William Melody, Dallas Smythe, Robin Mansell, Oliver Angus, Allister Pedersen and William Goodacre

The level and structure of license fees in the microwave band: an investigation of economic and operational aspects of using license fee schedules in particular bands as part of radio spectrum management.

Unpublished Report

THE LEVEL AND STRUCTURE OF LICENSE FEES IN THE MICROWAVE BAND

by

William H. Melody
Professor
Department of Communication
Simon Fraser University
Principal Investigator

with the assistance of:

Dallas W. Smythe
Professor
Department of Communication
Simon Fraser University

Research Assistants:

Robin Mansell
Angus Oliver
Allister Pedersen
William Goodacre

AN INVESTIGATION OF ECONOMIC AND OPERATIONAL ASPECTS OF USING LICENSE FEE SCHEDULES IN PARTICULAR BANDS AS PART OF RADIO SPECTRUM MANAGEMENT

for

DEPARTMENT OF COMMUNICATIONS
Ottawa, Ontario

Contract No. OSU79-00191
October 1, 1979 to March 15, 1980

DOC Scientific Authority: Dr. E. Marquis

March 1980

ABSTRACT

The study examines the changing nature of radio spectrum management, noting that future tasks will increasingly be directed toward longer range policy problems of priority of spectrum allocation and assignment. Increased management activity will be required to actively stimulate technical and economic efficiency, to define and implement economic, social and political objectives and to incorporate economic factors such as license fees more directly as an integral part of the process.

The economic basis for spectrum license fees is analyzed, with reference to economic theory and the experience of Canada and the United States. License fees should cover full spectrum management costs as a minimum. In many instances, the case for recovering more than costs is compelling, but in the microwave bands it is weak because most users do not attempt to realize economic rent. The economic theory of common resources is found to be more relevant to spectrum management and worthy of further development in relation to spectrum problems. The experience of federal management of fisheries is not found to be useful for an analysis of spectrum license fees, but that of British Columbia provincial management of forests is instructive. More detailed study of the forestry analogy is recommended.

The new DOC license fee schedule (1979) covers only about one-third of the direct costs of spectrum management for the microwave bands. Indirect costs represent, it is believed, approximately 50% of direct costs. DOC should undertake a detailed functional cost analysis as a more refined basis for fees in the future.

The new fee structure, based on RF and voice channels is an improvement over the old one. But the use of bandwidth quantity would represent a further improvement. Other important parameters are band location and geographical location. Because of data limitations, only aggregate bandwidth is employed in this study. A fee formula of $F_i = \$26.00 + aB_i$ is recommended where B_i is bandwidth in MHz and "a" is calculated to achieve revenues that will cover full costs. Exemptions and reduced fees to governments and their agencies cannot be justified and should be eliminated. Bandwidth assignments in lightly used bands, in bands at the extensive margin and in rural, uncongested areas should pay only the $26.00 license processing fee because their use is not creating congestion and related spectrum management problems. However, when the DBMS provides more detailed information, the formula can and should be applied by category of band and geographical location.

On the basis of available information, the "a" value in the fee formula should be at least $4.00 and possibly as high as $8.00 or $9.00, if full spectrum management costs are to be recovered. Comparable increases in satellite fees should be set to cover costs. At present, the taxpayer is subsidizing users of the microwave bands. It should be eliminated as soon as possible.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF CHARTS

I. INTRODUCTION

Historically, the international and domestic allocation of portions of the radio spectrum to different types of use, and the assignment of specific frequencies to different users, has been an administrative process. The spectrum has been recognized as a scarce natural resource that is subject to administrative allocation by national government and international agencies rather than economic allocation by private markets.

As demands for increasing use of the spectrum have grown dramatically over time, the economic value of major portions of the spectrum also has increased dramatically. In turn, the problems and costs of congestion and interference have increased significantly. Evidence has been uncovered demonstrating the inefficient use of portions of the spectrum as measured in traditional economic terms. An administrative process that allocates valuable spectrum without charging a "price" to users has come to be recognized as one that provides incentives to promote the wasteful use of the spectrum resource and to encourage uneconomic stockpiling of spectrum assignments.

For more than a decade now, professional journal articles, studies and reports, in the United States and Canada and other western countries, have addressed various aspects of the problem of failing to recognize economic factors in the process of allocating the radio spectrum. The issue was discussed in the 1968 President's Task Force on Communications Policy. It was discussed in Canada in Instant World, 1971. More recently, it was discussed in the 1977 Options Papers of the United States House

Sub-committee on Communications as part of its reconsideration of the 1934 Communications Act. Presently, both the FCC in the United States and the Federal Department of Communication in Canada are considering making greater use of fees and charges in their spectrum allocation policies.

Suggestions from economists for modifying the existing administrative process of spectrum allocation in North America range from the incorporation of market criteria into the administrative allocation process to the complete substitution of private market allocations for the administrative process. At the same time, interest in the radio spectrum has grown to include developing nations which now represent a majority within the International Telecommunications Union. The World Administrative Radio Conference met for the first time in 20 years, during fall 1979, to consider revisions to past policies and practices for administering the spectrum. What in the past had been quite technical sessions for engineers, was expanded to encompass not only economic but also political and social issues.

In an earlier research study for DOC, herein referred to as the Spectrum I Report,[1/] we examined the feasibility of applying the opportunity cost concept of economic theory to the spectrum allocation process. In a second study, herein referred to as the Spectrum II Report, we focussed our attention on the applicability of economic cost and value criteria in establishing license fee schedules for radio spectrum assignments, with particular reference to the range of frequencies known as the Microwave

---

1/ "Opportunity Cost and Radio Spectrum Allocation", Report to DOC under Contract No. OSU77-00368, March 1978. [Spectrum I Report]

Band, 890 MHz to 16 GHz.[2/] In the present study, we have built on our prior work and directed our attention specifically to the new license schedule recently implemented in the Microwave Band, critically analyzing the different parameters that an economically efficient license fee schedule might take and suggesting possible improvements in the license fee schedule.

The Spectrum I Report noted that with the exception of technical parameters, administrative allocations and assignments suffer from a severe lack of specification of operational criteria upon which basic decisions are made. The spectrum management process has been criticized for the uncertainty that is created by its failure to specify clearly its criteria as well as its failure to incorporate economic factors explicitly. Our analysis led us to the conclusion that the failure to specify the criteria for spectrum allocations appears of greater consequence than the failure to incorporate economic factors explicitly. A close examination of the spectrum management process shows that in making administrative decisions, spectrum managers do obtain some important economic information. For example, under Radio Standards Procedure, RSP-113, Issue 2, applications for planned radio stations above 890 MHz in terrestrial fixed service must include an identification of available alternatives and an economic evaluation of these alternatives.[3/] What is not clear is how this information and other economic information influences spectrum management decisions.

2/ "Economic Analysis and Radio Spectrum License Fees: The Microwave Band", Report to DOC under Contract No. 02SU-36100-809528, March 1979. [Spectrum II Report]

3/ DOC, Telecommunication Regulatory Service, RSP-113, Issue 2, 1975, Appendix B, p. B-2, item 1.k.

We also noted that the objectives of spectrum management always have included more than technical and economic factors. Public needs and the social importance of different uses are factors that are included in most statements of administrative decision criteria. Here also, the major difficulty lies in specifying these criteria in operational terms and applying them in a consistent and objective manner.

However, the criticism relating to economic considerations goes beyond the failure to incorporate specific economic factors as criteria for administrative decisions. If spectrum licensees are not faced directly with charges for their assignments, they still will be provided with incentives to treat the radio spectrum as a resource with almost zero cost, and therefore to use the spectrum inefficiently. The adoption of license fees has brought a change in the direction of forcing licensees to recognize that the radio spectrum is not a free resource, but the license fee schedules have had no necessary relationship to the economic cost or market value of the spectrum. Rather, the fees have been designed to cover the aggregate cost of administration of the spectrum management function, which still does not include any costs of using the valuable spectrum resource and denying its availability to others for the same or alternative uses.

The Spectrum I Report examined the proposal to adopt the concept of opportunity cost from economic theory as a basis for spectrum allocation and assignment. We observed that the general notion of recognizing that the economic costs of using the spectrum resource in one application is related to its value in the best alternative application foregone is valid.

However, we concluded that an attempt to apply directly the opportunity cost concept of neoclassical economic theory to radio spectrum allocations would be a mistake because the theory has many insuperable deficiencies. These include: (1) an assumption of perfectly competitive markets that would generate economically efficient alternative spectrum applications; that would permit and encourage complete freedom of market entry and exit; and that would permit easy and frequent market exchanges whenever economic conditions changed; (2) failure to handle effectively major problems associated with market externalities and the non-competitive nature of the markets in which spectrum users operate -- including, for example, use by regulated monopolies, participation by government agencies dependent on non-market fiscal budgetary systems, international constraints and recognition of social and equity factors; and (3) the personal and subjective nature of opportunity cost definitions and calculations that are required in markets that are not actively competitive, as would be all spectrum markets.

The Spectrum I Report also reviewed the range of proposals to incorporate economic criteria into the spectrum allocation process that have appeared in the literature over the past quarter century, noting their strengths and limitations. The Report concluded that if the opportunity cost notion is to be applied usefully to improve the process of spectrum allocation and assignment, it will have to be broadly interpreted and selectively applied in very careful, limited ways.

The Spectrum II Report took as its point of reference the specific process of spectrum assignments in the microwave band. The nature of the spectrum licensing process in Canada was reviewed generally. The licensing

process in the microwave band was examined in more detail. The basis for the license fee schedule then in effect was analyzed. Alternative standards for determining license fee schedules to the existing administrative cost recovery standard were evaluated. In this evaluation, classical economic theories of rent and taxes were reviewed as possibly a more relevant standard for determining fee schedules than the opportunity cost concept of neoclassical competition theory. General guidelines for the structuring of fee schedules in the microwave band were suggested in light of the specific market conditions in the industries using the frequencies in the microwave band. Finally, spectrum management activities in the areas of the research and development/obsolescence problem and the spectrum discipline/common user interest problem were discussed to emphasize a much neglected point in the economic literature, that the issue of economic efficiency in radio spectrum allocation involves much more than determining the appropriate level of license fees.

The present study builds on the prior work in several ways. First, it places the economic aspects of the spectrum allocation problem in the context of the total problem by briefly examining recent developments at DOC relating to the microwave band and at WARC-79. This review emphasizes that the objective of the spectrum allocation process is much broader than the narrow concept of allocational efficiency from economic theory that so much of the economic literature assumes. Thus, the level and structure of any schedule of license must be designed to meet the broader objectives.

Second, our examination of the relevance and applicability of economic theory is extended to cover the special case of efficient allocation of a common resource. This builds on the earlier investigations of opportunity cost from neoclassical competitive market theory and the classical theory of rent and taxes which were found to have very limited applicability as guidelines for the establishment of license fee schedules.

Third, the current license fee schedule as applied to the microwave band is examined critically in light of the minimum, or first level economic objective of covering the costs of spectrum management. This investigation encompasses both the license fee level (the total revenue to be collected) and its structure (the components of the license fee formula). It includes an analysis of the different possible parameters that should be considered in the design of an efficient fee schedule, and it recommends that certain changes in the fee schedule be made. Then, within the constraints of currently available data, rough estimates are made of the implications of implementing some of the changes in the fee schedule that this study recommends.

II. THE SPECTRUM ALLOCATION PROBLEM

A. Implications of Expanding Use

Historically, spectrum assignments have been made on a first come, first served basis. This principle reflects the fact that as a general proposition, spectrum capacity far exceeded spectrum demand. There was no need to be concerned about congestion. Harmful interference was easily controllable. Administrative authorities were not confronted with major problems of having to deny spectrum requests because all spectrum capacity had been assigned, or to establish priorities of uses and users, or to require existing assignments to be given up or reallocated. The spectrum management problem has not been choosing from competing applications. The problem always has been figuring out ways to fit in assignments of new applicants with assignments previously made.

However, the spectrum is not a homogeneous resource. Some frequency bands are better than others for certain types of communication. For virtually all kinds of communication, some bands are considered less costly than others. Given these characteristics as well as the different growth rates in demand for spectrum for different types of use and the different effects of improved technology, it was inevitable that apparent scarcity in some frequency bands would appear while abundant spectrum capacity would remain in other bands. This has meant that in a general condition of adequate spectrum availability, some serious scarcity problems have developed.

The first level solution to problems of increased congestion is to expand the role of spectrum management. Spectrum congestion is a matter of degree. Congestion is not saturation. And an expanded involvement of spectrum management can reduce congestion and make it possible to accommodate more assignments within frequency bands. To date, spectrum management has been concerned primarily with the technical characteristics of spectrum use. By tightening technical specifications, new frequency assignments can be accommodated. By employing more detailed and sophisticated spectrum engineering, the number of possible assignments in a given band can be increased. By monitoring spectrum usage, by obtaining more detailed information relating to assignments and their use, and by implementing accountability standards at license renewal time, spectrum waste and inefficiency can be reduced. Thus, by incurring increased costs for spectrum management, the frequency assignment capacity can be expanded on an ad hoc basis as problems arise.

In addition, the possibility of congestion that is sufficiently severe to restrict spectrum assignments, and therefore the sale of spectrum-dependent communications equipment and facilities, stimulates changes in the design of equipment so that more intensive use of the spectrum is possible. And it stimulates the application of research and development and the development of equipment that can use frequencies at the extensive margin of the spectrum. In this manner, the capacity of the spectrum continues to be expanded and the congestion problem is kept manageable in the sense that requests for new assignments can continue to be accommodated by more active spectrum management focussing on the technical parameters.

As problems of congestion and harmful interference become more widespread, more serious, and involve increasing values of investment in spectrum-dependent equipment, ad hoc solutions through more intensive spectrum engineering are insufficient. The spectrum management function must be expanded to include longer range policy planning considerations. Longer range policy planning permits the spectrum management authority to address developing congestion trends rather than individual assignment problems and to establish standards and guidelines directed to congestion issues and their management over the longer term. This point was reached at DOC in the early 1970s when a spectrum management policy group was formally organized at DOC.

Long range policy planning as part of the spectrum management process also is addressed to the problem of establishing conditions so that the second and third wave of applicants for frequency assignments can be accommodated. They may not be accommodated as well as if they were a first come applicant, but they do not have to be denied. Although there is no inherent reason why first comers should retain grandfather rights to the most desirable frequency assignments, neither is there a case for revising the priority. Since all assignment requests can be accommodated, the priority issue is not crucial and the first come, first served principle appears to be as justifiable as any other.

However, as spectrum demands continue to grow, the issue of assignment priorities eventually is forced. When two users want the same frequency assignment, or when one user wants an existing user to be forced to change frequencies, or when a legitimate assignment request cannot be

accommodated, then the difficult issue of choosing among users or uses and of establishing assignment priorities must be confronted. When it is raised, the spectrum management authority must seek standards or criteria for making the necessary judgements. And these standards and criteria must go beyond technical considerations to encompass economic, social and/or political factors.

To date, DOC has not had to deny a frequency assignment in the microwave band to any applicant. However, priority issues have been raised on several occasions. Conflicts between telephone companies and cable television companies, or telephone companies and hydro companies for specific frequencies now are occurring on a fairly regular basis. Instances where one spectrum user is willing to pay to have an established user modify equipment, adjust usage or move to a different frequency are becoming more prevalent. In at least one significant instance, DOC was found to resolve a conflict between B. C. Tel and B. C. Hydro over the same frequency by undertaking an independent evaluation of the cost penalties for each company, thereby implicitly applying a particular economic standard of cost efficiency for priority selection.4/

It is apparent that DOC now is resolving the issues of priority selection between uses or users on an ad hoc basis as the problems arise. The problems have not yet become frequent enough, or serious enough to prompt movement toward policy planning and the establishment of general

---

4/ Canada, Department of Communication, Amortization Issues Associated with the 7.125-7.725 GHz and 7.725-8.275 GHz Policies. National Telecommunications Branch, 1977.

standards. It also seems apparent that in selecting among competing claimants, DOC is moving toward a recognition of standards of economic efficiency as the most relevant criteria in most instances.

Once the congestion problem has reached the point where priority selection issues arise, and economic criteria are brought more directly into the analysis, it is appropriate to consider the possibility of license fees as a possible basis for establishing priorities. License fees can be used as an incentive to conserve spectrum, and in some instances as a rationing device that could prompt some users to seek spectrum assignments in less congested bands or in alternative technologies.

The economic basis for spectrum license fees was examined in the Spectrum I and II Reports, and will be discussed further in Section IV below. The remainder of this section is addressed to important steps leading to the establishment of policy planning in spectrum management.

B. DOC Policy Planning in the Microwave Band

A report released in 1979 by the DOC, The Utilization of the Radio Spectrum in the Range 0.890-10.68 GHz, identifies concerns in the microwave band that confront DOC spectrum managers, and seeks to obtain information that will enable more definitive policy planning in the future. The report outlines in general terms the anticipated growth in demand for frequencies in the microwave band, areas of existing and potential congestion and alternative suggestions for reallocation of services. Table 1 summarizes current information relating to principal users, spectrum demand, current usage and congestion, as presented in the DOC Report.

