

Originally Processed With FOIA(s):
2005-0336-F

FOIA Number:
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UNITED STATES DEPARTMENT OF
COMMERCE
NEWS

WASHINGTON, D.C. 20230

National
Telecommunications
and Information
Administration

NTIA 91-01

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**REPORT ON SPECTRUM
MANAGEMENT SUGGESTS
COMPETING BIDS AND
OPEN GOV'T PROCESS**

FOR IMMEDIATE RELEASE

The Commerce Department today released results of a year-long study on future management of the radiocommunications spectrum, calling for a greater private sector role in the allocation of airwaves among various users.

Commerce Secretary Robert A. Mosbacher said, "Effective management of the spectrum is a crucial link in developing the U.S. telecommunications infrastructure.

"The radio spectrum serves a major portion of our economy and is a vital factor in our nation's competitiveness. In fact, in 1990, U.S. shipments of radiocommunications equipment totaled over \$55 billion."

"NTIA will move to open the federal spectrum management process to greater private sector participation. This includes more private sector participation in meetings of the Interdepartment Radio Advisory Committee, and greater public access to NTIA spectrum management information," Mosbacher said.

The report, prepared by the National Telecommunications and Information Administration (NTIA), titled "U.S. Spectrum Management Policy: Agenda for the Future," recommends ways for NTIA and the Federal Communications Commission (FCC) to improve their spectrum management systems. NTIA manages spectrum use by the federal government, and the FCC manages private sector spectrum use.

Assistant Secretary Janice Obuchowski, head of NTIA, said, "NTIA recommends in the report that the FCC be given authority to use competitive bidding in initially assigning spectrum, the term used to describe airwave space available for radio, television and other telecommunications uses." The report said that such a market-based approach would considerably improve the efficiency and fairness of the current U.S. system.

Competitive bidding would not apply to licenses of incumbent users or specific public interest uses to be determined by Congress or the FCC.

The report also recommends ways to introduce greater flexibility into the block allocation system, to quantify and measure spectrum use more efficiently, and to emphasize further long range planning.

NTIA is the Commerce agency responsible for domestic and international telecommunications issues. It is principal advisor to the White House on telecommunications policy, develops long range U.S. spectrum management plans, and has statutory authority to license radio frequency use.

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2/27/91

EXECUTIVE SUMMARY

Use of the radio spectrum is crucial to U.S. communications, and indeed, the national economy. In 1990, shipments of radiocommunications equipment were estimated to be over \$55 billion. Industries that use the spectrum, such as broadcasting and cellular telephony, also make substantial contributions to the economy, while other manufacturing and service industries use spectrum to increase their productivity. Moreover, spectrum use is essential to government functions ranging from defense and public safety to air traffic control and weather forecasting. U.S. policies for managing the spectrum must ensure that the spectrum is used efficiently and fairly while promoting innovation and serving users' needs. Protracted administrative procedures and inflexible regulation will not permit the United States to reach those goals.

Current spectrum management policies -- administered by the National Telecommunications and Information Administration (NTIA) for federal government users, and by the Federal Communications Commission (FCC) for all other users -- are under increasing strain as the demand for existing spectrum-based services grows, and new spectrum-related technologies and applications emerge. NTIA, in its role as federal spectrum manager and as the principal Executive branch adviser on telecommunications policy, prepared this report with the goal of benefiting all users of the spectrum resource.

This report makes specific proposals and recommendations in five areas:

Regulatory Issues The report first examines the regulatory processes of both NTIA and the FCC. NTIA will move to open its process of managing federal government spectrum use to permit a greater degree of public participation, by increasing the availability of information concerning federal spectrum use and by opening a portion of the meetings of the Interdepartment Radio Advisory Committee (IRAC) to the public. The report makes some suggestions for increasing the efficiency and speed of the FCC process, and recommends increased emphasis on NTIA-FCC coordination and on U.S. coordination on international spectrum issues.

The Block Allocation System and Flexibility To address some fundamental concerns about the rigidity of the block allocation system, under which spectrum managers set aside blocks or bands of spectrum for specific uses, the report proposes that spectrum managers introduce additional flexibility into the allocation system. It suggests several ways of doing so, including increased sharing of spectrum between private sector and government users, increased flexibility in technical standards, and increased choices for users in employing their assigned spectrum.

Market-Based Spectrum Management Although changes in regulatory procedures and the block allocation system can improve spectrum management incrementally, the report concludes that greater reliance on market principles in distributing spectrum, particularly in the assignment process, would be a superior way to apportion this scarce resource among competing and often incompatible users.

To introduce this approach to spectrum management, the report recommends that the FCC be given the authority, through legislation, to make new assignments through a competitive bidding process. This approach would not apply to incumbent licenses or renewals, but only on a prospective basis to the grant of new licenses, and could exempt certain uses with a high "public interest" component.

The report also proposes that NTIA study the possibility of "leasing" spectrum from the federal government to private sector uses, as well as possibly explore establishing a fee system for federal government spectrum users, to encourage greater spectrum efficiency among such users, and to provide funds to improve management of federal spectrum.

Spectrum Use and Efficiency The report examines how spectrum use and efficiency can be quantified. It recommends increased use of advanced engineering techniques and computer data bases to permit more efficient measurement and management of spectrum uses.

Planning and Forecasting The report emphasizes the importance of long-range planning by the FCC and NTIA, not to micro-manage spectrum use, but to anticipate user needs and to avoid unnecessary conflicts among proposed uses. NTIA proposes to increase the level and quality of coordinated long-range planning with the FCC, and presents specific recommendations to meet that goal.

No one reform in isolation would be a panacea for the increasing pressures placed on U.S. spectrum management. However, the combination of reforms recommended in this study -- some regulatory, some market-based, some process-oriented, some technical -- will together create an improved spectrum management system for the United States as we move into the future.

SUMMARY OF RECOMMENDATIONS

Chapter 1 - Introduction

Chapter 2 - Regulatory Issues

● Openness of the Federal Process

- NTIA will provide a period at the beginning of meetings of the Interdepartment Radio Advisory Committee (IRAC) for members of the public to present new proposals for spectrum use or management and comments on spectrum policy issues, and to seek, in turn, the advice and perspectives of IRAC members on such proposals and issues.
- When practical, NTIA will publicize, and seek public comment on, major new policy proposals that could significantly affect the private sector. NTIA will make these proposals available through a dial-in, computerized, electronic bulletin board and by mail to parties interested in spectrum management. NTIA will also publish significant new policy proposals in the Federal Register.
- NTIA will begin to make non-classified NTIA and IRAC spectrum management documents readily available through a public reference room.
- NTIA will also place on its new electronic bulletin board IRAC agendas, issues under consideration in the IRAC and at NTIA, IRAC recommendations, and proposed NTIA decisions for review and comment.
- NTIA will, using existing resources, appoint a coordinator and staff as needed to act as a focal point for private sector access to IRAC meetings and NTIA policy decision makers.
- To clarify the roles of IRAC and NTIA, NTIA will appoint two IRAC vice-chairs. The first vice-chair, appointed from among the IRAC members, will work closely with NTIA to develop meeting agendas and with the agencies to develop positions on issues under review. The second vice-chair, appointed from the NTIA staff, will coordinate activities of the IRAC with the private sector.

● Advisory Bodies

- NTIA will seek to expand the current Frequency Management Advisory Council to include government sector as well as private sector representatives and to expand its role to include a strategic planning function.

● Spectrum Use Databases

- NTIA will investigate, with the assistance of the FCC, the establishment of a common frequency assignment database, with compatible, modern file formats, to provide comprehensive information on spectrum use in the United States.
- NTIA will seek to distribute NTIA frequency assignment data more widely. Thus, NTIA will re-evaluate the need for classifying all lists of individually unclassified Government Master File (GMF) records, in order to declassify, to the extent possible, GMF listings. NTIA will also explore ways to make specific data on spectrum use available that may satisfy some private sector requirements.
- As NTIA creates unclassified databases, it will examine methods of making them available, including remote on-line access for a fee. This proposal is contingent on NTIA having the resources to develop such access, as well as adequate resolution of the security issues discussed above. As resources permit, NTIA will also pursue developing access through read-only memory on compact discs (CD-ROMs).

● Access to Shared and Exclusive Federal Spectrum

- NTIA will establish impartial procedures to evaluate private sector requests for sharing use of the spectrum in bands allocated either exclusively or on a primary basis to the government. This could include requests for new systems seeking an allocation change or individual stations seeking authorization to operate on a specific frequency. Specifically, NTIA will undertake to:
 1. advise the FCC of any preliminary conclusions on allocation changes for use in FCC allocation and authorization decisions; and
 2. forward any objective data developed during consideration of private sector frequency assignment requests to the requesting party for use in preparing a license application, as well as to the FCC.

● The FCC Process

- NTIA recommends that the FCC consider imposing deadlines on its allocation rulemaking proceedings to accelerate the process. Although such deadlines could be imposed through legislation, we believe that a sounder and more flexible approach would be to have the FCC adopt and enforce such deadlines on a trial basis.
- NTIA recommends that the FCC undertake a program of further streamlining its processing functions. For example, the FCC could actively investigate additional proposals to speed the licensing process, such as an "instant" temporary licensing concept advocated by Digital Microwave Corporation. Moreover, even such ministerial improvements as an electronic application filing capability could ease concerns about timeliness and access expressed generally in the comments.
- The certified coordinating groups used by the FCC in the Private Land Mobile Radio Service (PLMRS) and the coordinating groups and consultants used by fixed service

licensees should be continued. The FCC should involve such coordinating groups in strategic planning for spectrum management.

- NTIA believes that the FCC should increase incentives for fairness, economy, and efficiency in private frequency coordination by:

1. accepting assignment applications directly from prospective licensees; or
2. investigating the possibility of certifying more than one coordination group for each suballocation subject to coordination.

- To facilitate these changes, the FCC should:

1. expand its data files to include all data required for frequency coordination;
2. develop the capability to permit on-line, dial-up access among coordinators and to the expanded files; and
3. use on-line access as a means of coordinating frequency assignment requests, granting licenses and updating the master file of frequency assignments.

- Domestic Spectrum Management Coordination

- NTIA proposes to formalize, together with the FCC, a Joint Strategic Planning Council, co-chaired by the Administrator of NTIA and the Chairman of the FCC.

- International Spectrum Coordination

- National policies on international spectrum management issues must be closely coordinated among NTIA, the FCC, and the State Department.

- NTIA will seek to:

1. review the procedures used for the development of policies on international spectrum management issues by incorporating the results of the ITU's High Level Committee process of the International Telecommunication Union (ITU);
2. make general improvements to the preparation process, emphasizing planning, coordination between groups, and an easily accessible database of international telecommunications activities;
3. encourage more involvement of the private sector in long-range preparations for international spectrum conferences with meaningful consultation on options; and
4. encourage establishment of a permanent telecommunications expert adviser position at the U.S. Mission in Geneva to provide expertise and continuity to the Mission in its dealings with the ITU.

Chapter 3 - The Block Allocation System and Flexibility

- General

- Although the basic structure of the block allocation system should be retained, NTIA and the FCC should seek to modify it in the next decade to increase flexibility.

- Enhancing Flexibility in Service Definitions

- NTIA strongly supports recent FCC efforts to increase flexibility in several services and recommends that the FCC conduct general proceedings to decrease the number of suballocations based on the type of user and to allow more sharing among the mobile radio services. NTIA also recommends that, when there is overlap and duplication among services, the FCC explore combining allocations for common carrier and private radio uses, such as microwave and land mobile.
- NTIA will evaluate and modify the federal government's mobile allotment plans as quickly as practicable, with the objective of reducing the barriers between federal mobile users through increased sharing of federal agencies' frequencies.
- NTIA will seek to work closely with the FCC to increase dynamic sharing techniques and innovative sharing arrangements.
- NTIA will also expand its Washington area trunking program to other areas and continue to encourage the use of trunked systems by federal agencies.
- Similar spectrum usage by federal and non-federal users should continue to be consolidated in shared bands.
- NTIA, after seeking the advice of the IRAC, will explore with the FCC ways for federal government and private sector users to share spectrum by extending the concept of federal procurement of private sector telecommunications services. For example, federal users could have a private contractor build and operate a "pooled" system using government spectrum to meet existing federal needs. As an incentive to operate most efficiently, the contractor could sell to the public any excess capacity on its system once federal needs were met as its first priority.

- Enhancing Technical Flexibility through Standards

- NTIA supports the FCC's objectives of reducing restrictive standards and encouraging technical flexibility, and shares the FCC's general preference for private sector standard-setting. However, when the market does not respond or there are no incentives for industry to agree on standards, the benefits of mandatory government standards may outweigh the costs and delays of the rulemaking process and the potential rigidity that such codification may impose.

- NTIA encourages the FCC to continue its efforts to increase technical flexibility for all services. NTIA also recommends that the FCC conduct rulemaking proceedings to determine those technical standards now codified in FCC rules that can be relaxed or eliminated.
- NTIA believes that when there is an established, expanding market for a technology, heavy government involvement in the setting of interoperability standards is often unnecessary. However, mandating interoperability standards may be useful for new technologies in services that involve substantial consumer participation or where there are public safety or national security concerns. NTIA is opposed to government-mandated performance standards.
- NTIA recommends that the FCC and NTIA jointly explore when, if ever, mandated standards are necessary to require greater technical spectrum efficiency.
- NTIA will continue to adopt standards that promote the most efficient operation of federal government spectrum-based systems, while maintaining a flexible spectrum management system.
- NTIA believes that the FCC has exercised reasonable judgment in not directly regulating receivers for use in the home. NTIA encourages the FCC to continue to foster spectrum efficiency, to the extent possible, through transmitter standards and by reducing distance and frequency separation requirements. However, mandated receiver standards may be appropriate when there are public safety or national security concerns or when complex sharing arrangements require receivers to have an active signaling function. The FCC should review such services on a case-by-case basis. NTIA is willing to work with the FCC to determine if there is a broader case for receiver standards.

- Increasing User Flexibility

- NTIA supports the FCC's existing approach in Part 15 of its rules for overlaying the use of nonlicensed devices across the allocated bands, believing it to be efficient and effective. However, NTIA proposes some modifications that may be necessary to ensure its long-term success.
- NTIA supports further efforts to promote user flexibility where warranted.
- NTIA will seek to work with the FCC to experiment with increasing user flexibility in frequencies above 10 GHz that are not currently heavily used. The program would allow a high degree of user flexibility with the only restriction being a minimum interference criterion or an electromagnetic compatibility control procedure.

Chapter 4 - Alternatives for Apportioning and Valuing Spectrum

- Market-Based Systems

- NTIA supports greater reliance on market principles in the U.S. spectrum management system.

- A market-based system for spectrum management would improve considerably the efficiency and fairness of the current U.S. system, and, if properly designed and implemented, can fully address concerns about such issues as competitive equity, spectrum "warehousing," and the preservation of socially-desirable services.

- A Proposal: The Assignment Process

- NTIA specifically proposes using market-based mechanisms for the government's initial distribution of spectrum to users and in subsequent private transfers among users.
- The FCC should be given the authority, through legislation, to make new assignments of spectrum licenses through a competitive bidding process.
- This competitive bidding system for assignments would not apply to incumbents and renewals.
- Successful competitive bidding would serve as an initial condition to obtaining a license, without changing the authority and conditions of the license itself.
- Moreover, competitive bidding need not apply to some specific "public interest" uses, to be determined by Congress or the FCC.
- The FCC should initiate rulemaking proceedings to decide on how a competitive bidding system should be implemented for different radio services. The FCC should consider such details as bidder qualifications, the form of competitive bidding, the basis for payment (e.g., flat fees, installment payments, or royalties), and the term of the rights awarded.

- Leases of Federal Spectrum to Private Sector Users

- NTIA intends to explore with the FCC the concept of "leasing" spectrum from the federal government to private sector users.

- User-to-User Transactions

- NTIA recommends that the FCC conduct an experiment in increasing private sector users' rights to transfer or "sublease" portions of their authorized spectrum to others. Such an experiment could be appropriate for spectrum above 10 GHz, or for spectrum reallocated from the federal government to private sector use.

- Fees

- Although NTIA prefers the market-based approach discussed above, NTIA intends to explore with the FCC various fee proposals that could apply when spectrum management objectives cannot be achieved through the market.
- NTIA plans to explore the potential benefits of establishing a system of user fees to promote greater efficiency among federal agency spectrum users and to provide a source

of revenue for federal spectrum management functions. NTIA will seek agency comment and work through the IRAC in examining such a fee program.

Chapter 5 - Spectrum Use, Efficiency, and Conservation

● Automated Computer Models

- NTIA will continue development of automated computer models for quantifying spectrum use, for both individual systems and for frequency bands. NTIA will seek to coordinate development and use of these models with the FCC and with the private sector.
- NTIA will pursue development of automated models for determining spectrum efficiency, and will encourage the FCC to do so as well.

● Data Availability

- The common frequency assignment database proposed in Chapter 2 should be designed to support engineering as well as administrative functions. In particular:
 1. The database should facilitate automated retrieval of spectrum use data; the addition, deletion, and modification of data fields; and the accommodation of assignments for diverse types of radiocommunication systems, without ambiguity. Various state-of-the-art database management techniques, such as relational and object-oriented database technologies, should be considered for the database.
 2. The database should include sufficient data to perform most types of large-scale engineering analyses. Specifically, data for receivers and passive systems should be included.
 3. NTIA will investigate the feasibility of obtaining equipment data directly from equipment manufacturers in order to improve the accuracy and consistency of the data and to reduce the burden on the applicants.

● Monitoring to Verify Spectrum Use

- NTIA will maintain its Radio Spectrum Measurement System to meet general measurement requirements, and to determine the actual use of particular bands when needed for making allocation decisions.
- As funding permits, NTIA will develop low-cost transportable monitoring systems for periodic long-term (several weeks or more) unattended occupancy measurements in congested areas and bands. NTIA will seek FCC cooperation in these monitoring efforts.

● Improving System Efficiency

- As practicable, NTIA and the FCC should vigorously pursue research on spectrum-related communications and the development of spectrum efficient technologies.

- To recognize directly private sector innovation in developing a wide variety of spectrum efficient radio technologies, NTIA, in conjunction with one or more industry groups, will seek to establish an annual award for an innovative technology or system that promises to improve significantly spectrum efficiency.
- Spectrum managers should consider whether cost-effective spectrum efficient technologies are available to relieve congestion problems before they allocate additional spectrum for a particular service or group of services. Typical approaches that can be used to increase spectrum efficiencies include trunking, cellular reuse, digital compression and coding, and spread spectrum techniques.

- Improving Band Efficiencies

- To promote band efficiency, NTIA will investigate the feasibility of working more closely with applicants to select frequencies.
- NTIA and the FCC should also periodically review frequency bands for possible repacking of station assignments.
- To facilitate repacking of assigned stations to use an allocation band more efficiently, NTIA and the FCC should require the use of radio equipment capable of being retuned over an entire allocation band.

- Eliminating or Combining Frequency Assignments

- NTIA will work with the IRAC to develop procedures for high-level certification of federal agencies' need for frequency assignments when they are requested or renewed. The FCC should also examine the feasibility of similar self-certification procedures for the private sector.

- Shared Systems

- To improve federal agency responsiveness to the regulations regarding separate government radiocommunication systems, NTIA will seek to require high-level certification of the need for a separate system when a proposal is submitted for review.

- Non-Radio Alternatives

- NTIA and the FCC should develop policies on the use of non-radio technologies as part of a coordinated effort to foster spectrum efficiency, when consistent with other public policies. NTIA and the FCC should develop additional regulatory or economic incentives for the use of alternative technologies in congested portions of the spectrum.
- In particular, NTIA and the FCC should examine the amount of spectrum allocated to the fixed service for wideband point-to-point microwave communication systems in light of recent advances in fiber optic technology and use.

Chapter 6 - Planning and Forecasting

● Spectrum Requirements Identification

- To promote effective long-range planning, the FCC should establish procedures to permit private-sector users and manufacturers to submit information on major new system developments that may affect spectrum use, particularly on those technologies or activities that will need allocation or service rules changes or will increase demand for current services.
- The common frequency assignment database proposed in Chapter 2 and discussed in Chapter 5 should be able to portray requirements in a way useful to planning. Additional data needed for planning includes system investment, numbers of equipment, mission criticality, and operational use.
- NTIA and the FCC should, on a scheduled periodic basis, monitor and measure spectrum occupancy of congested bands and locations to determine the level of spectrum use. Where feasible, the two agencies should coordinate and assist each other in these monitoring and measurement efforts to maximize the impact of their combined resources.

● Spectrum Forecasting

- To aid in long-range planning through forecasting, NTIA and the FCC should draw expert input from their constituent users to attempt to predict spectrum requirements for five years, ten years, and beyond. Users should identify specific trends and new technologies. The committee of federal and non-federal users, described in Chapter 2, should convene under the joint oversight of NTIA and the FCC to discuss and report on long-term future demands for spectrum.
- NTIA and the FCC should cooperate in developing spectrum-use trend analysis to predict congestion.
- Staff members at NTIA and the FCC should be designated to track technology trends by annually compiling information from trade publications, research and development centers, and market analysis reports.

● Long-Range Planning

- NTIA and the FCC should seek to institute a coordinated, strategic, long-range planning process. A two- to five-year planning cycle should be established with fixed target dates for public input and document publication. The output should be a formal joint FCC/NTIA plan that states goals, policies, and specific actions to provide for future spectrum requirements and improve spectrum management.
- To support this effort, NTIA and the FCC should assess, on a scheduled basis, the adequacy of allocated spectrum to meet the needs of the various radio services. These assessments should be closely tied to international allocation conferences.

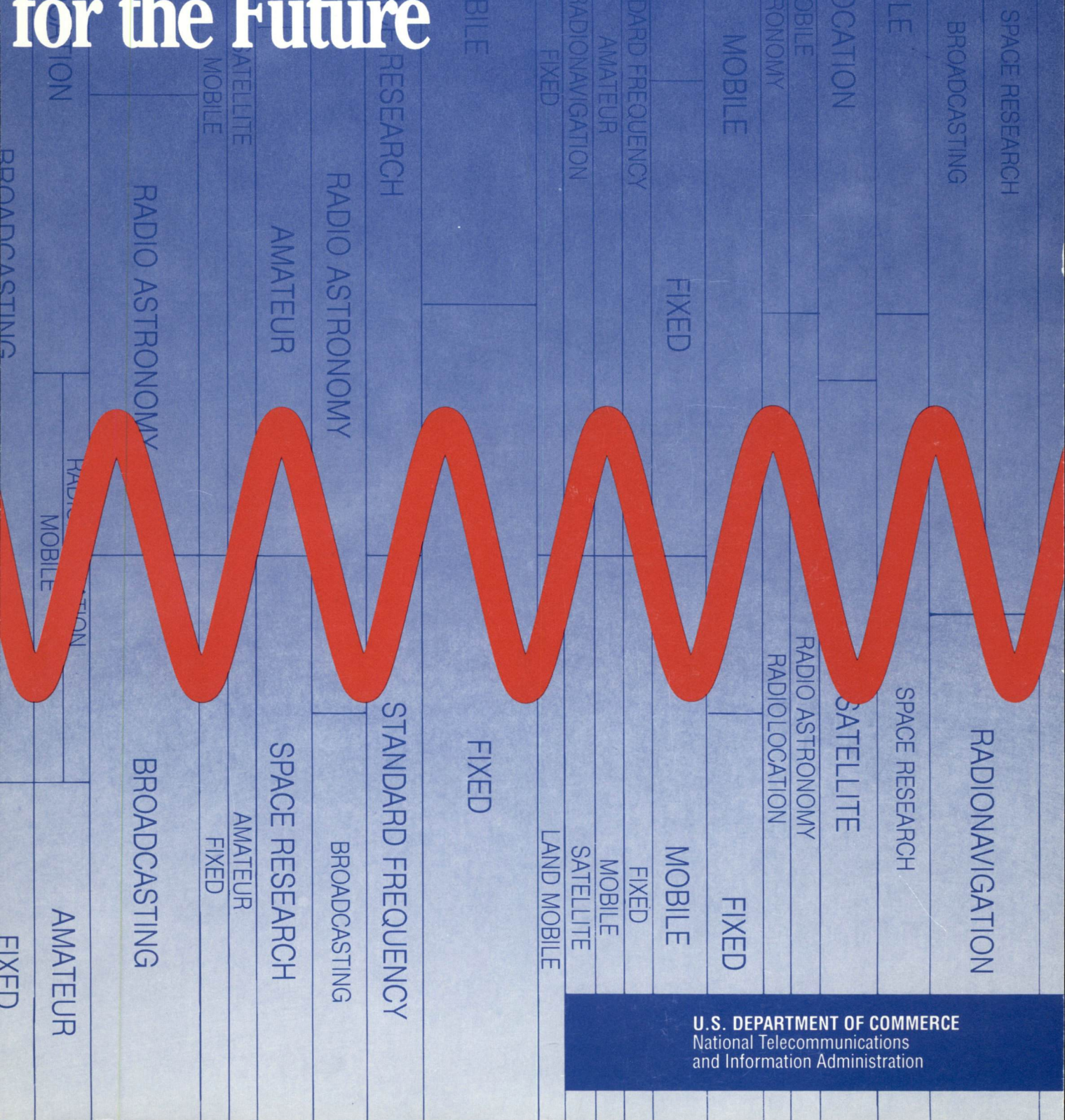
- Accommodating Unforeseen Requirements

- NTIA and the FCC should coordinate in developing strategies to meet those needs for the spectrum not foreseen during planning. While strategies based on flexibility and market-system incentives, as discussed in Chapters 3 and 4, may be the most desirable, more direct intervention by spectrum managers may be necessary.
- NTIA and the FCC should jointly analyze the costs, benefits and techniques for implementing spectrum reserves.

- Spectrum Planning Resources

- NTIA and the FCC should carefully allocate their limited staff and resources to meet critical spectrum management needs.

U.S. Spectrum Management Policy: Agenda for the Future



U.S. DEPARTMENT OF COMMERCE
National Telecommunications
and Information Administration

U.S. Spectrum Management Policy: An Agenda for the Future



U.S. DEPARTMENT OF COMMERCE

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ACKNOWLEDGEMENTS

The project team wishes to express appreciation for guidance from Thomas J. Sugrue, Deputy Assistant Secretary for Communications and Information. We also appreciate input received from the Frequency Management Advisory Council (FMAC).

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EXECUTIVE SUMMARY

Use of the radio spectrum is crucial to U.S. communications, and indeed, the national economy. In 1990, shipments of radiocommunications equipment were estimated to be over \$55 billion. Industries that use the spectrum, such as broadcasting and cellular telephony, also make substantial contributions to the economy, while other manufacturing and service industries use spectrum to increase their productivity. Moreover, spectrum use is essential to government functions ranging from defense and public safety to air traffic control and weather forecasting. U.S. policies for managing the spectrum must ensure that the spectrum is used efficiently and fairly while promoting innovation and serving users' needs. Protracted administrative procedures and inflexible regulation will not permit the United States to reach those goals.

Current spectrum management policies -- administered by the National Telecommunications and Information Administration (NTIA) for federal government users, and by the Federal Communications Commission (FCC) for all other users -- are under increasing strain as the demand for existing spectrum-based services grows, and new spectrum-related technologies and applications emerge. NTIA, in its role as federal spectrum manager and as the principal Executive branch adviser on telecommunications policy, prepared this report with the goal of benefiting all users of the spectrum resource.

This report makes specific proposals and recommendations in five areas:

Regulatory Issues The report first examines the regulatory processes of both NTIA and the FCC. NTIA will move to open its process of managing federal government spectrum use to permit a greater degree of public participation, by increasing the availability of information concerning federal spectrum use and by opening a portion of the meetings of the Interdepartment Radio Advisory Committee (IRAC) to the public. The report makes some suggestions for increasing the efficiency and speed of the FCC process, and recommends increased emphasis on NTIA-FCC coordination and on U.S. coordination on international spectrum issues.

The Block Allocation System and Flexibility To address some fundamental concerns about the rigidity of the block allocation system, under which spectrum managers set aside blocks or bands of spectrum for specific uses, the report proposes that spectrum managers introduce additional flexibility into the allocation system. It suggests several ways of doing so, including increased sharing of spectrum between private sector and government users, increased flexibility in technical standards, and increased choices for users in employing their assigned spectrum.

Market-Based Spectrum Management Although changes in regulatory procedures and the block allocation system can improve spectrum management incrementally, the report concludes that greater reliance on market principles in distributing spectrum, particularly in the assignment process, would be a superior way to apportion this scarce resource among competing and often incompatible users.

To introduce this approach to spectrum management, the report recommends that the FCC be given the authority, through legislation, to make new assignments through a competitive bidding process. This approach would not apply to incumbent licenses or renewals, but

only on a prospective basis to the grant of new licenses, and could exempt certain uses with a high "public interest" component.

The report also proposes that NTIA study the possibility of "leasing" spectrum from the federal government to private sector uses, as well as possibly explore establishing a fee system for federal government spectrum users, to encourage greater spectrum efficiency among such users, and to provide funds to improve management of federal spectrum.

Spectrum Use and Efficiency The report examines how spectrum use and efficiency can be quantified. It recommends increased use of advanced engineering techniques and computer data bases to permit more efficient measurement and management of spectrum uses.

Planning and Forecasting The report emphasizes the importance of long-range planning by the FCC and NTIA, not to micro-manage spectrum use, but to anticipate user needs and to avoid unnecessary conflicts among proposed uses. NTIA proposes to increase the level and quality of coordinated long-range planning with the FCC, and presents specific recommendations to meet that goal.

No one reform in isolation would be a panacea for the increasing pressures placed on U.S. spectrum management. However, the combination of reforms recommended in this study -- some regulatory, some market-based, some process-oriented, some technical -- will together create an improved spectrum management system for the United States as we move into the future.

SUMMARY OF RECOMMENDATIONS

Chapter 1 - Introduction

Chapter 2 - Regulatory Issues

● Openness of the Federal Process

- NTIA will provide a period at the beginning of meetings of the Interdepartment Radio Advisory Committee (IRAC) for members of the public to present new proposals for spectrum use or management and comments on spectrum policy issues, and to seek, in turn, the advice and perspectives of IRAC members on such proposals and issues.
- When practical, NTIA will publicize, and seek public comment on, major new policy proposals that could significantly affect the private sector. NTIA will make these proposals available through a dial-in, computerized, electronic bulletin board and by mail to parties interested in spectrum management. NTIA will also publish significant new policy proposals in the Federal Register.
- NTIA will begin to make non-classified NTIA and IRAC spectrum management documents readily available through a public reference room.
- NTIA will also place on its new electronic bulletin board IRAC agendas, issues under consideration in the IRAC and at NTIA, IRAC recommendations, and proposed NTIA decisions for review and comment.
- NTIA will, using existing resources, appoint a coordinator and staff as needed to act as a focal point for private sector access to IRAC meetings and NTIA policy decision makers.
- To clarify the roles of IRAC and NTIA, NTIA will appoint two IRAC vice-chairs. The first vice-chair, appointed from among the IRAC members, will work closely with NTIA to develop meeting agendas and with the agencies to develop positions on issues under review. The second vice-chair, appointed from the NTIA staff, will coordinate activities of the IRAC with the private sector.

● Advisory Bodies

- NTIA will seek to expand the current Frequency Management Advisory Council to include government sector as well as private sector representatives and to expand its role to include a strategic planning function.

- Spectrum Use Databases

- NTIA will investigate, with the assistance of the FCC, the establishment of a common frequency assignment database, with compatible, modern file formats, to provide comprehensive information on spectrum use in the United States.
- NTIA will seek to distribute frequency assignment data more widely. Thus, NTIA will re-evaluate the need for classifying all lists of individually unclassified Government Master File (GMF) records, in order to declassify, to the extent possible, GMF listings. NTIA will also explore ways to make specific data on spectrum use available that may satisfy some private sector requirements.
- As NTIA creates unclassified databases, it will examine methods of making them available, including remote on-line access for a fee. This proposal is contingent on NTIA having the resources to develop such access, as well as adequate resolution of the security issues discussed above. As resources permit, NTIA will also pursue developing access through read-only memory on compact discs (CD-ROMs).

- Access to Shared and Exclusive Federal Spectrum

- NTIA will establish impartial procedures to evaluate private sector requests for sharing use of the spectrum in bands allocated either exclusively or on a primary basis to the government. This could include requests for new systems seeking an allocation change or individual stations seeking authorization to operate on a specific frequency. Specifically, NTIA will undertake to:
 1. advise the FCC of any preliminary conclusions on allocation changes for use in FCC allocation and authorization decisions; and
 2. forward any objective data developed during consideration of private sector frequency assignment requests to the requesting party for use in preparing a license application, as well as to the FCC.

- The FCC Process

- NTIA recommends that the FCC consider imposing deadlines on its allocation rulemaking proceedings to accelerate the process. Although such deadlines could be imposed through legislation, we believe that a sounder and more flexible approach would be to have the FCC adopt and enforce such deadlines on a trial basis.
- NTIA recommends that the FCC undertake a program of further streamlining its processing functions. For example, the FCC could actively investigate additional proposals to speed the licensing process, such as an "instant" temporary licensing concept advocated by Digital Microwave Corporation. Moreover, even such ministerial improvements as an electronic application filing capability could ease concerns about timeliness and access expressed generally in the comments.
- The certified coordinating groups used by the FCC in the Private Land Mobile Radio Service (PLMRS) and the coordinating groups and consultants used by fixed service

licensees should be continued. The FCC should involve such coordinating groups in strategic planning for spectrum management.

- NTIA believes that the FCC should increase incentives for fairness, economy, and efficiency in private frequency coordination by:

1. accepting assignment applications directly from prospective licensees; or
2. investigating the possibility of certifying more than one coordination group for each suballocation subject to coordination.

- To facilitate these changes, the FCC should:

1. expand its data files to include all data required for frequency coordination;
2. develop the capability to permit on-line, dial-up access among coordinators and to the expanded files; and
3. use on-line access as a means of coordinating frequency assignment requests, granting licenses and updating the master file of frequency assignments.

- Domestic Spectrum Management Coordination

- NTIA proposes to formalize, together with the FCC, a Joint Strategic Planning Council, co-chaired by the Administrator of NTIA and the Chairman of the FCC.

- International Spectrum Coordination

- National policies on international spectrum management issues must be closely coordinated among NTIA, the FCC, and the State Department.

- NTIA will seek to:

1. review the procedures used for the development of policies on international spectrum management issues by incorporating the results of the ITU's High Level Committee process of the International Telecommunication Union (ITU);
2. make general improvements to the preparation process, emphasizing planning, coordination between groups, and an easily accessible database of international telecommunications activities;
3. encourage more involvement of the private sector in long-range preparations for international spectrum conferences with meaningful consultation on options; and
4. encourage establishment of a permanent telecommunications expert adviser position at the U.S. Mission in Geneva to provide expertise and continuity to the Mission in its dealings with the ITU.

Chapter 3 - The Block Allocation System and Flexibility

- General

- Although the basic structure of the block allocation system should be retained, NTIA and the FCC should seek to modify it in the next decade to increase flexibility.

- Enhancing Flexibility in Service Definitions

- NTIA strongly supports recent FCC efforts to increase flexibility in several services and recommends that the FCC conduct general proceedings to decrease the number of suballocations based on the type of user and to allow more sharing among the mobile radio services. NTIA also recommends that, when there is overlap and duplication among services, the FCC explore combining allocations for common carrier and private radio uses, such as microwave and land mobile.
- NTIA will evaluate and modify the federal government's mobile allotment plans as quickly as practicable, with the objective of reducing the barriers between federal mobile users through increased sharing of federal agencies' frequencies.
- NTIA will seek to work closely with the FCC to increase dynamic sharing techniques and innovative sharing arrangements.
- NTIA will also expand its Washington area trunking program to other areas and continue to encourage the use of trunked systems by federal agencies.
- Similar spectrum usage by federal and non-federal users should continue to be consolidated in shared bands.
- NTIA, after seeking the advice of the IRAC, will explore with the FCC ways for federal government and private sector users to share spectrum by extending the concept of federal procurement of private sector telecommunications services. For example, federal users could have a private contractor build and operate a "pooled" system using government spectrum to meet existing federal needs. As an incentive to operate most efficiently, the contractor could sell to the public any excess capacity on its system once federal needs were met as its first priority.

- Enhancing Technical Flexibility through Standards

- NTIA supports the FCC's objectives of reducing restrictive standards and encouraging technical flexibility, and shares the FCC's general preference for private sector standard-setting. However, when the market does not respond or there are no incentives for industry to agree on standards, the benefits of mandatory government standards may outweigh the costs and delays of the rulemaking process and the potential rigidity that such codification may impose.
- NTIA encourages the FCC to continue its efforts to increase technical flexibility for all services. NTIA also recommends that the FCC conduct rulemaking proceedings to determine those technical standards now codified in FCC rules that can be relaxed or eliminated.
- NTIA believes that when there is an established, expanding market for a technology, heavy government involvement in the setting of interoperability standards is often unnecessary. However, mandating interoperability standards may be useful for new technologies in services that involve substantial consumer participation or where there

are public safety or national security concerns. NTIA is opposed to government-mandated performance standards.

- NTIA recommends that the FCC and NTIA jointly explore when, if ever, mandated standards are necessary to require greater technical spectrum efficiency.
- NTIA will continue to adopt standards that promote the most efficient operation of federal government spectrum-based systems, while maintaining a flexible spectrum management system.
- NTIA believes that the FCC has exercised reasonable judgment in not directly regulating receivers for use in the home. NTIA encourages the FCC to continue to foster spectrum efficiency, to the extent possible, through transmitter standards and by reducing distance and frequency separation requirements. However, mandated receiver standards may be appropriate when there are public safety or national security concerns or when complex sharing arrangements require receivers to have an active signaling function. The FCC should review such services on a case-by-case basis. NTIA is willing to work with the FCC to determine if there is a broader case for receiver standards.
- Increasing User Flexibility
 - NTIA supports the FCC's existing approach in Part 15 of its rules for overlaying the use of nonlicensed devices across the allocated bands, believing it to be efficient and effective. However, NTIA proposes some modifications that may be necessary to ensure its long-term success.
 - NTIA supports further efforts to promote user flexibility where warranted.
 - NTIA will seek to work with the FCC to experiment with increasing user flexibility in frequencies above 10 GHz that are not currently heavily used. The program would allow a high degree of user flexibility with the only restriction being a minimum interference criterion or an electromagnetic compatibility control procedure.

Chapter 4 - Alternatives for Apportioning and Valuing Spectrum

- Market-Based Systems
 - NTIA supports greater reliance on market principles in the U.S. spectrum management system.
 - A market-based system for spectrum management would improve considerably the efficiency and fairness of the current U.S. system, and, if properly designed and implemented, can fully address concerns about such issues as competitive equity, spectrum "warehousing," and the preservation of socially-desirable services.

- A Proposal: The Assignment Process

- NTIA specifically proposes using market-based mechanisms for the government's initial distribution of spectrum to users and in subsequent private transfers among users.
- The FCC should be given the authority, through legislation, to make new assignments of spectrum licenses through a competitive bidding process.
- This competitive bidding system for assignments would not apply to incumbents and renewals.
- Successful competitive bidding would serve as an initial condition to obtaining a license, without changing the authority and conditions of the license itself.
- Moreover, competitive bidding need not apply to some specific "public interest" uses, to be determined by Congress or the FCC.
- The FCC should initiate rulemaking proceedings to decide on how a competitive bidding system should be implemented for different radio services. The FCC should consider such details as bidder qualifications, the form of competitive bidding, the basis for payment (e.g., flat fees, installment payments, or royalties), and the term of the rights awarded.

- Leases of Federal Spectrum to Private Sector Users

- NTIA intends to explore with the FCC the concept of "leasing" spectrum from the federal government to private sector users.

- User-to-User Transactions

- NTIA recommends that the FCC conduct an experiment in increasing private sector users' rights to transfer or "sublease" portions of their authorized spectrum to others. Such an experiment could be appropriate for spectrum above 10 GHz, or for spectrum reallocated from the federal government to private sector use.

- Fees

- Although NTIA prefers the market-based approach discussed above, NTIA intends to explore with the FCC various fee proposals that could apply when spectrum management objectives cannot be achieved through the market.
- NTIA plans to explore the potential benefits of establishing a system of user fees to promote greater efficiency among federal agency spectrum users and to provide a source of revenue for federal spectrum management functions. NTIA will seek agency comment and work through the IRAC in examining such a fee program.

Chapter 5 - Spectrum Use, Efficiency, and Conservation

● Automated Computer Models

- NTIA will continue development of automated computer models for quantifying spectrum use, for both individual systems and for frequency bands. NTIA will seek to coordinate development and use of these models with the FCC and with the private sector.
- NTIA will pursue development of automated models for determining spectrum efficiency, and will encourage the FCC to do so as well.

● Data Availability

- The common frequency assignment database proposed in Chapter 2 should be designed to support engineering as well as administrative functions. In particular:
 1. The database should facilitate automated retrieval of spectrum use data; the addition, deletion, and modification of data fields; and the accommodation of assignments for diverse types of radiocommunication systems, without ambiguity. Various state-of-the-art database management techniques, such as relational and object-oriented database technologies, should be considered for the database.
 2. The database should include sufficient data to perform most types of large-scale engineering analyses. Specifically, data for receivers and passive systems should be included.
 3. NTIA will investigate the feasibility of obtaining equipment data directly from equipment manufacturers in order to improve the accuracy and consistency of the data and to reduce the burden on the applicants.

● Monitoring to Verify Spectrum Use

- NTIA will maintain its Radio Spectrum Measurement System to meet general measurement requirements, and to determine the actual use of particular bands when needed for making allocation decisions.
- As funding permits, NTIA will develop low-cost transportable monitoring systems for periodic long-term (several weeks or more) unattended occupancy measurements in congested areas and bands. NTIA will seek FCC cooperation in these monitoring efforts.

● Improving System Efficiency

- As practicable, NTIA and the FCC should vigorously pursue research on spectrum-related communications and the development of spectrum efficient technologies.
- To recognize directly private sector innovation in developing a wide variety of spectrum efficient radio technologies, NTIA, in conjunction with one or more industry groups,

will seek to establish an annual award for an innovative technology or system that promises to improve significantly spectrum efficiency.

- Spectrum managers should consider whether cost-effective spectrum efficient technologies are available to relieve congestion problems before they allocate additional spectrum for a particular service or group of services. Typical approaches that can be used to increase spectrum efficiencies include trunking, cellular reuse, digital compression and coding, and spread spectrum techniques.

- Improving Band Efficiencies

- To promote band efficiency, NTIA will investigate the feasibility of working more closely with applicants to select frequencies.
- NTIA and the FCC should also periodically review frequency bands for possible repacking of station assignments.
- To facilitate repacking of assigned stations to use an allocation band more efficiently, NTIA and the FCC should require the use of radio equipment capable of being retuned over an entire allocation band.

- Eliminating or Combining Frequency Assignments

- NTIA will work with the IRAC to develop procedures for high-level certification of federal agencies' need for frequency assignments when they are requested or renewed. The FCC should also examine the feasibility of similar self-certification procedures for the private sector.

- Shared Systems

- To improve federal agency responsiveness to the regulations regarding separate government radiocommunication systems, NTIA will seek to require high-level certification of the need for a separate system when a proposal is submitted for review.

- Non-Radio Alternatives

- NTIA and the FCC should develop policies on the use of non-radio technologies as part of a coordinated effort to foster spectrum efficiency, when consistent with other public policies. NTIA and the FCC should develop additional regulatory or economic incentives for the use of alternative technologies in congested portions of the spectrum.
- In particular, NTIA and the FCC should examine the amount of spectrum allocated to the fixed service for wideband point-to-point microwave communication systems in light of recent advances in fiber optic technology and use.

Chapter 6 - Planning and Forecasting

● Spectrum Requirements Identification

- To promote effective long-range planning, the FCC should establish procedures to permit private-sector users and manufacturers to submit information on major new system developments that may affect spectrum use, particularly on those technologies or activities that will need allocation or service rules changes or will increase demand for current services.
- The common frequency assignment database proposed in Chapter 2 and discussed in Chapter 5 should be able to portray requirements in a way useful to planning. Additional data needed for planning includes system investment, numbers of equipment, mission criticality, and operational use.
- NTIA and the FCC should, on a scheduled periodic basis, monitor and measure spectrum occupancy of congested bands and locations to determine the level of spectrum use. Where feasible, the two agencies should coordinate and assist each other in these monitoring and measurement efforts to maximize the impact of their combined resources.

● Spectrum Forecasting

- To aid in long-range planning through forecasting, NTIA and the FCC should draw expert input from their constituent users to attempt to predict spectrum requirements for five years, ten years, and beyond. Users should identify specific trends and new technologies. The committee of federal and non-federal users, described in Chapter 2, should convene under the joint oversight of NTIA and the FCC to discuss and report on long-term future demands for spectrum.
- NTIA and the FCC should cooperate in developing spectrum-use trend analysis to predict congestion.
- Staff members at NTIA and the FCC should be designated to track technology trends by annually compiling information from trade publications, research and development centers, and market analysis reports.

● Long-Range Planning

- NTIA and the FCC should seek to institute a coordinated, strategic, long-range planning process. A two- to five-year planning cycle should be established with fixed target dates for public input and document publication. The output should be a formal joint FCC/NTIA plan that states goals, policies, and specific actions to provide for future spectrum requirements and improve spectrum management.
- To support this effort, NTIA and the FCC should assess, on a scheduled basis, the adequacy of allocated spectrum to meet the needs of the various radio services. These assessments should be closely tied to international allocation conferences.

- Accommodating Unforeseen Requirements

- NTIA and the FCC should coordinate in developing strategies to meet those needs for the spectrum not foreseen during planning. While strategies based on flexibility and market-system incentives, as discussed in Chapters 3 and 4, may be the most desirable, more direct intervention by spectrum managers may be necessary.
- NTIA and the FCC should jointly analyze the costs, benefits and techniques for implementing spectrum reserves.

- Spectrum Planning Resources

- NTIA and the FCC should carefully allocate their limited staff and resources to meet critical spectrum management needs.

CHAPTER 1 INTRODUCTION

Spectrum use is an essential element of the U.S. communications infrastructure, and as such, its effective management promotes continuing U.S. economic and social development. The current system of spectrum management has been reasonably successful to date, but problems are increasingly appearing as the demands placed on the system expand rapidly. It is imperative that U.S. spectrum management ensure that the spectrum resource is used efficiently and fairly while promoting innovation and serving users' needs. Protracted administrative procedures and inflexible regulation will not permit the United States to reach those goals.

Because use of the spectrum is a vital component of many communications systems, the United States has developed strong industries based in radio-related technologies. Shipments in radio communications equipment alone are estimated to be more than \$55 billion annually,^{1/} while revenues from broadcasting and cellular radio services, two industries built on spectrum use, are estimated to exceed \$30 billion annually.^{2/} The United States is highly competitive in the industries related to spectrum. It is a leader in the manufacture of satellite, microwave, and cellular radio equipment, as well as in innovative uses of radio technology for purposes ranging from new forms of mobile communications and advanced military applications to garage door openers and baby monitors.

However, in light of technological and marketplace changes, the United States must evaluate whether its spectrum management policies will permit it to continue in this leadership position. Demand for spectrum is growing rapidly from both the expanded use of existing services and the development of new services, such as personal communications services (PCS), satellite-based mobile services, digital audio broadcasting, and advanced television (ATV). While technical advances, the traditional means of meeting such growth in services, have been making more spectrum available, this increased supply is being overtaken by an even more rapidly increasing demand. Moreover, technology may be "pushing the envelope" of practicality, at least in the short term. How much more can technologists compress signals to permit additional use of increasingly crowded low frequencies? How useful will the higher frequencies be for inexpensive wireless communications? Accordingly, U.S. spectrum managers must ensure that their processes effectively promote, and provide strong private incentives for, efficient spectrum use. If, as many industry observers predict, the 1990s are to see the widespread deployment and strong consumer demand for mobile communications and advanced broadcasting services, the increased requirement for spectrum can only mean an increase in the challenges of managing spectrum to benefit the public. Successfully meeting

^{1/} U.S. Department of Commerce, Radio Communication and Detection Equipment in 1991 U.S. Industrial Outlook, at 31-1 (Jan. 1991).

^{2/} Cellular Telecommunications Industry Association, Data Survey (June 1990); R. Coen, Insider's Report #22, McCann-Erickson (Dec. 1990).

these challenges in the coming decade can make a critical contribution toward enhancing the competitiveness of the U.S. economy and the quality of life of our citizens.

U.S. spectrum management has traditionally combined centralized administrative decisionmaking and planning with private sector investment and initiative to develop radio-based services. Central management, with the National Telecommunications and Information Administration (NTIA) managing the federal government spectrum users and the Federal Communications Commission (FCC) managing the non-federal users, has served several important functions, such as providing clear regulatory authority and a framework of consistent practices to limit radio interference among users as new applications emerge. In part, this was a response to early disputes over interference among the radio broadcasters of the 1920s -- the so-called "radio wars." By reserving spectrum for potential future uses, centralized management has also helped to shape and define the developing communications infrastructure.

Concurrently, the reliance on private sector investment has also led to considerable success. For example, when radio broadcasting first came of age in the 1920s, the United States did not establish government-owned radio stations, nor did it choose to regulate radio communication as a public utility, despite the recommendations of the first radio conference convened by then-Commerce Secretary Herbert Hoover.^{3/} Instead, commercial broadcasters were allowed to establish themselves, and they prospered on the basis of selling paid advertising. Similarly, as technologies permitting efficient, two-way voice communications over radio spectrum developed, the United States relied on the initiative of common carriers and private radio operators to bring these services to the American public. One of the triumphs of U.S. communications policy is the successful development of a strong and independent system of privately-owned and operated radio-based services.

Those familiar with the history of spectrum management may find that the issues we have mentioned -- crowded spectrum, excess demand, technology placing pressures on the system -- seem familiar. Users, engineers, and politicians have struggled with similar spectrum management issues almost since the first practical application of radio, altered only by the specific context and the technology of the day. Current conditions raise questions as to whether the prevailing system of spectrum management continues to be both efficient and fair. To address such questions, in December 1989, NTIA released a Notice of Inquiry (the Notice) seeking information on key issues in spectrum use and management.^{4/} In response, we received 118 initial and reply comments from more than 100 different organizations and individuals.^{5/}

The extensive public response to the Notice is one indication that once again, the management and use of spectrum is an item of increasing national interest. Spectrum issues are moving to the foreground of communications policy debates. During the past year, spectrum use and management, a subject previously relegated to technical engineering and economics

3/ G.O. Robinson, The Federal Communications Act: An Essay on Origins and Regulatory Purpose, in A Legislative History of the Communications Act of 1934 at 9-10 (M.D. Paglin, ed. 1989) (Robinson Essay).

4/ Comprehensive Policy Review of the Use and Management of the Radio Frequency Spectrum, 54 Fed. Reg. 50,694 (1989) (Notice).

5/ See Appendix A for a complete list of all commenting parties. Appendix B contains abbreviations used throughout the document in discussing individual comments.

journals, found its place in major business and policy publications -- including a Business Week cover story, a Wall Street Journal editorial, and a National Journal feature article.^{6/}

In addition to the questions asked in the Notice, fundamental spectrum management issues are being raised throughout the federal government. The FCC has recently begun several spectrum-related proceedings that address aspects of these issues.^{7/} Moreover, legislative efforts are focusing national attention on managing and planning for future uses of the spectrum.^{8/}

NTIA, as the Executive branch telecommunications policy adviser and manager of federal government uses of the spectrum, has a strong interest in, and is well qualified to examine, these issues. In preparing this report, comments on the Notice provided one extremely valuable source of information for analysis. NTIA also considered both academic and technical research and FCC proceedings on spectrum issues, including proposals for new apportionment and regulatory strategies. This report avoids recreating existing work, but seeks to focus attention on how to accomplish the fundamental changes necessary to improve the current spectrum management system.

Considering the diversity and dynamism of the spectrum-using industries in the United States, NTIA believes that U.S. spectrum management should rely less on a centralized administrative system and more on private sector incentives to achieve national goals. Accordingly, we strongly support increased use of market mechanisms to apportion spectrum among private users, and increased flexibility to provide users with greater ability to determine for themselves how spectrum should be employed. Moreover, because of the extensive use of spectrum by the federal government as well as by the private sector, we strongly believe that the public should have increased access to the process by which NTIA manages federal spectrum. In this report, NTIA states its plans for increasing public access to the process.

While NTIA strongly recommends making these fundamental reforms, we recognize that much can be accomplished in the short term through specific changes to the existing system.

6/ See, e.g., Airwave Wars, Business Week, July 23, 1990, at 48; M.E. Kriz, Supervising Scarcity, The National Journal, July 7, 1990, at 1660; Congress's Wheel of Fortune, Wall Street Journal (editorial), July 27, 1990; see also P. Huber, Underground Networks, Forbes, Oct. 29, 1990, at 144; No Vacancies, Wall Street Journal, Nov. 9, 1990, at R14; A. Sikes, Brink of a Revolution, Newsweek, Jan. 14, 1991 at 8.

7/ See, e.g., Establishment of Procedures to Provide a Preference to Applicants Proposing an Allocation for New Services, Notice of Proposed Rule Making, 5 FCC Rcd 2766 (1990) (Pioneer's Preference); see also Amendment of the Commission's Rules to Establish Personal Communications Services, Notice of Inquiry, 5 FCC Rcd 3995 (1990) (Personal Communications Services); New Digital Audio Radio Services, Notice of Inquiry, 5 FCC Rcd 5237 (1990) (Digital Audio Broadcasting). The Chairman of the FCC recently announced his intention to develop a spectrum reserve for new communications uses. See remarks of Alfred C. Sikes, Chairman, Federal Communications Commission, Before the Practicing Law Institute (Washington, D.C., Dec. 6, 1990).

8/ S. 218, the Emerging Telecommunications Technology Act of 1991, 102d Cong., 1st Sess. (1991) and H.R. 531, the Emerging Telecommunications Technology Act of 1991, 102d Cong., 1st Sess. (1991); see also H.R. 2965, the Emerging Telecommunications Technology Act of 1989, 101st Cong., 1st Sess. (1989).

These changes include improving current procedures and data files, making better use of available measurement tools, establishing strategic spectrum management goals, and planning the steps needed to achieve those goals.

However, as in the past, the challenge of ensuring efficient and fair spectrum use will not be met by these "fixes" or by simply seeking to accommodate new users by moving existing users. Simply opening tracts of spectrum for reallocation will not necessarily result in long-term efficiencies. Only basic changes in the U.S. system can achieve that goal. The fundamental changes to the U.S. spectrum management system recommended in this report acknowledge that spectrum has economic value, and rely on marketplace incentives and a flexible regulatory system to maximize that value in the interests of the American public. Under our proposals, in encouraging new uses of the spectrum, current users would not be disadvantaged. Instead, incentives would exist and regulation would allow for these users to change and adapt as they find necessary. The FCC and NTIA would retain their central oversight role in controlling interference and assuring that socially necessary services reach the public. In this report, we seek a better balance between these important government roles and the fairness and efficiency provided by private ordering through use of the marketplace.

CHAPTER 2 REGULATORY ISSUES

I. Overview

A. General

This chapter examines the regulatory provisions and institutions that govern the current spectrum management process and identifies changes that would improve that process. As discussed in the Notice, U.S. spectrum management authority is divided between the FCC and the President. The Communications Act of 1934 (the "Act")^{9/} established the FCC and gave it the authority to assign frequencies to all radio stations in the United States, except for those belonging to the federal government. Under Section 305 of the Act, the President retains the authority to assign frequencies to the latter stations. The President has delegated this authority to the Secretary of Commerce, who has delegated it in turn to the Administrator of NTIA.^{10/} The Act provides for the functions of developing classes of service, allocating frequency bands to the various services, and authorizing frequency use. However, the Act does not mandate specific allocations of specific bands for specific services or for exclusive federal or non-federal use; all such allocations stem from agreements made between NTIA and the FCC that result in allocations to various services and classes of user. In other words, there are no statutory "federal" or "non-federal" bands.

NTIA and the FCC manage their particular constituents' uses of the spectrum; however, both must keep in mind the overall public interest, since 63% of the spectrum below 30 GHz is shared.^{11/} NTIA cannot be solely the advocate and protector of federal sector use, nor can

9/ 47 U.S.C. § 151 et seq.

10/ See Exec. Order No. 12,046, as amended, 3 C.F.R. 158 (1978), reprinted in 47 U.S.C. § 305 app. at 127 (1989); U.S. Department of Commerce, Department Organization Orders 10-10 and 25-7.

Section 2-401 of Exec. Order No. 12,046 provides that: "[t]he Secretary of Commerce shall serve as the President's principal adviser on telecommunications policies pertaining to the Nation's economic and technological advancement and to the regulation of the telecommunications industry." The Executive Order thus requires that NTIA, on behalf of the Secretary of Commerce, develop policies in the overall national interest, rather than limiting its scope to the interests of only the federal government agencies.

11/ National Telecommunications and Information Admin., U.S. Department of Commerce, Manual of Regulations and Procedures for Federal Radio Frequency Management, ch. 4 (May 1989 ed., rev. through May 1990) (NTIA Manual). This figure includes as shared that spectrum between 0 and 30 GHz allocated to both federal government users and to non-federal government users either within the allocation table itself or by footnote.

(continued...)

the FCC be solely the advocate and protector of private sector use. The two must work together for the public good.

B. Objectives of Spectrum Management

The Act provides limited guidance regarding spectrum management objectives. It states that the FCC is to regulate:

so as to make available . . . a rapid, efficient, Nation-wide, and world-wide wire and radio communication service with adequate facilities at reasonable charges, for the purpose of the national defense, [and] for the purpose of promoting safety of life and property.^{12/}

Title III of the Act authorizes the FCC to regulate generally the "channels of radio transmission," including the licensing and operation of radio stations, but provides few details on the FCC's objectives for spectrum management. The Act empowers the FCC to act consistently with the "public interest, convenience, and necessity." The "public interest" standard is the primary criterion for apportioning non-federal spectrum in the United States,^{13/}

11/(...continued)

The NTIA Manual is the principal document for federal government spectrum management policies, rules, and technical standards. NTIA maintains the NTIA Manual with the advice of the federal government agencies and issues necessary revisions several times a year. The NTIA Manual and all changes to it are incorporated by reference in 47 C.F.R. § 300.1 (1990).

12/ 47 U.S.C. § 151 (1989).

13/ See 47 U.S.C. §§ 302a, 303, 307(a), 308, 309, and 316 (1989).

Section 302a of the Act authorizes the FCC to regulate, consistent with the public interest, devices that interfere with radio reception.

Section 303 establishes the public interest standard for both allocation and assignment of spectrum. The section mandates the FCC to act "as the public convenience, interest, or necessity requires" in exercising general powers that include the classification of radio stations, prescribing the nature of service to be provided by each class of station, and setting aside bands of frequencies for classes of stations.

In addition, Section 307(a) directs the FCC to grant a station license to applicants, provided that the "public convenience, interest, or necessity will be served thereby" Section 308 establishes requirements for new or renewed licenses. Applicants must provide facts to the FCC showing (1) the applicant's citizenship, character, and financial, technical, and other qualifications to operate the station; (2) ownership and location of the proposed station; (3) desired frequencies and power levels; (4) proposed hours of operation; (5) the purposes for which the station will be used; and (6) any other information the FCC may require. Section 309 requires the FCC to determine for each application whether the public interest will be served by the granting of the application. Section 316 allows the FCC to modify any station license or construction permit at any time if it determines such action will promote the public interest, convenience, and necessity.

although the Act mentions the goals of preventing interference among stations, promoting the efficient use of spectrum, and promoting public safety.^{14/} The Act does not define the "public interest," but instead gives the FCC broad discretion to elucidate and give specific content to the public interest standard.^{15/}

NTIA has identified spectrum management objectives to guide federal users of the radio spectrum. These are similar in intent to the Act's guidelines and state that the federal agencies are to "make effective, efficient, and prudent use of the radio spectrum in the best interest of the Nation, with care to conserve it for uses where other means of communication are not available or feasible."^{16/} NTIA interprets the standard "effective, efficient, and prudent," and the reference to "the best interests of the Nation" as encompassing the overall benefits the American public derives from radiocommunication services, both federal and non-federal, as well as the needs of various federal users and choices among competing users.

Several commenters on the Notice state that goals and objectives of spectrum management should be clearly identified. They say that the goals and objectives should be to provide the widest possible range of wireless services to those who desire them, maximize the spectrum available to those who must depend upon wireless technologies, and assure maximum spectral efficiency.^{17/}

Recent legislative efforts have focused national attention on managing and planning for future uses of the spectrum.^{18/} NTIA believes that legislation is needed for some spectrum policy reforms, as described in the remainder of this study. Although the general objectives stated in the Act and in the NTIA Manual continue to provide guidance and flexibility to NTIA, the FCC, and spectrum users, this study makes numerous recommendations for regulatory reform to satisfy better those objectives.

14/ See, e.g., 47 U.S.C. §§ 302a, 303.

15/ See, e.g., FCC v. WNCN Listeners Guild, 450 U.S. 582 (1981). For a criticism of the public interest standard, see M. Fowler & D. Brenner, A Marketplace Approach to Broadcast Regulation, 60 Tex. L. Rev. 207 (1982).

16/ NTIA Manual, supra note 11, at § 2-1.

17/ See, e.g., Southwestern Bell Comments at 1-2; Contel Comments at 3.

18/ See supra note 8.

II. The NTIA Process

A. NTIA and the Federal Agencies

1. Current Arrangements

NTIA's authority in spectrum management policy is extensive. The governing Executive Order and OMB Circular No. A-11 clearly provide NTIA with the power to assign frequencies and approve the spectrum needs of new systems.^{19/} Federal users must obtain frequency assignments before they can operate transmitters. OMB Circular No. A-11 requires that federal users obtain certification of spectrum support from NTIA (certification that new radiocommunication systems are expected to be able to operate compatibly with existing and planned stations) before developing and procuring equipment.

Pursuant to the delegations from the President and the Secretary of Commerce, the Administrator of NTIA is the ultimate authority in all spectrum management decisions for the federal government, except for frequency assignment decisions, which can be appealed to the Director of the Office of Management and Budget.^{20/} The Administrator, in turn, has delegated most spectrum management decisions to the Associate Administrator for NTIA's Office of Spectrum Management (OSM), who draws upon the advice of the Interdepartment Radio Advisory Committee (IRAC). The current member agencies of the IRAC are the 20 most active federal users of the spectrum and a liaison representative from the FCC.^{21/} The IRAC reports to the OSM Deputy Associate Administrator, who presently serves as its chairman. The IRAC consists of a main committee, 3 subcommittees and over 20 ad hoc committees that consider various aspects of spectrum management policy.^{22/} NTIA provides to the IRAC

^{19/} Exec. Order No. 12,046, supra note 10, at §§ 2-201, 2-405 and 2-408. Office of Management and Budget Circular No. A-11 cited in NTIA Manual, supra note 11, at §§ 8.2.5, 10.0.2.

^{20/} Exec. Order No. 12,046, supra note 10, § 3-202.

^{21/} Section 2-502 of Exec. Order No. 12,046, supra note 10, enables the Secretary of Commerce to establish interagency advisory committees and, in this regard, specifically refers to the IRAC. Section 2-502 states, in part, the following:

As permitted by law, the Secretary of Commerce shall establish such interagency committees and working groups composed of representatives of interested agencies, and shall consult with such departments and agencies as may be necessary for the most effective performance of his functions. To the extent he deems it necessary to continue the Interdepartment Radio Advisory Committee that Committee shall serve in an advisory capacity to the Secretary

The Secretary of Commerce transferred the responsibility for telecommunications policy and spectrum management to NTIA via Department Organization Orders 10-10 and 25-7.

^{22/} The permanent subcommittees are:

The Frequency Assignment Subcommittee (FAS), which reviews agency requests for frequency assignments and recommends specific operating frequencies to government radio
(continued...)

Executive Secretariat support, technical advice and usually the chairmen of the subcommittees.

The primary function of the IRAC is to:

assist the Assistant Secretary [of Commerce, through the Deputy Associate Administrator of OSM] in assigning frequencies to U.S. Government radio stations and in developing and executing policies, programs, procedures and technical criteria pertaining to the allocation, management, and use of the spectrum.^{23/}

In addition, the IRAC forum provides a mechanism for coordinating federal use of the spectrum and resolving interference conflicts among the federal agencies that use the spectrum.

Representatives to the IRAC are able to propose new frequency assignments and new radiocommunication systems, or raise any other spectrum management issue of interest to their agencies, in the appropriate subcommittee. The IRAC considers each request and provides a recommendation agreed upon by the majority (normally a consensus) to the OSM, via the Deputy Associate Administrator (also the IRAC Chairperson), who accepts, rejects, or modifies the recommendation. Members can appeal findings of any subcommittee to the main committee or to the OSM at any time.

