such private activities will continue to be indispensable to good spectrum management and engineering, the spectrum management authority clearly requires adequate engineering and analytic capabilities to establish and continually improve technical standards and to independently evaluate allocation and interference issues which arise among users.

The process of apportioning spectrum use among government agencies is less difficult than that used by the FCC, with somewhat greater attention to individual uses. However, the growing volume of applications (now 37,000 per year) has made it increasingly difficult for the DTM to conduct detailed analyses of individual applications. A growing tendency toward use of allocation tables and other methods of routinization is the result.

IV. CLEAR POLICY OBJECTIVES AND A NEW APPROACH TO SPECTRUM MANAGEMENT SHOULD BE ADOPTED

A. A Basic Guide is Needed for Spectrum Use and Management

A lack of clear national policy objectives has been cited by the Director of Telecommunications Management and others as a major deterrent to more effective spectrum use. Fundamental public policy regarding the spectrum should be to seek that combination of spectrum uses which offers maximum social and economic contribution to the national welfare and security.

This guideline emphasizes our concern with maximizing the efficient use of spectrum resources. A particular spectrum use should not be favored if its potential contribution to net social and economic welfare is less than a competing use. Such comparisons require that all costs and benefits (including imbedded capital investments) be taken into account. Interference with other uses by a particular use is a major factor in judging its contribution to net social and economic welfare. The combination of all spectrum uses should be the focus of public policy, rather than some selected few. Thus, one corollary of the basic guideline is to seek the continuing substitution

<u>of higher-valued spectrum uses for lower-valued uses -- and the addition of uses whose net effect is to increase overall social or economic benefits -- with due consideration of all imbedded capital investments.</u>

The spectrum is not subject to depletion through use. It may be converted to new uses on demand. Thus, greater benefits will normally accrue from making spectrum available for productive use when and as required, rather than "banking" it for possible future uses. Some "banking" may be desirable as an incentive for the economical development of equipment and services, or indeed to preserve for future development some spectrum free from substantial user-investment which would be difficult or impossible to overturn. But this should be permitted only as an adjunct to broad, long-range planning guides. It should not include anticipatory allocation of spectrum rights to particular users in the absence of a clearly foreseeable need. As a second corollary to the basic guideline, <u>unused spectrum resources should be employed to meet any legitimate need provided that this does not cause excessive interference to existing uses, conforms with established standards and</u>

international agreements, and does not interfere with established plans for higher-valued uses.

In our economy, most scarce resources are allotted through a free market of buyers and sellers. The market mechanism is attractive because it encourages transfer of resources from lower-valued to higher-valued uses. A willingness to buy and sell at a price, rather than administrative priorities, establishes value. Thus buyers are stimulated to conserve a resource when cost is incurred in its use.

One of the first concepts we explored in our spectrum study was the potential of market mechanisms to allocate spectrum efficiently. We examined such issues as: the extent to which social values of spectrum use (i.e., those values not fairly reflected by market dynamics) could be properly taken into account in a market allocation system; the problem of defining rights in spectrum use that would be adaptable to free market exchange without leading to inefficient use of spectrum; and the problem of protecting rights and resolving disputes between rights holders.

As discussed later, we conclude that greater emphasis be placed on economic factors in allocating spectrum resources among competing claimants. We further believe that the most effective means for reflecting economic value is through the direct interplay of buyer and seller. However, we cannot at this time recommend adoption of a full-scale free market mechanism for spectrum use. The most basic problem is of identifying spectrum rights suitable for unrestricted trading, which at the same time would not result in great waste of spectrum resources.

If a free market is to operate effectively, the rights exchanged must be reasonably distinct, quantifiable, and divisible, and without strong interaction between uses. These features would permit the resource to be transferred easily from one use to another, and for segments to be subdivided or consolidated in accordance with variations in supply and demand.

The spectrum possesses several special characteristics which, while contributing immensely to its ability to support telecommunications, makes quite complex the definition of rights, in workable, quantitative terms. First, the spectrum is not depleted through use -- as are resources such as coal, oil, minerals, etc. -- but remains ever available for further use. Second, the use of a particular "part" of the spectrum for one radio service does not necessarily deny use of the same "part" to another service, either simultaneously or appropriately phased in time, either in the same or a different geographic area.

Third, while radiation characteristics can be well defined in terms of energy, bandwidth occupancy, and time, the spatial distribution of energy cannot be confined within discrete boundaries at all times, except in a probabilistic sense, because of the nature of radio waves and the effects of earth-atmosphere environment. Interference with another user, whether in the same frequency band or as a result of interaction in any other frequency band, may also be predicted or controlled only in a probabilistic sense. Though spectrum uses may to some degree be considered diffuse and overlapping, technical means used at the transmitter and receiver can control such overlap and interaction. Almost any degree of protection may be achieved at some cost, between potentially interfering uses. Indeed, the incentive to balance the cost of protection against the cost of spectrum use underlies the attraction of the market system to achieve efficient utilization.

Because of these characteristics, spectrum uses interact with one another in complex, variable, and potentially harmful ways, even though much duplication is technically possible in the use of each part of the spectrum. Thus, the ability of one user to employ a particular spectrum right can be greatly affected by how others employ their rights. Yet every approach we have examined for coping with this problem of "externalities" -- by identifying sufficiently discrete and unique spectrum rights to permit them to be freely exchanged, subdivided, or combined -- carries the prospect of significant overall inefficiency in the use of the spectrum.

We have concluded, first, that further study of the question of definition of rights, with due regard to rapidly changing technology, is clearly essential before a full-scale market system could be employed. The understanding of the resource, and its measure, which would come from such a study is important to any scheme for frequency management. Second, the most effective allocation of the spectrum is so complex a technical, social and economic problem that it requires centralized coordination if important interactions that accompany spectrum use are to be taken adequately into account. Thus, an additional principle of spectrum management is that comprehensive coordination of all spectrum use is required under a continuing framework of public administration.

B. Greater Consideration of Economic Factors is Necessary

Use of the spectrum should be subject to more direct economic forces in the future rather than being treated as a free right. It is of real economic value to the user which should be fairly reflected in allocation of the resource. Moreover, the government incurs significant expenditures in managing the spectrum and making it available for use. The direct beneficiaries should be called upon to bear a fair share of those costs. Economic incentives would also encourage users to apply their innovative skills toward more efficient spectrum use.

Since a full-scale market system would entail potentially serious problems, requiring further study as mentioned above, the means of bringing economic forces to bear are somewhat limited. Of the approaches we have examined, the use of license fees which bear a reasonable relation to the amount of spectrum used or potentially denied to other users and to the demand for spectrum use within the area is attractive.

Because of the difficulty of establishing an initial schedule of fees which would fairly reflect relative values of spectrum use, at the outset they should be set at relatively low levels, though in reasonable proportion to the amount of spectrum use (e.g., bandwidth, power, and other indicators).

This would serve several purposes: (a) provide a source of revenues to cover the cost of an expanded spectrum management service; (b) discourage use of the spectrum by those whose needs or motivation are truly marginal; and (c) provide a clearer indication, through analysis of the license applications, of the actual demand for spectrum use as a function of service category, geographic location, and fee schedule. Later, the fee schedule and service allocations could be adjusted periodically as a quasi-market mechanism to reflect relative demands for spectrum use. Before moving to this second stage, however, detailed studies investigating the administrative feasibility and the economic and social impact of an adjustable fee system for spectrum licenses will be required.

Other direct economic incentives may also be effective. For example, the right to transfer licenses between users should encourage increasing substitution of higher for lower-valued uses. Under present practices, transfers are permitted only between users within a specific sub-allocation (e.g., taxicab services). We find neither technical nor operational justification for most sub-allocations within a given type of service (e.g., land mobile). Therefore, consistent with other regulatory policy considerations, license transfer should be permitted across as wide a range of users as is technically and operationally feasible.

Many trade-offs exist between equipment cost and reduction in interference between users --- an especially important factor in considering the needs of "clear channel" use, as in commercial broadcasting and point-to-point services, where very little interference can be tolerated. Among other things, special equipment can be installed at one antenna site to cancel certain kinds of interference emanating from another site. Quite conceivably, the added cost to the prospective user of reducing interference to the existing user to a tolerably low level would be less than the social value gained by conserving the spectrum through greater shared use. In such cases, society would benefit by permitting expanded shared use in combination with a procedure with which the cost of adding protection from interference would be appropriately borne.

Therefore, we recommend several steps to bring stronger economic forces into play:

1. An improved schedule of fees for spectrum licenses should be developed which reflects the extent of spectrum use (e.g., bandwidth, power, service area, time availability) and the level of demand for spectrum access. And intensive studies should be conducted of other means to account for economic value, including adjustable license fees, spectrum leasing, and taxation.

2. License privileges should be clearly stated for each class of spectrum use (e.g., land mobile, radio relay, etc.) in terms of channel loading, interference probability, service quality, and other appropriate factors.