Table 1

MICROWAVE FREQUENCY BANDS AND USES[1]

Band (MHz)	Allocation[2]	Principal Users	Current Band Usage	Demand for Spectrum
980-960	fixed, radio location	common carriers oil pipelines, broadcasters (STL)	heavy use, congestion, Edmonton, Calgary	fixed links supporting mobile sources, STL, restrictions, CB/GSR/mobile
960-1427	--[3]	MOT, DND, government	--	--
1427-1525	space operation, fixed, mobile	experimental sm. cap. digital systems, rural telephone (SRS)	light usage, fixed digital	digital, non-rural SRS, analogue pt/pt, mobile telemetry
1525-1535	space operation	--	none	mobile telemetry
1535-1660	--	--	--	--
1660-1700	meteorological aids and satellite (ITU fixed)	government	light usage, no fixed use Canada/U.S.	meteorological operations
1700-1710	fixed, space research	common carrier (CNT)	extremely light	meteorological-satellite
1710-1900	fixed	common carriers, TCTS, hydro	heavy use, low capacity analogue, low capacity digital	short and long haul analogue, multiple data distribution digital

(continued)

Band (MHz)	Allocation	Principal Users	Current Band Usage	Demand for Spectrum
1900-2290	fixed	common carriers, hydro	Manitoba, heavy use, other locations, light, TV portable cameras	long haul, high capacity, intermediate capacity, digital
2290-2300	fixed, space research	common carriers (CNT)	light use	--
2300-2450	radio location, amateur	remote radar	radar, amateur satellite, ISM	one-way, data, video, occasional interference, multipoint distribution TV, paging, industrial/ institutional video, data digital, telemetry
2450-2548	fixed, radio location, fixed sat., BC sat.	radar speed meters, radio astronomy	radio location, ISM	electronic news gathering/electronic journalism, multi-distribution systems light route analogue/ digital satellite telemedicine, education, conferencing
2548-2686	fixed, BC sat., fixed sat.	school boards	ITV systems, limited use, no growth	pt/pt multi pt. video distribution
2686-2690	fixed, fixed sat., BC sat.	--	--	--
2690-3500	--	government, MOT, private	--	--
3500-4200	fixed, radio location, fixed sat.	common carriers	shared 4 GHz, heavy use, TCTS, CN/CP, analogue TV transmission	long haul TV trans., digital overbuilding

(continued)

Band (MHz)	Allocation	Principal Users	Current Band Usage	Demand for Spectrum
4200-4400	--	--	--	--
4400-4990	fixed, fixed sat.	common carriers	light use, Nfld. fixed TV, U.S. government use	overflow from other bands
4990-5925	--	--	--	--
5925-6425	fixed, fixed sat.	common carriers	CN/CP, TCTS sharing, heavy use, Vancouver, Halifax	intermediate capacity digital, sharing, analogue and digital
6425-6590	fixed	common carriers	light use, earth	back haul, utilities
6590-6770	fixed	STL, TV pickup, TV networks	heavy use	permanent STL, TV pickup, space usage
6770-6930	fixed	hydro	station back haul, Telesat	other than TCTS traffic
6930-7125	fixed	common carriers	heavy use	permanent STL, TV pickup, space usage
7125-7725	fixed, fixed sat.	common carriers hydro	heavy use, analogue digital systems, co-ordination problems	analogue/digital, co-ordinate space-terrestrial
7725-8275	fixed, fixed sat., earth exploration, meteorological sat.	common carriers, hydro	medium capacity, digital, heavy use	alternative to 8 GHz in medium capacity digital, digital-analogue co-ordination

(continued)

Band (MHz)	Allocation	Principle Users	Current Band Usage	Demand for Spectrum
8275-85-0	earth explo-ration, fixed, fixed sat.	CATV, broadcast MOT, common carriers	urban heavy use, TV, radar, video, common carriers, government	accommodate addi-tional systems
8500-10.55	radio loca-tion, fixed radio astro-nomy	MOT-private	--	--
10.68-10.7	--	government	--	--
10.7-11.7	--	common carriers	--	--
11.7-12.2	--	--	--	--
12.7-12.95	--	CATV	--	--
13.25-13.4	--	--	--	--
13.4-14.0	--	--	--	--

Source: DOC, The Utilization of the Radio Spectrum in the Range 0.890-10.68 GHz, 1979.

Notes: 1. Information in this table was derived and summarized from DOC Report, pp. 38-73.

2. Current spectrum allocations for Canada, 1979. Underlining indicates primary service for which band is allocated.

3. No data available.

The Report emphasizes the need to assess fixed services. The existing demand for fixed radio services and estimates of projected demand by large users, i.e., federal and provincial governments, common carriers, electric utilities, broadcasters and cable television operators, is not documented with quantitative evidence in the Report. Apparently, an adequate data base for assessing expanded demand for a variety of fixed services is not available at present to facilitate spectrum planning. Hopefully, DOC will have better data after it receives responses to the Report from the various user groups.

DOC's analysis of present utilization of fixed services indicates problems of frequency congestion and suggests bands where alternative uses can be considered. The need to accommodate growth of new digital systems in the microwave band and relocation of mobile services in this band is considered. However, DOC suggestions for future utilization of the 1-10 GHz band will be difficult to implement unless better indicators of demand for services, large user spectrum requirements, and investment levels in spectrum related equipment are developed.

The Report also specifies issues that must be addressed to achieve more efficient utilization of the microwave band. Here also, reliable data concerning spectrum requirements and the cost of locating or relocating existing and new services is required. Possible criteria for assessing alternative spectrum uses are discussed. These include the extent to which actual transmissions occupy assigned channels, and the amount of information transmitted per bandwidth assigned. Propagation factors and tolerable limits of interference for different services are discussed as

a means of establishing priorities for spectrum allocations and assignments. However, the Report does not consider such factors as the economic basis for projections of service and facilities growth, the economic implications of changes in policies and technical standards, and the impact of fee schedules applied to spectrum users. These factors also are important for consideration in future spectrum planning and management.

There is a clear need to address the basic policy issues outlined in the DOC Report. However, current DOC information on demand and growth of services is insufficient to satisfy that need. Thus, at present, it would appear that the DOC must react to industry demands for additional spectrum without adequate knowledge of the impact of additional assignments on congestion throughout the microwave band. Industry responses to the DOC Report are expected by March, 1980. On the basis of these responses, hopefully DOC will be in a position to establish a more extensive information base so that it can effectively implement an expanded policy planning program.

C. Toward International Policy Planning: WARC-79

The purpose of the 1979 WARC was to consider revisions to the regulations governing radio communications at the international level. The ITU's continuing primary objective is to reconcile the competing demands for spectrum of the 154 participating nations. The revised ITU Table of Frequency Allocations and rules and procedures must embody diverse economic and political concerns of all nations. Revision of allocations and frequency assignments has been required to reduce congestion,

to meet the rapid growth in demand for additional spectrum from industrial countries and the increasing new demands for spectrum from Third World countries, who heretofore had not had significant spectrum requirements. In addition, the need for revisions to existing international spectrum allocation has been stimulated by technical innovation in radio equipment resulting in more intensive and alternative uses of certain spectrum bands.

Historically, the "first come, first served" principle has governed the assignment of international frequencies. Industrial countries with the economic and technical capability to use the spectrum have obtained registrations for frequencies, often in excess of actual need. The ITU's continuing application of this principle under conditions of rapid growth in the industrialized countries has restricted the flexibility and growth of radio communications in Third World countries who have now requested frequency assignments as second comers. The administrative rules and procedures in spectrum management prior to WARC-79 were designed to co-ordinate existing uses and users of the spectrum. Planning to incorporate future demands from Third World countries who had not been active spectrum users in the past has been largely absent from the decision-making process.

At the 1959 WARC the need for a change in approach that would employ expanded spectrum planning and management was recognized. Generally, modifications to the "first come, first served" principle have been resisted by industrialized nations. Changes to existing arrangements are seen as a threat to the rapid growth of communications. Changes in criteria

governing international frequency assignment present a threat to the security of the dominant share of frequencies held by the first comers, the industrialized countries. A change to a system of expanded planning would introduce new criteria for establishing priorities among uses and users on the basis of economic, social or political considerations that would shift priorities from the industrialized to the Third World countries.

The 1979 WARC did not abandon the "first come, first served" principle. However, it was modified significantly. The developed countries made commitments to review assignments in several spectrum bands and return those not being used. Criteria giving priority to the importance of use, the need for back-up frequencies, and finally frequencies that are little used will be incorporated in reassigned and future administration of the spectrum. Changes in allocation will occur over the next decade with developing countries receiving priority in future frequency assignments.

The need for continuous management and planning to alleviate future congestion, interference, and inequitable allocation of frequencies, was recognized at the 1979 WARC. A series of WARCs have been planned for land mobile, aeronautical, broadcast and space services. These conferences will be intended to increase the continuity and integration of the ITU's administrative process.

Although the 1979 WARC postponed decisions on many crucial uses, it succeeded in revising the Table of Frequency Allocations to reflect changing conditions that have occurred over the last 20 years. Changes were made in several key areas of concern. The HF (3-30 MHz) bands have

been allocated primarily for fixed services. Developing and industrial countries have argued for expansion of broadcast services to these bands. Extensive changes would reduce vital bands for fixed services that are needed to supply telecommunications services to remote and rural areas. Consequently, a limited number of changes were made. Broadcast services received only a 40% increase and no new allocations were made in HF bands below 9 MHz. The need for additional planning postponed decisions on the future use of HF bands to a WARC in 1983.

Another problem area has been the increasing congestion of mobile services in industrial countries. Canada and others proposed additional allocation of spectrum for these services. Several new bands were allocated and a proposal for a world conference on mobile radio to be held in the future was accepted.

A contentious issue facing WARC-79 concerned the future of satellite space services. Proposals supporting the need for planning in allocating positions in geostationary orbit and frequencies were countered by the United States' position that planning, i.e., assignment in advance of actual use, would not ensure equitable access. A compromise proposal for a conference on space services in 1984 stated that it would "guarantee in practice for all countries equitable access to the geostationary orbit and frequency bands allocated to space services."[5/] The "guaranteed access" policy proposed by Canada, and the similar United States concept of "geostationary orbit access procedure" (GOAP), would guarantee all countries

---

5/ Intermedia, Vol. 8(1), January 1980, p. 4.

access to communications satellites without allocating specific spot beams. The developing countries have yet to respond to these proposals, but it is clear that a major matter of concern will be whether "guaranteed access" will provide protection and control to developing countries over international signals beamed at them from direct broadcast satellites. Many economic, political and social factors will be considered before this issue is resolved.

These issues demonstrate the complexity of the political and economic interests involved in the process of spectrum allocation. Resolution of disparate national concerns requires that decisions must be made to minimize congestion and interference, and promote growth of national communications systems in the future. The limited availability of spectrum to meet the anticipated very rapid growth in demand means that band allocations among alternative uses, and frequency assignments to different countries must restrict some growth possibilities for national communications services. The resolution of issues at the international level will mean that in the future some uses and users will be denied or restricted for all nations.

Canada's proposals for the need for planning of future aeronautical, and broadcast satellite services, and allocations of additional spectrum for mobile services were accepted at the 1979 WARC. However, it is clear future demands for additional frequencies will be negotiated and compromises must be reached to reconcile the competing interests of other nations. The international spectrum management process is moving now into the stage of policy planning that must address the issue of priority on

the basis of non-technical criteria. Effective spectrum planning and management requires that criteria be established that reflect national economic and political considerations. Effective methods of ensuring that the spectrum is used efficiently in economic terms and meets national/regional objectives for growth in communications services will have to be developed.

D. Directions for Change

It is apparent that both in Canada and in the international community, spectrum management is crossing a fundamental threshold where the major problems of allocation and assignment are changing from ad hoc technical problems to problems of priority selection on the basis of economic, political and social criteria. This will require an expansion of spectrum management activity to include longer range policy planning. Policy planning, in turn, will need to focus attention in three specific areas: (1) The establishment of policy objectives for priority allocations and assignments reflecting specified economic, social and/or political criteria. (2) Changing the traditional spectrum management function from a primarily passive resolver of technical problems to an active, initiator of practices that will require increased technical and economic efficiency. The Spectrum II Report referred to this activity as stimulated organizational innovation for efficiency (SOIFE). (3) The extent to which market forces and other economic considerations can be used to facilitate the spectrum allocation and assignment process and promote efficient spectrum utilization.

One important aspect of the economic considerations is the role of spectrum license fees. This subject of fees is examined in detail in following sections.

III. SPECTRUM LICENSE FEES

A. The Basis for License Fees

License fees can be employed to meet a number of objectives. The minimal standard is the recovery of spectrum management costs. Such costs are incurred for the benefit of spectrum uses. Spectrum management is an essential function for the creation and maintenance of the value of the spectrum. Under the most basic criteria of economic analysis, the beneficiaries of spectrum management should cover the costs of performing those functions efficiently.

Criticism of minimum license fees designed to cover spectrum management costs can be made on two grounds. First, if the spectrum management function is being performed inefficiently and incurring excessive costs, the license fees would reflect that inefficiency. But there is no economic justification for charging any inefficiency in spectrum management to the general taxpayer. The solution is to improve the efficiency of the spectrum management function. And those in the best position to press for an efficiency improvement are the spectrum users. Thus, recovery of full spectrum management costs should represent the minimum level of license fees.

Second, spectrum management involves the performance of many different functions, some for the direct benefit of specific users, or user groups, e.g., the processing of applications, and some for the common benefit of all users, e.g., policy planning. An economically efficient cost-based structure of license fees should assign or allocate costs among user classes to reflect the benefits recovered from the performance of the

different spectrum management functions. Without a sound economic basis for cost analysis, some spectrum users could be subsidizing others even though the total license fees collected were covering costs. But here also the resolution of the problem should be to establish an appropriate system of cost analysis, not to abandon the standard of covering spectrum management costs as a minimum.

Because the spectrum is an extremely valuable social resource, economic analysis indicates that in principle license fees should be established at levels higher than spectrum management costs. The difficulty lies in developing an appropriate theory and the related operational standards for determining the fee levels. Clearly, the higher the fee, the greater the incentive for users to conserve spectrum and to use it more efficiently. But since, for most users in the microwave band, the fee is an extremely small portion of costs, the level of the fee will not influence investment decisions in any significant way.

The Spectrum I Report examined the relevance and applicability of opportunity cost from neoclassical competitive market theory as a basis for determining fees that would improve economic allocational efficiency. The Spectrum II Report examined the theory of economic rent as a basis for taxing the unearned increment of monopoly profit from use of the spectrum. In a later section of this report, we shall examine the theory of "common resources" as a possible basis for economically efficient management of the spectrum.

All of these theories, if relevant and applicable would yield license fees in excess of the level necessary to cover spectrum management costs.

In this section, we shall review briefly the experience of the United States and Canada with respect to spectrum license fees.

B. Spectrum License Fees in the United States

Management of non-government uses of radio spectrum in the United States is conducted by the FCC, which levies the fees for such uses. The FCC fee schedule of 1963 was established at nominal levels designed only to recover approximately 25% of the Commission's administrative costs and was subsequently revised in 1970 so as to provide for the full recovery of costs. The new schedule was designed primarily to satisfy the cost recovery objective, but it also sought to reflect more accurately the value to the recipient of the license granted. Among the more interesting features of this schedule were the following items: (1) annual broadcast station fees based upon commercial station rates; (2) annual cable television fees based upon the number of system subscribers; (3) variable fees, based on construction costs, for new point-to-point microwave and satellite stations; and (4) separate application and grant fees for many services.

A further revision to the fee schedule was planned for implementation in 1974. Prior to its adoption, however, the 1970 fee schedule was set aside by a United States court ruling and in 1975 a new schedule was instituted that attempted to meet the standards established by the court. This schedule was again set aside by the courts in 1976 and the FCC then suspended the collection of fees and is now in the process of undertaking a full review of its fee schedules. A fee refund program was also instituted

to refund all fees paid the Commission between 1970 and 1976, net of any amounts that would have been paid under a schedule that conformed with the court's requirements. The process of the schedule review together with the details of the refund program provide many useful insights into the possible workings of the licensing mechanism.

The 1976 court ruling stated that the United States legal requirements to which the FCC fee schedule must adhere are as follows:

> "First, the Commission must justify the assessment of a fee by a clear statement of the particular service or benefit which it is expected to reimburse. Second, it must calculate the cost basis for each fee assessed. This involves: (a) an allocation of the specific direct and indirect expenses which form the cost basis for the fee to the smallest practical unit; (b) exclusion of any expense incurred to serve an independent public interest; and (c) a public explanation of the specific expenses included in the cost basis for a particular fee, and an explanation of the criteria used to include or exclude particular terms. Finally, the Commission must set a fee calculated to return this cost basis at a rate which reasonably reflects the cost of the service performed and the value conferred upon the payor...the agency must look not at the value which the regulated party may immediately, or eventually derive from the regulatory scheme, but at the value of the direct and indirect services which the agency confers."