The meetings of the IRAC presently are not open to the general public, largely because they often involve review of considerable data on classified uses of the spectrum, examination of documents that are likely to be exempt under the Freedom Of Information Act (FOIA),^{24/} and deliberation and development of advice on federal policies.

2. Clarifying the Roles of the IRAC and NTIA

Since the IRAC chairman is the Deputy Associate Administrator of OSM and most of the subcommittee chairmen are also NTIA employees, it may appear to some that NTIA decisions are actually made by IRAC, or vice versa. The advisory role of IRAC and the

^{22/}(...continued)
stations.

The Spectrum Planning Subcommittee (SPS), which makes recommendations to NTIA on agency requests for spectrum support for new systems and is charged with planning for use of the spectrum.

The Technical Subcommittee (TSC), which develops new spectrum management standards for consideration by NTIA.

The membership on these subcommittees and the ad hoc committees includes representatives of agencies affected by the work of the committees.

^{23/} NTIA Manual, supra note 11, § 1.3.4

^{24/} 5 U.S.C. § 552 (1989).

decisionmaking role of NTIA should be clarified and the ability of the IRAC to develop independent policy proposals emphasized.^{25/}

In order to alleviate such concerns, NTIA will appoint two IRAC vice-chairs. The first vice-chair, appointed from among the IRAC members, will work closely with NTIA to develop meeting agendas and with the agencies to develop positions on issues under review. This executive position could strengthen the role of the member agencies and permit the IRAC to develop proposals more directly based on their views. The second vice-chair, appointed from the NTIA staff, will coordinate activities of the IRAC with the private sector.^{26/} This management structure will allow the IRAC to balance the views of the private sector more easily with those of federal users in developing recommendations to NTIA. It will also help NTIA in implementing the new procedures for private sector input discussed below.

B. Openness of the Federal Process

One aspect of federal spectrum management that has drawn widespread criticism is what the commenters on the Notice call its "closed" nature, due largely to the closed meetings of the IRAC and the generally perceived inaccessibility of NTIA decisionmakers to the public. In fact, because of this perceived "closed approach," many of the commenters express suspicions that federal spectrum use is inefficient. As one commenter says:

There is considerable suspicion and distrust on the part of the non-government users that the government is not using, or is not efficiently using, the spectrum allocated to it. Records of the government's use of the spectrum are not available to non-government users and thus a natural auditing mechanism is not at work.^{27/}

Some commenters even state that legislative action, like the Emerging Telecommunications Technologies Act of 1991, is needed to address these problems and extract unused frequencies from the government.^{28/}

One federal agency, the Coast Guard, also believes that greater openness is needed, stating:

[T]he best and most effective means for ensuring [that the] radio spectrum is managed fairly and efficiently is to ensure that it is done openly. . . . We

^{25/} This lack of clarity has often caused disagreement between NTIA and the IRAC representatives. For example, the Army states that, "NTIA has on occasion rejected the IRAC consensus. . . . The managerial relationship of the IRAC should be better defined or clarified by the NTIA." Army Comments at 1. Interior believes that the primary role of NTIA ought to be obtaining frequency resources for the federal users. Interior Comments at 1.

^{26/} This IRAC vice-chair will also be the point person for interactions between the public and NTIA spectrum managers. A more complete discussion of the NTIA/private sector coordinating position and duties of this position appears on page 26.

^{27/} CSAA Comments at 8.

^{28/} See MST Comments at 4; MRFAC Comments at 4-5; NYNEX Comments at 9; LMCC Comments at 12-13; GTE Service Corp. Reply Comments at 3.

believe that the NTIA process should be more accessible to the public, and that general data bases of UNCLASSIFIED frequency assignments (NTIA and [sic] as well as FCC) should be publicly accessible. . . . [M]aking the process of federal allocation as open as possible may well save time and protect federal use of the spectrum in the long run by cleaning up the "mystery" and associated feelings of secrets being kept (protectionism).^{29/}

Many commenters request release of data on federal use of the spectrum, but the commenters' concerns go beyond that. Together, the comments request greater openness in three areas:

Policy and Decisionmaking Several parties note that private sector users cannot formally comment on or appeal NTIA policies. They contrast this with FCC procedures, which provide an opportunity for all spectrum users, including the federal agencies, to comment on FCC spectrum management decisions as they are being made and to appeal them when necessary.^{30/}

General Accountability for Efficient Use of the Spectrum Resource Several commenters contend that the federal spectrum management process should be opened up to encourage or ensure efficient use of the spectrum by federal users and permit analysis of actual federal spectrum use to determine its efficiency.^{31/}

Access to Exclusive and Shared Federal Spectrum Some private sector users argue that it is difficult for non-federal users to gain access to spectrum allocated exclusively, or even on a shared basis, to the federal government.^{32/}

While we conclude that commenters' concerns about lack of openness have merit, we do note that they are, in certain respects, overstated. For example, they largely ignore the numerous avenues for private parties to provide their input into the federal process and sources of information already available.^{33/} Furthermore, some of the commenters' complaints reflect a lack of sensitivity about legitimate national security needs. Nevertheless, we agree that more openness in the federal process is both desirable as a matter of public policy and achievable as a matter of spectrum management. Private sector users have no formal methods for influencing NTIA policy or administratively appealing decisions. As USTA notes, NTIA has a responsibili-

^{29/} Coast Guard Comments at 6-7.

^{30/} See, e.g., MST Comments at 18-20; LMCC Comments at 12-13; GTE Service Corp. Reply Comments at 3; Coast Guard Comments at 6-7; USTA Comments at 5-6; API Comments at 10-11.

^{31/} See, e.g., NYNEX Comments at 9; NSF Comments at 6; Contel Comments at 12-13.

^{32/} See, e.g., LMCC Comments at 13; MRFAC Comments at 3-4; MMR Comments at 4-5; API Comments at 10-11.

^{33/} For example, the NTIA Manual, *supra* note 11, describes the procedures used by NTIA to process requests for spectrum allocation and authorization as well as all standards and rules applied to the federal users of the spectrum. In addition, every six months NTIA publishes summaries of the spectrum management activities proposed by IRAC and approved by NTIA and other spectrum management activities undertaken directly by NTIA. Semi-Annual Report of the Interdepartment Radio Advisory Committee (NTIA, Washington).

ty above that of an agent or advocate for federal users of the spectrum: "[C]ompeting users are dependent upon NTIA to ensure its management policies encourage the efficient use of the spectrum and provide incentives for development of new technologies."^{34/}

NTIA uses four mechanisms to obtain input from the public in making its spectrum management decisions: direct contact; coordination between the FCC and NTIA staffs at the IRAC and elsewhere; advisory bodies; and notices of inquiry. The commenters and others have made suggestions on how to improve these mechanisms. We address those suggestions, and discuss our initiatives in "opening" the federal system, in the following sections.

1. Direct Public Contact

a. Current Procedures

Private sector users often meet directly with the NTIA Administrator or Deputy Administrator, or the staffs of OSM and the Office of Policy Analysis and Development (OPAD) on such issues as use of frequencies allocated to the federal government for private purposes or on general policy concerns. OSM deals primarily with proposals directly affecting federal spectrum use, while OPAD often addresses more general communications policies. This direct, individual contact should and will continue, as it does in the FCC. However, because private users initiate contacts to pursue their own particular agendas, this mechanism should not be used as the primary source of public views for policy development. In receiving private sector input, we seek to ensure that our procedures are fair and impartial.

b. Direct Participation in IRAC

Some commenters recommend direct private sector participation in the IRAC, as either observers or full participants, as a way to obtain public participation in the decisionmaking process.^{35/} However, it is important to recall that NTIA, not the IRAC, is the decisionmaker for federal spectrum management policies; IRAC serves an advisory purpose that represents the views of federal agencies.^{36/} Thus, it is entirely possible that the IRAC may not follow private sector wishes in providing advice on the needs of the federal government.

The IRAC can, and does already, open its doors to private sector briefings and dialogue when specific issues are identified.^{37/} Because of the importance of cooperation and coordina-

^{34/} USTA Comments at 8.

^{35/} See, e.g., BellSouth Comments at 7; Contel Comments at 12-13.

^{36/} Although the IRAC By-Laws, which are contained in the NTIA Manual, supra note 11, § 1.4.2, provide that the role of the organization is to "function, when in Committee, in the interest of the United States as a whole," the individual IRAC members do tend, as a practical matter, to reflect the interests of their respective agencies.

^{37/} See, e.g., Agenda - 1471st Meeting - Nov. 14, 1990, of the IRAC, IRAC Doc. 27080, when representatives of the ALERT Users-Groups and Southwestern ALERT Users discussed their use of radio frequencies for flood alerting; Agenda - 1467th Meeting - Sept. 11, 1990, IRAC Doc. 26977, when representatives of the CYLINK Corporation discussed their Part 15 Spread Spectrum Systems; and Agenda - 1453rd Meeting - Feb. 13, 1990, IRAC Doc. 26713, (continued...)

tion between federal users and the private sector, NTIA will seek to formalize this policy by providing a period at the beginning of IRAC meetings for members of the public to present new proposals for spectrum use or management and comments on spectrum policy issues, and to seek, in turn, the advice and perspectives of IRAC members on such proposals and issues. This will add structure and regularity to the present informal, ad hoc procedures and should provide a useful exchange of information and viewpoints between private and federal users.

However, the benefits from increased public participation in IRAC must be balanced with the need to preserve the ability of federal agencies to develop advice on federal spectrum policies. When the IRAC is considering a federal position to be presented to the NTIA, the deliberations are likely to be predecisional under the FOIA. In addition, many proposals or issues before the IRAC involve consideration of classified information, which cannot be shared with the public. Thus, the initial portion of each IRAC meeting will be open to the public, followed by a closed portion for IRAC to consider classified matters and deliberate on policy proposals.

c. Procedures for Formal Public Comment to NTIA

Although commenters on the Notice seek to gain access to federal spectrum management decisionmaking processes, they propose to do so primarily through more open access to the meetings of the IRAC. NTIA believes that the federal process can be opened further, and will begin seeking public review of and comment on NTIA spectrum decisions that have a particular and substantial impact on private users. Under this proposal, the IRAC will continue to develop recommendations for action. When practical,^{37/} NTIA will publicize, and seek public comment on, major new policy proposals of NTIA, IRAC, or other specific users that could significantly affect the private sector. NTIA's procedures for these reforms will provide opportunities for all interested parties to receive such information and to comment. NTIA will make these proposals available through a dial-in, computerized, electronic bulletin board and by mail to parties interested in spectrum management. NTIA will also publish significant new

37/(...continued)

when representatives of International Mobile Machines, Inc. discussed their current digital land mobile systems.

38/ While the commenters appreciate the openness of the FCC procedures, they also acknowledge that the procedures can sometimes result in excessive and counterproductive delays in decisionmaking. See, e.g., ATA Comments at 6; Harris Comments at 8; FIT Comments at 3; GPT/Stromberg Comments at 7; USTA Comments at 8; MCI Reply Comments at 6; LMCC Comments at 42. Thus, there may be occasions when the requirements for timely response by NTIA outweigh the benefits of public comment. Even in these circumstances, NTIA will make information on the action available to the public after it has been taken.

There also may be some decisions that affect private users, but implicate national security or public safety concerns as well. In these cases, only limited information, if any, may be made available. There are also a number of cases in which NTIA, IRAC, and the FCC share information. When this information is likely to be exempt under FOIA as predecisional, or if it is otherwise likely to be publicly available, NTIA generally will not need to make the information available. As NTIA gains experience with these new procedures, it will assess their efficacy and seek to refine them to ensure that they are adequately fulfilling the goal of providing meaningful opportunities for public input on major federal spectrum policy decisions without jeopardizing other important federal interests.

policy proposals in the Federal Register. After considering all relevant comments, NTIA will explain its decision on the issue. Similarly, if a private party has a proposal for federal spectrum management action,^{39/} NTIA will, when appropriate, request and consider comment on the proposal from IRAC and other affected parties outside the IRAC.

These procedures will give the public greater access to the government's spectrum management and policymaking processes. They will also permit the federal agencies to understand how NTIA evaluates IRAC recommendations and the reasons for NTIA decisions. NTIA will continue to give the IRAC's recommendations due weight, but the public will have ample opportunity to comment on those recommendations. This should strengthen NTIA's ability to make balanced decisions on spectrum management issues and policies.

In addition to providing increased opportunities for comment on recommendations from the IRAC and other parties outside the IRAC, NTIA will begin to make all non-classified NTIA and IRAC spectrum management documents, and those that are unlikely to be exempt under the FOIA, readily available through a public reference room. NTIA will also place on its new electronic bulletin board IRAC agendas, issues under consideration in the IRAC and at NTIA, IRAC recommendations, and proposed NTIA decisions for review and comment. NTIA will also consider publishing lists and abstracts of the documents in the Federal Register, making them available to the press, and making copies of these documents available, at cost, upon request. If sufficient demand exists, NTIA will examine contracting with a private sector vendor to reproduce and sell copies.

NTIA will, using existing resources, appoint a coordinator and staff as needed to act as a point person for private sector access to IRAC meetings and NTIA decisionmakers.

2. Coordination through the FCC

FCC and NTIA have a long history of cooperative management of the spectrum. FCC is a liaison member of the IRAC, and the FCC and NTIA consult closely on spectrum management decisions. Both exercise limited veto rights when consulting together to resolve issues regarding shared spectrum. Some have expressed an expectation that the FCC would act as the representative of the private sector in NTIA spectrum management deliberations.^{40/} Some commenters, such as Bell Atlantic, recommend giving the FCC "a more formal position within IRAC, including full voting membership" to help ensure that "FCC views, as spokesman for the non-government users it licenses, are fully heard within the IRAC."^{41/}

As a practical matter, however, it is difficult for the FCC in its roles as liaison to IRAC and direct negotiator with NTIA to represent accurately all the individual concerns of the private sector groups that are interested in an issue. Thus, although continued close liaison between NTIA and the FCC and with the IRAC is extremely desirable and must be bolstered from a planning and policy development viewpoint, this approach should not be used as the sole source of public views for spectrum policy development by NTIA.

^{39/} Proposed procedures for requests for specific allocation or authorization requests are discussed infra, page 34.

^{40/} See, e.g., USDA Comments at 1.

^{41/} Bell Atlantic Comments at 13.

Indeed, the FCC, as a regulatory agency with a great deal of spectrum management authority, has a different status from that of the IRAC members, which are federal agency spectrum users that advise NTIA. Because the IRAC is an advisory body that provides federal user advice and information to NTIA, the FCC role as a liaison is to provide input to help the IRAC formulate its position, not to directly advise NTIA. Moreover, if the FCC staff were charged with taking formal positions and casting votes in the IRAC process, they might have a greater burden of obtaining clearance from the Chairman and Commissioners or, on delegated authority, the various Bureau and Office Chiefs with spectrum-related responsibilities.^{42/} This could make it difficult for the FCC to provide input to the IRAC process in a timely manner, which is a virtue of the present system of informal advice and consultation. Accordingly, we do not recommend any change to the status of the FCC vis-à-vis the IRAC.

3. Advisory Bodies

The Frequency Management Advisory Council (FMAC or Council) now provides advice to NTIA on spectrum management matters. FMAC is composed of "15 non-Federal members . . . appointed by the Secretary of Commerce to insure a balanced representation in such functional areas as manufacturing, analysis and planning, operations, research, academia, and international negotiations."^{43/} The chair of the FMAC is the Associate Administrator of OSM. The FMAC Objectives and Duties state that:

1. The Council will advise the Secretary of Commerce on radio frequency spectrum allocation and assignment matters and means by which the effectiveness of federal government frequency management may be enhanced.
2. Specifically, the Council will draw on the expertise of its members to:
 - (a) review, as appropriate, recommendations of the IRAC;
 - (b) review the progress of electromagnetic compatibility programs; and
 - (c) provide recommendations for United States positions on spectrum matters with respect to International Telecommunication Union conferences.^{44/}

While FMAC meetings are open to the public, the FMAC is not designed to provide day-to-day public input to NTIA. It is not tasked to obtain or present the views of the public on spectrum management issues. The FMAC therefore reflects only the views and considerable expertise of its members. MST argues that the FMAC is under-used.^{45/} While this sometimes may have been the case in the past, we believe it is less so in the present. In particular, it is NTIA's recent experience that when the FMAC has been given specific policies to review and tasks to complete, it provides effective, high quality, expert advice. For example, the FMAC

^{42/} On major policy issues, there might be prejudgment problems (or at least the appearance of such) if the same or similar issues were later to come before the FCC for decision.

^{43/} NTIA Manual, supra note 11, § 1.5.3. FMAC is subject to the provisions of the Federal Advisory Committee Act (FACA), 5 U.S.C. app. 2 § 9 (Supp. 1990).

^{44/} Id.

^{45/} MST Comments at 19-20.

has provided substantial advice and views on the Notice, and it will continue to play an important advisory role for NTIA.^{46/}

As noted above, we will seek to provide an opportunity for private sector and government agency representatives to interact during open portions of IRAC meetings. NTIA believes that such opportunities will allow for an interchange of information on spectrum management issues that would lead to better decisions and planning in both the private and government sectors. We also believe, however, that to maximize the interchange of information and to improve strategic planning aspects of spectrum management, other opportunities for public/private sector coordination and joint planning would be valuable. We conclude, therefore, that a private-sector/government-agency planning group consisting of experts from both the private sector and from the government agencies, should be established to provide input from both sectors for spectrum planning. This advisory committee could address both specific, immediate problems and long-term issues to assist NTIA and the FCC in developing rational, unified spectrum management plans and policies based on the best interests of the nation as a whole. Therefore, in addition to the openness provisions discussed at page 25, NTIA will seek to expand the current FMAC to include government sector as well as private sector representatives and to expand its role to include a strategic planning function.^{47/}

4. Notices of Inquiry

The Notice is an example of NTIA using a tool long used by the FCC, i.e., the notice of inquiry, to obtain private sector comment on a number of spectrum issues. Although an inquiry can be time-consuming, it provides notification of an intent to develop policy in a given area and an opportunity for the public to comment before the decisions are made. If NTIA uses this method regularly, however, it must ensure that issues affecting current or future non-federal use are identified early to obtain adequate private sector responses. This method is the only one currently being used by NTIA that provides an opportunity for organized public comment. As discussed above, NTIA intends to provide additional opportunity for public review of and comment on proposed NTIA spectrum management policies.

C. General Accountability for Efficient Use of the Spectrum - Access to Spectrum Use Data

1. The Need for Spectrum Data

Many private sector commenters contend that access to data on federal spectrum use would allow the private sector to determine where available spectrum might be found.^{48/} Various functions of spectrum management, including planning, frequency coordination, and resolution of interference problems, require knowledge of the electromagnetic environment --

^{46/} Both Senate and House versions of The Emerging Telecommunications Technology Act of 1991 would, in fact, rely upon an advisory committee very much like the FMAC to provide advice on how best to reallocate the spectrum from the government to the private sector and recommend changes to the current procedures of managing the spectrum by NTIA and FCC. H.R. 531, supra note 8, at § 4.d; S. 218, supra note 8, at § 4.d.

^{47/} These changes require a change in the FMAC charter. See FACA, supra note 43, at § 9.

^{48/} See, e.g., MRFAC Comments at 4-5; COMSAT Comments at 28-29.

that is, the aggregate of radio systems in use.^{49/} An organization planning to employ a new radio system chooses its frequency so as to preclude interference with existing systems. A user experiencing interference from another system often needs spectrum use data to identify the source of interference.

The primary sources of data on spectrum use in the United States are the frequency assignment and license data files maintained by NTIA and the FCC. NTIA's Government Master File (GMF) contains data on frequency use by the federal government. Information on frequency use by the private sector and by state and local government agencies is contained in the FCC's Master Frequency File. While this file has basically the same type of data as the GMF, the data formats in the two files are different.^{50/}

The GMF includes numerous classified records and records that the user agencies have stated are exempt from the release requirements of the FOIA. Moreover, NTIA classifies lists of two or more otherwise unclassified frequency assignment records from the GMF to prevent the disclosure of matters related to national security.^{51/}

2. Areas for Improvement in Access to Frequency Assignment Data

The record indicates that the current system of data files hinders access to spectrum use data in three ways. First, spectrum managers and users have no comprehensive source of spectrum use data for the United States. Second, the classification of government records limits their availability to the private sector. Third, data on current spectrum use is not available in a form amenable to automated analysis. We discuss these in turn below.

a. Comprehensive Data Sources

Information from both NTIA and FCC files is necessary to provide a complete picture of overall spectrum use, or of spectrum use in a shared frequency band. However, since the data files use different formats, combining and comparing the data are difficult tasks.

One solution suggested by several commenters is a unified database containing both government and non-government data.^{52/} A unified database, maintained by NTIA, the FCC,

^{49/} See infra Chapter 5 for a discussion of the difficulties inherent in comparing different uses of the spectrum.

^{50/} Further details of these and other relevant data files appear infra Chapter 5.

^{51/} The basis for this classification is explained on page 30-31.

^{52/} NSF states that:

A nationally-kept, publicly-accessible frequency assignment data base, which would incorporate both government and non-government assignments, would constitute an extremely valuable asset for the planning of scientific research and for tracking down sources of interference.

NSF Comments at 6. See also Bell Atlantic Comments at 3; US West Comments at 3-4; USTA Comments at 6; CTIA Comments at 4; McCaw Comments at 37; Ericsson Comments at 8.

or both, would provide a single source of spectrum use data in a consistent format. Software developed for government data would also work for non-government data or a combination of both. The unified database could also be designed to include the international data filed with and maintained by the International Frequency Registration Board (IFRB).^{53/} Administrative efficiency would be increased by eliminating the duplication of these efforts by NTIA and the FCC.

The implementation of a unified database, however, presents some difficulties. If NTIA and the FCC continue to retain their separate frequency assignment responsibilities, they would still represent two distinct sources of data for the database. Short-term administrative problems might also result from the shifting of database responsibilities.

Alternatively, and less expensively, the goal of compatible data sources could be realized without physically combining the data of NTIA and the FCC, as long as the data fields were made consistent in the respective files. As COMSAT notes:

There is an absolute need for comprehensive data bases of spectrum use. A centralized spectrum information bureau would be useful, but it would suffice if potential users had access to all necessary data, even if these data were not at the same location but rather were available from several known complementary sources. What is important is that the data should be correct, comprehensive and current.^{54/}

Based on the record compiled in the proceeding and our own experience in spectrum management, NTIA will investigate with the assistance of the FCC, the establishment of a common frequency assignment database, with compatible, modern file formats, to provide comprehensive information on spectrum use in the United States.^{55/}

b. Data Security

Since the early 1980s, NTIA has restricted access to lists of two or more frequency assignments from the GMF on national security grounds. NTIA's Security Classification Guide For Frequency Assignment Records provides for protection of lists of unclassified GMF records:

^{53/} For a discussion of international database requirements, see Handbook: Spectrum Management and Computer Aided Techniques, International Radio Consultative Committee, International Telecommunication Union, Geneva, Switzerland (1983 ed., rev. 1986) Annex IV.

^{54/} COMSAT Comments at 28-29. Under this type of system, NTIA and the FCC would each maintain their own frequency assignment records. As long as the data fields within these records are consistent, the NTIA and FCC files could be merged to create a comprehensive file. If, however, a relational database structure were used, as recommended in Chapter 5, records in several files (e.g., the equipment characteristics files) would pertain to both NTIA and the FCC and would require a cooperative effort.

^{55/} See infra Chapter 5 for a discussion of the details of such formats. The new common frequency assignment database could be implemented either as a single database on a single computer or, in a distributed system with separate, but compatible, NTIA and FCC databases and interlinked computers, depending on costs of implementation and any administrative difficulties identified.

Although most of the frequency assignment records in the GMF are unclassified per se, lists of unclassified frequency assignment records in a given range of frequencies or in a given area can be classified . . . because they can provide information leading to the disclosure of military or national security related operations, and scientific and technological matters relating to the national security. Such lists can indicate the overall strategic telecommunications capabilities of the United States and their disclosure could cause damage to the national security. The continued protection of this information is essential to the national security because it pertains to communications security and it reveals vulnerability and capability data, the unauthorized disclosure of which can reasonably be expected to result in nullifying the effectiveness of the telecommunications networks and capabilities of the United States.^{56/}

In short, virtually all listings of two or more frequency assignment records are currently classified, regardless of whether the individual records are classified.

Several private sector entities have expressed opposition to this classification of otherwise unclassified data.^{57/} The Coast Guard shares this view, stating: "We believe that . . . general databases of UNCLASSIFIED frequency assignments (NTIA. . . as well as FCC) should be publicly accessible."^{58/}

A reexamination of the need for classification of groups of unclassified assignments is warranted, given the 10-year period since the creation of the NTIA Classification Guide and the difficulties created by the consequent restrictions on data flow. Declassification of many lists of records may be appropriate. In addition, if certain unclassified records must be protected (e.g., records of assignments used in law enforcement) they might be protected via an FOIA exemption.

Besides declassification, another way of making records more available would be for NTIA to release lists of unclassified records on a "need to know" basis, i.e., when a group can demonstrate that the records requested are needed for coordination or for the resolution of interference. Another alternative, if it proves feasible, would be for specific entities, such as recognized private coordination groups, to obtain the proper security clearances for access to classified federal spectrum management data. These groups would be required to obtain the

^{56/} NTIA Manual, supra note 11, Annex C § 1.1.

Furthermore, "a list of frequencies" includes "[a] compilation of 2 or more complete or partial GMF frequency assignment records", "[s]tatistical summaries based on data from 2 or more GMF frequency assignment records", and "[m]aps or drawings showing data from two or more GMF frequency assignment records." id. § 3.1.

The Guide, while prohibiting the release of data by any second party including NTIA, makes provisions for a U.S. government agency to coordinate data on its own frequency assignments with "any other entity." id. § 2.1.

^{57/} See, e.g., AAR Comments at 12; NYNEX Comments at 11.

^{58/} Coast Guard Comments at 6-7.

needed clearance and to protect the data, but would be able to use the data in formulating their decisions.

Some private sector information requirements could be met without disclosing classified GMF data. For example, an entity requesting a license to operate a station in an exclusive government or shared band could be given a list of acceptable frequencies, instead of merely an answer on a specific frequency requested. Techniques such as the Spectrum Use Measure (described below in Chapter 5) could be used to convey information on government use of a band to the private sector, without disclosing classified information.

NTIA will reevaluate the need for classification of lists of unclassified GMF records, with a purpose of declassifying, to the extent possible, the GMF. NTIA will also explore ways to make specific data on spectrum use available that should satisfy most private sector requirements:

c. Physical Access

Paper listings of frequency assignments were once the only form of data file available. Today, such a listing is rarely adequate for spectrum management. Automated analysis of large numbers of assignments by NTIA, FCC, or users requires access to computer files with the necessary spectrum use data. A common means of obtaining data uses networked computers. One commenter states that "all non-classified NTIA databases should be available for remote (electronic) access by non-federal users and the FCC."^{59/} As NTIA creates non-classified databases, it will examine methods of making them available, including remote on-line access for a fee. This proposal is contingent on NTIA having the resources to develop such access, as well as adequate resolution of the security concerns discussed above.

NTIA also is developing an access method employing read-only memory (ROM) on compact discs (CDs). The CDs can be produced inexpensively and supplied to those who need the data. This method will eliminate the expense and potential security problems associated with providing network access to government computers, since if a comprehensive database is available on CD ROMs, private firms could obtain electronic access using their own computers. As resources permit, NTIA will pursue developing access through CD ROMs.

D. Access to Exclusive and Shared Federal Spectrum

Private sector commenters argue that they lack access to spectrum allocated to the federal government, claiming among other things, that "users must blindly file with the FCC in the hope that federal spectrum might somehow be available for their proposed operations."^{60/} MRFAC states that the concern applies to both shared and exclusive federal spectrum, and that:

Since non-government applications for shared spectrum cannot be designed at the outset to minimize interference to government users, the result is often unnecessary redesign, delay, and expense, when (and if) NTIA discloses the particulars of government usage for a given frequency. . . . [N]ew technologies or uses

^{59/} US West Comments at 3.

^{60/} LMCC Comments at 13.

for the spectrum are often stymied by the lack of information regarding government usage.^{61/}

In almost every shared band, either the government allocation or the non-government allocation has a primary status, with the other sector's allocation having a secondary status. Use of bands shared in this way is coordinated as if the band were allocated on an exclusive basis to the primary user; users wishing to operate on a secondary allocation are treated almost as if their service had no status in the band.

The private sector depends on NTIA to give full, equitable consideration to requests for spectrum access. However, NTIA, because of the spectrum management structure created in the Act, cannot directly authorize requests from the non-government sector for spectrum. NTIA can only make recommendations to the FCC, which the FCC considers in light of its internal policies when making decisions to approve specific operations. We discuss the issues pertaining to assignments and allocations in the next Subsection and offer a recommendation in the following subsection.

1. Frequency Authorizations and Allocations

Private sector requests for frequencies used by the government on a shared or exclusive basis are coordinated by FCC with NTIA and the federal agencies through the FAS. Ongoing coordination between the FCC and the federal agencies within the FAS on specific private sector requests for frequency authorization does not generally involve NTIA.^{62/} The FCC decides on private sector requests for federal spectrum after having examined, through the FAS, potential conflicts with federal users. If a non-federal user does not agree with the response that it gets from the FCC, the FCC must resolve the issue.

Using current, informal procedures for interacting with NTIA, private sector users that desire access to federal spectrum can continue to approach NTIA directly for support with the FCC. MMR requests that "a mechanism be established for informally coordinating government and non-government spectrum use so that private sector interests may have an informed basis for applying to the Federal Communications Commission for license authority."^{63/} Also, API "supports the development of more formal procedures to address and provide for direct private sector requests for federal spectrum."^{64/}

MRFAC asserts that:

[E]nterprises developing new technologies or uses for the spectrum are often stymied by the lack of information regarding government usage. In a typical

^{61/} MRFAC Comments at 3-4.

^{62/} Just as the FCC relies on private sector coordination groups, NTIA relies on the FAS to resolve conflicts and thereby arrive at an "approvable" assignment. The FCC and NTIA still have the granting authority; however, agreements on individual assignments developed by the coordinating groups or the FAS are likely to be approved.

^{63/} MMR Comments at 5.

^{64/} API Comments at 10. This already can occur, although, in most cases, NTIA submits the request to the IRAC for comment before responding.

scenario an entity files a spectrum allocation proposal with the FCC which in turn seeks the comment of NTIA. If NTIA objects, the petitioner may be told in only the most conclusory of terms what the government's problem is. There is no opportunity to hear the viewpoints of the various government agencies represented in the Interdepartment Radio Advisory Committee, much less comment on those viewpoints. Thus, there is little or no opportunity for efficiently designing an allocation proposal so as to avoid untoward effects on government usage.^{65/}

While we believe that these comments substantially understate the opportunities available to work with federal users in developing authorization and allocation proposals under current procedures,^{66/} we recognize that some private sector users find the current system too informal and *ad hoc*. Some of the reforms already discussed that would increase the openness of the federal process and the availability of spectrum use data should help respond to these concerns. Moreover, we present below a proposal to permit more direct interaction between NTIA and private sector users that wish to make use of federally allocated spectrum.

2. A Proposal: Develop Procedures for NTIA to Receive and Evaluate Private Sector Needs for Spectrum Directly

Given the interest expressed in the establishment of a more formal process for the consideration of private sector requests for use of spectrum allocated on an exclusive or shared basis to the federal government,^{67/} we believe that users and system developers from the private sector should be able to directly request assistance from NTIA. NTIA thus will establish procedures to be open to the private sector on an impartial basis, and to evaluate private sector

^{65/} MRFAC Comments at 4.

^{66/} If private sector users wish to approach NTIA, or be referred to the IRAC, to discuss how new private sector developments may best be made compatible with federal uses, there is nothing barring them from doing so now. The IRAC forum is useful for such discussions, and it has been so used in the past. The developers of the Codex Radio Local Area Network (RLAN), *see* DOD (Air Force) Comments at 7, and the LoJack system (IRAC Document No. 26063) are recent examples.

In the former case, the developer sought informal guidance from both the FCC and NTIA before identifying the frequency band 1700-1710 MHz as a candidate for an RLAN scheme. However, the widespread use of the band for the reception of weather satellite transmissions made the use of the band for the RLAN impossible, under the conditions desired by the developer, even though the proposed use was in conformity with the allocation tables.

In the second case, the developer, with the active support of the FBI, produced a device that uses frequencies allocated to the government for land mobile operations for tracking stolen cars. NTIA and the FCC were able to agree and approve on the use of a particular frequency for these devices.

These contacts have occurred through the direct mechanism mentioned above. There is no formal process whereby such proposals can be examined, until they have been presented to the FCC as requests for rulemaking.

^{67/} *See, e.g.,* GPT/Stromberg Comments at 7.

requests for sharing use of the spectrum in bands allocated either exclusively or on a primary basis to the government. This could include requests for new systems seeking an allocation change or individual stations seeking authorization to operate on a specific frequency. NTIA will advise the FCC of any preliminary conclusions on allocation changes for FCC use in allocation and authorization decisions.^{68/} In addition, NTIA will forward any objective data developed during consideration of private sector frequency assignment requests to the requesting party to prepare an FCC license application, as well as to the FCC.^{69/}

E. Policy Conclusions

The debate on the "openness" of federal spectrum management demonstrates that NTIA must consider the needs of the private sector in developing federal spectrum management policies. In addition, NTIA must provide more data on how the federal government uses the spectrum to assist private sector developers in their own planning. NTIA will use the public input it gains in its new processes to bolster analysis of the broad policy issues associated with the apparently technical matters that spectrum management decisionmakers and analysts often address within both NTIA and the IRAC. NTIA will continue to base its spectrum management decisions on the technical, economic, and societal merits of spectrum-use proposals, and not on the status of the proponents. NTIA will strive to conserve the spectrum as a natural resource for innovative uses and growing needs, and will seek to devise ways to recover "wasted" spectrum to meet future needs.

The reforms needed to accomplish this are not cost-free. In addition to the direct expenses involved in implementing these new procedures and avenues for public access, they will introduce some degree of delay in the federal decisionmaking process on spectrum policy issues. However, the potential benefits to be derived from the more equitable and comprehensive decisions that could result from increased public input should outweigh such costs. In implementing these reforms, NTIA will seek to maximize the net benefits while ensuring that costs are minimized and reasonable in light of the benefits obtained.

III. The FCC Process

The NTIA process, while relatively speedy and responsive to the needs of federal users, could be opened to more input from private sector interests, and we have outlined steps for doing so. In contrast, the FCC spectrum management process relies on extensive public proceedings to determine, under "public interest" standards, allocations and assignments. However, some commenters characterize the FCC process as slow and complex.

In the following subsections, we discuss fundamental reforms that could result in substantial long-term improvements in the FCC's spectrum management process by increasing regulatory flexibility and placing greater reliance on market principles. We start by briefly

^{68/} Formal coordination on private sector allocation requests will not be provided unless the FCC subsequently requests it, and formal comments from government users have been provided through the IRAC.

^{69/} Private sector users must understand that if methods to more directly coordinate frequencies with NTIA are formalized, time will still be required to assess the interference impact of dissimilar uses. A principal reason why private sector coordinating groups are able to work fairly rapidly is the uniformity of the equipment they analyze.

describing the FCC's allocation and assignment procedures and suggest a number of changes to the current procedures to address immediate concerns expressed by commenters.

A. Allocation

The FCC makes allocation decisions for non-federal spectrum use through public rulemakings that seek to determine the public interest.^{70/} Implementing domestic changes to the non-federal portion of the allocation table through this process can be time-consuming and contentious, often lasting several years.

Numerous commenters state that the allocation process should be streamlined or improved. GPT/Stromberg claims that the expense and delay of the "existing regulatory process hampers the technical and market development of significant telecommunications services in the United States."^{71/} USTA believes that the FCC should act to reduce delay in allocation decisions.^{72/}

Harris describes a lengthy rulemaking in which it petitioned the FCC in 1979 to change a sub-channel bandwidth within an allocation in the 17.7-19.7 GHz band. Four years were required to rechannelize, causing substantial delay before the industry could start production.^{73/}

MCI supports a more flexible allocation process. It states that there have been situations:

in which delays in the allocation process have effectively retarded deployment of new technology. . . . When decisions languish, existing allocations become more congested and they can no longer adequately address user needs. In these circumstances, the growth of radio systems is impeded, and the public that relies upon the services they provide is inconvenienced.^{74/}

NYNEX advocates the imposition of time limits for FCC action at each stage of a proceeding. It states that unless deadlines are tightened, the process will become increasingly contentious and drawn out as competition increases. NYNEX recommends that the FCC adopt a rule requiring that within six months of receipt of reply comments for a spectrum rulemaking, the FCC should grant the requested allocation, deny it, or issue a Further Notice.^{75/} Similarly,

^{70/} The FCC is subject to the procedural requirements of the Administrative Procedure Act, 5 U.S.C. §§ 551-59, 701-706 (1989).

^{71/} GPT/Stromberg Comments at 7.

^{72/} USTA Comments at 8.

^{73/} Harris Comments at 4.

^{74/} MCI Reply Comments at 6.

^{75/} NYNEX Comments at 8.

CTIA suggests that the FCC commit in writing to conclusion dates at the beginning of a proceeding and devise a means of making the dates meaningful.^{76/}

API, however, argues that "[t]here should be no effort to streamline the existing allocation process. . . . [T]he safeguards built into the existing process, such as they are, remain essential to preserving the rights of other interested parties."^{77/} Ameritech, ATA, and BellSouth indicate that, regardless of what reforms are pursued, the FCC's "public interest" standard should be maintained in the allocation process.^{78/}

A number of parties support increased resources for the FCC. For example, GTE says that the resource requirements of the FCC should be carefully reviewed in the light of its current responsibilities, and that adequate provisions should be made to permit needed enhancements to the spectrum management process.^{79/}

Delays in the FCC rulemaking and allocation process can seriously affect the economic vitality of businesses attempting to introduce new spectrum-based technologies. In this manner, the regulatory process itself can become an impediment to innovation and a barrier to entry into spectrum-related markets. This situation can be particularly burdensome for smaller firms, which may lack the resources to withstand substantial regulatory delay. NTIA recommends that, as suggested by NYNEX and CTIA, the FCC consider imposing deadlines on its rulemaking proceedings to accelerate the process. Although such deadlines could be imposed through legislation, we believe that a sounder and more flexible approach would be to have the FCC adopt and enforce such deadlines on a trial basis.

B. Frequency Assignment

Within particular allocations, the FCC assigns spectrum through various means for different services. If the characteristics of a service require competing applications for a license, the FCC chooses licensees through either an adjudicative comparative hearing process,^{80/} or by lottery.^{81/} When users are not assigned exclusive use of a frequency, the FCC

^{76/} CTIA Comments at 4. These proposals are consistent with general recommendations made in 1979 by the American Bar Association (ABA). The ABA recommended that the FCC establish deadlines for general classes of proceedings, such as rule makings, and implement procedures for enforcing deadlines and making exceptions when necessary. Federal Regulation: Roads to Reform, Commission on Law and the Economy, American Bar Association (1979).

^{77/} API Comments at 7.

^{78/} See ATA Comments at 19; Ameritech Comments at 6; BellSouth Comments at 2.

^{79/} GTE Reply at 5; see also UTC Comments at 3-4.

^{80/} 47 U.S.C. §§ 307, 309(e) (1989); see also Ashbacker Radio Corp. v. FCC, 326 U.S. 327 (1945); Johnston Broadcasting Co. v. FCC, 175 F.2d 351 (D.C. Cir. 1949).

^{81/} 47 U.S.C. § 309(i) (1989). The FCC first employed lotteries in 1983 to process cellular telephone and low power television applications, and has since increased the number of services licensed by random selection. See, e.g., Amendment of the Commission's Rules to Allow the Selection from Among Mutually Exclusive Competing Cellular Applicants Using Random (continued...)

will generally grant licenses on a "first-come, first-served" basis until a frequency or band is fully "loaded" -- that is, until the FCC determines that further users would interfere with the operations of others.

Some commenters criticize comparative hearings as being overly time-consuming and expensive to applicants as well as to the FCC,^{82/} although others support them.^{83/} Commenters state that, ironically, the substantial record gathered in the course of such lengthy and expensive proceedings may not materially assist decisionmaking because sometimes there are relatively few objective criteria available to the FCC to apply in distinguishing among competing applicants.

A comparative hearing imposes substantial costs on the FCC as well as the applicant.^{84/} The FCC has said that "the substantial time consumed in the process of selecting among competing applicants greatly disserves the public," and noted that the average hearing case takes almost three years to complete through a hearing, initial decision, review board decision, and Commission decision.^{85/} To address such concerns, the FCC recently adopted new rules to

81/(...continued)

Selection or Lotteries Instead of Comparative Hearings, 98 FCC 2d 175 (1984), on recon., 101 FCC 2d 577, on further recon., 59 R.R. 2d 407 (1985) (Cellular Lotteries).

82/ See, e.g., GTE Comments at 10-11; LMCC Comments at 42. According to NBC, FCC broadcast license renewal procedures should be revised to ensure that licensees providing an adequate level of service not be subjected to comparative renewal challenges every five years. NBC Comments at 11.

83/ See, e.g., NPR Comments at 17; see also NYNEX Comments at 33.

Many parties that support the use of comparative hearings over lotteries also acknowledge their drawbacks. FIT, while supporting comparative hearings over lotteries, also states that "it might take the wisdom of Solomon to continue to assign frequencies based on the public interest" FIT Comments at 7. LMCC and McCaw both note that timeliness can be adversely affected by comparative hearings, but argue that these delays may be minimized by streamlining and simplifying comparative hearing procedures through stricter threshold qualifications such as a firm financial commitment, a site availability agreement, and an independent engineering analysis. McCaw proposes that the FCC use more objective and relevant selection criteria, and institute additional rules against speculation. LMCC Comments at 41-42; McCaw Comments at 33-34; McCaw Reply Comments at 14.

84/ A 1985 FCC staff paper discussed three types of costs involved in comparative hearings: the cost to the federal government, the cost to applicants, and the cost of delay in making assignments. E. Kwerel & A.D. Felker, Using Auctions to Select FCC Licensees, Federal Communications Commission, Office of Plans and Policy, at 11-15 (working paper, May 1985). The paper estimated the average cost per hearing of comparative hearings for cellular radio licenses to be about \$20,000 to the FCC, and \$130,000 to applicants. Both estimates concerned cellular service applications. The cost to the FCC was based on the salary costs of the 13 professionals who worked two years to dispose of the Round I cellular comparative hearings. The applicant cost was estimated based on cellular industry officials. Id. at 30.

85/ Proposals to Reform the Commission's Comparative Hearing Process to Expedite the Resolution of Cases, Notice of Proposed Rule Making, 5 FCC Rcd 4050 (1990).

expedite its comparative hearing process for new applicants. The new rules are intended to encourage settlements (but limit such settlements to the payment of expenses); expedite pre-hearing discovery; encourage written rather than oral proceedings; impose other time limits; and expedite appeals.^{86/} Although these procedural changes do not eliminate some of the difficulties inherent in performing the comparisons required in these hearings, they should result in a somewhat more streamlined process. In other proceedings, the FCC has sought additional reforms in the comparative process, such as a limitation on settlement payments in cases involving competing applications for construction permits for new broadcast stations, and changes in various aspects of comparative hearings in the broadcast license renewal context.^{87/}

The FCC instituted lotteries for some services after congressional authorization in 1982, as a spectrum management reform measure.^{88/} Some parties support lotteries as an alternative to the time-consuming and intricate comparative hearing process.^{89/} The FCC uses lotteries for such services as cellular radio and specialized mobile radio licenses.

The lottery process, however, has been criticized on at least three grounds: 1) lotteries are inappropriate in situations where there are public interest differences among license applicants, or contenders propose truly diverse or innovative systems;^{90/} 2) lotteries encourage

86/ See Proposals to Reform the Commission's Comparative Hearing Process to Expedite the Resolution of Cases, Report and Order, Gen. Docket 90-264 (released Dec. 21, 1990).

87/ See, e.g., Settlement Agreements Among Applicants for Construction Permits, Notice of Proposed Rulemaking, 5 FCC Rcd 3921 (1990); Policies and Rules Relating to Broadcast Renewal Applicants to the Prevention of Abuses of the Renewal Process, Third Further Notice of Inquiry and Notice of Proposed Rulemaking, 4 FCC Rcd 6363 (1989).

88/ See generally Cellular Lotteries, supra note 81.

89/ As LMCC states: "The strength of the lottery process is its ability to expedite the assignment of spectrum as well as to choose equitably from among a large number of competing applicants." LMCC Comments at 41.

Under the 1982 amendment to the Act that instituted lotteries, preferences may be awarded to applicants who would increase the diversity of mass media communications ownership and to applicants controlled by members of minority groups. 47 U.S.C. § 309(i)(3)(A) (1989).

90/ GTE notes that in the current satellite services, for example, contenders for spectrum "propose widely diverse technology and designs." GTE Comments at 11.

UPS believes that lotteries are "ill-suited" for frequency assignments to new technological applications, stating that submitting an innovator who has incurred extensive research costs to a "gamble" is "not only unfair but also creates serious disincentives." UPS Comments at 7.

speculators, who flood the FCC with applications;^{91/} and 3) particularly in the case of cellular licenses, lottery "winners" obtain extremely valuable rights with little initial investment.^{92/}

In addition to comments on specific FCC assignment processes, parties raise more general points. As with allocations, commenters criticize the delays in the FCC assignment process, arguing that the application procedures for licensing should be simplified. For example, Telocator claims that assignments must be made expeditiously to enable prompt delivery of service to the public.^{93/}

McCaw contends that an "ideal" spectrum assignment system would ensure that only bona fide entities were permitted to participate and that assignment decisions were based on an evaluation of which applicant would offer the best service to the public. McCaw believes that both the comparative hearing and lottery processes have flaws, and that lotteries have been unsuccessful in the cellular service. McCaw proposes that the FCC impose additional threshold criteria to guard against "insincere" applicants. Such criteria could include requirements concerning financial commitment, site availability, and technical requirements. McCaw further states that the FCC should use an "objective selection criteria" relating directly to the service to be assigned.^{94/}

Contel claims that the licensing system should provide incentives to promote efficient use of frequency bands, such as preferences in awarding licenses to those applicants who propose the use of more efficient technology.^{95/} RTT advocates a form of "pioneer's preference" for experimental licenses associated with new technologies: "experimental licenses should be granted with a clear understanding that if the technology succeeds in commercially establishing itself, licensees will be given the right to expect either permanent rule authorization or continued operation under a waiver, so as to complete commercial deployment and recoup their investment."^{96/}

DMC suggests eliminating waiting periods in the licensing process for point-to-point microwave operations using spectrum at 10 GHz and above, through a user self-certification

91/ McCaw notes that some speculators seek profit in settlement agreements, and adds that problems were compounded in the case of cellular lotteries by the lack of significant threshold requirements for applicants. McCaw Comments at 31. LMCC also suggests that speculation problems could be reduced by enforcement of stricter threshold requirements for applicants, and stringent limits on settlement payoffs. LMCC Comments at 42. See also NYNEX Comments at 35 (noting the huge increase in cellular lottery applications after the FCC eliminated financial qualifications); Southwestern Bell Comments at 9 (stating that "the doors have been opened too wide" in lotteries for speculators).

92/ See, e.g., GTE Comments at 12 and MMR Comments at 8 (both referring to "instant millionaires" that can sell the license at a huge profit). See also FIT Comments at 7; Contel Comments at 8; Southwestern Bell Comments at 9.

93/ See Telocator Comments at 16-19.

94/ McCaw Comments at 28-37. See also NYNEX Comments at 35-37.

95/ Contel Comments at 3-4.

96/ RTT Comments at 10.

process. This would be similar to the process instituted by the FCC in the land-mobile area in 1989.^{97/} According to DMC, there is ample spectrum available in the microwave bands above 10 GHz and current coordination practices virtually eliminate the risk of interference. As a result, DMC claims that almost all microwave applications in those bands are routinely granted. DMC petitioned the FCC in May 1989 to examine the possibility of adopting an "instant" temporary licensing scheme for common carrier and private point-to-point microwave operations in the 10 GHz, 18 GHz, and 23 GHz bands, similar to that adopted by the FCC in certain private land mobile operations.^{98/}

The FCC has been active in searching for ways to improve its processes in order to make spectrum management more efficient and to encourage innovation. In addition to the procedural rules to reform the comparative hearing process discussed above, the FCC has proposed to establish a so-called "pioneer's preference" to promote innovation^{99/} and a "finder's preference"^{100/} to encourage full use of the allocated spectrum. NTIA applauds these initiatives by the FCC to reform its processes and improve its service to the public.

In addition to the major reforms discussed in Chapters 3 and 4, NTIA recommends that the FCC undertake a program of further streamlining its processing functions. For example, the FCC could actively investigate additional proposals to speed the licensing process, such as the "instant" temporary licensing concept advocated by DMC. Moreover, even such ministerial improvements as an electronic application filing capability could ease the concerns about timeliness and access expressed generally in the comments.

C. Private Sector Frequency Coordination Groups

1. Introduction

Under FCC rules, prior to applying for a station license for certain services, an applicant must provide technical coordination information or evidence of "prior coordination" of the station with existing stations.^{101/} Private groups often perform this prior coordination function. In the Private Land Mobile Radio Services (PLMRS), the FCC has certified groups

97/ Amendment of Part 90 of the Commission's Rules to Implement a Conditional Authorization Procedure for Proposed Private Land Mobile Radio Services, Report and Order, 4 FCC Rcd 8280 (1989).

98/ DMC Comments at 3-4; see Amendment of Parts 1, 2, 21, and 94 to Implement a System of Instant Temporary Licensing for Point-to-Point Microwave Operations in the 10, 18, and 23 GHz Bands, Petition for Rulemaking, RM-6909 (filed May 1, 1989.) DMC's proposal would apply to frequency bands that do not require prior coordination with NTIA.

99/ See Pioneer's Preference, *supra* note 7.

100/ Amendment of Part 90 of the Commission's Rules Concerning the Construction, Licensing, and Operation of Private Land Mobile Radio Stations, Notice of Proposed Rule Making, 5 FCC Rcd 6401 (1990).

101/ See, e.g., 47 C.F.R. §§ 90.175, 94.63 (1990); see also 47 U.S.C.A. § 332(b) (West Supp. 1990). As a practical matter, it is our understanding that services that use certified coordinators do not generally include applications where mutually-exclusive determinations need to be made.

for specific sub-allocations (e.g., public safety, industrial, and land transportation services) to coordinate frequency assignments prior to their submission for the actual license.^{102/} Under this system, applicants proposing new stations or modifying existing licenses send their completed applications to the certified coordinator for the appropriate sub-allocation. The coordinator checks the application for completeness, accuracy, and compliance with the FCC's rules, recommends the most suitable frequency for the applicant, and forwards the completed application to the FCC, which issues the license directly to the applicant upon approval. The FCC oversees the performance of the coordinating committees.^{103/} Private frequency coordinators often charge a fee for their services.

Through this requirement for prior coordination, the FCC attempts to ensure that interference conflicts are resolved through private negotiations before applications are filed. Successful coordination through this method lessens the need for increased federal government administrative processes to resolve conflicting private claims to the spectrum.^{104/}

NTIA requested comments in the Notice on the appropriate role of private coordinating groups and companies in spectrum management. We sought to determine how effective user group coordination has been, how equitable the process has been for non-members, what improvements could be made in the program, whether other types of services could be managed through the use of private groups, and what type of government oversight is needed. Many of the commenters addressed these issues, and we consider their positions and present our conclusions on the appropriate role for frequency coordination groups.

2. Frequency Coordination

The coordination and assignment of radio frequencies has long been a governmental function. In fact, the 1927 Federal Radio Commission, the predecessor to the FCC, was established partly to provide a means to coordinate radio frequencies in the private sector. Some commenters oppose the concept of private user group frequency coordinators and state that because the federal government is ultimately responsible for use of the spectrum, it alone should "handle these spectrum management functions."^{105/} Others note that since the spectrum

^{102/} Prior coordination takes place in other services as well. Users in the FCC's Common Carrier Point-to-Point Microwave Radio Service and the Private Operational Fixed Microwave Service also share spectrum. Prior to obtaining a license, applicants for these services are required to engineer their proposed systems to avoid interference and to coordinate with others who could potentially experience interference from these proposed systems.

^{103/} Performance consistently below FCC standards could lead to an inquiry and eventual decertification of the committee. See Frequency Coordination in the Private Land Mobile Radio Services, Report and Order, 103 FCC 2d 1093 at para. 8 (1986) (Frequency Coordination Order); see also 47 U.S.C.A. § 332(b) (West Supp. 1990).

^{104/} Such coordination potentially could provide a mechanism in which users have a vital interest in designing more efficient systems and in selecting frequencies that minimize interference to others.

^{105/} Du Treil, Lundin & Rackley Comments at 6.

is a "scarce natural resource belonging to the public, it should be managed by the government."^{106/}

Most commenters, however, support frequency coordination by private user groups or clearinghouses. They argue that an exclusive reliance on the federal government for all coordination activities is unnecessary and would only serve to make the licensing process less efficient. In support of this position, several commenters note that since the FCC established the certified frequency coordinator program in 1986, with clear guidelines for the recognized coordinators, the speed of service has improved and the FCC's licensing burden has been reduced.^{107/} In its comments AAR notes that private frequency coordination groups are "highly familiar with the specialized spectrum needs of the user groups they represent."^{108/} Because of this familiarity, private frequency coordinators contend they can provide fast, efficient, conflict-free assignments to industry users. Comsearch states that because of their unique third-party status, private coordination groups "are in a position to provide a highly efficient and expeditious method of frequency coordination that is not usually available to either the end user or the FCC."^{109/} With improvements in standards of service and oversight by the federal government, private frequency coordination can result in an efficient, responsive system.

Nevertheless, even supporters of private coordination groups express a need for government involvement in the process. For example, CSAA, while acknowledging the budgetary and efficiency savings that the FCC has realized by using private frequency coordinators, cautions that the FCC must maintain effective oversight of the private coordination process.^{110/} A number of other commenters, including several that support the use of coordinating groups, also state that the government should maintain and exercise an oversight role in non-government frequency coordination.^{111/}

We agree that frequency coordination by private groups is an activity that the FCC must actively oversee. We also agree, however, that the use of such groups for certain coordinating functions has increased the efficiency of the FCC's licensing procedures. In our view, the very great number of users in the services that use private coordinators and the limited FCC resources to coordinate such a large number of diverse users are compelling reasons for continuing the current system of FCC recognition of private frequency coordination groups in the licensing process.

^{106/} CORF Comments at 4; see also CSAA Comments at 5.

^{107/} See, e.g., NABER Comments at 4; MRFAC Comments at 6; ASNA Comments at 6; API Comments at 9; UTC Comments at 5.

^{108/} AAR Comments at 8.

^{109/} Comsearch Comments at 3.

^{110/} CSAA Comments at 6-7.

^{111/} See AAR Comments at 10; FCCA Comments at 12; APCO Comments at 11; NSMA Comments at 6; MRFAC Comments at 7-8; ARRL Comments at 10; Comsearch Comments at 4; NPR Reply Comments at 9; AAR Reply Comments at 4.

3. Coordinators and Planning

AAR states that their role has expanded beyond the frequency coordination function to include spectrum management (e.g., assistance in communications planning).^{112/} According to AAR, their user group coordination and frequency selection activities have been highly successful over the years and recognized coordinators should be given more responsibility to assist the federal government in spectrum planning. Contel, because of the effectiveness of private frequency coordination, also encourages increased responsibility to such groups to "manage the coordination and assignment process."^{113/} Ameritech also supports "[i]ncreased reliance on private user groups for purposes of coordination and tracking [frequency assignments]."^{114/}

NTIA agrees that involving coordinating groups in planning and cooperative management of the use of the spectrum they coordinate could increase efficient usage. However, efficiencies in management of resources like the spectrum may not result from user-based planning unless users have proper incentives to act efficiently. Long-range planning efforts that include coordination groups should be sufficiently broad to consider general demand conditions for the spectrum. Thus, national planning groups should include private sector coordinating groups.

4. Improving Frequency Coordination

Several commenters and other observers think that the current system establishes the recognized coordinators as monopolists and allows them to adopt practices that work to the detriment of prospective end users.^{115/} To improve the current frequency coordination system, commenters call for fair fee structures for the coordinators and fair and equitable treatment for the constituents. The FCC, in a rulemaking initiated in 1989,^{116/} is reviewing alternatives to the PLMRS frequency coordination program. We address several, non-mutually exclusive approaches to revising the frequency coordinator process to ensure that user interests are adequately served.

^{112/} AAR Comments at 6-7.

^{113/} Contel Comments at 5.

^{114/} Ameritech Comments at 3. See also MCI Reply Comments at 2; NYNEX Comments at 17.

^{115/} See US West Comments at 3; R.H. Schwaninger, Jr., Coordination: Pursestring Politics?, Communications, at 64 (Apr. 1989).

^{116/} Frequency Coordination in the Private Land Mobile Radio Service, Notice of Proposed Rule Making, 4 FCC Rcd 6325 at 6325 (1989) (Frequency Coordination Notice). Alternatives reviewed in the notice include "stricter performance standards, fee regulation, exempting some applications from coordination requirements, field studies, multiple coordinators and Commission coordination." Id. para. 5. The FCC is seeking comment on two alternatives, "Direct Access Applications" and "Monitoring" as a basis for selecting a frequency, id.

a. Direct Coordination by FCC

One alternative to the current private frequency coordination system would be for the FCC to accept applications supported by an engineering study directly from users as well as through certified coordinators. This would, in effect, interject an element of competition into the frequency coordination process by giving end users a choice in how to obtain a frequency assignment. It could benefit the end user without eliminating the certified coordinator completely. Applicants would be able to engineer a communications system and obtain a license themselves, or use a consulting engineer, without going through a certified coordinator. Some certified coordinators believe that this proposal would lead to "a rapid degradation of coordinators' databases and increased instances of interference."^{117/} However, at least one certified coordinator, FIT, indicates that it has consistently supported carefully designed and appropriately supervised alternatives.^{118/} NTIA believes that this alternative could be beneficial if a means were developed to prevent database degradation, as suggested below.

b. Multiple Certified Coordinators

Another alternative to the present system would be to certify more than one coordinating entity for each group. This would give each user a choice among private sector coordinators, which could improve their performance. The FCC has previously addressed and rejected this recommendation because of concerns for maintaining an accurate and up-to-date database and ensuring the integrity of the frequency assignment process. In initially establishing private coordination, the FCC stated that "if multiple coordinators were involved in coordination for a single service, it would be very difficult to keep track of the pending frequency selections of the various coordinators."^{119/} We recognize the potential for difficulties in organizing the efforts of such coordinators. However, the FCC should consider the benefits of such an approach, which would require some means of ensuring that all coordinators and users have access to all data needed for both existing and pending frequency licenses.

c. Implementation

In order for these proposals to be most effective, the FCC needs to develop more fully its databases so that all coordinators can have rapid access to all data needed to coordinate proposed licenses and develop rapid, electronic methods of submitting coordination requests and license applications. These issues are discussed below.

(1) Updated Databases

The previous suggestions for improvement of the certified frequency coordinator process hinge on the general availability of data required for coordination, which is currently maintained only by the coordinators. The FCC has recognized that, "[w]ithout accurate and current information, a coordinator cannot make sound frequency recommendations to applicants"^{120/} Currently, the FCC data files are not designed, and are not adequate, to

^{117/} ATA Comments at 8.

^{118/} FIT Comments at 5.

^{119/} Frequency Coordination Order, supra note 103, para. 29.

^{120/} Id. para. 13.

support frequency coordination in the services where there are private coordinators; the coordinators themselves are required to maintain separate databases containing additional data in order to coordinate proposed assignments.^{121/}

To make possible the increased use of direct applications to the FCC for assignment and the use of multiple coordinators, the FCC should develop a database and computer system capable of providing access to the public on a commercial basis at a reasonable cost. All coordinators and users would then be able to use a centralized, upgraded FCC database rather than maintaining separate databases. This would require major improvements to current FCC data files, including developing a means for rapid accessibility to appropriate coordinators and parties interested in submitting a direct application. In order to preclude different coordinators from selecting the same frequency for two different applicants, the FCC should also establish a pending applications file for review by coordinators and applicants prior to them choosing a frequency for their own application.^{122/}

(2) Electronic Transfer of License Applications and Coordination Requests

There are a number of PLMRS and point-to-point microwave frequencies with suballocations for more than one radio business service. When different coordinators for different suballocations are involved, coordinators cannot recommend a particular frequency until they have received concurrence from each of the other services having sharing rights to the frequency. In the past this coordination has taken place using the mails. An element in improving the frequency coordination system would be to establish a method of more rapidly coordinating frequency proposals when more than one coordinating group can oversee a frequency. In its comments, NYNEX recognizes the problems of interservice coordination and provides extensive recommendations encouraging more structured cooperative management and FCC resolution of conflicts that develop with respect to sharing allocations.^{123/}

One way to accomplish this result is for the FCC to require remote dial-up, electronic access among the databases of the affected frequency coordinators. In the longer term, the FCC could establish such access to the improved database described above, while developing procedures for remote, on-line submission of applications for review by other affected coordinators and, after coordination, to the FCC. US West states "the FCC can also prevent abuse of spectrum information by providing remote access to users who wish to do their own frequency studies."^{124/} If this were coupled with a remote dial-up to a pending applications file,

^{121/} See also the discussions on database requirements in Chapter 5.

^{122/} If NTIA recommendations, discussed on page 30 and in Chapter 5, for a fully developed, unified frequency assignment database were implemented, the new database would include all the data requirements for coordination of frequency assignments and the pending applications file mentioned here.

^{123/} NYNEX Comments at 17.

^{124/} US West Comments at 3.

coordination and frequency selection could be completed very quickly.^{125/} License approval by the FCC could also be transmitted electronically, allowing an applicant to begin operations immediately upon FCC action. The time and resources expended for all parties -- applicant, coordinator, and FCC staff -- would decrease dramatically.

In some point-to-point services, NSMA has attempted to provide a forum for coordination efforts. NSMA states that it is investigating the use of electronic distribution of prior coordination notices and has found that, "[t]he combination of regulatory guidelines and user cooperation is effective in helping the FCC manage the spectrum."^{126/} APCO, in conjunction with the FCC, has conducted a pilot project for electronic transfer of mobile public safety radio license applications from APCO to the FCC and filed a petition for rulemaking with the FCC looking toward electronic application filing on a permanent basis.^{127/} In addition, APCO has invited other coordinators to exchange data electronically and notes that such a system would speed the coordination process, particularly with respect to interservice sharing of frequencies, and improve the accuracy and consistency of all the databases employed in the process.

d. Funding for Frequency Coordination

A number of commenters state that budgetary constraints currently make improvement to the FCC data files and alternative coordination mechanisms impractical, if not impossible.^{128/} MRFAC believes that "a significant factor in the delays and added costs in the processing of FCC applications is due to the budgetary constraints which the agency has experienced over the past several years."^{129/} In this regard, Schwaninger argues that despite the current fiscal restraint in the federal government, the "FCC should not be denied the funds necessary to effectively manage the spectrum in the public interest."^{130/} Implementing these recommendations to improve the frequency coordination system could well require the expenditure of additional resources. Therefore, the FCC should evaluate carefully whether some level of additional resources is needed, or whether resource reallocation will allow them to fulfill these tasks.

5. Findings and Recommendations

FCC-certified coordinators for the PLMRS and the somewhat more informal coordination accomplished by user groups and coordination consultants in the fixed services perform valuable services, partly because such groups have extensive knowledge of their constituents' requirements and maintain extensive and specific databases. This is particularly important

^{125/} The FCC has provided such a file for land mobile applications. It is part of the Automated Land Mobile Application Processing System (ALMAPS) and can be accessed through a third party data contractor.

^{126/} NSMA Comments at 6.

^{127/} Alan Chase, APCO Tests Electronic Transfer of License Applications, Asks FCC for Approval, APCO Bull., at 38 (Oct. 1990).

^{128/} See AAR Comments at 5; CSAA Comments at 6.

^{129/} MRFAC Comments at 6.

^{130/} Schwaninger, Coordination: Pursestring Politics?, supra note 115, at 63-64.

because the data maintained by the FCC is inadequate for coordination of frequencies in the PLMRS and fixed services. Thus, NTIA recommends that:

- a. The certified coordinating groups used by the FCC in the PLMRS and the coordinating groups and consultants used by fixed service licensees should be continued.
- b. The FCC should involve such coordinating groups in strategic, long-range planning for the management of the spectrum with active FCC oversight.
- c. The FCC should encourage greater fairness, economy and efficiency by:
 1. accepting assignment applications directly from prospective licensees.
 2. investigating the possibility of certifying more than one coordination group for each suballocation subject to private coordination.
- d. To facilitate these changes, the FCC should:
 1. expand its data files to include all data required for frequency coordination. This would include the creation of a pending applications file for all included services.
 2. develop the capability to permit on-line, dial-up access among coordinators and to the expanded files.
 3. use on-line access as a means of coordinating frequency assignment requests, granting licenses and updating the master file of frequency assignments.