3. Administrative procedures should be modified to permit greater transferability of licenses among legitimate spectrum users within broad service classifications, subject to all relevant conditions of the initial license,

including the requirement that all exchanges or transfers be registered and approved by the spectrum management authority.

4. Procedures should be developed whereby a prospective spectrum user may obtain a license even though this would represent a potential source of harmful interference to an established clear channel user, provided that prior arrangements are concluded between all affected parties, including adequate compensation or indemnification by the new user.

C. Greater Attention to Individual Spectrum Uses Should be Achieved Through "Spectrum Engineering" and Related Technical Considerations

In the previous section we described steps for introducing stronger economic incentives into the spectrum management process. As a vital complement, continuing improvement will be needed in standards for the design and operation of transmitters, receivers, and antennas. Indeed, these standards will take on increased significance as demand and technology advance. Technological advances affecting spectrum use are so rapid that new, more efficient systems often cost no more to use than facilities developed in an earlier technological era. Only through continuing --

but selective -- updating of technical standards (with appropriate protection for past investments) are obsolete equipment and operating practices likely to be abandoned as early as is justified in the overall national interest.

The Joint Technical Advisory Committee (JTAC) of the Institute of Electrical and Electronic Engineers (IEEE) and the Electronic Industries Association (EIA) recently completed a study of the engineering problems associated with spectrum use. A source of much valuable information, this study recommends a "next generation" approach to spectrum engineering which focuses upon individual use rather than broadly applied standards. We agree with the basic principle of individualized planning and engineering of spectrum uses to achieve greater overall benefits from the spectrum. However, an expanded program of spectrum engineering would entail a cost for monitoring and for such modifications as redesigned antennas and improved transmission techniques to meet more stringent standards. This cost could, at some point, exceed the value to society from increased spectrum use. Therefore, the spectrum engineering approach must be suitably modified to incorporate the economic considerations treated above.

Accordingly, we recommend that:

1. A more flexible approach to spectrum management should be adopted, under which the National Table of Frequency Allocations is transformed over time from a fixed allocation by user category to a basic planning guide by service classification.

2. A comprehensive spectrum engineering capability for individualized planning and engineering of spectrum uses should be developed, charged with continuing improvement in technical design and operating standards for all transmitting and receiving equipment and other devices that materially affect use of the spectrum.

V. THE ABOVE FINDINGS HIGHLIGHT THE NEED FOR ACTION IN SELECTED PROBLEM AREAS

A. Land Mobile Radio Services

Present policy affecting the VHF and lower UHF region of the spectrum (30-1000 MHz), that portion most useful for mobile radio and broadcasting services, has generated widely-voiced concern about the inadequacy of spectrum to meet growing demand. We have already discussed the spiraling demand for land mobile channels. Land mobile groups cannot fairly be asked to achieve more intensive use of presently allocated spectrum space while major blocks of spectrum allocated to -- but unusable by -- UHF television broadcasting lie idle, when these spectrum resources could meet land mobile needs without interfering with the present operations or growth of television broadcasting. The FCC has recently undertaken steps to make part of these unusable spectrum bands available for land mobile use. This study should be broadened to cover all unusable allocations for possible use by all services now experiencing spectrum scarcity.

Additional spectrum made available in this manner should not, however, be employed inefficiently by land mobile services, for a new crisis could soon materialize. More stringent limitations on power, antenna height, modulation, and other technical parameters; greater use of common-user systems (including inter-station trunking when appropriate); and more explicit and varied channel-loading (i.e., time-sharing) criteria should be emphasized. User license fees should fairly reflect the varying service quality to be expected under different channel-loading criteria, as an incentive to economize on spectrum use.

B. Public Safety Radio Services

State and local public safety agencies now obtain spectrum allocations from the FCC, in competition with commercial interests, while federal public safety users (such as the National Guard, and the FBI) have access to the government spectrum allocations. This arrangement is not conducive to sound spectrum management. This arrangement appears to put local public safety forces at a disadvantage in obtaining frequency resources. The use of different bands hampers coordination of local and federal forces during major civil disturbances. Our studies indicate some federal spectrum allocations may be relatively unused or lightly loaded in major metropolitan areas; in many cases public safety users may be the best group to share these allocations.

At the same time, State and local public safety users should seek more efficient spectrum use and improved coordination. Establishing improved operating standards to provide greater sharing among public safety users, and the adoption of common-user systems wherever practical, should be a continuing goal.

C. Television Broadcasting

The basic allocation of spectrum for television broadcasting covers a large part (492 MHz or 50%) of the entire spectrum range between 30 and 1000 MHz -- the most useful frequency range for many broadcast and mobile communications services. As discussed more fully in our chapter on broadcasting, the existing allotment plan for television has reserved spectrum in that range for extensive additional growth in the number of over-the-air UHF-TV stations. For example, there are 84 assignable commercial UHF-TV channels in the top 100 markets which remain unapplied for. Continuing review by the FCC of the need for these assignable channels by the television industry is warranted. In the meantime, non-interfering use by other services of spectrum lying within the overall television broadcast allocation may be possible on a city-by-city basis, without reducing the number of assignable UHF-TV channels.

Taking a longer view, as other television distribution modes become available, it may be appropriate to reconsider the need in some geographic areas for broadcasting in the UHF spectrum bands. The technical and economic feasibility of providing television broadcasting in other frequency bands (particularly higher frequencies where multi-channel broadcast capabilities would be possible with greater prospects for geographic re-use) and of employing narrower bandwidths for television broadcasting to conserve spectrum should both be the subject of federal R&D in support of spectrum management.

D. Microwave Services (1000-10,000 MHz)

This region of the spectrum is generally useful for line-of-sight transmission. It is used mainly for various radar and radio-navigation services, point-to-point radio relay, and communication satellite services.

For radio relay systems several possibilities exist for more efficient spectrum use. Some of these are already being implemented (particularly by the domestic common carriers). Included are: use of new antenna designs which improve directivity and suppress undesired radiation, use of modulation techniques offering higher resistance to the effects of undesired radiation (noise and interference) and use of multiple, geographically separated sites (space diversity) for similar purposes. These steps should be encouraged and accelerated through improved equipment and operating standards applicable to all radio relay systems.

A much discussed issue involves satellite use of frequency bands below 10,000 MHz, and frequency sharing by satellite and terrestrial systems. Under the sharing criteria established by the ITU in 1963, no harmful interference between the international (INTELSAT) satellite system and existing radio relay systems has been detected. Some believe that the significant technical differences between international and domestic satellite systems may further reduce the likelihood of interference between domestic satellite and terrestrial systems. Operators of radio relay systems have expressed the opposite view, holding that an increasing number of earth stations in a domestic system, with greater inland dispersal of antennas, may create serious problems.

While concern over potential interference is real, a general consensus exists within the engineering community that, with coordinated planning, no substantial problems would stem from the siting of at least one domestic earth station in the vicinity of a major urban center (e.g., New York City) where radio relay routes are most congested.

The situation in smaller urban centers should be no more restrictive than this, and likely much less so.

A major uncertainty in the development of economical domestic satellite communications concerns the amount of suitable spectrum resources available for these services. Therefore, a thorough reevaluation should be undertaken of various alternatives for satellite/terrestrial sharing of spectrum bands below 10,000 MHz, including analyses of relative costs and benefits of those alternatives to both satellite and terrestrial systems. Spectrum sharing between satellite and terrestrial systems adds a significant third spatial dimension to spectrum use, resulting not in a division of available communications capability but rather a net increase in overall communications capability. The benefits of this net gain must be carefully weighed against any loss in service quality or reliability which might result from potential interference between such uses.

Finally, there is the question of spectrum and orbital sharing among satellite systems themselves. Four major spectrum bands (and several minor ones) below 10,000 MHz are allocated to satellite use on a shared basis with radio relay services. The 7 and 8 GHz bands are authorized in the U.S. for government use on an interim basis, while the 4 and 6 GHz bands have been similarly designated for non-government uses. There are various possibilities for more efficient sharing of these allocations among government and non-government uses, including the use of orbital location and/or reverse spectrum assignments to avoid inter-system interference. For example, one system might use specific allocations in one direction (e.g., 6 or 8 GHz uplink and 4 or 7 GHz downlink); while another system used these same allocations in reverse directions (i.e., 4 or 7 GHz uplink, 6 or 8 GHz downlink). Such possibilities merit thorough evaluation, since they may also increase the total communications capacity from a particular frequency range.

E. Millimeter Wave Services (above 10,000 MHz)

The potential communications capacity of the spectrum regions above 10,000 MHz greatly exceeds the capacity of the lower bands, but their use is restricted by their fundamental propagation characteristics and by a lack of reliable, economic equipment at the present time. Some have nonetheless suggested that segments of this spectrum range should be used for domestic satellite service on an exclusive basis, as a way to avoid interference between satellite and terrestrial systems. However, satellite communications equipment capable of using these spectrum bands has not yet been developed, and energy losses due to atmospheric absorption -- known to be a factor of increasing importance as operations are extended above 10,000 MHz -- may render the use of these bands considerably less economical than those below 10,000 MHz for some services. This could be a particularly severe problem for satellite services which penetrate the atmosphere and require wide-area, continuous coverage -- such as television distribution, and mobile services.