While DOC is not subject to the same statutory constraints as the FCC and thus need not accept the constraints defined above, the quotation does identify several key aspects of the fee setting process that are of a more general application. First, there is a clear need to define the service performed by the licensing agency. Second, there is a need to determine the various costs incurred in providing the service in the "smallest practical units" and to determine for whose benefit these costs

were incurred. Third, there is a need to determine value accorded the licensee and then to form a basis upon which these cost and value elements are to enter the fee schedule.

For the purpose of undertaking its fee refund program, the FCC has decided to calculate its allowable fees on the basis of direct costs incurred only. To this end it has devoted great effort in allocating such costs as closely as possible to existing service categories, and thus has created a data bank and has embarked on devising a cost accounting system that allows it to match costs and fees on a much closer basis than is available under DOC's corresponding data breakdowns. If DOC wishes to avoid cross subsidization among services, while remaining within the framework of a cost recovery based fee schedule, it too in the future will need to embark upon such an effort.

Of equal relevance are the FCC's current efforts to move towards a revised fee schedule. Its efforts in this regard are occurring along two separate avenues. First, it is considering a prospective fee schedule that conforms with existing legislative authority. In this regard, it has undertaken to review fully and to categorize the various services rendered by the Commission and to institute a corresponding system of cost accounting. This system then will be employed to allocate all such costs between services. Direct costs that confer benefits on particular private interests will be allocated to such parties through the fee schedule, with indirect and other costs being allocated on the basis of the value of service principle.

A second avenue of approach that is being considered by the Commission is to seek legislative relief that will permit it to employ a fee schedule that will yield revenues that are not constrained to match the Commission's budget. In this regard the Commission is examining not only fees that are based on cost recovery but also fees that are based on spectrum value and that would undoubtedly yield revenues far in excess of Commission costs. Issues raised in the course of this examination will undoubtedly be of considerable interest to DOC in Canada, which is not constrained in its fee schedule options to the extent that the United States FCC is constrained by the court decision.

C. DOC License Fee Schedule

(1) Historical Background

On April 1, 1979, a new schedule of license fees applicable to radio stations, other than broadcasting stations, was formally implemented by the DOC. The schedule had been designed in response to a 1976 Cabinet directive requiring the Minister of Communications to examine the feasibility of adjusting the license fees so as to better reflect the revenue producing capability of the license holder. The principal motivation for so doing appears to have been a desire to recoup the governmental costs of spectrum management which were at that time substantially in excess of license fee revenues. Further objectives considered by the Department in the fee design process are noted in the following subsection.

Historically, in Canada, fees have been imposed in respect of radio station licenses since 1914. A brief summary of such fees is contained in the Spectrum II Report, which noted that both the absolute level

and the structure of such fees have been substantially varied at periodic intervals. Unfortunately little historical information appears to exist that would indicate the underlying rationale behind such changes. A DOC internal study,[6/] undertaken by A. Thusenwalder does, however, suggest that as an empirical hypothesis, most fee schedules were principally motivated by the desire to: (1) "encourage the entry of spectrum users, in proportion to society's gain or need for a particular service"; (2) "induce adherence to the institution of licensing in proportion to the 'size' of the license holder (ability to pay, commercial profitability, etc.)"; and (3) "recover a portion or all of total cost to DOC".

The proposition is an interesting one, for much of the current intense interest in the economics of the spectrum management and licensing fee process appears to have arisen out of a spate of journal literature during the 1960s and early 1970s that suggests that the management process could be enhanced by increased reliance upon economic incentives. Implicit in the bulk of this literature has been the suggestion that economic criteria were not currently considered in the management process and that in fact no clear rationale existed with respect to current procedures. Thusenwalder's paper, however, provides some interesting evidence to the contrary. If the thesis of that paper is correct then both economic and social criteria have played an important role in the design of past license fee schedules.

6/ Thusenwalder, A., Radio Station License Fee Study Review, 1976.

Viewed from this perspective the recent license fee revisions may be seen as one step in an on-going and continuing process of rationalizing the spectrum management process. As the following subsection indicates an important aspect of this review process has been the attempt to make explicit the objectives of the spectrum management authority and to thereby lay a firm foundation upon which future fee policy decisions may be based.

(2) Current Fee Schedule Objectives

The April 1, 1979 license fee revision closely follows the recommendations contained in a November 1977 internal DOC Report entitled Licence Fee Study and henceforth referred to by that title. While several supporting studies were also prepared by DOC it is in this document that the fundamental rationale for the revision is to be found, together with DOC's analysis of the principal issues involved in the licensing fee process.

While the aforementioned Cabinet directive stated that the fee review should focus upon the feasibility of adjusting fees so as to better reflect the license holder's revenue producing capability, explicit objectives considered in the License Fee Study also included: (1) the recovery of the direct costs associated with spectrum management activity; (2) the promotion of telecommunications service provision to rural areas; (3) the avoidance of cross-subsidy, defined on a cost recovery basis, as between different user classes; (4) administrative simplicity, and understandability; and (5) the promotion of efficient resource allocation.

Unfortunately the License Fee Study provided little discussion as to how these objectives were decided upon and perhaps more importantly, did not explicitly analyze their relative priorities and/or the extent to

which they were fundamentally conflicting. Implicitly it is clear, however, that the foremost objective was that of direct cost recovery and that other objectives were considered only within the confines of that constraint.

The Spectrum II Report provided a general analysis of the extent that the revised fee schedule was successful in meeting DOC objectives. It concluded that the new fee schedule provided for a much better degree of cost recovery and a better means of tracking costs than the schedule it replaced. The new fee schedule was found to be relatively unsuccessful in meeting the objective that spectrum management costs relating to each service class should be recovered by revenues from users in that class. The new fee schedule achieved some reduction in the level of cross-subsidization that existed previously, but did not do so significantly.

The revised fee schedule also provided some incentive for extension of telecommunications services to remote and rural areas through the introduction of a variable fee for fixed stations performing a fixed service, thus facilitating implementation of this objective. By reducing the number of station classes and using a simple variable fee structure, the objective of achieving administrative simplicity was met. The final DOC objective of promoting efficient resource allocation was met only minimally by the revised schedule. The introduction of a variable fee was a positive step towards this objective. However, the limitation of the revised fee schedule to recovery of DOC direct administrative costs prevents any significant impact in this regard.

In summary, an analysis of the revised fee schedule concluded that its major deficiencies were related to its failure to eliminate user cross subsidization and to promote efficient resource allocation. While our earlier reports, Spectrum I and Spectrum II, suggested that such a constraint was in fact necessary and that on both economic and social grounds, fees could appropriately be set at levels substantially in excess of those implied by cost recovery, we will here confine ourselves to the assumption that such a constraint is operative. Within that framework the next subsection will consider the success of the revised fee schedule, as it relates to the microwave band, in meeting DOC's subsidiary objectives.

(3) Microwave Fee Schedule

Prior to the license fee schedule revision the license fee applicable to microwave assignments varied according to the classification of the service performed at the licensed station and was levied upon a per station basis independent of any measure of spectrum use or system capacity. No fees were levied in respect of either earth or space stations performing a space service and, as in all other bands, fee exemptions were accorded to federal and provincial governments and their agencies and fee reductions were accorded to the municipalities.

While the latter governmental exemptions were retained in the revised fee structure, all other aspects of the microwave fee schedule were substantially altered by the revision. Specifically, a single fee applicable to all fixed stations[7/] performing a fixed service or a fixed

---

7/ Note that all microwave stations other than space stations are included in this category but that the category does include some stations outside the microwave sector.

satellite service was instituted and was determined according to the following formula:

$$F_i = \$3.00\ (T_i + R_i) + \$0.025\ (VC_{T_i} + VC_{R_i}),\ \text{where}$$

T_i = number of transmitted RF channels from station i

R_i = number of received RF channels from station i

VC_{T_i} = total number of equivalent voice channels transmitted from station i

VC_{R_i} = total number of equivalent voice channels received at station i

F_i = annual fee at station i

The fee is subject to a minimum of $26.00 and in the case of space stations is raised by a conversion factor, stated to be based on the equivalent number of terrestrial microwave hops covered by actual Canadian satellites, or $\alpha = 40$.

The License Fee Study provides little discussion of how this formula was specifically arrived at other than to say that "the fee is directly related to the revenue-producing capability of the station as measured by the number of RF channels and equivalent voice channels" and to note that a higher value of the $3.00 co-efficient "would, relatively speaking, discourage the extension of services to rural and remote areas". Nor does the Study provide any discussion of why RF channels and equivalent voice channels are deemed to provide the preferred measure of revenue-producing capability, or how the formula was structured so as to promote efficient resource allocation or of how the level of the fees was determined in regard to the cross-subsidy objective.

On the latter count it is noted in the License Fee Study that total revenues from fixed stations under the revised schedule were estimated at approximately 33%[8/] of the corresponding administrative costs and that the revenue deficit was expected to be compensated for by GRS revenues in excess of associated GRS costs. If the avoidance of cross-subsidy is, however, a DOC objective, there is no apparent reason why this cross-subsidy need be maintained. Given the nominal level of the fixed service fees, in relation to user value, it is clear that the fixed service fees could be raised sufficiently to cover administrative costs without any need to compromise the other stated study objectives. In this report it will in fact be recommended that such an action be undertaken, particularly given that GRS revenues have fallen substantially below the level forecasted in the License Fee Study and thereby have eliminated an important source of the cross-subsidy.

Unfortunately DOC's cost accounting has been insufficiently detailed to provide for a separation of fixed service costs as between microwave and other users and it is thus not possible to calculate with any precision the extent of any cross-subsidy to microwave users. This issue is further compounded by the fact of the substantial downward revisions recently made to DOC's future cost estimates vis spectrum management. An informal estimate provided to us by DOC personnel was, however, that microwave revenues currently account for only half the associated costs of

---

8/ This figure would be even smaller were it not for the fact that fee exemptions were considered as revenues in the License Fee Study.

spectrum management. This estimate may or may not be unreasonable given: (1) the License Fee Study estimate of 33% cost recovery vis fixed services; (b) the fact that the License Fee Study treated fee exemptions as revenues; and (c) the recent downward revision of DOC's cost estimates.9/

In regard to the License Fee Study assertion that RF channels and equivalent voice channels provide a preferred measure of revenue-producing capability, we may note that this issue is intimately connected with that of the formula's ability to promote an efficient resource allocation. Specifically, it is necessary to distinguish between the revenue-producing capability of the spectrum itself, i.e., spectrum value, and the revenue-producing capability of the spectrum in its current use, i.e., current use spectrum value. Considerations of efficient resource allocation suggest that the license fee, even if set at nominal levels only, should be based on actual spectrum value rather than upon spectrum value in actual use. Viewed from this perspective then, it might well be preferable to base the license fee upon a measure of bandwidth utilization as opposed to RF channels and equivalent voice channels.

9/ With regard to satellite revenues, the License Fee Study suggests that 44% (≃ $80,000/$183,000) of associated costs are estimated to be recovered.

IV. THEORETICAL BASIS FOR SPECTRUM LICENSE FEES

A. Introduction

It has been established that the minimum level of spectrum license fees should be based upon coverage of spectrum management costs. There is also little question that there is economic justification for fees in excess of those that would cover spectrum management costs. The debate is over the objectives of charging higher fees and the criteria for establishing the fees.

The Spectrum I Report examined in detail the fee standard of opportunity cost in competitive markets from neoclassical economic theory as a basis for achieving improved allocational economic efficiency. It found this approach deficient on both theoretical and operational grounds. In addition to restrictive assumptions that render the theory virtually irrelevant to the problem, and the heretofore unresolved issue of defining spectrum property rights so that they are transferable in private markets the desirability of a market system remains extremely questionable on other grounds: (1) Such a market system would fail to take into account the very substantial externalities associated with the provision of spectrum using services. This divergence between social and private valuations of spectrum worth in a particular use implies that market allocation would be socially inefficient even when considered on its own terms. (2) The non-competitive nature of the markets in which spectrum users operate implies a further divergence between social and private valuations of spectrum worth in particular uses. The implications in this regard are particularly serious when monopoly users regulated on a

cost-plus basis are involved, e.g., telephone common carriers, pipeline, railroad and electric utility firms. (3) Major users of the spectrum are government and other public agencies at local, provincial and national levels, that neither dispense services nor attract capital through private markets. The nature of the fiscal budgetary systems for such agencies precludes them from equal market participation. (4) Administrative discretion would be severely narrowed. It would restrict, and could render the system incapable of achieving broader economic, social and political objectives.

The above obstacles are sufficiently serious to preclude consideration of a market system in spectrum rights, at least for the foreseeable future. The objective of the spectrum administration process is not simply to imitate a market, or to adopt the economic valuations that a market might yield. Given the essential characteristics of the spectrum, neoclassical market theory and the perfectly competitive market model seem particularly inappropriate as a relevant analytical paradigm for seeking standards for an efficient allocation of the spectrum resource.

More directly, relevant analysis of the spectrum is likely to be developed by building on other branches of theory. The Spectrum II Report explored Ricardian rent theory and the vast literature addressed to the taxation of economic rent as the "unearned increment" from private ownership of land. There are many direct parallels in the analysis between these two natural resources.

The spectrum, like land, is not homogeneous in its productivity. There is a level of economic rent determined at the margin of cultivation. There is an intensive margin measured by the cost of expanding the communi-

cation capacity of existing radio frequencies. There is an extensive margin measured by the cost of making higher frequencies useable. The cultivation and expansion of spectrum productivity is governed by spectrum research and development. The latent communications capacity of the spectrum is vast, if society is willing to incur the costs necessary to make it productive. Yet, at any given time there is a general scarcity that is unevenly distributed throughout the spectrum. The uneven incidence of interference and congestion within the radio spectrum suggests the applicability of Ricardo's extensive and intensive margins of cultivation. Historically, the extensive margin of the spectrum has been pushed from low frequency to higher and higher frequency bands. At the intensive margin, where congestion and interference have become intolerable, research and development has been directed to reduce it.

There is substantial economic rent being realized by some users of the spectrum. The beneficiaries of the economic rent have been determined by the administered frequency assignment decisions. Not all users are able to convert this economic rent directly into profit by selling their frequency licenses, but all users do benefit from the opportunity to employ the spectrum resource in their respective production processes at costs that are less than its economic value, including rent.

For those users who employ the spectrum, but cannot sell their licenses directly, the problem of spectrum valuation is a difficult one. And several of the problems raised above in respect to neoclassical market theory will apply to rent theory as well. However, where there exists a market in licenses, spectrum valuations can be obtained readily. Thus,

there is a reason to focus attention initially on those license assignments where a market already exists, not those where markets do not exist. The prime candidate is the broadcast services which generate their substantial unearned increments almost exclusively from using the spectrum.

A second area of theory and practice directly relevant to spectrum analysis is that concerned with the efficient allocation and management of common resources, including forests, fisheries and other natural resources that have essential characteristics of the proverbial "commons". Theory that directly considers interdependence, externalities, the need for sharing and compensation rules and the necessity of total systems management for system efficiency must represent more fertile ground for analysis than neoclassical market theory with its assumptions of independence and atomistic private markets.

The spectrum resource is a public commons. The right to enter and use the commons presently is governed by administrative authority. Under the existing institutional arrangements, there are some distorted economic incentives and inefficiencies. Improved efficiency requires that these distortions be examined within a context of the characteristics of the spectrum commons and the institutional relations surrounding its allocation and use.

B. Efficient Management of a Common Resource

The distinguishing characteristic of all resources which have been, are, and in the future will come to be known as "common resources" is that they cannot be treated as discrete units, subject to private ownership

and competitive market exchange. They cannot be treated as were the "stock" resources (e.g., minerals, forests, fisheries, etc.) in the 400-year period ending in late 20th century. Those resources were exploited for maximum private gain, regardless of the ecological disasters caused by such exploitation. The externalities thus created are no longer supportable. Considerations of efficiency in terms of sustained yield and control of undesirable externality effects requires that they be treated as "common resources". The radio spectrum has characteristics which place it among common resources. It is therefore necessary to explore the character of common resources and their management.