IV. Domestic Spectrum Management Coordination

A. Introduction

As noted earlier, NTIA and the FCC share domestic spectrum management responsibilities, while NTIA, the FCC, and the State Department share preparations for international telecommunication conferences and negotiations on other issues.

B. Existing Coordination Processes

NTIA and the FCC work closely in spectrum management, particularly within the IRAC. The FCC, through its liaison to the IRAC, is a party to most IRAC proceedings and can learn of developing NTIA policies in time to provide guidance or propose changes as necessary. In turn, the FCC consults with the IRAC on non-government spectrum issues involving shared or exclusive government bands. Prior to formal request for public comment, the FCC often consults with the IRAC on draft notices of inquiry and notices of proposed rulemaking. The FCC's liaison to the IRAC also receives comment from the IRAC members during meetings, as recorded in the IRAC minutes. The IRAC generally reaches consensus on FCC proposals, and in most cases, both NTIA and the FCC take action in accordance with the consensus. From time to time, NTIA also files formal comments with the FCC on behalf of the Executive Branch, and occasionally NTIA and one or more of the agencies will file separate formal comments.

Another important point of contact between NTIA and the FCC is in the FAS, the IRAC subcommittee charged with coordinating operating frequencies for government radio stations. The FCC representative, as a full voting member, submits proposals for private sector use of spectrum in exclusive or shared government bands or in other situations that might involve federal operations. The FCC considers the views of the federal agencies before acting on requests for such licenses. The FCC representative also reviews all federal requests for authorization to operate in shared or exclusive non-government bands, and refers any conflicts to the responsible FCC bureaus for further review, as necessary.

In addition to coordination through the IRAC forum, senior NTIA management regularly coordinates with appropriate FCC staff members on a number of spectrum management issues. These relationships have become increasingly important as the complexity of both radio-communication technology and the issues involved have increased. As an indication of their commitment to this process, the Administrator of NTIA and the Chairman of the FCC have recently begun a series of meetings to promote even closer coordination and cooperation between the two agencies in their spectrum management activities.

C. Strategic Decisionmaking

Recognizing the investment that manufacturers and all users have in spectrum resources, and the stake that the nation has in radio services, NTIA and the FCC must consider the long-term impacts of each spectrum management decision. Decisions must thus be based on well-defined goals, and spectrum managers must make radiocommunications users and manufacturers aware of the factors influencing those decisions.^{131/}

The division of spectrum management responsibilities between NTIA and the FCC obviously complicates unified, national policymaking, even as it becomes increasingly apparent that the demand for spectrum necessitates consideration of long-term effects on all users. A decision to accommodate one activity denies others the use of the spectrum or increases the potential for interference to others, even if only in the distant future. Therefore, in making its spectrum decisions NTIA will always consider FCC concerns on national spectrum priorities. We are confident that the FCC will show similar sensitivity. Decisions on spectrum management and policies should reflect an understanding that physically, technically, and economically, there is no difference between "government" and "non-government" spectrum. There are only different federal and non-federal management responsibilities.

D. Alternative Coordination Approaches

Commenters state that one of the most significant problems facing U.S. spectrum management today is coordination of the activities of the many parties involved,^{132/} including both day-to-day activities and the strategic planning necessary to manage the spectrum for the

^{131/} For instance, because meeting user needs through technical spectrum efficiency is an important goal, NTIA and the FCC should make clear to the user community that they will consider a system's spectrum efficiency in making their spectrum management decisions. Without such defined direction, inconsistency among decisions is likely to develop, which will cause confusion among users and undermine the ability of the two agencies to achieve their long-term spectrum management goals.

^{132/} See, e.g., Harris Comments at 2; Thomson Comments at 3-4; Contel Comments at 11-13.

future. Former NTIA Administrator and FCC General Counsel Henry Geller has also examined the federal structure and identifies the problems with the present structure as a lack of focused responsibility, policy drift, and the failure of Congress to set policy.^{133/}

Several commenters advocate replacing the existing, "dual" domestic spectrum management structure with a single organization.^{134/} Although Geller believes it would be easier to implement other, more limited organizational changes as discussed below, he prefers a single Executive Branch agency headed by a single administrator handling all telecommunications matters except mass media. The FCC and NTIA would be absorbed into this new agency.^{135/}

In contrast, several commenters express satisfaction with the present dual spectrum management arrangement. Harris, for example, believes that over the years, the current system has functioned adequately to meet the country's telecommunications requirements, and that policymakers should emphasize improving the present structure to make it work better rather than replacing it.^{136/}

Over the years, policy analysts have made diverse suggestions for improving spectrum management while retaining the dual structure. Some proposals have called for the presence of an entity within the Executive Office of the President to coordinate Executive Branch telecommunication policies;^{137/} others support a separate Executive Branch agency combining existing Executive Branch telecommunications responsibilities (not those of the FCC), which would also be the focal point for international negotiations.^{138/} Several commenters call for the

133/ H. Geller, The Federal Structure for Telecommunications Policy, at 10-19 (Benton Foundation, 1989).

134/ See, e.g., FCCA Comments at 2-3; DVA Comments at 1; Thomson Comments at 3; Wertime Comments at 1.

135/ Geller, The Federal Structure for Telecommunications Policy, supra note 133, at 21-23.

136/ Harris Comments at 7; see also AAR Comments at 3; GTE Comments at ii.

137/ The FMAC, too, recommended that a small group be established within the Executive Office to coordinate executive branch telecommunication policies. FMAC Recommendations for NTIA Spectrum Management and Use Study, minutes of June 22, 1990 meeting; see also NASA Comments at 2, 21-23; H.R. 323, Telecommunications Policy Coordination Act of 1987, 100th Cong., 1st Sess. (Jan. 6, 1987); S. 999, International Telecommunications Act of 1983, 98th Cong., 1st Sess. (Apr. 7, 1983); H.R. 277, Telecommunications Policy Coordination Act of 1991, 102d Cong., 1st Sess. (Jan. 3, 1991); and National Telecommunications and Information Administration, NTIA TELECOM 2000: Charting the Course For A New Century (1988) at 173-184.

138/ Geller acknowledges that this solution, too, would be difficult and recommends that a Presidential Assistant for Telecommunications, with a small staff of two or three persons, be established in the Executive Office. Geller, The Federal Structure for Policy, supra note 133 at 21-23.

creation of advisory and coordinating committees to develop more rationalized, unified radio communication policies in the United States.^{139/}

E. Conclusions and Recommendations

Current U.S. spectrum management problems require strong leadership, that is willing to provide direction for the achievement of specific policy goals. NTIA, through this report and other spectrum management activities, and the FCC, through an ambitious series of proceedings that examine spectrum management issues, are together attempting to provide that leadership.

However, because of the sheer number of parties affected, the development of spectrum management policies in the United States is difficult. Policies involving interests of both the government and private sectors require coordination between NTIA and the FCC as the primary spectrum managers.

A mechanism for direct coordination between NTIA and FCC needs to be established whereby major spectrum management decisions can be considered. Recent meetings between the Administrator of NTIA and the Chairman of the FCC, together with their key support personnel, could be formalized as a planning group to perform this function. That group could meet prior to the finalization of major spectrum decisions, striving toward a unified approach to managing the spectrum in the national interest.

Accordingly, NTIA proposes to formalize, together with the FCC, a Joint Strategic Planning Council, co-chaired by the Administrator of NTIA and the Chairman of the FCC. This Council would be charged with coordinating spectrum management policies to avoid conflicts in the short run and to encourage the development and accommodation of new technologies in the long run. In order to obtain the widest possible input from all users of the spectrum, the Joint Strategic Planning Council should explore the use of the advisory group, as discussed at page 28.

V. International Spectrum Coordination

A. Introduction

NTIA, the Department of State, and the FCC also work together on international spectrum issues. NTIA, as the President's adviser on telecommunications matters, is responsible, in part, for "develop[ing] and set[ting] forth, in coordination with the Secretary of State and other interested agencies, plans, policies and programs which relate to international telecommunications issues, conferences and negotiations."^{140/}

The International Telecommunication Union (ITU), a specialized agency of the United Nations, works to ensure that worldwide telecommunications systems operate in efficient and orderly manners. The United States, as one of over 160 member nations, participates in the

^{139/} See, e.g., Southwestern Bell Comments at 7; Bell Atlantic Comments at 15; NASA Comments at 2.

^{140/} Exec. Order No. 12,046, supra note 10, § 2-404.

ITU to enhance domestic and international communications. Spectrum use and management is an important part of international telecommunications coordination.

Among its numerous duties, the ITU conducts administrative radio conferences that develop international radio regulations. These regulations have treaty status and provide the principal guidelines for world telecommunications operations and spectrum management. They serve as the framework for development of our national frequency allocations and regulations. The Final Acts of the ITU conferences are normally approved by the President following ratification by the Senate.

The process, which is often two to three years long, undertaken in the U.S. to prepare for international conferences reflects the dual spectrum policymaking authority of NTIA and the FCC. The NTIA normally forms a special IRAC ad hoc committee comprised of interested IRAC members. The FCC normally forms a public advisory committee and issues notices of inquiry to receive public input. NTIA and FCC coordinate both directly and through the IRAC forum.

The State Department's Bureau of Communications and Information Policy (CIP) coordinates the State Department's activities with those of NTIA, the FCC, and other federal agencies concerned with international communications and information policy. The CIP forms U.S. delegations for international conference meetings, coordinates their preparations, and appoints the heads of the delegations.

In order to coordinate actions on pending international issues and ensure proper policy coordination, the heads of NTIA, the FCC, and CIP hold quarterly planning meetings, which examine key international policy issues. An interagency working group meets monthly to carry out necessary actions.

B. Current ITU Study Efforts

Just as NTIA is reviewing national planning for international conferences, the ITU, through a High Level Committee (HLC), is, among other things, reviewing the way it conducts these conferences. The purpose of the HLC is to review the structure and functioning of the ITU and recommend improvements.

Midway through its planned schedule of deliberations, the HLC has under consideration a proposal to restructure the ITU substantive activities into three basic organizational elements. These elements will deal with 1) telecommunications development, 2) network systems standardization, and 3) radiocommunications matters. The third element is envisioned to be created through the amalgamation of two existing organizational entities, the specialized secretariat of the International Radio Consultative Committee (CCIR) and the specialized secretariat of the International Frequency Registration Board (IFRB). The IFRB itself, currently composed of five full-time elected officials, may also be restructured as a part-time body with more narrowly defined responsibilities. The HLC is also addressing the ITU's functional approach to conference organization and scheduling, including radio conferences. A more orderly and routine process is foreseen.

Concurrently, a separate group, the Voluntary Group of Experts (VGE), is undertaking an examination of the International Radio Regulations with the objective of recommending simplification of that complex body of rules. Should the recommendations of the HLC and VGE be adopted by the Membership of the ITU, the manner in which the Members interact with each other and with the ITU Headquarters Secretariat will change somewhat and with that

change will come a consequent change in the way the United States prepares for and implements its dealings with the ITU.

With such changes, it can be expected that there will a more routine preparation process for radio conferences, greater opportunity for more orderly identification of U.S. objectives at each conference, and improved preparation of U.S. strategies for achieving those objectives.

C. International Coordination Issues

Commenters describe the difficulties inherent in a three-agency approach to developing national policies on international spectrum management issues. For example, NASA states that NTIA should consider "suggestions that telecommunications policy issues should be elevated to a higher level in the Executive Branch."^{141/} NASA believes that this would be particularly beneficial in preparations for international telecommunications treaty conferences.

COMSAT recommends a number of improvements to the international policy coordination and conference preparation processes. First, the United States should develop a strategic approach to meeting objectives in international fora and should continue to address telecommunications, spectrum management, and ITU issues at high levels within government and industry. Second, the United States should improve and expedite government decisionmaking and coordination of policies and positions and use a more formal, continuing mechanism to develop and coordinate U.S. views and positions for ITU conferences with other countries.^{142/} Third, the United States should form delegations to conferences as early as possible to ensure time for adequate preparation, while increasing private sector participation in ITU conferences and more effectively using government and industry advisory committees.

COMSAT also recommends that the United States work towards improving the effectiveness of the technical arm of the ITU and provide sound technical proposals for consideration. COMSAT also supports training offered to telecommunications advisers in developing countries by the United States Telecommunication Training Institute (USTTI) as being effective in gaining broad support for U.S. goals and objectives.^{143/}

Henry Geller describes the present U.S. government institutional relationships in the area of international telecommunication policy development as inadequate. He recommends that the position of Presidential Assistant for Telecommunications be established, which, he argues, would ensure proper coordination and, when appropriate, presidential focus on telecommunication issues.^{144/}

^{141/} NASA Reply at 1.

^{142/} As noted in Chapter 6, the accurate portrayal of spectrum requirements is essential to planning. There, we, too, recommend that the requirements considered in international conference preparation committees be based on data gathering linked to ongoing spectrum management activities rather than primarily upon ad hoc data collection efforts for each conference.

^{143/} COMSAT Comments at 17-22. NTIA annually offers one USTTI course in cooperation with the FCC and industry entitled Radio Spectrum Management and Computer Aided Techniques.

^{144/} Geller, The Federal Structure for Telecommunications Policy, supra note 133, at ii.

A 1984 Georgetown University (CSIS) study of the U.S. role in the ITU also supported early selection of delegations and increased involvement of the private sector in long-range preparations for conference. The study also recommended that the United States develop a new corps of telecommunications-trained foreign service officers. We should also emphasize more bilateral discussions of spectrum management issues with developing nations, and strengthen U.S. presence in the Inter-American Telecommunications Conference (CITEL) and other regional concerns.^{145/}

D. Conclusions and Recommendations

National policies on international spectrum management issues must be closely coordinated among NTIA, the FCC, and the State Department. We believe that the views of both government and private sector users of the spectrum are essential to the development of these policies. Thus, the NTIA, FCC, and CIP coordination group could obtain information from an advisory committee composed of private sector and federal agencies such as the domestic group discussed above. Moreover, the U.S. government should provide meaningful opportunity for public comment on proposed international policy positions and decisions before they are implemented.

NTIA, the FCC, and the State Department are in the process of implementing many of these recommendations. In addition, NTIA will seek to:

- (a) review the procedures used for the development of policies on international spectrum management issues by incorporating the results of the ITU's HLC process;
- (b) make general improvements to the preparation process emphasizing planning, coordination between groups, and an easily accessible database of international telecommunications activities;
- (c) encourage more involvement of the private sector in long-range preparations for international spectrum conferences with meaningful consultation on options; and,
- (d) encourage establishment of a permanent telecommunications expert adviser position at the U.S. Mission in Geneva to provide expertise and continuity to the Mission in its dealings with the ITU.

^{145/} L. Milk & A. Weinstein, United States Participation in the International Telecommunication Union: A Study of Policy Alternatives, Georgetown University Center for Strategic International Studies, at 70-74 (1984).

CHAPTER 3 THE BLOCK ALLOCATION SYSTEM AND FLEXIBILITY

I. Introduction

A. Block Allocation Issues

In the Notice, NTIA asked questions regarding the continuing suitability of the block allocation system for managing spectrum. In particular, the Notice asked whether the current system impedes technical advances in spectrum-based systems, leads to excess demand for spectrum, or further entrenches incumbent technologies.^{146/} In this chapter, NTIA addresses these issues and, in addition, explores the extent to which the current system constrains efficient sharing between federal and non-federal users.

The basic concept of the block allocation system is that a band of contiguous frequencies is dedicated to a type of radio service with somewhat uniform technical standards. Limitations of the radio technology of the early 20th century,^{147/} the physical properties of radio waves, and the block system's low-cost, regulatory simplicity, helped to determine the original system of block allocations. This eventually led to the structure of service boundaries and standards that spectrum managers use today to limit or control radio interference. Over the better part of a century, this structure of delineating and defining blocks of spectrum for particular uses has served a valuable function.^{148/}

As discussed in the Notice, the block allocation system has several advantages. It assists in planning for demand by apportioning spectrum for future uses; sets out reasonably easy coordination procedures to avoid interference; provides for stability and design certainty for equipment manufacturers; and reserves spectrum for socially desirable, but otherwise uneconomic, uses. The block system also has the advantage of familiarity, since the allocations are well known, both nationally and internationally.^{149/}

^{146/} See Notice paras. 25-36.

^{147/} For example, the size of the current AM radio band resulted from the capabilities of early technology.

^{148/} In federal spectrum use, the blocks are limited to the ITU-defined radio services, while in the non-federal spectrum, such blocking continues to a level of services for individual businesses. Thus, in federal spectrum use, for example, the narrowest definitions of mobile services are for services such as aeronautical, maritime, and land mobile. On the other hand, in non-federal use, land mobile is divided into private radio and common carrier users, and then, for example, within private land mobile, further divided by type of business service.

^{149/} See Notice para. 25, citing A. Felker & K. Gordon, A Framework for Decentralized Radio Service, Federal Communications Commission, Office of Plans and Policy, (Sept. 1983); W. Longman, Flexible Allocation of the Radio Spectrum, 55 Telecomm. Journal 692 (1988).

While the benefits of this system are well-known, its disadvantages are also clear. It tends to limit each service to a block of spectrum and a set of technical standards. Once settled in a block, user investment in the equipment needed for a particular service commits use of that block to that service, even if, as a result of changes in technological or marketplace forces, demand for those particular services decreases. Moreover, once users gain access to spectrum, there generally are no legal requirements or financial incentives for them to consider accommodating other uses or, in many cases, even to move to more spectrum-efficient technologies for their own uses. As a result, some blocks may not be fully used, while other blocks are highly congested. These characteristics of the block allocation system, particularly when strictly enforced, tend to support the status quo and handicap the development of new technologies and new services.^{150/}

Despite these problems, commenters overwhelmingly support retention of the block allocation system.^{151/} AMI likens the system to Winston Churchill's observation on democracy, "the worst system devised by the wit of man, except for all others."^{152/} Some commenters argue that the block allocation system, with its known quantities of spectrum for particular uses, actually provides incentives to existing users to improve services, because the system's predictability promotes equipment development and innovation within services.^{153/} There is also general concern that changes to the system will do more harm than good.^{154/}

NTIA believes that the essential benefits of the basic system of block allocation can be retained while reforming certain elements of the system. As reformed, the system should fairly and efficiently balance new and existing users' needs, avoid arbitrary and unnecessary distinctions on competing spectrum uses, provide for timely introduction of new systems, and generally encourage efficient use of a valuable resource.

The goals of increasing efficiency and fairness in spectrum management and use, and promoting innovation in spectrum-based services and technologies can be furthered by permitting increased flexibility in using the spectrum. In investigating the issues associated with the block system, through the comments and other sources, NTIA has identified several ways to increase flexibility in spectrum use within the block allocation system.

^{150/} For recent discussion of the block allocation system, see, e.g., Longman and Felker & Gordon, id.; see also M. Mueller, Technical Standards: The Market and Radio Frequency Allocation, Telecommunications Policy at 43 (Mar. 1988). The popular and business press is actively debating the issue of supply and demand for spectrum. See supra note 6.

^{151/} See, e.g., AAR Comments 14-15; see also ARINC Comments at 10; AMI Comments at 7; ASNA Comments at 3; APCO Comments at 8-9; AT&T Comments at 9; COMSAT Comments at 30-41; LMCC Comments at 19; MST Comments at 33; NAB Comments at 14.

^{152/} AMI Comments at 7.

^{153/} See ARINC Comments at 11; NAB Comments at 15.

^{154/} See ARINC Comments at 10 for discussion of aeronautical safety concerns; BellSouth suggests that while abandonment of the current system would be unwise, refinements to the system are appropriate. BellSouth Comments at 8-9.

B. Increasing Flexibility in the System

The current block allocation system, while nominally quite rigid, does permit at least a modicum of flexibility through the use of "footnotes," or exceptions, to the allocation table,^{155/} and through regulatory accommodations that NTIA and the FCC perform on a case-by-case basis. However, both methods require time-consuming and occasionally contentious processes. In recent years both NTIA and the FCC have addressed some spectrum congestion concerns by introducing additional flexibility in the way assignments are made in certain blocks and in the way licensees can use spectrum assigned to them.

We agree with parties that note that the block system is inherently stable, and that stability and certainty, can, in fact, encourage investment and thus lead to innovation to some degree.^{156/} For example, a block structure can promote innovation within a service, if demand for spectrum within a block places sufficient pressure on the licensees to innovate, and when technical regulations are flexible enough to allow such innovation to occur expeditiously.

Although the block system as currently structured may provide incentives for innovation within certain services, we are not confident that it will continue to be sufficiently responsive to increasing demand for potential new uses. A new service that does not meet existing service rules may be completely excluded from any existing allocated bands. As a result, it may not be introduced because of a perceived lack of spectrum, denying the market the opportunity to judge its usefulness. For example, there is no specific spectrum identified for new services like personal communications services or digital audio broadcasting, although FCC proceedings are pending on both services.^{157/}

Administrative proceedings associated with the current system also can impose a considerable burden on potential innovators. Although innovators now can obtain experimental authorizations for development of new services,^{158/} they usually must attempt to determine what spectrum is potentially available in both the private and federal sectors. Then, once the innovator sufficiently develops the service, it must petition the FCC to reallocate spectrum for the service, and the FCC must implement new service rules before the product can be brought to market. Depending on the technical characteristics of the new service, spectrum may not be readily available. If spectrum is not available, the innovator must engage in further proceedings to reallocate the spectrum. The outcome of such (frequently lengthy) proceedings is uncertain,

^{155/} 47 C.F.R. § 2.106 (1990).

^{156/} See generally E. Mansfield, Economics of Technological Change (1968) for a discussion of the importance of certainty and stability to research and development and thus innovation.

^{157/} See Personal Communications Services, *supra* note 7; Digital Audio Broadcasting, *supra* note 7. These new proposals fit into the ITU radio service definitions and can be more readily accommodated under these broadly defined services, e.g., land mobile or broadcasting, than under the FCC rules. However, there are still problems that the 1992 WARC will address regarding worldwide allocations for these services.

^{158/} See 47 C.F.R. Part 5 (1990). For example, there are currently more than 35 experimental licenses for personal communications systems throughout the 800-900 MHz and the 1.7-2.5 GHz bands.

and although the innovator has disclosed publicly the nature of the proposed services, there is no assurance that any suitable spectrum will eventually be made available.

Administrative recognition of the dilemma for innovators, such as the "pioneer's preference" currently under consideration at the FCC, could address these concerns in part.^{159/} However, such procedural fixes, including those discussed in Chapter 2, cannot, by themselves, encourage innovation in all services. Although we strongly support administrative reform of, and improved spectrum planning within, the current system, administrative processes will always generate inefficiencies and spectrum managers cannot be omniscient as they plan. Greater flexibility in the block allocation system is not a panacea for the difficulties of meeting user demand, resolving inefficiencies, and accommodating new services, but it could substantially mitigate such problems.

The federal government's system of managing spectrum tends to be more flexible than that of the FCC, because there are fewer constraints on federal users and considerably less burdensome procedures to institute changes. For example, within bounds of technical interference and service definitions, federal government users operate relatively independently. Furthermore, NTIA changes spectrum allocations through small group consensus^{160/} that is not subject to delays inherent in a rulemaking. In opening the federal decision-making process to more private-sector input, as discussed in Chapter 2, we will seek to maintain this flexibility.

Although the basic structure of the block allocation system should be retained, NTIA and the FCC should seek to modify it in the next decade to increase flexibility. The following subsections discuss a number of ways to increase the flexibility of the block system. These include, first, breaking down arbitrary and inefficient boundaries among users by increasing the flexibility of service definitions to accommodate a wider range of potential services. Second, we discuss facilitating innovation in the various services by allowing greater "technical flexibility" through the use of adaptable technical standards for services in a block. Finally, we address proposals for greater "user flexibility," which seek to increase efficiency by allowing users to determine the best use for the spectrum they are assigned.^{161/}

^{159/} Pioneer's Preference, *supra* note 7.

^{160/} For a more complete discussion of this federal decision-making process and the federal agencies' role in IRAC, see Chapter 2, p. 20.

^{161/} An argument for maintaining the current block allocation system is that broad changes might well conflict with the international system of spectrum allocation. *See, e.g.,* AT&T Comments at 9-10. Any major changes in the block system would need to be carefully considered in the international context. In fact, the ITU has chartered a Voluntary Group of Experts (VGE) to consider ways to improve use of the radio frequency spectrum and simplifications of the ITU Radio Regulations. Establishment of a Voluntary Group of Experts to Study Allocation and Improved Use of the Radio-Frequency Spectrum and Simplification of the Radio Regulations, ITU R. No. 1009. The CCIR's Task Group 1/1 will support the VGE by examining the technical operational methods used for the allocations. CCIR Circular CE1/1598 (Nov. 13, 1990). The work of these groups should be complete in approximately three years and is tied closely to the ITU reorganization described in Chapter 2, p. 52. The ITU's High Level Committee (HLC) is proposing changes to the ITU structure and working methods that may lead to corresponding changes to simplify the radio regulations.

(continued...)

II. Enhancing Flexibility in Service Definitions

The very nature of the block system implies that bands or blocks of spectrum are matched with specific types of services. Without an administrative proceeding to reallocate spectrum among services, great demand for a service in one block will not encourage the users of another service in another block to operate efficiently. Therefore, in order to encourage more efficient use, it may make sense to define blocks broadly, thus allowing users a range of spectrum options, without the delays associated with reallocation proceedings.

Some commenters argue that the basic notion of the block allocation system -- that is, aggregating similar uses into contiguous blocks, provides for efficient use of the allocated spectrum and allows for long-range planning.^{162/} However, it is not clear that homogeneous use is most efficient. Some studies suggest that homogeneous use of blocks of spectrum will usually permit a greater number of frequency assignments in a band,^{163/} while others suggest that a band is used more efficiently if the use is heterogeneous -- that is, if different services are mixed in a band.^{164/} In some cases, it is appropriate to "zone" spectrum in certain geographic areas for narrow uses, such as some forms of radar, which technically preclude most other uses, or passive services such as radio astronomy, for which even a minimum amount of interference would be unacceptable.^{165/} In general, however, we conclude that many of the definitions used in the current block allocation system are too restrictive. By defining services more broadly, the system would still exhibit the benefits of the block system, without experiencing the demand inefficiencies that occur as a result of narrowly defined blocks. Spectrum managers should seek to eliminate artificial service boundaries that prevent the realization of these efficiencies.

A. FCC Efforts to Broaden Service Categories

Within the service-defined block allocations, the FCC often subdivides spectrum and suballocates it to specific groups defined by those groups' identity or purpose. For example, the private land mobile radio service (PLMRS) is subdivided into categories such as police, taxicab, and business radio services. Further, both land mobile and microwave services are

^{161/}(...continued)

Implementation of NTIA's, however, recommendations should be designed not to hinder either U.S. participation in worldwide spectrum negotiations or, more specifically, U.S. relationships with Mexico and Canada. Moreover, while change in the international system as a whole moves slowly, many individual countries are experimenting with new, non-administratively based, methods of spectrum management.

^{162/} See, e.g., AT&T Comments at 9; AAR Comments at 14; LMCC Comments at 19.

^{163/} See Longman, supra note 149, at 693.

^{164/} See L.A. Berry & D.H. Cronin, Spectrum-Efficient Frequency Assignment in Mixed Service Bands, 1982 IEEE Symposium on Electromagnetic Compatibility (1982).

^{165/} Webbink compares this system of suballocating service blocks to zoning land for a specific use. See D.W. Webbink, Radio Licenses and Frequency Spectrum Use Property Rights, in Communications and the Law at 3, 4 (June 1987).

subdivided for "common carrier" or "private" providers. Several commenters on the Notice suggest that one way to increase flexibility and thus improve opportunities for efficiency would be for the FCC to reduce the number of these suballocations and rely instead solely on broader, "macro" allocations.^{166/}

NTIA believes that the FCC could ease pressure on some services and better use spectrum currently allocated to others by reducing the number of management boundaries between technologically similar services. Further consolidation of the current suballocations in the land mobile and private microwave services would eliminate unnecessary allocations to specific subclasses of users, and could help to alleviate the remaining demand inefficiencies created when similar services are effectively excluded from using each others' spectrum. One commenter recommends that the distinction between common carrier and private microwave be reexamined, suggesting that both could be subjected to the same rules, standards, and obligations.^{167/}

The FCC has pursued such consolidations in the PLMRS over the years. In 1974, as part of the proceeding that allocated 115 MHz in the 806-947 MHz band for use by the land mobile service, including both cellular and PLMRS, the FCC introduced the Specialized Mobile Radio Service (SMRS) in the 800-900 MHz bands.^{168/} Until 1974, most PLMRS allocations were determined by the type of user, for example, forestry, railroad, motor carriers, taxicab, fire, or police radio services. Now, as defined by that proceeding, SMRS can serve a broad range of users, including all other legitimate PLMRS users.

Since the introduction of SMRS, the FCC has not significantly consolidated the many users of PLMRS. In fact, in 1989 the PLMRS still included more than 25 individual radio services or categories in addition to SMRS.^{169/} In the further proceedings regarding reserved spectrum in the 806-947 MHz band, the FCC decided initially not to reserve channels for commercial or industrial systems.^{170/} However, in 1982, it revised that controversial decision, when it released reserved spectrum in the 806-821 MHz and 851-866 Mhz bands for new land-mobile uses. The FCC allocated these frequencies to, and allowed exclusive licenses for, four "pools" of users, with a provision that, after three years, these pooled uses would share

166/ See, e.g., ARINC Comments at 12; AMI Comments at 9-11; ASNA Comments at 4.

167/ Southwestern Bell Comments at 3-4.

168/ See Future Use of the Frequency Band 806-960 MHz, Second Report and Order, Docket No. 18262, 46 FCC 2d 752 (1974); Memorandum Opinion and Order, 51 FCC 2d 945 (1975); NARUC v. FCC, 525 F.2d 630 (D.C. Cir. 1976) (Future Use of 806-960 MHz).

169/ See Frequency Coordination Notice *supra* note 116, at 6325 (1989).

170/ Responding to arguments that "slow growth" users could not effectively compete with SMRS licensees or Business Radio users for channels, the FCC decided initially that local government systems were the only ones in which "true external constraints on immediate system implementation existed," and that it could not otherwise determine the priority of other licensees. See Amendment of Part 90 of the Commission's Rules to Release Spectrum in the 806-821/851-866 MHz Bands and to Adopt Rules and Regulations Which Govern their Use, Report and Order, 45 Fed. Reg. 81,204 (1980) (800 MHz Reserve Channel Release).

frequencies.^{171/} These pools were Public Safety, Industrial/Land Transportation, Business, and Commercial. With the exception of public safety frequencies, restrictions on "inter-pool" sharing were later removed.

The FCC's approach of suballocating blocks among industry groups permits it to use private frequency coordinators,^{172/} which are responsible for groups of land mobile and private microwave users such as the railroad, petroleum, and trucking industries. Industry groups that act as coordinators express concern that any changes to the block allocation system might weaken or eliminate the frequency coordination process, claiming that the FCC needs outside support^{173/} and that this process has been shown to meet user needs efficiently.^{174/}

NTIA recommends that the FCC conduct general rulemaking proceedings to decrease the number of suballocations based on the type of user and to allow more sharing among the mobile radio services.^{175/} Although we recognize that this process could be difficult, we believe that it would ultimately increase efficiency. Such consolidation could continue to make use of the FCC's existing private frequency coordinators, for example by allowing each private frequency coordinator to serve multiple user groups. For example, if a business user fails to find an appropriate frequency through its coordinator or through an SMRS, it could seek frequencies from other coordinators. As a result, users seeking access to spectrum could choose among frequency coordinators, thus relieving demand pressures within the present suballocations. NTIA acknowledges the importance of the private frequency coordinators and the needs of their constituencies, but believes that such consolidation will not adversely harm these constituencies. Coordinators could be given expanded rights, and corresponding responsibilities, to assign frequencies to broader classes of users, while continuing to meet the needs of their traditional clientele on a priority basis.^{176/}

In addition, NTIA recommends that, when there is overlap and duplication among services, the FCC explore combining the spectrum allocations, and thus assignments for, private

^{171/} See 800 MHz Reserve Channel Release, Second Report and Order, 90 FCC 2d 1281 at 1299 (1982).

^{172/} Chapter 2 discusses the current system of private frequency coordinators, their rights as currently defined, and potential reforms to that system. This section is primarily a discussion of the benefits of fewer suballocations, and how it might be accomplished within the current structure of private frequency coordinators.

^{173/} See NABER Comments at 4.

^{174/} See, e.g., AAR Comments at 10; see also API Comments at 9; FCCA Comments at 12; LMCC Comments at 21.

^{175/} The FCC recently issued a Report and Order taking limited action to address these concerns, specifically allowing Business Radio Service to provide services to all users eligible under Part 90 and to the federal government on paging-only channels. See Expanded Eligibility and Shared Use Criteria for Private Land Mobile Frequencies, PR Docket No. 89-45, Report and Order, para. 16 (released Jan. 30, 1991).

^{176/} NTIA believes that a system of fewer suballocations, in combination with the reforms mentioned in Chapter 2, could provide incentives to ensure that private frequency coordinators were motivated to serve other than these traditional constituents.

and common carrier radio uses, such as microwave and land mobile. NTIA notes that while certain legal requirements for each of the services might remain distinct due to differences in service provision,^{177/} the technical configurations can be quite similar, suggesting that the FCC could subject them to the same assignment procedures.

B. Federal User Categories

NTIA similarly classifies some government land-mobile services according to user category -- that is, by agency.^{178/} c NTIA's "allotment plan"^{179/} lists, for a limited number of frequencies, the channels that each government agency has available in various areas.

Even with such an allotment plan, the current federal system has flexibility, because an agency that needs access to a frequency can negotiate directly with other agencies for use of their channels. NTIA also has a category of frequencies known as All Government Agencies (AGAs), in which any agency can seek to operate any mobile service station. Nevertheless, we believe that by designating frequencies to an agency within a service category, an allotment plan creates a greater potential for inefficient use.

As is the case with private sector users, some federal agencies have argued informally that the federal land mobile allotment plan is necessary if they are to manage and plan for their own needs. However, working with IRAC, NTIA will evaluate and modify the land mobile allotment plan as quickly as practicable, with the objective of reducing the barriers among federal mobile users, through increased sharing of federal agencies' frequencies.

C. Increased Spectrum Sharing

A potential solution to the problem of excess demand for a particular frequency block is to reduce the rigidity of service boundaries and allocate spectrum for use by more than one service -- that is, to share spectrum among technically different uses.^{180/} Sharing effectively

^{177/} For example, the FCC cannot grant common carrier licenses less than 30 days after issue of a public notice of the acceptance of or amendment to a license application -- there is no such restriction on the granting of private radio licenses. See 47 U.S.C. § 309(b) (1988). It should be noted that even the distinctions between services provided are blurring. FleetCall, Inc. recently requested -- and the FCC approved in part -- a waiver of certain of the private radio rules to develop an "enhanced" SMR (ESMR) system using digital technology, multiple transmitter sites with frequency reuse, and cell-to-cell handoff, that some have called a "third cellular network." Petition by Fleet Call, Inc. for Rule Waiver to Create an Enhanced Specialized Mobile Radio System in Six Markets, DA 90-571, FCC ref. LMK 90036 (Apr. 12, 1990); News Release, (Memorandum Opinion and Order adopted Feb. 13, 1990).

^{178/} NTIA allocates all other services according to type of radio service and assigns frequencies to users on a first-come, first-served basis.

^{179/} See, e.g., NTIA Manual, *supra*, note 11 § 4.3.6 and Memorandum from R. Parlow to the Executive Secretary, IRAC, IRAC Document 27181/1 (February 5, 1991) (Narrowbanding of the 162-174 MHz Band).

^{180/} We discuss in this subsection primarily sharing among uses or services, rather than sharing among licensees in a particular service. Sharing among services, when possible, can (continued...)

broadens service categories in that it opens a block of spectrum to a wider range of users. The discussion in the previous chapter advocates eliminating barriers between existing services that are based on the user's identity. Sharing can further expand service definitions to encompass an even broader range of users, by, for example, eliminating the barriers between mobile satellite services to include maritime and aeronautical applications. Sharing also includes allowing dissimilar services to operate in the same block of spectrum, for example, as currently occurs between terrestrial fixed service microwave and fixed satellite, or between land-mobile and broadcasting.

Shared spectrum already exists throughout the block allocation system. In some blocks of the spectrum used for fixed terrestrial and fixed satellite, service rules were initially designed to facilitate sharing. In others, such as television channels 14-20, sharing was added later. Sharing can take many forms. Users in different geographic areas can reuse the same frequency if separated by sufficiently large distances. Users can also share spectrum in time, as when taxicabs alternately use the same frequencies in the same city, or Citizens Band (CB) radio operators share frequencies. Co-channel frequency sharing is also possible, as with nonlicensed "Part 15" devices, which have such low power that they can operate at the same time, and on the same frequencies, as licensed services.^{181/} Sharing can involve sophisticated coordination procedures, as when fixed satellite service and terrestrial microwave, or Radiodetermination Satellite Service (RDSS) and radio astronomers, share the same spectrum. Sharing can also be accomplished through transmission techniques, such as spread spectrum, that spread low-power density signals across wide frequency bands simultaneously used by other services.^{182/}

Several commenters suggest that increased sharing of spectrum will allow for increased use. For example, ASNA suggests that sharing enables "technically and operationally compatible users to access frequencies assigned primarily to a different class of eligible [users] upon a showing that no regularly assignable channels are available."^{183/} CORF also suggests refinements to the system that would include blocks "partitioned according to geographical region, spatial direction, and time of day."^{184/} In particular, COMSAT suggests that the basic dimensions of spectrum sharing (i.e. time, frequency, and geography) could be better managed by improving tools to measure and access spectrum use.^{185/} It should be noted, however, that

^{180/}(...continued)

increase the potential use of a set of frequencies. Sharing among licensees can have similar effects, but must be structured to eliminate perverse incentives for individual licensees to act inefficiently in using the shared frequencies. The proposals for increased user flexibility and market-based assignments discussed *infra* could provide such a structure.

^{181/} See *infra* p. 80 and Appendix C for a discussion of nonlicensed devices.

^{182/} The FCC has also suggested sharing as a way to accommodate PCS in fixed use bands. See *Personal Communications Services*, *supra* note 7 at 3998.

^{183/} ASNA Comments at 4.

^{184/} CORF Comments at 8.

^{185/} See COMSAT Comments at 29. See also Chapter 5, p. 138 for a general discussion of measuring and monitoring spectrum use.

MST suggests that increased sharing of the broadcast bands has been detrimental to that service.^{186/}

1. Dynamic Sharing

Using advanced computer techniques, spectrum managers have greater opportunities to share frequencies, and thus greater opportunities to reduce inefficiencies created by rigid service boundaries. "Dynamic sharing" of frequencies between different services allows more than one system to use the same frequencies essentially at the same time, in the same geographic region. This is a special case of the "time division" sharing discussed above. Traditionally, sharing the same frequencies at similar, high power in the same geographic area required adoption of discrete time periods for use by each service. "Dynamic sharing" techniques permit such sharing on an "as needed" basis. Increased dynamic sharing would require further reliance on sophisticated technologies and methodologies.

Trunking is an example of dynamic sharing.^{187/} In a trunked system, channels that might otherwise be assigned to individual users are joined in a single system, and frequencies are automatically assigned to individual users on an "as needed" basis. Trunked systems allow disparate users to share spectrum, and generally provide a significant increase in efficiency over conventional assignment methods. Since the FCC approved trunking for land mobile use in 1974, many private sector groups have developed trunking systems. Private sector use has thus far exceeded federal government use of such systems. However, the federal government has approved more than 40 single agency trunking systems. In addition, in the Washington, D.C., area, NTIA has developed a pilot trunking system, constructed and operated by a private entrepreneur, that mixes small and large agency use.^{188/}

In the United Kingdom, another type of dynamic sharing occurs between cellular providers and military users in the 900 MHz bands. Access to these frequencies has greatly expanded the pool of available channels for cellular use. In this arrangement, the U.K. military has preemptive access to these frequencies, and as they need them, computer software programs automatically reclaim the frequencies for military use, excluding them from cellular access. In such instances, civilian users would experience graceful degradation, rather than a complete loss of service.^{189/}

^{186/} See MST Comments, Appendix at 15-19.

^{187/} Trunked land mobile radios share radio channels in an analogous way to landline telephones sharing trunked wireline circuits.

^{188/} Letter from J. Obuchowski to Rep. E.J. Markey, Chairman of the House Subcommittee on Telecommunications and Finance (Nov. 21, 1990) (Land Mobile Trunking Pilot Program).

^{189/} U.K. Department of Trade and Industry, Radiocommunications Division, Report of the Civil Spectrum Review Committee -- Stage 1: 470-3400 MHz, (4th Draft, Issue 3) at 99-100 (Apr. 10, 1989).

Dynamic sharing also has been a major issue in recent international discussions.^{190/} A possible means to improve efficiency in radio spectrum use is to merge services, and thus broaden radio service definitions.^{191/} The effect of such sharing would be similar to our previous recommendation that the FCC reduce distinctions among subclasses of users. For example, mobile satellite radio currently is divided into three radio services: aeronautical, maritime, and land mobile satellite. While the services are different, they have common aspects that could allow a sharing of the services under a broader classification, mobile satellite services.^{192/}

The system now proposed for sharing among the mobile satellite services is quite complex. It would involve a process of "dynamic allocation," where each of the mobile satellite services would be allocated spectrum on an "as-needed" basis, requiring a mechanism to implement priority and preemptive access, as necessary. Such a system would serve a variety of users with diverse needs, including different and continuously changing requirements for channel bandwidth, signal power, priorities, and network interfaces.^{193/} However, some commenters strongly oppose this combination of services because of the technical difficulty of such sharing arrangements.^{194/} It should be noted, however, that the replacement of analog with digital transmission technology may alleviate some of these difficulties and increase the potential for dynamic sharing.

In general, NTIA recommends that both the FCC and NTIA encourage increased use of dynamic sharing techniques, including trunking systems, and innovative sharing arrangements such as the United Kingdom's shared civilian and military uses. In particular, NTIA will expand its Washington area trunking program to other areas and will continue to encourage the use of trunked systems by the federal agencies.

NTIA also plans to work closely with the FCC to increase dynamic sharing of spectrum for mobile services. We agree with COMSAT that such sharing can be complex, and we recognize that the FCC must carefully coordinate dynamic sharing arrangements and ensure that

^{190/} Design of Mobile Satellite Systems Providing Aeronautical, Land and Maritime Services using Shared Resources, (Draft New Report of CCIR Interim Working Party 8/14 2nd Meeting) (Design of Mobile Satellite Systems).

^{191/} See, e.g., discussion of the activities of ITU's High Level Committee in Chapter 2, p. 52, and of current CCIR activities in note 161.

^{192/} NTIA has supported such dynamic sharing in the Mobile Satellite Service, and has recommended that the FCC consider adopting standards necessary for success of such sharing. See Technical Standards and Licensing Procedures for Aircraft Earth Stations, Notice of Proposed Rule Making, 5 FCC Rcd 3933 (1990) (AMSS(R)); see also NTIA Comments at 2-3 (filed Oct. 29, 1990).

^{193/} Design of Mobile Satellite, *supra* note 190, para. 4.2.9.

^{194/} In particular, COMSAT claims that frequency sharing between different satellite systems is difficult because mobile terminals' antennas offer little transmission or reception interference isolation, and also because these systems must provide distress and safety-of-life services using frequencies on "an exclusive or instantly preemptable basis to assure availability and the absence of harmful interference." See COMSAT Comments at 26.

technical specifications provide adequate protection of services.^{195/} Nevertheless, in our view, such sophisticated dynamic sharing can produce substantial benefits in promoting efficiency that far outweigh its costs.

2. Federal/Non-Federal Sharing

Another type of sharing that would help relieve demand inefficiencies created by rigid service boundaries is spectrum sharing among federal users and all other users. As currently defined, the U.S. block allocation system allocated a portion of the spectrum for exclusive use by federal agencies, a portion for exclusive non-federal government use, and a portion to be shared among such users.

In recent years, the FCC and NTIA have worked increasingly at formally sharing spectrum between federal and non-federal users. Of the entire allocated spectrum, which ranges to 300 GHz, approximately 93.1 percent is shared. Below 6 GHz -- the spectrum that is currently most commercially valuable -- approximately 65 percent is shared.^{196/} Some sharing arrangements also exist among federal and state government users, such as federal and state law enforcement agencies, and agricultural and natural resource agencies, though not formally defined.

However, current sharing arrangements may hinder full use of the spectrum by users in both jurisdictions. Even in shared spectrum, there are often "primary" and "secondary" users. Primary users, as the name suggests, have first rights to the use of a particular band of frequencies. Secondary users can operate in a band if they do not interfere with primary users.^{197/} This often results in the primary user having a de facto exclusive allocation, even though the spectrum is nominally shared.

In Chapter 2, we discuss ways to open the federal government process and improve private sector access to information about federal government spectrum.^{198/} The essential reason for providing this access is to improve efficiency that may be hampered by the split between federal and non-federal users. Another way to address the question of inefficiencies created by this split would be to consolidate similar spectrum usage by federal and non-federal users. As NTIA stated in its 1989 Long Range Plan (LRP):

A trend toward sharing of federal and nonfederal bands is evident. Parochial interests will be overtaken by technological advances and it will no longer be practical or cost effective to sustain an exclusive allocation, except in situations

^{195/} See AMSS(R), Notice of Proposed Rule Making, supra note 192, para. 3. NTIA acknowledges the difficulty of ensuring the absence of harmful interference to distress and safety-of-life services, and, given the complexity of such systems and the need for interoperability, has suggested that the FCC consider adopting receiver standards for this service. See NTIA Comments to AMSS(R), supra note 192 at 8-11.

^{196/} NTIA calculated the amount of shared spectrum using the Table of Frequency Allocations, taking into account primary and secondary services, and footnotes. See NTIA Manual, supra note 11 § 4.1.

^{197/} See id. § 4.1.3

^{198/} See Chapter 2, supra p. 24.

involving safety and national security. Thus, planning must be open to technological advances and the associated progression leading to increased sharing of frequency bands between two sectors.^{199/}

Further, as suggested in the LRP: "[s]pectrum for the exclusive use of the Federal Government is required when impairment of critical, mandated functions could occur or undue costs would be incurred as the result of sharing. . . . Noncritical uses should be guided into shared bands."^{200/}

Another means of providing more effective sharing between government and non-government users of spectrum would be to extend the concept of federal procurement of private sector telecommunications services. Federal government users could define a use common to all or most agencies, such as land mobile dispatch or cellular radio, and a band of appropriate frequencies currently allocated for federal use. Rather than each agency using its assigned frequencies for duplicative systems, the government could pool assignments within the common band, which would be "privatized." A private contractor could build and operate the system on behalf of the federal government, and as an incentive for it to operate most efficiently, the contractor could sell to the public excess capacity on its system once federal needs were met as its first priority.

NTIA, after seeking the advice of the IRAC, will explore with the FCC ways for federal government and private sector users to share spectrum through such procurement. Such a proposal would not be simple to implement. To ensure that federal government requirements for use of the spectrum are satisfied, the contractor would have to be able to meet all federal government needs for an extended period, regardless of private use of the system. Because NTIA currently has jurisdiction only over federal spectrum users, and the FCC has jurisdiction over private users, it is unclear when either or both would have jurisdiction over the procurement contractor.^{201/} Difficulties could arise if, as a result, such uses would be subjected to the typical FCC assignment process. To eliminate delay associated with that process would require either legislation or regulatory provisions to ensure that the federal government's chosen service provider would be permitted to use its authorized spectrum for private purposes -- perhaps through a "contractor's preference" adopted by the FCC. NTIA will consider such implementation issues with the FCC.

^{199/} NTIA Long Range Plan for Management and Use of the Radio Spectrum by Agencies and Establishments of the Federal Government, NTIA Special Publication 89-22, para. 3.21 (June 1989).

^{200/} Id. para. 3.18. As suggested above, in the microwave bands, coordination procedures are well established, and the affected equipment has well-known technical characteristics. Therefore, sharing could be carried further to the elimination of the assignment distinctions between Federal and non-Federal microwave frequencies, as well as distinctions between private and common carrier microwave.

^{201/} Depending on how the procurement arrangements are structured, it may be necessary to ensure that the FCC and NTIA have the necessary joint or overlapping jurisdiction to implement and enforce such arrangements. Furthermore, whether such "procurement contractors" would be deemed private or federal users may also be in question. The FCC and NTIA would have to resolve these and similar issues in order for such an arrangement to be practicable.

III. Enhancing Technical Flexibility through Adaptable Standards

An important goal of the block allocation system is to provide simple technical and service rules for avoiding harmful interference. The block system sets standard rules for the compatible development and operation of devices and radio services with similar technical characteristics to operate in a given band of allocated frequencies. Standards for particular services are the primary vehicles for equipment manufacturers and services to achieve the design certainty inherent in the block system.

Spectrum allocation processes could promote efficiency by seeking to increase "technical flexibility" through adaptable standards. The initial impact of increased technical flexibility would be to further reduce the need for a separate rulemaking proceeding each time users wish to implement new technical methods, allowing for the more rapid introduction of technical innovations within services. In addition, by permitting flexible and broadly defined technical standards, government regulators would reduce the likelihood of hindering the development of technologies not yet imagined. Indeed, in services for which there is considerable demand, flexible technical standards would provide the impetus and the means for using spectrum more efficiently.

While standards can be extremely important to spectrum management, we also recognize that standards that are set too early or too restrictively may impede technical innovation. Ideally, standards allow the user to perform minimum technical interpretation or calculations to permit the operation of a new system with acceptable levels of interference and appropriate interoperability. However, certain kinds of standards may limit or impede development of new, more efficient technologies. Further, it is not always clear, even in cases where standards are necessary, that the government, rather than industry, should choose these standards. Difficulties with the block system also arise when the government unnecessarily codifies technical standards, resulting in the need for rule changes in order to permit technical innovation. Increased "technical flexibility" would result from service definitions that include adaptable technical standards that allow for the easy introduction of new technologies.

A. Types of Standards

Improving technical flexibility requires an understanding of the role and types of standards in spectrum use, which we divide into three types: interoperability, spectrum, and performance standards.^{202/} First, interoperability standards seek to permit systems from different manufacturers to operate compatibly from the user's perspective. Setting interoperability standards is particularly important in cases where one entity controls the transmitter and another the receiver. For example, interoperability standards permit cellular radio users to communicate with all other public switched network users and establish the technical capability for cellular users to roam freely among cities using the same equipment.^{203/} Such standards for the

^{202/} These are roughly equivalent to the FCC's categories of interoperability, interference and efficiency, and quality standards.

^{203/} It should be noted that technical interoperability standards are only one aspect of providing cellular customers the capability to "roam" freely -- that is, use their equipment throughout the country. Cellular interoperability also depends on developing customer accounting and billing standards and designing systems and procedures that will achieve (continued...)

broadcasting service permit television or radio users to purchase receivers from a wide variety of manufacturers and be assured they will be able to receive all the stations available in any part of the country. In addition, these standards also ensure that television or radio users will be able to use their receivers not only at present, but into the future.

Second, spectrum standards,^{204/} like interoperability standards, specify certain technical characteristics of telecommunications equipment.^{205/} However, the purpose of spectrum standards is to control "the potential impact of any system or station on the normal operation of other systems or stations."^{206/} Spectrum standards assure that the transmitter emissions and, occasionally, receiver susceptibility of the existing systems, will fall within specified bounds. As such, spectrum standards, which are partially designed to reduce out-of-band and spurious (unwanted) emissions, can also reduce the costs to each new user in minimizing the level of interference to its neighbors. These standards directly affect users' interference to, and expectation of interference from, other radio services. Thus, spectrum standards define the level of permissible interference between services and determine certain equipment specifications and the distance separations required.

Spectrum standards can also address spectrum efficiency. By specifying minimum requirements for transmitter emissions, frequency and distance separation requirements, and receiver susceptibility limits, these standards limit the spectrum resources used by radio-communication systems.

Third, performance standards define levels of signal performance or signal quality. Common examples are standards that specify signal-to-noise ratios and minimum field strength requirements for television transmitters, and the minimum transmission system requirements for FM broadcast transmitters.^{207/}

203/(...continued)

seamless handoff at system boundaries. For example, prohibitions in the AT&T antitrust consent decree (the Modified Final Judgment or "MFJ") have restricted the provision of roaming capability by the Bell Operating Company cellular subsidiaries. With regard to the latter, in a recent opinion, the district court with jurisdiction over the MFJ granted a waiver of certain "inter-LATA" restrictions that had been impeding nationwide cellular interoperability. See Telecommunications Reports, Oct. 15, 1990, at 18.

204/ NTIA Manual, supra note 11, § 5.0. The FCC often describes what NTIA calls "spectrum" standards as "interference" and "efficiency" standards.

205/ Much technical literature refers to "interoperability" standards as "compatibility" standards. However, "spectrum" standards, as we define them, also attempt to ensure that radio-based systems are "compatible" in the sense that they cause only permissible levels of interference. Indeed, these standards attempt to define the "electromagnetic compatibility" (EMC) of services. These technical "compatibility" concerns are different from those addressed by "interoperability" standards. Therefore, to avoid confusion, we use the terms "interoperability" and "spectrum" standards.

206/ NTIA Manual, supra note 11, § 5.0.

207/ The FCC sometimes describes performance standards as "quality" standards.

B. Benefits and Costs of Setting Standards

A large body of theoretical literature exists on the benefits and costs of setting standards, and on the forces that drive industry and government to standardize, particularly in technology-intensive industries.^{208/} Standards play an important role in the development of most products and services, and spectrum-based products and services are no exception.

Standards can be beneficial when they decrease transaction costs and protect consumer investment by reducing the likelihood of "premature" technological obsolescence,^{209/} as is the case with television and radio broadcast standards. Standards also help satisfy the user's desire to consume a "portfolio" of goods, that is, "sample from (or have the potential to do so) possible services of the system, present and future. . . ." ^{210/} Standards can reduce the price of goods sold, both through production economies of scale^{211/} and lower costs of complementary inputs.^{212/} Moreover, by reducing risk and transaction costs, a standard can also motivate users to accept a new product or service, thus stimulating the market.^{213/}

While the benefits of standards are well known, costs are also associated with standardization. For example, performance standards can reduce consumer choice. Standardization can be particularly difficult in rapidly-changing, high-technology industries. Although one of the benefits of standardization is that it can prevent premature technological obsolescence, it can also cause technological development to stagnate by fixing products to their status at the time the standard took effect. Thus, standards can seriously limit innovation and product choice, and potentially affect the efficient use of spectrum. On the other hand, any change in standards can disrupt the status quo and impose costs on incumbent users with

^{208/} See, e.g., C.H. Sterling, The FCC and Changing Technological Standards, Journal of Communications, at 137 (Autumn 1982); C.P. Kindleberger, Standards as Public, Collective and Private Goods, 36 Kyklos 377 (1983); J. Farrell & G. Saloner, Standardization, Compatibility, and Innovation, 16 Rand Journal of Economics 70 (1985); M.L. Katz & C. Shapiro, Network Externalities, Competition, and Compatibility, 75 The American Economic Review 424 (1985); Y.M. Braunstein & J. White, Setting Technical Compatibility Standards: An Economic Analysis, The Antitrust Bulletin, at 337 (Summer 1985); S.M. Besen & L. Johnson, Compatibility Standards, Competition, and Innovation in the Broadcasting Industry, The Rand Corporation, prepared under a grant from the National Science Foundation (Nov. 1986); M. Mueller, supra note 150; S.M. Besen & G. Saloner, Economics of Telecommunications Standards, in Changing the Rules: Technological Change, International Competition, and Regulation in Communications, at 177 (1989); S. V. Berg, Technical Standards as Public Goods: Demand Incentives for Cooperative Behavior, 17 Public Finance Quarterly 29 (1989).

^{209/} See id., Besen & Johnson, at 8.

^{210/} See Braunstein & White, supra note 208, at 339.

^{211/} See Besen & Johnson, supra note 208, at 8.

^{212/} See Farrell & Saloner, supra note 208, at 70-71.

^{213/} See R. Ducey & M. Fratrick, Broadcasting Industry Response to New Technologies: The Complementary Roles of Stations and Consumers, at 7 (1989) (included in NAB Comments as Appendix E).

investments in equipment built to the old standard -- the larger the affected group, the higher the costs, both economic and political, and the more difficult the change.

The standard-setting process can be difficult.^{214/} In some cases, standards develop in the marketplace without any formal process (de facto standards). While this often is the most effective and efficient approach to arrive at standards, it does not always work (*i.e.*, sometimes standards fail to emerge). Even when it does work, the standards may not necessarily represent the best technology, but rather may be those associated with products of dominant firms.^{215/} Moreover, in the absence of clear market preferences, so-called "cooperative" standard-setting processes,^{216/} in which industry committees develop standards, can be hampered by delay. Such delays can be much greater if government manages the standard-setting process,^{217/} with the outcome not necessarily a better decision. NTIA and the FCC must balance the benefits of setting standards and of government involvement in this process against the difficulties that can result if premature or inefficient standards foreclose options.

C. Mandatory Radiocommunication Standards

NTIA and the FCC are often involved in the development of radio standards. The FCC has set all types of standards, *i.e.*, interoperability, spectrum, and performance. Once it codifies standards, the FCC requires evidence of compliance with the standard before it will issue a license.

^{214/} See Besen & Johnson, supra note 208, at 1-2 for a discussion of three types of standard-setting: "noncooperative" and "cooperative" behavior, and "government action."

^{215/} See Farrell & Saloner, supra note 208, at 180.

^{216/} The U.S. standard-setting process for radio-based products and services is, for the most part, a cooperative, voluntary effort. As with many other industries, there is a presumption regarding telecommunications standards that the federal government should rely on privately created, voluntary standards. See, *e.g.*, OMB Circular No. A-119, Federal Participation in the Development and Use of Voluntary Standards (Oct. 26, 1982).

The American National Standards Institute (ANSI) is a nonprofit industry organization that provides a process for the development of voluntary American National Standards. There are a multiplicity of organizations involved in the development of radio standards in the United States, primarily as ANSI members. For example, the Electronics Industry Association (EIA) and the Institute for Electronics and Electrical Engineers (IEEE) act as secretariats for ANSI but also normally publish approved standards on their own. Moreover, the Telecommunications Industry Association (TIA) cooperates with these organizations in developing some radio standards. Both EIA and IEEE are ANSI-accredited and may submit their standards to ANSI for publication as American National Standards.

Standards that are not determined by the market are developed through consensus in an open, pluralistic fashion. Participation in ANSI committees is available to all segments of the industry, including service providers, manufacturers, and users. Government representatives may serve on ANSI councils or boards. Results of these deliberations are open and available to all.

^{217/} See generally Sterling, supra note 208, at 142.

On the other hand, NTIA limits its standard-setting activities primarily to spectrum standards.^{218/} NTIA's standard-setting process, as with much of the federal government spectrum management process, involves building consensus among federal agencies in the IRAC and its subcommittees. Unlike the FCC, which can deny users licenses if they do not meet mandatory standards, NTIA enforces its spectrum standards by requiring federal users who do not comply with them to correct any interference that might result from their noncompliance.^{219/}

A major issue in discussing the role of standards in determining technical flexibility lies in defining when the FCC and NTIA should mandate standards. For example, in the FCC's direct broadcast satellite (DBS) proceeding, several parties argued that the FCC should mandate DBS transmission or receiver standards to ensure compatibility of signals, in order to reduce consumer and producer risk.^{220/} While many commenters believe that standards, in general, are important to efficient and effective spectrum management,^{221/} many also believe that the FCC should encourage flexible standards,^{222/} or rely on voluntary standards to the extent possible.^{223/} Some commenters suggest, however, that the FCC should take a more active role in standards that are currently formulated by voluntary committees.^{224/} Some commenters say that significant government involvement in standard-setting is most needed in controlling interference.^{225/} Others criticize the FCC's relaxation of spectrum standards, particularly in preventing interference to broadcasting services.^{226/}

In reviewing technical regulations as part of its 1984 Re-examination of Technical Regulations (Technical Regulation) proceeding, the FCC established a number of guidelines governing when it should be involved in setting mandatory standards.^{227/} The Technical Regulation proceeding culminated in an FCC finding that it is generally not in the public

^{218/} Other federal agencies are involved in setting standards relating to spectrum. For example, the National Communications System (NCS) develops nationwide emergency interoperability standards for federal coordination and approval.

^{219/} NTIA Manual, supra note 11, § 5.0.1.

^{220/} See Regulatory Policy in Regard to Direct Broadcast Satellites for the Period following the 1983 Regional Administrative Radio Conference, Report and Order, 90 FCC 2d 676 at 716 (1982). The FCC decided not to adopt such standards.

^{221/} See, e.g., AAR Comments at 26; FEMA Comments at 7; FAA Comments at 4, Lichtenstein Comments at 3-4; FCCA Comments at 15.

^{222/} See, e.g., AAR Comments at 26.

^{223/} See, e.g., Bell Atlantic Comments at 16, TIA Comments at 5-6.

^{224/} See Ericsson Comments at 15-16.

^{225/} See, e.g., LMCC Comments at 62; TIA Comments at 5.

^{226/} See NAB Comments at 24; see also MST Comments at Appendix (discussion of FCC standards and policies and television interference).

^{227/} See Re-Examination of Technical Regulations, Notice of Inquiry and Proposed Rule Making, 48 Fed. Reg. 14,399 (1983); Report and Order, 99 FCC 2d 903 (1984).

interest to mandate technical standards designed to maintain the quality of signals, or even, in many cases, technical standards designed to maintain interoperability. The FCC emphasized that while such standards may be necessary, the private sector, not government, should decide when that is the case. While the FCC suggested that industry generally is best situated to determine interoperability standards, there is still the important government role of setting goals and objectives and working with industry regarding public safety and national security.^{228/} Also, the FCC indicated that "[d]irect Commission regulation of interoperability" is useful in "helping the introduction of new services involving large public participation."^{229/}

The FCC also found in Technical Regulation that although spectrum efficiency is a valid regulatory concern, government-mandated efficiency standards are not necessary when there are incentives for users to operate efficiently. However, the FCC noted that under the current regulatory system, not all services are subject to such incentives and that, in certain instances, regulating spectrum efficiency may be appropriate.^{230/} Technical Regulation does not provide guidelines for determining when there is an absence of such incentives. Finally, the FCC stated that government's role in mandating standards for interference control, is "a valid, even an essential government function," and that these standards are necessary to control unwanted emissions.^{231/}

To the extent that the FCC does mandate the various types of standards, it generally has chosen to achieve these objectives by designing standards that specify the results required and not the methods used to obtain these results. In this context, even mandatory standards have provided the user some design flexibility.

In general, NTIA believes that the guidelines outlined in Technical Regulation are wise policy for both federal and non-federal spectrum use. NTIA supports the FCC's long-held objectives of reducing restrictive standards and encouraging technical flexibility. Thus, we share the FCC's general preference for private sector standard-setting, in coordination with government, as opposed to standard-setting by government regulation. However, if, in addition to minimizing interference, the goals of technical regulation are to promote efficient use of the spectrum, and to insure interoperability and rapid diffusion of a specific technology, there may be cases in which the market does not respond or where there are no incentives for industry to reach a cooperative agreement. Ducey and Fratrick suggest generally that mandatory standards may be important where the market cannot effectively reach such an agreement.^{232/} We recognize the difficulty of determining when the benefits of government-mandated standards

^{228/} See id., Report and Order, para. 910-911.

^{229/} Id.

^{230/} Id. at 907.

^{231/} Id. at 905-906. These standards would be a subset of what we have defined as "spectrum standards."

^{232/} See Ducey & Fratrick, supra note 213, at 24-25. Further, they suggest that this is more likely to occur where such standards must occur in more than one point in the production chain. They also suggest that, in these circumstances, government either mandating or protecting industry-developed standards may be necessary to promote technological development. Id.

outweigh the costs of the delays involved in the rulemaking process and in the unnecessary rigidity that such codification may impose.^{233/}

In such cases, it may be necessary for the government to mandate interoperability standards or promulgate standards specifically to improve spectrum efficiency. The difficulty is in developing criteria that will anticipate when markets will fail and when such government actions are appropriate. NTIA believes that the FCC's general guidelines for government-mandated interoperability standards provide appropriate criteria for evaluating when government should consider mandating standards versus relying on the private sector.^{234/} A principal role for government, in some circumstances, may not be to select a new standard, but to manage the transition from the old to the new interoperability standard. For example, government might require "backward compatibility" and set timetables to phase in a new standard, as it may be difficult for industry to manage such a transition.