Notwithstanding these difficulties, potentially attractive applications for use of the millimeter wave bands may arise, not only for satellites but also for terrestrial radio relay systems, multiple-channel television broadcasting and distribution, and mobile radio services.

We currently lack an adequate base of technical, economic, and operational data to plan the optimum use of these bands. Domestic allocation of these bands on an exclusive basis today could well foreclose attractive options which cannot now be adequately foreseen.

F. Scientific Uses of the Spectrum

Throughout the electromagnetic spectrum there are frequency bands of particular value for scientific research. Radio astronomy, for example, includes observations in the vicinity of characteristic emission and absorption frequencies for certain highly significant atoms and molecules which may be found in widely dispersed regions of the spectrum. Such research involves passive monitoring of very low signal levels and requires essentially clear-channel operation free from man-made interference. Moreover, scientific research is required in some small fraction of every major frequency band (e.g., HF, VHF, UHF and so on) to evaluate the propagation characteristics in these bands. The policy of providing reasonable interference protection for appropriate requirements of research -- particularly in those geographical areas where such research is conducted -- is clearly in the public interest and should be continued.

VI. ENHANCED MANAGEMENT CAPABILITIES AND A RESTRUCTURING OF RESPONSIBILITY AND AUTHORITY ARE REQUIRED

The challenges we foresee and the goals we have suggested demand a vigorous, flexible administrative mechanism, emphasizing productive use -- not restrictive conservation -- of the spectrum. The spectrum should be managed as the valuable resource it is, instead of being relegated in importance to a broad range of regulatory and other policy interests. In particular, the spectrum management function should not be used as a convenient regulatory tool in the pursuit of a variety of objectives other than achieving the maximum social and economic benefit from spectrum uses.

Reform is required in "block" allocations, in developing more objective criteria for apportionment of spectrum resources, in dividing spectrum resources between government and non-government uses, in conducting a co-ordinated program of R&D designed to produce better use both intensively and extensively of spectrum resources, and in reducing non-productive spectrum waste. Such reform should embody greater reliance on economic incentives, as well as improved engineering and should include more flexible and comprehensive administrative procedures.

We doubt the feasibility of such a program within the existing institutional framework of divided responsibility for spectrum management. We are persuaded that a single spectrum manager must be established within the Executive Branch if significant improvement in management is to be achieved.

The weakness of past management practices is evidenced by the large amount of usable spectrum lying fallow under the present scheme of exclusive nationwide allocation of bands of frequencies to specific user categories. As the relative disparity of uses varies between different geographic areas, waste results. With a single manager trying to maximize the use-value of the spectrum, this condition would be less likely to exist under the pressure of growing demand.

While at one time there may have been reason to separate the management of that portion of the spectrum assigned to the Federal Government from that used by all others, the present and future environment of scarcity dictates a different approach. The fact that a certain frequency band has been assigned to the Federal Government -- or to a particular non-government user category -- is no reason to leave it unused in geographic areas where it may be productively employed.

In addition to geographic location, other factors can be enlisted to achieve multiple use of spectrum. For example: time sharing, antenna directivity, variation of tolerable interference levels among different services, and more can, under proper management, be usefully exploited.

Under the weight of increasing demands, spectrum management will increasingly become more complex. To keep pace, the manager must constantly exert effort not only to improve existing tools, but to develop new ones along the lines discussed above. Separate government and civil management responsibilites are likely to blunt the effectiveness of this effort.

Every significant study of the spectrum problem in the past several years has emphasized that the Federal Government does not have adequate technical and economic information on which to base valid judgments affecting allocation and utilization of the spectrum. The adequacy of institutional arrangements to assure continuing availability of such information has been frequently questioned.

There is presently no single government program for comprehensive planning and coordination of spectrum uses at the local level, although the FCC and DTM have recently proposed a pilot project of this type for the Los Angeles area. */ Moreover, available reources and present levels of personnel render any attempt at such a large-scale program wholly impracticable. The economic, engineering, and administrative reforms discussed above will require in the near future a substantial increase in resources and capabilities, whatever the organizational structure. Unified action is necessary particularly in establishing a common data base for radio frequency management and in developing standardized management techniques.

The longer the present management structure remains, the greater the likelihood that considerable duplication and inefficiency will result. Establishing a single manager should reduce these problems significantly: It would facilitate establishment of (a) common data collection programs, (b) common bases for projecting demands and

*/ The FCC and the DTM would establish joint field offices in the Los Angeles area, with computer support at their central offices, to investigate the feasibility of applying improved engineering techniques rather than block allocations in making certain frequency assignments.

services and for developing, implementing, and enforcing equipment and operating standards, (c) a single spectrum engineering capability for both government and non-government uses, and (d) a consistent system of priorities derived from a common base.

A single management would also facilitate the introduction of flexible administrative procedures -- including a reduction in the number of lengthy proceedings and inter-agency negotiations -- essential to effective management with rapid accommodation to individual needs, and co-ordination of interacting uses of the spectrum.

A consolidation would make possible more efficient use of technical and analytic capabilities now fragmented among various offices. It would provide a framework for coordination and a strengthened, mission-oriented approach to spectrum research now carried out in certain government laboratories. It would also provide a focal point for coordination with industrial and academic research activities. This should lead to an improved capability for establishing and enforcing the technical standards and licensing requirements needed to prevent harmful interference among spectrum users, and for conducting the necessary long-range studies in spectrum management recommended earlier.

Unification of spectrum management within the Executive Branch would also relieve the FCC of complex managerial tasks which (subject to qualifications noted below) need not be tied to its regulatory responsibilities. It would subject federal usage claims to scrutiny by an agency charged also with protecting non-federal interests in spectrum use. It would enhance the ability to plan and implement Presidential control of communications in times of national emergency, which is today handicapped by divided responsibility. And it would provide more effective U.S. participation in international telecommunication conferences and related activities.

In sum, we see substantial benefits on all sides from consolidated spectrum management functions. The management structure and operations would benefit by eliminating duplicate offices, personnel, research facilities, data collection and analysis facilities, and other resources; this increased efficiency would result in more comprehensive and sorely needed management capabilities. Private users would benefit from this improved management capability, because more spectrum resources could be made available within virtually every area of use. Government users would likewise benefit in those areas where their needs are greatest, and should incur little or no loss in communications capability in any area. Finally, the public would benefit from the increased spectrum resources made available for both public and private use, in terms of added services and/or reduced rates.

One argument advanced against unification is that an agency such as the Department of Defense, given its vital role of national security, should not be subordinated to a separate authority dealing with both public and private claimants for spectrum. But the national security of the U.S. depends on many resources other than spectrum. Government agencies experience little difficulty obtaining other resources through normal procedures, whether by purchase or expropriation. There is no reason to suppose that acquisition of spectrum rights would pose any greater difficulty.

It has also been suggested that unification of spectrum management would encroach upon the FCC's exercise of regulatory responsibilities in broadcasting and common carrier services. This argument is predicated on the notion that spectrum allocation and assignment is a fundamental determinant of the structure and performance of these sectors, and therefore cannot be separated from FCC's broadcast licensing and common carrier regulatory role. However, after careful analysis, we have concluded that this concern is not well founded.

The FCC's responsibilities in the field of broadcasting, such as determining the proper number, location, and qualifications of broadcast entities and regulating their operations, are quite distinct from responsibilities for managing use of the spectrum. While policies underlying these functions may occasionally conflict or overlap, the crucial fact is they represent distinctly separate activities which can properly be performed by different agencies.

An Executive Branch spectrum manager and the FCC should encounter no major obstacles in working out together (under the watchful eye of Congress) any needed changes in the existing broadcast station allotment plan */

*/ 47 CFR, Part 73606

which would appropriately reflect the objectives of both agencies. We have no reason to expect that disagreement would frequently arise on the need for such changes given (a) the present stage of broadcast development, (b) the present station allotment plan (essentially unchanged for over 15 years, (c) the recognition by the FCC in recent proceedings of the potential benefits of releasing certain unused portions of the UHF broadcast band to other services, and (d) the unlikely prospect of any major modifications to the existing allotment plan in the near term. The Commission would continue to license broadcast stations, according to the existing station allotment plan.

Infrequently, conflict might arise between two broad policy interests, e.g., between national security and promotion of broadcasting or between broadcasting policy and efficient spectrum use. */ The legislation establishing a single spectrum manager could provide

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*/ Such a conflict, in theory, already exists under the present division, and might well arise between any two agencies charged with mandates which at some point interrelate.

suitable guidance for such eventualities. For example, it could make clear that the spectrum manager coordinate questions transcending ordinary considerations of efficient spectrum use with other appropriate agencies of government. And in the infrequent instances where irreconcilable conflict based on the interplay between such broad mandates did arise, it seems only proper that the competing considerations be brought to Congressional attention.