What are common resources (or common property)? At the outset we must clarify the meaning of "property". For at least 2,000 years the law in western countries has held that the concept of property means a relation-ship, not a thing. The common use of the term "property" to refer to land, an automobile, or stock certificate is misleading. In reality, one's property as regards, e.g., an automobile, is the bundle of rights and obligations which make up one's relationship to the vehicle. It may be used on certain surfaces, at certain speeds, by drivers with certain qualifications; it may not be used as a weapon; you may sell it; etc. Mere possession of something does not make it property. In order to be one or another kind of property, the claim of a particular kind of relation-ship to the thing must be enforceable, and if necessary enforced. This means that law, custom or convention or a combination of them provide the basis for the enforcement of the claim. This is not the full extent of the concept, however. A justification has to support the movement of the

legal machinery to enforce the claim. Typically, the justification takes the form of holding that the claim in question is one of a type which can be perceived as a "necessary human right" because it is grounded on "natural law" or on its necessity as a means to realize the human potential for development or even simply the pursuit of happiness. It is apparent that the law on property rights and its justification exists in the political process. And regardless of what kind of property we consider, its definition as an enforceable right is defining a political relation between persons.10/

There have been, in fact, three kinds of property. Private property is the enforceable claim to exclude other persons from possession or use of a thing. Common property is the enforceable claim of individuals to use certain common things which are not susceptible to private property relations. The third kind of property is state property, e.g., military activities of all kinds, state business corporations. All three types have been well established at least since Ancient Greece. The first type, private property, expanded prodigiously as the modern capitalist system took shape beginning in the 17th century -- to the point where private property came to be thought of in the business system as <u>things</u> rather than rights. The law stuck fast to defining property as rights although it did allow the private business corporation the property rights previously pertaining to individuals. As Macpherson says, common property was a viable institution in ancient and medieval times:

10/ This analysis of property draws heavily on Macpherson, C. B., <u>Property</u>. Toronto: University of Toronto Press, 1978, Chapters 1 and 2.

> "Jean Bodin, the first of the great early modern political theorists, in making a strong case at the end of the sixteenth century for modern private property, argued that in any state there must also be some common property, without which there could be no sense of community and hence no viable state."11/

And he notes that in the past half century the predominance of private property has receded:

> "Even in the most capitalist countries, the market is no longer expected to do the whole work of allocation. The society as a whole, or the most influential parts of it, operating through the instrumentality of the welfare state and the welfare state -- in any case, the regulatory state -- is doing more and more of the work of allocation. Property as exclusive, alienable, 'absolute' individual or corporate rights in things therefore becomes less necessary...
>
> "Positive social pressures against [private] property are now developing as a fairly direct result of the unpleasant straits to which the operation of the market has brought the most advanced societies. The most striking of these pressures comes from the growing public consciousness of the menaces of air and water pollution. Air and water, which hitherto had scarcely been regarded as property at all, are now being thought of as common property -- a right to clean air and water is coming to be regarded as a property from which nobody should be excluded."12/

The category of common properties (or common resources) contains, as we might expect, a variety of types of resources or property, some of which are also to be found in the category of state property (minerals, forests). In which category should the electromagnetic spectrum be placed? Here it will be helpful to review the characteristics of the

---

11/ Sup. cit., p. 10.

12/ Sup. cit., pp. 10-11.

electromagnetic spectrum. We offer the following list of unique characteristics. In the case of some of them, certain other natural resources under certain conditions can exhibit the same characteristic but the weight of the characteristic is greater in the electromagnetic spectrum:

(1) The electromagnetic spectrum's principal use is the act of sharing something else (i.e., information) between transmitter and receiver. For no other resource is the principal function the transmission and retention of information. Some exceptional cases prove the rule, e.g., radar, geodetic use of spectrum to locate oil, etc.

(2) For one nation or class of user to use the spectrum, all nations and classes of users which have the necessary technical equipment and skill must also be able to use it.

(3) It is non-depletable and self-renewing. To be sure there is interference between radio users (which international regulation works to minimize), but unlike pollution of water, air or land, it is a necessary result of the use of the radio spectrum. And it disappears immediately as soon as the interfering transmitters cease interfering.

(4) Control of the use of the radio spectrum to transmit information lies close to the seat of sovereignty in nation states, while at the same time the necessary joint decision-making by all nations at the world level concerning radio frequency allocation contributes to the practice of world sovereignty and confirms that ownership of the radio spectrum rests in all humanity.

(5) It follows that the radio spectrum is not subject to the rights of direct, physical, private ownership or open and frequent market exchanges. Because the rights to use the radio spectrum are not private property rights,

they must be either common property rights or state property rights. But which? The answer seems to be: some of each. It is undeniable that nation states were and are the immediately most influential decision-makers about the process by which the radio spectrum was developed and is used. To this extent, radio spectrum rights are state property rights. But at the same time all the nations have consistently disclaimed any national ownership of spectrum rights, leaving them as a common property of human beings on both a world and an international scale.13/

Can or should private property rights be formally introduced in the fabric of administration of the electromagnetic spectrum? In the Spectrum I Report we analyzed opportunity cost theory as it might be applied to the spectrum and concluded that the assumptions underlying it did not correspond to the conditions in which the spectrum is used. Therefore we were convinced that private property rights should not be formally recognized in the use of the radio spectrum. Collateral information confirms this conclusion. As is well known, the legal system of the United States tends to protect and advance private property rights to the fullest extent possible. William Howard Taft, President of the United States between 1908 and 1912, and Chief Justice of the United States Supreme Court, 1921 to 1930, was a leading exponent of private property rights. Yet Robert Coase reports that while Taft was Chief Justice the Supreme Court did not consider any cases involving the radio spectrum. Coase explains why:

13/ Macpherson uses as an example of state property the state-operated radio and television systems (sup. cit., p. 5). A better example would be military use of the spectrum or control of international radio communication.

> "Mr. William Howard Taft, who was Chief Justice of the Supreme Court during the critical formative period of the broadcasting industry, is reported to have said: 'I have always dodged this radio question. I have refused to grant writs and have told the other justices that I hope to avoid passing on this subject as long as possible.' Pressed to explain why, he answered: "...interpreting the law on this subject is something like trying to interpret the law of the occult. It seems like dealing with something supernatural. I want to put it off as long as possible in the hope that it becomes more understandable before the Court passes on the questions involved.'"14/

While no inference that the radio spectrum is occult or supernatural is warranted it does appear that the legal profession and the private sector in the United States had given the possibility of private property rights in the radio spectrum their best efforts and concluded it was impossible.

Garrett Hardin's "The Tragedy of the Commons"15/ is a classical treatment of the problem of managing common resources (or property). He uses "tragedy" in the sense of "...the solemnity of the remorseless working of things" (Whitehead). As a biologist, he focusses on the relation of population to resources. And he finds the tragic dilemma in the prototypical case of the common pasture lands. Following his individual self-interest, it behooves each herdsman to add additional animals to his herd even when the capacity of the pasture no longer suffices to feed everyone's herd:

> "Therein lies the tragedy. Each man is locked into a system that compels him to increase his herd without limit -- in a world that is limited. Ruin is

---

14/ Coase, R. H., "The Federal Communications Commission", The Journal of Law and Economics, Vol. II, October 1959, p. 40. The quotation from Taft is given as C. C. Dill, Radio Law 1-2 (1938).

15/ Science, December 13, 1968, pp. 1243-1248.

> the destination toward which all men rush, each pursuing his own best interest in a society that believes in the freedom of the commons. Freedom in a commons brings ruin to all."16/

It was precisely the market forces which ruined the old commons:

> "Numerous examples exist of over-exploitation of the environment because of the collapse of social restraints based on tradition, myth, and custom, following the geographic expansion of capitalist economies. Richard Cooley's study of the Alaskan salmon fishery shows how property rights and the ownership of a fishing site were held by specific tribes and clans. The salmon were a group totem for the Alaskan Indians who identified their genealogical continuity with the migrating cycles of the salmon and so were particularly careful not to deplete the fish stock. Over-exploitation of the fishery began only when the Indians came into contact with the rest of North America and the fish became a marketable commodity....S. L. Udall observed that 'the land and the Indian were bound together by the ties of kinship and nature, rather than by an understanding of property ownership...the Indian's title, based on the idea that he belonged to the land and was its son, was a charter to its use -- to use in common with his clan or fellow tribesman, and not to use up.'"17/

Hardin's thesis is that there is no technical solution for this dilemma. Only a change in human values and morality will avoid the tragic end. He takes the pasture commons as a paradigm for the tendency for private property interests to produce similar tragic results in many areas where ecological crises are appearing. He does not deal with the radio spectrum. But his

---

16/ Sup. cit., p. 1244

17/ Victor, Peter A., "Economics and the Challenge of Environmental Issue", in Leiss, William, Ecology versus Politics in Canada. Toronto: University of Toronto Press, 1979, pp. 45-46. The quotation from Cooley is cited as Politics and Conservation. New York, 1963. The quotation from Udall, as The Quiet Crisis. New York, 1963.

logic is applicable to it, if private property rights were introduced in it. His analysis leads to optimistic conclusions: (1) The tragedy of the commons can be avoided by enforcing "responsibility" and responsibility is "the product of definite social arrangements". (2) These definite social arrangements amount to mutual coercion, mutually agreed upon. In practice this requires use of the government as custodian of the common resources. (3) Central to these social arrangements is the determination of the right to use the resource. Here he mentions three alternatives: first come, first served, a lottery, and some agreed upon welfare criterion. He urges that perfection is not to be expected. "An alternative to the [unrestricted] commons need not be perfectly just to be preferable....Injustice is preferable to total ruin."18/

In the Spectrum II Report we proposed Stimulated Organizational Innovation for Frequency Efficiency (SOIFE), as a desirable alternative to the passive first come, first served legislated system of radio frequency allocation now practiced in Canada and the United States. Hardin's agreed upon welfare criterion is another version of SOIFE, prescribed for all the common properties.

What conclusions may be drawn from this analysis of common resource management regarding our concern with setting appropriate fees or prices for use of the radio spectrum? (1) The so-called competitive (or free) market simply will not serve to allocate spectrum rights or their transfer. That road leads to the tragedy of the commons. (2) Prices or fees can be

---

18/ Sup. cit., p. 1247.

used by spectrum managers to allocate or ration, but the burden rests on management policies. (3) The recovery of economic rent from the commercial use of spectrum rights is supported by the long tradition of common property. Because spectrum rights are common property the human community is amply justified in recovering rent for the use of its property. (4) There is no clear operational standard for determining the appropriate price or fee for a particular class of spectrum right. (5) The actual cost of managing the spectrum should be the minimum level of fees for the use of spectrum rights. (6) Some agreed upon welfare criterion should be developed to serve to determine actual fees.

C. Experience in Common Resources Management: Fisheries

Canada has been blessed by geography with fish resources that have provided experience widely representative of both the natural and international aspects of "the tragedy of the commons" in a private market setting. National policy has consistently used licensing to protect depleted fish stocks beginning with the Fisheries Act of 1868 -- one of the first pieces of federal legislation -- which had this objective. Initially, restrictions on access were not politically possible because of the individual's "natural right to be a fisherman"[19/] so restrictions ran to length of season and prohibitions against the use of particularly productive gear. Later legislation committed the federal government to "development" of the fisheries which added restrictions on licenses designed to improve economic welfare of fishermen and to promote the continued conservation objective.

19/ Copes, Parzival, "The Evolution of Marine Fisheries Policy in Canada", (unpublished), Fall 1979, p. 11.

Within this broad policy, differentiation was necessary to meet the unique needs of fisheries on the Atlantic Coast and the Pacific Coast. License fees have been charged, but without the objective of either covering the costs of administering the fisheries or recovering rent from the exploitation of the common property. Rather, the policy objective has been to use the government power to promote and improve the economic welfare of the fishing industry. Apparently the only respect in which fees have been regarded as a significant source of revenue was in 1968 on the Pacific Coast when a "buy-back" program designed to remove some excess capacity from the fishing fleet was introduced. At that time annual fees for Class A boats were raised and the increased fee revenue was dedicated to a fund for buying up Class A boats. The program was suspended when only a 5% reduction in fishing capacity was achieved.

The license fees presently charged in British Columbia are nominal. They range for salmon from $100 to $400 depending on length and tonnage of the vessel. To fish abalone requires a $200 fee, while a license for a Seiner is $2,000 and for a Gillnetter, $200. Status Indians pay $10 for any type of license.

Some pioneering theoretical work has been done in Canada on the economic aspects of fishery management, of which Scott Gordon's "A Common Property Resource: The Fishery"[20/] is particularly noteworthy. These studies concern the efficient allocation and management of common resources. The theory in them directly considers interdependence, externalities, the need for sharing and compensation rules and the necessity of total system management for system efficiency. They are

---

20/ Journal of Political Economy, 1954

more fertile than neoclassical market theory with its assumptions of independence and atomistic competitive private markets. They are part of a growing literature devoted to the analysis of policy problems in major common resource industries. Cross-fertilization as a result of comparative study of such literature with that concerning the radio spectrum will accelerate understanding of the common policy problems involved, despite the markedly different characteristics of the different common resources and the necessarily unique and specific policy issues which will emerge.

D. Experience in Common Resource Management: Forestry

Forest resources in Canada have been principally a provincial concern. We may take British Columbia as an example of the management of this common resource. For the first half century after the first sale of Crown forest lands began in 1858 on Vancouver Island, forest policy exemplified the "tragedy of the commons". Crown forest lands were sold for trivial prices (10 shillings per acre in 1858). Leases were substituted beginning in 1865, with indefinite term; charges and terms were later imposed by the government. With the Land Act of 1888, the province evidenced a concern for development of manufacturing. Forest leases then required the leasee to operate a sawmill, and with the growth of the pulp timber business, about 1900, pulp timber leasees were required to build a pulp mill in the province, and all timber cut on Crown lands thereafter was required to be manufactured in the province. In 1888, special timber licenses, term one year, renewable at government discretion, with annual fee of $50 and royalty of 50¢ per Mfbm were introduced.

In 1905 a new policy was adopted which continues today. The timber licenses were conditioned on a principle: in place of fixed fees, the government would annually fix fees with the object of recovering for the public treasury a share of the increment of value of standing timber as it accrues:

> "The value of timber standing in the forest is measured by what it would be worth after it is cut and delivered to some market or utilization centre less the costs of harvesting and transport. This net value (gross value minus costs) or surplus is often referred to as the 'unearned increment' or, in economists' jargon as 'economic rent'. The cost must include, of course, a reasonable return to the operator's capital as well as his necessary operating costs in harvesting the resources. Over the years the government, in its role as public landlord, has attempted to appropriate this economic rent for the public through a variety of levies on timber harvested from Crown forests."21/

With the adoption of this policy, the objectives of British Columbia's Forest Service were broadened. Originally the objective had been merely to develop forest products industry. About 1905 two other objectives were added: recovery of some "economic rent" from Crown-owned forest resources, and a systematic program of conservation, including reforestation, fire prevention, measures against diseases and pests. We pursue here the policy on access and fees.

As indicated above, the early history of dealing with Crown forest resources covered experience with:

(1) Outright sale. This was on a first come, first served basis with trivial purchase prices.

21/ Task Force on Crown Timber Disposal, First Report, 1974, p. 17.

(2) Leases with royalties in dollars per physical unit of forest production. These royalty rates were fixed for the duration of the lease. This type of arrangement which predominated between 1888 and about 1910 had the advantage of administrative simplicity. Only a physical count of timber harvested was necessary to compute it. It did not require identification of species or grades of timber, the costs of logging and transport, or the forest of origin. Its disadvantages were that the incidence of the royalty could appreciate or depreciate with changes in the price level, that it assumed that all timber was of equal value (which encouraged loggers to take only the best timber), and it failed to recognize that timber in different locations varied in value because of difference in logging and transportation costs.

(3) Leases with royalties determined by competitive bidding. In 1892 legislation provided that 21-year timber leases be put up for competition. The experience with competitive bidding is obscure, but apparently unhappy from the public point of view. Thus, an otherwise searching review of British Columbia forest policy (the reports of the Task force on Crown Timber Disposal, 1954) disposes of this competitive policy by saying simply:

> "If vigorous competitive markets prevailed for standing timber everywhere, the government could simply accept the highest bid which could be expected to approximate the full net value of each tract. Thus in 1892, it was provided that 21-year timber leases be put up for competition, and the principle of competitive sales has been recurrent ever since. But, for institutional and technical reasons which are beyond the scope of this inquiry, competitive markets for standing timber cannot be depended upon throughout

> British Columbia, and in any event the old temporary tenures obviously preclude competition for the timber they contain as long as they are held in good standing."22/

(4) Leases with royalties determined by appraisal of "expected surplus value harvested above cost", on current basis. A succinct explanation is:

> "Another alternative is for the government to appraise separately each tract of Crown timber made available for harvesting, taking account of its unique timber inventory, transportation conditions, and the costs of harvesting, development and forestry. With adequate information, such an appraisal can approximate the price that a competitive market would yield -- the expected surplus of value harvested over cost. All Crown timber alienated since 1912 has been appraised by the British Columbia Forest Service to establish the minimum 'stumpage price' per unit of wood that the government would accept for each major species. This 'upset price' was intended to be a minimum or reserve bid, above which competitors could tender. In recent years it has become, with rare exception, the actual price at which the timber is sold."23/

The stumpage royalties have been for many years the predominant form of revenue obtained by the government from Crown timber resources in British Columbia; in the five years ending with 1978, stumpage royalties averaged 80% of total forest service revenue. In addition, there is a logging tax collected by the Department of Finance since 1953 as a levy at a fixed rate (15% after 1968) on logging profits, with profits of less than $10,000 exempted. The government also collects taxes on logging from privately owned forest resources.