^{233/} Although private sector standard-setting is generally preferable to government imposition of standards, it is not a strategy that guarantees success in all cases. The market can fail to produce a standard and the development of new products or services can suffer as a result. For example, the FCC's controversial decision not to mandate, or even protect, a single AM stereo broadcasting standard has been criticized widely as hindering the development of that AM service. See, e.g., NAB Comments at 23-34.

The FCC's AM stereo decision reflected its concern that a government agency could not establish the superiority of one particular standard and that mandating a single standard would negatively affect the technological development of the service. See Radio Broadcast Services: AM Stereophonic Broadcasting, Report and Order, Docket No. 21313, 47 Fed. Reg. 13,152 para. 49 (1982).

The FCC later reaffirmed this decision when, in response to a petition filed by TEXAR, Inc., it chose not to conduct a rulemaking proceeding to determine a single AM stereo transmission standard. AM Stereophonic Broadcasting, Memorandum Opinion and Order, 3 FCC Rcd 403 (1988).

Despite the technical feasibility of AM stereo, no industry standard has emerged in the marketplace, and AM stereo has yet to develop as a viable service. Had the FCC applied the guidelines outlined in Technical Regulation, it might have viewed AM Stereo as a new service with the potential for broad consumer participation, and thus subject to mandated interoperability standards.

On the other hand, in its TV stereo decision, the FCC protected from interference the "pilot tone" of a particular stereo system. The regulations permit licensees to use other systems without FCC permission, if they believe an alternative is superior. 47 C.F.R. §§ 73.669, 73.682(c) (1990). This action encouraged industry to adopt the Broadcast Television Systems Committee (BTSC) standard, while not precluding future changes in the provision of stereo television. The FCC's action thus was a limited form of government intervention that also permitted flexibility.

^{234/} On the other hand, the guidelines for setting standards to achieve greater technical efficiency are less clear.

1. Technical Flexibility in Non-Federal Spectrum Use

Reducing technical barriers through flexible standards is not a new concept. Indeed, the FCC has had considerable success with reducing some of the more rigid standards that might impede technical innovation in services. Throughout the 1980s, the FCC made major gains in achieving greater technical flexibility by relaxing many mandatory technical requirements.^{235/} As part of the Technical Regulation inquiry,^{236/} the FCC subjected a wide variety of its technical standards to public scrutiny. Its primary objective in seeking public comment was to assess ways in which the FCC could maximize users' flexibility in introducing new technologies. Although the specific rule changes brought about by the Technical Regulation proceeding were limited,^{237/} it did set some basic policy guidelines to promote technical flexibility.

While acknowledging the importance of its role in managing interference, the FCC is also seeking to adjust its Type Acceptance rules to provide greater flexibility.^{238/} Type acceptance is an equipment authorization issued by the FCC, indicating that a particular piece of equipment meets the standards for a particular radio service. In this proceeding, the FCC has suggested new rules, Alternative Type Acceptance (ATA), for land mobile transmitters, which would allow easier certification of new equipment in these bands than under the current type acceptance rules.^{239/}

The FCC also encouraged technical flexibility in its 1988 decision declining to mandate new cellular interoperability standards. Instead it established general cellular rules that flexibly permit cellular operators to use a variety of product designs.^{240/} In keeping with its policies stated in the Technical Regulation proceeding, in its Cellular Radio rulemaking, the FCC

^{235/} See Webbink, supra note 165, at 12-15 for a discussion of FCC activities with regard to increasing technical flexibility. For example, in 1982, the FCC chose not to impose technical interoperability standards on DBS. Also in 1982, in releasing the 800 MHz reserve for public and private land-mobile use, the FCC allowed users substantial technical flexibility: both the capability to subdivide a channel into multiple smaller channels, as well as the option for multiple channel licensees to use adjacent channels as one large channel. In 1986, the FCC eliminated the AM stereo quality standards that it had earlier sought to remove in Technical Regulation.

^{236/} See Technical Regulation, Notice of Proposed Rule Making, supra note 227.

^{237/} The proceeding proposed several specific rule changes, including deleting from the rules quality standards related to AM, FM, and television broadcasting, while retaining certain television interference and interoperability standards. Technical Regulation, Notice of Proposed Rule Making, supra note 227, paras. 30-39. The FCC chose not to adopt rules that would allow greater flexibility in AM, FM, and television broadcasting interoperability standards.

^{238/} See Technical Flexibility in the Mobile Communications Services Rules, Further Notice of Proposed Rule Making, 3 FCC Rcd 1655 (1988).

^{239/} See 47 C.F.R. § 2.981 to 2.1005.

^{240/} See 47 C.F.R. § 22.900 - 22.930 (1989); see also Liberalization of Technology and Auxiliary Service Offerings in Domestic Public Cellular Radio Telecommunications Services, Report and Order, 3 FCC Rcd 7033 (1988); Memorandum Opinion and Order, 5 FCC Rcd 1138 (1990) (Cellular Radio).

declined to mandate technical interoperability standards for future cellular systems.^{241/} Unlike the first-generation cellular systems, for which interoperability standards were necessary to ensure the development of the service,^{242/} in Cellular Radio, the FCC found that the large group of existing cellular users and operators would drive the industry to reach an agreement on compatible systems.^{243/} The rapid rate at which the industry appears to be reaching agreement on new cellular interoperability standards underscores the wisdom, in this instance, of providing the industry standard-setting process with maximum design flexibility and of not mandating standards by government regulation.^{244/}

NTIA strongly encourages the FCC to continue its efforts to increase technical flexibility for all services, and implement the basic policy objective of increasing technical flexibility, as stated in the Technical Regulation proceeding.^{245/} Further, NTIA recommends that the FCC conduct rulemaking proceedings to determine further those technical standards now codified in FCC rules that can be relaxed or eliminated.

As exemplified by the FCC's treatment of digital cellular radio, when there is an established, expanding market for a technology, heavy government involvement in the interoperability standard-setting process is often unnecessary. Nevertheless, as indicated in Technical Regulation, mandating interoperability standards may be useful for new technologies in services, such as broadcasting, that involve substantial consumer participation.^{246/} In such cases, NTIA would support a process similar to that which the FCC is currently using to determine a terrestrial transmission standard for advanced television service (ATV) -- that is, a mechanism for industry testing and evaluation of proponent systems, with eventual FCC adoption of standards that will undoubtedly rely heavily (although not uncritically) on the outcome of the industry efforts.

NTIA recommends that the FCC and NTIA jointly explore when, if ever, mandated standards are necessary to require greater technical spectrum efficiency. We agree that when the FCC grants licensees technical flexibility and there are incentives for users to operate

^{241/} See id., Report and Order at 7040.

^{242/} See Technical Regulation, Report and Order, supra note 227, at 910-911.

^{243/} See Cellular Radio, Report and Order, supra note 240, at 7039.

^{244/} In May 1990, two years after the adoption of new cellular rules, the cellular industry adopted interim standards for digital cellular using time division multiple access (TDMA). See Cellular System Dual-Mode Mobile Station - Base Station Compatibility Standard, EIA/TIA Interim Standard 54 (May 1990). While there continues to be controversy as to whether TDMA or other, purportedly more efficient techniques, such as code division multiple access (CDMA) should be the industry standard (and industry efforts are continuing in this regard), there is fairly widespread agreement that it would not have been appropriate for the FCC to have attempted to mandate a new interoperability standard.

^{245/} Technical Regulation, Report and Order, supra note 227.

^{246/} See id. at 910-911. NTIA would also include an expectation of nationwide interoperability as a possible criteria for the government to evaluate whether to mandate standards.

efficiently, few standards governing spectrum efficiency may be necessary.^{247/} However, because efficiency in spectrum use is extremely important, certain situations may require government-mandated standards to encourage users to operate more efficiently. For example, one service may be operating at peak technical efficiency, and yet still face unmet demand, while another service, using frequencies contiguous to the first, may not encounter such demand. In the absence of incentives, NTIA or the FCC might want to require that the second service operate more efficiently to free spectrum for the first service.^{248/}

2. Technical Flexibility in Federal Spectrum Use

In many ways, federal users have considerably more technical flexibility than non-federal spectrum users. Although NTIA has authority to set interoperability standards,^{249/} we generally prefer that industry or, where appropriate, agencies acting with the advice of industry, establish these standards.

NTIA sets "spectrum standards" for federally-used transmitters and, to a limited extent, for receivers when there are interference concerns. As with the FCC, spectrum standards define for federal users the minimum interference between services and thus affect certain equipment specifications as well as required frequency and distance separations. Spectrum standards further define the authorization that NTIA gives federal users to operate a telecommunications system.

NTIA's regulations state that an agency operating a system not in conformance with spectrum standards is normally responsible for eliminating interference resulting from its nonconformance.^{250/} Further, as with the FCC's type acceptance rules, procurement specifications for equipment for federal agencies must meet or exceed NTIA's standards.^{251/}

^{247/} See id.

^{248/} Moreover, Webbink suggests that "if users develop technologies that split their channels in half, they may be doubtful about whether the FCC will take half of the newly available channels away from them. In that case, those users may choose not to use or to reveal the existence of the channel splitting technique." See D. W. Webbink, Spectrum Deregulation and Market Forces, paper presented at the Center for Telecommunications and Information Studies at 4-5 (Oct. 14, 1988, revised July 8, 1989). Generally, as in the discussion beginning on page 79 of this chapter, NTIA believes that by increasing "user flexibility," the FCC can increase users' incentives to operate efficiently and thus avoid unnecessary technical efficiency standards. The use of additional market-based principles in spectrum management, as discussed in Chapter 4, can also provide such efficiency-enhancing incentives.

^{249/} The Assistant Secretary of Commerce for Communications and Information is authorized to "assist in the formulation of. . . standards for the telecommunications activities of the Executive Branch including considerations of interoperability, privacy, security, spectrum use, and emergency readiness." Department Order 10-10, supra note 10, § 6.05. However, the NCS, through its Federal Standards program, develops many government-wide interoperability standards for emergency situations. NTIA sits on a number of the NCS standards committees.

^{250/} NTIA Manual, supra note 11, § 5.0.1.

^{251/} Id., § 5.0.2.

Moreover, NTIA requires federal agencies to use new telecommunication systems in such a way that their operations do not interfere with existing systems that conform to the standards.

NTIA supports increased technical flexibility for both federal and private sector users, and recognizes that this policy will generally encourage innovation. In addition, when a service provider -- whether private sector or governmental -- faces increasing demand, flexibility also encourages more efficient use of spectrum. As discussed above in the context of non-federal spectrum use, in the absence of these incentives, spectrum standards can play a constructive role in promoting efficient spectrum use. Thus, as noted above, NTIA will work with the FCC to develop criteria for determining the appropriate role of government in setting standards to achieve greater technical efficiency. Further, NTIA will continue to adopt standards that promote the most efficient operation of federal government spectrum-based systems, while maintaining a flexible spectrum management system.

D. Receiver Standards

Receivers are another focal point of the current debate regarding government-mandated standards, particularly with regard to home television and radio receivers.^{252/} While the FCC has authority to regulate home receivers,^{253/} it generally has not done so.

NTIA believes that the FCC has exercised reasonable judgment in not directly regulating receivers for use in the home. Generally, interference and spectrum efficiency are controlled through transmitter standards, distance separation requirements, and receiver standards. In that the FCC controls transmitter spectrum standards and distance separation requirements, it, in effect, has control over receiver standards.^{254/} We encourage the FCC to continue to foster spectrum efficiency, to the extent possible, through transmitter standards and through reducing frequency and distance separation requirements.

NTIA recognizes, however, that mandated receiver standards may be appropriate when there are public safety or national security concerns. Also, sophisticated communications systems, when there are complex sharing arrangements, may require that the receiving equipment have an active signalling function, raising both interoperability and interference standards concerns. In such cases, the FCC and NTIA might have a legitimate role in regulating receivers, both as emitters of potentially interfering signals and, from a public safety point of view, to ensure interoperability.

^{252/} For example, NPR suggests that interference and spectrum efficiency problems lie not in the relaxation of spectrum standards, but in the lack of receiver standards, particularly for television receivers. NPR Comments at 10-11.

^{253/} 47 U.S.C. § 302a(a) (1988).

^{254/} In addition, since most home receivers do not emit appreciable electromagnetic radiation, a substandard receiver will not directly affect the operation of any other system, and therefore does not need to be subject to interference standards. The FCC does regulate television and other receivers for unintentional radiation emissions. See 47 C.F.R. §§ 15.101-15.111 (1990). In addition, the FCC currently regulates the basic tuning mechanism, tuning controls, and channel readout of television receivers and will shortly add new regulations to implement the Television Decoder Act of 1989. See 47 C.F.R. § 15.117 (1990); see also Rules to Implement the TV Decoder Circuitry Act of 1990, Gen. Docket No. 91-1, Notice of Proposed Rule Making (released Jan. 4, 1991).

NTIA has previously suggested that the FCC consider adopting industry-developed receiver standards for the Aeronautical Mobile Satellite Service (AMSS(R)).^{255/} NTIA acknowledges the difficulty of ensuring the absence of harmful interference to distress and safety-of-life services, and, given the complexity of such systems and the need for interoperability, has suggested that the FCC consider adopting receiver standards for this service.^{256/}

NTIA supports FCC review of such services on a case-by-case basis to determine the appropriate government role in support of this process. In addition, NTIA is willing to work with the FCC, through the Joint Strategic Planning Council discussed in Chapter 2, to determine if there is a broader case for government-mandated receiver standards, and further explore and define the conditions that would justify such action.

IV. Increasing User Flexibility

In seeking efficient use of the spectrum, the notion of flexibility can be extended still further. Not only should the block allocation system allow a greater variety of uses of a single block of frequencies, and flexible operations within a service, in previous sections of this chapter, it should also provide more discretion for users to determine the most valuable use for assigned spectrum.

We define "user flexibility" to include ways to increase users' rights granted pursuant to an authorization to use spectrum. Giving users greater ability to determine the use of a particular portion of spectrum arguably would build more flexibility into the system as a whole, and also introduce the basis for workable market mechanisms that could maximize efficient use of spectrum. Users with such well-defined rights would be positioned to implement service changes quickly in response to changes in demand.

A. Recent Efforts to Increase User Flexibility

Both NTIA and the FCC have promoted increases in user flexibility. For example, over the years, the FCC has granted broadcasters increased flexibility in subcarrier authorizations, allowing broadcasters to use their subcarrier frequencies for paging or common carrier services.^{257/} It also has approved use of television's vertical blanking interval for closed captioning and teletext services.^{258/} In addition, NTIA has combined telecommand and telemetry

^{255/} See NTIA Comments in AMSS(R), supra note 192, at 8-11.

^{256/} See id. One federal government frequency band where NTIA has implemented receiver standards is the 2700-2900 MHz band allocated to the aeronautical radionavigation and meteorological services that perform safety functions. NTIA requires that all new systems planned for the band include interference suppression circuitry because of the crowded conditions in this band. These receiver standards have resulted in more users being accommodated and thus more efficient use of the band.

^{257/} See, 47 C.F.R. §§ 73.295, 73.665, 73.667 (1990).

^{258/} 47 C.F.R. § 73.646 (1989).

in radio location bands when such operations are conducted as an integral part of a radio location system.^{259/}

In 1986, as part of the proceeding allocating the remaining 32 MHz of the land mobile reserve, the FCC established the General Purpose Mobile Service (GMS), a service which is both user and technically flexible.^{260/} This service is a radical departure from previous service allocations in the PLMRS. Not only can the FCC assign channels to any type of user in the GMS, a situation similar to SMRS, it can also assign any kind of mobile use, including mobile satellite or land mobile services. While this only applies to a limited, and in fact, noncontiguous portion of the spectrum,^{261/} it is an important step in providing greater user flexibility within the PLMRS.

In liberalizing the cellular rules,^{262/} the FCC also permitted cellular operators greater flexibility to use assigned frequencies, other than the cellular control channels, for provision of auxiliary services. This allows cellular operators to offer common carrier mobile services other than cellular, such as paging. In addition, current FCC rules do not, on their face, prevent providers from operating some of the new personal communications systems, with notification to the FCC the only requirement.

Another example of broadly-based user flexibility involves the set of systems known as "nonlicensed devices" that operate under Part 15 of the FCC's rules.^{263/} Such devices range from radio-controlled toys to computers to cordless telephones. FCC rules limit the emitted power of nonlicensed devices, which permits them to "overlay" the licensed services for which blocks of spectrum have been allocated. Some nonlicensed devices transmit a signal for radiocommunications, while others, such as computers, emit radio energy incidental to their operation. The use of nonlicensed devices is spreading rapidly, as new applications develop.

This overlay approach provides a great deal of flexibility to nonlicensed users, and has stimulated a considerable amount of innovation, particularly in the development of consumer products. Many U.S. homes now have various types of remote control and devices for wireless intra-home communications. However, this approach also clearly illustrates the hazards in increasing user flexibility. Some users of licensed services express concern over interference problems associated with nonlicensed devices.^{264/} As a regulatory matter, nonlicensed devices are not "protected; they must accept interference from, and not interfere with, licensed uses.

^{259/} NTIA Manual, *supra* note 11, § 1.18.

^{260/} Allocation of Frequencies in the 900 MHz Reserve Band for Private Land Mobile Use, Report and Order, 2 FCC Rcd 1825 at 1841 (1986).

^{261/} Original proposals were to apply to a much larger portion of spectrum. *See* Mueller, *supra* note 150, at 42.

^{262/} Cellular Radio, *supra* note 240.

^{263/} *See* Appendix C for a detailed discussion of regulatory concerns regarding nonlicensed devices.

^{264/} *See, e.g.*, ARRL Comments at 23; *see also* MST Comments, Appendix at 16; du Treil, Lundin & Rackley Comments at 9; FAA Comments at 3; NBC Comments at 15; NSF Comments at 13-14.

However, as a practical matter, when there are a large number of such devices in consumers' hands, it can be difficult for licensed users to enforce their ostensible "rights."

NTIA supports the existing FCC approach for overlaying the use of nonlicensed devices across the allocation bands, believing it to be efficient and effective. It generally provides users flexibility and a light regulatory burden. However, NTIA proposes some modifications that may be necessary to ensure its long term success.^{265/}

Moreover, as we discussed in the Notice, the FCC's 1985 "flexible use" initiative in the Land-Mobile/UHF Further Sharing docket proposed to grant UHF television licensees the rights to operate other services, such as land mobile, on their assigned channels.^{266/} This proposal would have applied only to channels 50-59, and would not have given rights to any spectrum outside the assigned broadcast channels. However, it would have allowed licensees to offer any technically feasible communications service.

It should be noted that NTIA assigns spectrum to federal agencies for provision of a service defined under a specific allocation. Once assigned, a federal agency must confine itself to that use. However, NTIA does not define services as narrowly for federal users as the FCC does for non-federal users. These broader definitions allow federal users some degree of flexibility in determining services to be offered.

NTIA supports further efforts to promote user flexibility where warranted, as generally described in the Land-Mobile/UHF Further Sharing docket. Because UHF broadcast spectrum is currently being reserved for broadcast ATV, it is reasonable to await the outcome of that proceeding before considering to offer such flexibility in the UHF television band. However, in the long run, such flexibility, applied to many services, could have a number of benefits. For example, it could reduce "parochialism" of blocks. Moreover, licensees would be encouraged to develop innovative uses for their spectrum and new services could emerge, if demand warrants, from existing spectrum allocations rather than through a process of administrative reallocation.

Nevertheless, there are a number of difficulties with implementing such an approach, particularly in applying it to existing services. For example, even with established spectrum standards, preventing interference and maintaining spectrum efficiency could be difficult, particularly as portions of the spectrum becomes crowded. This approach could make it more difficult to establish nationwide interoperability for some services. Further, some could argue that existing licensees would be receiving a "windfall" if allowed to offer services not originally permitted under their license. Finally, by eliminating blocks of spectrum dedicated to a single use, such flexibility could divert spectrum away from services that have less economic value in the market place, but that further the public interest in other ways. However, none of these problems are, in NTIA's view, insurmountable.

In order for spectrum managers to gain some experience with implementing this type of increased flexibility, NTIA recommends that it and the FCC experiment with increasing "user

^{265/} For more detail and NTIA proposals regarding Part 15 regulation, see Appendix C.

^{266/} Further Sharing of the UHF Television Band by Private Land Mobile Radio Services, Notice of Proposed Rulemaking, FCC General Docket 85-172, 50 Fed. Reg. 25,587 (1985) (Land-Mobile/UHF Further Sharing). This proceeding was suspended pending a decision in the ATV inquiry. Order, 2 FCC Rcd 6441 (1987).

flexibility" in frequencies that are not currently heavily used. Although this is only one aspect of user flexibility, we believe that it will provide spectrum managers useful information for implementing such programs throughout the spectrum. We describe this proposal below.

B. Interference Rights: Limited Experiment with EMC Methods above 10 GHz

Some analysts suggest that the outcome of a system where there is greater user flexibility would be a more efficient spectrum management system:

Just as the Part 68 rules make it possible for any certified telephone to be plugged into the public network regardless of its design or manufacturer, a flexible radio allocation would allow any type of service to be plugged into the available frequencies as long as it did not create interference.^{267/}

This type of flexibility is evident in the operation of nonlicensed devices; but, as the name suggests, these devices do not have the rights associated with a license. It is also the type of flexibility that the FCC suggested in the UHF/Land Mobile Sharing docket. A number of commenters to the Notice object to this proposal, suggesting that such flexibility will only lead to increased interference to existing services.^{268/}

Applying such principles of flexibility to licensed uses would require a shift in thinking in spectrum management. Systems would not be licensed according to a set of technical and service rules, but would be accommodated according to other users' "interference rights."

There is some precedent in the current system for this kind of user flexibility.^{269/} However, the more typical way for spectrum managers to control out-of-band and out-of-service interference in many radio services is through distance and frequency separation criteria. These are estimates of interference and service coverage areas, with stations assigned to prevent interference contours from overlapping. Spectrum managers most often determine these requirements when they first allocate spectrum for a service. These requirements are based on the characteristics of then-current transmission and receiver technology. The FCC uses this method of determining spectrum assignments in FM radio, television, and some land mobile bands.

An alternative method of assigning frequencies, and one that would be required if licenses were granted on the basis of other services' "interference rights," uses EMC techniques to assess the interference potential of each user and "engineer" new systems into place. The FCC uses this method in assigning low power television stations. EMC techniques permit users to share spectrum among several different services. The key to the successful use of EMC

^{267/} See M. Mueller, supra note 150; see also 47 C.F.R. Part 68 (1990).

^{268/} See, e.g., NAB Comments at 18-19.

^{269/} The most notable examples are the nonlicensed devices permitted under Part 15 of the FCC's rules and discussed in Appendix C.

techniques is for spectrum managers and users to agree to interference criteria that are acceptable to all affected services.^{270/}

The FCC and NTIA would have to control interference caused by licensees with "user flexibility" using EMC techniques. Some commenters, notably engineering firms, support using EMC methods to manage spectrum, even suggesting that using interference criteria, rather than distance separation requirements, would promote technological advances.^{271/} However, some question the FCC's technical ability to perform this engineering and contend that spectrum management by interference avoidance should not occur until the FCC develops and implements a satisfactory methodology.^{272/} Further, commenters argue that these methods are useful "only to the extent that correct criteria are used."^{273/}

Testing the viability of EMC techniques as an alternative spectrum management method, and as a potential means to manage licensees with "user flexibility," would require experimenting with managing a block of spectrum using these methodologies. In particular, it is important that spectrum managers develop correct "interference criteria." Even in a system where the user determines what services are offered in which portions of the spectrum, the FCC and NTIA would likely have a role in regulating interference between systems. Moreover, according to some analyses,^{274/} services with widely varying bandwidth and technical requirements might not efficiently use a block of spectrum.

While NTIA believes that EMC methods of managing the spectrum eventually may be useful in providing for full spectrum efficiency, we recognize the difficulties in implementing such a system. Given these difficulties, and the need to understand how such a system would work in order to comfortably allow more user flexibility, NTIA recommends that the FCC, with the technical assistance of OSM and ITS, develop a program of experimental EMC management to test these concepts and the requirements for their implementation. To avoid problems with heavily-used services, NTIA suggests that such an experiment should take place in a band of little-used frequencies such as those above 10 GHz. Such an experiment would consist of spectrum managers using EMC techniques to engineer a variety of different services into a limited band.^{275/}

^{270/} See R. Mayher, Sharing Techniques for Using the Radio Spectrum in the Year 2000, paper presented at the Tenth International Wroclaw Symposium on Electromagnetic Compatibility (June 26-29, 1990).

^{271/} See, e.g., Comsearch Comments at 13.

^{272/} See, e.g., du Treil, Lundin & Rackley Comments at 8-9. NTIA's laboratory, the Institute for Telecommunication Sciences (ITS), has developed sophisticated assignment models that could be used for this purpose.

^{273/} See Comsearch Comments at 15.

^{274/} See Longman, supra note 149.

^{275/} Thus, this experiment would focus on testing EMC techniques on numerous services. As an initial matter, we would not apply such techniques in lower, commercially-desirable bands.

V. Flexibility and Markets

Webbink states that by increasing flexibility within blocks, the FCC also is increasing the "rights" that accompany use of the spectrum.^{276/} These rights are necessary components of a market system.^{277/} As such, by increasing the flexibility of the spectrum management system, the FCC and NTIA are making incremental movements toward full realization of the efficiencies possible through markets, such as the private sales and purchases that constantly occur among spectrum users. However, as stated in the Technical Regulation proceeding, the FCC has suggested that as long as the incentives of the licensee do not reflect the economic value of spectrum, there will still be a tendency for the licensee to be "profligate in its use," thus requiring some level of technical regulation.^{278/}

Generally speaking, NTIA believes that U.S. spectrum policies should recognize the economic value of spectrum, and should permit users to realize that value. Promoting flexibility helps ensure that the spectrum can be used for the purpose for which it is best suited.

Thus, to the extent that the block allocation system can be modified to permit additional flexibility, users, their customers, and the economy as a whole, will benefit. More rational suballocations will permit users greater opportunities to harness unused spectrum for similar functions. Greater technical flexibility would permit manufacturers to focus on the best standards for their products to meet user needs. And greater user flexibility would permit more private ordering of desirable spectrum uses.

Even without other reforms, increased flexibility could improve U.S. spectrum management. However, the flexibility that we have discussed in this chapter would benefit the user even more if coupled with increased recognition of user's rights to offer multiple services as a result of such flexibility and to transfer those rights freely. We discuss these issues in the next chapter.

^{276/} See Webbink, supra note 165, at 9-18.

^{277/} See Chapter 4, infra, for a discussion of markets and a licensee's "property rights."

^{278/} See Technical Regulation, Report and Order, supra note 227, at 907.

CHAPTER 4

ALTERNATIVES FOR APPORTIONING AND VALUING SPECTRUM

I. Introduction

A. Alternative Spectrum Management Approaches

Long-term solutions to the problems of "spectrum shortages" in many bands, inefficient spectrum use, and impediments to innovation in spectrum-related technologies may require a redefinition of the legal and regulatory concepts underlying domestic spectrum management. Thus far we have suggested improvements in the regulatory framework for spectrum management and in the block allocation system. Further improvements may best be realized by adoption of alternative strategies to permit more explicit use of economic incentives as a tool for spectrum management.

Every spectrum management system must apportion spectrum among competing and often incompatible uses and users.^{279/} To prevent harmful interference, most spectrum users must be separated by frequency, distance, or time. Without proper separation, spectrum use becomes impossible, as incompatible transmissions drown each other out -- such as happened during the chaotic "radio wars" of the 1920s. With the necessary separations in place, however, there may be a limit, given current technology, on the number of spectrum users that can operate in a frequency range.

Whether there is in fact a "spectrum shortage" is the subject of continual debate. On the one hand, most usable spectrum has been allocated to services and assigned to particular users. Motorola says that "a crisis is at hand" and states that spectrum is needed for the "cataclysmic economic struggle" in which the U.S. is currently engaged with other countries.^{280/} At the same time, actual usage in some bands may be low, and some uses may not be economically efficient. Accordingly, some observers argue that perceived spectrum scarcity is the result more of current inefficient spectrum management policies than of any technologically-based shortage.

There have been efforts to increase the usefulness of the spectrum solely through manipulation of the management system --for example, the creation of a reserve of spectrum for land-mobile services primarily from UHF broadcast spectrum, which provided most of the spectrum now used by cellular radio. This reallocation took place under unique circumstances. The UHF band was not widely assigned in 1968 when the reallocation was made, and there

^{279/} The term "apportion" encompasses both the process by which competing and often incompatible services are accommodated in the spectrum resource, as well as the process that determines access for individual users. As such the term includes the fundamental spectrum management functions of "allocation" and "assignment."

^{280/} Motorola Comments at 15, 3. Motorola urges NTIA to abandon its spectrum study and instead search for federal government spectrum to be transferred to the private sector.

were few incumbents affected by the change. Other, more recent reallocation efforts have met considerable opposition,^{281/} although the Chairman of the FCC has recently announced plans to initiate an examination of spectrum use in ranges or bands that appear feasible for new radio-based technologies, with the ultimate goal of creating a new spectrum reserve for emerging technologies.^{282/}

Forced reallocations of spectrum from one service to another can be successful if spectrum managers are able to judge correctly the relative values of services, both currently and in the foreseeable future. However, such judgments can be extremely difficult, requiring spectrum managers to gather and accurately evaluate substantial amounts of information about technological and marketplace developments (which often must be obtained from sources with vested interests in the decisions). Moreover, this process necessarily relies on the expertise of those making the reallocations, which, even if substantial, may not be foolproof. Such an approach also may infringe on the operations of incumbent spectrum users, who find themselves pitted against potential users in contests that some liken to "range wars."^{283/} Thus, even if spectrum managers are able to design a reallocation plan that is economically efficient, its effects on current users may raise equity concerns and almost certainly will raise political concerns that can make the actual implementation of the plan extremely difficult.

NTIA believes that, for most purposes, a spectrum management system that provides users with both incentives and opportunities to use spectrum in ways that are economically efficient^{284/} will produce greater benefits for society than a centrally planned, highly regulatory system that attempts a "top down" approach to managing spectrum use. As AT&T states, "[a] multiplicity of human judgments, sharpened and focused by economic interest, can do a better job of serving the public good than even the best-willed central planners."^{285/} The reforms of the block allocation system proposed in Chapter 3 would go far toward meeting that goal, by

281/ For example, amateur users strongly opposed the reallocation of spectrum in the 220-222 MHz band from the amateur radio service to the land mobile service. Amendment of the Commission's Rules Regarding the Allocation of the 216-225 Mhz Band, Notice of Proposed Rulemaking, 2 FCC Rcd 798 (1987). For opposing perspectives on this issue, compare ARRL Comments at 8, with UPS Comments at 3-4. See also Airwave Wars, supra note 6, at 48 (describing the proposed alternative use and the ARRL's opposition).

282/ Remarks of Alfred C. Sikes, Chairman, Federal Communications Commission, Before the Practising Law Institute, mimeo at 5-6 (Washington, D.C., Dec. 6, 1990) supra note 7.

283/ See, e.g., IMM Comments at 4-6. IMM and others analogize current spectrum use to the closing of the American frontier. Inefficient "slash and burn" agricultural methods were acceptable so long as land was abundant. With little new land available, settlers could either acquire the land of others (legally, or through a "range war"), or learn to become more efficient. IMM laments that "the focus of the [current] policy debate appears to be more free spectrum, i.e., reallocation from government to the private sector." Id. at 12 [emphasis in original]. See also J. Taylor, Dividing Up the Radio Spectrum, Telephony, Oct. 8, 1990, at 24 (also using the frontier and "slash and burn" analogies). (Taylor authored the IMM Comments.)

284/ In this chapter we discuss the economic aspects of efficiency. See infra note 334. In Chapter 5 we discuss engineering aspects of efficiency, which we call "spectrum efficiency."

285/ AT&T Reply at 5-6.

providing users with additional flexibility in adopting standards for services and in choosing uses for the spectrum they occupy.

However, the improvements in the block allocation structure already discussed do not address the most fundamental apportionment issues: when should one user have access to spectrum if others desire to use the same spectrum at the same time? Among federal users, the choice is difficult because of the value judgments associated with choosing among many important uses, such as defense, drug enforcement, and air traffic control, all of which have demands for the spectrum. For most private-sector users, a choice mechanism suggests itself that could be much more efficient than the current system -- the market.

Markets could apply to two types of transactions: transfers among users and transfers from the government to users. Many private-sector spectrum users already employ the market for their own commercial purposes, as witnessed by the brisk business in sales and transfers of cellular franchises, other land-mobile operations, and radio and television stations. Indeed, for these and many other of the most commercially valuable uses of spectrum, the predominant means of "acquiring" spectrum is through market transfers of licenses. These are, in many respects, the economic equivalent of purchases and sales of spectrum use rights.

The federal government likewise employs market principles in managing other natural resources (e.g., oil, mineral, timber, and grassland resources).^{286/} This approach provides an additional benefit -- charges from leases and auctions of rights to use these resources have returned substantial amounts to the Treasury.^{287/} In these contexts, ordinary taxpayers share in the private benefits derived from the grant of an exclusive license to use a resource for commercial purposes.

The "ordering" of spectrum uses -- the apportionment of the spectrum resource -- that the operation of such markets produces for commercial applications is both more efficient and more fair than centralized management approaches because markets tend to apportion spectrum to the uses and users that can produce the greatest economic value for society. Indeed, competitive bidding for spectrum assignments could increase the efficiency of use in heavily-occupied frequencies and also provide incentives for prospective users to develop services and supporting technologies that utilize less crowded, higher frequency, portions of the spectrum. The "opening up" of the higher frequency bands will be actively pursued when the costs of creating technologies to operate within those portions of the spectrum are less than the costs of obtaining spectrum in more heavily used frequencies.

In this section, NTIA explores whether greater reliance on market principles should be incorporated into the U.S. system. We conclude that while market mechanisms are not a panacea for all the problems the spectrum management process must address, they can make a substantial contribution toward improving that process, particularly when combined with the regulatory reforms discussed elsewhere in this study. We address in this section both overall

^{286/} CPB equates spectrum licenses with federal licenses of other public resources such as "oil, mining, timber and agricultural interests" that generate revenue from the public, and "sees no reason to distinguish spectrum use from any other commercial exploitation of a public resource." CPB Comments at 13.

^{287/} See Federal User Fees: Data Compilation with Addendum, prepared for the Administrative Conference of the United States, Symposium on User Fees, Washington, D.C., May 3, 1988.

policy issues and particular implementation problems that are involved in moving toward a more market-based system of spectrum management, and we propose a specific, conservative approach to introducing market principles into one aspect of the current management system - the assignment of commercial licenses.

B. Value of Spectrum

1. Societal Value

As commenters point out, spectrum use is of great value to the public. Governmental spectrum users, such as law enforcement agencies, fire departments and other public safety agencies,^{288/} and military and other national security agencies, obviously benefit society at large. Spectrum plays an increasingly important role in ensuring that these agencies can effectively serve their critical public purposes. Many other licensed spectrum users, such as public utilities,^{289/} public broadcasting, and amateurs, provide direct public benefits.^{290/} Scientific users, such as geologists, meteorologist, and radio astronomers, also benefit the public through their contributions to scientific knowledge, and the medical profession relies on a variety of spectrum-based technologies in providing health-care services.^{291/}

Societal benefits from the use of the radio spectrum are by no means limited to the activities of governmental, publicly regulated, and non-profit users. Commercial broadcasters make important contributions to this nation's culture and business, and themselves play a role in emergency preparedness. Other, strictly commercial common carrier providers such as cellular radio, or private spectrum users, including the many business users of spectrum, provide a host of important services to the public and contribute substantially to U.S. industrial growth, technological innovation, and national competitiveness.^{292/} The public realizes value

^{288/} As APCO emphasizes, public safety users encompass more than police and fire departments, and also include emergency medical services, forestry conservation, and highway maintenance. See APCO Comments at 5.

^{289/} These include electric, gas, water, and steam utilities eligible for frequencies in the Power Radio Service under 47 C.F.R. §90.63(a). See UTC Comments at 1-2.

^{290/} See, e.g., ARRL Comments at 4-5, 20-22 (amateur radio is a "volunteer-based system that provides critical life- and property-saving communication services at no cost to the public, private or government sectors"). See also Thomas G. Reel Comments.

^{291/} CORF cites a host of developments in science and medicine to support this point, including breast cancer detection through use of centimeter wavelengths, detection of forest fires, and earthquake forecasting, among many other examples. CORF Comments at 21-22. See also attachment to NSF Comments, National Radio Astronomy Observatory (compilation), Technology Developments Fostered by Radio Astronomy (Nov. 1989).

^{292/} LMCC states, for example:

Additional allocations of spectrum are essential if American businesses who rely upon land mobile communications are to remain competitive and continue to provide basic services to the American public, including heating oil, fuel, food and transportation. Moreover, without doubt, additional allocations are critical

(continued...)

from these activities by the licensees' provision of service. But more generally, and just as importantly, commercial users serve society by pursuing economic returns through the provision of services that the public values highly. In this fashion, societal benefits result from users' private decisions to maximize profits.

2. "Dollar Value"

As a reusable natural resource that, when combined with the right technology, can be used to provide a wide variety of commercially valuable communications services, spectrum can produce substantial tangible economic benefits for licensees. Such benefits can be realized directly, in the form of revenues from allowing others to use the spectrum for a fee, such as through sale of air time (e.g., from broadcasters to advertisers, or from cellular providers to consumers). Or they can be realized indirectly, such as increased productivity through the use of radio services in the general business community (e.g., the use of mobile radios by delivery or taxicab services, or the use of cellular telephones by a wide range of businesses). Spectrum use can also reduce costs compared to non-spectrum alternatives (e.g., using microwave rather than fiber optics to transmit telephone signals over mountains or in sparsely populated rural areas, or using the airwaves rather than coaxial cable or cassette tapes to deliver television or radio programming).

292/(...continued)

if Public Safety entities, including Police and Fire Departments, are to continue their efforts to protect and serve the nation. For many areas of the American economy, international competitiveness is also a function of spectrum availability. And additional spectrum is likewise necessary for the development and provision of new, innovative and modern service offerings to the public at large.

LMCC Comments at iii-iv. Moreover, according to Motorola: "The United States is at a critical juncture in its ability to sustain technological leadership in land mobile communications markets worldwide. . . . New spectrum will be required." Attachment to Motorola Comments: Motorola Comments at 2 (filed with the FCC, Feb. 16, 1990) in Preparation for the International Telecommunication Union World Administrative Radio Conference, GEN. Docket No. 89-554.

Similarly, Telocator notes that not only do paging and cellular services "enhance the efficiency and productivity of millions of mobile U.S. employees, but they also allow hardworking businesspeople greater freedom to conduct their lives outside the office." Telocator Comments at 5. Telocator also identifies direct benefits of mobile radio when in crisis management, public safety, and medicine, for example, in addition to the more general contributions to the nation's economy. Id. at 5-7.

But cf. McCaw Comments at 12-13. McCaw argues that while the need to keep up with developments in other countries, and the need for additional spectrum, are serious issues, "it would be a mistake to assume that the unconsidered allocation of spectrum to new mobile services will necessarily promote the public interest."

Estimating a dollar value for the entire radio spectrum now in use is extremely difficult, if not impossible.^{293/} A great number of users provide a wide range of services. Some of these services produce revenue directly from spectrum use; others services are simply inputs into the production of other goods and services. There is no formal spectrum market to provide an indication of spectrum's value; for many applications, there is also no functioning de facto spectrum market.

Rough estimates of the value of a particular portion of spectrum used for a designated purpose can, however, be made from sales prices of spectrum-based enterprises or based on revenues from use of the spectrum. For example, one approach to estimating the value of the 50 MHz of spectrum currently allocated nationwide for cellular radio service is based on a standard method often employed by industry analysts for evaluating the worth of cellular radio properties for sale -- i.e., as a function of the population (or "pops") in a franchise area. Monetary value is generally expressed as dollars per "pop." One way to value cellular spectrum is to multiply these estimates by an estimate of pops in all U.S. metropolitan areas, and then multiply the result by two to reflect the fact that there are generally two cellular franchises in each market.

Financial analysts have estimated that the dollar value of an average urban cellular license ranges somewhere between \$175 and \$256 "per pop," based on the discounted value of projected future cash flow.^{294/} These numbers would suggest that urban cellular radio licenses have an aggregate nationwide value of approximately \$66.5 to \$97 billion,^{295/} based on a 1989 estimate of 190 million urban pops.^{296/} As explained more fully in Appendix D, however, other valuation approaches that use "per pop" values derived from recent sales of cellular properties and cellular stock prices produce estimates for the value of cellular spectrum in urban areas that range from approximately \$46 to \$80 billion. Estimates of value based on actual sales prices may be a better reflection of the true worth of cellular licenses than estimates based on the present value of projected future cash flow. However, all of these estimates indicate that spectrum allocated to cellular radio has considerable value.^{297/}

293/ See D. Webbink, The Value of the Frequency Spectrum Allocated to Specific Uses, IEEE Transactions on Electromagnetic Compatibility, Vol. EMC-19, No. 3, at 350 (Aug. 1977). See also Management of the Radio Frequency Spectrum in New Zealand at Appendix II, p. 72 (Nov. 1988) (N/E/R/A Study).

294/ See, e.g., Donaldson, Lufkin & Jenrette, The Cellular Communications Industry, Winter 1990-91, at 39, 40; see also Smith Barney, The Cellular Industry: A Reevaluation, Apr. 3, 1990, at 3.

295/ This figure represents the value of the cellular licenses alone, excluding other firm assets. Unless buying a "naked" license, a purchaser of a cellular radio franchise also obtains a network, consisting of valuable equipment, and the goodwill of an on-going enterprise. Nevertheless, most industry observers attribute the bulk of a franchise's value to the license, rather than to these other factors.

296/ Smith Barney, supra note 294, at 8.

297/ It should be noted that cellular valuation analyses reflect existing constraints in the marketplace, such as the limited amount of spectrum allocated for cellular radio, and the duopolistic nature of domestic cellular service. Currently, a cellular license carries with it not
(continued...)

Estimating the value of the spectrum used for radio and television broadcasting is also complex. One method is to examine recent sales prices of broadcast stations.

In 1990, the average sales price of AM broadcasting stations for sales approved by the FCC was \$363,000.^{298/} In that same period, the average sales price for FM stations was \$1,705,000. Also in that time period, the average sales price for television stations was \$12,016,000.^{299/} If these sales transactions are representative of the industry as a whole, the aggregate value of commercial broadcast properties can be estimated to be about \$23 billion.^{300/} It has been estimated that over half the value of a mass media property is attributable to its license, as opposed to tangible or other non-tangible assets.^{301/} Using a 50% factor as an estimate of the percentage of a station's value represented by its license, the value of all broadcast licenses derived from this analysis would therefore be about \$11.5 billion. For a

297/(...continued)

only the right to use the radio spectrum, but also the right to be one member of a service duopoly within a specified geographic area. The value of cellular systems undoubtedly reflects, in part, the semi-exclusive nature of the licenses. Thus, if spectrum were made available for competing systems, the market value of the spectrum would probably be less than the estimates described above suggest.

298/ See Station Trading 1990: Picking Up the Pieces, Broadcasting, Feb. 11, 1991, at 40. Broadcasting compiles these statistics from individual station data reported to the FCC in applications for transfer of a license. The figure cited excludes all transactions for which the price of the AM station was not separately reported.

299/ Major market television stations are the most valuable type of commercial broadcast property. Because these stations are rarely sold, however, the average market value of stations in this sample is probably less than the actual average value for all stations. When major market TV stations have been sold, they have often commanded prices in the hundreds of millions of dollars. For example, in 1985, KTLA in Los Angeles was sold for \$510 million. See The N.Y. Times, Oct. 7, 1985, D2, col. 3. In addition, a 10.6% interest in WWOR, the New Jersey station formerly owned by MCA, was sold recently for about \$30 million. If this value were imputed to the other 89.4% of the outstanding stock, it would suggest a total value of about \$300 million. Based on an earnings analysis, however, some experts place the value of the entire station at around \$400 million. See The N.Y. Times, Feb. 7, 1991, at D20, col. 1. This station, which is not affiliated with any of the three major networks or with Fox, is one of six commercial VHF stations in the New York metropolitan area.

300/ This figure was derived by multiplying the average sales price for each service by the number of commercial stations in that service. See FCC News Release (released Feb. 6, 1991) (4,986 commercial AM radio stations, 4,402 commercial FM radio stations, and 1,117 commercial television stations, as of Jan. 31, 1991).

301/ See, e.g., Communications Transfer Fee Act of 1987: Hearing on S. 1935 Before the Subcomm. on Communications of the Senate Comm. on Commerce, Science and Transportation, 100th Cong., 2d Sess. 59 (1987) (statement of Charles H. Kadlec).

number of reasons, this estimate is probably conservative;^{302/} nevertheless, it suggests that the spectrum licenses for commercial broadcasting properties also have substantial economic value.

C. Private Spectrum Markets

Although the Act does not permit sale of spectrum, de facto spectrum markets already exist in the guise of user-to-user transactions within many of the various services. Initial allocation and assignment decisions by spectrum managers do not overtly involve market factors; in general, however, private sector licenses are freely transferable, usually as part of a sale of a spectrum-related business, with only minimal FCC review.^{303/} Broadcast licenses change hands routinely when broadcasting stations are sold.^{304/} Non-wireline cellular licenses are bought and sold, often soon after the FCC grants initial licenses by lottery.

Some refer to these transactions as "private auctions."^{305/} Such transfers can be economically efficient because they permit those potential users who most value the spectrum

^{302/} The aggregate fair market value of commercial broadcast properties may be higher than the estimates in the text suggest. As discussed in note 299, the actual average value of television stations could be considerably higher than the \$12 million average cited above. Moreover, due to the unavailability of information, Broadcasting does not include group sales in computing an average sales price. To the extent that there are economies of scale in owning a group of stations, such exclusion also may understate the true average value of broadcast stations.

^{303/} Section 310(d) of the Act prohibits the transfer or assignment of any license or construction permit except upon a finding by the FCC that the public interest will be served thereby. However, the Act prohibits the FCC from considering whether the public interest would be served by a transfer to a person other than the proposed transferee.

The current administrative system does not consider such license transfers to be "sales" of spectrum (or even "sales" of licenses), but treats them as if they were by-products of the sales of operating businesses or tangible assets.

^{304/} There were some significant restrictions on alienability broadcast licenses under earlier FCC rules. From 1962 to 1982, the FCC maintained a three-year anti-trafficking rule applicable to broadcast licenses, which required a full FCC hearing for any proposed transfer in which the license was held for less than three years, unless the licensee could show unforeseen circumstances or hardship. See generally, United Church of Christ v. FCC, 911 F.2d 803 (D.C. Cir. 1990) (upholding the FCC's decision to eliminate the rule).

^{305/} See, e.g., H.R. 2965: The Emerging Telecommunications Technology Act of 1990, Hearings Before the House Subcomm. on Telecommunications and Finance of the Comm. on Energy and Commerce 68 (1989) (testimony of H. Geller). See also H. Geller & D. Lampert, Charging for Spectrum Use, Benton Foundation Project on Communications and Information Policy Options, at 13 (1989); Spectrum Auctions: FCC Proposals for the Airwaves: Hearing Before the Subcomm. on Telecommunications, Consumer Protection, and Finance of the House Comm. on Energy and Commerce, 99th Cong., 2d Sess. 8-12 (Oct. 1, 1986) (statement of Mark S. Fowler, Chairman of the Federal Communications Commission); and id. at 16 (opening statement of Hon. Thomas J. Tauke).

to obtain the right to use it, with a minimum of delay and expense.^{306/} For example, in the cellular areas, these transfers generally result in the acquisition of the license by a firm with the technical and business experience and expertise to quickly build and efficiently operate a cellular telephone system in the community of license -- capabilities often lacking in the winners of cellular lotteries. On the other hand, these transfers often provide a windfall to the original licensee, who obtains valuable spectrum use rights without charge from the government.^{307/}

D. Other Countries

Several other countries either have adopted or are considering some form of market-based system for spectrum management. New Zealand has established a market for spectrum by adopting legislation, effective in 1989, that created a system of spectrum management that recognizes broad, tradeable spectrum rights.^{308/}

The New Zealand spectrum rights are legally defined and publicly registered. They are for a finite time period (normally 20 years), are fully tradeable in whole or in part, and may be aggregated. There are two forms of such rights. The first is a "management right," which is essentially a legal title that confers spectrum "ownership" for particular frequency bands on a national basis. This spectrum "title" is initially registered in the name of the New Zealand government, but eventually will be transferred from the government to private parties wishing to use spectrum. As Hutchings states: "These rights give the manager an ability to issue licenses to himself or others, within the technical conditions of the management right, and the technical certification requirements of the [New Zealand] Act."^{309/} The title permits considerable latitude in how spectrum covered by the right will be used.

^{306/} In comments filed in a recent FCC proceeding on Digital Audio Broadcasting (DAB), the FTC staff states that "[r]egardless of who initially is awarded the use of a particular portion of the spectrum, a party who places a higher value on it than does the initial licensee should be able to pay that licensee enough to induce a voluntary transfer." Comments of the Staff of the Bureau of Economics and the San Francisco Regional Office of the Federal Trade Commission at 5 (filed Jan. 25, 1991) in Digital Audio Broadcasting, supra note 7 (FTC Staff DAB Comments).

^{307/} Noting this windfall, DOJ/Antitrust states that "[t]his windfall may be more properly and productively used to reduce the government's budget deficit." DOJ/Antitrust Comments at 6.

^{308/} New Zealand's Radiocommunications Act of 1989 is based largely on recommendations made in a private consultant's report to the New Zealand government by the National Economic Research Associates (N/E/R/A). See N/E/R/A Study, supra note 293. A follow-up to the N/E/R/A project was presented by C. Jackson and R. Foster in The New Zealand Spectrum Project: Description and Observations, prepared for the Seventeenth Annual Telecommunications Policy Research Conference, Airlie, Virginia, October 1-3, 1989.

For descriptions of implementation of the New Zealand program, see Speech by I.R. Hutchings, The New Zealand Experience, at IBC Mobile Communications in Australia and Asia conference (March 12-13 1990); and I.R. Hutchings, Spectrum Deregulation in New Zealand: A Paper Presented to the Spectrum Management Division of ICC (draft) (Apr. 1989).

^{309/} Hutchings, The New Zealand Experience, supra note 308, at 4.

The other spectrum right in New Zealand is a more limited "use" or "license" right, roughly analogous to the present U.S. license, that specifies, among other things, technical requirements. These rights are derived from the title; the title holder issues the rights to the party using the spectrum. The rights "are necessary for any substantive transmission of radio waves."³¹⁰ Such rights last for a term determined by the parties, but cannot exceed the 20 years of the underlying management right.

New Zealand initially distributes new spectrum through competitive bidding, employing a sealed-bid tender system in which the highest bidder obtains the spectrum right, but pays the government the amount of the second highest bid (a so-called "Vickrey auction"^{311/}). According to Hutchings, the tendering system is not specified in the legislation directly. Instead:

As the nature of the rights system gives legal certainty and defined tenure, they are "property rights" and can be disposed of by the holder as they wish. Anyone can be a right holder, including the Government, and where Government is the holder of rights they intend to allocate by tender.^{312/}

The tendering process begins with a "call for expressions of interest" from potential spectrum users to determine requirements or proposed uses. From this, spectrum "packages" are designed for tendering.^{313/} The call for tenders is then formally made, and the eventual allocation made to the highest bidder.

Although incumbents in specific services are exempt from bidding, they are nevertheless required to pay a fee over the term of the management right to provide a "balance" between existing users and new applicants. Incumbents have the option of making an annual payment of 1.5% of their gross income over 20 years, or "an equivalent capitalised lump sum."^{314/}

Several tenders have occurred to date under the new system. The first auctions were held in the UHF band, primarily for television broadcasting. The New Zealand government received 807 bids for "70 lots" by 50 bidders.^{315/} The winning bids were reportedly worth up

^{310/} Id.

^{311/} A description of various methods of auctions, including the "Vickrey" auction, can be found in R.P. McAfee & J. McMillan, Auctions and Bidding, 25 J. of Econ. Literature 699-738 at 701 (1987). A discussion of alternative auction methods in the context of auctioning spectrum appears in C. E. Agnew, R. G. Gould, D. Dunn, & R. D. Stibolt, Economic Techniques for Spectrum Management: Final Report, prepared for NTIA by MATHTECH, Inc. and Telecommunications Systems, at VIII-45 - VIII-61 (Dec. 1979).

^{312/} Hutchings, The New Zealand Experience, supra note 308, at 4.

^{313/} Id. at 5.

^{314/} Id. at 5-6.

^{315/} Id. at 6.

to NZ\$2 million each.^{316/} More recent bidding for cellular telephone spectrum rights has been estimated to have yielded over NZ\$20 million for the New Zealand government.^{317/}

New Zealand has only recently begun to implement the new system, and its effectiveness as a spectrum management technique is difficult to evaluate. To prevent the possibility of anti-competitive behavior, the New Zealand government intends to rely on its equivalent of the U.S. antitrust law, and its Commerce Commission, "an administrative enforcement body." Moreover, not all spectrum is subject to auctions. Some frequencies, for example, are reserved for use by noncommercial users and by the indigenous Maori people.^{318/}

Australia, Canada, and the United Kingdom are all currently exploring whether to adopt similar spectrum management systems. Australia already levies both "radiocommunications fees" for certain non-broadcast spectrum uses and users, and "broadcasting fees" for radio and television.^{319/} The broadcasting fee structure, in place since 1964, is based on annual gross revenues. In 1987-1988, for example, the Australian government received Aus.\$85.9 million from broadcasters, and Aus.\$44.2 million from other radiocommunications, exceeding government outlays of Aus.\$17.3 million and Aus.\$20.4 million, respectively, for spectrum management services.^{320/}

According to the Australian Bureau of Transport and Communications Economics (BTCE), there have been three significant changes recently to Australian broadcasting license fees: "establishment fees" and "conversion fees," in place since 1987, and closed auctioning of FM radio frequencies, since 1989.^{321/} The establishment fee applies to new broadcast stations and is calculated based on the gross earnings of existing nearby stations, or if none, on a "per pop" basis. The conversion fee applies to conversions of stations from AM to FM and is 30 percent of what an establishment fee would have been in a particular area. The government used auctions to choose licensees for seven specific FM channels from among existing AM

316/ See 18 Intermedia, Aug.- Sep. 1990, at 7. (One New Zealand dollar currently is worth approximately \$.61 in U.S. dollars.)

317/ See New Zealand Reeling In Profits from Auction of Cellular Spectrum, Radio Comm. Rep., July 23, 1990, vol. 9, no. 14, at 1.

318/ See, e.g. 18 Intermedia, supra note 316.

319/ See Australia, Bureau of Transport and Communications Economics, Management of the Radio Frequency Spectrum: An Economic Analysis, BTCE Occasional Paper 102 at 54, 58 (Sept. 1990) (BTCE Occasional Paper 102). Australia, like the U.K. and New Zealand, regulates broadcasting separately from other services. Id. at 54.

See also Australia Department of Transport and Communications, The Radio-Frequency Spectrum in Australia: Its Pricing and Management, Submission to the House of Representatives, Standing Committee on Transport, Communications, and Infrastructure, at 21 (Nov. 1990). (One Australian dollar currently is worth approximately \$.79 in U.S. dollars.)

320/ BTCE Occasional Paper 102, supra note 319, at 54, table 5.1.

321/ Id. at 60.

licensees in four cities. The bid in Adelaide, Australia, for example, was Aus.\$6 million.^{322/} The winning bidders were to vacate their existing AM channels and return them to the government for other uses.

The BTCE has proposed to restructure Australia's existing radiocommunication (non-broadcast) management system by adopting an alternative "market based" system that would include competitive bidding when feasible. In proposing this system, the BTCE stated:

A market-based approach (as opposed to the administrative-based approach) would set, and constantly re-adjust, a price (or prices) for spectrum access. The market price mechanism rations scarce resources so that, if the resource is in short supply, the price generally increases so that demand decreases and equilibrates with supply. * * * Users would sell, lease, or subdivide their spectrum if they were able to obtain a price to cover net losses from forgoing the communications capability, moving to less valued parts of the spectrum or moving to alternative communication methods (for example, fibre optic cable).^{323/}

The proposal, similar to New Zealand's, would create tradeable "spectrum access rights." In some cases, these rights would be subject to competitive bids, but in other cases they would be available "over-the-counter at a charge consistent with efficient pricing principles . . . "^{324/}

Canada has a system of user fees for the radio spectrum, intended to recover all administrative costs associated with management of the spectrum. The fees apply to all users, including national government users, such as the military. Canada's fee policy "was shaped and driven by the themes of cost recovery, fairness, and equity."^{325/} Revenue from this fee system rose from under Can.\$35 million in 1985 to over Can.\$70 million in 1988.^{326/} Canada also has begun a consideration of market-based allocation or assignment alternatives, such as auctions, in a recent reassessment of its spectrum management policy.^{327/}

The United Kingdom is also considering various market-based proposals, and has begun to implement competitive bidding to award and renew franchises for its independent television

^{322/} See "Media Release" of Hon. Ralph Willis, M.P., Minister for Transport and Communications (Nov. 8, 1989), provided in correspondence to NTIA from R. N. Smith, First Assistant Secretary, Communications Policy and Planning Division (Dec. 5, 1989).

^{323/} BTCE Occasional Paper 102, supra note 319, at 69-70.

^{324/} Id. at 77.

^{325/} See, e.g., A.T. Collier, Spectrum Pricing and Radio Licensing: A Canadian Experience, at 5 (undated draft paper).

^{326/} Id. at chart. (One Canadian dollar currently is worth approximately \$.87 in U.S. dollars.)

^{327/} Canada, Spectrum and Orbit Policy Directorate, Telecommunications Policy Branch, Radio Systems Policy, Towards a Spectrum Policy Framework for the Twenty-First Century, Discussion Paper, at 25-29 (Sept. 1990).

stations.^{328/} In addition, in the context of non-broadcast spectrum, a 1987 study prepared by private consultants for the U.K. government examined, among other things, the possible benefits of relaxing rules governing access to the spectrum, transferring some management functions to the private sector, and the use of a price mechanism to encourage greater economic efficiency.^{329/}

II. Market-Based Systems

A. General Policy Issues

The primary basis for apportioning non-federal spectrum in the United States is an administrative finding by the FCC of the "public interest, convenience, and necessity."^{330/} The Act does not define the "public interest." Instead, it gives the FCC broad discretion to elucidate and give specific content to the public-interest standard.^{331/} Similarly, NTIA makes apportionment decisions for the federal government using a "national interest" criterion.^{332/}

A system of spectrum management that incorporates, at least in part, market-based principles is one way of meeting public interest goals. As discussed in Chapter 2, the success of the present system of spectrum management has been limited by its dependence on a combination of time-consuming, expensive administrative processes, and random selection procedures. Furthermore, the present system also suffers from an overall lack of incentives for more efficient use of this limited resource. Greater reliance on well-designed, market-based techniques could help ameliorate this situation.

1. Characteristics of Market Systems

a. General Principles

Under general economic principles, greater use of a market system in spectrum management, both to distribute spectrum initially among competing uses and users, and in later private "user-to-user" transfers, should produce results that are more efficient than those

^{328/} Under the U.K.'s Broadcasting Act, applicants must first satisfy a quality threshold for proposed service, and also submit the highest cash bid, to be eligible to bid for a franchise to British independent television channels. The U.K. Independent Television Commission has already solicited applications for some franchises, and is expected to announce the successful bids in the fall. See TV Changes Give Fuzzy Picture of Progress, Financial Times, Feb. 16, 1991, at 9.

^{329/} Department of Trade and Industry, Deregulation of the Radio Frequency Spectrum, report prepared by CSP International (1987).

^{330/} See discussion supra Chapter 2, at note 13.

^{331/} See, e.g., FCC v. WNCN Listeners Guild, 450 U.S. 582 (1981). For a criticism of the public interest standard, see M. Fowler & D. Brenner, A Marketplace Approach to Broadcast Regulation, 60 Tex. L. Rev. 207 (1982).

^{332/} See discussion supra Chapter 2, at 18-19.

realized under the current administrative system. This greater economic efficiency means that the total value society realizes from spectrum use should increase.

Over the years, theorists have analyzed spectrum management in terms of economic efficiency and have advanced a number of proposals to incorporate market principles into management of some or all of the radio frequency spectrum.^{333/} Many observers have argued that broadening the rights granted to users could be the basis of a spectrum market that could serve as an efficient method of apportionment. These proposals for market-based management would clearly define a set of flexible, spectrum-use rights in order to promote greater efficiency in the transfer of spectrum from the government to users and from user to user. A common thread running through such proposals is that each would explicitly rely on the economic value of spectrum to achieve the efficiency and fairness goals of spectrum management. Generally, the proposals encompass three broad objectives: to improve the spectrum allocation process; to improve the spectrum assignment process; and to raise revenue for the federal government.

A strong theoretical case has been made for greater reliance on market principles in spectrum management. A market for spectrum licenses or rights, if properly structured, can maximize both "allocative efficiency" (i.e., prices bid for spectrum reflect the costs to society of spectrum use) and "distributive efficiency" (i.e., those who value the spectrum the most will use it).^{334/} It can also promote "technical efficiency" (i.e., total costs are minimized for a given

333/ See, e.g., I. Barron, There's No Such Thing as a Free Airwave: A Proposal to Institute a Market Allocation Scheme for Electromagnetic Frequencies, 9 J. of Legis. 205 (1982); R.H. Coase, The Federal Communications Commission, 2 J. of L. and Econ. 1 (Oct. 1959); A.S. DeVany, et al., A Property System for Market Allocation of the Electromagnetic Spectrum: a Legal-Economic-Engineering Study, 21 Stan. L. Rev. 1499 (June 1969); T. Hazlett, The Rationality of U.S. Regulation of the Broadcast Spectrum, 33 J. of L. and Econ. 133, 136 (Apr. 1990); H. Levin, The Invisible Resource: Use and Regulation of the Radio Spectrum (1971); J.R. Minasian, Property Rights in Radiation: An Alternative Approach to Radio Frequency Allocation, 18 J. of L. and Econ. 221 (Apr. 1975); M. Mueller, Technical Standards, *supra* note 150; D.W. Webbink, Radio Licenses and Frequency Spectrum Use Property Rights, *supra* note 165.

The federal government has also examined these issues in the past for both private sector and federal users. See, e.g., A.D. Felker & K. Gordon, *supra* note 149; E. Kwerel & A.D. Felker, Using Auctions to Select FCC Licensees OPP Working Paper No. 16 (May 1985); D.W. Webbink, Frequency Spectrum Deregulation Alternatives, OPP Working Paper No. 2 (Oct. 1980) (Webbink, Frequency Spectrum Alternatives); C. E. Agnew, R. G. Gould, D. Dunn, & R. D. Stibolt, Economic Techniques for Spectrum Management: Final Report, *supra* note 311; OTP, Paying for Airwaves Use, and attached working paper, C.B. Thompson, Economic Efficiency and the Allocation, Allotment, and Assignment of Government Spectrum Space, both *infra* note 470. See also E.V. Rostow, Final Report: President's Task Force on Communications Policy ("Rostow Report") at Chapter 8 (Dec. 7, 1968).

334/ "Allocative efficiency" refers to the way in which society's resources are allocated among the goods and services produced in the economy. Allocative efficiency is promoted when the prices consumers pay for goods or services are equal to the marginal costs that society incurs in providing them. See J.D. Gwartney & R.L. Stroup, Economics: Private and Public Choice, at 442 and Appendix A (1987).

(continued...)

level of production or output).^{335/} At least for commercial users, a spectrum market also would be equitable in the most basic sense -- users would pay for using a valuable resource. Any spectrum user denies someone else the use of the spectrum, that is, a user causes an "opportunity cost" to society.^{336/} It is eminently equitable for commercial users to pay for these opportunity costs, and the easiest way to determine those costs is through a market in which other prospective users can compete for the spectrum.^{337/}

We also recognize, however, that despite its advantages, there are real practical issues involved in designing and implementing a market-based system for spectrum management. The comments in this proceeding have been very helpful in elucidating the many dimensions of these issues. Nevertheless, we believe that the public interest would be better served if spectrum management in the United States made greater use of the "management" approach relied on so successfully throughout our economy to allocate resources and produce those goods and services most valued by consumers -- the market system.

This is not to say that adoption of market principles in spectrum management would mean the abdication of regulatory oversight by the federal government. Rather, it means determining those areas of spectrum management where government decision-making is preferable, and those where private decision-making will yield better results. NTIA is proposing to expand the role of market mechanisms in those latter cases. In the following paragraphs we address specific concerns, both conceptual and practical, raised by commenters about the use of market mechanisms in spectrum management.

b. Issues

(1) Introduction

A number of commenters support various degrees of market-based management.^{338/} The Department of Justice's Antitrust Division strongly supports the use of competitive bidding

334/(...continued)

"Distributive efficiency" refers to the way a product or service is distributed among consumers, and is maximized when a product or service is distributed among consumers in such a way that no mutual gains from trade are possible. See W.J. Adams & J.L. Yellen, Commodity Bundling and the Burden of Monopoly, 40 Q.J. of Econ. 475, 490-494 (1976).