Similarly, accommodation between FCC responsibilities and those of the spectrum manager seems feasible in the area of common carrier services, where considerations relevant to the grant of frequencies are more technical and economic -- in contrast to the range of sensitive and heavily value-oriented issues involved in broadcasting. The division of responsibility for allocating a resource among claimants, and for regulating the behavior of firms in an industry, has worked successfully in other areas. There seems little reason to expect a significant divergence in this area between the objectives of the FCC and the spectrum manager. In developing the statutory framework for an improved spectrum management authority, appropriate provisions should be incorporated to ensure that (a) in the case of the common carriers, proposed investments in facilities would require FCC approval on regulatory grounds, and (b) in the case of private applicants for licenses, the proposed use would have to be consistent with FCC regulatory rules relating to competition with common carrier services. Whatever the statutory mechanism chosen, a Commission decision based on regulatory grounds would have full effect, exactly as under today's procedures.

With respect to services usually outside the scope of FCC regulation of broadcasting and common carrier services, e.g., safety and special services, social values as well as technical and economic considerations may be involved in determining spectrum use. However, unlike the broadcasting and common carrier fields, no special considerations require that responsibility for making such determinations be lodged in the Commission.

As a final consideration, we note that the Commission is headed by seven Commissioners and operates as an independent agency with quasi-judicial procedures -- quite appropriate in view of the important and sensitive judgments it must make among applicants competing for broadcast licenses (and, to a lesser extent, in formulating rules to govern the performance of broadcasters and common carriers). But neither in its structure nor in its procedures is the Commission equipped to ensure efficient spectrum management. The need for comprehensive planning, rapid response to changing conditions, and close co-ordination with a variety of government R&D efforts and policies entrusted to other Executive agencies suggest an Executive capability in spectrum management separated from the regulatory functions of the FCC. Accordingly, we conclude that:

1. Legislation should be considered which would vest in an Executive Branch agency overall responsibility for efficient spectrum use for all government and non-government uses. This legislation should contain appropriate guidance as to coordination between the spectrum manager and the FCC in areas of mutual interest and concern.

2. The agency should be given the resources needed to develop a strong interdisciplinary capability embracing technical, economic, social, and legal skills,

to support its spectrum planning, management, and coordination responsibilities as described in this Report.

3. The agency should: (a) determine and continually update the division of spectrum among various classes of users, and administer its use on the basis of detailed planning and engineering at local and national levels; (b) establish and enforce technical standards applicable to all transmitting and receiving equipment and other devices that materially affect the use of spectrum; (c) coordinate federal R&D activities oriented toward spectrum management and use, except those directed to fulfill a specific mission of another agency; and (d) administer any user fee systems now existing or later established.

4. In the interim, to meet existing spectrum management problems and to prepare for the future, resources should be provided to begin effectively to implement the general and specific recommendations of this report.

VII. SUMMARY OF CONCLUSIONS AND RECOMMENDATIONS

Clear policy objectives and a new approach to spectrum management should be adopted --

A. AS A BASIC GUIDELINE, WE SHOULD SEEK THAT COMBINATION OF SPECTRUM USES WHICH OFFER MAXIMUM SOCIAL AND ECONOMIC CONTRIBUTION TO THE NATIONAL WELFARE AND SECURITY.

Accordingly, the following principles emerge:

1. We should seek the continuing substitution of higher valued spectrum uses for lower valued uses and the addition of uses whose net effect is to increase overall benefits, with due consideration of all imbedded capital investments.

2. Unused spectrum resources should be employed to meet any legitimate need provided that this does not cause excessive interference to existing uses, conforms with established standards and international agreements, and does not interfere with established plans for higher valued uses.

3. Comprehensive coordination of all spectrum use is required, under a continuing framework of public administration.

B. GREATER CONSIDERATION OF ECONOMIC FACTORS IS NECESSARY

1. An improved schedule of fees for spectrum licenses should be developed, which reflects the extent of spectrum use (e.g., bandwidth, power, service area, time availability) and the level of demand for spectrum rights. And intensive studies should be conducted of other means to account for economic value, including adjustable license fees, spectrum leasing, and taxation.

2. License privileges should clearly be stated for each class of spectrum use (e.g., land mobile, radio relay, etc.), in terms of interference probability, channel loading, service quality, and other appropriate factors.

Summary -

3. Administrative procedures should be modified to permit greater transferability of licenses among legitimate spectrum users within broad service classifications, subject to all relevant conditions of the initial license, including the requirement that all exchanges or transfers be registered and approved by the spectrum management authority.

4. Procedures should be developed whereby a prospective spectrum user may obtain a license even though this would represent a potential source of harmful interference to an established clear channel user, provided that prior arrangements are concluded between all affected parties, including adequate compensation or indemnification by the new user.

C. GREATER ATTENTION TO INDIVIDUAL SPECTRUM USES SHOULD BE ACHIEVED THROUGH "SPECTRUM ENGINEERING" AND RELATED TECHNICAL CONSIDERATIONS

1. A more flexible approach to spectrum management should be adopted, under which the National Table of Frequency Allocations is transformed over time from a fixed allocation by user category to a basic planning guide by service classification.

2. A comprehensive spectrum engineering capability for individualized planning and engineering of spectrum uses should be developed, charged with continuing improvement in technical design and operating standards for all transmitting and receiving equipment and other devices that materially affect spectrum use.

D. ENHANCED MANAGEMENT CAPABILITIES --- AND A RESTRUCTURING OF RESPONSIBILITY AND AUTHORITY --- ARE REQUIRED

1. Legislation should be considered which would vest in an Executive Branch agency overall responsibility for ensuring efficient spectrum use for all government and non-government uses; this legislation should contain appropriate guidance as to coordination required between the spectrum manager and the FCC in areas of mutual interest and concern.

2. The agency should be given the resources needed to develop a strong interdisciplinary capability embracing technical, economic, social, and legal skills, to support its spectrum planning, management, and coordination responsibilities as described in this Report.

3. In particular, the agency should: (a) determine and continually update the division of spectrum among various classes of users, and administer its use on the basis of detailed planning and engineering, at local and national levels; (b) establish and enforce technical standards applicable to all transmitting and receiving equipment and other devices that materially affect spectrum use; (c) coordinate Federal R&D activities oriented toward spectrum management and use, except those directed to fulfill a specific mission of another agency; and (d) administer any user fee system now existing or later established.

4. In the interim, to meet existing spectrum management problems and to prepare for the future, resources should be provided to begin effectively to implement the general and specific recommendations of this report.

E. SPECIFIC RECOMMENDATIONS IN SELECTED PROBLEM AREAS

1. Land Mobile Radio Services

a. Land mobile radio services should be authorized to use spectrum resources now within the national allocations for UHF television broadcasting which are unusable by television stations under the present TV station allotment plans; subject to operating criteria which will avoid harmful interference to television broadcasting on adjacent channels or in adjacent geographic areas.

b. Equipment and operating standards should be established for engineering future land mobile services to permit closer spacing of base stations sharing the same frequency assignment: the use of multi-channel radio equipment should be encouraged wherever this would economically provide more efficient spectrum use.

c. Development and use of common-user and common-carrier mobile radio systems -- including those employing wire-line trunking between individual base stations -- should be encouraged, particularly for users with intermittent service requirements.

d. A range of channel loading criteria should be established to encourage effective frequency sharing among complementary uses and to provide a satisfactory and well defined quality of service to each user.

e. The sub-allocation of land mobile spectrum bands by user class should be substantially discontinued. Any remaining sub-allocations should be flexibly administered within each geographic area.

f. Procedures should be established whereby members of the general public now restricted to the Citizens Radio classification may be licensed to use certain land mobile spectrum resources subject to compliance with reasonable technical and operating standards and appropriate channel-loading criteria.

2. Public Safety Radio Services.

   a. The public safety radio services should be incorporated into the government spectrum allocation and management framework.

   b. Operating standards requiring greater time and geographic frequency sharing among public safety agencies should be established.

   c. Development of common-user mobile radio systems for public safety services should be encouraged.

3. Television Broadcasting.

   a. Spectrum resources presently allocated for broadcasting which are unusable for that purpose under existing station allotment plans should be made available for land mobile and other uses.

   b. Studies of improved techniques for television broadcasting should be carried out on a continuing basis, with respect to alternative distribution methods, channel bandwidth reductions, and reduction in total spectrum allocations.

4. Microwave Services (1000 - 10,000 MHz).

   a. Improved operating standards (e.g., modulation, antenna directivity, space diversity, etc.) should be established to achieve greater spectrum re-use and interference protection between terrestrial facilities sharing the same frequency ranges.

b. The criteria for satellite/terrestrial sharing of all spectrum allocations below 10,000 MHz should be re-evaluated, giving due consideration to the significant technical differences between domestic and international satellite systems and to improvement in technical data since the existing criteria were established.

c. Experimental programs should be conducted to ascertain the probability of interference between satellite earth stations and terrestrial radio relay stations, in shared frequency bands below 10,000 MHz.

d. Improved criteria and coordination procedures should be developed for efficient sharing of spectrum allocations and orbital locations among domestic and international satellite systems, both government and non-government.