22/ Task Force on Crown Timber Disposal, First Report, 1954, pp. 20-21.

23/ Sup. cit., p. 21. Emphasis added.

In recent years there has been a tendency to reduce the number of different kinds of royalties and fees derived from the variety of different types of holdings which had been "grandfathered" since the last century. Stumpage royalties have been substituted in their place.

The question arises as to the yield of royalties and taxes on Crown forest resources, and its relation to the expenses of administering the forest service. The aggregate yield of such royalties and taxes has more than covered the expenses of the forest service of British Columbia in all but a very few years since 1910. The amount in excess of management costs that have been returned to the public treasury is not readily available but apparently could be calculated from raw data.

In principle the royalty policy is to be geared to the unearned increment produced by the Crown forest resources. The 1954 Task Force Report states the policy as follows:

> "We have not set out to generate any predetermined level of public revenue. Had an increase in revenue been our goal we might have simply recommended higher fixed royalties, rentals or taxes; but this would not bring about the desired equity and consistency, nor would it meet our Terms of Reference. During recent decades, representations of the former Forest Council and its successor organizations have repeatedly argued that royalties should not be considered as a tax to be adjusted according to the vicissitudes of government revenue needs. The Task Force agrees with this argument insofar as we believe that royalties should reflect, instead, a consistent share in the varying unearned increment of public forest values." 24/

24/ Sup. cit., p. 39.

It is important to note that in the operation of the stumpage royalty program, the managers of this common resource have a flexible instrument for achieving a principled purpose. There is an intimate interface between the process which produces the actual stumpage royalty fee as a result of realistic appraisal and monitoring of the books and records of the holders of the leases on the one hand, and the operations of the forest products industrial organizations which are dependent on the Crown forest resources for their existence on the other hand. This is a relevant model which managers of the radio spectrum might study in more detail, and use as a basis for an active program of resource management and recovery of unearned increment.

Finally, we remark that it is interesting that after more than half a century of experience with the stumpage royalty principle, the Forest Service no longer aspires to recover all the unearned increment from the private use of Crown forest resources. Note that the Task Force alludes to obtaining a "consistent share" of such unearned increment. This reflects the pressures exerted by the private leasees, typically very large enterprises, for more and more generous application of the procedure. Nevertheless, the principle of tapping the unearned increment remains firm.

V. THE SPECTRUM MANAGEMENT COSTS TO BE RECOVERED

A. Costs to be Recovered

As a matter of economic principle, it is appropriate to establish, as a first step, a license fee structure designed to cover DOC's cost of spectrum management.

The License Fee Study, as noted above, took as its overriding constraint the need to devise a fee schedule that would yield revenues sufficient to recover the costs of spectrum management. The Study at p. 8 provides its most detailed statement of this criteria as follows:

> "The revenues generated by all spectrum-related activities, including those for which the spectrum fees are not collected, should equal the total spectrum management costs defined as the direct costs of operation and associated capital expenditures of the Regulatory Spectrum Management Service (Headquarters and Regions)."

Having argued at p. 36 of the Spectrum I Report that spectrum users "should as a minimum be required to bear the administrative costs associated with according them user status" we must now agree that the adoption of this objective constitutes a useful first step in the process of rationalizing the spectrum management procedure. In this section, therefore, we will assume that the cost recovery objective is in fact at this time an operative constraint and will confine our discussion to the two related issues of the treatment of fee exemptions and the definition of costs.

On the first of these issues our position is unchanged from that of earlier reports in which we argued that current fee exemptions should be phased out on grounds of both economic efficiency and equity. While some legitimate arguments might be made in opposition to charging currently fee exempt users on a value basis, such arguments surely do not apply with

respect to fees established only so as to recover associated administrative costs. At the very least DOC should undertake to study seriously the legal and political feasibility of removing such exemptions.

With regard to the definition of costs to be removed we would also argue that the logic requiring the adoption of a cost recovery objective compels DOC to consider not only the direct but also the indirect costs of spectrum management as being costs that should be recovered via the license fee process. Such costs are ultimately incurred as a result of spectrum management activity and for the benefit of spectrum users, and in this respect are no different from direct costs of spectrum management. While it is apparent that the current status of DOC's cost accounting system does not permit such an undertaking at this time, we would urge that detailed cost studies should be undertaken with a view to the future inclusion of these costs in the cost recovery base.

B. DOC Cost Estimates

In this subsection we will briefly review and comment upon the cost estimates made available to us by DOC for the purposes of this study. It should be noted throughout that the aggregate costs referred to are those stated at p. 8 of the License Fee Study as quoted in the previous subsection, i.e., direct costs only.

Spectrum management costs classified by personnel, goods and services, capital and other (miscellaneous) forecast in the License Fee Study for the years 1978-1981 and as recently revised are contained in Table 2. The substantial size of the recent revisions may be attributed in part to the failure of projected G & S growth to materialize and in part as a result of

Table 2

SPECTRUM MANAGEMENT COST PROJECTIONS (000)

License Fee Study Projections[1]

Fiscal Year	Personnel	G & S	Capital	Other	Total
1978-1979	$18,137	$6,575	$3,171	($737)	$27,146
1979-1980	21,344	6,969	2,447	(781)	29,979
1980-1981	23,820	7,387	2,657	(828)	33,036

Revised Projections[2]

Fiscal Year	Personnel	G & S	Capital	Other	Total
1978-1979	$18,451	$4,123	$2,899	($737)	$24,736
1979-1980	19,909	4,123	1,555	(781)	24,806
1980-1981	21,290	4,123	2,282	(828)	26,867

Sources: 1. License Fee Study, p. 35.

2. DOC data as per November 15, 1978.

revised budgeting procedures. The magnitude of the revisions does, however, suggest that some severe problems exist vis the budgetary estimate process and that unless these deficiencies are remedied it will be extremely difficult to establish a fee formula that matches revenues and costs closely.

This problem is compounded by the fact that the above costs must be further allocated as between broadcasting, fixed, mobile, space and GRS services if cross-subsidization is to be avoided in constructing a license fee schedule. Unfortunately we have been provided with these allocations only for the period 1977-1978 and have further not been adequately advised as to the nature of the allocation process itself.

For the purposes of this report, as noted in section III(C) above, we face a further difficulty in determining the proportion of the fixed service costs that are attributable to the microwave sector.

To determine the revenues that must be obtained from the microwave sector if direct cost recovery is to be satisfied for that sector several alternative estimates may be constructed. Throughout we employ 1979-1980 data as it is to this period that our licensing data pertains.

Alternative #1: 1979-1980 microwave revenues for major microwave users (excluding Telesat) totalled $522,459. License Fee Study estimates were that revenues from these users would account for 91% (≃ $366,975/$402,800) of total microwave revenues excluding Telesat. $522,459/0.91 = $574,130. Raising this amount by a factor of 2, on the stated basis that microwave revenues account for one-half of associated costs, yields $1,148,262. License Fee Study projections also indicated that fee exemp-

tions for 1979-1980 would account for 9% (≃ $1,742,000/$19,927,000) of fee revenues. If we raise our estimate of $1,148,262 by this amount we obtain $1,251,606. In addition, costs associated with satellite users were estimated as $183,000 for 1977-1978, with corresponding revenues estimated at $80,000 under the revised fee schedules.

Alternative #2: The License Fee Study estimated fixed service revenues as 32% of fixed service costs. Total costs estimated for 1979-1980 have been revised downwards by 21%. 32% raised by 21% equals 39%. Employing 39% rather than 50% as the factor by which microwave revenues fall short of microwave costs in a calculation as above we obtain total costs to be recovered of $1,472,128 ignoring fee exemption and $1,604,620 including fee exemptions.

Given the current inadequacies of cost data available to DOC and made available to us, the above figures provide an approximate range of the total revenues that would be required from the microwave sector if cross-subsidy is to be avoided. Any inaccuracies inherent in these estimates should be considered to be of only second order importance given that exact dollar for dollar cost recovery is not at this stage a sacred objective.

C. The Design of the Fee Structure

A license fee structure can be designed in many different ways. Some structures will provide users with an incentive to waste spectrum. Other structures will encourage spectrum efficiency. An economically efficient fee structure will increase as spectrum usage increases, thereby imposing at least a modest cost on users for additional assign-

ments and providing some savings to users who can cut back their spectrum demands.

The new license fee structure currently employed is a considerable improvement over the old structure, as noted above. The greatest improvement from the standpoint of economic efficiency is the adoption of a variable fee structure so that the fee varies in relation to spectrum usage. The selection of radio frequency channels and voice channels as the units of usage measurement, and the weighting of each in the license fee formula are matters of judgement based upon the availability of data relating to these and other possible usage measurements, as well as other objectives of the fee structure, including simplicity and ease of administration.

The design of any fee structure can be improved conceptually by greater theoretical refinement. But how far these theoretical refinements can be implemented at a reasonable cost of implementation depends upon a number of other considerations, including the costs of information gathering, fee calculation and processing and other factors, in light of the multiple, and sometimes overlapping, objectives of the fee structure. The following sections consider the relevant parameters for consideration in the design of an efficient fee structure and then assess specific proposals for implementation.

VI. PARAMETERS IN THE DESIGN OF AN EFFICIENT FEE STRUCTURE

Determination of the important factors to be considered in the design of a license fee structure depends upon the objectives. For this analysis it is assumed that the DOC objectives as specified in the License Fee Study, and summarized in section III(C) above, are the appropriate ones. In light of these objectives, the most relevant factors for consideration in the design of an efficient license fee structure are examined.

A. Measures of Spectrum Usage

An essential element in a microwave radio license fee structure is some measure of the amount of the radio spectrum used or required by a licensee in a particular geographical location. The amount of bandwidth in kilohertz, the number of radio frequency channels and the number of voice channels are three different methods of measuring the amount of radio spectrum assigned to a licensee.

The 1968 report ("Spectrum Engineering -- The Key to Progress") of the Joint Technical Advisory Committee of the IEEE discussed the use of the voice channel as a measure of spectrum usage as follows:

> "The 4 kHz telephone channel has evolved as a universal communications channel available almost anywhere in the world, and represents a widely used basic unit of spectrum usage. It has the advantage of simplicity, being understandable by the professional communications engineer as well as the general public. It represents a communications channel tailored to the human voice and, therefore, represents a reasonable datum point (similar to, say, horsepower). It has been general practice to specify spectrum capabilities of a system or a device in terms of the number of voice channels or fractions thereof that it can transmit with only a specified degradation.

> "It is proposed that, for the present, consideration be given to the 4 kHz voice channel (as specified by CCIR, CCITT) as the basic unit of spectrum usage, but that also work should begin in evolving a more generalized definition based on information theory, this being beyond the scope of this preliminary investigation."25/

In certain situations, however, the number of voice channels may not be a useful parameter in determining the amount of spectrum assigned to users. The number of voice channels being carried by a station can vary from very few to very many even though the amount of spectrum assigned to the user is the same. The License Fee Study recognized this situation when developing the rationale for license fees for fixed stations performing a fixed service. The formula considers both "equivalent voice channels" and the "number of RF channels" as factors for calculating the license fee. The License Fee Study outlines the features associated with this type of license fee structure:

> "The fee is directly related to the revenue-producing capability of the station as measured by the number of RF channels and equivalent voice channels. The effect of this is that a major microwave station with thousands of equivalent voice channels will no longer pay the same fee as a small station with only a few channels.
>
> "With the particular constants chosen, the second term of Equation 1 [equivalent voice channels factor] is the controlling factor for all but the smallest stations.
>
> "The first term of Equation 1 [RF channel factor] is the dominant factor for stations with an equivalent voice capacity of less than 800 channels.

25/ Joint Technical Advisory Committee, Spectrum Engineering -- The Key to Progress. New York: Institute of Electrical & Electronics Engineers, Inc., 1968, pp. S4-47.

> "The particular values of the constants k_1 and k_2 were chosen so as to reflect the revenue-producing capability of a station. A higher value for k_1 would, relatively speaking, discourage the extension of services to rural and remote areas. If a lower value was fixed, then the fee begins to approximate the cost of collecting it for the smallest systems. The particular value of k_2 has been selected so as to allow a differentiation between the station with a capacity higher or lower than one television channel (960 equivalent voice channels)."26/

Assigned bandwidth is another technical parameter that is relevant to a study of microwave fee structures. Neither of the previously mentioned parameters of RF channels or voice channels have been related to necessary bandwidth, that is, the amount of spectrum actually assigned for use by a particular user in a specified area. In proposing the adoption of the 4 kHz voice channel as the basic unit of spectrum usage the IEEE Joint Technical Advisory Committee noted this unit had some inherent limitations related to concepts of efficiency and state-of-the-art technology.

> "Percent saturation of a communications channel using the 4 kHz channel as a basic unit would then be the ratio of 4 kHz channels in use to the maximum number of 4 kHz channels that could be supported by the communications channel. The question then arises as to what is the maximum number of 4 kHz channels that a given spectrum can support. The maximum number of channels that a given spectrum can practically support is a function of present-day technology and the specification of the quality of the 4 kHz channel. This maximum number will tend to vary as technology advances and for the particular mode of communications, e.g., microwave, HF radio, UHF, etc. However, in the various transmission modes, the effort and evolution

---

26/ Canada, DOC, License Fee Study, pp. C-3 to C-4.

over the years have always been to pack as many high-quality voice channels as possible into a given band, and the practical limits are pretty well recognized."27/

The IEEE JTAC discussion of voice channels and bandwidth concluded with the suggestion that two methods could be utilized to relate voice channels and necessary bandwidth:

"The process of stating what number should be used for the maximum number of channels capable of being supported by a given portion of spectrum can be established in two ways:

"(1) A survey of what has been practically achieved and a statement of a maximum number by a duly appointed group of experts. This method has the advantage of practical implementation at the present time but the disadvantage of being based on a number of channels that can be practically transmitted at the present time. As technology improves, the maximum number will tend to increase with a consequent decrease in percent saturation and reference will always be made to an arbitrary datum.

"(2) An objective statement of channel capacity based upon information theory. This method has the advantage of providing an unsurpassable unchangeable maximum (if this number can be found) to use as a datum or reference mark, recognizing that this maximum will never be achieved and that percent saturation will always be low under this definition. (This is a concept similar to absolute zero.) We can thus talk about usage relative to this datum. Problems of obtaining additional channels as a practical matter, will, of course, set in at a very low level of percent saturation; again, as in the first method these are dependent upon the state of technology.

"Method 2 is much to be preferred if possible, but presents some formidable and perhaps impossible mathematical techniques which have not yet been solved at the present time. It is very worthwhile, however, that this problem be attacked by experts."28/

27/ Joint Technical Advisory Committee, pp. S4-48.

28/ Op. cit., pp. S4-48.

Method 1, a statement by a duly appointed group of experts, is the method that currently prevails in Canada in the sense that the various Standard Radio System Plans (SRSPs) outline the radio frequency channel arrangement and minimum loading capacities for 11 different bands in the 1-10 GHz portion of the spectrum. For example, SRSP 301 outlines the technical requirements for line-of-sight radio-relay systems operating in the 5925-6425 MHz bands:

> "RADIO FREQUENCY CHANNEL ARRANGEMENTS -- These arrangements are defined in this Standard to provide for the development of multiple hop radio-relay systems transmitting up to 8 two-way channels in the prescribed 500 MHz bandwidth. The separation between adjacent channels permits 1,800 SSB FDM telephony channels, or the equivalent loading, or television to be carried on each RF channel. Provision is also made for two duplex auxillary RF channels.
>
> "Loading Capacity -- Systems submitted for licensing on a preferred basis must have the capability to transmit at least 600 SSB FDM telephone channels or the equivalent loading, or television on each RF channel. Systems may carry less than these stated minimum loadings in the initial installation. For additional radio channels, users shall be required to demonstrate the present and future efficient use of the spectrum."29/

Similar statements regarding RF channelling arrangements and loading capacity can be found in other SRSPs whether they are analogue or digital in nature. In the case of digital systems the loading capacity (or efficiency) is expressed in terms of the number of "bits per hertz".

29/ Canada, Department of Communications, Standard Radio System Plan 301 -- Issue 2. Technical Requirements for Line-of-sight Radio-relay Systems Operating in the 5925-6425 MHz Band, 1973, pp. 2,5. Emphasis in original.

It is apparent that voice channels, RF channels and necessary bandwidth are all relevant technical parameters in the license fee structure. They are all useful measures of spectrum usage. RF channels and voice channels are explicit factors in the present license fee structure, while bandwidth is an implicit factor that is included under the guise of the SRSPs that set minimum levels of spectral efficiency.

Necessary bandwidth, however, is the best measure of spectrum usage for a microwave radio fee structure. Voice channels and RF channels are really approximations, or proxy measures of assigned bandwidth. If assigned bandwidth can be measured directly, it is the superior unit to use.