335/ Economists use the term "technical efficiency" to refer to the manner in which inputs are combined to produce outputs. Technical efficiency is maximized when a firm chooses its inputs in a manner that minimizes the production cost of its output. See Gwartney and Stroup, supra note 334.

336/ See, e.g., Stanley H. Cohn Reply at 6 (discussion of "resource denial").

337/ See generally, A.E. Kahn & W.B. Shew, Current Issues in Telecommunications Regulation: Pricing, 4 Yale J. on Reg. 206-207 (1987); W.J. Baumol, Superfairness: Applications and Theory 105-110 (1986).

338/ FTC staff, commenting in the FCC's DAB proceeding, expresses support for allocation of spectrum through market transfers. See FTC Staff DAB Comments, supra note 7. The FTC staff provides an excellent review of the theoretical work cited supra. See id. at 6-12.

over comparative hearings or lotteries "as it is quick, discourages rent-seeking behavior, and generates revenue for the government."^{339/} DOJ/Antitrust states that the market would be an efficient mechanism "in the sense that the alternative with the highest economic value among all competing applicants will be one that receives the license."^{340/}

IMM states that "the Commission and the government must find some way to value spectrum." It notes the absence of incentives for more efficient spectrum use and a common "yardstick" for measuring efficiency, and supports finding some way "to place an economic burden on [licensees] for inefficient use of spectrum," including competitive bidding.^{341/} NAPTS/PBS acknowledges that "reliance on market forces might be appropriate in some instances for certain services," although not for public television.^{342/} NPR states:

There is increasing recognition that this highly valuable resource [spectrum] can benefit more Americans if the primary users pay for its use. Such a system may offer the dual benefits of increased spectrum efficiency and some monetary compensation for use of a scarce public resource.^{343/}

NSF observes that spectrum auctioning or leasing of frequencies used solely for commercial purposes "may be preferred to the current scheme."^{344/} Several parties specifically support trials of competitive bidding principles. AT&T recommends "an experiment with public auctions under government auspices" where there are "mutually exclusive applications, with no apparent or readily discernible distinction among them. . . ."^{345/} NYNEX finds "much

^{339/} DOJ/Antitrust Comments at 6.

^{340/} *Id.* at 6-7.

^{341/} IMM Comments at 19-20.

^{342/} NAPTS/PBS Comments at 13.

^{343/} NPR Comments at 18. NPR, however, argues that "any revenue enhancement scheme must be designed to ensure the integrity of services which by their nature do not generate large revenues, but are nonetheless valued and essential components of modern American society." *Id.* at 19.

^{344/} NSF Comments at 10, 15. NSF believes that the same apportioning scheme need not be applied throughout the entire spectrum. Similarly, CORF states that "while market-based systems may be appropriate for commercial users of the spectrum, non-commercial users must be exempt from any type of spectrum fees." CORF Comments at 20.

^{345/} AT&T Comments at 13. AT&T also urges safeguards, such as preventing a buyer from acquiring all of the spectrum put up for auction. In addition, AT&T advocates a test to permit incumbents in an existing band to sell their spectrum rights. *Id.* at 14-15.

to be said in favor of license auctions," and supports auctions on a "limited trial basis."^{346/} In contrast, some commenters favor fees over auctions.^{347/}

Some federal agencies, commenting as spectrum users, also support increased use of market-based management. The Navy, for example, states that revenue proposals could be beneficial, if carefully crafted, and likens free use of spectrum to granting private firms free rights to operate concessions in national parks.^{348/} Treasury supports "qualified or limited" proposals such as auctions or leases.^{349/} NASA suggests setting aside portions of most current spectrum blocks as "enterprise zones" for compatible services within existing blocks and "recommends that any new apportionment procedure apply to both Federal and non-Federal systems."^{350/}

Some parties, while expressing reservations about application of market systems to their own services, support them to a limited degree. For example, CORF states that "market-based rents" for commercial uses "could be advantageous to the scientific community by . . . providing the government with additional funds to better police spectrum usage and by encouraging non-essential spectrum users to convert their services to wire or fiber optics."^{351/} Several commenters support spectrum "leasing."^{352/} NYNEX "could support" a spectrum lease awarded to a qualified applicant that pays fees according to some revenue formula.^{353/}

^{346/} NYNEX Comments at 37. NYNEX notes that a marketplace offers a "fair and reasonable playing field," and that auctions would weed out unqualified applicants, as well as "strike a better balance between the cost of providing a service using radio . . . and the cost of providing the . . . service using other media." *Id.* NYNEX also recommends safeguards to prevent anticompetitive practices.

^{347/} GTE, for example, "does not endorse using the spectrum as a revenue generation vehicle," but finds that certain types of fees "have the potential merit of spreading the financial burden across the entire spectrum." GTE Comments at 13; *see also* GTE Reply at 5-6. GTE also recommends that NTIA convene a working group to address alternative apportionment systems. GTE Comments at 14; GTE Reply at 6.

Bell Atlantic favors fees over auctions, believing the former to be more equitable. It proposes a "spectrum conservation" fee (discussed *infra*, page 124). *See* Bell Atlantic Comments at 9-14, and Bell Atlantic Reply at 2-4.

But cf. AT&T Comments at 11-12. AT&T opposes fees as a matter of fairness. *See infra* p.121. For a discussion of spectrum fees generally, *see*, Section III, *infra* p. 119.

^{348/} DOD Comments (Navy) at 3.

^{349/} Treasury Comments at 3.

^{350/} NASA Comments at 3.

^{351/} *See, e.g.*, CORF Comments at 20, n.13.

^{352/} GTE Comments at 13.

^{353/} NYNEX Comments at 39.

(2) Public Interest Issues

(a) Socially Desirable Services

Commenters express concern that many socially desirable services (that benefit society, but that do not necessarily yield profits) would be at a disadvantage in a market system, or that those seeking to provide particular socially desirable services would be unable to compete in obtaining spectrum.^{354/} They argue in the alternative that if market-based apportionment systems are to be incorporated into spectrum management, specific exemptions be created for these socially desirable services. Commenters making such assertions include a wide variety of spectrum users.^{355/}

Other commenters, however, question the fairness of exempting or targeting various parties in application of specific market proposals. Some state, for example, that it would be unfair to exempt broadcasters from competitive bidding proposals;^{356/} others that it would be unfair to include public mobile users and SMRS.^{357/} Some parties state that market systems cannot be adopted in a piecemeal fashion;^{358/} or that in order to aid efficiency, all spectrum should be included.^{359/} Some federal agencies state that market systems could put them at a disadvantage vis-a-vis private users.^{360/}

Others state that markets would not take into account important noncommercial spectrum uses or needs.^{361/} CPB, for example, states that "[p]ublic broadcasting is not a mere economic endeavor. It is a social and cultural enterprise which was never intended to and should not be bound by the constraints of the open market."^{362/} NAB and NBC state that while auctions may measure willingness to pay, they do not measure value to the public. In particular, NBC

^{354/} UTC, for example, states that it is "categorically" opposed to auctions and other market-based systems because "allocating spectrum to the highest bidder will not assure that spectrum will be put to the highest and best social use." UTC Comments at 17; accord McCaw Reply at 17.

^{355/} See, e.g., AAR Comments at 19; Ameritech Comments at 5; APCO Comments at 10; ASNA Comments at 9; ATA Comments at 16; CORF Comments at 20-21; CPB Comments at 3; FIT Comments at 8; MST Comments at 39-40; NAB Comments at 19; NAPTS/PBS Comments at 20; NSF Comments at 15; NTCA Comments at 4-6; OPASTCO Comments at 5.

^{356/} See, e.g., CTIA Comments at 15-16; Motorola Comments at 11; OPASTCO Comments at 6.

^{357/} OPASTCO Comments at 5.

^{358/} See, e.g., ASNA Comments at 9.

^{359/} Motorola Comments at 11.

^{360/} See, e.g., DOD Comments (Air Force) at 10; DOJ/JMD Comments at 6; FEMA Comments at 5.

^{361/} See, e.g., UTC Comments at 18; INTV Reply at 7.

^{362/} CPB Comments at 5.

asserts that market systems may not reflect consumer preference in an advertiser-supported free broadcast system.^{363/} Several commenters believe that comparative hearings are the best way to determine the public interest or choose the applicant best suited to serve the public interest.^{364/}

While there are many socially desirable spectrum uses, it does not necessarily follow that all of those services should be exempted automatically from efficiency-enhancing changes to the spectrum management system. Virtually no socially desirable service provider is exempt from paying other operating costs -- that is, even government agencies, hospitals, and public broadcasters pay for such resources as heat, light, and labor. Thus it is not self-evident that any particular service must be exempt from the requirements, including competitive bidding, of an otherwise efficient and equitable spectrum management system.

In evaluating arguments in favor of exemptions, however, we note that concerns about harming valuable services can be addressed through careful crafting of a management system, including, if necessary, limitations on its application, to ensure that socially desirable needs are met. As DOJ/Antitrust states in addressing this issue: "It is an accepted principle of welfare economics that the government should subsidize those goods and services where the social benefit is greater than the private benefit."^{365/} As DOJ/Antitrust suggests, spectrum could continue to be set aside for certain socially desirable services as a matter of government policy, even while market principles were applied to other parts of the spectrum.^{366/} For example, in land use management, substantial tracts of land are routinely set aside for public parks or other public uses, even while an active market system operates in other areas of real estate.^{367/} Moreover, a market system does not need to be applied universally to increase efficiencies, particularly as compared to today's spectrum management systems.

(b) Economic Speculation

Some commenters say that competitive bidding would lead to speculation and to the control of radio spectrum by those with profit as their sole motive,^{368/} whom some characterize

^{363/} NBC Comments at 16. See also NAB Comments at 20 (because broadcasters earn revenues from providing audiences to advertisers, there is no measure of the intensity of value audiences place on broadcasting services).

^{364/} See, e.g., AMI Comments at 20; BellSouth Comments at 16 ("Would a system encompassing 'free trade' of spectrum without some form of deliberative process be in the public interest?") [emphasis in original]. See also FIT Comments at 7; LMCC Comments at 46; OPASTCO Comments at 5.

^{365/} DOJ/Antitrust Comments at 8.

^{366/} AT&T suggests that as an alternative to exempting some services from competitive bidding, they be given "'a dollar-value advantage,' i.e., a reverse handicap." AT&T Reply at 11.

^{367/} See, e.g., DOJ/Antitrust Comments at 10 (noting that there are economic reasons for zoning land).

^{368/} See e.g., UTC Comments at 18.

as "gamblers."^{369/} As Southwestern Bell views it, auctions would improperly reflect near-term market conditions and not long-term planning goals.^{370/} Some state that market-based pricing would ignore or detract from efficiency goals that serve the public interest,^{371/} and that government revenue-raising and deficit reduction would drive the system.^{372/} Some commenters fear that the government would lose control of the spectrum.^{373/}

In NTIA's view, these commenters overstate their case. Much of the radio spectrum is now used by commercial entities that seek to earn a profit, including many of the commenters that raise this concern. Indeed, it is the current system, particularly in those areas in which assignments are made by lottery, under which speculators or gamblers can profit most spectacularly. In contrast, a competitive bidding mechanism would force potential users to make their best estimates of the long-term value of spectrum to them, and bid "real dollars" based on that estimate. This process tends to reduce speculation and accurately reflects, in the present, the expected future value of the spectrum.

(c) Statutory Public Interest Requirements

More specifically, however, some commenters contend that the Act does not authorize a market-based system, and that such systems conflict with the Act's "public interest" requirements.^{374/} Others find market systems contrary to their reading of congressional intent regarding the establishment of public television,^{375/} or other FCC policies such as localism.^{376/}

^{369/} See e.g., FIT Comments at 9.

^{370/} Southwestern Bell Comments at 10.

^{371/} See, e.g., CPB Comments at 3; NAPTS/PBS Comments at 20; OPASTCO Comments at 5; Pacific Comments at 18; see also Ameritech Comments at 5.

^{372/} See, e.g., ATA Comments at 16; Ameritech Comments at 6.

^{373/} Hubbard Comments at 4 (sale or lease of spectrum would eliminate accountability of broadcasters); LMCC Comments at 47; USTA Comments at 8 (government would lose the ability to consider whether future public needs may require a different allocation of spectrum).

^{374/} See, e.g., ARINC Comments at 13; Contel Comments at 8; LMCC Comments at 47 (the Act does not grant property rights); Motorola Comments at 10 (auctions are not consistent with the public interest.); RTCM Comments at 4; USTA Comments at 7. See also MST Comments at 40; COMSAT Comments at 43; CPB Comments at 4; GTE Comments at 13; LMCC Comments at 45; Telocator Comments at 14; NTCA Reply at 3.

^{375/} See, e.g., NAPTS/PBS Comments at 19-20 (market systems are contrary to congressional intent regarding public television, and may constitute an abdication of the FCC's statutory duty under the Act to assign licenses in the public interest; an auction system would require congressional approval).

^{376/} See RNJ Reply at 1 (auctions would encourage national and broad regional uses rather than local ones); INTV Reply at 7 (auctions contradict the policies underlying the Act).

Although there is some dispute as to whether the FCC needs congressional authority to institute competitive bidding for spectrum assignments or allocations,^{377/} on a practical level the issue can be resolved through enactment of legislation to implement any such proposal. However, many comments reflect a view that any market-based management system is per se contrary to the "public interest" requirement of the Act. We discuss the relationship between that standard and market-based systems below, for broadcasting as well as other services.

Broadcasting: Regulation of broadcasting under the Act's public interest standard has led to the view that broadcasters hold a special position as "trustees" of the spectrum resource they use.^{378/} One analysis explains the public trustee concept as follows:

[The] colliding statutory ground rules governing the freedom and obligations of broadcasters have been melded into one of the law's most elastic conceptions the notion of a "public trustee." The FCC views a broadcast license as a "trust," with the public as "beneficiary" and the broadcaster as "public trustee." The public trustee concept is a natural consequence of the conflicting statutory goals of private use and regulated allocation of spectrum space."^{379/}

Broadcasters commenting on the Notice emphasize the public service obligations imposed on them by the Act. NAB states that "[b]roadcasters, as trustees for the public, have the obligation to provide programming that is responsive to the needs, desires, problems, and interests of the audience served."^{380/} Similarly, INTV "recognizes that as trustees of

^{377/} Geller and Lampert, for example, argue that the FCC has the legal authority to conduct competitive bidding in some areas without specific congressional approval, although the FCC has been reluctant to proceed on this basis. See H. Geller & D. Lampert, Charging for Spectrum Use, supra note 305, at 23.

^{378/} See, e.g., Office of Communications of the United Church of Christ v. FCC, 425 F.2d 543, 548 (D.C. Cir. 1969) (Broadcasters are "temporary permittees -- fiduciaries -- of this great public resource."). See also Central Florida Enterprises v. FCC, 683 F.2d 503, 507 (D.C. Cir. 1982), cert. denied, 460 U.S. 1084 (1983) (public trust is subject to termination for breach of duty). For discussion and criticism of the public trustee model, see e.g., M. Fowler & D. Brenner, supra note 331, at 3; E. Krasnow, L. Longley & H. Terry, The Politics of Broadcast Regulation, at 21 (3d ed. 1982); and J.R. Wollenberg, The FCC as Arbiter of "The Public Interest, Convenience, and Necessity" in A Legislative History of the Communications Act of 1934 at 78 (M.D. Paglin, ed., 1989).

Several commenters refer to the trusteeship model. NAB states that "[b]roadcasters, as trustees for the public, have the obligation to provide programming that is responsive to the needs, desires, problems, and interests of the audience served." NAB Comments at 21; see also NAB Reply at 13. See also CPB Comments at 4 (broadcasters are "temporary stewards"); NYNEX Comments at 33; INTV Reply at 7.

^{379/} E. Krasnow, L. Longley, & H. Terry, supra note 378, at 21.

^{380/} NAB Comments at 21. NAB also identifies some services broadcasters provide, including issue-responsive programming, weather reports, emergency information and other services that "may very well not be the communications services with the highest profit potential, or services with the most prosperous entrepreneurs or investment backers." Id.

government spectrum, broadcasters have a special public interest responsibility.^{381/} Indeed, while FCC deregulation has removed many of the specific obligations previously imposed on broadcasters, several explicit public interest obligations remain.^{382/} In addition, and perhaps more importantly, many broadcasters voluntarily perform public-spirited services without specific regulatory requirements. NTIA recognizes and seeks to promote these valuable contributions made by the broadcasting industry.

NAB and INTV add, however, that the public interest programming provided by broadcasters constitutes compensation for their use of the spectrum, and this, along with the broadcasters' payments of federal taxes and FCC fees for license applications and renewals, should be reason to exempt broadcasters from any potential spectrum fee.^{383/} Thus, these broadcast associations argue, in effect, that there is a quid pro quo between the federal government and broadcast licensees under which broadcasters are exempt from payments to the government for their licenses in exchange for provision of public service and issue-responsive programming.^{384/}

NTIA research of the legislative histories of the Radio Act of 1927 ("1927 Act") and the 1934 Act does not establish the existence of such a quid pro quo, or of any congressional intent to link broadcasting "public interest" obligations with the continued availability of free spectrum. Although Congress recognized that, as an "infant industry," many broadcasters were financially pressed in the late 1920s and early 1930s,^{385/} the legislative histories evidence no congressional recognition of the purported quid pro quo. Indeed, the fact that Section 301 of the 1934 Act expressly limits the rights associated with licenses to the terms, conditions, and periods of those licenses^{386/} indicates that Congress intended the FCC licensing scheme to define explicitly the rights of all licensees, including broadcasters, in using the spectrum. Nowhere in the Act or the FCC's rules is any other arrangement established or recognized. Thus, a decision to impose competitive bidding or fees on broadcasters is not controlled by the existence

^{381/} INTV Reply at 7. INTV also emphasizes the value of over-the-air broadcasting. *Id.* at 3.

^{382/} See Appendix E, The Public Interest Obligations of Broadcasters.

^{383/} See NAB Comments at 21; INTV Reply at 7. INTV states that since most broadcasters have acquired their licenses through the transfer process, they have "paid full dollar value for use of the spectrum. It adds that "even though they have paid the market price for the station, they are continuing to 'pay' for the privilege of broadcasting above and beyond the market prices by providing issue responsive programming to their respective communities. See also Comments cited *infra* in text accompanying notes 456-459.

^{384/} NAB has asserted that "[b]roadcasters differ from all other spectrum users because of their 'contract' with the government to provide public interest programming free to the American public." NAB, Epitaph for a Killer Tax, at 3 (Aug. 1990).

^{385/} See, e.g., 69 Cong. Rec. 3028 (daily ed., Feb. 5, 1927) (Senator Dill noted that "the radio industry is a new and undeveloped industry.")

^{386/} 47 U.S.C. § 301 ("It is the purpose of this chapter . . . to provide for the use of [radio] channels, but not the ownership thereof, by persons for limited periods of time, under licenses granted by Federal authority, and no such license shall be construed to create any right, beyond the terms, conditions, and periods of the license . . ."). See also 47 U.S.C. § 304.

of a "bargain" or "contract" between broadcasters and the government concerning the provision of free spectrum in exchange for public interest programming.^{387/}

Other Services: In allocating and assigning spectrum to non-broadcast spectrum licensees under Title III of the Act, the FCC must also apply a general statutory public interest standard.^{388/} However, such licensees are seldom referred to as "public trustees" with commensurate public interest obligations.^{389/}

Indeed, non-broadcast spectrum users are not required to devote air time to "public interest" obligations. Again, for non-broadcast spectrum users, there appears to be nothing in the Act or its legislative history that specifically prohibits such users from coming under any market-based system of spectrum management purely on the basis of public interest contributions made to the public.

(3) Competitive Issues

A number of commenters claim that market-based spectrum management systems would create competitive inequalities among various users or potential users of spectrum.

Incumbents: Some commenters believe that proposed market systems may favor incumbents by giving them a competitive advantage over new spectrum users.^{390/} Others say that a market system would hurt incumbents, overlooking the substantial investments they have already made in their spectrum-related businesses.^{391/}

In considering the impact of market-based spectrum management on the relative competitive positions of incumbent spectrum users and new entrants, the principal issue is whether competitive bidding should be imposed on currently assigned spectrum when existing licenses are up for renewal.

^{387/} Nor, apart from the statutory arguments, is there anything inherently inconsistent about requiring a licensee to fulfill certain public interest obligations and using market-based mechanisms to assign the license. See discussion accompanying notes 424 - 425, infra.

^{388/} As Wollenberg notes, the FCC's "powers under Title III extend to all non-governmental uses of the spectrum -- to common carriers, public safety and industrial uses, as well as to broadcasting." J.R. Wollenberg, The FCC as Arbiter of "The Public Interest, Convenience, and Necessity", supra note 378, at 61.

^{389/} But see AMI Comments at 5, 15. Although AMI supports increased reliance on market forces "to ensure proper allocation and usage of spectrum," it "believes that spectrum must still be "considered a public asset" not subject to privatization, and the "users thereof should continue to be deemed holders of a public trust".

^{390/} See, e.g., ASNA Comments at 8 (as an allocation tool, would hurt prospective licensees); CTIA Comments at 15 (would handicap entrepreneurs); GTE Comments at 12 (would deter challengers who might have innovative technology but lack market share); OPASTCO Comments at 5.

^{391/} See, e.g., NASA Comments at 4, 8.

There are a number of reasons for including incumbent users in any new competitive bidding system. Incumbent spectrum users already occupy most of the currently usable spectrum. Subjecting incumbents to competitive bidding could make more of this spectrum available to new spectrum users. This would happen directly by providing an opportunity for new entrants to bid against incumbent users for currently assigned spectrum, and indirectly by providing incentives for incumbent users to operate more efficiently, thus potentially "freeing up" their spectrum for use by others. Moreover, it is argued that subjecting new entrants to competitive bidding, while exempting incumbent license holders, would create an imbalance in the marketplace. Because new entrants would have to pay for their spectrum, it is contended, they would be disadvantaged in attempting to compete with current users who received their spectrum for free.

There are, however, countervailing factors. For example, subjecting incumbents to the risk of losing a license could be disruptive to current services. Incumbent users have an imbedded investment in their businesses and equipment, and rely on continued access to this spectrum. Indeed, to the extent that many incumbents acquired their licenses through private transfers from former license holders, they have in effect purchased their licenses and the market has already functioned. The prices these parties paid to obtain spectrum in all likelihood reflected an expectation that the current renewal system would continue.

In light of these concerns, it may not be desirable to require incumbent spectrum license holders to undergo competitive bidding for the spectrum they now use. Some of the proposals described elsewhere in this report, for greater flexibility and improved monitoring and reporting, should provide incentives for greater efficiency among incumbent users. Moreover, applying competitive bidding on a prospective basis only should not seriously handicap new competitors in existing service categories. Under the current system, the predominant means of "entering the market" in existing services is to acquire a spectrum license at a price set by the private market.^{392/} When a cellular license is transferred, for example, the purchaser is paying often a substantial amount for the right to compete against an incumbent provider that has acquired spectrum for "free" -- namely, the "wireline" licensee, which is owned by the local telephone company. Nevertheless, these transactions occur frequently, with established cellular firms often bidding against each other to acquire available franchises. Finally, to the extent there is a competitive disadvantage to new entrants from having to pay for a license, this would be reflected in the bidding levels. No party would be forced to bid itself into a competitively untenable position.

Competitive Inequalities: Commenters also voice concern that a market system would put radio-based systems at a disadvantage vis-a-vis competing systems based on wireline technologies. McCaw believes that market proposals could put radio-based services at a disadvantage compared to land-line services.^{393/} Viewed from another perspective, however, changes in the relative cost of radio and non-radio systems could be a benefit of a market

^{392/} For example, in 1986 the Chairman of the FCC estimated that over 65 percent of commercial television stations and 75 percent of commercial radio stations are not owned by the initial licensee, and that similar turnover in the newer cellular and SMRS markets had begun. See Spectrum Auctions: FCC Proposals for the Airwaves: Hearing Before the Subcomm. on Telecommunications, Consumer Protection, and Finance of the House Comm. on Energy and Commerce, *supra* note 305, at 9 (testimony of Mark S. Fowler, Chairman, Federal Communications Commission).

^{393/} McCaw Reply at 18 (citing Southwestern Bell Comments at 10).

system, because it would represent a societal decision on how to use resources.^{394/} Under the discipline of the market, some systems will migrate to non-spectrum alternatives, thus freeing spectrum for other uses, while other systems will continue to use spectrum when it is economically efficient to do so.^{395/}

"Deep Pockets" and "Warehousing": Commenters often express concerns that competitive bidding would favor large, wealthy entities with "deep pockets," which would prevail over smaller, possibly more innovative parties without the same access to capital.^{396/} A related concern is that a market-based system would increase costs and drive away smaller firms.^{397/} LMCC, for example, states that such a system would deter those with difficulty in obtaining financing.^{398/} Commenters also state that market systems would lead to "warehousing" of spectrum -- that is, hoarding of spectrum by speculators, or a user's acquisition of spectrum to deny it to competitors.^{399/}

Commenters provide only conclusory statements in voicing their concerns that a market system for spectrum would create severe "deep pockets" or "warehousing" problems. The vibrant private market in user-to-user license transfers that now exists does not raise red flags that "deep pockets" or "warehousing" effects would predominate in a market system.^{400/} In any event, competitive bidding systems can be designed to ensure that such concerns are not realized. For example, to reduce the possibility that prospective bidders would not have sufficient "up front" funds to participate in competitive bidding, winning bidders could be permitted to spread their payments out over the term of the license, or base their payments at

^{394/} DOD, for example, goes so far as to state that "spectrum should not be used unless absolutely necessary." DOD Comments (Exec. Summary).

^{395/} See Chapter 5, *infra*, for a discussion of non-spectrum alternatives.

^{396/} See, e.g., ASNA Comments at 10; AAR at 19; MST Comments at 39; CTIA Comments at 15; COMSAT Comments at 46; GTE Comments at 12; INTV Reply at 7 (referring to spectrum "redlining"); LMCC Comments at 46 ("would likely cause the price to escalate beyond all proportion . . ."); McCaw Comments at 16; McCaw Reply at 18; NAB Comments at 20 ("shallow pockets may have very real communications needs"); NTCA Comments at 4; OPASTCO Comments at 5; Pacific Comments at 18; RTCM Comments at 4 ("preference to those with capital"); Southwestern Bell Comments at 10; Telocator Comments at 15; USTA Comments at 8; Robert Wertime Comments at 1.

^{397/} See NABER Comments at 8; OPASTCO Comments at 5; Southwestern Bell Comments at 9-10 (auctions are "a hidden tax that would likely increase prices for spectrum dependent services.").

^{398/} LMCC Comments at 46. See also RNJ Reply at 1 (auctions would favor companies based on size).

^{399/} See, e.g., Eric Albrecht Comments at 2; CTIA Comments at 15 (auctions would exacerbate problem; but FCC could eliminate through safeguards); CTIA Comments at 15 (would "exacerbate"); COMSAT Comments at 45; FIT Comments at 8; GTE Comments at 12; LMCC Comments at 46 (spectrum would "lay fallow"); OPASTCO Comments at 5; U S West Comments at 8; INTV Reply at 7.

^{400/} Indeed, current spectrum users include a wide variety of firms of all sizes.

least partially on "royalties" (i.e., a percentage of the revenues derived from spectrum use), rather than flat fees. Moreover, the current system, with its lack of effective incentives for efficiency, tends to create spectrum shortages in particular bands, which allows incumbent licensees to extract substantial "rents" from others for providing access to their spectrum. It is the present system that results in an economic environment for certain services in which only firms with "deep pockets" can effectively participate.

Furthermore, while "warehousing" of spectrum is a concern under any system of spectrum management, the situation should be better, not worse, under a market-based system. The existing system of "free" spectrum assignments provides users with more incentives to "warehouse" than a market system would, because under current practices users are not required to pay market rates for any spectrum they might consider "hoarding" or denying to others.^{401/} Thus, with a market-based system there would be additional disincentives to "warehousing" spectrum that do not exist under the current system.

Also, certain protections could be built into any competitive bidding system. For example, as suggested by some commenters, the FCC could by rule prohibit any single firm from acquiring a substantial portion of the spectrum allocated to a particular service. Moreover, the FCC currently has rules to address warehousing, and these or similar rules could apply to licenses obtained through competitive bidding.^{402/} Finally, increased monitoring of spectrum use, as proposed elsewhere in this report,^{403/} would also discourage the incidence

^{401/} Barron identifies three areas in which a user has an incentive to "over-use or stockpile" spectrum under the current system: (1) a user can hold spectrum to meet increased future demand, without incurring costs, even where no new spectrum is available for allocation to a service; (2) a user can reduce competition by consuming a large quantity of spectrum, thereby precluding others from using the resource; and (3) a user can reduce its costs in the short run by wasting spectrum because spectrum-efficient technologies require higher technology, and therefore carry a higher cost. I. Barron, supra note 333, at 214.

^{402/} The FCC has rules designed in part to reduce the incidence of "warehousing." See, e.g., Amendment of Part 90, Subparts M and S, of the Commission's Rules, Report and Order, 3 FCC Rcd 1838, 1844-1846 (1988), revised in 4 FCC Rcd 356 (1989) (FCC retained and revised loading standards in the Specialized Mobile Radio Service (SMRS)); Revision of Part 21 of the Commission's Rules, Report and Order, 2 FCC Rcd 5713 (1987), modified, 4 FCC Rcd 2287 (1989) (FCC revised rules regarding common carrier fixed radio facilities to, among other things, discourage warehousing through the adoption of strict requirements for construction times).

There have been anecdotal reports of fraudulent practices to circumvent such rules, and calls for "bounty hunting" to aid their enforcement. See, e.g., Bounty Hunters (editorial by D. Bishop) in Mobile Radio Technology, May, 1990, at 4.

While it is unclear from the comments whether FCC rules have had the effect of preventing warehousing, we believe that the FCC could reexamine them to determine whether they or similar rules would be needed to assure further the absence of warehousing.

^{403/} See discussion infra Chapter 5, at 138.

of warehousing. Finally, the antitrust laws could provide a check on behavior such as warehousing when undertaken for anticompetitive purposes.^{404/}

Innovation: Several commenters believe that market systems or competitive bidding could discourage the development of new technologies, rather than encourage such development. Such approaches would, some say, stifle research and development, deter innovation, and discourage the production of more efficient equipment.^{405/} NAB, on the other hand, is concerned that competitive bidding would "benefit entrepreneurs over the public."^{406/}

There is no evidence that a market system, operating by itself, would hinder innovation, particularly as compared to the rigid and administratively complex spectrum management system now in place.^{407/}

Because a market-based system would recognize spectrum's value, there would be strong incentives for innovation in developing technologies that could maximize efficient use of that resource. Moreover, increased technical and user flexibility, as discussed in Chapter 3, in combination with a market system, would increase opportunities for innovators to obtain spectrum that they need at a fair price. And if a market system creates incentives for efficient use, more spectrum should thereby be freed up and become available for new services.

As noted above, various payment arrangements could minimize the resources that bidders would need initially. Finally, we do not discount the initiative and resourcefulness of innovators in obtaining financing to cover the costs of bringing new products or services to market.

(4) Property Rights

Many commenters presume that a market system requires the creation of new property or ownership rights in spectrum.^{408/} Some market proposals, however, would not grant greater rights to licensees than those that now exist.^{409/}

^{404/} See DOJ/Antitrust Comments at 8 (if spectrum acquisitions had the effect of "hoarding" or monopolization, spectrum allocations would be subject to the antitrust laws).

^{405/} See, e.g., AAR Comments at 20; FIT Comments at 8; UPS Comments at 8; McCaw Comments at 16; Southwestern Bell Comments at 11; Watercom Comments at 5-6; INTV Reply at 7.

^{406/} NAB Comments at 20.

^{407/} NTIA has supported reforms like the FCC's "pioneer's preference" because of the harm that the current system causes to innovation. See NTIA Comments (filed with FCC June 29, 1990) in Pioneer's Preference, Notice of Proposed Rulemaking, supra note 7.

^{408/} See, e.g., COMSAT Comments at 42 (any market-based system would need to define the spectrum "property" to be auctioned or leased); Contel Comments at 9 (fee confers a property right).

^{409/} For example, while S. 170, The Spectrum Assignment Improvements Act of 1989, 101st Cong., 1st Sess. (1989), would have permitted competitive bidding for FCC licenses, (continued...)

Some commenters state that explicit or altered property rights would not lead to better spectrum management,^{410/} and would deprive NTIA and the FCC of regulatory flexibility, making reallocation more difficult.^{411/} AAR states that the existing rights to transfer licenses have not been useful.^{412/} Some commenters call for a return of anti-trafficking rules.^{413/}

Although some construe the term "spectrum property rights" to mean outright ownership of the spectrum by licensees,^{414/} this need not be the case. Indeed, some observers believe, and we agree, that "the present scheme is not radically different from a limited property rights scheme."^{415/} The term "property rights" is used by some to describe the rights now granted to FCC licensees. Webbink, for example, uses the term "property rights," and related terms such as "zoning," to describe how the FCC currently manages spectrum and how improvements might be made. He states that in order for individuals to have a property right, at least three conditions are necessary:

- (1) the individuals must have the right to exclusive use of the resource; (2) individuals must have the right to receive income from the use of that resource; and (3) individuals must be allowed to transfer voluntarily that right in whole or in part to others.^{416/}

409/(...continued)

observers noted that "none of the rights and responsibilities of FCC licensees would change." J.L. Gattuso, Raising Revenues with the Auction Option for the Telecommunications Spectrum, The Heritage Foundation Issue Bulletin No. 147, at 8 (May 11, 1989).

410/ See, e.g., AAR Comments at 21 (because users already may transfer and renew, "redesignation" would not add to value); CTIA at 17 (current "fairly free transfer" has not resulted in increased spectrum efficiency).

411/ See, e.g., NYNEX Comments at 40. NYNEX, however, supports competitive bidding, with safeguards. See also OPASTCO Comments at 7 (spectrum cannot be reclaimed once sold); USTA Comments at 8 (spectrum difficult to reclaim once sold).

412/ See, e.g., AAR Comments at 21-22 (transferability has caused concentration of ownership and control).

413/ See discussion supra note 408. In addition, some commenters recommend that the FCC take steps to prevent trafficking in licenses through a license transfer fee, set high during the first years of a license. See, e.g., NYNEX Comments at 36.

414/ See, e.g., GTE Comments at 2 ("spectrum is not 'owned' by anyone -- including the federal government").

415/ Robinson Essay, supra note 3, at 10. See also Mueller, supra note 150, at 44 ("radio channels are virtually identical to real estate.")

416/ D. Webbink, Radio Licenses and Frequency Spectrum Use Property Rights, supra note 165, at 4 [emphasis in original]. For a similar definition of property rights, see G. Liebcap, Contracting for Property Rights, at 1 (1989).

FCC licenses granted today generally have these attributes to some extent. Licensees receive "exclusivity" in terms of authorization to use specific frequencies and protection from harmful interference, to the extent specified in the license.^{417/} Licensees can receive income from the use of the license. Finally, licensees have the de facto right to transfer a license as part of a sale of assets, even though FCC approval is required. From this perspective, despite the possibility of license revocation under certain circumstances and other regulatory constraints, current spectrum licenses have some of the attributes of property.^{418/}

As a matter of law, the 1934 Act does not recognize spectrum property rights in licensees.^{419/} The 1927 Act prohibited licensees from making any claim of ownership. The 1934 Act contains similar provisions, and early court decisions emphasized this policy decision.^{420/} Moreover, the legislative histories of both the 1927 Act and the 1934 Act suggest that Congress did not view spectrum as something that would be "owned."^{421/}

From a historical perspective, however, Hazlett argues that the U.S. government assumed "ownership" of the spectrum with the Radio Act of 1912, and, with the creation of the Federal Radio Commission in 1927, "began to behave like an actual owner." But in what Hazlett calls "an interesting twist," the government "chose to assign rights only on a short term lease basis, according to the broadcaster's furtherance of 'the public interest, convenience or necessity'"^{422/}

In practice, many licensees function as if they "own" the spectrum they use. For analytic purposes, we view spectrum authorizations, including current FCC licenses, as creating quasi-property rights with characteristics similar to licenses granted for the use of other natural resources.^{423/}

We agree with those commenters that assert that a market-based system for spectrum management requires that the rights a user obtains with a spectrum license be clearly defined. We disagree, however, with those commenters that suggest that a market-based system necessarily require that those rights be somehow broader in scope or different in quality from

^{417/} As noted above, licenses for some services are not mutually exclusive and thus are subject to some interference.

^{418/} CTIA contends that although licensees may now hold "quasi-property rights" in spectrum, they "are nothing like true property rights" because the FCC can expand or contract these rights as policy considerations dictate. CTIA Comments at 16.

^{419/} See 47 U.S.C. §§ 301, 304. This point was raised by several commenters. See, e.g., LMCC Comments at 47.

^{420/} 47 U.S.C. § 301. See also FCC v. Sanders Bros. Radio Station, 309 U.S. 470, 475 (1940).

^{421/} See Barron, supra note 333, at 208; and Webbink, Frequency Spectrum Alternatives, supra note 333, at 7. See also Robinson Essay, supra note 3, at 11-12.

^{422/} T. Hazlett, supra note 333, at 135-136.

^{423/} CPB states that it "sees no reason to distinguish spectrum use from any other commercial exploitation of a public resource." CPB Comments at 13.

the rights now conveyed by a license. For certain purposes, it may be extremely desirable to redefine those rights,^{424/} but it is not necessary to do so. This is illustrated by the active private market for the transfer of spectrum licenses that prevails today. These transactions, involving billions of dollars each year, reflect the fact that parties are willing, and in many cases eager, to purchase the package of rights (and obligations) represented by a current FCC spectrum license. There is no reason to think that a different situation would prevail when the government, rather than a private party, conveys the license and receives the payment.

To the extent the license is subject to certain limitations or conditions on use (e.g., secondary status) or various "public interest" obligations, its market value will be lower than if the license were not so encumbered. But there is nothing inherently inconsistent about using market mechanisms to transfer a package of rights that are conditioned by specified limitations or obligations.^{425/} Indeed, market mechanisms are well-suited to such a task, and are routinely used in the private sector for such purposes.

2. General Conclusion and Recommendation

NTIA supports greater reliance on market principles, and in particular the use of competitive bidding in the government's initial distribution of spectrum to users, as well as greater reliance on such principles in subsequent transfers among spectrum users. The arguments in favor of and against such a system have been discussed at length in the academic and policy literature on this subject and in the comments on the Notice. Even acknowledging that the present administrative system has some benefits, we believe that U.S. spectrum management can be improved considerably by the incorporation of market-based principles into the system. Indeed, based on our review of the debate in the literature^{426/} and in the comments submitted in this proceeding, as well as our own experience in the spectrum management process, NTIA concludes that market mechanisms should be a principal component of a comprehensive management system for the U.S. spectrum resource. In supporting such a system, we are mindful of the concerns of incumbents, public service organizations, and innovators. In the next subsection, we discuss means of implementing a market system through competitive bidding for assignments that accommodate many of the concerns expressed by the commenters.

B. Implementation

1. Government-to-User Transactions

a. Allocation

Theorists have proposed many different ways of applying market principles to government allocation of the spectrum. Such proposals attempt to provide a basis for dividing spectrum among disparate, unrelated services. The solutions they offer are based on injecting competition into the allocation process to permit the market, through users' choices about what services to provide, to determine the services to be located in various frequency bands.

^{424/} Indeed, the proposals in Chapter 3 for increased flexibility of the block allocation system are essentially proposals for such redefinition.

^{425/} Accord AT&T Reply at 6.

^{426/} See, e.g., references cited supra note 333.

Market-based spectrum allocation proposals rely on individual market transactions to "order" or allocate services throughout the spectrum. They generally build on two aspects of spectrum use rights: substantial flexibility in the offering of services, and greater rights of "alienability" -- the ability for one user to buy or sell all or part of the spectrum rights of another, and to aggregate or subdivide rights as needed.^{427/}

We have recommended a number of forms of increased flexibility in Chapter 3 that could benefit spectrum management regardless of whether further market-based reforms occur. NTIA believes that such further reforms are important. To complement such reforms, the FCC should permit users to exercise greater flexibility to transfer or "alienate" their spectrum licenses, such as the ability to subdivide and transfer interests. However, in light of the known benefits of the block system, the complexity of implementing a competitive bidding system for allocations, and the efficiency of the regulatory reforms proposed in Chapter 3, we do not at this time propose more expansive substitution of market-based techniques for current allocation procedures. Instead, we focus on application of market principles to the assignment process.

b. Assignment

(1) Competitive Bidding for New FCC Licenses

(a) General Framework

In NTIA's view, competitive bidding could improve the current FCC assignment process for private sector users. As an alternative to current lottery and comparative hearing proceedings, competitive bidding would rationalize the assignment process while recovering a portion of spectrum's value for American taxpayers. Under this arrangement, successful competitive bidding could serve as an initial condition to obtaining a license. It would not change the authority granted by the license itself.^{428/} For the reasons discussed above, we believe that a competitive bidding system for assignments should apply prospectively to new licenses and should not be extended to incumbents or renewals. Moreover, it should not apply to some specific "public service" uses, to be determined by Congress, or by the FCC after public comment.

^{427/} Extreme proposals could call for the elimination of all allocation boundaries by granting users unlimited rights to buy and sell spectrum from the government and from others, and to determine the services to be offered using that spectrum. We do not advocate these "absolute market" approaches, because they would eliminate the established benefits of the block system and would be of concern in international spectrum coordination.

^{428/} For example, previously introduced legislation for spectrum auctions would have simply awarded FCC licenses, with no increase in spectrum rights. See supra note 409.

(b) Details

In designing an assignment process based on competitive bidding, there are a number of specific implementation details that must be addressed.^{429/} We consider some of these issues below:

i) The Nature of the Right Awarded.

Potential bidders must have complete information on the spectrum for which they bid and the rights they obtain through such bidding, including the frequencies and geographic areas to be assigned, the uses permitted, and the technical requirements for such use. Such rights initially could be identical to those contained in existing FCC licenses for current services. In the future, they should reflect the flexibility described in Chapter 3.

ii) Bidder Qualifications

While in NTIA's view, a competitive bidding system should be relatively open, without a large number of restrictions on the persons eligible to participate, certain minimum qualifications could be established. For example, potential bidders could be required to meet the qualifications that currently exist under the Act or the FCC's rules, as a prerequisite to the grant of an FCC license. In addition, Congress or the FCC could establish additional requirements on bidders to protect the integrity of the process or to promote other public interest goals.^{430/}

iii) The Form of Competitive Bidding

Competitive bidding can take a number of different forms, and each has different economic characteristics.^{431/} The most familiar is the so-called "English" auction, in which the highest bidder wins and pays the price it bid. An alternative would be the "Vickrey" auction, a sealed-bid procedure in which the highest bidder wins, but pays the second highest price.^{432/}

^{429/} Many similar details are discussed in E. Kwerel & A.D. Felker, Using Auctions to Select FCC Licensees, *supra* note 333. See also C. E. Agnew, R. G. Gould, D. Dunn, & R. D. Stibolt, Economic Techniques for Spectrum Management: Final Report, *supra* note 311, at VIII-45 - VIII-61.

^{430/} NYNEX suggests that bidding be among selected "finalists." NYNEX Comments at 39. See also AT&T Reply at 13-14.

^{431/} For an analysis of various bid forms generally, see, e.g., R.P. McAfee and J. McMillan, *supra* note 311, at 699-737.

^{432/} This was the bid form adopted in New Zealand, based on a consultant's study. See N/E/R/A Study, *supra* note 293.

iv) Basis for Payment

Successful bidders can be required to pay a fixed price up front for the rights they obtain,^{433/} or to pay "royalties" based on the value they extract from use of the spectrum. Even with a fixed price, the payments could be spread over the course of the license term, like lease payments, rather than be paid in a lump-sum, up-front amount. As noted above, periodic payments, whether "lease payments" or royalties, could reduce concerns about "deep pockets," since bidders would compete largely on the basis of future payments, which would be due only after they had access to the spectrum to produce revenues. On the other hand, for at least some purposes, a pure royalty system (in which bidding is solely based on a percentage of revenues) may not be as useful on efficiency grounds as other forms of payments, since no costs would be imposed from inefficient underutilization of the spectrum.^{434/} Combinations of these payment approaches (e.g., a lump sum plus royalties) are also possible and are often used in other competitive bidding situations in which government makes public resources available for commercial use or development.^{435/}

v) Term of Rights Awarded

The term of rights awarded has important consequences. If a user obtains spectrum rights for a limited time, it may not be motivated to make efficient investments in spectrum use if it fears that it will lose use of the spectrum at the next renewal time. This argues for a long-term license or a renewal expectancy. On the other hand, license renewals provide an opportunity for the FCC to ensure that the license is being used for the purpose intended. As such, the renewal process serves as a regulatory "safety valve" to correct egregious situations, and could continue to so under a competitive bidding system.

Under the current assignment system, the license terms for various services vary in length, and many licensees enjoy a "renewal expectancy" of some type. Both these characteristics could be maintained under the competitive bidding approach proposed in this report.

The issues discussed above need not necessarily be resolved in the same manner for all spectrum to be offered through competitive bidding, or for all services affected by the bidding. In legislation authorizing competitive bidding, the FCC should be directed to initiate rulemaking proceedings to decide how to establish these details for different services subject to competitive bidding. The FCC should base its decisions on a goal of maximizing allocative, distributive, and technical efficiency, while balancing the equity concerns expressed in the Act.

^{433/} Payment of a fixed price could be spread over several years, to minimize financial hardship.

^{434/} Thus, a licensee that made only marginal use of the spectrum to produce very little revenue would have a correspondingly small royalty obligation. Under certain circumstances, this might potentially permit an inefficient user to outbid an efficient user. For example, an efficient user that could earn \$10 million per year in revenues from the use of the spectrum and would be willing to pay a royalty of 10% on that amount conceivably could be outbid by an inefficient user that could produce only \$1 million per year from its use of the spectrum, but would be willing to pay a royalty of 20% of that amount.

^{435/} For example, most federal oil leases, awarded through competitive bidding, include payment of both a "cash bonus" and a royalty. See, e.g., 43 U.S.C. § 1337 (outer continental shelf oil leases).

Because of the detailed nature of these issues, the extensive deliberations that these criteria require, and the benefits of public input on them, the FCC should decide these issues based on a complete rulemaking record and with appropriate congressional oversight.

(2) Leases of Federal Spectrum to Private Sector Users

The Notice proposed to examine the concept of spectrum "leases" as a method "to make spectrum currently allocated to federal use available to the private sector, while maintaining the government's ability to reclaim the spectrum at a later date if needed."^{436/} As defined in the Notice, a "lease" would require payment of a fee in exchange for the right of a party to operate on spectrum for a limited duration. The ability of the federal government to lease spectrum now allocated to federal use in this manner would be akin to the proposals discussed in the next subsection to allow a private sector user the flexibility to permit others to use spectrum in exchange for a payment. In a sense, therefore, it is a type of user-to-user transaction, as well as a government-to-user transaction.

NTIA intends to explore the concept of leasing spectrum in conjunction with the FCC. In so doing, it will address such issues as the legality of such a leasing program, the spectrum that might be included, procedures for awarding leases (including by competitive bidding), terms of the lease, and the extent to which the federal government would retain rights to the spectrum so leased, such as the right to preempt the private sector use during times of emergency or war, or requirements that spectrum be shared where technically feasible.

2. User-to-User Transactions

Because incumbents already occupy most of the usable spectrum, and most transactions in spectrum occur among users on a market basis, further reforms in the flexibility permitted for such transactions also could increase efficiency.

As noted above, theorists propose, and other countries have adopted or are considering, improving the efficiency of user-to-user transactions through new definitions of users' rights to the spectrum. Such rights provide greater flexibility and alienability than under the current licensing system. If the proposals of Chapter 3 for greater user flexibility are adopted, a licensee would be able to provide a variety of services. However, in some cases it may not be economically efficient for a licensee to offer a particular service itself. Greater ability to "alienate," or transfer, the spectrum needed for that service would permit a user to "lease" a portion of its spectrum authorization to another party that could put the spectrum to better use. Thus, for example, a broadcaster that desired only to offer mass media services could nevertheless permit another party to operate on a portion the broadcaster's assigned channel, while maintaining sufficient control to prevent harmful interference. Similarly, users could aggregate spectrum rights in order to provide a desired service.

As noted in Chapter 3, the presence of incumbents in spectrum blocks complicates the task of making such changes in user-to-user transactions. NTIA recommends, therefore, that the FCC conduct an experiment in increasing flexibility and alienability to determine the feasibility of such changes. It may also be appropriate to combine such an experiment with competitive bidding as described above. Such an experiment may be appropriate for any spectrum above 10 GHz, as noted in Chapter 3, or for spectrum reallocated from the federal government to private sector use.

^{436/} Notice, para. 65.

III. Revenue Enhancement and Fees

A. Policy Issues

Given the potential enormity of spectrum's value, the Notice raised the issue of whether the federal government should recover at least part of that value through some mechanism.^{437/} This is particularly important in this time of federal deficits and budget constraints.^{438/}

Imposition of spectrum fees is a possibility for encouraging more efficient spectrum use, while recovering a portion of the spectrum's value for the American public. Fees offer the prospect of significant revenue generation for the federal government. Some commenters express the opinion, however, that maximization of governmental revenues would be inconsistent with the federal government's obligation to manage the spectrum resource in the public interest, and that revenue should be a by-product, but not the objective, of spectrum management.^{439/} UTC regards any revenue enhancement as a tax on spectrum use, which it describes as "unconscionable."^{440/} McCaw states that "the nation's scarce radio spectrum should not be viewed as a resource to be marketed according to its potential to generate revenue for

^{437/} The FCC currently charges fees for processing license applications. See 47 U.S.C. § 158. It is unclear whether the FCC currently has the legal authority to impose spectrum fees that would raise revenues in excess of its administrative costs.

The Congress has considered in detail several fee proposals in the past. For example, it considered three such proposals in 1979. S. 611 and H.R. 3333, Communications Act rewrite bills, each contained provisions for "public resource use fees" to be determined by the FCC. S. 611, 96th Cong., 1st Sess., §106; H.R. 3333, 96th Cong. 1st Sess., §414. The third bill, S. 622, would have imposed a fee to recover the FCC's costs in processing the user's license, and also the costs of regulating the licensee. S. 622, 96th Cong., 1st Sess., § 6. A summary of these proposals can be found in H. Geller & D. Lampert, Charging for Spectrum Use, *supra* note 305, at 3-7, and a comparison of the bills is contained in E. Krasnow, L. Longley, & H. Terry, The Politics of Broadcast Regulation, *supra* note 378, at 255-258. In addition, a 1987 Senate bill proposed to assess a fee on license transfers. See S. 1935, Communications Transfer Fee Act of 1987, 99th Cong., 2d Sess.

^{438/} A number of recent press reports have questioned the wisdom of giving away spectrum "for free." See, e.g., Congress's Wheel of Fortune, *supra* note 6, at A10, col. 1; Why Should Airwaves Be Free As Air? (editorial), *Business Week*, July 23, 1990, at 86; The Phone Flushaway, *The New Republic*, Oct. 9, 1989, at 13; and B. Weingardt, Monday Memo (spectrum fee commentary), *Broadcasting*, Dec. 10, 1990, at 42.

^{439/} See, e.g., ANSA Comments at 11; Ameritech Comments at 6-8. BellSouth Comments at 15-16; CTIA Comments at 18 ("does not believe it is a good idea to consider revenue enhancement proposals and spectrum management issues in the same proceeding"); LMCC Comments at 46; NAB Comments at 19-20; Southwestern Bell Comments at 11; UTC Comments at 17-20.

^{440/} UTC Comments at 20.

the federal government."^{441/} NAB expresses the concern that the application of fees to broadcasting "inevitably would lead to the erosion of [the] important [public] trustee concept. . . ."^{442/} GTE "does not endorse using the spectrum as a revenue generation vehicle. . . ."^{443/}

Some commenters believe that fees would be "especially harsh" for noncommercial spectrum users, such as public safety or public utility users.^{444/} FIT distinguishes between services that use spectrum as a "tool," and those using spectrum to produce income.^{445/} NAPTS/PBS recognizes "the considerable revenue-generating possibility of a spectrum fee system," but states that any such system "should provide for an exemption for public television," because it lacks the resources a fee system requires, and would place some stations in jeopardy.^{446/} Other commenters, however, believe that fees would be unfair if they apply only to commercial spectrum users.^{447/}

Other commenters give varying degrees of support for fees. Cohn proposes that "if a significant change is made in the apportionment method, . . . it be based on user fees." ^{448/} CPB states that commercial licensees should generate "public revenues" and therefore favors spectrum license fees for commercial interests.^{449/} ITI "recognizes the wireless alarm industry's responsibility to participate in the development of sound revenue enhancement programs."^{450/} OPASTCO opposes auctions, but suggests various types of fees that could be imposed.^{451/}

^{441/} McCaw Reply at 17.

^{442/} NAB Comments at 21.

^{443/} GTE Comments at 13; GTE Reply at 5.

^{444/} LMCC Comments at 48.

^{445/} FIT Comments at 8.

^{446/} NAPTS/PBS Comments at 22-23. With respect to the use of funds generated by a fee program, however, NAPTS/PBS states that "targeting public television as a recipient of spectrum fees would be consistent with established federal funding of the public broadcasting system," but any fee payment system "should supplement, and not replace, existing federal funding of public television." *Id.* CPB states that revenue enhancement mechanisms cannot substitute for direct congressional appropriations for public broadcasting. CPB Comments at 14. FIT states that such revenue should be used for spectrum management, and not go to the general treasury or for public broadcasting. FIT Comments at 8.

^{447/} *See, e.g.,* Southwestern Bell Comments at 10.

^{448/} Stanley H. Cohn Reply at 10. *See also* Common Ground/USA Comments at 2.

^{449/} CPB Comments at 13.

^{450/} ITI Comments at 18-19.

^{451/} OPASTCO Comments at 7.

Some commenters state that they would accept increased fees collected to offset the FCC's and NTIA's administrative costs of spectrum management. Some commenters propose that the additional funds be used for such purposes as database improvement.^{452/}

Some proponents of fees contend that the application of fees to users across the spectrum is a highly equitable approach, since broadly-imposed fees would not single out a particular industry group.^{453/} Numerous users oppose such broad fees. AT&T, for example, states that "charging fees to present incumbents is fundamentally unfair. They incurred risks and made investments based on the understanding that if they qualified to use spectrum, that use was without charge."^{454/} AT&T also argues, however, that it would be unfair to charge fees to new users while incumbents continue to use spectrum without charge, because incumbents would then have a competitive advantage; such an approach causes market distortions.^{455/} Some commenters express opposition to any fee proposal. MST contends that most licensees have already contributed a portion of their stations' value to the Treasury:

The vast majority of television broadcasters acquired their stations the same way that other companies acquire their assets -- they bought them for valuable consideration. Moreover, the seller in most such transactions had taxable income on the appreciation in the value of his station; thus, the Treasury received a percentage of the capitalized value of the license.^{456/}

Other commenters echo these sentiments. Hubbard states that "broadcasters have taken the frequencies licensed to them by the government and have risked their own capital to build the broadcast infrastructure which makes these frequencies valuable today."^{457/} Hubbard also states that a fee based on revenues would be "wholly unjustified" because the government already taxes profits.^{458/} INTV states that because most licensees acquired their licenses through the transfer process, they have already "paid full dollar value" for use of the spectrum and are continuing to "pay" by providing issue-responsive programming.^{459/}

^{452/} See NYNEX Comments at 40 and Southwestern Bell Comments at 11 (both stating that fees could defray FCC and NTIA expenses, and help create state-of-the-art databases). See also FIT Comments at 8; OPASTCO Comments at 7 (funds should be used for FCC expenses). Commenters were particularly interested in seeing an increase in the FCC's budget, which several call "woefully inadequate." See, e.g., Linear Reply at 5, n.4.

^{453/} Southwestern Bell expresses concern that license fees would apply only to selected services, and exclude, for example, non-commercial services. Southwestern Bell Comments at 10.

^{454/} AT&T Comments at 11-12.

^{455/} Id. at 12.

^{456/} MST Comments at 41.

^{457/} Hubbard Comments at 9.

^{458/} Id.

^{459/} INTV Reply at 7.

A number of commenters believe that fees would encourage greater efficiency in spectrum use. For example, according to AMI, fees "would spur operators to seek only the amount of spectrum they intend to use, and use it efficiently . . . and "would discourage underutilization or warehousing of spectrum . . ."^{460/} AT&T states that fees "intended to approximate market prices have roughly the same effect as market prices themselves," but opposes fees on fairness grounds.^{461/}

Although NTIA believes that market-based spectrum management, as proposed above, is preferable, periodic spectrum user fees could be an alternative means of returning a portion of spectrum's value to the public, while at least providing sufficient revenue to allow the government to recover its costs of regulation. Moreover, depending on how they are designed, such fees could conceivably help increase economic efficiency in use of the spectrum resource, particularly in situations where markets cannot operate.^{462/}

Fees have several drawbacks, however, that make them less appealing than the market-based approach we endorse above. First, fees would not improve administrative efficiency in the assignment of spectrum. Comparative hearings and lotteries would still be the prevailing methods of awarding licenses among competing applicants. Indeed, the imposition of fees potentially could cause additional administration and enforcement costs. Second, fees would not necessarily contribute to the achievement of efficiency goals. The degree to which a fee can increase such efficiency depends in large part on how closely it replicates prices that would be charged if a market system were in place.^{463/} As discussed below, the fee structures that most closely duplicate market prices are the most difficult to design and implement. In practice, therefore, fee proposals often sacrifice efficiency enhancement for simplicity of operation. As a result, fees would not necessarily free up valuable spectrum for new services or users.^{464/}

Noting these concerns, NTIA therefore intends to explore, with the FCC, various fee proposals that could apply where spectrum management objectives cannot be achieved through the market.

^{460/} AMI Comments at 17-18.

^{461/} AT&T Comments at 11.

^{462/} For a discussion of the objectives of federal user fees, and their ability to improve economic efficiency, see generally C.P. Gillette & T.D. Hopkins, Federal User Fees: A Legal and Economic Analysis, 67 B.U.L. Rev. 795 (1987).

^{463/} See id. at 806-807. The authors note that such value can be identified "through auction, bidding or private markets for comparable services."

^{464/} Although a fee conceivably could help improve the efficiency of spectrum use in some circumstances, spectrum allocation and assignments would not be affected by the imposition of a fee. While a fee could increase a user's costs, even if that user were to vacate the spectrum, an alternative user could not have access to that spectrum without an allocation or assignment proceeding.

B. Types of Fees

Fees have been proposed in several forms. We discuss several possibilities below:

1. Periodic Administrative Cost Recovery Fee

Some observers have stated that, at the least, spectrum fees should be set at the minimum amount necessary to recover the yearly costs to the FCC and NTIA of managing the spectrum resource. Although the FCC's current license application and filing fees recover almost \$40 million per year for the U.S. Treasury,^{465/} these are not designed to cover the annual costs of spectrum management and the revenues are not dedicated to funding spectrum management efforts.^{466/} As discussed above, other countries, including Canada and Australia, have imposed such cost recovery fees.^{467/} A major disadvantage of this approach, however, is that fees designed to recover administrative costs are not tied to the value of spectrum used, and as such, may not make a major contribution to encouraging spectrum efficiency.

2. Fees Based On "Shadow Prices"

Recognizing that efficiency would be most enhanced by a fee that replicates competitive pricing, some theorists have attempted to design "shadow prices" for spectrum. As Agnew, *et al.* state:

Shadow prices are derived from economic or technical studies which are intended to approximate users' individual willingness to pay. Levin's phrase "market simulation" . . . aptly summarizes the idea. By charging a fee equal to the shadow price, the spectrum management authority can, in principle, approximate the pricing effect of a free market. The shadow pricing approach substitutes an administrative calculation of the potential users' marginal willingness to pay for his own calculation. Hence, the effectiveness of shadow pricing in promoting economic efficiency depends on the ability of the spectrum management authority to correctly reproduce users' decisions.^{468/}

^{465/} According to the FCC's Office of the Associate Managing Director for Operations, the FCC projects that it will recover approximately \$39.2 million in fees in FY 1991, based on fees recovered in the first quarter of this fiscal year.

^{466/} However, the Administration's FY 1992 budget proposes annual FCC user fees in addition to the current fees, and these new fees are estimated generate approximately \$65 million annually for the Treasury. See New FCC User Fees Proposed in Bush Budget, *Communications Daily*, Feb. 6, 1991, at 1.

^{467/} In Canada, the fees apply to virtually every spectrum user, including military and other government users. The fees charged in Australia, originally based on recovering the costs of administration, have been levied as taxes since 1983, and are generally increased each year based on the consumer price index. See Department of Transport and Communications, The Radio-Frequency Spectrum in Australia: Its Pricing and Management, *supra* note 319, at 44.

^{468/} C. E. Agnew, R. G. Gould, D. Dunn, & R. D. Stibolt, Economic Techniques for Spectrum Management: Final Report; *supra* note 311, at IV-23. See also Levin, *supra* note 333.

Agnew, *et al.* provide a review of "econometric approaches" and "engineering approaches" to determine shadow prices in existence as of the date of their study.^{469/} In addition numerous suggestions for determining such a fee for federal spectrum users have been examined extensively in prior reports.^{470/}

3. "Spectrum Conservation" Fees

Commenters also offer suggestions for establishing fees that would promote greater spectrum efficiency. Cohn states that fees "should be based on the amount of spectrum used; i.e., the area (or volume), bandwidth and time product (ABT) denied other users."^{471/} Cohn proposes a four-tiered method for such fees that would consider co-channel conditions set to cover administrative costs, a higher fee for the excess ABT for other than co-channel conditions, a surcharge reflecting demand for spectrum use, and a variable surcharge imposed if the spectrum use could be satisfied by a non-spectrum alternative.

Bell Atlantic proposes a "spectrum conservation" fee intended "to provide an economic incentive to conserve the use of the spectrum."^{472/} The fee would apply to all new spectrum authorizations granted after a date certain, including federal users, except those of any party or service specifically excluded by Congress or the FCC. The fee would not apply to existing licensees or create a property interest in spectrum. The FCC and NTIA would administer the fee for spectrum under their respective jurisdictions. The fee would be determined according to certain variables to reflect the value of the spectrum used -- the bandwidth occupied, the population covered, and the area (or "zone") in which the system operates.

4. Gross Revenue Fees

A gross revenue fee would apply to commercial spectrum users, based on a percentage of a user's revenues. It would seek to recover for the public a portion of the

^{469/} *Id.* The discussion refers to numerous studies, including Levin, *supra* note 333, and D. Webbink, The Value of Frequency Spectrum Allocated to Specific Uses, *supra* note 293.

^{470/} The former Office of Telecommunications Policy (OTP) of the Executive Office of the President (predecessor to NTIA) undertook extensive work in this area almost two decades ago with respect to federal spectrum use. See, e.g., OTP, Management of Federal Spectrum Use through Shadow Prices: Can it be Rendered Practicable? (technical proposal submitted by General Electric Company - TEMPO Center for Advanced Studies) (Apr. 3, 1972); OTP, Paying for Airwaves Use: Concept and Experiment for Including the Economic Value of Spectrum in OTP/IRAC Process to Allocate and Assign Airwaves Use within the U.S. Government (June 1973), with attached working papers; C.B. Thompson, Economic Efficiency and the Allocation, Allotment, and Assignment of Government Spectrum Space (Report prepared for OTP) (Mar. 1973); and OTP, The Possible Effects of a System of User Charges for Spectrum on the Use of the 2700-2900 MHz Band, 1956-1972 (Mar. 1973). Shadow prices were also examined within the Commerce Department. See J. H. Alleman, The Shadow Price of Electromagnetic Spectrum: A Theoretical Analysis, Office of Telecommunications, U.S. Department of Commerce (July 1974).

^{471/} Stanley I. Cohn Reply at 10. (These comments draw heavily on his 1979 congressional testimony on H.R. 3333, cited *supra* note 437.)

^{472/} Bell Atlantic Reply at 2.

spectrum's value obtained through commercial revenues. Compared to other fees that attempt to approximate market prices, a gross revenue fee would be administratively simple to administer. The fee would not have universal application to all spectrum users, however, because it presumably would apply only to those users with revenue directly attributable to spectrum use, such as broadcasters and cellular telephone providers, and not other commercial users who reap indirect financial benefits through spectrum use. Nor could it be applied to noncommercial users, such as the federal government.