5. Millimeter Wave Bands (above 10,000 MHz).

a. Continuing research and development activities needed to bring about effective and efficient use of these spectrum bands should be encouraged, through Federal R&D programs and flexible policies with regard to the potential uses of these bands.

b. Existing domestic allocations of all millimeter-wave bands should be reviewed to determine the feasibility of inter-service sharing of these bands as an alternative to exclusive domestic allocations to satellite and terrestrial services.

CHAPTER IX

CHAPTER NINE

THE ROLES OF THE FEDERAL GOVERNMENT IN TELECOMMUNICATIONS

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CHAPTER NINE

THE ROLES OF THE FEDERAL GOVERNMENT IN TELECOMMUNICATIONS

I. INTRODUCTION

This report has explored issues of national communications policy in a variety of settings. And our conclusions and recommendations embrace a wide range of actions. A few imply no change in the existing structure or activities of government in the telecommunications field; e.g., our suggestion that teleprocessing remain a non-regulated activity. Others explicitly entail organizational changes; e.g., a unification of the spectrum-management functions now performed separately by the Director of Telecommunications Management and the Federal Communications Commission. Still others strongly imply the need for government to improve its capabilities; e.g., the recommendation for the formation of a single U.S. international transmission entity subject to informed public regulation.

Specific organizational recommendations are beyond the scope of this report. We attempt, rather, to identify the implications of our policy recommendations for the role and general structure of the federal establishment, and thereby to furnish a new and useful perspective on our conclusions in specific substantive areas. In sum, we ask the questions: What are the appropriate roles of the federal government in relation to telecommunications? And to what extent do our policy recommendations call for changes in present federal activities?

II. TRADITIONALLY, GOVERNMENT HAS VIEWED TELECOMMUNICATIONS PRIMARILY AS A MISSION-SUPPORT FUNCTION, RATHER THAN A FOCUS FOR PUBLIC POLICY. THE RESULT HAS BEEN THAT POLICY HAS EVOLVED AS A PATCHWORK OF LIMITED, LARGELY AD HOC RESPONSES TO SPECIFIC ISSUES, RATHER THAN A COHESIVE FRAMEWORK FOR PLANNING. GOVERNMENT ORGANIZATION FOR THE FORMULATION AND IMPLEMENTATION OF COMMUNICATIONS POLICIES REFLECTS THIS EVOLUTION

A. Early Government Involvement in Telecommunications Often Involved Ad Hoc Responses to Individual Problems as They Appeared

The federal government's involvement in telecommunications dates back to the earliest days of telegraphy in the mid-nineteenth century, when the Post Office provided the first commercial telegraph service. Until the turn of the century, however, the government concerned itself with the industry only sporadically. Two steps taken early this century soon proved to be inadequate.

The Mann-Elkins Act of 1910 gave jurisdiction over interstate and foreign telephone and telegraph service to the Interstate Commerce Commission. The Commission soon found that it could not devote sufficient attention to what was rapidly becoming a major industry. The Radio Act of 1912, passed in part to protect certain radio frequencies for governmental use, proved unable in its simple scheme to cope with the problems caused in the 1920's by a tremendous growth in demand for radio communications from both government and non-government users.

In 1922, the Secretary of Commerce formed the Interdepartment Radio Advisory Committee (IRAC), composed of representatives from the various federal agencies that used radio communications, to allocate frequencies among the agencies in order to prevent harmful interference. In 1927, Congress established a five-member Federal Radio Commission empowered to classify, license and regulate non-government stations to prevent interference among them.

B. The Framework Established by the Communications Act of 1934, Although Combining the Broadcasting and Common Carrier Regulatory Functions, Remains Limited in Scope

The Communications Act of 1934 created a permanent, seven-man Federal Communications Commission as an independent agency with the regulatory powers over communications carriers that the Mann-Elkins Act had vested in the Interstate Commerce Commission and the licensing powers over radio communications that the Federal Radio Commission had enjoyed. But some gaps remained. As indicated in Chapter Six, these were later to create problems: carriers were not required to obtain Commission permission to raise new capital or to make additions to plant, other than the communications lines themselves; the Commission was given no direct authority over procurement of communications equipment or facilities by regulated carriers, over their affiliations with manufacturers of such equipment, or over inter-carrier contracts; nor was it given authority to approve mergers or consolidations of international telephone or telegraph carriers, should they be needed. The advent of cable television and computers, moreover, raised problems on which the Act provided little guidance.

The 1934 Act vested the FCC with sweeping powers (more fully described in Chapter Eight) over use of the radio spectrum by all entities (including state and local government) other than the federal government, plus some specific powers over broadcasters -- e.g., equal time for political candidates. Authority to assign frequencies to federal agencies, however, remained with the President. And no agency was empowered to resolve conflicts between federal and non-federal use of the spectrum or to optimize their combined uses.

Finally, the Communications Act of 1934 evinced little recognition of a federal role in communications beyond the duties assigned the FCC. Thus, consonant with the view of communications as primarily a government mission-support function, no agency was created to administer federal spectrum use, to coordinate federal research and development in telecommunications or the procurement of communications services and equipment by federal agencies, or otherwise to act as a focal point for the Executive Branch interest in the communications field.

C. The Post World War II Period Has Been Characterized by the Growth of Communications Activities and a Series of Narrowly Focused Studies and Limited Organizational Changes

These deficiencies became increasingly conspicuous with the enormous growth in the variety, complexity and use of telecommunications during and after World War II. In 1950, President Truman launched the first of a long and continuing series of internal studies of government organization in the telecommunications field. This study led in October 1951 to the creation by executive order of a Telecommunications Advisor to the President, charged with assisting the President on telecommunications policy and with assigning radio frequencies to federal agencies. IRAC, although formally relegated to an advisory role, continued to play a principal role in the assignment process.

In November 1958, the government's role in managing its own telecommunications facilities and in frequency allocation once again served as the focus of study. A special Advisory Committee on Telecommunications was convened by the Director of the Office of Civil Defense Mobilization, who then had the functions of the Office of Telecommunications Advisor by Presidential delegation. The Committee concluded that the creation of a Telecommunications Board in the Executive Office would help the President to meet these responsibilities. A proposal to set up a five-member Special Telecommunications Commission, submitted to Congress in March 1959, failed to obtain final approval.

A task force appointed by President-elect Kennedy in 1960 called attention to the absence of government capability for long-range and comprehensive policy-making in the telecommunications area, and recommended transfer of all OCDM telecommunications powers to a new Office for Coordination and Development of Communications Policy within the Executive Branch. But the only organizational change actually implemented was more limited in scope. By Executive Order 10995, President Kennedy in February 1962 established the position of Director of Telecommunications Management (DTM), to be held by an Assistant Director of the Office of Emergency Planning, successor to OCDM.

The President delegated his authority over government frequency allocations to the Director of OEP, authorizing him to re-delegate it, which he did, to the DTM. The President also delegated to the DTM certain Presidential emergency responsibilities under Section 606 of the Communications Act. In addition, the DTM was charged with coordinating government telecommunications policies and, in his further role as Special Assistant to the President for Telecommunications, with advising the President on telecommunications matters.

In connection with the Communications Satellite Act of 1962, a number of specific functions dealing with promotion and coordination were assigned to the President. Most of these functions were delegated to the DTM, except for the foreign relations aspects, which the President assigned to the Department of State. The FCC was invested with broad regulatory jurisdiction, patterned on its authority over existing communications common carriers. The Satellite Act also lodged certain functions in NASA, principally technical assistance to, and cooperation with, Comsat, and the provision of launch services. This assignment underscored the role of the federal government as a prominent source of communications R&D. Not only was the satellite itself a spillover from the rocket work of NASA and the Defense Department, but both agencies are also engaged in extensive research and development into specific communications applications of space technology. Defense has also supported a variety of other research and development projects in communications, and the Department of Commerce has for years maintained several laboratories in which research into radio communication is conducted.

The inadequate performance of government communications systems during the Cuban missile crisis prompted a Security Council investigation headed by the Deputy Under Secretary of State for Administration, William H. Orrick, Jr. As a result of that investigation, the President in 1963 established the National Communications System to facilitate the interconnection of the major existing government systems. The largest of these was the Defense Communications System, managed by the Defense Communications Agency. This system, a worldwide complex of DOD communications networks, had been formed in 1960. Prior to that time, military communications had been independently selected and implemented as an individual system for each service.

The mission of NCS was not to take over or displace, but to integrate and coordinate. The objectives were to improve performance in support of national command authorities under emergency conditions and, in the longer run, to eliminate unnecessary duplication of facilities. The Secretary of Defense was made Executive Agent and the Director of the Defense Communications Agency was made Manager, NCS. The Executive Agent and Manager are responsible for integrated planning and operations. The DTM was given a policy-advisory role.