The use of voice channels or RF channels may discourage to some degree efforts to improve spectrum efficiency where spectrum efficiency is defined to be the amount of information transferred per unit of bandwidth per unit time. As quoted above SRSP 301 notes that 1,800 voice channels can be carried on each RF channel. If under the present license fee structure a user developed a more efficient modulation process whereby 3,600 voice channels instead of 1,800 could be transmitted over the same bandwidth, the license fee would be approximately doubled. Under a license fee structure where fees are related to equivalent voice channels a licensee has no incentive to improve spectrum efficiency. On the other hand, if necessary bandwidth was the basis for the license fee structure, the user is provided with an incentive to increase the number of voice channels transmitted per unit of bandwidth per unit of time.

Another advantage of bandwidth over RF channels or voice channels as a measure of spectrum use is its applicability to all types of emissions and intelligence being transmitted. It can be applied easily to analogue and digital systems, to amplitude, frequency and pulse type emissions as well as the relaying of audio, video and data information without the need to resort to conversion factors such as "one video channel is equivalent to 960 voice channels."

Finally, perhaps the strongest reason for selecting bandwidth as the best unit of measurement of spectrum use is that bandwidth is what the DOC assigns and what users receive a right to use. Bandwidth is currently a requirement in DOC's radio licensing process under Radio Standard Procedure 113 (Application Procedures for Planned Radio Stations Above 980 MHz in Terrestrial Fixed Service) and Radio Standard Procedure 114 (License Application Procedures for Planned Radio Stations in Satellite Systems).

Data on necessary bandwidth is available for all radio assignments in Canada and the impact of any proposed change in licensing fee structures to include bandwidth could be examined from currently available data. It should also be recognized that necessary bandwidth is an internationally recognized unit of spectrum usage, one that has been recognized by the ITU for many years.

An historical perspective on increased efficiency in the use of the radio spectrum reveals that more efficient spectrum use generally has been realized through more efficient modulation techniques leading to increases in information transfer per unit of radio spectrum (or bandwidth). For example, double sideband modulation was dropped in favour of single sideband

modulation in the Maritime mobile services recently resulting in a 2:1 improvement in spectrum utilization. Similarly wideband frequency modulation emissions were replaced by narrow band FM in the land-mobile services. The December 1979 issue of DOC's "Modulation" contains an item noting that "CRC has demonstrated that two video signals of acceptable quality can be transmitted over a single satellite transponder and received on the new low-cost earth terminals."30/ Bandwidth (and the associated process of modulation) then is by far the most significant single factor to be considered in the microwave radio license fee structure.

Some presently operating microwave systems are twice as efficient as other systems in terms of bits/second/hertz or voice channels/MHz. And some systems under development will increase bandwidth by further multiples. For example, the Bell Telephone Lab analogue SSB-AM system, may be over six times as efficient as current systems in use.31/

It should be emphasized that this analysis is comparing the relative merits of assigned bandwidth and voice channels as measures of spectrum usage. In comparison to most other measures, voice channels has many attributes, as noted in the License Fee Study, and has provided a substantial improvement over the prior license fee formula.

30/ Canada, Department of Communications, "Cost Cutting Satellite Transmission Demonstrated", Modulation, No. 23, December 1979, p. 3.

31/ See Oguchi, B., "Microwave Radio System", Telecommunication Journal, Vol. 45, No. VI, 1978, p. 326.

B. Power

Another technical parameter that could be included in a radio license fee structure in the 1-10 GHz bands is effective radiated power (ERP). However, ERP is not particularly useful in a fee structure because with few exceptions the ERP of stations falls within very narrow limits that are related to physical factors of ambient noise and internal receiver noise. The ERP used by most stations is the minimum necessary to transmit information from point A to point B. The point-to-point user has no incentive to use more power than is necessary to exceed a pre-determined noise level, including a protective margin.

Also, power is not a direct function of spectrum use in point-to-point communication. Increased power could result in a reduction in useable spectrum available to others. But it could also result in an increase in useable spectrum available to others. Therefore, power will not be pursued as a factor for inclusion in a revised license fee structure.

C. Geography

Geography is a particularly important factor in the license fee structure with regards to congestion problems in the highly used "corridors" between major population centres. A variable fee that is higher in the congested areas could be used to encourage spectrum conservation. At the same time, the objective of developing rural communications facilities could be recognized by reduction of the basic license fee to a sufficiently low level so that it is not a restrictive factor in development of new systems in rural areas. A detailed analysis of present congestion from

a geographical point of view is required before this important variable can be incorporated specifically in a license fee structure. However, the geography variable is so important that it should be recognized, in some manner, in the implementation of any license fee structure.

D. Directionality

A spatial factor that could be used in a radio license fee structure is directionality. Basically we could consider two situations under this parameter; point-to-point systems and omni-directional systems. A variable fee could be implemented for stations that are not strictly point-to-point systems, where point-to-point systems are defined as those transmitting almost all of their power within ±15% of their directional antenna azimuths or 30^{o} of arc. Omni-directional systems such as those employed by ENG (electronic news gathering) links all around a city to link a mobile television crew to a central studio could be charged a variable fee to reflect the large spatial use made of a particular band of frequencies to the exclusion of any other user.

It should be clarified that an ENG communiations system operates as a point-to-point system relaying information from the location of a news story to a central studio. The system, however, must be licensed and co-ordinated as an omni-directional system because the locations of the news stories will vary all around the city which necessitates protection of the bandwidth involved and the exclusion of other possible users. The fee for an ENG should be a linear function of that for a point-to-point system, that is the fee for an ENG system should be twelve times that of a fee for a point-to-point system (360^{o} divided by 30^{o} equals 12).

E. Time Sharing

The time dimension is the most straightforward parameter in a licensing fee structure. With respect to licensing fees, consideration could be given to a license fee that is variable and a function of the amount of time the licensee wishes to use the assigned portion of the spectrum on a time-sharing basis with another user.

An example of such sharing might be the use of a certain bandwidth during the business day for voice traffic when such demand is high while the same bandwidth might be used at night by a television network for distribution of national programming material for the next day.

The time dimension, however, does not appear to be a reasonable criterion for incorporation in a radio license fee structure at the present time because it becomes rather complex from an administrative point of view. The time criterion, however, should not be disregarded as a possible solution to future congestion problems in the microwave bands. A proposal was recently made to alleviate congestion in the HF bands by time-sharing between the fixed service and international broadcasting service.32/ The idea behind the proposal was that variable propagation conditions resulted in little use of segments of the HF spectrum by international broadcasting during part of the day. "The 3 MHz band for example could be used between 0800 to 1700 (8:00 a.m. - 5:00 p.m.) for fixed services while international broadcasting could operate between 2000 to

---

32/ Anderson, D. P., "Sharing Between Fixed and International Broadcasting -- A Time-sharing Approach", Telecommunication Journal, Vol. 46, No. 10, October 1979, p. 621.

0500."[33/] Similar variable propagation conditions, however, are not found in the spectrum above 50 MHz although other situations leading to part-time use of the microwave spectrum should not be ruled out.

F. Transmit versus Receive-only Stations

A hasty analysis might conclude that only transmitting stations actually make use of the radio spectrum and receive-only stations should be exempt from licensing. This, however, is not the case. A receive-only station requires protection from all undesired on-channel signals except for those that it was originally designed to receive. A receive-only station then precludes the use of a certain bandwidth of frequencies in a particular geographical area unless inter-station interference can be eliminated through antenna directivity or some other technique. License fees then should take account not only of transmitting stations but also of receiving stations.

The license fee should reflect in a linear manner the number of receive-only stations in a particular system. If, for example, a cable television system has a central processing centre and 10 "receive-only" hubs the licensee should pay a fee for all 11 stations. Care, however, should be taken to ensure that no "double-counting" occurs. A licensee paying a fee for an omni-directional transmit system should not also at the same time have to pay for "receive-only" stations where such stations are already taken account of in the fee for the omni-directional nature of the system.

33/ Ibid., p. 3.

G. Extensive versus Intensive Use of the Spectrum

One of the objectives of a licensing fee structure should be promotion of the as yet unused portions of the radio spectrum, i.e., the spectrum at the extensive margin. A strong argument can be made for a license fee structure that encourages research and development in and promotes use of the relatively unused portion of the spectrum. A license fee structure directed toward the encouragement of spectrum efficiency should include significant fee reductions for use of the undeveloped and lightly used portions of the spectrum.

A problem associated with the adoption of the extensive/intensive use criterion is determining where to draw the line between intensive and extensive use of the spectrum and deciding what fee will be charged extensive users. A guide to the first question should be information relating to use, usage, growth and congestion in the different bands. The license fee level for use at the extensive margin should be a nominal amount, but should be above zero.

H. The Homogeneity of the Spectrum

The spectrum between 1 and 10 GHz is often considered to be relatively homogeneous with respect to its propagation variables and the value of one part of this spectrum as a communications medium versus another part, i.e., 2 GHz is as good to most users as is 8 GHz for most purposes, equipment availability not being considered. Therefore, it may not be necessary to recognize a variable factor in the fee structure to account for different relative "values" of various portions of the spectrum to various users.

However, above 10 GHz precipation attenuation becomes a problem and above 50 GHz attenuation due to absorption by oxygen molecules becomes significant. Microwave radio license fee structures designed to cover these portions of the spectrum should recognize that the "value" of this part of the spectrum may be significantly less than comparable bandwidths in the lower part of the spectrum.

I. Terrestrial versus Satellite Systems

The foregoing analysis has not directly addressed the fee structure for fixed services provided through satellite systems consisting of a number of earth stations working through a space station (satellite). The earth station segment of a satellite system is not unlike a land station in the terrestrial service and should, therefore, pay a license fee identical to a comparable land station in the terrestrial service.

The appropriate fee for the satellite (space station) is, however, a more complicated matter. The present fee structure incorporates a factor termed an "equivalent space factor" for space stations. This factor, equal to 40, is used to multiply the fee for the space station as if it had been calculated on the basis that it was a land station. Therefore, space station fees are 40 times higher than a comparable earth station. The "equivalent space factor" is derived on the basis of the equivalent number of terrestrial hops covered by actual Canadian satellites. However, this method appears to be an over-simplification of the situation. First, the "equivalent space factor" does not appear to be a good approximation of the actual terrestrial hops covered by satellite links. The

Anik satellites link Cowichan Lake on Vancouver Island with Allan Park in Ontario which would require considerably more than 40 terrestrial hops. Secondly, relating a space service fee to a terrestrial service fee does not yeild a good approximation unless the two services can be considered equivalent to the requirements for bandwidth. Insufficient information is available to enable us to make a recommendation. It is recommended that further detailed study be given to the matter of space station fees, with the objective being to charge fees based upon the bandwidth that is rendered unavailable for use by others.

VII. DEVELOPMENT OF AN IMPROVED FEE STRUCTURE

A. Introduction

The foregoing analysis has shown that, as a minimum, license fees in the microwave band should cover the full spectrum management costs. There is a basis in economic theory for charging fees that are greater than costs, but the theory is quite deficient at providing useful guidelines for the determination of the appropriate fee level. Also, current data limitations would prevent implementation of such a fee schedule at the present time.

Finally, the vast majority of spectrum usage in the microwave band is by regulated and/or publicly owned utilities, telecommunications common carriers, railroads and government agencies. These users provide public services. They do not operate in competitive markets. They do not attempt to realize monopoly rents. Thus, the case for charging fees in excess of spectrum management costs is very weak in conparison to that for broadcasting and other profitable commercial uses. We will assume, then, that our analysis here will consider only the step of adjusting fees to cover full spectrum management costs.

B. Parameters for Application

On the basis of our analysis in the previous section, we concluded that bandwidth was a superior measure of assigned spectrum to RF channels and voice channels. Therefore, we propose to adopt bandwidth, as measured in MHz, as the single usage variable.

Because spectrum assignments may be of widely varying bandwidth, it is appropriate to use total bandwidth assigned as the portion of the spectrum rendered unavailable to others. Since quantities of bandwidth are additive for this purpose, a linear fee structure is proposed. To allow for consideration of a minimum fee for the smallest bandwidth assignments to cover license processing costs, a minimum charge is proposed as a fixed element of the fee structure.

The proposed fee structure for application, then, is:

$$F_i = L + aB_i, \text{ where}$$

F_i is the annual license fee associated with licensed station i, containing assignments within the microwave bands;

L is the fixed charge per license;

a is a constant calculated so that aggregate revenue collected in fees will cover the spectrum management costs;

B_i is the total bandwidth assigned to users within the microwave bands, in MHz.

If this fee structure is applied in a manner parallel to the current formula, it will be applied using aggregate bandwidth per user as accumulated across all bands in the microwave region. Although such an application provides an improved fee structure, there is a strong case for determining a separate fee structure for frequency bands of similar characteristics. Similarly, there is a strong case for determining a separate fee structure for geographical locations with similar characteristics.

It is apparent that some bands and some locations have greater use and congestion than others. We can reasonably infer that a much higher than average share of spectrum management costs are devoted to the congested

bands and locations. In addition, the economic value of those spectrum assignments generally will be much higher than in other bands and locations, and the need for spectrum conservation and efficiency is greater. Therefore, considerably higher fee structures should be imposed upon assignments in congested bands in the areas where they are congested. To apply the same fee structure to all bands and locations is to ask lightly used bands and locations to subsidize congested bands and locations.

The present fee structure provides exemptions for provincial government users and fee reductions for municipal government users. As discussed in the Spectrum II Report, and earlier in this report, there is no justification for such exemptions. In fact, such exemptions promote inefficient spectrum use. Therefore, for the present analysis it will be assumed that these exemptions will be eliminated.

C. The Data Base

The implementability of any fee structure depends upon the data available, or obtainable. Table 3 shows the revenues from license fees in the microwave bands by major industry and company for the 1979-1980 fiscal year. Data broken down by frequency band and geographical location could not be obtained.

In the Spectrum II Report, the number of assignments by band and by industry category was listed in Charts 2 and 3, pp. 42-44. But since the quantity of bandwidth may vary substantially among assignments, this data is not sufficient to be useful for specific calculations. In like manner, detailed data relating to location is not available for use in the calculation of our proposed new license fee structure.

Table 3

MICROWAVE FEE REVENUES COLLECTED UNDER 1979 LICENSE FEE SCHEDULE

Major Microwave Users	Billing Beginning of 1979/80 Fiscal Year
Telecommunications Carriers	
B. C. Tel	$ 82,923
Bell Canada	191,724
Eastern Tel & Tel	576
Maritime Tel & Tel	34,519
New Brunswick Telephone	29,459
Newfoundland Telephone	13,584
Okanagan Telephone	632
Quebec Telephone	21,407
Telebec Ltd.	10,199
	$ 385,023
Railways	
CN Railway	$ 88,756
Canadian Pacific	35,173
Quebec North & Labrador Railways	4,362
	$ 128,291
Hydro Utilities[1]	
B. C. Hydro	--
Calgary Power	--
Ontario Hydro	--
Societe d'Energie de la Baie James	--
Other	
Ontario Northland Transportation Commission	$ 9,145
TOTAL (excludes Telesat)	$ 522,459

Source: Data supplied by DOC, Summary of Major Microwave Users, 1980.

Notes: 1. Fee exemption.

However, some data relating to bandwidth quantities was obtainable so as to enable useful aggregate calculations. The data listed the bandwidth quantities of individual assignments, and the number of occurrences of each quantity.

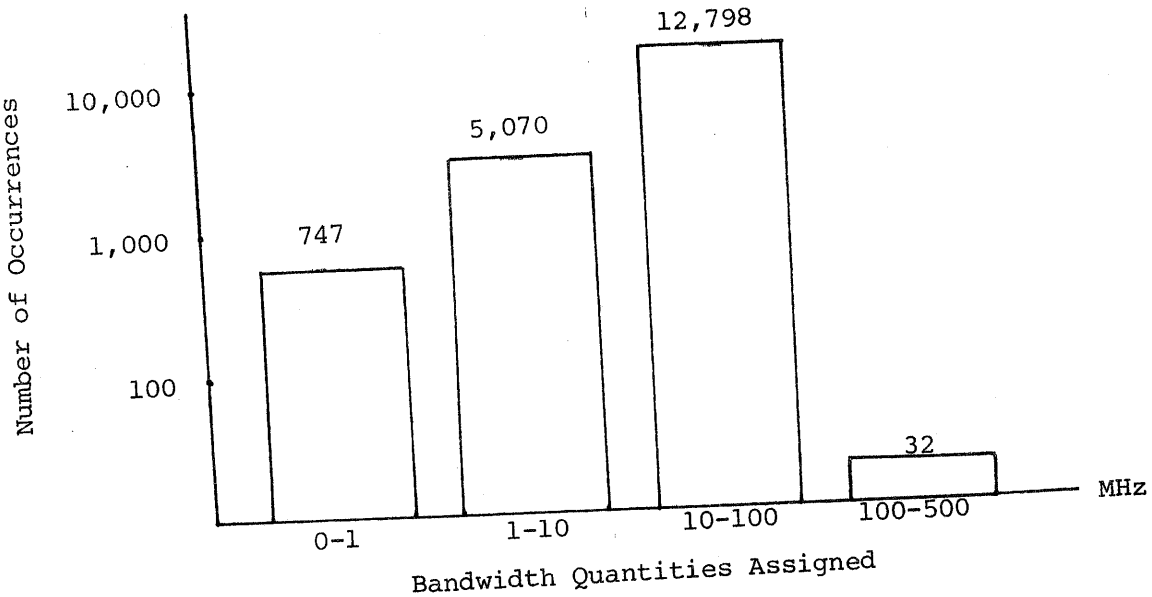
Chart 1 exhibits the distribution of bandwidth quantities assigned in the microwave region as of January 1980. It represents the number of assignments of a given magnitude of bandwidth and is not specific to spectrum bands in the microwave region, to geographical location, or to bandwidth held by particular user classifications. The top bar chart shows that 68% (12,798) of assignments of spectrum capacity fall between 10-100 MHz in order of magnitude. A further 27% fall between 1-10 MHz quantities of spectrum. The two additional bar charts provide a more detailed breakdown for quantities of bandwidth assigned.