Moreover, such a fee would probably have limited value for increasing spectrum efficiency because it would be unrelated to the amount of spectrum used to produce the revenues. In fact, insofar as increased efficiency in spectrum use produced increased revenues, the licensee's fees would rise as it became more efficient, while underutilization of the spectrum would lead to reduced fees (and warehousing would cost little or nothing).^{473/} This could result in disincentives for efficiency.

Nevertheless, as a practical matter these disincentives are not likely to be substantial if the fee level is set at a reasonably low level. Furthermore, a gross revenue fee has the advantage of adjusting licensees' payments based on the value of the commercial activity for which the spectrum is authorized, otherwise a difficult task for a fee system.

5. Fees for Federal Users Only

As noted above, NTIA and its predecessor offices have examined the issue of user charges for federal agencies in a number of studies prepared in the 1970s.^{474/} A spectrum fee applicable to federal agencies could encourage more efficient spectrum use by the federal government, by creating economic incentives among federal users to conserve spectrum, and instituting a higher degree of accountability for spectrum usage. Unlike other fees, however, a fee applied to federal users only would not have a revenue-enhancement effect for the U.S. Treasury.

Such a fee could be calculated using several of the methods discussed above, (except, of course, by revenue). Thus, for example, as in Canada, the fee could be assessed on a cost recovery basis. Agencies could be charged for each spectrum authorization to recover the cost of NTIA administration.^{475/} Alternatively, the fee could reflect the "shadow price" of spectrum, or the amount of spectrum used by a system, or federal agency as a whole, in order to achieve greater efficiency.^{476/}

NTIA plans to explore the potential benefits of establishing a system of user fees to promote greater efficiency among federal agency spectrum users and to provide a source of

^{473/} As CTIA states, "a straight gross revenue fee would penalize the licensee that most fully developed its spectrum and reward the spectrum warehouser." CTIA Comments at 18.

^{474/} See studies cited supra note 470.

^{475/} This would not preclude a "surcharge" for authorizations in congested bands.

^{476/} The Canadian government has reported success with its cost-recovery fee program, which applies to all spectrum users, including agencies of the national government. Canada is in the process of expanding this program to include provincial and local government users.

revenue for management functions. Some federal agency commenters oppose such fees.^{477/} NTIA will seek agency comment and work through the IRAC in exploring the institution of a fee program. However, NTIA expects that any such fee system would consider, among other things, some or all of the following factors:

- The number of authorizations held by an agency;
- The amount of spectrum (as determined by a spectrum use measure) used by a system or agency;
- The relative value to private sector users of equivalent spectrum (a shadow price).
- The cost of administering such a program.

In addition, NTIA will explore whether some portion of the funds from such a fee program could be designated to support its spectrum management programs, including the additional costs incurred in opening federal spectrum management activities to the public, improving spectrum databases, and continuing research on improving spectrum efficiency. In this way, there would be a direct connection between the fees paid by the federal spectrum users and the resources needed to operate an efficient, modern spectrum management system.

^{477/} The Air Force, for example, opposes fees for government users on the grounds that 1) fees would essentially constitute a charge to the public for use of a public resource; 2) fees would amount to a transfer of funds "from one pocket to another," at an administrative cost; and 3) government users are not in competition with each other. DOD Comments (Air Force) at 10. The Army also opposes such fees, but indicates a willingness to examine the matter further. DOD Comments (Army) at 4.

CHAPTER 5

SPECTRUM USE, EFFICIENCY AND CONSERVATION

I. Introduction

In this chapter, we describe how the engineering facets of spectrum use and efficiency can be quantified, and examine ways to conserve spectrum resources.

Although the spectrum resource is not consumed through use, a radio system can deny the use of part of the spectrum resource to another system that would either cause interference to, or experience interference from, the first system. A radio system is said to "use" spectrum resources^{478/} when it denies other systems the use of those resources.^{479/} Spectrum use can be quantified, subject to certain assumptions, both for a single radiocommunication system and for a related group of systems.

The electromagnetic spectrum is theoretically boundless, but the portion currently useful for communications, while substantial, is finite. The properties of radio wave propagation and electronic equipment limit practical radio communications to the allocated frequencies (between 9 kHz and 300 GHz). These properties also constrain particular types of communications systems to certain portions of the allocated spectrum, limiting the spectrum available for specific uses.

In other chapters of this study, we address the economic and regulatory aspects of efficiency and discuss ways to use market-based mechanisms and greater regulatory flexibility to improve the economic efficiency of spectrum use. In this chapter, we consider the engineering aspects of efficiency in spectrum use, including techniques to measure spectrum use and technological approaches to improve "spectrum efficiency."^{480/} One radiocommunication

^{478/} See infra p. 129 for a discussion of spectrum resources.

^{479/} Thus, a radio system "uses" not only the frequency on which it is said to operate, but also all the other frequencies that are not available for other communications because of the first system's operations. For example, a transmitter with significant spurious emissions may "use" a wide range of frequencies in addition to its operating frequency if its spurious emissions prevent interference-free use of the adjacent frequencies by others.

^{480/} "Spectrum efficiency" is defined infra, page 128. Spectrum efficiency, as used in this chapter, is an engineering concept similar, but not identical to, the economic concept of technical, or productive, efficiency. See supra note 335.

system is more "spectrum efficient" than another if it conveys the desired information using less of the spectrum resource than the other.^{481/}

Another aspect of spectrum efficiency is the arrangement of communications systems within the spectrum resource. In this "macro" sense, spectrum is used inefficiently when systems are not packed together as tightly as possible in frequency bands (as when excessive guard bands are used), or when portions of frequency bands are unused while other bands with similar physical characteristics are congested. The allocation of frequency bands, the development of channeling plans, and the assignment of frequencies to specific systems all affect spectrum efficiency.

Spectrum conservation entails the use of spectrum-efficient technologies and techniques to meet current spectrum requirements and to preserve the radio spectrum for additional uses. By employing spectrum-efficient systems, a user will deny a minimum of spectrum resources to future users. By efficiently packing systems into frequency bands, spectrum managers can better accommodate users. If spectrum managers and users do not meet these goals on an ongoing basis, serious shortages of spectrum resources can develop, making it difficult for spectrum users both to expand their current services and to develop and implement new, innovative service offerings.

II. Determining Spectrum Use and Efficiency

A. Introduction

In order to promote spectrum efficiency, spectrum managers must possess some means of quantifying spectrum use and evaluating various radio technologies and frequency selection techniques. Management decisions can then be based on the relative spectrum efficiency of the various technologies and techniques.

The spectrum use of a telecommunication system is determined by calculating the total spectrum resources denied to other systems. The more the system restricts the operation of other telecommunication systems (e.g., by requiring them to be located far away to operate without interference) the more spectrum resources it uses. Extending the concept, the quantity of spectrum resources used in a frequency band is the sum of the resources used by each individual system operating in the band.

The spectrum efficiency of a system is generally calculated as "the ratio of the useful output to input."^{482/} The International Radio Consultative Committee (CCIR) thus defines

^{481/} Spectrum efficiency, while important, does not by itself necessarily determine the overall value to society of a radiocommunication system or service. Various other factors, many of them subjective, often must also be considered. In this regard, National Public Radio argues that "[i]nnumerable factors such as geography, alternative service availabilities, economic considerations, public service qualities, and established public policies [should] contribute to allocation decisions for non-federal allocations in compliance with the Communications Act." NPR Comments at 21. Under current practices, these factors often influence spectrum management decisions as much as or more than spectrum efficiency.

^{482/} IEEE Standard Dictionary of Electrical and Electronics Terms, The Institute of Electrical and Electronics Engineers, Inc., New York, 1984.

spectrum efficiency as the ratio of the "information transferred over a distance" or the "communications achieved" (the useful output) to the "spectrum space used" (the input).^{483/}

$$\text{spectrum efficiency} = \frac{\text{communications achieved}}{\text{spectrum resources used}}$$

The problem of determining the "communications achieved" by a radiocommunication system is manageable if spectrum efficiency is being used to compare systems of the same type. While no set definition exists, the "communications achieved" is a function of the information transmitted (perhaps in bits per second for a digital system), the number of users, and the distance over which the information is transferred.^{484/}

As discussed below, more extensive work has focused on determining the "spectrum resources used," or spectrum use. The equation shows that spectrum use and spectrum efficiency are inversely proportional: the less spectrum resources a system uses to achieve its desired function, the more spectrum efficient it is.

B. Determining Spectrum Use

1. General

Early efforts to quantify the spectrum resources "used" by telecommunication systems involved representing, in a spectrum resource space, the frequency, physical space, and time resources denied to other systems and calculating the volume of resources denied using

483/ CCIR, Definition of Spectrum Use and Efficiency, CCIR Report 662-2, § 2.2 (1986) (CCIR, Definitions). While many engineering definitions of efficiency are expressed as a percentage, there are numerous other such definitions that have dissimilar units in the numerator and denominator. Perhaps the most familiar example is the computation of the efficiency of an automobile in miles per gallon of fuel.

An alternate definition for spectrum efficiency is the ratio of the spectrum resources used by an "ideal" system to those used by the system being evaluated. L.A. Berry, Spectrum Metrics and Spectrum Efficiency: Proposed Definitions, IEEE Transactions on Electromagnetic Compatibility, Vol. EMC-19, No. 3, at 258 (Aug. 1977) (Berry, Definitions). In practice, the "ideal" system (theoretically the system that would achieve the desired communications using the minimum spectrum resources) is replaced by some practical system that is known to be very spectrum efficient. While efficiency by this definition could conveniently be represented as a percentage, the definition does not conform to the basic concept of an output-to-input ratio.

484/ R.L. Hinkle, Spectrum Conservation Techniques for Future Telecommunications, 1990 International Symposium on Electromagnetic Compatibility -- Symposium Record, The Institute of Electrical and Electronics Engineers, Inc., New York, at 413, 413 (1990). Various suggested measures include the product of the number of communications channels and distance between the transmitter and the receiver, the dimensions of the service area, the capacity of a communications link (with or without consideration of the distance), and even financial profits. See CCIR, Definitions, supra note 483, Annexes I and II; Berry, Definitions, supra note 483, at 258; R.L. Hinkle & A. Farrar, Spectrum-Conservation Techniques for Fixed Microwave Systems, NTIA Report 89-243, U.S. Department of Commerce, National Telecommunications and Information Administration, May 1989, at 3-2.

integration.^{485/} Much subsequent work, however, is based on a simplified definition of spectrum use: the product of the bandwidth, space, and time "used."^{486/} More recent work has returned to the more general technique, adding additional dimensions (such as antenna polarization and coding separation) to the spectrum resource space.^{487/} Appendix F provides examples of this process.

Both transmitters and receivers contribute to the spectrum resources used by communication systems. Transmitters deny spectrum resources to receivers that would experience interference from them.^{488/} Receivers, if protected from interference, e.g., by technical regulation, deny spectrum resources to transmitters that would potentially cause interference to them.^{489/}

The two basic techniques for quantifying the use of spectrum resources are based on different types of criteria. The more straightforward technique uses power density criteria for transmitters and susceptibility criteria for receivers. A transmitter "uses" a combination of resources (e.g., a frequency at a location) if the emissions at that location and frequency exceed the power density criterion. A receiver "uses" a combination of resources if the receiver susceptibility, referenced to that location and frequency, exceeds the susceptibility criterion.

An alternate technique employs a "reference system," a hypothetical transmitter-receiver pair. In this case, a transmitter "uses" a combination of resources if the reference system receiver could not operate there without interference. Likewise, a protected receiver "uses" a combination of spectrum resources if the reference transmitter could not operate there without causing interference to the protected receiver.

485/ D.R. Ewing & L.A. Berry, Metrics for Spectrum-space Usage, OT Report 73-24, Office of Telecommunications, U.S. Department of Commerce (Nov. 1973). To prevent interference, operation of radiocommunication systems must be sufficiently separated in frequency, physical space, or time. A system will therefore "deny" spectrum resources to other systems by creating frequencies, locations, etc. at which they cannot operate compatibly. Each system "uses" those combinations of resources that it denies to other systems.

486/ See, e.g., Berry, Definitions, *supra* note 483, at 254; CCIR Definitions, *supra* note 483, § 2.1. When using this simplified approach, the bandwidth denied is assumed to be constant rather than a function of distance from the system. Multiplication can then be used instead of integration to calculate the volume denied.

487/ R.H. Haines, Quantification of Spectrum Use: Spectrum Management Tools for the Twenty-first Century, 1990 International Symposium on Electromagnetic Compatibility -- Symposium Record, The Institute of Electrical and Electronics Engineers, Inc., New York, at 390, 390 (1990) (Haines, Quantification).

488/ Transmitters also deny spectrum resources to other transmitters indirectly. For example, using current technology, a UHF television station transmitting on Channel 21 would interfere with reception of Channel 22 and several other channels on nearby receivers. For this reason, the FCC will not assign certain channel pairs to UHF transmitters in close proximity. The Channel 21 transmitter therefore indirectly denies other transmitters the use of Channel 22 and several other channels at nearby locations.

489/ Receivers also indirectly deny spectrum resources to other receivers.

2. Automated Computer Models

a. Current Efforts

The types of analysis needed to determine spectrum use require automated computer models and databases. NTIA's major effort in this area has been the development of the Spectrum Use Measure (SUM), which quantifies aggregate spectrum use in a frequency band.^{490/} The SUM model computes the spectrum use factor (SUF) for regularly-spaced test points and produces maps such as the one shown in Figure F-3 of Appendix F. The model also computes the spectrum use index (SUI), which quantifies the overall spectrum use for the frequency band.

The SUM model has several potential applications in the spectrum management process. These include certification of the compatibility of a proposed system with its electromagnetic environment, selection of frequency bands and specific frequencies for proposed systems, comparison of the relative congestion of frequency bands, identification of congested areas, and assessment of the growth of spectrum use. This latter application could prove very valuable in forecasting.^{491/}

Several NTIA studies have sought to quantify spectrum use for a single system, using the product of bandwidth, space, and time as the definition of spectrum use.^{492/} More recent NTIA work has demonstrated the feasibility of quantifying spectrum use with the integration approach, but actual models employing this technique have not yet been developed.^{493/} Spectrum managers could potentially use these models to evaluate the relative spectrum efficiency of systems that perform similar functions and for frequency selection.

Some responses to the Notice support the development and use of these automated techniques in spectrum management. For example, ITI supports the investigation and

^{490/} R.J. Mayher, R.H. Haines, S.E. Litts, L.A. Berry, G.F. Hurt & C.A. Winkler, The SUM Data Base: A New Measure of Spectrum Use, NTIA Report 88-236, National Telecommunications and Information Administration, U.S. Department of Commerce (Aug. 1988); NTIA, Memorandum of July 5, 1989 from Robert J. Mayher, Director, Spectrum Plans and Policies, to Holders of NTIA Report 88-236 The SUM Data Base: A New Measure of Spectrum Use, Subject: Revisions and Additions to the Report (NTIA, SUM Revisions and Additions); R.H. Haines & S.E. Litts, The SUM Land Mobile Model: Application of the Spectrum Use Measure to the Land Mobile Service, NTIA Report 89-248, National Telecommunications and Information Administration, U.S. Department of Commerce (Sept. 1989).

^{491/} Haines, Quantification, *supra* note 487, at 393. See *infra* Chapter 6, at 173.

^{492/} Hinkle & Farrar, *supra* note 484, at A-1; L.A. Berry, E. Chang, W.E. Frazier, J. Levy & M. Sussman, Application of the Technical Spectrum Efficiency Factor (TSEF) to the Fixed Service in Three Frequency Bands, NTIA TM 86-115, National Telecommunications and Information Administration, U.S. Department of Commerce, at 3-1 (Sept. 1986) (Berry, *et al.* TSEF); W. Shelton, D. Cohen, G. Crandall, G.F. Hurt & W.D. Speights, Assessment of Narrowband Modulation Technologies for Government Land Mobile Operations, NTIA Report 84-156, National Telecommunications and Information Administration, U.S. Department of Commerce (Aug. 1984) (especially Annex B).

^{493/} Haines, Quantification, *supra* note 487, at 391-92.

implementation of "new methods for determining the efficiency of spectrum use."^{494/} However, other commenters expressed concern about automated techniques such as the SUM model. For example, the Air Force cautions that those who would be making administrative decisions based on the output of such models may not fully understand their limitations.^{495/} NTIA agrees. It is of paramount importance to know, for example, the spectrum use criteria used in a SUM analysis, whether they involve emission and susceptibility levels or a reference system. A transmitter or a receiver's spectrum "use" may vary dramatically with a small change in the spectrum use criteria. Inaccuracies in the GMF data and the simplified propagation and antenna pattern models used can also affect the output.^{496/} Decision makers must be aware of these assumptions and simplifications.

Thus far, NTIA has developed the SUM model for the fixed and land mobile services in a limited number of frequency bands. In light of its utility, NTIA plans to extend the SUM technique to cover most frequency bands and radio services. Because a joint effort involving NTIA and the FCC will more likely produce models useful to both groups, NTIA intends to work with the FCC and seek its participation in the development and use of such models.^{497/} We would also welcome input from entities in the private sector that have expertise in this area.

b. Recommendations

Computer models that quantify the use of spectrum resources by individual systems and by all systems in a frequency band have broad applications in spectrum management. NTIA will continue development of automated computer models for quantifying spectrum use, both for individual systems and for frequency bands. NTIA proposes to coordinate further with the FCC in developing and using these models, and will also seek private sector participation in these efforts.

3. Data Availability

The numerical analyses performed in spectrum management, including determination of spectrum use, require adequate and accurate technical information on communications systems. This includes data on the characteristics of the systems, which is available from the manufacturers,^{498/} and data on where, when, and how the systems are used, which is available from the users.

^{494/} ITI Comments at 14.

^{495/} DOD (Air Force) Comments at 11.

^{496/} Retrieval and interpretation of spectrum use data from the GMF has posed perhaps the greatest obstacle to the further development of the SUM model.

^{497/} The FCC has thus far not been involved in this effort, except to have NTIA apply the SUM model to FCC data in one frequency band.

^{498/} The radio equipment data needed for spectrum management includes data pertaining to the equipment design, such as the power and bandwidth of transmitters and the sensitivity of receivers, and data pertaining to interference properties, such as the "spurious" emissions of transmitters and the susceptibility of receivers to interfering signals.

A database serves as a link between these sources of data and the spectrum manager. The spectrum manager collects the initial data from these sources and then updates it as needed. Besides providing a single repository for data, a well-designed database permits the direct retrieval of necessary data by automated computer models. This retrieval capability makes models requiring large quantities of data possible (e.g., the SUM model). If the database requires extensive programming to retrieve and process data, its value for supporting these models is greatly diminished.^{499/}

Current NTIA and FCC data capabilities for spectrum management are far from ideal. NTIA and the FCC collect data on radiocommunication systems primarily through their frequency assignment application processes. NTIA stores frequency assignment data in the GMF, which contains information on all frequency use authorized by NTIA. Limited data on the radio equipment used by government agencies is available from two sources. The U.S. Department of Defense Electromagnetic Compatibility Analysis Center (ECAC) maintains an Equipment Characteristics File (ECF), containing data primarily on equipment used by the military. NTIA also maintains an automated equipment characteristics file separate from the GMF known as the Systems Review File (SRV). This file contains administrative data on space systems and other "major" systems, which NTIA reviews as part of its system review process.^{500/} The FCC's Master Frequency File contains data pertinent to the radio licenses it grants. For certain frequency bands and services, private frequency coordination groups maintain additional data.^{501/}

Although the NTIA and FCC data files provide a wealth of data on spectrum use in the United States, significant improvements are needed. The primary concern about data files expressed by commenters is access to federal frequency assignment data as a means of gaining access to spectrum assigned to federal users and to shared spectrum. Chapter 2 describes the changes that would be necessary to overcome the security hurdles and incongruities between the NTIA and FCC data files that limit access.^{502/}

Other commenters object to the way that NTIA and FCC maintain frequency use data. PRSG criticizes the FCC for poor maintenance and verification of its database, which, it

^{499/} See supra note 496.

^{500/} NTIA Manual, supra note 11, § 10.2.1. Although NTIA collects a significant amount of equipment characteristics data in the system review process, most of the data is not part of the automated file.

^{501/} In addition, frequency assignments notified to the International Frequency Registration Board (IFRB) of the International Telecommunication Union (ITU) are recorded in its Master International Frequency Register (MIFR); ITU, Radio Regulations, International Telecommunication Union, Art. 10, § 2 (1986).

^{502/} See supra Chapter 2, at 28.

claims, harms policy making.^{503/} BellSouth describes the lack of an accurate database for interference studies as "one of the primary difficulties encountered in the private sector."^{504/}

In addition to the changes recommended in Chapter 2, current data files need substantial improvements in three areas: the adequacy of data for engineering analyses, the availability of receiver and passive system data, and data file structure.

a. Data Adequacy

NTIA and the FCC developed their data files to record basic information on frequency assignments. These same files, however, are the only automated source of frequency assignment data for engineering analyses. They therefore perform a dual role, for which originally they were not primarily intended.

The data currently available, though adequate for cursory engineering analysis, is insufficient for the more rigorous analysis on which many spectrum management decisions should be based. If the data available in the data files is inadequate, the engineer performing a small-scale analysis will consult non-automated sources. However, the engineer doing a large-scale automated analysis will generally make assumptions about missing data and consider troublesome records apart from the automated analysis.

NTIA and the FCC should coordinate in adding technical data to their data files to increase the usefulness of engineering analysis in spectrum management. The NTIA and FCC engineering staffs should meet to determine what information is needed for each service. Adding new technical data to the NTIA and FCC data files poses two problems. The lesser of these is modification of the files to accommodate the new data. A much greater problem is collecting the data from manufacturers and users.

NTIA and the FCC should work to obtain equipment data directly from manufacturers, as well as from users. Presently, federal government applicants for frequency assignments provide information to NTIA on their equipment and its intended use. Equipment characteristics, however, could be obtained more reliably and probably more easily from manufacturers than from users.^{505/} This would greatly reduce the burden on the user to act as a "middleman" with such data. Using data obtained from manufacturers would also provide consistency among assignments using similar equipment. Under such a system, manufacturers would be required to supply certain equipment data before NTIA or the FCC would authorize frequency assignments for its use. Applicants for the frequency assignments would then identify the equipment to be used and specify any exceptions (such as modifications or optional features) to its normal configuration. NTIA will explore ways of collecting necessary equipment data directly from the manufacturers without imposing undue burdens on them.

^{503/} PRSG Comments at 11. PRSG also claims that there is no feasible procedure for outside parties to submit corrections, and claims that during one six month period, it found that more than 80% of renewed licenses and 50% of new licenses had errors.

^{504/} BellSouth Comments at 7.

^{505/} Since the manufacturers generate the equipment data, regardless of who submits it to NTIA or the FCC, requiring the manufacturers to provide the necessary data directly would probably involve less burden than having them supply it to each frequency assignment applicant.

Users would have to provide any additional data on the use of the equipment, such as which modulation types correspond to which transmitter-receiver pairs. To avoid burdening spectrum users, spectrum managers could require this additional data when the users update their records -- that is, when the term of the frequency assignment expires. NTIA currently reviews frequency assignments every five years.^{506/} The FCC licenses also are for specific terms.^{507/} We recommend that NTIA and the FCC collect additional data as needed when frequency assignments are first granted or when they are renewed.

b. Data on Protected Receivers

While the use of most radio transmitters requires authorization from NTIA or the FCC, this does not generally apply to the use of receivers, principally because receivers generally produce only nominal emissions and therefore do not usually cause interference to other systems. Because NTIA and the FCC do not need to authorize receiver operation, receiver data is in many cases not stored in data files. Receiver data, however, can be important. For example, spectrum managers can only provide interference protection to a specific receiver if they know its location and characteristics.^{508/}

The NTIA and FCC data files already contain some receiver data. Records of frequencies assigned to transmitters contain fields for basic data on associated receivers as well as the transmitters. Susceptibility data, however, is not generally provided.

Other receivers, while needing protection from interference, do not appear in the data files at all. If many receivers are associated with a single transmitter, they may not be recorded in the appropriate transmitter record. This omission recently caused problems when a U.S. manufacturer chose to develop a wireless local area network for the 1700-1710 MHz band, which is allocated, in part, to the meteorological satellite service. NTIA did not initially object to this use of the band, believing that the few government earth station receivers listed in the GMF could be protected from interference. The revelation that a multitude of government and private sector earth station receivers were in use across the country eventually led NTIA to recommend against the use of the band.^{509/}

Radio astronomy receivers and other "passive" systems represent another class of receivers that, until recently, did not appear in frequency assignment records, since they are not associated with specific transmitters. These systems, however, require protection, particularly the radio astronomy receivers, which are extremely sensitive to interference. NSF, in its

^{506/} NTIA Manual, supra note 11, § 8.2.6. This procedure is discussed in greater detail infra, p. 152.

^{507/} See, e.g., 47 C.F.R. § 21.45 (1990).

^{508/} Spectrum managers can protect certain classes of receivers, such as television receivers, without knowing their specific locations. These receivers, though far too numerous to include in a database, are protected by spectrum standards imposed on potentially interfering transmitters. The standards are developed assuming that the receivers are scattered throughout each broadcast station's service area.

^{509/} Letter from Alfred C. Sikes, Assistant Secretary of Commerce for Communications and Information, to Dennis R. Patrick, Chairman, Federal Communications Commission (Mar. 11, 1988) (discussing spectrum support for radio local area networks).

response to the Notice, expressed its belief that information on passive systems is essential to the development of any national spectrum use database.^{510/}

Recently, IRAC's FAS developed procedures to record data on passive sensor stations and radio astronomy stations in the GMF.^{511/} Submission of the data, however, is voluntary. Further, the FCC does not currently have a procedure for submitting data on passive systems. We believe that NTIA and the FCC should coordinate their efforts in adding data on protected receivers to their data files. NTIA will start this process for federal users.

c. Structure

The current NTIA and FCC frequency assignment data files were developed before database management systems (DBMSs), which combine multiple data files in a database, were widely available. The frequency assignment data files were therefore designed for narrow applications and all the information pertaining to an assignment was stored in a single record. However, there are often logical relationships between data items that are difficult to represent in a single record.^{512/} DBMSs use more sophisticated data storage techniques that indicate relationships between data items.

Both "relational" and "object-oriented" DBMSs have advantages that could mitigate many of the current problems. Relational databases store data in multiple files or data sets. The data sets are related by key fields, which associate records in one data set with those in another. Object-oriented databases, based on a new technology, substitute "objects" for records and store the objects along with information regarding relationships between them.^{513/}

NTIA and the FCC should upgrade the structure of their data files, using modern DBMS methods. A relational frequency assignment database, for example, might consist of an administrative data file logically linked to transmitter, receiver, and antenna equipment characteristics files. The assignment file would have one record (usually) for each assignment and the equipment characteristics files would have one record for each unique piece of equipment. The assignment file would have a field in common with each of the equipment files where an equipment code would be stored. A computer program retrieving data on a frequency assignment would be automatically directed to the correct records in the equipment files by the equipment codes.

510/ NSF Comments at 6.

511/ IRAC Document 27011/1, Subject: Recording Passive Sensor Receiving and Radio Astronomy Stations in the GMF (Sept. 5, 1990).

512/ For example, while a GMF record allows only one transmitter, that transmitter may communicate with one receiver, or with several. The GMF addresses this problem by setting a maximum number of receivers for each transmitter and by using a variable length record to store data for however many receivers are used. If a transmitter sends a voice signal to one receiver and a data signal to another, the GMF record can accommodate both signal types and both receivers, but it cannot show which signal is sent to each receiver.

513/ T.M. Atwood, The Case for Object-Oriented Databases, IEEE Spectrum, Feb. 1991, at 44, 44-45.

This type of database structure has many advantages over the data file systems currently used by NTIA and the FCC. The use of equipment files, as described above, would provide consistent data for similar pieces of equipment, and would avoid the redundancy that occurs if equipment data is stored in each assignment record. If manufacturers, rather than users, were to provide equipment characteristics, as suggested above, equipment files would simplify this process. The user would simply specify the equipment to be used for a particular assignment. If an assignment used a modified version of the equipment, an additional record reflecting that modification would be stored in the equipment characteristics file.

Another benefit of such a system is flexibility. The current frequency assignment files store data on many different types of systems in records with the same format. However, different data may be needed for a satellite system than for a fixed service or mobile service system. For example, a single-frequency mobile system might have a single assignment for both the base-to-mobile and mobile-to-base links. But, in the current NTIA and FCC systems, the two transmitters cannot be indicated in the assignment records without ambiguity. With a multiple-file database, separate files, each with a distinct format, could be used for each major type of system. The files, of course, would all be tied back to the frequency assignment file by common fields.

Implementation of a new database structure would be a major undertaking, warranting careful planning. All parties involved with the databases should provide input for the design of the databases. Once a new format is implemented, data collection, storage, and retrieval processes would need to be updated. For those that use the data but are unable to immediately update their retrieval software, a capability for translating the data from the upgraded database format to current file formats could be maintained during a transitional period.

d. Recommendations

The common frequency assignment database proposed in Chapter 2 should support engineering as well as administrative functions. NTIA will consult with the FCC, the other federal agencies, non-federal users, private coordinating groups, and other interested parties to determine the requirements of the various potential users of the database. NTIA will also solicit input from these groups in designing the database to best meet these requirements. In particular:

- The database structure should facilitate automated retrieval of frequency assignment data, the addition, modification, or deletion of data fields, and the accommodation of assignments for diverse types of radiocommunication systems without ambiguities. To this end, state-of-the-art database management techniques, such as relational and object-oriented database technologies, should be considered for the common database.
- The common frequency assignment database should include sufficient data to perform most large-scale engineering analyses. Specifically, data for receivers and passive systems should be included. Decisions to include specific additional data should balance the potential benefit of having the data against any additional burden placed on those who would submit the data.
- NTIA will investigate the feasibility of obtaining equipment characteristics data directly from the manufacturers, in order to improve the reliability and consistency of the data and to reduce the burden on the applicants.

4. Monitoring to Verify Spectrum Use

The spectrum use data collected by NTIA and the FCC represents authorization to use a frequency, as opposed to the actual use of the frequency. If the assigned frequency is used essentially without interruption, frequency assignment data adequately describes spectrum use. However, when assignments are inactive^{514/} or used only intermittently, the data misrepresents actual spectrum use, since the assignments in most cases authorize continuous operation. When used in conjunction with frequency assignment data, monitoring^{515/} provides a means of determining the extent to which frequency assignments are actually being used.^{516/} Monitoring systems can detect signals from nearby transmitters and produce statistics on the use of individual channels.

NTIA currently operates a Radio Spectrum Measurement System (RSMS) that has several applications in addition to quantifying spectrum use:

A spectrum measurement program was established in October 1973 under which a van-mounted Radio Spectrum Measurement System . . . is used a) to determine whether radio installations operated by the Federal Government are utilizing authorized frequencies and are operating in accordance with applicable regulations, b) to provide information to help determine whether additional uses can be made in a particular band at a particular location, and c) to provide information to prevent or resolve cases of interference between two or more users.^{517/}

Although the RSMS van is capable of transporting a variety of equipment to the measurement site, the mobility of the van is limited and measurements can only be made at one location at a time. NTIA has recently expanded the RSMS using a portable "suitcase" monitoring system, which can more easily be transported to the monitoring site. Several suitcase systems can also be assembled at a relatively low cost. While a suitcase system is sufficient for many monitoring tasks, it is inadequate for specialized tasks requiring more sophisticated equipment.

The FCC has conducted several monitoring studies that categorized spectrum occupancy in the private sector land mobile bands. These studies looked at selected bands in major U.S. markets. Most recently, a report was prepared on occupancy levels of selected police and

^{514/} For purposes of this chapter, an "inactive" assignment is one for which the specified equipment has not performed its intended communication function within a specified, significant period of time.

^{515/} The term "monitoring" means the use of electronic equipment that indicates activity of specific channels. No attempt is made to determine the information being transmitted on the channels. Moreover, we recognize the importance of protecting the confidentiality of users, if it were necessary to retain proprietary data regarding channel activity of individual licensees.

^{516/} Monitoring is particularly valuable because, unlike frequency assignment data, it provides a "real world" picture of the actual emissions that can cause interference.

^{517/} NTIA Manual, *supra* note 11, § 8.2.6.

business channels in Tucson, Arizona, for the purpose of establishing occupancy factors for use with the SUM model.^{518/} Further refinements are underway this fiscal year.

The FCC has an inventory of receivers and micro-computers that can be used for collecting occupancy measurement data. The FCC also has prototype fixed remote receivers with automatic direction finders installed in Boston and Washington, and under construction in San Diego. These systems could be modified through software enhancements to collect occupancy data. The FCC additionally has a proposal under consideration for installing remote fixed receivers with computers in 120 major U.S. cities. These would be available continuously to collect occupancy data.

a. Identification of Lightly Used Frequencies

In areas where the demand for frequency assignments is particularly great, as in some large cities, ongoing spectrum occupancy measurements could provide a valuable tool for identifying available frequencies. Monitoring equipment can be configured to step quickly through all the channels in a frequency band, noting those that are in use in the vicinity of the monitoring station. Over a period of time, such a system can determine how heavily each channel is used, expressed as a fraction of time. In services for which separate frequencies are assigned to each user,^{519/} this would indicate the activity of each user, identifying inactive or lightly used assignments. In services in which frequencies are shared, this technique would identify lightly-used frequencies that could accommodate additional licensees, but would not identify specific inactive assignments.^{520/}

GTE supports the use of monitoring to identify frequencies that are lightly used, used only in a few geographic areas, or inactive so they can be used by others.^{521/} ARRL states that monitoring can provide useful data, noting a 1985 FCC study showing that roughly a third of all private land mobile licensees were not operating.^{522/}

Opponents of this use of monitoring question its value, noting that monitoring must be extensive to be realistic. Motorola states that:

Reliance on monitoring, for example, to assess spectrum occupancy has been raised several times over the years. It has a facile appeal: one monitors, hears nothing all or most of the time, and can then conclude the subject channel is not used or not used enough. Thus, more users can be assigned to that channel.

^{518/} FCC, Tucson Occupancy Study -- 200 Police and Business Channels, Federal Communications Commission, Field Operations Bureau, Sept. 28, 1990.

^{519/} For many users, including the federal agencies, public safety common carriers, and broadcasters, NTIA and the FCC assign different frequencies to each applicant in a particular geographic area. Most other private sector users must share channels in areas where demand is high.

^{520/} Unless, of course, no activity was found on a particular frequency, in which case all assignments on that frequency would be inactive.

^{521/} GTE Comments at 16.

^{522/} ARRL Comments at 25-26.

Unfortunately, reality negates that promise. Further analysis all too often reveals that there was occupancy but the monitoring program was not extensive enough to have heard the transmissions.^{523/}

LMCC agrees, asserting that, "[h]istorically, . . . monitoring programs have overwhelmingly failed as an allocation or licensing tool."^{524/}

To be accurate, then, monitoring must take place over an extended period and must consider factors that would prevent detection of some users, such as a large distance or the presence of an obstacle between the monitoring station and a particular base station.

NTIA believes that one practical method for identifying inactive and lightly-used assignments would be to set up several unattended monitoring stations in a congested area for a period of weeks or months. The use of several locations would reduce the probability of not detecting users. After the measurement period, the equipment would be moved to another congested area. This way, spectrum occupancy could be measured periodically in several congested areas. We intend to confer with the FCC to determine whether a joint monitoring program based on this, or some other approach would provide information on actual spectrum use whose value for spectrum management purposes would exceed the costs of operating the monitoring program.

b. Identification of Lightly Used Bands

Spectrum occupancy measurements can also be used to verify light use over an entire band, possibly indicating low demand. Such a band could be a candidate for reallocation, if the existing users can be readily moved to another band.

Objections to the use of monitoring for allocation decisions are similar to those described above. WATERCOM emphasizes the need to consider information on the user community's operating characteristics, describing an FCC proposal to redesignate certain VHF maritime commercial channels to non-commercial use. The proposal was based on FCC monitoring in a small sector of the Great Lakes, where non-commercial use predominated. The proposal would have adversely affected commercial users in areas where the frequencies were heavily used.^{525/}

Unlike ongoing monitoring to identify lightly used frequencies in congested bands, NTIA and the FCC would only employ this type of monitoring in response to specific requests for reallocation of a band.^{526/} Rather than conducting ongoing spectrum occupancy measurements for this purpose, NTIA will employ its Radio Spectrum Measurement System (RSMS), described below, on an ad hoc basis to verify that bands are lightly used when reallocation is requested.

^{523/} Motorola Comments at 12; see also DOD (Air Force) Comments at 12; LMCC Comments at 60.

^{524/} LMCC Comments at 60.

^{525/} WATERCOM Comments at 7.

^{526/} Absent a specific request, the effort required to quantify very low levels of activity would provide little benefit.

c. Identification of Heavily Used Bands

If spectrum managers are able to identify pending congestion in frequency bands, they may be able to avert severe shortages of spectrum by implementing adequately stringent spectrum standards or spectrum-conserving techniques. Ongoing spectrum occupancy monitoring could be used for this purpose. Spectrum managers could also use monitoring to verify congestion of frequency bands in which additional assignments are not available. They could then attempt to find additional spectrum to allocate to that service.

Information derived from frequency assignment records provides an initial indication of whether a frequency band is heavily used or is becoming so. However, since this information may not indicate actual spectrum use, NTIA believes that monitoring should also be used, to the extent possible, to verify such information. In that role, monitoring could also aid prudent policy decisions regarding, for example, the reallocation of frequency bands.

d. Recommendations

NTIA will maintain its Radio Spectrum Measurement System (RSMS), using van and suitcase measurement systems, to meet general measurement requirements, and to quantify spectrum use, on an ad hoc basis, to support allocation decisions. As funding permits, NTIA will develop low-cost transportable monitoring systems for periodic long-term (several weeks or more) unattended occupancy measurements in congested areas. NTIA will seek FCC cooperation in these monitoring efforts.

C. Determining Spectrum Efficiency

1. Automated Computer Models

NTIA has developed computer models for determining spectrum efficiency for fixed microwave systems based on the definitions of efficiency given above. The "spectrum conservation factor" model is based on the output-to-input definition: the "communications achieved" is the number of voice channels of a system while the "spectrum resources used" is the product of the receiver system bandwidth and the denial area.^{527/} The model has been used to compare antennas, modulation, signal processing, and RF filtering techniques.^{528/} An NTIA study recommends using this model for additional services and for developing spectrum standards in areas of spectrum congestion.^{529/}

Using the spectrum efficiency definition based on the ratio of the spectrum resources used by "ideal" and actual systems, NTIA has developed the Technical Spectrum Efficiency Factor (TSEF) model.^{530/} For the "ideal" system, the TSEF model employs a "reference

^{527/} Hinkle & Farrar, supra note 484, at A-1.

^{528/} Id. at 2-1 to 2-4.

^{529/} Id. at 2-4.

^{530/} Berry et al., TSEF, supra note 492, at 3-1.

system,"^{531/} defined as a "practical, state-of-the-art system that accomplishes the same mission as the evaluated system The reference system should be procurable and should use the minimum [spectrum resources]."^{532/} While acknowledging the difficulties in defining this reference system, NTIA has recommended that the TSEF model be used to evaluate alternate system designs in the system review process.^{533/}

2. Recommendations

While automated computer models for determining spectrum efficiency have potential applications in spectrum management, they have been developed only for very limited cases. NTIA will pursue development of these models, and will encourage the FCC to do so as well. Because of the inherent difficulties in defining an "ideal" system, efforts in this area should focus on models using the "output-to-input ratio" definition of spectrum efficiency.

III. Spectrum Conservation

Spectrum conservation involves the use of spectrum-efficient radiocommunication systems and efficient frequency assignment techniques. It can be compared to efficiently packing for an automobile trip. In this analogy, the trunk of the car is the spectrum resource space. The items to be taken on the trip are individual radio systems. The "suitcases" containing the items (one item to a suitcase) are the spectrum resources each system uses.^{534/} Packing the trunk is analogous to assigning frequencies to the radio systems.^{535/}

This section explores ways of improving system efficiency (analogous to fitting items in smaller suitcases), improving band efficiency (improving the arrangement of the suitcases in the trunk), and using alternatives to radio technologies (buying the items at the destination or shipping them separately).

A. Improving System Efficiency

1. Technologies that Improve Spectrum Efficiency

During the past several decades, a number of technical and engineering methods have emerged for more efficient use of spectrum resources. Some of the most important are trunking and cellular reuse methods for public land mobile radio, digital compression and coding, and spread spectrum.

^{531/} This "reference system" is not related to the "reference system" used in some computations of spectrum use.

^{532/} Berry et al., TSEF, *supra* note 492, at 3-2.

^{533/} *Id.* at 2-3.

^{534/} These resources are shown as the solids in Figures F-1 and F-2 of Appendix F.

^{535/} But see *infra* Appendix F, note 6.

a. Trunking

A conventional land mobile radio system consists of a base station and associated mobile units assigned to one or more channels or channel pairs.^{536/} Since the channel can only accommodate one conversation at a time, conversations can routinely be "blocked." If the system has more than one channel, a blocked user can switch to an unoccupied channel to communicate.

A trunked system supports a number of users on a group of channels, providing the spectrum efficiency benefits of channel sharing while minimizing blocking. When a user wishes to make a call, the system selects an available channel from the group and automatically tunes the user's transmitter to that channel. The user will not be blocked unless all the channels are in use. Trunking improves spectrum efficiency by providing more communications on a given number of channels.

b. Cellular Reuse

Cellular systems divide a normal land mobile service area into smaller "cells," each with a base station and an assigned set of frequencies. The frequencies are "reused" in non-adjacent cells.^{537/} Mobile units within a cell communicate by radio with that cell's base station, which uses wirelines or fixed microwave radio to relay the signal to a central switching office. Each cell operates as a trunked system, with the base station selecting the first available frequency for each call. Furthermore, since the cellular base stations cover smaller geographic areas than conventional base stations, they require less power and therefore deny the use of the channels over a smaller area. This decrease in the use of spectrum resources also increases spectrum efficiency.

Recently, the cellular reuse concept has been suggested for personal communication services (PCS), which include proposed cordless telephones and portable radios. Proposed PCS systems would use even smaller cells, or "microcells," enhancing the spectrum efficiency of the cellular concept, and digital modulation.^{538/}

c. Digital Compression and Coding

Transmission of communications signals using digital radio also promises improvements in spectrum efficiency. Since audio and video signals begin as analog signals, they must be converted to digital format prior to transmission to exploit this technology. Ironically, the bandwidth of the digital signal is greater than the analog version. The spectrum efficiency benefit of digital technology is derived from different factors, including compression techniques. Compression involves removing redundant information from the signal, allowing transmission at a much lower bit rate, and thus a smaller bandwidth, without a decrease in quality. For

^{536/} Many land mobile systems transmit and receive on the same frequency (simplex operation). Others use separate frequencies for the base station and the mobile units. In this trunking discussion, "channel" is used to describe either a channel or a channel pair.

^{537/} The cellular reuse concept is of particular interest in that it was developed in response to an FCC docket seeking to provide a spectrum-efficient mobile telephone system. See generally Future Use of 806-960 MHz, Docket No. 18262, supra note 168.

^{538/} See Personal Communications Services, supra note 7, at 1.

example, digital linear predictive coding may permit voice transmission with a bit rate as low as 2.4 kb/s, compared with conventional telephone toll quality voice of 64 kb/s.^{539/} The decreased bandwidth permits smaller channel spacing, allowing more users to operate in a given frequency band. The use of digital modulation for the second generation of cellular telephone, now under development, could eventually increase cellular communications capacity 3 to 20 times over the current analog cellular technology.^{540/}

Another digital technique, called forward error correction, permits correction of bit errors occurring during transmission. While requiring a somewhat larger bit rate, systems using forward error correction can tolerate a smaller signal level at the receiver, thus using less power and denying a smaller area to other systems. The overall effect is an increase in spectrum efficiency.

d. Spread Spectrum

Like digital modulation, spread spectrum techniques initially seem contrary to the goal of improving spectrum efficiency. Transmitters using spread spectrum techniques "spread" the signal over a bandwidth many times larger than the original signal bandwidth, using a predetermined repeating code. The receiver uses the same code to "despread" the signal back into its original form.^{541/} One technique, known as direct sequence spread spectrum, expands the signal's frequency spectrum over a wider bandwidth. Interference from a direct sequence system to a narrowband receiver will appear similar to random electrical noise. Frequency hopping, the other primary spread spectrum technique, alternates frequencies over the spread bandwidth in a seemingly random manner. Interference from a hopped system, although of the same power as a conventional system, is so brief that it does not adversely affect many types of systems.^{542/}

Until recently, the military agencies were the primary users of spread spectrum systems, exploiting their anti-jamming capabilities. Commercial interest in the interference-suppression benefits of spread spectrum, however, has been increasing as the systems, once extremely expensive, have become more affordable and usable spectrum has become more scarce. Potential commercial applications include personal communications, cellular telephones, wireless alarm systems, local area networks, and paging systems.^{543/} Millicom Inc. and SCS Telecom

^{539/} N.S. Jayant, High Quality Coding of Telephone Speech and Wideband Audio Services, IEEE Communications Magazine, Jan. 1990, at 10.

^{540/} See, A.G. Sleky, What's Ahead Worldwide for Digital Cellular, Mobile Radio Technology, May 1990, at 28; Hughes Network Systems Jumps into the Cellular Arena with GM Backing, Telecommunications, Feb. 1991, at 15, 16.

^{541/} D.L. Schilling, R.L. Pickholtz & L.B. Milstein, Spread Spectrum Goes Commercial, IEEE Spectrum, Aug. 1990, at 40, 40.

^{542/} Many voice communication systems, for example, tolerate intermittent interference well. For other types of systems, however, the effects are more significant. For example, frequency hopped systems can cause recurring black lines on a television picture, substantially degrading the quality of service. Id. at 41.

^{543/} Id. at 44.

Inc. are testing the ability of spread spectrum PCS networks to coexist in the same frequency band with conventional microwave.^{544/}

While "overlaying" spread spectrum systems on frequency bands^{545/} could improve spectrum efficiency (as with the Part 15 devices described in Appendix C), the possibility of interference increases with an increasing number of spread spectrum systems. The proliferation of direct sequence systems may substantially raise the "noise" floor, degrading the operation of all narrowband systems. If the number of frequency hopping systems increases dramatically, the occurrences of interference, though brief, may become so frequent as to degrade operation.

2. Roles of Industry and Government

Although the development of spectrum-efficient technology has primarily been the role of industry, both NTIA and the FCC have responsibilities that affect this area. One of NTIA's responsibilities, discharged by its ITS laboratory, is to "perform research . . . on methods for the more efficient use of the electromagnetic spectrum for telecommunications purposes."^{546/} The FCC's Office of Engineering and Technology (OET) is charged with "conduct[ing] scientific and technical studies in advanced phases of terrestrial and space communications, and special projects to obtain theoretical and experimental data on new or improved techniques."^{547/} Both ITS and OET have been involved in the evaluation of new technologies for their spectrum conservation potential, making the results of their studies available to the public in published reports.^{548/} As practicable, NTIA and the FCC should pursue these activities vigorously, not to champion or promote any particular technology, but to promote further development by industry of a wide variety of spectrum-efficient radio technologies.

In addition, NTIA believes that private firms should receive recognition for research and development in spectrum-conserving technologies. NTIA thus proposes to directly recognize innovation in this area. NTIA, in conjunction with one or more industry groups, will seek to establish an annual award for an innovative technology or system that promises to significantly improve spectrum efficiency.

As we discuss throughout this study, however, economic incentives provide the surest means of increasing efficiency. NTIA believes that the primary factor that will spur development of spectrum-conserving technologies and systems will be the existence of a

^{544/} Id.

^{545/} Thus far, all spread spectrum systems have shared frequency bands with conventional systems.

^{546/} NTIA Manual, supra note 11, § 1.1 (quoting from Department of Commerce Organization Order 10-10 § 6.15 (May 9, 1978)).

^{547/} 47 C.F.R. § 0.31(c) (1990).

^{548/} See, e.g., L.A. Berry & E.J. Haakinson, Spectrum Efficiency for Multiple Independent Spread-Spectrum Land Mobile Radio Systems, NTIA Report 78-11, U.S. Department of Commerce, National Telecommunications and Information Administration, Nov. 1978; D.H. Cronin & L.A. Berry, The Effect of Bandwidth and Interference Rejection on the Spectrum Efficiency of Land Mobile Radio Systems, NTIA Report 83-139, U.S. Department of Commerce, National Telecommunications and Information Administration, Dec. 1983.

substantial market for such systems. Thus, a spectrum management system that, through regulations and the application of market-based principles, provides incentives for spectrum conservation would be the most effective way of promoting the development of spectrum-efficient systems.

3. Implementation

This section has documented the usefulness of spectrum-efficient technologies in averting congestion in the radio spectrum. Later in this section we will discuss alternatives to radio technology. Both of these approaches improve spectrum efficiency by decreasing the spectrum resources needed to satisfy a communications requirement.

Unfortunately, since users obtain authorization to use spectrum for a minimal cost, and generally cannot use their frequency assignments for multiple purposes, they often have little or no incentive to decrease their use of spectrum resources.^{549/} In many cases, it may be necessary to apply regulatory or economic measures to persuade users to adopt spectrum-efficient or non-radio technologies.

a. Regulatory Measures

NTIA and the FCC are empowered to authorize the use of the radio spectrum and to set conditions for its use. They can enforce compliance with spectrum standards and other regulations as preconditions for receiving authorization. Both NTIA and the FCC have established spectrum standards constraining the emissions of transmitters and, in some cases, the characteristics of receivers.^{550/} These standards are designed to prevent the use of equipment that is very spectrum inefficient (e.g., by virtue of spurious emissions).

NTIA also has a general policy on the use of spectrum-conserving systems:

The Federal Government, in its role of leadership in the application of advanced technology, shall foster the application of spectrum-conserving methods for radio communication systems used by the Federal Government. Spectrum-conserving systems are new or existing systems . . . that result in efficient use of frequency, space and time. Efficient use is a mission-oriented factor that combines the requirements of the mission with available techniques to provide the most effective solution. Federal agencies are encouraged to use spectrum-

^{549/} In situations where spectrum is plentiful and assignments are easily obtained, the user -- whether private sector or government -- has little, if any, incentive to conserve spectrum. Indeed, the spectrum manager has no reason not to allow low-cost spectrum-inefficient systems if long-term growth can be accommodated. (Of course, if other bands are congested in the area, reallocation of the little-used band may be a possibility.) Even in congested bands, individuals' use of spectrum-efficient systems may not necessarily free up spectrum for their own use, as opposed to use by others, possibly competitors. If, however, users with additional communications requirements can increase the communications achieved on their assignments by using spectrum-efficient technology, they have an incentive to do so. For example, digital cellular telephone system operators of the future would have an incentive to employ spectrum-conserving compression techniques if the opportunity cost of potential customers not accommodated exceeded the cost of the technology that would accommodate them.

^{550/} See supra Chapter 3, p. 69 for a discussion of these standards.

conserving technologies and methods where they will satisfy agency operational requirements and will enhance service, economy of operation, and the more efficient and effective user of the radio spectrum. However, where spectrum is readily available . . . or where mission requirements mandate, security, economics, or some . . . performance criterion may be the determining factor in system selection.^{551/}

Although the relative spectrum efficiency of comparable systems can be determined objectively, this policy essentially equates spectrum efficiency with effectiveness. It also provides broad exceptions, even when spectrum is in great demand.

Numerous commenters favor requiring the government agencies to use spectrum-efficient technologies. For example, MST "urges NTIA to require or encourage more efficient spectrum usage by the Federal Government -- for example, by adopting policies that would require federal users to use, where possible, more efficient narrowband analog or digital transmissions systems in conjunction with spectrum savings techniques such as trunking."^{552/} MST suggests "periodic auditing by the General Accounting Office of effective spectrum management and common FCC/NTIA spectrum monitoring [as] other techniques for improving the efficiency of federal spectrum use."^{553/}

NYNEX favors requiring the private sector to use spectrum-efficient technologies as well, particularly to "accommodate growing consumer demand for mobile communications."^{554/} NYNEX suggests that "when a license comes up for renewal, the FCC should inquire into whether newer equipment or technology exists, [and,] when appropriate, condition the renewal on deployment of new technology."^{555/}

b. Economic Measures

Chapter 4 describes how competitive bidding for the use of spectrum resources could be used to improve spectrum efficiency. It also describes how spectrum fees, if set correctly, could provide users an economic incentive to share channels or to use spectrum-efficient or non-radio technologies. Such a policy would also have the effect of increasing the demand for spectrum-efficient systems, thus encouraging the development of such systems by industry.^{556/}

^{551/} NTIA Manual, supra note 11, § 2.3.10.

^{552/} MST Comments at 4.

^{553/} Id. at 5.

^{554/} NYNEX Comments at 31.

^{555/} Id.

^{556/} As discussed in more detail supra in Chapter 4, by providing millions of licensees with incentives to use their spectrum efficiently, economic measures could potentially provide a much more powerful and effective means of achieving spectrum efficiency than regulatory measures that seek to impose spectrum-conserving behavior on licensees despite their economic incentives to behave otherwise.

4. Recommendations

NTIA and the FCC have responsibilities to pursue research on spectrum-related communications and the development of spectrum-efficient technologies. As practicable, NTIA and the FCC should pursue these activities vigorously, not to champion or promote any particular technology, but to promote further development by industry of a wide variety of spectrum-efficient radio technologies. To directly recognize private sector innovation in this area, NTIA, in conjunction with one or more industry groups, will seek to establish an annual award for an innovative technology or system that promises to significantly improve spectrum efficiency.

Spectrum managers should consider whether cost-effective, spectrum efficient technologies are available to relieve congestion problems before they allocate spectrum for a particular service or group of services. Typical approaches that can be used to increase spectrum efficiencies include trunking, cellular reuse, digital compression and coding, and spread spectrum techniques.

B. Improving Band Efficiency

The concept of spectrum efficiency can be extended to a frequency band, reflecting both the spectrum efficiency of the systems in that band and the efficiency with which systems are "packed" in the band. In this case, the "communications achieved" applies to the aggregate of systems, and the "spectrum resources used" are the total spectrum resources in the band, less any part of the band set aside for future growth. The spectrum efficiency of a frequency band is improved by increasing the communications achieved in the band, or by using spectrum-efficient systems and packing techniques to free up spectrum for later use.

The "packing techniques" amount to judicious selection of spectrum resources for each system. Currently, in designing radiocommunication systems for many applications, prospective users determine the frequency band, location, and most other parameters of their systems according to their needs.^{557/} Users also generally select the actual frequencies for their systems, often without regard for the effect of such selections on overall spectrum efficiency.

In order to improve spectrum efficiency in a frequency band, spectrum managers should exercise more fully their authority to select initially the frequencies for assignments, even if those assignments permit subsequent technical or user flexibility. Federal agencies applying to NTIA for frequency assignments specify the frequencies for their telecommunication systems. These applications are routinely approved if the other agencies give their approval through the FAS. FCC procedures vary for different services, but in general, applicants or private frequency coordinators choose frequencies for the systems. To promote spectrum efficiency, NTIA and the FCC should change their procedures to work more closely with applicants to optimally select frequencies. This more active role probably would be more costly and more controversial than the current system. NTIA and the FCC could be subject to increased complaints, and even legal action, if their selections result in increased levels of interference. Therefore, NTIA and the FCC should only take on this responsibility if they possess proven techniques for frequency selection to maximize spectrum efficiency.

^{557/} For example, a prospective land mobile service user will begin with a required coverage area, a base station location, and one or more frequency bands in which suitable equipment can operate. A prospective fixed service user will be constrained by available equipment and antenna locations.

Actually, frequency assignment techniques do not usually reduce the total spectrum resources used by the systems in a frequency band. That quantity is the sum of the spectrum resources used by each of the systems, except where the systems overlap. The benefit of careful frequency assignment is that the spaces remaining after the systems are assigned will be large enough to accommodate additional systems.

While both NTIA and the FCC defer to the users in the selection of frequencies, both have policies concerning the best frequency to assign to a system, although the policies are very different. NTIA's policy is based on reserving spectrum resources for future requirements:

In order to have available the greatest possible spectrum support for future radiocommunication requirements, each new frequency assignment should be made in such a way that the increase in the total spectrum space committed is as small as possible. Accordingly, it shall be the normal practice, where feasible and consistent with frequency allocation and assignment plans, to assign the most heavily occupied frequency channel before resorting to those less heavily occupied.^{558/}

Studies have shown the benefits of orderly packing of the spectrum space. Specifically, when a system is assigned the lowest interference-free frequency available in the band, more systems can be accommodated over the long run than if frequencies are assigned to minimize interference.^{559/} This "lowest frequency" technique is analogous to packing containers tightly together beginning at one side of the trunk, rather than putting each new container as far from the previously packed containers as possible.

In contrast, the FCC's general policy is to assign frequencies in such a way as to minimize interference.^{560/} This implies that a new assignment should be separated from existing assignments in the spectrum space as much as possible. While this policy, indeed, tends to minimize interference in the short term, we are convinced that a policy incorporating spectrum-efficient packing or retunable systems would accommodate more users without interference in the long run.

1. Group Assignment

Just as the packing process is simplified if large containers are packed first, improvements can be made over the "lowest frequency" assignment technique if the "most incompatible" systems can be assigned first.^{561/} This requires some a priori knowledge of the systems to be assigned. In bands for which NTIA and the FCC regularly receive frequency assignment

^{558/} NTIA Manual, supra note 11, § 8.2.16.

^{559/} L.A. Berry, The Potential Contribution of Optimum Frequency Assignment to Efficient Use of the Spectrum, presented at the IEEE 1990 International Symposium on Electromagnetic Compatibility, Washington, DC, Aug. 21-23, 1990, at 409, 411 (Berry, Assignment).

^{560/} See, e.g., 47 C.F.R. §§ 21.100, 22.100, 23.20, 25.203, 87.41, 90.173 (1990).

^{561/} Berry, Assignment, supra note 559, at 411.

applications, this technique can be applied if the applications can be held until a suitable number can be assigned as a group.^{562/}

2. Repacking

Repacking involves reassigning spectrum resources (in most cases frequencies) to the systems in a frequency band to obtain a more spectrum-efficient arrangement. If spectrum managers can reassign frequencies to most or all systems in a band, they can correct spectrum-inefficient frequency assignments or respond to a new channeling plan. Repacking can also assist in accommodating new technologies by opening sufficient contiguous spectrum in a frequency band for reallocation.

The success of repacking depends upon having systems that can be retuned. Retuning can take several forms, ranging from turning a knob to replacing a crystal "in the field" to modifying the equipment more drastically "in the shop." If systems in a frequency band can be retuned at a nominal cost, then repacking is probably feasible for that band.

NTIA's spectrum standards include tunability standards for certain types of radars and fixed and mobile service systems.^{563/} Most fixed and mobile service equipment manufactured today is capable of tuning over an entire frequency band, since this capability usually is not difficult to achieve and manufacturers apparently gain from being able to sell the same equipment to all users in a band. Nonetheless, NTIA standards, when they are provided for certain types of fixed and mobile service systems, require only that a system be capable of operation on certain frequencies "within its tuning range."^{564/}

Carrying this concept further, future telecommunication system designs could include a capability for dynamic modification of operating parameters to minimize spectrum use. PRSG, in its response to the Notice, describes currently available microprocessor-controlled radios capable not only of tuning across the band, but also of adjusting their operating parameters to use only the spectrum resources necessary as communications requirements change.^{565/} These systems hold promise not only for repacking bands, but also for future automated spectrum management systems that would dynamically swap spectrum resources among systems in a

^{562/} Id.

^{563/} For radars operating under Radar Spectrum Engineering Criteria (RSEC) A and B, NTIA requires that:

Each radar shall be tunable in an essentially continuous manner either over the allocated bands for which it is designed to operate, or over a band which is 10% of the midband frequency. Crystal controlled radars conform to this requirement if operation at essentially any frequency across the band can be achieved with a crystal change.

NTIA Manual, supra note 11, §§ 5.3.1, 5.3.2. Radars operating in the 2700-2900 MHz band under Criteria D must be tunable over the entire band. Id. § 5.3.3. See also id. § 5.4.1, 5.5.1 for the fixed and mobile services.

^{564/} Id. § 5.4.1, 5.5.1.

^{565/} PRSG Comments at 2, 4-5.

particular location, assigning resources to systems only as long as they are needed. NTIA and the FCC should investigate the possibility of exploiting such systems.

3. Recommendations

To promote band efficiency, NTIA will investigate the feasibility of working more closely with applicants to select frequencies. NTIA and the FCC should periodically review frequency bands for possible repacking (reassignment of frequencies to users). To facilitate repacking, NTIA and the FCC should also require the use of radio equipment capable of being retuned over the entire allocated band.^{566/} NTIA and the FCC should also investigate the potential for increased sharing of spectrum resources using microprocessor-controlled radiocommunication equipment.

C. Eliminating or Combining Frequency Assignments

Thus far we have discussed two ways to improve spectrum efficiency: improving the efficiency of radiocommunication systems and packing them more efficiently into frequency bands. In the car packing analogy, they were compared, respectively, to fitting items into smaller suitcases and arranging the suitcases properly in the trunk. But if the trunk is nearly full, we may question whether certain items might be left at home or shipped separately. This subsection describes several cases in which inactive frequency assignments could be eliminated and intermittently used assignments could be combined to accommodate additional users in the existing spectrum.

Since users now obtain authorizations to use spectrum at a relatively low cost, and frequently can renew these authorizations at virtually no cost, they sometimes have an incentive to retain "inactive"^{567/} assignments. A business might "warehouse" spectrum for a number of reasons. For example, it might anticipate a need for additional spectrum at a future time when additional assignments might be harder to obtain. A business might also engage in a "warehousing" strategy in order to limit its competition, or to reap speculative profits in transferring its spectrum. ARRL describes other cases when a licensee might engage in "paper loading": when a station holds licenses in several bands but prefers not to use some of them, or when a licensee is no longer in business or is no longer using its radio equipment.^{568/}

An intermittently used assignment, as opposed to an "inactive" one, is in use for only a small fraction of the total time it is available. The land mobile service is probably the most familiar example of intermittent use of assignments. Even a relatively heavily used channel in that service might be used less than ten percent of the time. In addition, assignments are often used only during a specific period of the day or week, such as on weekdays during business hours.

^{566/} Conversely, it is desirable that systems not be so easily retunable that novice users could inadvertently operate on frequencies for which they do not have authorization.

^{567/} See supra note 514.

^{568/} ARRL Comments at 24-25.

Inactive and intermittently used assignments that have exclusive authorizations for their channels^{569/} deny spectrum resources continuously. Yet the "communications achieved" often remains low.^{570/} In congested locations, potential users could be unable to get assignments while others have inactive or little-used assignments. NTIA and the FCC could promote spectrum efficiency by providing incentives for users to relinquish inactive assignments and share little-used assignments, or regulations that require these actions, along with a means of identifying inactive and intermittently used assignments.^{571/}

1. Inactive Assignments

Both NTIA and the FCC have policies requiring users to surrender inactive frequency assignments. NTIA requires agencies to review their assignments at least every five years to determine "a) whether the assignment is essential to meet the agency's requirements; b) if so, whether other existing assignments will meet the requirements"^{572/} If an assignment is not qualified for retention under these criteria, the agency must submit an action to have it deleted.^{573/} FCC rules require licensees who no longer use their frequencies to return their licenses for cancellation.^{574/} In the PLMRS and the private operational-fixed microwave service, these rules specifically apply to stations that have not operated for one year or more.^{575/}

While these rules promote spectrum efficiency, their effectiveness is substantially mitigated, first, because they are not aggressively enforced, and, second, because compliance requires only a subjective assessment of need (in the case of the federal agencies) or token annual operation (in the case of the private radio services). While not a perfect solution, one possible approach to improving user responsiveness in this area would be a requirement for

^{569/} See supra note 519.

^{570/} Some have implied that exclusive use of a channel by a public safety service represents efficient use, even if the channel is rarely used, since a quiet emergency channel informs the listeners that there are no emergencies. Motorola Comments at 13; see also DOD (Air Force) Comments at 11; DOD (Navy) Comments at 3. While the exclusive use of a radio channel may be an efficient way of guaranteeing communications in an emergency, it is not spectrum efficient on an overall basis, because, at best, very little information is conveyed on a quiet channel. There may be more spectrum-efficient ways to communicate both the lack of an emergency during quiet periods and necessary information during actual emergencies. Alternatives such as multiple access systems that guarantee priority access for the emergency users are among the options that should be explored.

^{571/} See supra p. 138 for a discussion of monitoring.

^{572/} NTIA Manual, supra note 11, Annex F.

^{573/} Id.