III. THE PATCHWORK NATURE OF THE PRESENT STRUCTURE IS NOT CONDUCIVE TO OPTIMUM PERFORMANCE OF THE TELECOMMUNICATIONS ACTIVITIES AND REQUIREMENTS OF THE FEDERAL GOVERNMENT

A. Existing Organizational Arrangements Make Effective Spectrum Management Difficult

Radio frequencies are now assigned to federal agencies by the DTM, with IRAC playing an important role in the actual determination. Under existing arrangements, however, the DTM lacks the resources and clear authority to impose wholly effective controls on government spectrum uses to conserve government use of spectrum for the benefit of private users, and, of course, has no authority with regard to non-government uses.

The FCC is represented on only one subcommittee of IRAC and has no authority over the use of the radio spectrum by the Federal government. Conversely, neither the President nor any executive agency has the legal right to review FCC frequency management for the non-federal sector. Thus, no agency is empowered to effect an equitable and efficient allocation of spectrum rights between the federal and non-federal sectors, nor to establish and enforce technical and operating standards equally applicable to all classes of users.

In addition, a lack of adequate technical staff and resources in the FCC has contributed to the procedure of allocating radio frequencies on a nationwide block basis, leading both to overuse and to underuse of the spectrum, depending on service and location. Although the government has considerable technical resources concerned with radio communications, they are principally to be found in Department of Commerce and DOD laboratories, rather than in the staffs of the spectrum managers, the DTM and the FCC. And the FCC, given the limited resources available to it and the demands placed upon it in licensing broadcasting and regulating the telephone and telegraph industries, has not devoted as much attention as seems necessary to the distinct role of spectrum manager.

B. The Absence of a Central Focus Possessing the Requisite Technological and Economic Skills Makes More Difficult the Development of a Sound and Forward-looking International Telecommunications Policy

Because telecommunications has international dimensions, the President's constitutional responsibilities for the conduct of foreign policy are inescapably involved in communications policy. This was recognized by Congress in the Cable Landing Act, which requires a Presidential grant of U.S. landing rights for any international cable, and in the Communications Satellite Act, whose special provisions for Presidential supervision were described earlier. Necessarily, therefore, the Department of State, through its Office of Telecommunications in the Bureau of Economic Affairs, plays a significant role in the formulation and implementation of U.S. communications policy, as it relates to foreign policy.*/ The expertise of this office, however, naturally leans more to

*/ The President has delegated his foreign policy responsibilities under both the Cable Landing Act and the Communications Satellite Act to State.

foreign policy and international relations than to the technology and economics of telecommunications, which underscores the need for providing strong technical and economic support to the State Department from elsewhere in the government

C. Government Research and Development and Procurement Efforts are not Organized to Ensure that Social Benefits Inherent in Telecommunications Technology are Promptly Realized

The communications industry looks to government as its most important customer in terms of product and system development. Decisions made with respect to the establishment and operation of government communications systems may have as great an impact on the future configuration of the commercial communications industry as all but a handful of policy or regulatory decisions. Yet it is precisely in the area of communications research and development and procurement that the potential for a coordinated government policy integrated with the regulatory and planning roles has gone unrealized. Government research and development efforts related to communications -- reflecting the variety of policy-formulation, resource-management, regulatory and mission-support tasks which they undergird -- are diverse in nature and scattered in organizational locale. Far greater research activities and technical expertise are to be found in the Departments of Defense and Commerce and in NASA than in the FCC and DTM; yet these capabilities are only rarely used in the formulation of telecommunications policy or in day-to-day operations of the FCC and the DTM. The FCC Chief Engineer's Office conducts technical studies of electromagnetic spectrum use, and the FCC's only laboratory, at Laurel, Maryland, tests new equipment for conformity to FCC standards. Studies similar to those conducted by the FCC are supported by the DTM in aid of its role as manager of government frequency assignments. DTM also sponsors studies of communications satellite technology and general telecommunications policy, usually through outside contracts. The scope and relevance of the information obtained, and the ability to implement conclusions reached, particularly with regard to spectrum, have been limited by the absence of a single central focus to plan and execute a coordinated program of research and by the multi-jurisdictional responsibilities.

Other agencies support primarily product-oriented communications research and development, in connection with the substantive missions for which they are responsible. This work, particularly that carried on in connection with the defense and space programs, has made significant contributions to the high rate of technological progress which has characterized the communications industry. But the differences in the product needs of government, industry and the general public reduce the impact of beneficial "spillover" effects.

A large and important area exists in which the federal government could promote */ the application of telecommunications concepts and technology to a variety of social ends. Currently, this role is highly fragmented -- to the extent that it is recognized at all. NASA has both the technical resources and mandate to explore the adaptation of communications satellite technology to the entire range of socially relevant purposes, but its interest in the communications aspect is incidental to its overriding

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*/ Promotion is used here not in the sense of "pushing" telecommunications beyond the limits justified by considerations of efficient resource use, but in the sense of assuring that justifiable applications are not overlooked because of lack of familiarity with current and potential state of the art.

concern with space exploration. The FCC has a general statutory responsibility to encourage the larger and more effective use of radio in the public interest, but as a regulatory agency it is limited in the degree to which it can play the role of communications promoter to executive agencies such as HEW, AID, and HUD. DTM lacks both the functional responsibilities and the in-house capability necessary to an effective promotional role.

A promotional policy would require a combination of two different, although closely related capabilities: a comprehensive and up-to-date knowledge of the present and potential technological state of the art, and the communications systems engineering competence to bring that knowledge to bear on the communications requirements of mission-oriented agencies. These capabilities do not exist in government today in the necessary form and quantity.

Neither FCC with its focus on regulatory matters, nor DTM with its focus on broad policy-making and spectrum allocation, nor even GSA, which is concerned with a wide variety of procurement and maintenance functions, possesses the requisite level of communications systems engineering skills.

Even DOD, by far the largest government consumer of communications products and service, has problems marshalling the skills and knowledge to enable it to evaluate a procurement proposal for a communications system, particularly in terms of the extent to which possibilities for systems engineering and technological innovation have been fully realized. This is not surprising. The justification for examining procurement proposals to determine whether possibilities for innovation have been fully realized relates less to the performance of a given mission than to the desirability of utilizing government's position as major consumer to ensure that the benefits of new technology are realized as promptly as possible. Unlike NASA in its field, DOD is not charged with the promotion of a technology. It is only to be expected that DOD would utilize its budgetary resources to develop capabilities directly related to its mission responsibilities, not to promote the general progress of communications technology.

The government's mission-related communications systems, especially those which form components of innovative social projects, offer wide opportunity for significant, innovative applications of new technological developments. HEW programs in the field of educational television, or medical telecommunications, for example, may well involve requirements for specially configured satellite ground stations; and specially tailored communications components might also be necessary to provide support for possible HUD programs seeking to define new relations among a variety of scattered urban groups. It is here -- in designing systems to meet mission-related communications needs -- that the need is greatest for a government capability which can bring to bear on systems requirements an intimate and comprehensive knowledge of the state of the art.

By incorporating a wide variety of technological innovations developed by a large number of firms in communications-related industries, the development of government systems and services could have a significant impact on developments within the industry as well. However, because responsibility for systems design and specifications is dispersed among a myriad of mission-oriented agencies, the procurement of telecommunications systems tends to be viewed as a mission-support function without relationship to overall national communications policy; because it is not integrated with other government policy, planning and regulatory goals, procurement policy tends to focus exclusively on the procuring of the system most closely tailored to the specific mission in question at the lowest possible cost. Except for limited cases among NCS agencies, opportunities for the sharing of systems, and for harnessing technological innovations to new social ends, thus tend to be ignored.

As a large user of communications services and products, moreover, the government has an obvious interest in bulk rates and in the development of products geared to the needs of large users. The granting of bulk rates, however, may in some cases result in an increase in charges to users who do not generate enough traffic to take advantage of them; and resources devoted to the development of products geared to the needs of large consumers are unavailable for the production of components specifically tailored to the requirements of other users. Yet government represents the public interest; and that public includes many small users. The need to relate government's roles as user and as representative of the public interest has not yet adequately been met.

D. The Absence of a Central Focus for Advice and Assistance to States and Localities has Resulted in Wasteful Duplication and Unmet Needs in Programs Utilizing Federal Funds

As a provider of technical assistance to, and as the funding and/or managing agent for a wide variety of non-federal projects which contain communications components (as in education and public safety), the federal government has a significant impact on the communications activities of state and local governmental units. The existing lack of coordination among the various federal agencies charged with responsibilities in these areas, however, together with the absence of any organization with a specific mandate to channel communications assistance and advice to state and local units, is said to have resulted in duplication of facilities, under-utilization of existing capacity, and in many instances, failure to meet the vital needs of state and local governmental organizations.