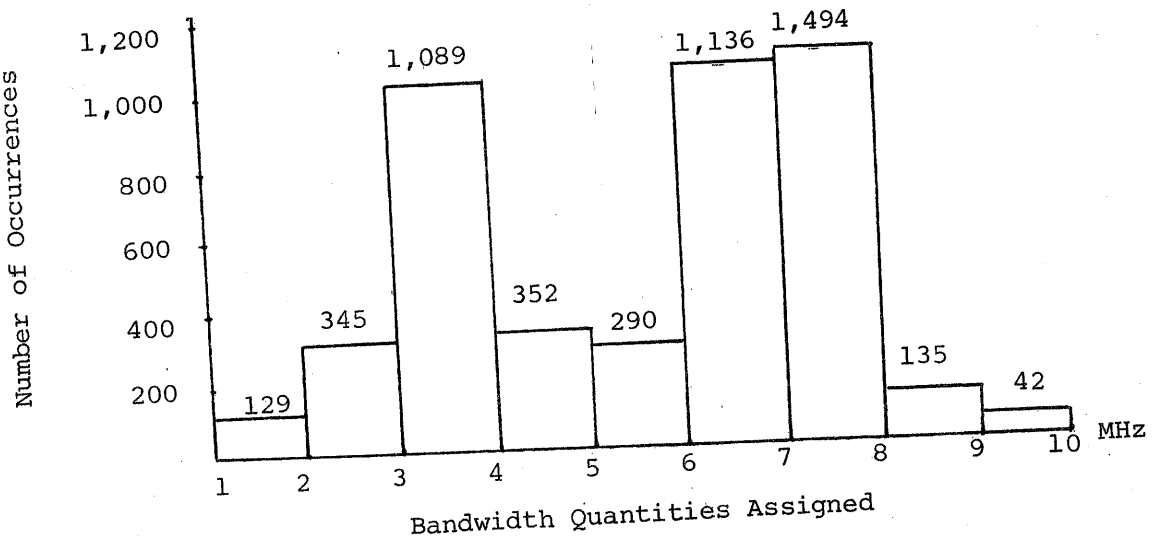
The bandwidth data supplied by DOC is sufficient to generate an aggregate figure of the total quantity of bandwidth assigned in the microwave region. The aggregate bandwidth was obtained by the addition of occurrences or assignments of particular bandwidth quantities. Thus, while it is possible to generate an aggregate figure using available data, it is not possible to calculate the amounts of bandwidth that have been assigned within microwave bands, within geographical regions, or to users of spectrum within these bands. This lack of specificity in the data precludes an accurate assessment of the impact of a fee calculated on the basis of bandwidth on particular microwave bands, geographical locations, or user groups. The distribution of revenues generated under the proposed fee structure cannot be calculated without this specific bandwidth quantity data.

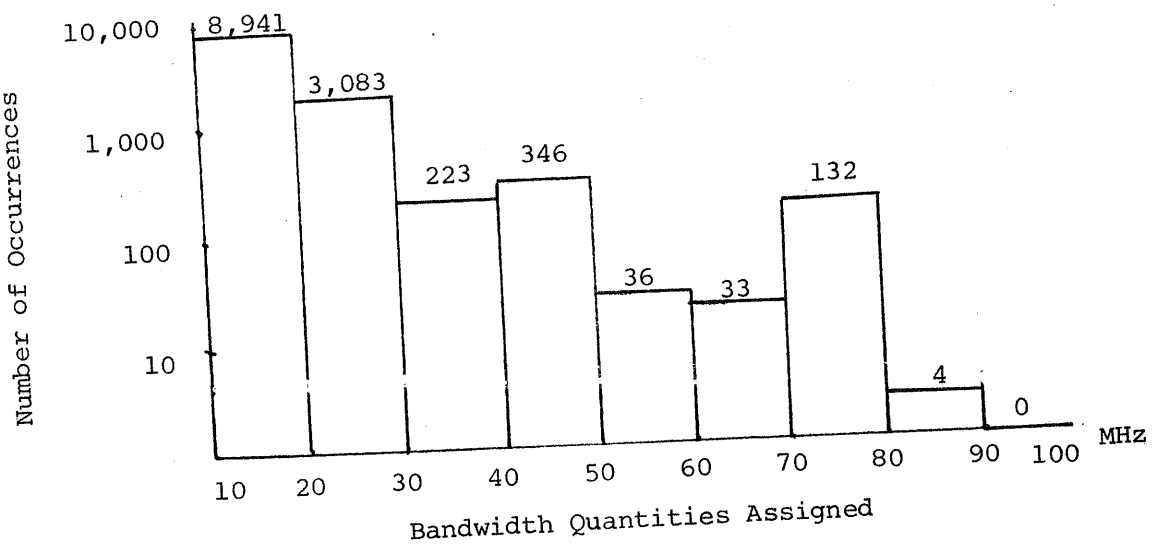
Chart 1

DISTRIBUTION OF BANDWIDTH QUANTITIES ASSIGNED IN FREQUENCIES ABOVE 890 MHz[1]

(in MHz, January 1980)







Notes: 1. The occurrences of assigned bandwidth in the above graphs do not indicate the specific band in the microwave region, or user class to which the spectrum bandwidth is assigned. It is the number of assignments or a given magnitude of bandwidth.

2. Total Occurrences, January 1980 = 18,704. Graph Total = 18,647. Difference accounted for by key punch and other errors.

Source: DOC data, January 1980.

In the course of this analysis, lists of data requirements were developed periodically. Appendix A is the most recent version of a data requirements statement. It outlines the specific data needed to enable the detailed analysis necessary to implement a fee structure that incorporates differential treatment for individual frequency bands and geographical locations. Fortunately, DOC is in the process of establishing an expanded data source through its Data Base Management System (DBMS). When it becomes fully operational, it will be possible to implement fully the fee structure principles recommended here.

D. A Proposed New License Fee Structure

Here we describe the calculations employed in determining suggested parameters to be applied in the proposed new license fee formula, $F_i = L + aB_i$. "L" should reflect the basic cost of processing a license application. Available DOC cost information does not provide such a cost breakdown. However, the minimum fee of $26.00 in the license fee structure implemented in 1979 presumably is designed to accomplish the same objective. Therefore, $26.00 is adopted as "L" in this analysis.

There are 3,653 licenses containing assignments above 890 MHz. Applying a base fee of $26.00 per license will yield total revenues of $94,978. While the licenses considered may also contain some assignments below 890 MHz we will treat these revenues as being attributable exclusively to the microwave sector.

In an earlier section we estimated that the direct costs of spectrum management were in the range of $1,000,000 to $1,500,000. Taking these two and certain intermediate figures as alternative cost estimates, we may then, for each approximation, subtract the base fee revenues and determine the revenues that would need to be recovered through the variable charge. To determine the appropriate level of the parameter "a", we then divide this amount by the total assigned bandwidth above 890 MHz (287,992 MHz).

The results are shown in Table 4, which also includes a calculation assuming total costs to be recovered of $1,875,000. This amount was selected on the basis that we have estimated the direct costs of the microwave sector to be within an approximate range of $1,000,000 to $1,500,000. Taking the mid-point of this range as $1,250,000 and raising it by a factor of 50% we obtain a rough approximation of the direct plus indirect costs associated with the microwave sector as $1,875,000

These calculations assume that the existing exemptions to provincial and municipal governments and their agencies would be eliminated. However, as discussed above, a substantially lower fee schedule should be applied to relatively little used frequency bands and to assignments in locations where spectrum usage is low. Because of the absence of detailed data, it is not possible to calculate different "a" values for little used and heavily congested bands, or for rural and urban locations. Thus, the best way to treat these factors in this analysis is to exempt little used bands and uncongested areas from the payment of the full fee schedule. This exemption is not a subsidy in any way. It is essential, if little used bands and locations are not to subsidize the congested bands and locations.

Table 4

CALCULATION OF PER MHz CHARGE FOR PROPOSED FEE SCHEDULE

Revenues to be Collected	Revenues less Revenues from Base Fee	Fee per MHz[1]
$ 1,000,000	$ 905,000	$ 3.14
1,100,000	1,005,022	3.49
1,200,000	1,105,022	3.84
1,250,000	1,155,022	4.01
1,300,000	1,205,022	4.18
1,400,000	1,305,022	4.53
1,500,000	1,405,022	4.88
1,875,000	1,780,022	6.18
2,000,000	1,905,022	6.62
2,500,000	2,405,022	8.63

Notes: 1. Equals (revenues less revenues from base fee) divided by total bandwidth assigned above 890 MHz.

To adjust for these exemptions from the full fee, it may be necessary to implement a formula based upon an even higher amount of revenues assumed to be collected. For that reason, amounts of revenue to be collected of $2 million and $2.5 million are included in Table 4. With reduced fees applicable to some bands and locations, this may be necessary to ensure that the actual revenues collected do cover all spectrum management costs.

Table 4 shows that to cover all direct costs, a license fee formula in the range of $F_i = \$26.00 + \$4.00(B)(MHz)$ would have to be applied, assuming no exemption or reduced fees for any reason. To cover direct and indirect costs, a fee formula in the range of $F_i = \$26.00 + \$6.18(B)(MHz)$ would have to be applied.

In rural areas, in frequency bands at the extensive margin and in little used bands, the license fee should be reduced to the minimum, $26.00. The second component of the formula, "aB_i", should not apply. This, of course, means that the "a" value in the formula must be increased. We do not have data available to permit a calculation of the increase in "a" that is necessary to yield revenues that will cover total spectrum management costs, if the justified fee reductions are applied. In order to provide benchmark information on this issue, the higher revenue requirement assumptions were calculated. With the reduced fee, the "a" value could increase to the $8.00 or $9.00 range.

With regard to satellites, although the above fee formula may be used to calculate the license fee applicable to fixed earth stations performing a fixed service, we have insufficient information at this point to suggest any structural revisions to the license fee applicable to space stations.

We would therefore, at this time, recommend simply that current fees applicable to space stations be raised at least by a factor of 2.25 so as to bring revenues from that sector into equality with the corresponding direct costs associated with the licensing of such stations.[34/] If indirect costs are approximately 50% of direct costs, then satellite fees would have to be raised by a factor of approximately 3.5 in order for revenues to cover total costs.

It is interesting to note, however, that annual fees applicable to each of the Anik satellites were estimated to be $25,920. Employing our proposed formula for non-space stations, a 24 channel satellite employing 20 MHz per channel would pay an annual fee of (24 x 20 x $4.01 + $26.00) $1,950.80 which when multiplied by the conversion factor of 40 employed under the current formula would imply an annual charge of $78,032. This amount exceeds the fee estimated under our proposed revision for covering direct costs by approximately $20,000, but falls short of the fee necessary to cover total costs by approximately $13,000. Here also, if specific satellites are employing frequencies at the extensive margin or in little used bands, a fee reduction would be warranted for those bands. However, this would require fee increases in the other bands so that revenues covered costs.

It must be emphasized that this analysis is based upon aggregate data approximations for costs, revenues and bandwidth. The results should be viewed as general benchmarks, not as definitive calculations. However, the

---

34/ In the License Fee Study, space station fee revenues were estimated to be $78,000 and corresponding costs to be approximately $180,000.

analysis clearly shows that a significant fee increase is required and that the bandwidth formula would represent an improvement that can be implemented without difficulty.

VIII. CONCLUSIONS AND RECOMMENDATIONS

On the basis of the foregoing analysis, the following conclusions and recommendations are derived:

(1) The requirements of spectrum management are in the process of being fundamentally altered. In the past the tasks primarily have been directed toward the ad hoc resolution of technical problems so that new frequency assignments could be accommodated. For the future, the tasks will increasingly be directed toward longer range policy problems of priority of allocation and assignment, the economic consequences of alternative priority assignments, and the design of operational standards for implementing economic, social and political objectives.

(2) This will require increased spectrum management activity of three different kinds:

(a) A shift in emphasis from relatively passive spectrum management addressed to specific problems as they are raised by users, to a much more active management role where the spectrum manager takes the initiative in proposing and implementing practices that will improve spectrum efficiency, but which users have no incentive to adopt on their own. We have described this activity as stimulated organization innovation for efficiency (SOIFE) initially in the Spectrum II Report, and also in this report.

(b) Defining and implementing operational criteria that will meet economic, social and political objectives relating to the spectrum, as well as the traditional objectives of technical efficiency.

(c) Increased attention to the role of economic factors in the spectrum management process, with particular reference to license fees, cost analysis and the characteristics of markets in different industries

(3) The use of spectrum license fees as a tool of spectrum management that can provide incentives for efficient use of the spectrum and penalties for inefficient use has been recognized in both Canada and the United States. In both countries, it has been recognized that in principle license fees should at least cover the administrative costs of spectrum management. In recent years, both countries have implemented new license fee schedules with significantly increased fees.

(4) Economic analysis indicates that the minimum level of license fees should recover the full cost of spectrum management. Economic theory indicates that there are grounds for charging higher fees, but it is quite deficient in providing operational standards for determining fee levels.

(5) The opportunity cost concept from neoclassical economic theory has been found (in the Spectrum I Report) to be neither relevant nor operational as a guide to establishing spectrum fees. The concept of economic rent has been found (in the Spectrum II Report) to be directly relevant to broadcast and other commercial uses by unregulated, private enterprises, but of questionable applicability to the microwave band where users do not attempt to realize economic rent.

(6) A more relevant branch of economic theory for analyzing the spectrum is that directed to "common" resources such as fisheries and forests. The theory demonstrates principally why competitive markets in common resources will lead to tragedy and why central management is necessary

to achieve economic efficiency. Prices, or license fees, are a crucial aspect of the task of economic management. However, without further development, the theory is quite unspecific about operational standards for fee setting.

(7) License fees have not played a significant role in the federal management of the fisheries. Fees remain nominal. No attempt is made to cover administrative costs. By contrast, licence fees have been an important tool of the British Columbia provincial management of forests. Fees are set at levels generally above adminstrative costs to achieve a policy of collecting a portion of the economic rent. The analysis undertaken is quite thorough and sophisticated. A more detailed study of forest management practices and their applicability to spectrum management would appear to offer significant benefits.

(8) The new DOC license fee schedule implemented in 1979 is designed to cover the direct costs of spectrum management. However, assignments in the microwave bands are only covering about one-third direct costs. License fees in the microwave bands should be increased at a minimum to a level that will cover not only all direct, but also all indirect spectrum management costs.

(9) Apparently, DOC has not developed a detailed analysis of its costs of spectrum management, but rather applies only very general criteria for cost allocation. We recommend that DOC undertake a detailed functional cost analysis of spectrum management activities, including cost allocations that differentiate by frequency band characteristics. This will provide an improved basis for setting fees in the future.

(10) The new fee structure is a substantial improvement over the old one because fees are related to measures of spectrum use, i.e., RF and voice channels. Our examination concludes that bandwidth, as measured in MHz, would be a significant further improvement because bandwidth is the direct measure of the unit assigned.

(11) The other important parameters of an efficient fee structure are a minimum fee to cover license processing costs and recognition of the important characteristics of band location and geographical location.

(12) Because bandwidth data is only available in aggregate form, we have developed a fee structure of the form: $F_i = \$26.00 + aB_i$, where "a" is calculated to achieve the desired amount of revenue and "B_i" is bandwidth measured in MHz. Bandwidth in lightly used bands, in bands at the extensive margin and in rural, uncongested areas should be charged only the $26.00 processing fee. The remaining revenues should be collected by applying a fee structure that will cover both direct and indirect spectrum management costs. Exemptions and reduced fees in the current fee structure for government bodies and their agencies should be eliminated. On the basis of available DOC cost information, it would appear that the license fee formula should have an "a" value of at least $4.00, and possibly as high as $8.00 or $9.00, if full spectrum management costs are to be recovered. Comparable increases in satellite fees should be set to cover spectrum management costs associated with satellites

(13) When more detailed data becomes available from the data base management system regarding band and geographical locations of bandwidth assignments, the proposed license fee formula should formally recognize

both band and geographical location characteristics. It is recommended that this be done as soon as possible.