^{574/} See 47 C.F.R. §§ 21.303(b), 22.303, 23.49 (1990) for common carriers, which require FCC approval to discontinue service. See also 47 CFR § § 73.1750, 80.31, 87.35, 90.157, 94.53 (1990), respectively, for the broadcast radio services, the safety and special radio services, the aviation services, the private land mobile radio services, and the private operational-fixed microwave service.

^{575/} See 47 CFR §§ 90.157(c), 94.53 (1990).

periodic self-certification by holders of frequency assignments that the frequencies involved are in fact being actively used. In such a process, a high-ranking official or other suitable principal representing the user would certify in writing that the user has complied with all regulations requiring the surrender of unused frequency assignments.

2. Intermittently Used Assignments

As described above,^{576/} policies on sharing frequency assignments vary for different services. While some intermittent users share channels in congested areas, using techniques such as coded squelch to distinguish between desired and undesired signals, others, such as public service users and federal agencies, have exclusive use of a frequency to guarantee its availability.^{577/}

For services in which sharing of frequencies is possible, lightly-used frequencies must be identified to guide the assignment of licenses to new users. User-supplied data would probably be less beneficial for this purpose than for identifying inactive assignments, since many users cannot quantify precisely how much they use their assignments.^{578/} However, monitoring can be valuable for this purpose, as described earlier.^{579/} For this reason, the FCC should monitor spectrum occupancy in congested bands allocated to services in which frequency sharing is possible.

Even when the availability of a frequency must be guaranteed, users are often able to share frequencies if they use them during different periods of the day or week. Users can generally predict accurately the times of day (e.g., during business hours) and the days of the week that their assignments are needed. If two users are compatible in this sense, they can be assigned the same frequency without conflict. This information is currently collected from the federal agencies and is used to coordinate frequency assignments.^{580/} We believe the FCC should determine whether collection of similar data from its licensees could result in increased sharing.

^{576/} See supra note 519.

^{577/} See supra note 570 and infra p. 154 for a discussion of shared systems.

^{578/} Lacking a trunked system, which would monitor channel activity automatically, even the most conscientious land mobile users would have a difficult time determining the fraction of time the system is actually transmitting on the channel.

^{579/} See supra p. 139 for a discussion of monitoring for identifying lightly used frequencies.

^{580/} The GMF contains a "Time" field indicating the period of time during which the assignment is normally needed. This field indicates whether the assignment is required regularly or occasionally, and whether the assignment is required during the normal workweek or for additional periods of the week. NTIA Manual, supra note 11, § 9.8.2 para. 19. The agencies (and NTIA on behalf of certain small federal organizations) use this data for frequency selection.

3. Recommendations

NTIA will work with the IRAC to develop procedures for high-level certification of the need for frequency assignments by the federal agencies. The FCC should also examine the feasibility of similar self-certification procedures for the private sector.

The FCC should monitor spectrum occupancy in congested bands for use in assigning frequencies in services for which users can share frequencies. The FCC should also investigate whether collection of data from its licensees on daily and weekly use of assignments could result in increased sharing.

D. Alternatives to Frequency Assignments

1. Shared Systems

The use of shared systems offers spectrum efficiency benefits similar to those of sharing frequencies: their use increases the communications achieved using a frequency assignment. Instead of using a dedicated system, a user can employ a shared system, increasing the occupancy of that system.

a. Federal Use of Private Sector Telecommunication Services

Federal regulations limit the establishment of communication systems by the federal agencies:

In order to emphasize the Government's proper role as a user, any proposal designed to provide needed telecommunication service, which requires the Government to perform [the design, engineering, system management or operation, maintenance, or logistical support] shall be adopted only if commercial service is: a) not available to the user during the time needed; b) not adequate from either a technical or operational standpoint; or c) significantly more costly.

...

The Government shall establish separate communication satellite systems only when they are required to meet unique governmental needs, or are otherwise required in the national interest.^{581/}

These regulations are enforced as part of NTIA's system review process, but compliance is based on agency assertion that the requirements are met. To improve the responsiveness of the federal agencies to these requirements, NTIA will seek to require high-level certification of the need for a separate system as part of the system review.

b. Private Sector Use

Shared systems also have spectrum efficiency benefits over separate systems for the private sector. Economic incentives described in Chapter 4 could encourage private sector use of such systems.

^{581/} NTIA Manual, *supra* note 11, § 2.3.3.

c. Recommendations

To improve federal agency responsiveness to the regulations regarding separate government radiocommunication systems, NTIA will seek to require high-level certification of the need for a separate system when the system is submitted for review.

2. Non-Radio Alternatives

For many communication systems, wire^{582/} provides an attractive alternative to spectrum-intensive media, both for the user and for the spectrum manager. For the user, these media, particularly optical fiber, promise greater capacity than radio. For the spectrum manager, alternative media can potentially eliminate some of the congestion in the spectrum.

a. Increased Capacity

Some modern digital telecommunications services, particularly data and video, require extremely high information transmission capacities. TABLE 1 shows how digital voice, data, audio, and video services span from the kilobit range through the megabit range and even approaching the gigabit range.

TABLE 12
Data Rate Demands for Various Services^{583/}

Telecommunication Service	Approximate Data Rate Requirement
Voice	3 kb/s - 100 kb/s
Voiceband Data	300 b/s - 30 kb/s
CD Audio	1 Mb/s - 3 Mb/s
High Speed Data	40 kb/s - 200 Mb/s
Teleconference Video	60 kb/s - 80 Mb/s
Entertainment Video	30 Mb/s - 600 Mb/s

The radio spectrum is not able to accommodate the telecommunication requirements at the upper end of this range because of the enormous bandwidth required.^{584/} In contrast, optical

^{582/} In this discussion, "wire" denotes any electromagnetic medium for which radiation is essentially contained, including wire pairs, coaxial cable, waveguides, and optical fiber.

^{583/} E. Nussbaum, Public Broadband Networks in an Information Society, ITU Telecommunications Journal, Apr. 1990 at 233, 234.

^{584/} In an attempt to cope with increasing transmission speeds, digital microwave radio relay systems are using advanced techniques such as tighter filtering and higher level digital modulations (64 QAM and above). Even so, these systems can accommodate digital traffic only into the megabit range. Systems using higher level digital modulation are also more susceptible to interference.

fiber has sufficient bandwidth to carry such traffic. In its response to the Notice, NYNEX observed that "the development of fiber optic technology has progressed to the point where bandwidth restrictions of the 'wire' network have essentially been eliminated."^{585/}

b. Increased Spectrum Efficiency

The use of alternative media improves spectrum efficiency by providing the desired communications while reducing the use of spectrum resources to zero, resulting in "infinite" spectrum efficiency. If radiocommunication users switch to wire and relinquish their assignments, the frequencies can be reassigned to others or even reallocated for other uses.

Some telecommunication requirements cannot be met except through radio systems. Others, specifically communications between fixed points, can use either radio or wire technologies. Numerous commenters suggested that the fixed^{586/} and broadcasting^{587/} services could be accommodated on wire media to free up spectrum for other uses.

Switching to wire media is not without difficulties; a major consideration is the expense. Other problems include the difficulty of running wire in remote or mountainous areas, and the vulnerability of wires and fibers to breakage from natural disasters or accidents. Moreover, requiring the use of alternative media may not be justified in areas where the spectrum is not congested. Some services, like broadcasting, use spectrum in place of other media to serve large audiences not constrained by wire.^{588/} Also, there may be important public policy considerations that argue for maintaining particular spectrum-based delivery systems. For example, the availability of free, over-the-air television is an important public policy that supports the dedication of spectrum resources to broadcast television.^{589/} As another example, the development of private fiber networks can sometimes be limited by state regulation.^{590/}

^{585/} NYNEX Comments at 45. NYNEX also describes why fiber is less expensive than radio for most long haul terrestrial transmission.

^{586/} See, e.g., APCO Comments at 12; GTE Comments at 8; MST Comments at 24; DOD (Navy) Comments at 3.

^{587/} See, e.g., APCO Comments at 12; LMCC Comments at 52; NYNEX Comments at 45.

^{588/} A significant portion of the American public's use of radio broadcasting services is mobile (e.g., in automobiles), while there is a smaller but growing use of television broadcasting on a mobile basis as well. Obviously, wire-based technologies cannot serve these broadcasting users.

^{589/} The availability of broadcast television is important both in its own right and for the competitive checks it imposes on the wire-based video delivery systems, such as cable television systems. The latter are often granted exclusive franchises in their operating areas and currently face extremely limited competition other than broadcasting in the delivery of television services to their communities. See NTIA Comments (filed Apr. 6, 1990; Feb. 14, 1991) in Reexamination of the Effective Competition Standard for the Regulation of Cable Television Basic Services Rates, MM Docket No. 90-4.

^{590/} See, e.g., Norlight, 2 FCC Rcd 132 (1987), recon. denied, 2 FCC Rcd 5167 (1987), dismissed sub nom., Public Service Commission of Wisconsin v. FCC, No. 87-1618 (D.C. Cir. Feb. 15, 1989).

NTIA favors the use of regulatory and economic incentives to encourage radio-communication users to switch to wire media in congested areas, when consistent with other public policies. In certain cases, the denial of frequency assignments may be appropriate when the use of alternative technologies is feasible.

Even if the users have an incentive to switch to alternative media, they need an additional incentive to relinquish their frequencies, making them available for reassignment. A weakness of the current spectrum management system is that there are few incentives for license holders to relinquish the spectrum they have been assigned if they choose to replace radiocommunication systems with alternative media such as fiber optics.^{591/}

c. Recommendations

NTIA and the FCC should develop policies on the use of non-radio technologies as part of a coordinated program to foster spectrum efficiency, when consistent with other public policies. NTIA and the FCC should also develop additional regulatory or economic incentives for the use of alternative technologies in congested areas.^{592/} In particular, while fixed microwave continues to be an invaluable service for some applications, NTIA and the FCC should examine whether some fixed service spectrum could be reallocated in light of fiber optic deployment.

^{591/} See supra, p. 146.

^{592/} The proposals discussed supra in Chapters 3 and 4 for greater regulatory flexibility and increased reliance on market mechanisms in the spectrum management process would help create such incentives.

CHAPTER 6 PLANNING AND FORECASTING

I. Introduction

Spectrum management planning can be defined as the establishment of strategic spectrum management goals and the steps necessary to achieve those goals. Such planning facilitates decisionmaking, by creating the basis for consideration and evaluation of courses of action. Thus, it provides the framework within which spectrum management is performed and the capabilities of spectrum management are developed. The purpose of U.S. spectrum management has been to satisfy the constantly evolving radio spectrum needs of the American people. Spectrum management planning attempts to provide spectrum for those changing needs.

Historically, the methods of management have been adequate to provide spectrum for those requesting access for new or expanding uses. The process has not always been easy or rapid, and advocates of particular uses have not always obtained the quantity or type of spectrum they were seeking. Nevertheless, some accommodation of the spectrum needs of the various competing services has generally been achievable. In light of this track record for spectrum management, it can be argued that the planning framework has also been adequate. However, the adequacy of the management process is not necessarily due to the capabilities built into the management structures or the spectrum plan, but may be the result of the past abundance of spectrum and technological advancements. These conditions are changing since, due to the properties of radio propagation at higher frequencies, many new requirements cannot be accommodated in higher frequency bands.

While spectrum management capabilities have improved, spectrum demand is growing so rapidly that there are grounds for concern. Demand for frequencies is now reaching the point where, according to some users, there is a "virtual exhaustion of usable spectrum".^{593/} In many cases, spectrum managers are using increasingly complex engineering solutions to allow adjacent or overlapping use of frequencies and locations, placing increased burdens on the spectrum management structure and staff.

In comments on the Notice, several organizations predict serious spectrum shortfalls for mobile technologies in the near future.^{594/} Others say that they have experienced a difficulty obtaining frequencies for advanced cordless telephone,^{595/} public radio and television,^{596/} radio

^{593/} IMM Comments at 4.

^{594/} See e.g., AMI Comments at 27; LMCC Comments at iii; Motorola Comments at 22-24. On the other hand, the PRSG comments that this shortage was more a perception than a reality, and that the lack resulted from resistance to use more efficient digital technology. PRSG Comments at 2.

^{595/} GPT/Stromberg Comments at 3.

astronomy,^{597/} federal law enforcement,^{598/} and satellite sound broadcasting.^{599/} Though commenters do not conclusively demonstrate that the planning system has failed in these cases, any review of the recent growth of communications use, as compared to the relatively minor changes in the management process and regulatory resources, raises concern as to the adequacy of the system.

Greater reliance on market forces to apportion spectrum resources and increased flexibility in management approaches hold potential for relieving some of the planning burden. Incorporating market principles into the management process, for instance, could reduce the need for continual government determinations of how much spectrum should go to the various types of radiocommunications and which proposed users should be granted the often extremely valuable rights to use the spectrum. Increased efficiency brought about by market incentives could lessen the need for spectrum managers to alter allocations or perform detailed engineering-analyses based frequency selection. Greater flexibility in the allocation, assignment, and use of frequencies may help spectrum managers by making the management processes more adaptable to evolving spectrum needs.

Notwithstanding the potential benefits of market approaches and flexibility, under most, if not all, systems of management, NTIA and the FCC will continue to allocate scarce spectrum resources, and their ability to plan and provide long-range guidance needs to be reviewed. Advance identification of spectrum conflicts could help ensure cost-effective solutions while continuing to encourage communications growth. Timely development of advanced spectrum management tools will be essential to finding such solutions. Delineation of strategic national goals could provide spectrum users and equipment manufacturers a framework for successful application of spectrum technology in the future.

The purpose of spectrum management planning is to optimize accommodation of users through the:

1. allocation of adequate spectrum; and
2. development and implementation of spectrum management techniques and policies that promote efficient spectrum assignment and use.

For instance, if needs for mobile spectrum will increase in five or ten years, the spectrum management process should attempt to anticipate those developments and ensure that adequate spectrum will be allocated to the mobile service to meet those needs. To be able to achieve that goal, it is essential that analysis capabilities, coordination procedures, and supporting databases be in place to support the accommodation of mobile systems. These capabilities take time to develop.^{600/}

^{596/} NPR Comments at 12-14; CPB Comments at 15-16.

^{597/} NSF Comments at 11-12.

^{598/} DOJ/JMD Comments at 3.

^{599/} VOA Comments at 6.

^{600/} For example, procedures for quantifying spectrum use, like those discussed in Chapter 5, have been in development for over ten years, and are as yet incomplete.

The following discussion considers the value of spectrum management planning. It then describes planning as a function of four steps:

1. requirements identification (the collection and dissemination of data concerning existing use and reasonably certain planned use,^{601/} and existing and planned management methods);
2. forecasting (the prediction, through empirical methods and informed judgment, of future spectrum needs or management capabilities beyond those that are certain);
3. publication of long-range plans (the development, dissemination, use, and revision by NTIA and the FCC of documented spectrum management plans); and
4. planning for unforeseen requirements.

We assess these four steps as NTIA and the FCC now perform them, propose improvements, and discuss the adequacy of resources devoted to planning.

II. Value of Spectrum Management Planning

Among spectrum users and managers, little consensus exists regarding the value of spectrum management planning or the proper approach to its use. The result is that spectrum managers perform planning on an ad hoc basis. APCO describes spectrum management as "crisis" oriented, emphasizing "immediate reaction to every development or need" rather than long-range planning.^{602/} Therefore, we consider the value of planning and its role in the overall spectrum management process.

Development or purchase of communications equipment generally requires a long-term commitment because of the equipment's expense and complexity. Therefore, spectrum management plans and spectrum-related decisions have long-term impacts -- that is, decisions implemented today will be in effect for many years, accommodating some users, while denying others or increasing the potential for interference to existing users. Planning must consider these long-term effects.

The primary argument against long-range spectrum management planning is that spectrum use and technology are so volatile that only reactive decisions or short lead-time decisions can be made. Thus, the argument goes, long-range planning will inevitably be flawed. It can also be argued that spectrum management has proceeded well without long-term projections and that inaccurate projections can lead to allocations to services that do not develop as anticipated (because of technological or economic difficulties). While such allocations are in theory reversible, it may be difficult to do so as a practical matter, once some

^{601/} Among the federal spectrum users, the term "planned use" generally refers to any system for which funds have been budgeted. The federal agencies indicate that they are constrained from requesting NTIA review for spectrum availability until some funds have been designated. Future systems that do not fit within this definition of "planned" are considered to be "forecast" uses. A similar distinction with respect to non-federal systems may be more difficult.

^{602/} APCO Comments at 2-3.

level of service has been established and investments in equipment by service providers and their customers have been made.

The volatility of a situation does affect planning; however, a refusal to plan is not an adequate solution. The costly near-term movement of preexisting uses is likely to be the result of failures to plan. When new uses and services are not adaptable to higher frequencies (where spectrum is still available and will be for some time), spectrum managers could face no choice other than to make room for them by moving preexisting uses and services that could feasibly be conducted at higher frequencies. These pressures to move preexisting uses could be especially great where the new uses appear to be very valuable and offer opportunities for rapid service growth and the resulting manufacture, sale, and export of new products. These decision criteria, however, put many users and related investment in jeopardy if spectrum managers do not provide sufficient lead-time for the moves. If planning does not provide the lead-time, then "grandfathering" approaches that slow implementation of new systems will be needed. Otherwise the true cost of developing and implementing new systems will often include the cost of replacing displaced equipment.⁶⁰³

Another argument against long-range planning is that decisions made, in light of particular immediate situations are better since more information is available. This presupposes an inability on the part of spectrum managers to update plans, when, in fact, any process of long-range planning must be linked to a schedule for regular review and revision.

Long-range plans are not useful if they become rigid and dogmatic. In a dynamic field like spectrum management, such plans should avoid irreversible decisions that lock-in particular results, but should survey a long period of time to set out a path to achieve spectrum management objectives. Any commitment to long-range planning must, perforce, include a commitment to a process of revision in which managers regularly reconsider plans in light of developments. Specific actions become essential only if, over time, they are appropriate in the near term and must occur if the long-term goal is to be accomplished.

Some do not agree, however, that federal planning is beneficial, arguing that it interferes with developer and manufacturer initiative. Recent developments in eastern Europe are dramatic reminders of the results of attempts to manage an economy through central planning by government. Thus, the proper scope of spectrum management planning must be identified. NTIA strongly believes that spectrum users and equipment suppliers, and not the spectrum managers, should determine the spectrum-based products and services to be offered. However, NTIA and the FCC still bear responsibility to plan for new uses of the publicly-held spectrum resource, and planning should deal more with improving the management and use of the spectrum rather than extending regulatory authority. In such plans, some aspects of spectrum use and management might be dealt with through general policies, while others need the delineation of more specific steps. Greater flexibility in the methods of spectrum management may provide room for innovation and changes of direction, but even the methods for achieving

^{603/} For example, the DOE and the FAA have indicated that if the 1710-1850 MHz band were transferred to the private sector, their lost investments in equipment now operating in that band would be approximately \$51 million and \$350 million respectively. Letter from R.M. Lewis, DOE, to E.E. Dinkle, IRAC Secretariat, enclosure, May 16, 1990; Letter from A. Aquilano, FAA, to J. Obuchowski, NTIA, enclosure at 3, Apr. 2, 1990. These estimates do not include the costs of purchasing new equipment for other bands or of any additional land required, nor do they provide answers to the fundamental question of where in the spectrum will these displaced uses go.

that flexibility must be planned. Thus, for example, developing and implementing greater reliance on market principles and user flexibility in the spectrum management process, as recommended in this report, are appropriate components of spectrum planning as we conceive it.

The importance of planning will grow as the demands for spectrum increase, unless spectrum management structures change completely. The IMMC describes planning as "the most important element of spectrum management."^{604/} Similarly, NASA believes that "planning, both near and long term, is an essential management tool that must be used effectively if timely access to spectrum for new requirements is to be achieved."^{605/}

Resistance to planning efforts could be expected within two groups -- those that believe they stand to lose by such efforts, particularly incumbent spectrum users, and those that will have to do the planning itself, particularly if their resources for spectrum management are already constrained. Those that have access to the spectrum may fear that long-range planning activity invites undesired change. Those that are using the spectrum may gain in a general sense from a failure to plan for new uses, but they also stand to lose if a new use forces their removal from a band. For those that perform the planning functions, the dedication of additional resources will be required,^{606/} and since long-range planning has no immediacy, it can always be postponed. Yet a spectrum management system of the quality required to meet today's demands will almost certainly need such planning. Few fields of business or government would venture ahead without it.

In the years to come, there will be gains and losses for all users, but with strategic long-range planning, the surprises should be fewer, and the costs of regrouping should be less.

III. Identification of Spectrum Requirements

In order to satisfy U.S. spectrum needs, NTIA and the FCC must first identify the known current and future requirements^{607/} within their individual spheres of oversight, and then jointly determine how best to accommodate those requirements. NTIA and the FCC must be able to portray requirements so as to permit analysis upon which to base planning decisions. The identification of future requirements must be timely, in order to ease any necessary redistribution of spectrum and spectrum assets.

^{604/} IMM Comments at 21.

^{605/} NASA Reply at 5.

^{606/} Meaningful improvements in the planning processes of NTIA and the FCC could be achieved at annual costs measurable in the hundreds of thousands of dollars; very substantial improvements could be realized with additional resources in the low millions of dollars. In either case, the cost of making such improvements is far less than the costs to users associated with large shifts in spectrum allocations and other disruptions from failures to plan.

^{607/} The term "requirements" is intended to be a general term for current and future spectrum needs, incorporating concepts of capabilities required, systems and their characteristics, and associated frequencies.

We agree with the position of du Treil, Lundin & Rackley, that "[b]efore the spectrum can be efficiently managed, it is necessary to have an accurate inventory of spectrum users."^{608/} In 1982, Sachs/Freeman reported that an "important element of the planning process is the collection and development of information."^{609/} We discuss below the adequacy of the spectrum management processes in portraying information on known requirements.

A. Non-Federal Requirements Identification

The FCC, as manager of non-federal spectrum use, depends on rulemakings and licensing procedures, spectrum monitoring, and inquiries to obtain data needed for decision-making. The FCC uses information obtained through these means to portray non-federal requirements.

1. Petitions for Rulemaking

The FCC's principal procedure for reviewing the spectrum requirements of proposed new systems is through the initiation of a rulemaking. As noted in Chapter 2, when a manufacturer or user envisions a use that is not in accordance with the allocation table, it must petition the FCC for a rulemaking.^{610/} A rule change favorable to the petitioner will result in amendment of the allocation tables. As a general matter, rulemakings can be an effective means of considering policy and allocation issues. Nevertheless, because they are usually initiated to address the needs of a particular private party, their focus may not necessarily be broad enough to consider the overall interests of the public in efficient use of the spectrum. Thus, during the period that a rulemaking is underway, information on other future uses for the same spectrum may not be available. As a practical matter, unless competing users are ready with concrete proposals, their needs cannot be effectively considered.

2. Licensing Process

The FCC approves, through the licensing process, the spectrum use of specific applicants. Since in some services the FCC has emphasized decentralized management, its decisions to license often formalize those made by user groups.

User groups maintain the technical resources to analyze compatibility, and keep data files on licenses, but their capabilities are not linked together to be used by the FCC for rapid or regular collation of data.

The FCC also has its own data files of licenses; however, as we have discussed in Chapter 5, many private sector users believe that the FCC databases are inaccurate and out of date.^{611/} Some commenters assert that they have regularly found errors in the FCC broadcast

^{608/} Du Treil, Lundin & Rackley Comments at 2.

^{609/} Sachs/Freeman Associates, Inc., Collection and Development of Information to Support Long-Range Spectrum Planning, Contract No. NT-81-SAC-00072 for NTIA, at 1 (1982).

^{610/} See Chapter 2, *supra* p. 36. Some systems complying with the tables may not comply with additional requirements of the FCC rules. In these cases, a rulemaking may also be necessary before the new use can be authorized.

^{611/} See Chapter 5, *supra* p. 133.

data files, but note that the FCC considers its computer data to be secondary resource compared to the files of "hardcopy" station applications.^{612/} However, timely, regular planning cannot be performed if the manual culling of those application forms is required. Therefore, it is difficult for the FCC to portray non-federal requirements for planning purposes.

3. Monitoring Spectrum Occupancy

Spectrum occupancy measurements are another tool in the process of portraying spectrum use. As discussed in Chapter 5, they can be used to determine the actual use level as compared to that shown on paper.^{613/} Portrayal of use levels can support the planning decision process in confirming the need for management action or in helping to identify the specific solution to spectrum conflicts.

4. Inquiries

The FCC also attempts to gather information on current and future use through notices of inquiry. Some of these may be for new domestic services, such as personal communications.^{614/} Inquiries permit the FCC to gather a wide range of information on specific topics, and as such, can give the agency a broad picture of public views on issues. However, because inquiries, by definition, do not immediately result in rule changes, there is concern that the views expressed in response to them by the private sector may not be useful for policymaking purposes.

Often, the FCC also uses notices of inquiry to begin preparations for ITU allocations conferences. These inquiries are intended to gather information on spectrum requirements as they may pertain to international issues that are the subject of such conferences. They are frequently successful in focusing the user community attention on their future needs and in motivating users to describe on the public record new spectrum-dependent technologies and systems that they want to have accommodated in the international allocation process. On the other hand, these inquiries can attract such a barrage of requests for spectrum, often with minimum documentation, that their value and potential for implementation can be substantially reduced. Thus, all requests may be submitted for international consideration, even those that conflict with one another. Private sector entities can also present their requirements through direct participation in U.S. committee preparation for international meetings and conferences. This process can produce useful data, but often collects a variety of allocation proposals, which may not be backed by documented requirements. Such a result may not provide adequate support for spectrum managers to identify requirements and formulate national positions.

B. Federal Requirements Identification

The identification of federal spectrum requirements occurs primarily through two ongoing, but separate, processes at NTIA -- the systems review and frequency assignment processes. Two standing subcommittees of the IRAC -- the SPS and the FAS -- support this task. Systems review and assignment information is supplemented through spectrum occupancy measurements, NTIA spectrum resources assessments, and preparations for international

^{612/} See du Treil, Lundin & Rackley Comments at 2.

^{613/} See Chapter 5, *supra* p. 138.

^{614/} See Personal Communications Services, *supra* note 7.

conferences. The aggregate information drawn from these sources portrays all known federal requirements.

1. Systems Review Process

The systems review process exists to satisfy the spectrum certification requirements of OMB Circular No. A-11.^{615/} The systems reviewed are "major" systems (including all space radiocommunications systems). A system is considered "major" if it will have a significant impact on existing or potential future use of the portion of the spectrum in which it is intended to operate.

The systems review identifies the degree of conformity of the system to the spectrum standards and to the National Table of Frequency Allocations. Systems that do not conform, but are otherwise compatible with existing uses, are generally approved on a secondary or noninterference basis to other systems, current or future, that do conform. Systems that have potential for interference, but are essential for national defense, are reviewed in regard to the coordination and conditions required to allow operation in the United States.

The systems review process is limited in its ability to assist the federal agencies in system planning, because few systems reviews are submitted for the conceptual or experimental stages of radio system development, when the information can be most useful for identifying the optimum frequency band and potential conflicts. From 1986 to 1989, approximately 50% of the review requests have been for the operational stage, the last in the development and procurement process. On the other hand, in cases where requests have been made early, especially when conflicts have existed, the process can lead to very useful coordination of spectrum requirements.

The process does provide NTIA with information on federal requirements. Although, as stated above, the information may only provide short- to near-term warning of a system's implementation, it is still helpful for strategic long-term planning, because the equipment that it represents will be in use for a long period of time.

Some question exists as to the utility of the review process, because the definition of "major" systems, with the exception of satellite systems, is not specified.^{616/} The existing definition provides a degree of flexibility to the federal agencies, yet raises the possibility that

^{615/} OMB Circular A-11, Section 13.2(o) requires that "[e]stimates for the development and procurement of major communications-electronics systems (including all systems employing satellite (space) techniques) will be submitted only after certification by the [NTIA] that the space in the radio frequency spectrum required for such systems is available."

^{616/} F. Hopkins & W. Schummer, Development of a Methodology for Improved Use of the Electromagnetic Spectrum by Federal Agencies, ORI, Contract 50-SANT-4-03565 for NTIA (1985). This study concluded that the lack of definition was a significant problem. Little agreement exists within the IRAC as to which factors, such as system mission, system characteristics, quantity of equipment, or cost of the system, make a system "major."

some significant systems may not be identified, thus hampering NTIA's spectrum planning process.^{617/}

Finally, NTIA places some information from the systems review requests within the Systems Review File (SRV), which NTIA uses as a submission record index. Because the SRV does not include many data items from the systems review requests, manual culling of information from the hard copy requests themselves is currently NTIA's primary method of obtaining systems review information, such as investment and numbers of equipment, for planning.

2. Frequency Assignment Process

The NTIA assignment process has become increasingly automated, improving the submission process for federal users as well as NTIA's ability to provide federal agencies with access to assignment information. However, because most assignment requests do not contain information that could add perspective to NTIA decisionmaking, such as system investment, numbers of equipment, mission criticality, and operational use,^{618/} the GMF cannot be used to produce aggregate information. The absence of this information can be a problem for planning because, when decisions impacting allocation of spectrum must be made, these are often the factors that must be considered. Moreover, as described in Chapter 5, the GMF is also not adequate to support, over a wide range of services, the use of spectrum use quantification tools, such as SUM, that could be useful in the planning process.^{619/}

One other inadequacy of federal spectrum requirements portrayal through the use of frequency assignments concerns receivers or other passive devices that need protection, such as radio astronomy telescopes. As noted in Chapter 5, there is no federal regulation requiring assignment or recording of such receivers.^{620/} Such a lack of information can impair effective planning.

3. Monitoring Spectrum Occupancy

Spectrum occupancy measurements, as another information source in the process of portraying federal spectrum use, enable NTIA to confirm the actual level of use associated with federal assignments. Federal users pose special issues in measurement. For example, because of federal agencies' roles in emergency or wartime conditions, measurements of everyday use may not help in portraying the spectrum use that would occur in such situations. In 1989, NTIA measured federal spectrum use in Washington, D.C. during the presidential inauguration, the first attempt to monitor federal use during such a period of high activity. An increase in use was experienced during the period, although it was a relatively moderate increase because

^{617/} NTIA has generally avoided approaching the systems review process from an enforcement standpoint due to the costs that would be required, but relies on the belief among federal agencies that the review benefits the users. Also, the GMF, the listing of frequency assignments, represents the largest source of federal requirements data.

^{618/} Categorizing spectrum uses on the basis of station class or service hinders the ability to ascertain the social impacts of telecommunications systems.

^{619/} See Chapter 5, *supra* p. 134.

^{620/} See Chapter 5, *supra* p. 135.

the ceremony proceeded without incident. NTIA plans to continue such measurement activities in the future.

4. Spectrum Resource Assessments

NTIA also draws information from federal agencies when it conducts specific spectrum resource assessments.^{621/} However, the information needed for federal spectrum planning decisions, such as system investment, numbers of equipment, and mission criticality, is often not available within the spectrum management offices of federal agencies. The result is that a great deal of effort is required to obtain information from agency field offices and users. For large agencies, it is a massive task, particularly if many bands are covered. If the information were provided when federal users request spectrum support or frequency assignment, it would be available for planning decisions.

The IRAC regularly questions the validity of information included in spectrum assessments. Two of the primary criticisms are that assessments based upon frequency assignments do not accurately portray the total numbers of equipment^{622/} or the usage (actual levels of use).^{623/} IRAC members have also been concerned that spectrum resource assessments do not thoroughly address agency funding commitments and the importance of system missions.^{624/}

5. Conference Preparations

Federal users' preparations for international meetings generally occur through direct involvement of the federal agencies on U.S. delegations. In preparation for major WARC's, IRAC ad hoc committees generally attempt to ready a consensus among federal users on the issues being considered prior to negotiating with other users. However, the federal preparations are prone to the same problems as those faced by the private sector. Whether due to existing

^{621/} NTIA performs assessments when it identifies issues that affect allocation or management of a band. Also, assessments are conducted when seeking a greater planning perspective on a band or radio service.

^{622/} IRAC DOC. 24620/2, Summary Minutes 1350th IRAC Meeting, Aug. 13, 1985, Comments by the NASA representative with respect to NTIA's Spectrum Resource Assessment of the Fixed and Mobile Services in the 947-17,700 MHz Band, at 3 (IRAC 24620/2). This discrepancy between the number of pieces of equipment and the number of assignments occurs mainly with mobile types of systems. The number of fixed location equipment, such as microwave links or air-route surveillance radars, usually correspond to the number of recorded assignments.

^{623/} IRAC DOC. 25584/2, Summary Minutes 1395th IRAC Meeting, July 28, 1987, Comments by the Army representative with respect to NTIA's Spectrum Resource Assessment of the Federal Government Fixed Service (Above 400 MHz), at 7; IRAC DOC. 25596/2, Summary Minutes 1396th IRAC Meeting, Aug. 11, 1987, Comments by the Army representative with respect to NTIA's Spectrum Resource Assessment of the Federal Government Fixed Service (Above 400 MHz), at 4.

^{624/} See IRAC DOC. 24620/2, supra note 622. Comments by the NASA, Energy, and Air Force representatives with respect to NTIA Spectrum Resource Assessment of the Fixed and Mobile Services in the 947-17,700 MHz Band, at 3-5.

users resisting changes or users placing a host of new requirements on the table to try to bid for spectrum, it can be difficult to accurately delineate federal requirements based upon these activities.

C. Conclusions

Allocation decisions, rulemakings, and international conference preparations by spectrum managers should be supported by information that adequately portrays federal and non-federal requirements. Without such information, planning is extremely difficult. Moreover, the current weaknesses in demonstrating federal requirements to the communications community increases suspicion among non-federal users that the federal users are hoarding spectrum. The data necessary to perform planning must be accumulated and presented by NTIA or the FCC in such a way that it can be useful for spectrum decisionmaking. This data must include system investment, numbers of equipment, mission criticality, and operational use. Currently, this information is not readily available.

Technical data must be readily available to support efforts to quantify spectrum use and to assist in the portrayal of requirements as determined by technical characteristics. Obtaining data necessary to perform interference analyses of individual situations is not usually difficult. However, if the system will be deployed across the United States, a capability to perform nationwide analysis is needed. Improvements in FCC and NTIA data availability and in analysis capability will be required if the spectrum management planning process is to operate effectively.

NTIA and the FCC should rely primarily on their normal ongoing activities such as frequency assignment, systems reviews, licensing, rulemakings, and inquiries to build an adequate base of information for planning. This information should also form the basis for documentation and evaluation of national requirements in preparation for international conferences, though it may be supplemented by information collected specifically as part of those preparations.

Spectrum occupancy measurements are needed to support the documentation of current use; however, these efforts should center on monitoring congested areas, and federal mission-driven high-activity periods where their results have direct application to planning and policy decisions.

D. Recommendations

There are a number of steps the FCC and NTIA could take to improve the "requirements identification" component of spectrum planning. While we realize that full implementation of these activities will be constrained by the availability of resources, we believe the two agencies should initiate efforts, both together and separately, along the following lines.

First, the FCC should establish procedures to permit private-sector users and manufacturers to submit information on major new system developments that may affect spectrum use, particularly on those technologies or activities that will require allocation changes or increase demand for current services. The FCC should encourage the submission of such information as early as possible during system or technology development, based on a clearly-expressed commitment to use this information for long-range planning. The FCC should also obtain data through periodic notices of inquiry requesting information on new technologies or systems.

Second, in upgrading their data files as discussed in earlier chapters, NTIA and the FCC should ensure that the files can also be used to portray requirements in a way useful to planning. The FCC and NTIA should pursue the development of common spectrum use quantification tools to assist in the portrayal of spectrum use.

Third, NTIA and the FCC should, on a scheduled periodic basis, perform ongoing monitoring and measurements of spectrum occupancy in congested bands and locations to determine the level of spectrum use. Where feasible, the two agencies should coordinate their monitoring and measurement efforts to maximize the impact of their combined resources.

IV. Spectrum Use Forecasting

We define "spectrum use forecasting" as the processes and methods of estimating spectrum requirements based on projections beyond data on known operating or funded systems. Forecasting often entails prediction of new technologies or spectrum demand trends, and estimation of their impact. Spectrum managers may base such forecasting on both empirical methods and informed judgment.^{625/} The analysis of predicted spectrum needs, combined with information on current use and specific known future requirements, potentially can play an important role in spectrum planning.

A. The Value of Forecasting

The necessity of forecasting in fields characterized by rapidly changing technology, such as radiocommunications, has been controversial for some time. The suggestion that forecasting is crucial to spectrum management frequently meets resistance. For example, several commenters state that forecasting future spectrum use would be very difficult, if not impossible. Du Treil, Lundin & Rackley believes that time and effort spent in long-range forecasting would be "futile." It cites previous failures to forecast the steady decline in AM listeners or the growth of cellular service as examples of that futility.^{626/} The Air Force states that there is no known way to forecast requirements accurately.^{627/} COMSAT states that "[f]orecasting. . . is an uncertain exercise at best, and if used as a basis for allocations can lead to costly waste of spectrum if forecasts are wrong."^{628/} COMSAT does, however, support the development and improvement of forecasting techniques as long as their limited accuracy is understood.

In contrast to these skeptical comments, several commenters encourage the use of forecasting. NYNEX recommends the use of a broad array of forecasting techniques, including

^{625/} Experts have defined technological forecasting as "prediction of future characteristics of useful machines, procedures, and techniques." See J. Martino, Technological Forecasting for Decision Making, at 2 (1983). Spectrum use forecasting is a special case of technological forecasting dealing with telecommunications use and capabilities.

^{626/} Du Treil, Lundin & Rackley Comments at 11.

^{627/} U.S. Air Force Comments at 13.

^{628/} COMSAT Comments at 48.

expert opinion surveys, trend observation, technology tracking, and analogies.^{629/} It contends that independent government forecasting activities must be used to validate the inputs from parties that have a direct stake in the decision process.^{630/} LMCC believes that FCC efforts to predict the requirements of new services have been effective in gauging acceptance of new technologies and anticipating growth.^{631/} MST recommends the use of informed and interested public comment to aid forecasting.^{632/} GTE cites the forecasts of CCIR Interim Working Party (IWP) 8/13 as excellent work.^{633/} The FAA reports success using historical data on air traffic growth to predict the need for channels in the aeronautical bands.^{634/} The Navy and NSF recommend R&D monitoring as a source of forecasting data for technology development.^{635/}

In addition, there exists a body of technical literature devoted to the general issue of technological forecasting, which generally supports the use of such prediction as a valuable planning tool if it is performed in a disciplined manner and is not followed blindly. For example, one author states:

Any individual, organization, or nation that can be affected by technological change inevitably engages in forecasting technology with each and every decision which allocates resources to a particular purpose. . . . Every decision then carries within it the forecast that technology either will not change at all or will change in such a way as to make the decision a good one. . . . [T]o avoid forecasts because anything can happen really amounts to a cover of something else - perhaps an attempt to avoid the effort of thinking through the implications of the forecast.^{636/}

NTIA believes, as the advocates of greater use of forecasting assert, that the real choice is not whether to forecast, but whether forecasting is explicit and well-structured or implicit and based on unstated and untested assumptions. As with planning in general, even those who are skeptical of formal forecasting necessarily make predictive judgments based on implicit, unstructured techniques. Among the virtues of structured methods is that they can be taught and results are repeatable. Furthermore, with such methods, the assumptions and data relied

^{629/} Nynex Comments at 51. In technological forecasting, analogies may be used when two technologies develop under like circumstances and will have a like impact on society. Through the analogy the progress of the later technology is predicted based upon the history of the former.

^{630/} NYNEX Comments at 51-56.

^{631/} LMCC Comments at 71 (LMCC cites FCC Private Radio Bureau Dockets 82-10, Future Private Land Mobile Telecommunications Requirements, and 84-232, Future Public Safety Telecommunications Requirements).

^{632/} MST Comments at 41.

^{633/} GTE Comments at 17-18.

^{634/} FAA Comments at 5.

^{635/} DOD (Navy) Comments at 4; NSF Comments at 21.

^{636/} Martino, supra note 625, at 4-6.

on are clearly stated and the analytic methods employed are open to review. As a result, the limitations and qualifications applicable to such forecasts are more easily understood.^{637/}

Rapid and unpredictable technological changes are often given as reasons for not using spectrum forecasts. However, technological breakthroughs seldom occur without some warning, and major changes usually involve incremental steps.

NTIA acknowledges that, in some cases, the costs of forecasts can exceed the value of the information produced.^{638/} However, the lesson is not that all forecasting is useless. Rather, as with any analytic tool, including traditional data gathering and reporting, spectrum managers must learn to assess the costs of applying forecasting to particular problems, and to develop reasonable applications in light of the potential value of the results, while considering other pressing resource demands. When assessed in that light, we believe forecasting can play an important role in the overall spectrum management process.

B. Government Forecasting

The FCC occasionally has solicited user forecasts, but has not established a regular process of systematic prediction. At NTIA, most forecasting is now based on the experience and judgment of senior staff members. Some monitoring of trade journals, and discussion with federal agencies occurs, though without formal structure. However, NTIA management decisions are now developed primarily from data on known requirements. NTIA has generally declined to consider future agency requirements that have not already been documented.^{639/} This approach reflects caution about relying on predictions, since allocation of frequencies for nonexistent or nonfunded uses, during a time of growing demand, represents a difficult and risky choice.

Adaptation of forecasting techniques to spectrum management requires careful definition of the scope of FCC and NTIA forecasting responsibilities. Because neither the FCC nor NTIA develops communication technology, their primary role has been to respond to user needs to manage spectrum in such a way that there is a long-term optimization of spectrum use in the national interest. Accordingly, NTIA and FCC forecasts should be based to a great extent on analysis of user predictions of spectrum requirements.

Attempts to define the proper role of U.S. spectrum managers in forecasting have a long history. In 1975, Systems Applications Inc. (SAI), under contract to study the use of market analysis in spectrum forecasting, stated that:

Neither the OTP [now NTIA] nor the IRAC generate demand forecasts; indeed, the forecasting of user-agency demand is not an appropriate OTP [read NTIA] activity. Forecasts of spectrum consumption should be drawn closely from federal agencies or user groups, which are obviously best placed to assess their own needs. However, if the OTP did have access to spectrum-relevant demand forecasts prepared for it by or for

^{637/} Some formal methods of forecasting are described in Appendix G.

^{638/} See also Martino, *supra* note 625, at 5.

^{639/} "Documentation" is generally synonymous with submission of systems review requests. Federal agency representatives indicate that they are unable to submit requests for systems that may be on the drawing board but are not funded. Thus, forecasting inputs may be prevented.

user agencies, it can be in a much better position than at present to conduct spectrum management.^{640/}

Despite the obvious utility and, indeed, practical necessity of relying on this approach, there are risks involved in accepting user predictions, since they may often be overstated to obtain a larger portion of the resource. User forecasts are bound to favor the purposes of those that prepare them, and spectrum managers should only rely on user forecasts that describe their forecasting methods and assumptions, and discuss how the forecasts might err.

To generate more useful predictions, NTIA and the FCC can add their own forecasting insights to user inputs. Although it would probably not be reasonable for the FCC and NTIA to predict growth for individual users, the accumulation of user estimates, as adjusted based on NTIA and FCC evaluations, can provide insight into broad, future needs and assist in the allocation of spectrum. In addition, the FCC and NTIA can develop quantifiable trends based upon spectrum use data for all their users.

C. Forecasting Tools in Use or under Development

NTIA is in the process of developing the SUM capability, described in Chapter 5, to help quantify spectrum use, which is a crucial link in trend extrapolation.^{641/} Trends for individual locations could be compiled to present trends in an area or across the country. Future spectrum use index values for a particular region (e.g., a metropolitan area, a state, or the entire country) could be forecast. SUM maps could be used to show qualitative growth trends in spectrum use. Trends such as the movement of telecommunications activity into or out of urban areas, or into new regions of the country, could be identified using maps of spectrum use factor values.

D. Conclusions and Recommendations

All forecasts are risky to some degree, but decisions about future spectrum demands can be improved if they take into account well-structured and carefully analyzed predictions. Each of the technological forecasting tools described in detail in Appendix G could be applied in some way to spectrum use. Forecasts of usage, technologies, congestion, etc., could be very helpful to the management process, particularly for spectrum allocation decisions.^{642/}

Development and implementation of these techniques will, in some cases, require a significant commitment of resources. For example, the computer support necessary for some of the forecasting techniques will require both program development and database upgrades. Years of data will be required to establish trends if data in existing files is not adequate and records of past use have not been maintained. The costs, length of time to implement, and value of such data collection and prediction must be determined. The use of techniques that are based on informed judgment will require less development time than empirical methods, but they suffer from being less precise and more dependent on subjective evaluations.

^{640/} P. Stanek, M. Drubin, and G.P. Mandanis, The Use of Demand Forecasting in Spectrum Management, Contract No. TP3AC001 for the Office of Telecommunications Policy, at 13 (Sept. 1974) (SAI).

^{641/} See Chapter 5 *supra* p. 129.

^{642/} See SAI, *supra* note 640 at 53.

Realizing that significant costs will be associated with any venture into forecasting and the results may or may not prove useful, NTIA and the FCC should pursue a long-term program, rather than a short-term "crash course", of progressively developing and using forecasting tools. NTIA and the FCC are already forecasting, but those forecasts are generally ad hoc, intuitive, and based upon limited input.

We believe that a balanced approach to spectrum forecasting at NTIA and the FCC should consist of three major parts:

1. Expert input;
2. Trend analysis; and
3. Technology tracking.

First, expert input should be drawn from the users -- the federal agencies and the private sector -- to predict spectrum requirements for five years, ten years, and beyond. Users should identify specific trends and new technologies. The committee of federal and non-federal spectrum users described in Chapter 2 should convene under the joint oversight of the FCC and NTIA to discuss and report on, in detail and over several days, long-term future demands for allocations.^{643/}

Second, NTIA and the FCC should cooperate in developing spectrum-use trend analysis, using the SUM concept, to predict congestion. This will require an expansion of the SUM capabilities to all services and bands. This effort, if successfully accomplished, will result in a versatile empirical forecasting tool.

Third, staff members at NTIA and the FCC should be designated to track technology trends by annually compiling information from trade publications, research and development centers, and market analysis reports.

V. Long-Range Planning

CBS correctly notes that there is no "institutionalized, coordinated planning function" in spectrum management.^{644/} NTIA is required to "[d]evelop, in cooperation with the Federal Communications Commission, a comprehensive long-range plan for improved management of all electromagnetic spectrum resources, including jointly determining the National Table of Frequency Allocations."^{645/} We now discuss the objectives of long-range planning, current efforts, and cooperation with the FCC.

^{643/} See Chapter 2, supra p.51. See also GTE Reply at 8. Alternatively, it may be easier and more consistent with existing processes for the FCC and NTIA to obtain non-federal and federal inputs separately through notices of inquiry and the IRAC. However, we believe that some interaction between the private sector and government users would be useful.

^{644/} CBS Comments at 8.

^{645/} Exec. Order No. 12,046, supra note 10; Department of Commerce DOO 10-10, supra note 10, § 6.

A. Objectives of Long-Range Planning

1. Improvements in Management Techniques and Capabilities

Any long-range plan for improved spectrum management should discuss future improvements in the techniques and technical capabilities available to spectrum management. The completion of a plan in this area can set in motion the step-by-step improvement of the management system. For example, specific plans for improving computer models, data gathering and data retrieval capabilities are increasingly important. Concrete plans are needed to put market and flexibility concepts into action. Ongoing analysis and assessment tasks need to be prioritized and scheduled.

2. Spectrum Use

Because the allocation of spectrum is a crucial aspect of spectrum management, lack of a plan to accommodate changing spectrum use could hamper U.S. management activities.

To develop a useful plan, NTIA and the FCC must identify spectrum requirements. Forecasting of future demand beyond known requirements, as discussed under Subheading IV, will also be needed. The necessary planning and forecasting should be general in nature, accounting for such factors as major shifts in spectrum use, new services for which the current allocation table makes no provisions, user plans for changes in use, and projected crowding in specific bands or locations.

3. Strategic National Goals

NTIA has expressed, throughout this report, its spectrum management goals -- to meet the spectrum needs of the American public by ensuring that the spectrum resource is apportioned and used efficiently and fairly. An ideal system will manage spectrum in such a way that valuable public and commercial services are fully available, innovative new services and technologies are encouraged, and changes in technical or market conditions are rapidly accommodated. It is important that they be kept visible within the telecommunications community and current with changing situations and needs.

B. Current Efforts

1. Federal Long-Range Planning Activities

NTIA's planning activities can be broken into three parts: the work of the IRAC, production of a general long-range plan, and completion of plans with respect to individual topics. These three parts form a framework for national and international planning.

a. IRAC

Besides overseeing the systems review process, the SPS is responsible to the IRAC for planning the use of the electromagnetic spectrum in the national interest, including the apportionment of spectrum space. It is also designated to maintain a continuing appraisal of the current and future needs of the various radio services, make recommendations for changes in the Table of Frequency Allocations, and undertake preparatory work relating to frequency allocation matters for international conferences. In its activities, the SPS is to consider: (1) current and planned national and international frequency uses; (2) anticipated needs at various points in the future, e.g., 5, 10, 15, and 20 years ahead; (3) new developments in existing

services; (4) new techniques, the application of which may require revision of the allocation table; (5) new services for which the current table makes no provisions; (6) specific proposals for expansion, reduction, or other changes in the allocated frequency bands, and the international aspects of changes recommended to the IRAC.^{646/}

It would appear that the SPS has been assigned most of the IRAC's long-range planning activities; however, the SPS performs only the systems review process on a regular basis, not planning functions.^{647/} While an ad hoc approach to planning may be adequate under the best of conditions, it is less than ideal for regular, comprehensive long-range planning. Plans and policies are formulated as circumstances dictate, not on an ongoing basis. This could result in haphazard or untimely evaluation of issues.

b. The Long-Range Plan

NTIA has interpreted the requirement for a long-range plan to include the formal presentation of NTIA goals, policies, and plans in management of the federal government's use of the spectrum. These form the basis for decisions that relate to national and international allocation tables, technical standards, and management procedures. NTIA drafted its first Long-Range Plan for Management and Use of the Radio Spectrum (LRP) in 1986. The second version of the LRP was printed in May of 1988, and the third in June 1989.^{648/} Succeeding versions have increasingly emphasized goals, policies, and plans, though covering primarily plans for federal spectrum management processes, such as analysis model development, rather than planning based on use of the spectrum.

The federal users are generally very supportive of planning. For example, the Navy states that "planning efforts should be increased," and encourages formal, joint activities between NTIA and the FCC.^{649/} Also, NASA recommends improving long-range spectrum requirements forecasting and adoption of a planning process that gets away from "reactionary" methods.^{650/} Still, the LRP itself has been controversial among federal users. NTIA staff prepared the current LRP without the participation of the IRAC. Therefore, the LRP may lack credibility in the eyes of federal agency representatives.^{651/}

c. Other Plans

In addition to the LRP, NTIA develops plans that cover specific topic areas. Many of these are developed with advice from IRAC. The most prominent plan of this type is NTIA's delineation of the government portion of the national allocation table, which usually follows the

^{646/} NTIA Manual, supra note 11 § 1.4.2, Art. V, § 3.

^{647/} Most preparations for international conferences occur via temporary IRAC ad hoc groups. National allocations issues are considered similarly or by the entire membership of the IRAC.

^{648/} LRP supra note 199.

^{649/} DOD (Navy) Comments at 4.

^{650/} NASA Comments at 14.

^{651/} See Interior Comments para. 96.

completion of a WARC. NTIA also has a five-year computer services plan, but it does not link specific spectrum management improvements to its activities.

2. Non-Federal Long-Range Planning Activities

In 1989, a GAO report noted the FCC's lack of a formal long-range planning process for anticipating future demands and setting aside spectrum to meet those demands. The report states:

[FCC officials] question the benefits of a formal long-range planning process given the difficulty of trying to anticipate future spectrum demands in an era of rapid technological change in the telecommunications industry. They emphasized that any FCC attempt to forecast spectrum demand would be extremely difficult because of the proprietary nature of technology undergoing research and development in the telecommunications industry. FCC would also need to know industries' plans for bringing new technology to the marketplace in order to accurately forecast spectrum demand.^{652/}

Despite this apparent aversion to long-range planning, the FCC does perform studies and plan for specific issues. As NTIA does, the FCC produces a set of allocation tables for private sector users. Moreover, the FCC performs a type of long-range planning through rulemakings and inquiries, such as its inquiry on personal communications services.^{653/}

C. Coordination of NTIA and FCC Long-Range Plans

NTIA and its predecessors have enjoyed a long history of cooperation with the FCC, coordinating preparations for international spectrum allocation activities, and jointly structuring the domestic allocation tables. The FCC regularly consults NTIA or provides opportunity for comment when altering non-federal allocations or standards, and NTIA welcomes input from the FCC on federal matters. These cooperative efforts directly affect long-range planning.

NTIA believes that joint long-range planning by the FCC and NTIA is crucial to effective spectrum management. However, NTIA's effort to establish a long-range plan for improved management of the spectrum has not received active FCC support. Therefore, the current LRP cannot be considered a cooperative plan, and NTIA has been careful not to claim that the LRP speaks for the FCC. Without FCC input, the LRP is severely limited as a statement of U.S. spectrum policy and plans. Furthermore, the plan loses a great deal of its potential practical benefit without FCC participation, since NTIA must obtain FCC agreement for most allocation actions. IMMC states that this situation "is analogous to a navigator charting a flight plan without talking to the pilot."^{654/} The Air Force agrees that planning must be a joint process, stating that the "major impediment to accuracy of spectrum planning is the lack of including the non-Federal needs/plans."^{655/}

^{652/} GAO, Federal Communications Commission Spectrum Management, GAO/RCED-89-62, at 5-6 (1989).

^{653/} See Personal Communications Services, *supra* note 7.

^{654/} IMM Comments at 22.

^{655/} DOD (Air Force) Comments at 13.

D. Conclusions and Recommendations

Improved long-range spectrum planning could make a valuable contribution toward the achievement of U.S. national spectrum goals. Accordingly, NTIA and the FCC should seek to institute a coordinated, strategic, long-range planning process. A two- to five-year planning cycle should be established with fixed target dates for public input and document publication. The output should be a joint FCC/NTIA formal plan that states goals, policies, and specific actions to provide for future spectrum requirements and improve spectrum management. The effort to develop this plan must have the continuing policy guidance of the leaders of the FCC and NTIA.

To support this effort, NTIA and the FCC should assess, on a scheduled basis, the adequacy of allocated spectrum to meet the needs of the various radio services. These spectrum resource assessments should be closely tied to international allocation conferences. The efforts and outputs of the forecasting tools discussed earlier should be directly linked with this planning activity.^{656/} The FCC should draw information from the private sector to support this effort, while NTIA should provide the federal users with the opportunity to provide input to this planning process.

The proposed plan should guide future allocations of spectrum, including predicted changes to the allocation tables for 5, 10, and 15 years in the future. These lead times should provide sufficient room for researchers, users, and manufacturers to direct their activities within the framework of the plan. It is also important that this plan become a primary source for planning and scheduling work within NTIA and the FCC to seek the improvement of the spectrum management process.

We believe that the public should have the opportunity to comment on any proposed plan, but some limitations, due to the national security classification of some federal agency information, may be necessary. However, the plan itself need only provide general unclassified summaries of spectrum use and future requirements. Also, the allocation table, resulting from the planning effort, is unclassified and serves as the primary framework for the private sector development and use of communications systems.

VI. Accommodating Unforeseen Spectrum Requirements

Any system of planning and forecasting, no matter how thorough and well-funded, will not predict all requirements, systems, or services in sufficient time to ease their entrance into the spectrum environment. If an unforeseen requirement is to be accommodated without severely straining the existing allocation structure, that structure must be sufficiently flexible to allow for the limitations of planning.^{657/}

^{656/} NTIA believes that it would be useful to centralize IRAC planning efforts within a specific group, or to clarify that the main body of the IRAC will handle those responsibilities. As noted earlier, the SPS is currently assigned planning duties, but performs primarily those related to the systems review process.

^{657/} AAR Comments at 28-29. The AAR states that when new uses cannot be accommodated, decisions should be made to eliminate certain uses on a priority basis. However, this approach should only be pursued as a last resort.

Chapter 3 contains several proposals for providing such flexibility in the allocation structure. In addition, some steps can be taken through planning to help meet unforeseen user needs.

A. Identification of Unused or Lightly Used Spectrum^{658/}

In commenting on the Notice, the CSAA, GTE, and DOJ/Anti-Trust recommend that spectrum managers should identify lightly used or unused spectrum.^{659/}

In June of 1988, the FCC provided the Chairman of the House Committee on Energy and Commerce with an inventory of unused or lightly used bands below 20 GHz. Commenting on this list, GAO noted that it showed "only 18 mostly small bands", and that 15 were at that time the "subjects of. . . rulemakings or expected. . . to have increased use".^{660/}

There is only a limited possibility of finding frequencies below 20 GHz that are lightly used and available on a national basis. However, lists of such frequencies prepared for limited geographic areas may produce more usable results. NTIA believes that recommendations within this study for greater openness, improved databases, and application of the SUM technique will prove useful in helping prospective users identify where frequencies are lightly used and may offer the greatest potential for new systems. The greatest limitation to this approach is the reality that in the frequencies and areas most desired by both federal and non-federal users, openings will be difficult to find.^{661/}

B. Set Aside Spectrum for Unforeseen Requirements

Another method to increase flexibility would be to set aside spectrum for unforeseen requirements. The availability of unused bands of sufficient size to accommodate unforeseen uses would allow for quick and simple action when conflicts arise. For example, spectrum reserves supplied the frequencies necessary to implement cellular systems. Reserve bands do not exist now and would have to be created if such an approach were to be taken. APCO, US

^{658/} In this case, the term "used" denotes having been assigned.

^{659/} CSAA Comments at 8; GTE Comments at 16; DOJ/Antitrust Comments at 12.

^{660/} GAO, supra 652, at 12-13. The FCC does not currently maintain such a list of frequencies, but can, as necessary, construct one from existing data sources.

^{661/} In some cases, frequencies that are assigned may not actually be used. GTE states that it believes that monitoring and enforcement would be needed for identification of unused frequencies. GTE Comments at 16. Through monitoring, these frequencies could be identified, but not without significant cost and effort. We discuss FCC and NTIA monitoring efforts and ways they could be made more effective in Chapter 5. We also consider in that section a proposal requiring users, both federal and non-federal, to certify on a regular basis that their frequencies are, in fact, being used as provided in their licenses. While these regulatory improvements are useful, NTIA believes that spectrum management methods that provide economic incentives for users to hold only those frequencies that they actually need for their operation, such as market-based mechanisms, would be more effective than regulatory means to address the unused and underused spectrum problem. See supra Chapter 4.

West, and OPASTCO suggested the concept of creating and maintaining spectrum reserves.^{662/} NASA voices interest in this idea, terming these bands "enterprize zones" and suggests that spectrum could be provided for new systems, and be withdrawn if the service failed to materialize.^{663/} Significantly, the Chairman of the FCC has recently proposed a Commission initiative with a goal of creating a new spectrum reserve for emerging technologies.^{664/}

One approach to creating and managing a spectrum reserve would be to identify frequency bands, or portions of bands, years before they will be cleared and stagger their implementation, opening a portion of spectrum every year or two in a different range of the spectrum.^{665/} This would give innovators flexibility and pre-existing users the time to vacate.

An undesirable effect of having frequencies available as long-term reserves would be the inefficiencies associated with maintaining such reserves in the face of increasing demand. The Air Force states that any such reservation of frequencies would be wasteful and that, due to difficulties in predicting future use, the process of addressing new requirements as they arise must continue.^{666/} However, the reserve approach may be preferable if it eliminates costly, unplanned displacement of other systems. As it stands now, decisions to move incumbent users for the sake of new innovative uses can be extremely costly and disruptive because spectrum managers may provide little warning of such displacements. These costs and disruptions create strong incentives for incumbent users to resist vigorously the spectrum reallocation efforts, which if successful will stop or substantially delay the introduction of the innovative new services. Reserves can be useful in creating both technological and political flexibility for spectrum managers in addressing the unanticipated, but socially desirable, new uses for the spectrum resource.

C. Conclusions and Recommendations

Spectrum managers may not always receive sufficient notice of developing systems and technologies to plan for their accommodation. The improved spectrum forecasting techniques discussed in this chapter will help to address this problem, but technology is developing so rapidly that there undoubtedly will continue to be innovative uses and applications that are not, and could not be, anticipated by spectrum managers. Accordingly, NTIA and the FCC should coordinate in developing strategies to meet such needs. While strategies based on flexibility and market-based principles, as discussed in Chapters 3 and 4, are the most desirable, more direct involvement by spectrum managers may also be necessary. For example, the listing of unused and lightly used frequencies may probably provide some useful information, although as a practical matter, it probably would not result in the identification of substantial amounts of spectrum in the areas and bands that are most desired. The creation and maintenance of spectrum reserves is one approach that could provide spectrum with the necessary flexibility to

^{662/} APCO Comments at 3-4; US West Comments at 11; OPASTCO Comments at 2.

^{663/} NASA Comments at 6.

^{664/} A. Sikes, supra note 7, at 5-6.

^{665/} Ten years is an example of a reasonable number. The actual cycle could be governed by the natural obsolescence identified for equipment in that band.

^{666/} U.S. Air Force Comments at 7.

accommodate new technology. The FCC and NTIA should jointly analyze the costs, benefits and techniques for implementing spectrum reserves.

VII. Spectrum Planning Resources

The spectrum management resources of the federal agencies and NTIA are currently adequate to participate in the formal processes now in place for the IRAC. With the participation of private coordination groups, the FCC carries out its daily functions.^{667/} However, the demands of spectrum management go beyond these activities. APCO states:

[T]he future of the most vital natural resource of all, the radio frequency spectrum, is managed by crisis. Lack of an adequate organization to study, plan and oversee this resource is responsible for the present state of disarray. . . . It is imperative that the federal and non-federal portions of the spectrum be planned and managed in a consistent manner. . . . Present budgets for both the NTIA and FCC are far below that which is needed for the task.^{668/}

US West states that funding is key for acquisition of modern computer systems and the associated human resources necessary for efficient spectrum management.^{669/} LMCC indicates that "[l]ack of funding for staff and equipment limits the [FCC's] ability to respond to identified needs and to act on pending issues in a timely and comprehensive manner."^{670/} API notes that the FCC must rely on surveys and analysis performed by users due to the lack of available resources.^{671/}

On the other hand, the demands on spectrum managers are growing in response to increasing use of radiocommunications systems and their importance to national goals. The wide array of services that rely on the spectrum play increasingly important roles in enhancing the efficiency of U.S. business enterprises and their competitiveness in global markets, and in improving the quality of life of U.S. citizens.

A. Planning Committee Participation

Effective planning requires spectrum managers to participate in a growing number of committees and conferences that involve foreign spectrum management organizations and private users. This participation is essential if U.S. spectrum managers are to be informed fully about domestic and international developments and if they are to safeguard fully U.S. national interests. However, more than attendance at domestic and international fora is required if the

^{667/} However, commenters state that NTIA and the FCC have insufficient staff to prevent "crisis" management and to permit timely oversight of the spectrum. See, e.g., APCO comments at 2-3; LMCC Comments at 65. Appendix H, *infra*, contains a discussion of training programs for NTIA spectrum managers.

^{668/} APCO Comments at 3.

^{669/} US West Comments at 11.

^{670/} LMCC Comments at 65.

^{671/} API Comments at 18-19.

United States is going to achieve its goals. Extensive preparatory work within the U.S. government, with the U.S. private sector, and with foreign governments and firms is critical to ensuring that U.S. efforts are effective. Moreover, U.S. participants must be able to proactively seek leadership roles, perform analyses, and draft papers. Otherwise, U.S. policy choices will consistently be limited by the interests of others.

Besides the IRAC and its three standing subcommittees, NTIA, the FCC liaison to the IRAC, and the federal agencies participate in approximately 15 IRAC subgroups and working groups, and over 20 IRAC ad hoc groups. Additionally, the CCIR has 10 study groups, supported by over 40 task groups or working parties. Though each of these committees may not have the active members from every agency, most are important for adequate spectrum planning and draw wide participation.

In addition to these activities, NTIA, the State Department, and the FCC participate in ITU Plenipotentiary conferences, administrative conferences and councils. There are also many non-ITU spectrum related activities that require support: International Civil Aviation Organization (ICAO), International Maritime Organization (IMO), NATO Allied Radio Frequency Agency (ARFA), Inter-American Telecommunications Conference (CITEL), bilateral coordination activities, and international and national training.

With the recent emphasis on industry self-regulation and international standardization of electronic products, numerous national and international industry groups have formed. These aspects of communications management are being addressed through the International Standards Organization (ISO) and the International Electrotechnical Commission (IEC) and their subgroups. The myriad of demands on NTIA and the FCC to participate in the various fora is substantially taxing their ability to provide consistent, credible input on technical and policy issues.^{672/}

B. Planning Support

As described throughout this study, significant improvements are required in spectrum management capabilities to support comprehensive planning. These improvements, including better data collection, collation, and analysis capabilities, require resources.