E. The Policy Coordination Necessitated by the Plethora of Government Telecommunications Roles is Inadequately Performed by a Multiplicity of Committees

Given the number of different federal roles in telecommunications, the necessity for coordination of policy is imperative. In theory, DTM is the focal point for coordination of federal telecommunications policy within the Executive Branch. In actuality, the coordinating role is diffused among a multiplicity of committees -- some permanent, and some *ad hoc* -- interwoven into a complicated web of formal and informal relationships. Many of these committees, moreover, have difficulty responding to the need for coordination of national and international policies and the requirements imposed by overall policy goals.

Much of this proliferation of coordinating mechanisms can be explained as a necessary response to the complexity of the issues presented and to the fact that there will always be a need for intra-governmental coordination prior to final decision. But it also would appear to reflect an attempt by the agencies concerned to adapt to the absence of a single focus for the coordination of national communications policy. Because that responsibility is at present fragmented among committees, neither the President nor the agencies concerned have available to them a source of coordinated and comprehensive policy advice. As a result, the Executive branch has difficulty presenting a coherent and consistent position on policy problems.

F. Recent Events have Underscored the Lack of an Effective Government Capability for Long-range Telecommunications Policy Planning

The lack of a central coordinating focus is closely related to the absence of an effective capability for long-range policy planning -- policy formulated not as an *ad hoc* response to a present crisis, but as a creative shaping of the future, anticipation and avoidance of crises, and well-thought-through solutions to fundamental, as well as immediate, problems. The continuing absence of such a capability -- which may reflect in no small measure the persistence of a traditional view of telecommunications as exclusively a mission-support function rather than a critical area of public policy in its own right -- has been repeatedly underscored in recent years. Thus, the creation in 1964 of the Intragovernmental Committee in International Telecommunications to study the question of a merger of U.S. international carriers, and the creation in 1967 of this Task Force, charged with a broad mandate to re-examine our communications policy, both attest to the lack of a permanent focus for review and revision of major policy positions. Our own work, reflected in previous chapters, adds urgency to the need for effective policy-making machinery to cope with the problems of even the near-term future.

IV. STEPS MUST BE TAKEN TO IMPROVE GOVERNMENT PERFORMANCE IN COMMON CARRIER REGULATION AND BROADCAST LICENSING

A. Prior Chapters have Disclosed Weaknesses in Government Regulatory and Licensing Roles

As discussed at length in both our international industry and domestic carrier chapters, the FCC's regulatory performance has not always proved fully effective. Rather than taking the place of competition in markets having pronounced natural-monopoly features, regulation in the communications industry, in our opinion, has at times acted as a constraint on competition even in markets which do not have such features. In addition, because of its emphasis on limiting the overall profits of regulated firms, regulation has not focused as clearly as it might on overall performance in common carrier communications. In large part, moreover, the Commission lacks the resources to develop sufficient in-house capability for the analysis of major issues having technical, economic and regulatory dimensions, even when these issues are central to its regulatory responsibilities. Given the highly complex and rapidly changing character of the industry, this is a troublesome deficiency.

Similarly, broadcasting policy as elaborated by the Commission implies a degree of supervision over programming which is difficult to enforce effectively, given present levels of personnel -- if, indeed, it can be enforced at all. Moreover, although the Executive Branch has begun to sponsor measures (e.g., the Public Broadcasting Act) to provide federal assistance to noncommercial broadcasting, the various Executive agencies have provided insufficient assistance in the policy field to the FCC in terms of bringing their diverse concerns and insights to its attention despite the obvious importance of television to such Executive Branch concerns as education.

B. Steps Must be Taken to Strengthen FCC Capabilities in These Areas

In both regulation and licensing, we find promising possibilities for strengthening the effectiveness of the FCC. As discussed in Chapter Six, relatively modest amendments to the Communications Act of 1934 would substantially strengthen the regulatory capability in the common carrier field.

In addition, the level of financial support for regulatory and licensing activities should be raised. In neither the broadcasting nor the common carrier area is the existing staff level sufficient to support effective regulation. The necessary beginning of any improvement in the broadcast licensing process continues to be the provision of sufficient resources to enable more than the superficial inspection and investigation efforts uncovered in the study of the FCC conducted by Booz, Allen and Hamilton in 1962. And sensitive and discriminating common carrier regulation requires more personnel trained in modern economic analysis and communications systems analysis than the FCC has today.

C. Greater Multi-disciplinary Capabilities Within the Executive Branch are Required, to Forecast Demand and Technology and to Provide a Framework for the Operation of Prototype Experiments

An Executive Branch capability could add to the efforts of the FCC in both the broadcast or common carrier fields. Thus, in broadcasting, the increasing importance of television in providing not only diversity but also support for the federal government's missions in a host of fields, highlights the need for an Executive Branch capability which can help to integrate and coordinate the variety of executive and legislative policies and interests involved. Similarly, in the common carrier field, even a substantially strengthened FCC could benefit from the assistance provided by an Executive Branch entity capable of taking the long view of policy and developing data and recommendations on a host of technological and economic aspects of telecommunications problems.

Furthermore, dramatic new technological developments -- the domestic satellite Chapter provides an extended illustration -- may raise technical, social and economic questions requiring experimental operations. If we wish to ensure that our domestic and international telecommunications systems are characterized by the optimum realization of the benefits of new technology, the Executive Branch should make available for use in the regulatory process its resources for technical assistance and the systematic assessment -- in technical, economic and social terms -- of technological innovations, and should provide a framework within which pilot programs can be carried on and evaluated.

V. A NEW GOVERNMENT TELECOMMUNICATIONS CAPABILITY IS URGENTLY REQUIRED

The United States is not now satisfactorily discharging its role in telecommunication management -- not one essential element of management exists to a sufficient degree -- a number do not exist. Our recommendations to correct this situation:

A. To Meet the Needs Described Above Requires the Creation of a New Government Capability Embodying a Variety of Both Missions and Personnel

Fully to meet the deficiencies outlined in prior parts of this and other chapters necessitates, in our opinion, the creation and deployment of a new set of governmental capabilities. What is required, in brief, is an adequately funded focus for the centralized responsibility for spectrum management recommended elsewhere in the report; a center capable of coordinating government research and development in spectrum problems and for the provision of guidance and evaluative frameworks for a variety of communications-related pilot programs; a focus capable of responding to requests for technical advice and assistance on procurement matters, either from other agencies or from State and local governments; and a center for the provision of technical assistance and the development of new concepts and procedures in connection with regulatory policy. The overall need, then, is for a long-range planning, policy formulating and coordinating and mission-support capability which can serve to integrate the various roles in which the Executive branch is presently engaged.

To its tasks, the proposed entity would bring the skills of engineers and scientists capable of analyzing the applicability of technological developments in terms of both component performance and systems design; and of lawyers, economists and statisticians capable of engaging in industry studies and, in cooperation with technical personnel, long-range technological, cost and demand fore-casting. As these programs began to be implemented, one could expect a constant flow of such personnel to other communications-related Government activities, including the FCC.

B. The Executive Branch Would be Able to Make Valuable Contributions to Regulatory Decisions

The proposed entity, designed to serve Executive needs, could provide valuable assistance to the FCC. Engaged in a variety of advisory roles and in the gathering of continuously up-dated operational knowledge, the new entity would have strengthened resources for communications systems analysis, and for long-range economic and technological forecasting. Accordingly, the new entity could be a valuable source of advice and inputs in regulatory proceedings, in much the same way that the Department of Transportation is beginning to participate in proceedings before a variety of regulatory bodies. In this role, moreover, the new entity might contribute substantially to resolving conflicts within the Executive Branch cited earlier between Government as user and Government as representative of the public interest.

C. A Framework Would be Provided for More Effective Spectrum Management

As more fully developed in the chapter on the use of the radio spectrum, we believe it essential to end the divided management of the spectrum, under which DTM manages spectrum use by Federal Government users and FCC manages all other uses, with no agency empowered to coordinate spectrum use between government and non-government interests. We are particularly concerned that many new and expanded uses of the spectrum which technology may make possible and the national interest demand, might be denied in the absence of more flexible management procedures rooted in a greater degree of localism and detailed planning than is possible with divided authority and responsibility.

In the award of licenses to individual broadcasting stations, many considerations come into play besides efficient use of the spectrum, having to do with broadcasting policy and the comparative qualifications of competing applicants. The licensing of individual broadcasting stations should therefore remain the responsibility of the FCC. Specific frequency channels would be allotted to specific areas for radio and television broadcasting, on the basis of mutual agreement as to the number and location of broadcast outlets required, with the FCC assigning these channels to particular applicants. Similarly, no displacement is proposed of the Commission's responsibility for determining whether the entry of a new common or private carrier or the construction of a new line or extension (wire or radio) should be permitted as a matter of sound regulatory policy. Thus, the Commission would either issue such licenses itself or, in any event, retain power on regulatory grounds both to veto and to urge acceptance of, applications for licenses involving use of the spectrum to provide private or common carrier services.