(14) The magnitude of the fee increase recommended in this study is high when measured in relation to fees paid in past years. However, that is an indication of the inadequacy of past fee levels, not excessive proposed fees. For almost all users in the microwave bands, license fees are an inconsequential portion of the annual costs of providing their services. Users should be given sufficient notice of forthcoming fee increases so that they may plan for them in future budgets. But there are no grounds here for any further delay, or lengthy phasing of the fee increases. At present, the Canadian taxpayer is subsidizing the users of the microwave bands. The sooner the subsidy is eliminated, the better.

Appendix A

DOC INFORMATION REQUEST

Provide the following data for licenses containing RF channel assignments in the above 890 MHz region:

(1) Number of licenses containing such assignments.

(2) Number of transmitted RF channels corresponding to assignments above 890 MHz.

(3) Number of received RF channels corresponding to assignments above 890 MHz.

(4) Number of equivalent voice channels transmitted corresponding to assignments above 890 MHz.

(5) Number of equivalent voice channels received corresponding to assignments above 890 MHz.

(6) Assigned bandwidth corresponding to assignments above 890 MHz subclass by F9.

(7) Power corresponding to assignments above 890 MHz (in Kw).

(8) Number of assignments above 890 MHz for which voice channel capacity is:

  (i) below 300.

  (ii) above 300 but below 1200.

  (iii) above 1200.

(9) Annual fees for licenses containing such assignments.

Aggregated over each of the following classifications:

(a) All assignments held in the above 890 MHz region.

(b) All assignments held in the above 890 MHz region by companies listed in Table A:

  (i) for each company separately.

  (ii) for all Table A companies.

  (iii) as in (ii) but subclassified by district office.

  (iv) as in (ii) but classified by regional office.

(c) As in (b) above for Table B companies.

(d) As in (b) above for Table C companies.

(e) As in (b) above for Table D companies.

(f) All assignments held in the spectrum bands listed in Table E:

(i) for each band separately.

(ii) for all Table E bands in total.

(g) As in (f) above but subclassified by:

(i) district office.

(ii) regional office.

(h) All assignments held in the above 890 MHz region for each of the SIC code classifications listed in Table F.

(i) Telesat by region in total (above 890 MHz).

Table A

New Brunswick Telephone
B. C. Telephone
Okanagan Telephone Co.
Eastern Tel. & Tel.
Alberta Government Telephone
Manitoba Telephone
Saskatchewan Telephone
Bell Canada
Quebec Telephone
Telephone du Nord du Quebec
Telebec Ltd.
Bonaventure and Gaspe Telephone
Newfoundland Telephone
Maritime Tel. & Tel.

Table B

C. N. Railway
Canadian Pacific
B. C. Railway
Ontario Northland Transportation Commission
Quebec Northshore and Labrador Railways

Table C

B. C. Television System
Grand River Cable Television

Table D

B. C. Hydro
Calgary Power
Manitoba Hydro
Ontario Hydro
Societe d'Energie de la Baie James
Quebec Hydro

Table E

Band (MHz)

890- 960
960-1427
1427-1525
1525-1710
1710-1900
1900-2290
2290-3540
3540-4200
4200-5925
5925-6425
6425-6590
6590-6770
6770-6930
6930-7125
7125-7250
7250-7300
7300-7725
7725-7975
7975-8025
8025-8275
8275-8500
over 8500

Table F

SIC Codes	
Railway Transport	00503
Radio and Television Broadcasting	00543
Telephone Systems	00544
Telegraph and Cable Systems	00545
Electric Power	00572
Pipeline Transport	00515

SELECTED BIBLIOGRAPHY

For additional bibliography, see Melody, W. H., and Smythe, D. W., Opportunity Cost and Radio Spectrum Allocation, Study Report for DOC under Contract OSU77-00368, March 1978; and Melody, W. H., Smythe, D. W., and Oliver, A., Economic Analysis and Radio Spectrum License Fees: The Microwave Band, Study Report for DOC under Contract O2SU-36100-809528, March 1979.

Adey, A. W., and Begley, G. R., Some Basic Principles or Rules for Guidance in the Development of Policies for the Utilization of the Radio Spectrum. Paper presented at the National Telecommunications Conference, Texas, November 1976. Ottawa: DOC, 1976.

Arrow, Kenneth J., "Criteria for Social Investment", Water Resources Research, Vol. 1(1), 1965, in R. Dorfman and N. Dorfman (Eds.), op. cit., pp. 409-421.

British Columbia, Ministry of Forests, First Report of the Task Force on Crown Timber Disposal. Victoria, February 1974.

_____, Ministry of Forests, Second Report of the Task Force on Crown Timber Disposal. Victoria, July 1974.

Burton, Thomas L., Natural Resource Policy in Canada. Toronto: McClelland & Stewart, 1972.

Calabresi, G., "Transaction Costs, Resource Allocation and Liability Rules", Journal of Law and Economics, April 1968, in R. Dorfman and N. Dorfman (Eds.), op. cit., pp. 252-259.

Canada, Canadian Radio-Television and Telecommunications Commission (CRTC), A New License Fee Policy. Unpublished report prepared by N. Weir, October 1974.

_____, CRTC, Regulation Respecting License Fees. Public Announcement, June 14, 1977.

_____, Department of Communications (DOC), A Discussion Paper on Canadian Spectrum Allocations in the 406-960 MHz Frequency Band, December 1977.

_____, DOC, A Plan for Departmental Microwave Operations. Memorandum prepared by J. de Mercado, September 26, 1977.

_____, DOC, A Proposal for Restructuring the Radio License Fee Schedule, December 30, 1976.

_____, DOC, Amortization Issues Associated with the 7.125-7.726 GHz and 7.725-8.275 GHz Policies. National Telecommunications Branch, 1977.

_____, DOC, Annual Reports. Various years.

_____, DOC, Annual Report Radio Station Licensing. Unpublished reports for 1972-1979.

_____, DOC, Canada and the 1979 World Administrative Radio Conference. Ottawa, 1979.

_____, DOC, Demand for Radio Frequency Spectrum Workload and Congestion. Telecommunications Economics Branch, July 1978. Reprinted April 1979.

_____, DOC, FML/AML Price Comparison 15 GHz Policy. Memorandum prepared by J. B. Young, March 15, 1977.

_____, DOC, The Impact of the 1976 Income Tax Amendment on United States and Canadian Television Broadcasters. Ottawa, 1979.

_____, DOC, Instant World. Ottawa, 1971.

_____, DOC, License Fee Schedule Revisions. Memorandum prepared by E. Piekaar, December 10, 1976.

_____, DOC, License Fee Study. Internal Report, November 1977.

_____, DOC, Microwave Communication Systems in Canada. Unpublished report prepared by P. Diamente, 1977.

_____, DOC, The Principal Canadian Telecommunications Carriers: Expenditures on Telecommunications Equipment, 1973-1982. Ottawa, 1979.

_____, DOC, Propagation Factors in the Operation of Millimetre-Wave Communication Systems in the Frequency Range 40-140 GHz. Study by A. W. Adey, July 1975.

_____, DOC, Proposals by Canada: ITU World Administrative Radio Conference (1979) for the Revision of the Radio Regulations. Ottawa, 1979.

_____, DOC, Revising the Rationale for the Tariff of Radio Station Fees -- A Feasibility Study, July 1976.

_____, DOC, Spectrum Allocation Policy in the 406-960 MHz Frequency Band, March 1979.

_____, DOC, Spectrum Allocations in the 406-960 MHz Frequency Band, August 1976.

_____, DOC, Technical Developments Relating to the Future Use of the Frequency Bands Above 30 GHz. Paper prepared by A. W. Adey for presentation at the CITEL Symposium on Preparations for the 1979 WARC, Rio de Janiero, 1978.

_____, DOC, Unpublished estimates of spectrum management costs incurred by DOC, as prepared by E. Marquis.

_____, DOC, Unpublished estimates of spectrum related investment in Canada, as prepared by DOC staff.

_____, DOC, Use of Broadcasting Spectrum Allocations for Fixed Relays in Support of Broadcasting Operations. National Telecommunications Branch, December 1979.

_____, DOC, The Utilization of the Radio Spectrum in the Range 0.890-10.68 GHz. Ottawa, 1979.

_____, DOC, Radio Standards Procedures. RSP 113, Application Procedures for Planned Radio Stations above 890 MHz in Terrestrial Fixed Service, 1975.

_____, DOC, Value of Equipment: 1-10 GHz Study. Unpublished report prepared by T. A. Kubacki, August 1978.

_____, Department of Fisheries and Oceans, License Limitation in the British Columbia Salmon Fishery. Technical Report Series #PAC/T-77-13. Prepared by G. A. Fraser for Economics and Special Industry Services Directorate, Pacific Region, 1977.

Canadian Radio-Technical Planning Board, Reappraisal of the Present Management of the Radio Spectrum. Telecommission Study 2, Ch. 1, Ottawa, 1971.

Ciracy-Wantrup, S. V., Resource Conservation, Economics and Policies. California: University of California Press, 1963.

Coase, Ronald H., "The Problem of Social Cost", Journal of Law and Economics, October 1960, pp. 1-44, in R. Dorfman and N. Dorfman (Eds.), op. cit., pp. 142-171.

Coase, R. H., Meckling, W., and Minasian, J. R., Problems of Radio Frequency Allocation. Unpublished Rand Corporation Study, May 1963.

Commoner, Barry, "The Environmental Costs of Economic Growth". Paper presented at a Resources for the Future Forum, Washington, D. C., April 1971, in R. Dorfman and N. Dorfman (Eds.), op. cit., pp. 331-353.

Dales, J. H., Pollution, Property and Prices. Toronto: University of Toronto Press, 1968.

_____, "The Property Interface", in Pollution, Property and Prices. Toronto: University of Toronto Press, 1968, in R. Dorfman and N. Dorfman (Eds.), op. cit., pp. 172-186.

de Mercado, J., Ahmed, S. N., and Racine, T., Spectrum Management in Canada. Paper for the ITU Journal Special Edition on Canada. Ottawa: Department of Communications, 1976.

Demsetz, Harold, "Exchange and Enforcement of Property Rights", Journal of Law and Economics, October 1964, pp. 11-25.

_____, "Toward a Theory of Property Rights", American Economic Review, May 1967, pp. 347-359.

DeVany, A. S., et al., "A Property System for Market Allocation of the Electromagnetic Spectrum", Stanford Law Review, June 1969, pp. 1499-1561.

Dorfman, R., and Dorfman, N. S. (Eds.), Economics of the Environment: Selected Readings. New York: W. W. Norton & Co., 1977.

Eckert, Ross D., Spectrum Allocation and Regulatory Incentives. OTP, Conference on Communication Policy Research, November 1972, Washington, D. C.

Elliot, A. R., Liefeld, J. P., and Spence, R. J., Spectrum Management: An Integrated Model of Management Alternatives and their Economic Implications. Telecommission Study 2(c), Ottawa, 1971.

Gifford, R. P., "What is the Value of Establishing Spectrum Value?", Annual Proceedings of the IEEE-EIA Joint Technical Advisory Committee, 1967-1968, pp. C37-C48.

Gordon, H. Scott, "The Economic Theory of a Common-property Resource: The Fishery", Journal of Political Economy, April 1954, pp. 124-142, in R. Dorfman and N. Dorfman (Eds.), op. cit., pp. 130-141.

_____, "Economics and the Conservation Question", The Journal of Law and Economics, Vol. 1, 1958, pp. 110-121.

Hardin, Garret, "The Tragedy of the Commons", Science, Vol. 162, 1968, pp. 1243-1248.

Hinchman, W., "Use and Management of the Electrospace: A New Concept of the Radio Resource". IEEE International Conference on Communications, Conference Record, Boulder, Colorado, June 1969.

Intermedia. "WARC: More Conferences will be Held"; "Broadcasting: Television by Satellite"; "Broadcasting: The Law is Confused", January 1980, Vol. 8(1).

International Telecommunications Union, Final Acts of the World Administrative Radio Conference. Geneva, 1979, Vol. I and II.

_____, Technical Bases for the World Administrative Radio Conference, 1979. Report of the Joint Meeting of CCIR Study Group Special Preparatory Meeting for the WARC-79, Geneva, 1978.

Jackson, Charles L., "Technologies for Spectrum Usage Charges". Paper presented at the 5th Annual Telecommunications Policy Research Conference, Airlie, Virginia, March 1977.

Johnson, Leland L., "New Technology: Its Effect on Use and Management of the Radio Spectrum", Washington University Law Quarterly, Fall 1967, pp. 541-542.

Krutilla, J. V., and Fisher, A. C., The Economics of Natural Environments. Baltimore: Johns Hopkins Press, 1975.

Levin, Harvey, J., "Spectrum Allocation without Market", American Economic Review, 1970 Proceedings, pp. 209-218.

_____, The Invisible Resource: Use and Regulation of the Radio Spectrum. Baltimore: Johns Hopkins Press, 1971.

_____, "The Radio Spectrum Resource", Journal of Law and Economics, October 1968, pp. 433-501.

MacPherson, C. B., "The Meaning of Property-Liberal-Democracy and Property", in C. B. MacPherson (Ed.), Property: Mainstream and Critical Positions. Toronto: University of Toronto Press, 1978.

Melody, W. H., "Radio Spectrum Allocation: Role of the Market", American Economic Review, May 1980 (forthcoming).

Minasian, J. R., "Property Rights in Radiation: An Alternative Approach to Radio Frequency Allocation", Journal of Law and Economics, April 1975, pp. 221-272.

Mishan, E. J., "Property Rights and Amenity Rights", in Technology and Growth: The Price we Pay, 1969, in R. Dorfman and N. Dorfman (Eds.), op. cit., pp. 245-251.

Nordhaus, W. D., and Tobin, J., "Growth and Natural Resources". New York: National Bureau of Economic Research, 1972, in R. Dorfman and N. Dorfman (Eds.), op. cit., pp. 400-407.

Perrakis, S., Silva-Echenique, J., and Zerbinis, T., The Economic Value of the Spectrum Resource in Broadcasting and Land Mobiles. Report submitted to DOC, Contract No. OSU77-00338, March 1978.

President's Task Force on Communications Policy, The Use and Management of the Electromagnetic Spectrum, Parts I and II. Staff Paper 7, June 1969.

Robin, Martin, The Rush for Spoils. Toronto: McClelland & Stewart, 1972.

Robinson, Glen, "Radio Spectrum Regulation: The Administrative Process and the Problems of Institutional Reform", Minnesota Law Review, 1969, pp. 1179-1268.

Robinson, J. O., An Investigation of Economic Factors in FCC Spectrum Management. FCC Spectrum Allocation Staff, Report SAS 76-01, Washington, D. C., August 1976.

_____, "Spectrum Allocation and Economic Factors in FCC Spectrum Management", IEEE Transactions on Electromagnetic Compatibility, August, 1977, pp. 182-190.

Scott, Anthony, "The Fishery: The Objectives of Sole Ownership", Journal of Political Economy, Vol. 63, 1955, pp. 116-124.

_____, Natural Resources: The Economics of Conservation. Toronto: McClelland & Stewart, 1973.

Smythe, Dallas W., Memorandum on Some Questions Regarding Telecommunications Development in British Columbia. Unpublished report prepared for the Province of British Columbia, November 1973.

_____, "The Electronic Information Tiger or the Political Economy of the Radio Spectrum and the Third World Interest". Unpublished paper, 1979.

Solow, R. M., "The Economics of Resources or the Resources of Economics", The American Economic Review, Vol. 64(2), May 1974, in R. Dorfman and N. Dorfman (Eds.), op. cit., pp. 354-370.

Thuswalender, A., Radio Station License Fee Study Review. Ottawa: Department of Communications, 1976.

Turvey, R., "On Divergences between Social Cost and Private Cost", Economica, August 1963, in R. Dorfman and N. Dorfman (Eds.), op. cit., pp. 187-191.

United States, Department of Commerce, Economic Assessment of Spectrum Scarcity, September 1977.

_____, Department of Commerce, Telecommunications Science Panel of the Commerce Technical Advisory Board, Electromagnetic Spectrum Utilization: The Silent Crisis, October 1966.

_____, Federal Communications Commission, Fee Refunds and Future FCC Fees. In the Federal Register, Vol. 43, No. 196, October 10, 1978, pp. 46658-46692.

_____, Federal Communications Commission, Fee Schedules and Commercial Radio Operator Licenses. In the Federal Register, Vol. 39, No. 161, August 19, 1974.

Webbink, D. W., "Setting FCC License Fees According to Frequency Spectrum Utilization: A Suggestion", IEEE Transactions on Broadcasting, September 1971.

_____, "The Value of the Frequency Spectrum Allocated to Specific Uses", IEEE Transactions on Electromagnetic Compatibility, August 1977, pp. 343-351.