The use of radio communications as an adjunct to an unrelated function, like taxi service, public safety, electric utility operations or air transportation, by amateur radio operators or by Federal agencies in support of their missions, does not raise the same difficult regulatory issues as in the case of broadcasting or in providing communications common carrier service. The licensing or assigning process in the case of these services is largely limited to ascertaining whether spectrum is available; coordinating and engineering assignment of frequencies;

and enforcing established technical and operating standards. Consequently, depending on the administrative framework chosen, such licensing could be done by the FCC or by the Executive agency that has general responsibility for spectrum management, provided that the spectrum manager retains the overall authority for achieving efficient and effective spectrum use.

Finally, the new entity should also be responsible for the establishment and enforcement of such technical standards and licensing requirements as may be necessary to prevent spectrum waste and "pollution" -- harmful interference with radio communications caused by users of radio frequencies for purposes other than communication; the conduct of the long-range studies in spectrum management outlined in our spectrum chapter; and the coordination of the Government radio laboratories and R&D centers conducting the technical research described in our spectrum chapter as essential to intelligent exploitation of the spectrum resource.

This complex of functions will form the core of the missions undertaken by the proposed entity. Following the pattern of the Communications Act of 1934, its central activity will be oversight and allocation of the public resource represented by the spectrum. The diverse array of disciplines involved in this task, however, can also beneficially be brought to bear on a variety of related Government telecommunications functions. Their uses in connection with regulation have already been discussed.

We turn now to a description of the benefits to be obtained from assigning to the proposed entity further supplementary functions in other areas.

D. Telecommunications Research and Development, Especially that Associated with Prototype Experiments, Would be Significantly Strengthened

Defense, Commerce, and NASA each have scientific and technical information programs through which the results of unclassified R&D sponsored by these organizations are made available to the scientific community. The R&D involved is, of course, responsive to the mission needs of the sponsoring agency. Except for the NCS, nowhere within Government, however, is this information continuously studied for potential application to the mission needs of other Government agencies, and for the accomplishment of broader national goals. The transfer of technological advances made by one agency to another is currently accomplished on an *ad hoc* basis as problems arise. It therefore appears desirable to establish a focal point within Government for the continuous collecting and monitoring of communications related R&D results and to search for broader applications of such R&D.

Further, communications forms a vital component of a wide range of socially innovative programs potentially involving the efforts of a broad cross-section of Government agencies. If the opportunities promised by prototype experiments are to be realized, the proposed entity will be required to play a significant role in both their initiation and organization. Thus, where the programs involved are multi-purpose or where the initiating agency lacks the requisite technical capability, the new entity would function as agent for such projects, except where they are of a type more properly sponsored by NASA. Even where the proposed entity did not itself identify the need for or initiate the project, moreover, it would provide both technical and organizational assistance and the evaluative capability that is required if such programs are to produce meaningful results.

E. Significant Opportunities Would be Presented, Especially in Connection with Procurement, for the Realization of the Benefits of New Technology

An important role of the proposed entity will be in areas where existing Government activity is rudimentary and where in some cases even the existence of a federal role is not clearly perceived. The new entity would embody both the resources and the specific mandate to help HEW, HUD, or other agencies search out new applications of communications technology which hold promise of social payoff in such areas as adult education and job training, medicine, alleviation of racial tensions, and public enlightenment and entertainment. In connection with procurement, the skills and resources associated with the proposed entity would be devoted to providing, upon request from the federal agency, State or municipality concerned, advice and assistance in technical design analysis of communications systems required to meet a given agency's needs. The systems engineering skills which the proposed entity would bring to bear on this task would make it possible for the first time, for such agencies rigorously to evaluate proposals for communications systems made by the private sectors, not only in terms of comparative costs, but also in terms of the extent to which the potential benefits of technological innovations have been realized.

In addition, where the user lacks the requisite in-house staff, the proposed entity might undertake procurement advisory responsibilities. Assume, for example, that a variety of agencies each developed program requirements which could most easily be satisfied by joint use of a single system. In such a situation, the new entity, assuming it did not itself operate the system, would function as the interface between the mission-oriented agencies involved -- HEW, HUD, and Labor, for example, none of whom possesses the requisite technical knowledge and skills -- and the operator of the system.

The changes proposed in connection with spectrum management ought to produce substantial benefits. The benefits in other areas, however -- in particular, the substantial improvement in terms of effective policy formulation and implementation and promotion of significant technological possibilities which would be realized through the proposed entity's integration of the various government roles -- ultimately depend upon the assumption by the proposed entity of a critical mass of functions. Thus, it is precisely the personnel and skills required to service a significant volume of requests for procurement and planning assistance which would be capable of bringing to bear on the investment decisions of common carriers the type of analysis previously outlined, and of providing to the State Department -- in connection with its policy role in international telecommunications matters -- the type of technological capability deemed in our view necessary. Similarly, an entity which was in continuous contact both with agency procurement officers and -- as a result of maintaining continuously up-dated knowledge concerning the entire range of communications-related R&D -- with interested manufacturers and common carriers, could ensure to private industry more effective participation on a variety of matters in the Government procurement decision-making process. As indicated above, however, the realization of that critical mass of functions will ultimately depend upon the proposed entity's ability to prove its usefulness to other governmental organizations.

F. On-going Mission-Support Telecommunications Activities Would Not be Supplanted

This proposal for a new entity does not mean centralized control over all Government communications. Indeed, such a result would be difficult to reconcile with the fact that many Government communication systems are necessarily supportive of a specific mission for which a particular agency bears ultimate responsibility. In many cases -- certain DOD systems and the FAA's Civil Aviation Communications Network, for example -- Government communications systems embody high-priority requirements for such factors as security or rapidity of response which cannot safely be subordinated to other goals. Where the mission-supporting role of communications is predominant because of the existence of an overriding need for a system geared to a mission-related set of priorities, the case is clear for leaving ultimate responsibility in the hands of the agency responsible for the mission involved. What is required, therefore, is the creation of an entity with sufficient operational responsibility to enable it effectively to integrate the various Executive roles, while avoiding that degree of preoccupation with operational responsibilities which would threaten performance of the dominant function of long-range planning and policy formulation.

Nor do we think that licensing of broadcasting and regulation of communications common carriers should be transferred from the FCC. The political sensitivity of broadcasting control, and the tradition of quasi-judicial rate regulations, counsel for the retention of these functions by an independent regulatory commission. Therefore, the suggestions that we have made for increasing the FCC's effectiveness remain important and should be adopted, and, even more important, its staff should be augmented to enable it to function more effectively than it can today.

G. Required New Programs to Meet the Pressing Need for Policy-Trained Personnel in the Telecommunications Field Would be Enhanced

One of the underlying deficiencies of the policy framework in telecommunications is the absence of programs to develop the unusual interdisciplinary skills required for the formulation and implementation of sound public policy in a field as technologically, economically and institutionally complex as modern telecommunications.

Formulation and implementation of effective telecommunications policy, moreover, is at present seriously handicapped by a shortage of qualified personnel. Our universities have not trained engineers, systems analysts, economists or lawyers equipped to grasp the interrelationships among technological developments, systems engineering requirements, the regulatory framework and economic and social policy goals; nor are opportunities afforded for officials in policy positions to obtain such skills at mid-career levels.

One answer to this need would be for government to sponsor graduate fellowships on the model of the National

Science Foundation grants. The difficulty at present, however, is not the students' need for support but the absence of settings in which the necessarily multi-disciplinary programs are being offered. Nor is the problem entirely one of individuals' training. We have been struck in our studies by the lack of interdisciplinary research into questions of communications policy. Yet, this is a field in which the benefits to be gained from cooperation among lawyers, engineers, and economists are clearly substantial.

Both needs -- for broad-gauged policy training and for interdisciplinary policy research -- could be met by the establishment of one or more federally funded Communications Policy Training Programs or Institutes, perhaps located in university settings, which would have as their objective the provision of advanced training at the graduate and mid-career levels in the interdisciplinary skills required to produce capable and qualified communications systems analysts and policy makers. The funding levels required for such a program would be relatively modest, since a prerequisite for such a funding ought to be the existence of an on-going program of empirical and theoretical research on telecommunications problems within the university itself. Given the existence of such a program, moreover, the costs of many of the teaching personnel required could be shared by government and the university.

H. The Proposed Capability and the Communications Policy Training Programs Would Provide the Prerequisites for the Formulation and Implementation of Coherent and Comprehensive Telecommunications Policy

Given the critical mass referred to above, another function of the new entity would be to provide a focal point for coordination of the views of the many federal agencies concerned with communications problems, to lead in developing a more responsive and closely coordinated network of committees. Thus, by virtue of its varied roles, functions and resources, the new entity would provide an apt perspective for the fashioning of long-range communications policy positions to meet the challenges that the years ahead undoubtedly hold in this dynamic field.

All of these roles should be mutually supporting, and the synergism of the new entity would bode well for its success in its various missions.