It is possible to reduce these resource demands, however, by proper design and implementation of these reforms. For example, in an improved planning process, spectrum requirements must be more thoroughly and more accurately portrayed. In the past, NTIA requests to the IRAC for information about federal and non-federal requirements have frequently met with objections by federal users and the FCC due to a lack of available personnel.^{673/} It may be possible to reduce data collection burdens and response time substantially by ensuring that adequate data is submitted as part of ongoing processes, rather

^{672/} The Coast Guard argues that, "except for CCIR, [the Federal Government is] not adequately represented at . . . standards organizations." The Coast Guard believes that participation in these activities would enhance safety related activities that are supported by radiocommunications, as well as overall U.S. competitiveness. Coast Guard Comments at 11-12.

^{673/} For the federal agencies, such requests often require contact with field offices to obtain information useful for policy and allocation decisions. The greatest problem, however, is the sheer magnitude of the task of collecting data when a major spectrum assessment is started.

than in response to special requests. More generally, NTIA will work with the IRAC and the FCC to ensure that improvements discussed in this study are implemented in the most cost-effective way so that the biggest spectrum management "bang" is obtained for the spectrum manager's "bucks."

C. Conclusions and Recommendations

As radiocommunications becomes more central to society's needs, there will be greater demands on spectrum management resources, especially for planning and coordination activities. Accordingly, NTIA and the FCC must use their limited resources effectively to meet the challenges described in this study. Both agencies should allocate staff and resources to best fulfill their responsibilities and seek aggressively to ensure that their spectrum-related resources are being used most efficiently and effectively to achieve national goals.

APPENDIX A
ALPHABETICAL LIST OF COMMENTS AND REPLIES

Initial Comments

Advanced MobileComm, Inc.
Aeronautical Radio Inc.
Albrecht, Eric K.
Alexander, Paul F.
American Mobile Satellite Corporation
American Petroleum Institute
American Radio Relay League, Inc.
American SMR Network Association, Inc.
American Telephone and Telegraph Company
American Trucking Associations, Inc.
Ameritech Operating Companies
Associated Public-Safety Communications Officers, Inc.
Association of American Railroads
Association of Maximum Service Telecasters, Inc.
Association of Independent Television Stations, Inc.
Bell Atlantic Operating Companies
BellSouth Corporation
BICE & Associates
CBS Inc.
Cellular Telecommunications Industry Association
Center for the Study of Economics
Central Station Alarm Association
Common Ground/U.S.A.
Communications Satellite Corporation
Comsearch
Contel Corporation
Corporation for Public Broadcasting
Digital Microwave Corporation
du Treil, Lundin & Rackley, Inc.
The Ericsson Corporation
Federal Aviation Administration (United States Department of Transportation)
Federal Emergency Management Agency
Forest Industries Telecommunications
Forestry Conservation Communications Association, Inc.
GEC Plessey Telecommunications, Ltd. and Stromberg Carlson Corporation
GTE Service Corporation
Harris Corporation -- Farinon Division
G. M. Howard
Hubbard Broadcasting, Inc.
Institute for Geonomic Transformation
Interactive Technologies, Inc.
International Mobile Machines Corporation
Land Mobile Communications Council
Lichtenstein, Irvin

LiTel Telecommunications Corporation
 Manufacturers Radio Frequency Advisory Committee, Inc.
 McCaw Cellular Communications, Inc.
 Mobile Marine Radio, Inc.
 Motorola Inc.
 National Academy of Science's Committee on Radio Frequencies
 National Aeronautics & Space Administration
 National Association of Broadcasters
 National Association of Business and Educational Radio, Inc.
 National Association of Public Television Stations & The Public Broadcasting Service
 National Broadcasting Company, Inc.
 National Oceanic and Atmospheric Administration (On behalf of the United States
 Department of Commerce)
 National Public Radio
 National Science Foundation
 National Spectrum Managers Association
 National Telephone Cooperative Association
 NYNEX Corporation
 Organization for the Protection & Advancement of Small Telephone Companies
 Pacific Telesis Group
 Personal Radio Steering Group
 Radio Technical Commission for Maritime Services
 Radio Telecom & Technology, Inc.
 Reel, Thomas G.
 Southwestern Bell Corporation
 Telecommunications Industry Association, Mobile Communications Division
 Telocator
 Thomson Consumer Electronics, Inc.
 Tideman, Nicolaus (Virginia Polytechnic Institute and State University)
 U S West, Inc.
 United Parcel Service
 United States Coast Guard (Department of Transportation)
 United States Department of Agriculture
 United States Department of Defense (With comments of Air Force, Army, and Navy
 attached)
 United States Department of Health & Human Services
 United States Department of Interior
 United States Department of Justice (Antitrust Division)
 United States Department of Justice (Justice Management Division with attached comments
 of Federal Bureau of Investigation)
 United States Department of Treasury
 United States Department of Veterans Affairs
 United States Telephone Association
 United Telecommunications, Inc.
 Utilities Telecommunications Council
 Voice of America
 Volunteers in Technical Assistance
 Waterway Communications System, Inc.
 Wertime, Robert, Independent Researcher
 WTNN, Knoxville, TN
 Zenith Electronics Corporation

Reply Comments

American Telephone and Telegraph Company
Association of American Railroads
Association of Independent Television Stations, Inc.
Association of Maximum Service Telecasters, Inc.
Bell Atlantic Operating Companies
Blackwell, Tom M.
Cohn, Stanley I.
du Treil, Lundin & Rackley, Inc.
Federal Emergency Management Agency
Gaffney, Mason
GEC Plessey Telecommunications, Ltd. and Stromberg Carlson Corporation
GTE Service Corporation
Interactive Technologies, Inc.
Linear Corporation
LiTel Telecommunications Corporation
McCaw Cellular Communications, Inc.
MCI Telecommunications Corporation
National Aeronautics & Space Administration
National Association of Broadcasters
National Public Radio
National Telephone Cooperative Association
Northern Telecom Inc.
NYNEX Corporation
Radio New Jersey
Southwestern Bell Corporation
United States Department of Energy
United States Department of Justice (Antitrust Division)
Utilities Telecommunications Council

APPENDIX B

ALPHABETICAL LIST OF COMMENTER ACRONYMS & ABBREVIATIONS

AAR	Association of American Railroads
Ameritech	Ameritech Operating Companies
AMI	Advanced MobileComm, Inc.
AMSC	American Mobile Satellite Corporation
APCO	Associated Public-Safety Communications Officers, Inc.
API	American Petroleum Institute
ARINC	Aeronautical Radio Inc.
ARRL	American Radio Relay League, Inc.
ASNA	American SMR Network Association, Inc.
AT&T	American Telephone and Telegraph Company
ATA	American Trucking Associations, Inc.
Bell Atlantic	Bell Atlantic Operating Companies
BellSouth	BellSouth Corporation
BICE & Assoc.	BICE & Associates
CBS	CBS Inc.
Coast Guard	United States Coast Guard (Department of Transportation)
Common Ground	
/U.S.A.	Common Ground/U.S.A.
COMSAT	Communications Satellite Corporation
Comsearch	Comsearch
Contel	Contel Corporation
CORF	National Academy of Science's Committee on Radio Frequencies
CPB	Corporation for Public Broadcasting
CSAA	Central Station Alarm Association
CSE	Center for the Study of Economics
CTIA	Cellular Telecommunications Industry Association
DMI	Digital Microwave Corporation
DOD	United States Department of Defense (With comments of Air Force, Army, and Navy attached)
DOE	United States Department of Energy
DOJ/Antitrust	United States Department of Justice (Anti-Trust Division)
DOJ/JMD	United States Department of Justice (Justice Management Division with attached comments of Federal Bureau of Investigation)
du Treil, Lundin & Rackley	du Treil, Lundin & Rackley, Inc.
DVA	United States Department of Veterans Affairs
Eric Albrecht	Albrecht, Eric K.
Ericsson	The Ericsson Corporation
FAA	Federal Aviation Administration (United States Department of Transportation)
FCCA	Forestry Conservation Communications Association, Inc.
FEMA	Federal Emergency Management Agency
FIT	Forest Industries Telecommunications
G.M. Howard	G. M. Howard, Esq.

GPT/Stromberg	GEC Plessey Telecommunications, Ltd. and Stromberg Carlson Corporation
GTE	GTE Service Corporation
Harris	Harris Corporation -- Farinon Division
HHS	United States Department of Health & Human Services
Hubbard	Hubbard Broadcasting, Inc.
IGT	Institute for Geonomic Transformation
IMM	International Mobile Machines Corporation
Interior	United States Department of the Interior
INTV	Association of Independent Television Stations, Inc.
Irvin Lichtenstein	Lichtenstein, Irvin
ITI	Interactive Technologies, Inc.
Linear Corporation	Linear Corporation
LiTel	LiTel Telecommunications Corporation
LMCC	Land Mobile Communications Council
Mason Gaffney	Gaffney, Mason
McCaw	McCaw Cellular Communications, Inc.
MCI	MCI Telecommunications Corporation
MMR	Mobile Marine Radio, Inc.
Motorola	Motorola Inc.
MRFAC	Manufacturers Radio Frequency Advisory Committee, Inc.
MST	Association of Maximum Service Telecasters, Inc.
NAB	National Association of Broadcasters
NABER	National Association of Business and Educational Radio, Inc.
NAPTS & PBS	National Association of Public Television Stations and the Public Broadcasting Service
NASA	National Aeronautics & Space Administration
NBC	National Broadcasting Company, Inc.
Nicolaus Tideman	Tideman, Nicolaus (Virginia Polytechnic Institute and State University)
NOAA	National Oceanic and Atmospheric Administration (On behalf of the United States Department of Commerce)
Northern Telecom	Northern Telecom Inc.
NPR	National Public Radio
NSF	National Science Foundation
NSMA	National Spectrum Managers Association
NTCA	National Telephone Cooperative Association
NYNEX	NYNEX Corporation
OPASTCO	Organization for the Protection & Advancement of Small Telephone Companies
Pacific	Pacific Telesis Group
Paul Alexander	Alexander, Paul F., Arnold, MD
PRSG	Personal Radio Steering Group
RNJ	Radio New Jersey
Robert Wertime	Wertime, Robert
RTMC	Radio Technical Commission for Maritime Services
RTT	Radio Telecom & Technology, Inc.
Southwestern Bell	Southwestern Bell Corporation
Stanley I. Cohn	Cohn, Stanley I.
Telocator	Telocator
Thomas G. Reel	Reel, Thomas G.
Thomson	Thomson Consumer Electronics, Inc.

TIA	Telecommunications Industry Association, Mobile Communications Division
Tom M. Blackwell	Blackwell, Tom M.
Treasury	United States Department of Treasury
United	United Telecommunications, Inc.
UPS	United Parcel Service
USDA	United States Department of Agriculture
US West	U S West, Inc.
USTA	United States Telephone Association
UTC	Utilities Telecommunications Council
VITA	Volunteers in Technical Assistance
VOA	Voice of America
Watercom	Waterway Communications System, Inc.
WTNN	WTNN, Knoxville, TN
Zenith	Zenith Electronics Corporation

APPENDIX C NONLICENSED DEVICES

I. Introduction

Part 15 of the FCC's rules defines a class of devices that use the spectrum for which licenses are not required.^{1/} Some of these "nonlicensed" devices, like cordless telephones, transmit a signal for radiocommunications, while others, like computers, emit radio energy incidental to their operation. Because nonlicensed devices are convenient, economical, and, in most cases, readily available to the public, their use is spreading rapidly.

By limiting the radiated power of most nonlicensed devices, spectrum managers are able to permit their use to "overlay" use by allocated services without causing harmful interference. This overlay approach provides a great deal of flexibility. Although it allows the spectrum to be allocated among the licensed services, the widespread use of nonlicensed devices has raised concerns over interference.

II. Regulatory Status

The FCC's basic objective in permitting the operation of nonlicensed equipment is "effective use of the radio spectrum while providing additional technical and operational flexibility in the design, manufacture and use of non-licensed devices."^{2/} The FCC indicated that "administrative convenience" in designing this system was also desirable.^{3/}

Under FCC rules, nonlicensed devices must not cause harmful interference to, and must accept interference from, authorized radio services. This lack of status creates a particularly difficult situation when users of a licensed radio service experience interference that is partly a result of poor design of the licensed equipment, such as poor receiver design. Also, the popularity of nonlicensed devices increases the potential for interference with licensed radio services, while making consumer pressure for continued operation of the nonlicensed device a significant factor in interference resolution. ARRL states that "in the real world of high-volume retailers and residential neighborhoods, it is unrealistic to expect that interference . . . will be resolved in a manner that is entirely satisfactory to the 'protected' service."^{4/} NTIA believes that there is value in both licensed devices and nonlicensed services, and that regulatory procedures must, through ensuring reasonable compatibility, encourage the use of both.

^{1/} See 47 C.F.R. Part 15 (1990).

^{2/} Revision of Part 15 of the Rules Regarding the Operation of Radio Frequency Devices Without an Individual License, First Report and Order, 4 FCC Rcd 3493 at 3493 (1989); Memo. Opinion and Order, 5 FCC Rcd. 3492 (1990) (Part 15 Revision).

^{3/} Id. First Report and Order, at 3494.

^{4/} ARRL Comments at 23-24.

Most of those responding to the Notice support the general FCC approach and the associated convenience and status of nonlicensed devices. However, since the completion of the FCC's 1989 revision of Part 15, users have begun requesting rule changes for particular applications.^{5/}

III. Interference Potential

Some commenters express concern about specific situations where they claim interference is more probable because of the current treatment of nonlicensed devices. NBC believes that interference to televisions is particularly a problem, and that the FCC should, before permitting a new nonlicensed device to be marketed, require greater proof that the device will not cause interference.^{6/} Du Treil, Lundin & Rackley states that radio frequency lighting devices cause widespread interference in the AM band and that stricter standards should be applied.^{7/} The FAA reports having experienced interference to safety services from nonlicensed transmitters. It believes that further nonlicensed uses should not be permitted in safety-service bands.^{8/} ARRL notes that nonlicensed systems could have a significant impact on amateur radio because four of the bands designated by the FCC as consumer bands are allocated to the amateurs.^{9/} NSF states that the increased number of nonlicensed devices represents a threat to ground-based radio astronomy activities.^{10/} It mentions that sharing arrangements between radio astronomy and other services depend upon the predictability of interference and the use of distance separation. Because, separation cannot be guaranteed for nonlicensed systems, radio astronomy bands have been included in the list of restricted bands for nonlicensed, intentional radiators. Still, harmonic and spurious signals for such devices concern NSF. NSF

^{5/} For example, the FCC has responded to General Motors Research Corporation and M/A-COM, Inc. petitions requesting reconsideration of harmonic emission limits for field disturbance sensors, see Part 15 Revision, 5 FCC Rcd 6288 (1990); LBP Inc., LocRad Inc., Burden Assoc., and the Intercollegiate Broadcasting System petitions for reconsideration of field strength limits applying to carrier current, "leaky cable, and campus radio systems, see Part 15 Revision, Memo. Opinion and Order, 5 FCC Rcd 7729 (1990).

^{6/} NBC Comments at 15. However, NTIA notes that the susceptibility of inexpensive television receivers can contribute to interference cases.

^{7/} Du Treil, Lundin & Rackley Comments at 9.

^{8/} FAA Comments at 3.

^{9/} ARRL Comments at 23-24. The term "consumer bands" refers to those bands where exceptions are made to the Part 15 general field strength limits. These bands are allocated for use by Industrial, Scientific, and Medical (ISM) equipment, and licensed services operate on a secondary basis. Licensed users believe that the large scale entrance of nonlicensed devices into these bands represents a significantly increased potential for interference over that due to ISM alone.

^{10/} NSF Comments at 13-14.

recommends that the FCC further tighten field strength limits for nonlicensed devices, and believes that burdens on consumers and manufacturers from such action would be "slight."^{11/}

DOJ/JMD is concerned about the additive result of out-of-band emissions from nonlicensed systems in metropolitan areas.^{12/} NBC expresses concern over the general increase of ambient interference levels.^{13/} However, ITI argues that the negative additive effects of these systems have not been shown.^{14/}

In contrast, Interior expresses greater concern over potential interference to nonlicensed systems than interference from them.^{15/} Also, DOJ/JMD fears that the public will be inconvenienced by interference to nonlicensed systems. It believes that warning labels on Part 15 devices, describing susceptibility to interference, may be useful in educating the public about the limitations of these devices.^{16/} NPR asserts that many instances of interference to nonlicensed systems, such as garage door openers, cordless telephones, and security devices, stem from the lack of quality in the device receiver.^{17/} Southwestern Bell states that the use of digital coding on some Part 15 devices would help make them less susceptible to interference.^{18/}

NTIA is aware of cases of interference both to and from nonlicensed devices, and the FCC maintains records of reported cases. Though such reports have been few, many users do not report interference that is resolved locally.^{19/} Also, the interference from nonlicensed systems may be intermittent or difficult to identify. NTIA believes that increased reporting of interference involving nonlicensed systems would help to evaluate the extent of this claimed problem. In addition, NTIA and the FCC should develop and validate analytic techniques to determine the cumulative impact of low-power radiations. Without such documentation, NTIA and the FCC must be cautious in applying unnecessarily strict and possibly costly regulations. Even in documented cases of interference, spectrum managers must ask whether a method of dealing as a whole with nonlicensed devices can be constructed based upon a few examples. The benefit of allowing public use of inexpensive nonlicensed devices appears to outweigh such problems. Obviously, particular care must be taken in preventing interference to safety systems. The existing FCC approach appears to be working adequately, though some modification may be necessary to ensure its long-term success.

11/ NSF Comments at 14.

12/ DOJ/JMD Comments at 5.

13/ NBC Comments at 15.

14/ ITI Comments at 8.

15/ Interior Comments para. 53.

16/ DOJ/JMD Comments at 5.

17/ NPR Comments at 10.

18/ Southwestern Bell Comments at 8.

19/ In order to minimize reporting, this is a matter of standard operating procedures for many federal agency field offices.

IV. Licensing of Part 15 Devices

Some manufacturers of Part 15 devices are concerned about protecting their equipment from interference; however, licensed users often argue that those devices must be licensed to provide protection. For example, NOAA supports licensing for any device that has a safety or security requirement.^{20/}

In general, NTIA believes that licensing would make it more difficult for individuals to obtain and use Part 15 systems. Licensing includes formal procedures for considering a device's ability to operate compatibly with other users. Moreover, it requires users to understand, to varying degrees, system operation and regulatory procedures. These characteristics of licensing limit the operational flexibility and the administrative convenience that the FCC intended in Part 15. If such devices had to be licensed, the sheer numbers of users of devices that radiate intentionally, such as cordless phones, door openers, and baby monitors, would place a tremendous administrative burden on the FCC. Furthermore, many nonlicensed systems do not radiate intentionally, or can be moved to any location. Therefore, licensing does not necessarily ensure compatibility. If at all possible, licensing of each "station" should be avoided. However, other forms of documentation may be helpful. For instance, manufacturers could provide information on product lines and associated frequencies to the FCC or to a nonlicensed device industry coordinating group. This information could be useful in coordinating Part 15 uses, but also may help licensed users avoid conflicts.

V. Allocating Frequencies for Nonlicensed Systems

Based on having experienced interference from nonlicensed devices, the Air Force recommends grouping them into one band.^{21/} The concept of designating frequencies for nonlicensed systems does have some merit. For instance, the designation of 2400-2500 MHz as an ISM band has enabled the ubiquitous use of microwave ovens.^{22/} In that band, licensed services operate at their own risk. Theoretically, a similar approach could be taken with other uses that, under Part 15, are not now licensed. However, the presence of a number of nonlicensed systems operating in the same band in the same environment could pose difficulties. On the other hand, the growing variety of nonlicensed uses, particularly for mass market items, could deny more and more essential spectrum to licensed uses if each were provided a frequency or group of frequencies.

Some commenters state that some Part 15 uses should have a higher status than they now have. For instance, CSAA contends that "low power sensor devices have become too important to continue to operate at sufferance" and Part 15 should specify "a way to identify the devices

^{20/} NOAA Comments at 5.

^{21/} DOD (Air Force) Comments at 10.

^{22/} ISM equipment, covered under Part 18, also is not licensed. However, the ITU has designated bands for their use. The ISM category includes such equipment as microwave ovens, medical diathermy equipment, and industrial heaters that use radio frequency technology to treat materials.

whose operations warrant protection from interference, not only from other low-power devices but also from the licensed services."^{23/} ITI recommends that spectrum should be set aside for alarm devices.^{24/} CSAA suggests that the FCC prioritize its treatment of nonlicensed devices, providing more interference protection to safety or emergency systems than to those used for entertainment, convenience, and business. CSAA believes that the FCC's effort to simplify the Part 15 rules has had a negative impact.^{25/}

For NTIA to conclude that specific types of nonlicensed devices should be provided frequencies or a more protected status than currently available under Part 15, we would have to balance the benefits to the public for such protection against its costs, including potentially substantial costs of relocating to new bands current Part 15 devices and licensed users. Such an analysis requires, among other things, interference data that documents actual incidents and the nature of the interference interaction that caused them. Without such data, it is difficult to determine sources of the interference and to select the proper solution. Such data did not appear in the record.

Though many other countries have specifically designated frequencies for individual uses, these regulations were written piecemeal as the growth of these systems was being experienced. That approach may no longer be adequate. Currently, the International Electrotechnical Commission (IEC) is considering adoption of a generic standard that applies to all equipment not covered by other standards. The result would be a "Part 15-like" treatment of many devices through general field strength limits.

VI. Standards as a Safeguard

Additional standards for could be used as another approach to dealing with the interference from nonlicensed devices. However, this method could add unnecessary costs. NTIA believes that Part 15 transmitter standards covering field strength levels are adequate. However, in some cases, receiver characteristics, both of nonlicensed equipment and licensed equipment, contribute to the problem. In a world of growing spectrum use, NTIA believes that manufacturers of nonlicensed devices and of licensed equipment should account for inevitable increases in radio noise and potential interference by paying greater attention to receiver susceptibility. Industry rating and labeling nonlicensed equipment to indicate product susceptibility to interference, or to warn buyers of interference potential could be helpful.

The manufacturers and users of nonlicensed devices should match the interference suppression capabilities of their equipment to the function performed. For example, equipment used for emergency or security purposes, such as health monitors used for protection of life, or security systems linked to police departments, should be of high quality. Security alarms, used strictly to frighten burglars, could be susceptible to interference-driven false alarms yet inexpensive, and still be useful to the customer. On the other hand, an alarm designed to alert the local police probably should not be susceptible. These design considerations directly impact equipment markets. However, alteration of the existing Part 15 regulations to grant protection

^{23/} CSAA Comments at 11.

^{24/} ITI Comments at 2.

^{25/} CSAA Comments at 11-12.

for these devices, and thereby minimize costs to nonlicensed device manufacturers and users, could work to the detriment of licensed use.

VII. Planning and Nonlicensed Devices

Proper planning in the design of Part 15 devices could eliminate problems by enabling manufacturers to select frequencies that would result in interference-free use. This is particularly important for intentional radiators, but can also be concern for other nonlicensed devices.^{26/} However, guidance given within the FCC rules is inadequate to aid in this planning process. Manufacturers are "advised to consider the proximity and the high power of non-Government licensed radio stations, such as broadcasting, amateur and land mobile stations, and of U.S. Government radio stations when choosing operating frequencies during the design of their equipment so as to reduce the susceptibility for receiving harmful interference" by "consulting the Table of Frequency Allocations in Section 2.106 of the Chapter" for information on non-federal users, and by "contacting: Director, Spectrum Plans and Policy, NTIA...." for information on federal use.^{27/} Mere consultation of the allocation tables provides little help in determining the proximity and power of non-federal systems. NTIA has established a procedure for supplying, in response to non-federal requests, summaries of federal use, but those summaries can only provide general information.

More specific, in-depth, analysis is needed to avoid conflicts. Many aspects of the problem should be investigated. First, considering the characteristics of a new nonlicensed system, are there any particular services that are innately compatible with the nonlicensed device in question? For example, if a satellite band is used, does the direction of the satellite transmission lessen the potential for interference to the nonlicensed device? Data openness concepts discussed in Chapter 2 may help equipment designers in their selections of appropriate spectrum bands.

Some cases of interference to nonlicensed systems have been due to the operation of other nonlicensed systems. An intra-industry coordinating group is a reasonable and simple approach to alleviating these issues. One approach that it could take would be to require manufacturers to prioritize their devices. If necessary this issue could be addressed by the FCC through a notice of inquiry.

^{26/} Recently, the United States raised concerns in CCIR Study Group 8 as to the impact of harmonic radiation from the MAC Packet Decoder, an internal device found in European designs for advanced technology television.

^{27/} 47 C.F.R. § 15.17 (1990).

VIII. Planning and Licensed Systems

The UTC recommends that radio communications users consider the operations of essential nonlicensed operations before planning services.^{28/} However, while licensed frequency use is documented in NTIA and FCC data files, nonlicensed use, in most cases, is not.^{29/} Therefore, the benefits of communications equipment developers researching the characteristics of nonlicensed devices would be limited. As noted earlier, NTIA believes that manufacturer listing of operating frequencies for intentional radiators with the FCC could serve as a useful database. Though they are not required to avoid interference to Part 15, licensed users could use this data to help avoid conflicts.

IX. Conclusions and Recommendations

NTIA supports the existing FCC approach for overlaying the use of nonlicensed devices across the allocated bands, believing it to be efficient and effective. It generally provides licensed users adequate interference protection, and the nonlicensed users flexibility and a light regulatory burden. However, some modification may be necessary to ensure its long-term success.

Licensing of these systems is not generally desirable. The costs to users in added time and expense, and the administrative burden that would be place on the FCC, would be too great. NTIA recommends that manufacturers provide information on product lines and associated frequencies to the FCC or to a nonlicensed device industry coordinating group to help coordinate Part 15 uses, and to identify, for licensed users, the frequencies on which nonlicensed devices operate.

Specifying frequencies for at least some nonlicensed devices could be desirable if spectrum were available and if a need for special protection of a particular device can be demonstrated to be in the public interest. However, the existence of interference problems must be well documented, not based strictly on a few cases.

In an environment of growing spectrum use, manufacturers of nonlicensed devices and licensed equipment should give greater attention, during device design, to interference susceptibility.

Manufacturers should base their selection of frequencies for Part 15 devices on in-depth analysis. Frequencies chosen for any device that may find widespread use by consumers must be carefully examined for potential interference.

Industry representatives should form a coordinating group to establish priorities among different nonlicensed devices and to help ensure that conflicts between Part 15 devices do not occur. The prioritization of nonlicensed devices may need to be considered by the FCC through the issuance of a notice of inquiry.

^{28/} UTC Comments at 17. UTC apparently refers to the current conflict between growing terrestrial and aeronautical use of LORAN-C and power-line-carrier systems operating near 100 kHz. Both the national power system and aviation navigation have public safety requirements.

^{29/} Power-line-carrier is the one notable exception.

Resolution of interference should continue to occur on a case-by-case basis. Interference from licensed use to large numbers of nonlicensed users is the most difficult to resolve. Proper planning must attempt to avoid these situations because resolution, in some cases, may not prove totally satisfactory to either licensed users or the manufacturers of susceptible nonlicensed devices, and it can be difficult for licensed users to enforce their ostensible rights.

Documentation of all cases of nonlicensed device interference, even those resolved locally among parties, should be provided to NTIA and the FCC for evaluation of Part 15 devices from an interference standpoint.

NTIA and the FCC should develop and validate analytic techniques to determine the cumulative interference impact of low-power radiations.

APPENDIX D

ESTIMATING THE VALUE OF CELLULAR LICENSES

I. Introduction

This Appendix describes two methodologies that were employed to estimate the current value of a particular portion of spectrum used for a designated purpose -- cellular telephone service. The steps necessary to derive these estimates illustrate the difficulty in estimating spectrum value.

II. Estimating the Current Value of Cellular Licenses in Urban Areas

There are numerous methods of estimating the value that firms place on an operating license, all of which suffer from one weakness or another.^{1/} One of the major problems in estimating the value of cellular licenses is to distinguish between the financial returns attributable to the spectrum input, and those returns attributable to the firm's other production inputs (e.g., capital, management).^{2/}

We employ two methodologies to estimate the current value of the 50 MHz of spectrum devoted to cellular uses in Metropolitan Statistical Areas (MSAs).^{3/} Both methodologies attempt to isolate the value of cellular licenses in MSAs by subtracting the value of other firm assets from the total market value of cellular firms. The first methodology derives total market value from recent sales of cellular franchises in MSAs, while the second derives market value from the stock price of firms that have cellular franchises in MSAs.

A. Methodology Based on Recent Sales Transactions

The first methodology employed to estimate the value of cellular telephone licenses in MSAs involves estimating the aggregate (i.e., total industry) market value of firms providing cellular service in urban areas, based on recent sales transactions, and the aggregate replacement cost of the tangible assets used by those firms. Because the market value should reflect payments made to all inputs (including spectrum) and the replacement cost reflects the cost of replacing all tangible assets, the difference provides an upper bound on the value that cellular providers place on spectrum. In particular, the difference between aggregate market value and aggregate replacement cost provides an estimate of the discounted value of the expected future earnings of the industry.

1/ See generally D. Webbink, The Value of the Frequency Spectrum Allocated to Specific Uses, IEEE Transactions on Electromagnetic Compatibility, Vol. EMC-19 (Aug. 1977).

2/ According to production theory, the value that a firm places on an input depends upon its contribution to revenues; the greater its contribution to revenues, the more valuable it is to the firm.

3/ We have not attempted to estimate the value of cellular licenses in rural service areas (RSAs).

1. Total Market Value Estimates

We used a multi-step procedure to derive an estimate of total market value of cellular properties in MSAs. First, we obtained recent sales prices for a sample of 24 cellular properties.^{4/} Then, because of limitations in the available data, including the "skewness" in the distribution of sales prices and populations served, we divided the sample into three market size categories: large markets (population over 500,000), medium markets (population from 162,501 to 500,000), and small markets (population 162,500 or less). For each category, we calculated a weighted average sales price (expressed in terms of price "per pop"), with the weights equalling the percent of the population represented by each property.^{5/} These values are provided in Table 1.

TABLE 1

<u>Market Size</u>	<u>Average Sales Price</u> (per pop)
Small	\$131.46
Medium	\$168.62
Large	\$250.98

Given the above information, the total market value of cellular properties in MSAs can be calculated by following a three-step procedure. First, we multiplied the average price "per pop" by the total population in each market size category.^{6/} Second, we summed the resulting products of each multiplication. Third, we multiplied this sum by a factor of two to reflect the current duopoly structure of the cellular market. According to these calculations, the total market value of cellular properties in urban areas is approximately \$86,660,800,000.

4/ Typically, financial analysts express the value of cellular properties as a function of the population potentially served in the franchise area (measured per person, or "pop"). We relied upon the sales price "per pop" figures reported by one leading industry analyst, Paul Kagan Associates, for 24 sales of cellular franchises in MSAs in 1990. See Paul Kagan, Cellular Investor, Feb. 22, 1990, at 10; id., Apr. 23, 1990, at 9; id., May 24, 1990, at 10; id., July 27, 1990, at 3, 9; id., Oct. 29, 1990, at 6; id., Nov. 16, 1990, at 3; id., Jan. 31, 1991, at 10; Paul Kagan, Cellular Investor News Roundup, Apr. 23, 1990, at 2. According to Paul Kagan Associates, the sales prices reported in its newsletter reflect the price paid for both the cellular license and all other assets of the licenseholder that change hands. For some of these transactions, information is not available on whether the payment terms included non-cash elements such as the transfer of stock or assumption of debt at below market interest rates.

5/ We obtained data to construct these weights from Smith Barney, The Cellular Industry: A Reevaluation, Apr. 3, 1990, at 4-8 (relying on 1989 MSA population data obtained from Donnelley Marketing Information Services).

6/ In 1989, the MSAs in the small market category had a total population of 11,990,000, the MSAs in the medium market category had a total population of 33,407,500, and the MSAs in the large market category had a total population of 143,920,000. See Smith Barney, supra note 5, at 4-8.

2. Total Replacement Cost Estimates

Estimates of total replacement cost are based on research conducted by Shew (1990).^{7/} Shew (1990) followed a three-step procedure to derive an estimate of the total replacement cost of tangible assets of firms in the cellular industry. First, Shew (1990) obtained from Malarkey-Taylor an engineering estimate of the reproduction cost of plant and equipment for each class of cellular property (i.e., small, medium, and large).^{8/} These estimates, on a "per pop" basis, are shown in Table 2.

TABLE 2

<u>Market Size</u>	<u>Reproduction Cost</u> (per pop)
Small	\$ 13.72
Medium	\$ 9.48
Large	\$ 12.95

Second, to account for the fact that existing plant acquired in a sale is partially depreciated, Shew (1990) adjusted those reproduction costs for depreciation.^{9/} The resulting estimates of the replacement cost of depreciable tangible assets are shown in Table 3.^{10/}

TABLE 3

<u>Market Size</u>	<u>Replacement Cost of</u> <u>Depreciable Tangible Assets</u> (per pop)
Small	\$ 11.26
Medium	\$ 7.78
Large	\$ 10.63

^{7/} Shew, W., Tobin's Q For Cable Television, Media and Telecommunications: A Comparative Assessment, filed as Appendix A, Reply Comments of Time-Warner (filed Apr. 2, 1990) in Competition, Rate Deregulation, and the Commission's Policies Relating to the Provision of Cable Television, MM Docket No. 89-600.

^{8/} Malarkey-Taylor is an engineering consulting firm located in Washington, D. C. that specializes in estimating the value of media and telecommunications properties.

^{9/} Shew (1990) obtained five annual observations on the ratio of net to gross plant. He concluded that the most recent observation -- in which net plant represented .821 of gross plant for Vanguard Cellular Systems Inc. in 1988 -- represented a conservative estimate of the amount of accumulated depreciation in the cellular industry.

^{10/} We derived the values in Table 3 by multiplying the values in Table 2 by .821 for each size class.

Third, Shew (1990) estimated the value of other, nondepreciable tangible assets, defined as the difference between the total book value of tangible assets and net plant.^{11/} Our estimates of these "other assets" are shown in Table 4.

TABLE 4

<u>Market Size</u>	<u>Replacement Cost of Other Tangible Assets</u> (per pop)
Small	\$ 8.41
Medium	\$ 5.81
Large	\$ 7.94

Finally, we derived an estimate of the total replacement cost of all tangible assets, expressed on a "per pop" basis, by adding the values in Tables 3 and 4. These estimates are provided in Table 5.

TABLE 5

<u>Market Size</u>	<u>Total Replacement Cost of All Tangible Assets</u> (per pop)
Small	\$ 19.67
Medium	\$ 13.59
Large	\$ 18.57

The total replacement cost of the tangible assets of firms providing cellular service in urban areas can be calculated by following a three-step procedure. First, we multiplied the total replacement cost "per pop" times the total population in each market size category. Second, we summed the resulting products of each multiplication. Third, we multiplied this sum by a factor of two to reflect the current duopoly structure of the cellular market. According to these calculations, the total replacement cost of the tangible assets of cellular firms with MSA licenses is approximately \$6,724,900,000.^{12/}

^{11/} Using balance sheet data for a sample of four cellular firms, Shew (1990) calculated the weighted average of the ratio of other tangible assets to net plant to be .747. Given this information, we derived the replacement cost of other tangible assets by multiplying .747 times the replacement cost of the tangible assets, as listed in Table 3.

^{12/} This estimate is similar to others developed by industry observers. See AT&T Receives \$600 Million Job from GTE, The Wall Street Journal, Dec. 14, 1990, at B9 (total capital invested to date in the cellular industry is about \$5.2 billion). This \$5.2 billion figure may not take into account depreciation of tangible assets.

3. Value of Cellular Licenses in MSAs

Subtraction of the estimate of total replacement cost from the estimate of total market value is an economically defensible measure of the value that current cellular operators in MSAs place on their licenses (i.e., the spectrum). This calculation is shown in Table 6.

TABLE 6

Estimated Total Market Value	\$86,660,800,000
Estimated Total Replacement Cost	<u>\$ 6,724,900,000</u>
Estimated Spectrum Value	\$79,935,900,000

This estimate of the value of urban cellular licenses represents an "upper bound" to the extent that it also includes other non-depreciable assets (e.g., goodwill). However, based on discussions with financial analysts and our own study of cellular properties, a large majority of the difference represents the value that cellular operators place on the spectrum.

This estimate of spectrum value in urban areas has two important strengths over other methods of estimation. First, we utilized estimates of average replacement cost and sales price "per pop" for three specific classes of cellular properties. This permitted more precise estimates of total market value and total replacement cost than estimates based on more aggregate averages. Second, consistent with economic theory, we adjusted the total market value of cellular properties for the cost of replacing tangible assets. This adjustment eliminates the upward bias associated with equating total market value to license value.

B. Methodology Based on Stock Market Prices

An alternative methodology to estimate the aggregate market value of cellular licenses in urban areas is based on the "public market" value of cellular firms. This benchmark represents the implicit valuation by equity shareholders of a firm's cellular licenses in MSAs.

1. Derivation of Public Market Values

The public market valuation benchmark is derived from the stock trading price of firms with cellular holdings. The methodology used is as follows.^{13/} First, the total market value of the company is computed by multiplying the number of shares outstanding by the current stock price. Second, the total capitalized value of the enterprise is calculated by adding in long-term debt (what the company owes to others). Third, the value of the firm's other assets (such as working capital, net property, plant and equipment, RSA holdings, and any non-cellular operations) is estimated,^{14/} which then is subtracted from the total value of the firm; the resulting figure represents the value of the firm's MSA licenses. Fourth, the aggregate value

^{13/} See, e.g., Bear Stearns, Cellular Mobile Industry, Part XVI, Investment Review and Strategy, Oct. 12, 1990, at 3 (Table I); Donaldson, Lufkin & Jenrette, The Cellular Communications Industry, Winter 1990-91, at 43 (Table 13); Smith Barney, supra note 5 at 11 (Table 7).

^{14/} Financial analysts typically assign a value figure to such assets based on information set forth in the company's financial statements.

of the firm's licenses is divided by the number of MSA pops attributable to the company to arrive at an "implied value per pop."

2. Recent Estimates of Public Market Values

Based on February 8, 1991 stock prices, the implied value of the MSA licenses held by a sample of ten cellular companies ranged from \$62 "per pop" for United States Cellular to \$199 "per pop" for LIN Broadcasting.^{15/} The weighted average for these ten companies was \$122 "per pop."

Given the above information, the total market value of cellular licenses in MSAs can be calculated by following a two-step procedure. First, we multiplied the weighted average value of \$122 "per pop" by the estimated 1989 total urban population of 190 million.^{16/} Second, we multiplied this sum by a factor of two to reflect the current duopoly structure of the cellular market. According to these calculations, the aggregate market value of cellular licenses in MSAs is approximately \$46,360,000,000.

C. Summary of Results

In some sense, each methodology represents a different, but complementary indicator of the economic worth of a firm. Under one methodology, the estimated aggregate value of spectrum used to provide cellular telephone service in urban areas is close to \$80 billion; under the other methodology, the estimated aggregate spectrum value is \$46 billion.^{17/} It is not surprising that the estimate of spectrum value based on stock prices is lower than the estimate based on actual sales transactions: across industries, equity shareholders often place a lower value on firms than does the transaction marketplace. One reason why this may be true is that the purchaser of a cellular property is likely to have better information about the true value of the franchise than do equity shareholders, and is willing to pay more to acquire control of the franchise. Furthermore, the purchaser may be able to make more efficient use of the firm's assets (e.g., through economies of scope and scale or managerial expertise) than the seller can, which enables the purchaser to pay a "premium" above the prevailing per share stock price in order to ensure acquisition of control. In any event, as a practical matter, the average price per share paid in acquisitions of all, or a controlling interest in, the stock of a company generally exceeds the price at which shares were trading prior to the acquisition activity.

^{15/} Material supplied by Donaldson, Lufkin & Jenrette.

^{16/} Smith Barney, supra note 5 at 8.

^{17/} These estimates of spectrum value in urban areas reflect the existing duopoly market structure. If additional competitors were to enter the market, the profits of cellular providers would presumably fall (i.e., the monopoly rents would drop), so that the value of spectrum devoted to cellular uses would likely be lower.

APPENDIX E SPECIFIC REGULATIONS APPLICABLE TO BROADCASTERS

Radio and television broadcasters must comply with a number of specific requirements that are directly relevant to a determination of whether they serve the "public interest, convenience, and necessity" (the "public interest").^{1/} These requirements are imposed by the Communications Act, (the Act)^{2/}, other provisions of the U.S. Code, or through FCC rules, policies, and decisions. The following is a summary of these requirements.^{3/}

I. Programming

Radio and television broadcasters have an obligation to provide programming that meets the needs of their communities.^{4/} "The method to be utilized in meeting this obligation is largely entrusted to the good faith discretion of each licensee."^{5/} A television licensee "in the exercise of its good faith judgment, will be able to address issues by whatever program mix it believes is appropriate in order to be responsive to the needs of its community."^{6/}

The FCC requires that applicants for a television broadcasting license provide a "narrative statement of their proposed programming."^{7/}

II. Local Public Inspection File

Radio and television licensees must maintain a file for inspection by the public,^{8/} which contains, among other things, a programming content log to be filed every three months, that

^{1/} See 47 U.S.C. §§ 302a (1988).

^{2/} See, e.g., *id.* §§ 312(a)(7) (administrative sanctions); 315 (equal opportunity for political broadcasting); 317 (announcements regarding certain broadcasts).

^{3/} Broadcasters, similar to other licensees, are subject to procedural requirements as well. See *id.* §§ 307(c) (term of licenses); 309 (action upon applications); 311 (application and renewal process); 325 (rebroadcasts).

^{4/} The Revision of Programming and Commercialization Policies, Ascertainment Requirements, and Program Log Requirements for Commercial Television Stations, Report and Order, 98 FCC 2d 1076, 1091 (1984), recon. denied, 104 FCC 2d 358 (1986) ("Commercial TV").

^{5/} Deregulation of Radio, Second Report and Order, 96 FCC 2d 930, 931 (1984).

^{6/} Commercial TV, *supra* note 4, 98 FCC 2d at 1092.

^{7/} 47 C.F.R. § 0.283(a)(7)(i)(A)(1989).

^{8/} *Id.* § 73.1800.

lists programs that have provided the station's most significant treatment of community issues during the preceding three month period. The list shall include "a brief narrative describing what issues were given significant treatment and the programming that provided this treatment."^{9/} The licensee should include in its description the time, date, duration, and title of each of the listed programs.^{10/} The licensee must retain the log for two years. The two year period may be extended if the log involves communications incident to a disaster or an FCC investigation.^{11/}

In addition, radio and television broadcast licensees are required to retain in their public files copies of applications filed with the FCC;^{12/} ownership reports;^{13/} records concerning broadcasts by candidates for public office;^{14/} annual employment reports;^{15/} letters from the public;^{16/} and notices of renewal filings.^{17/}

III. Ascertainment

Under the old rules, applicants for broadcast licenses were required to follow specific formal ascertainment procedures.^{18/} Under the current rules, applicants for new and renewal television licenses "may determine the issues in their community that warrant consideration by whatever means they consider appropriate. The FCC will not request "standardized documentation and submission of these efforts."^{19/}

Applicants for renewal radio licensees are obligated to determine the issues facing their communities by "reasonable means."^{20/}

^{9/} Id. § 73.3526(a)(9).

^{10/} Id.

^{11/} Id. § 73.1840(a).

^{12/} Id. §§ 73.3526 (a)(1), (a)(2).

^{13/} Id. § 73.3526(a)(3).

^{14/} Id. § 73.3526(a)(4).

^{15/} Id. § 73.3526(a)(5).

^{16/} Id. § 73.3526(a)(7).

^{17/} Id. § 73.3526(a)(10).

^{18/} See, e.g., Commercial TV, supra note 4, 98 FCC 2d at 1097-98.

^{19/} Id. at 1098.

^{20/} Deregulation of Radio, Report and Order, 84 FCC 2d 968, 971 (1981).

IV. License Renewal Forms

In 1981, the FCC instituted a "postcard" renewal application for licensees.^{21/} In 1984, the FCC similarly instituted short form requirements for television licensees.^{22/}

The postcard renewal form, while less lengthy than the previous renewal forms, still contains several questions relevant to the "public interest" obligation. The renewal form requires a licensee to provide: (1) information on the licensee's equal opportunity programs; (2) a description of the licensee's other media interests; (3) a certification of compliance with the Act's alien ownership requirements; (4) information about a licensee's character; and (5) a certification that the licensee included all required materials in its file.^{23/}

V. Personal Attacks

When an attack is made on the character or integrity of an individual or group during a broadcaster's presentation of views on a controversial issue of public importance, the broadcaster must notify the attacked individual or group and allow that party a reasonable opportunity to respond.^{24/} This rule does not apply if the attack is made by a political candidate or parties acting on his or her behalf, during a newscast or news interview, or against a foreign group or foreign public figure.^{25/}

VI. Political Advertising

Broadcasters must provide competing legally qualified political candidates equal access to their stations and broadcasters may not censor candidates' campaign announcements.^{26/} Broadcasters must offer legally qualified political candidates the lowest advertising rates available during the 45 days preceding a primary and the 60 days preceding a general election.^{27/} The FCC may revoke a station's license if the station willfully or repeatedly fails to allow a candidate reasonable access or to purchase air time.^{28/}

21/ Radio Broadcast Services: Revision of Applications for Renewal of License of Commercial and Noncommercial AM, FM, and Television Licensees, Report and Order, 46 Fed. Reg. 26,236, 49 Rad. Reg.2d (P&F) 740 (1981).

22/ Commercial TV, supra note 4, 98 FCC 2d at 1111-1112.

23/ See Black Citizens For A Fair Media v. FCC, 719 F.2d 407, 414 (D.C. Cir. 1983) (upholding the streamlined renewal process), cert. denied, 467 U.S. 1255 (1984).

24/ 47 C.F.R. § 73.1920(a) (1989).

25/ Id. § 73.1920(b).

26/ 47 U.S.C. § 315(a) (1988).

27/ Id. § 315(b); 47 C.F.R. § 73.1940(b)(1).

28/ 47 U.S.C. § 312(a)(7) (1988).

VII. Political Editorials

A broadcaster must offer a political candidate "reasonable opportunity" to respond when the station either endorses or opposes another candidate in an editorial.^{29/}

VII. Children's Television

Congress recently enacted the Children's Television Act of 1990^{30/}, which institutes commercialization limits and children's programming recommendations for broadcasters. The Act limits commercials on children's television to 10½ minutes per hour on weekends and 12 minutes on weekdays. Additionally, the Act requires the FCC to consider whether a station has provided programming serving the "educational and informational needs of children" when deciding whether to renew the station's license.

The FCC has undertaken a rulemaking proceeding to conform FCC regulations to the new Act.^{31/} The FCC has proposed adopting children's television advertising limitations of 10½ and 12 minutes per hour on weekends and weekdays, respectively, and limiting program-length commercials.^{32/} Under the proposed rule changes, the FCC would require stations to assess children's needs using four criteria: (1) the local community's circumstances; (2) the licensee's other programming; (3) programming by other broadcasters in the community; and (4) other programming, such as cable, available to children in that area. Licensees would have to submit records on their children's programming along with their renewal applications.^{33/}

IX. Emergency Broadcasting

All broadcast stations participating in the Emergency Broadcast System (EBS) may operate during emergency situations for the purpose of providing the President, the federal government or state and local governments a means of communicating to the public.^{34/} Upon activation of the EBS at the national level, all non-participating radio and television stations must broadcast the EBS Attention Signal and the appropriate EBS message and then remove their carriers from the air.^{35/} In addition, for state and local level emergencies, all licensees

^{29/} 47 C.F.R. § 73.1930(a) (1989).

^{30/} Children's Television Act of 1990, Pub. L. No. 101-437, 104 Stat. 996 (1990).

^{31/} Policies and Rules Concerning Children's Television Programming, Notice of Proposed Rulemaking, 5 FCC Rcd. 7199 (1990) ("Children's TV").

^{32/} See id., 5 FCC Rcd 7199 at para. 2.

^{33/} Id. para. 8.

^{34/} 47 C.F.R. § 73.902 (1989).

^{35/} Id. § 73.918.

may, at the discretion of management, discontinue normal programming and transmit emergency announcements.^{36/}

X. Minority Programs

The FCC encourages minority ownership of broadcast media through tax certificates and special distress sales for minority-owned groups.^{37/} Additionally, in the comparative hearing process the FCC awards priority to license applicants with minority or female ownership.^{38/} The Supreme Court recently upheld the constitutionality of the distress sale and comparative preference doctrines.^{39/}

Once the FCC awards a station a broadcast license, the station must comply with the FCC's Equal Opportunity requirements. Under the FCC's rules, "[e]ach broadcast station shall establish, maintain, and carry out a positive continuing program of specific practices designed to ensure equal opportunity in every aspect of station employment policy and practice."^{40/}

XI. Miscellaneous Provisions

A. Advertiser/Sponsor Identification

For each sponsored broadcast matter, radio and television stations must announce that the matter was paid for in whole or part and the party by whom or for whom the ad was purchased.^{41/} For commercial products, an announcement stating the sponsor's corporate name or the name of the product must be made.^{42/}

B. Lotteries

Generally, licensees may not broadcast advertisements or information concerning lotteries or games of chance. However, in certain circumstances a licensee may advertise lotteries run

^{36/} Id. §§ 73.936(d), 73.937(d). See also id. § 73.1250(b) (station may transmit emergency point-to-point messages at its own discretion if requested by public officials).

^{37/} Statement of Policy on Minority Ownership of Broadcasting Facilities, 68 FCC 2d 979 (1978), clarified, 44 RR 2d 479 (1978).

^{38/} WPIX Inc., New York, 68 FCC 2d 381, 411-12 (1978) (minority enhancement); Mid-Florida Television Corp., 69 FCC 2d 607, 652 (Rev. Bd. 1978), set aside on other grounds, 87 FCC 2d 203 (1981) (female enhancement).

^{39/} See Metro Broadcasting v. FCC, 110 S.Ct. 2997, reh. den., 111 S.Ct. 15 (1990).

^{40/} 47 C.F.R. § 73.2080 (1989).

^{41/} See 47 U.S.C. § 317 (1988); 47 C.F.R. § 73.1212(a) (1989).

^{42/} 47 C.F.R. § 73.1212(f) (1989).

by a state, a charitable organization, or, if a promotional lottery, run by a commercial organization.^{43/}

C. Obscenity and Indecency

Under 18 U.S.C. § 1464, "[w]hoever utters any obscene, indecent, or profane language by means of radio communication shall be fined not more than \$10,000 or imprisoned not more than two years, or both."^{44/} The FCC enforces § 1464 for indecent programming aired before 8 p.m. and for obscene programming aired anytime day or night. The FCC is seeking to enforce a 24-hour ban of indecent programming.^{45/}

D. Public Notice of Broadcast Applications

A radio or television licensee who files for license renewal "must give notice of this filing by broadcasting announcements on applicant's stations."^{46/} Licensees must air specific renewal announcements on the 1st and 16th of each calendar month commencing with the sixth month prior to the renewal. The FCC requires licensees to air as many as five daily announcements.^{47/}

E. Station Identification

Television and radio stations must broadcast station identification announcements hourly, as close to the hour as feasible, and at the beginning and end of each broadcast day.^{48/}

F. Minimum Operating Schedule

Radio stations are required to operate at least two-thirds of the total hours they are authorized to operate between 6 a.m. and midnight.^{49/} After 36 months of operation, television stations are required to operate at least 28 hours per week.^{50/}

^{43/} Id. § 73.121.1 (amended May 7, 1990).

^{44/} 18 U.S.C. § 1464 (1988). See also 47 C.F.R. §§ 73.4165, 73.4170 (1989).

^{45/} See Enforcement of Prohibitions Against Broadcast Indecency in 18 U.S.C. § 1464, 5 FCC Rcd 5279 (1990). The 24-hour ban has been stayed by the Court of Appeals pending judicial review. See Action for Children's Television v FCC, No. 88-1916 (D.C. Cir. Jan. 23, 1989) (stay order).

^{46/} 47 C.F.R. § 73.3580(d)(1) (1989).

^{47/} Id. § 73.3580(d)(4).

^{48/} Id. § 73.1201.

^{49/} Id. § 73.1740(a)(1).

^{50/} Id. § 73.1740(a)(2)(ii).

G. Cigarette and Smokeless Tobacco Advertisements

Broadcasters may not air cigarette or smokeless tobacco commercials. Since 1971, it has been "unlawful to advertise cigarettes and little cigars on any medium of electronic communication subject to the jurisdiction of the Federal Communications Commission,"^{51/} and a similar law applies for smokeless tobacco.^{52/}

^{51/} See 15 U.S.C. § 4402(f) (West Supp. 1990).

^{52/} See 15 U.S.C. § 4402(f) (1988).

APPENDIX F

EXAMPLES OF SPECTRUM USE QUANTIFICATION

Chapter 5 describes how the quantity of spectrum resources used by radiocommunication systems can be calculated. This Appendix shows how spectrum use can be represented, and describes how it can be calculated, for a single system and for the aggregate of systems in a frequency band.

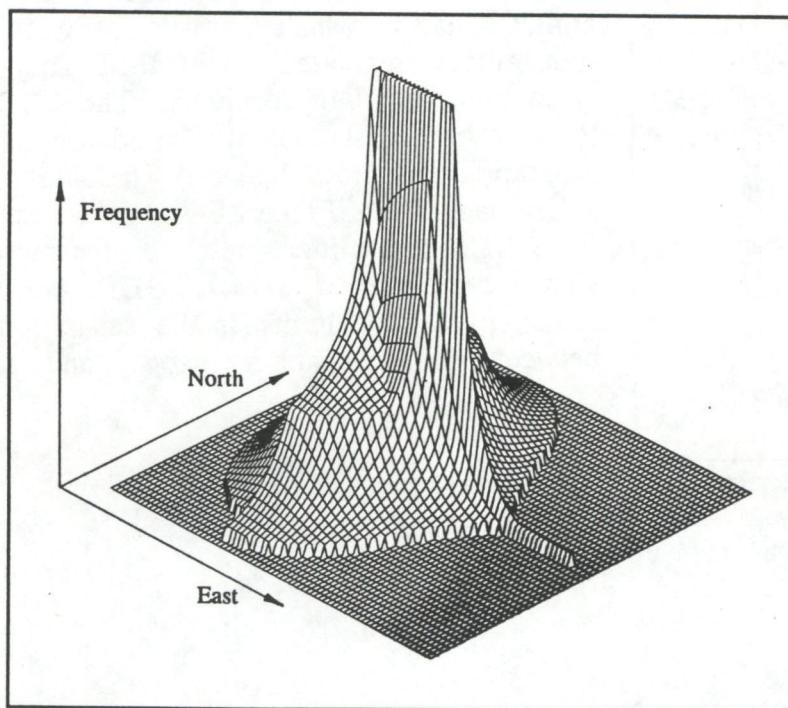


Figure F-1. Spectrum resources used by a microwave radio-relay transmitter.

Figure F-1 shows a surface enclosing the spectrum resources used by a microwave radio-relay transmitter in a three-dimensional spectrum resource space, based on a power density criterion.^{1/} The horizontal dimensions are spatial (distance east and north of the origin) while the height represents frequency separation. At locations and frequencies inside the surface, the power density exceeds the criterion. In the antenna mainbeam direction, the signal strength is maintained over a greater distance, as shown by the eastward protrusion.^{2/} A similar volume below the plane is used by the transmitter but is not shown in this figure.

^{1/} See *supra*, Chapter 5, for a discussion of the criteria used to evaluate spectrum use.

^{2/} The diagram is simplified in that it uses an envelope antenna pattern and does not include effects such as intermodulation and harmonics.

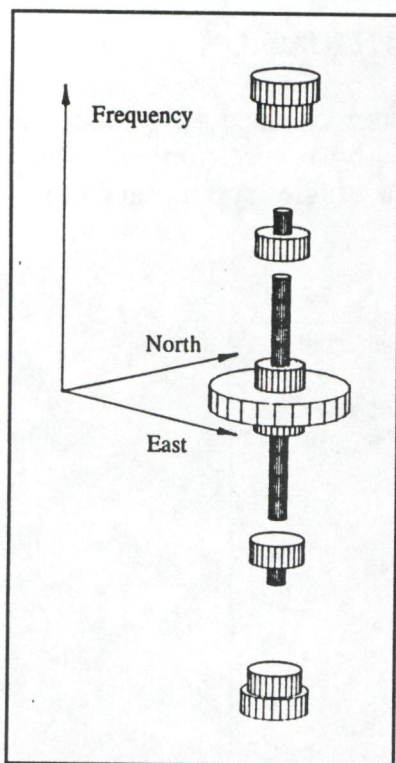


Figure F-2. Spectrum resources used by a UHF television transmitter in Zone I.

The quantity of spectrum resources used by this transmitter is twice the volume enclosed by the surface shown (since the same quantity is used below the plane). This value would be calculated using approximate (numerical) integration techniques, and could be expressed in units of MHz-km².^{3/}

A second example is the UHF television system in the United States, which consists of a number of broadcast transmitters, regulated by the FCC, and millions of essentially unregulated UHF receivers. The FCC assigns frequencies to new broadcast stations based on a system of required separation distances between stations, commonly called the "UHF taboos".^{4/} Figure F-2 shows a spectrum use diagram for a UHF transmitter, based on the taboos.^{5/} Each cylinder shown represents a 6 MHz UHF television channel. The radius of each cylinder is the separation distance required between the transmitter shown and the nearest existing

3/ See R.H. Haines, Quantification of Spectrum Use: Spectrum Management Tools for the Twenty-first Century, 1990 International Symposium on Electromagnetic Compatibility -- Symposium Record, The Institute of Electrical and Electronics Engineers, Inc., New York, at 390, 390 1990. (Haines, Quantification). The "spectrum resources used" can be calculated based on denial of a specifically defined reference system or on the emissions of transmitters and the susceptibility of receivers. If the simplified approach were used, eliminating all dimensions other than frequency and space (see supra Chapter 5), the figure would have a uniform height above the plane.

4/ 47 CFR. §§ 73.610, 73.698 (1990).

5/ The co-channel separation distance shown applies to Zone I, an area encompassing most of the northeastern U.S. and extending westward to Illinois. The separation distances required for Zone II (all U.S. areas not included in Zones I and III) and Zone III (the region of the U.S. bordering the Gulf of Mexico) are somewhat greater. Maps of the zones are found in 47 CFR. § 73.699 (1990). The example assumes that all the adjacent channels shown are in the UHF television band.

transmitter on that channel.^{6/} The total spectrum resources used (the volume enclosed) is roughly 2.9 million MHz-km². Of that total, the cochannel spectrum use (represented by the broad cylinder in the center) accounts for 1.2 million MHz-km² or 41%. In other words, well over half of the spectrum use lies outside the assigned channel.

In both of these examples, the spectrum resource space has dimensions of frequency and space. Portrayal of the time dimension is not necessary, since microwave radio relay and UHF television systems generally operate continuously.^{7/} For radio services that operate intermittently, however, the time dimension is important. A mobile system, for example, uses a frequency channel over a wide area, but only for short periods. Often several systems will share a channel, each using spectrum resources proportional to the fraction of time it uses the channel.

Spectrum use can also be quantified for the aggregate of communications systems in a frequency band within an area of interest (e.g., the United States, as shown in Figure F-3). In this case, spectrum use is determined at each of a large number of geographic points as the fraction of spectrum resources used at that point. This value is known as the spectrum use factor (SUF). SUF values can be portrayed on a map as shown in the figure.^{8/}

Averaging the SUF values over the area being studied yields the spectrum use index (SUI), the ratio of the spectrum resources used to the total spectrum resources in

6/ At first glance one might try to maximize band efficiency by packing these "solids" together as tightly as possible without overlapping. Even closer packing is possible, however, because each solid indicates the locations denied to the other transmitters' antennas. In other words, the "solids" may overlap as long as the center of one solid (the antenna location) does not fall within another solid.

7/ If the time dimension were included, all cross sections in that dimension would be identical, providing no additional information. The SUF would be unchanged, having been multiplied by one.

8/ Haines, Quantification, supra note 3 at 392.

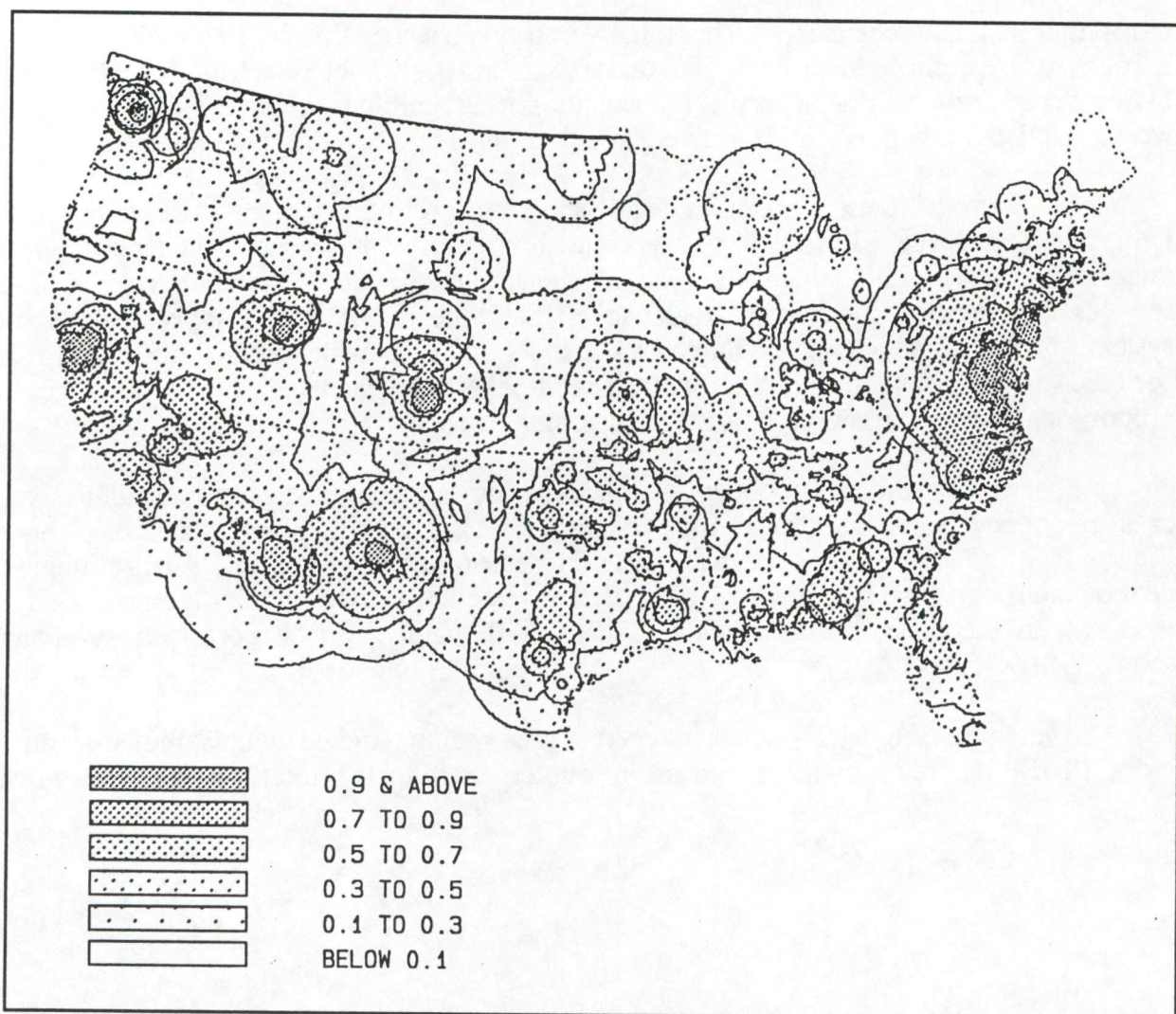


Figure F-3. Fraction of spectrum resources used by all systems in a land mobile service frequency band.

the area.^{9/} The SUI provides a single value describing spectrum use and is valuable for comparing spectrum use in different areas or for assessing the growth of spectrum use in an area.^{10/}

^{9/} R. H. Haines, An Innovative Method for Quantifying Spectrum Use, IEEE 1989 National Symposium on Electromagnetic Compatibility -- Symposium Record, The Institute of Electrical and Electronics Engineers, Inc., New York, at 234, 238 (1989).

^{10/} Haines, Quantification, *supra* note 3 at 393.

APPENDIX G FORECASTING

I. Background of Technological Forecasting

Technological forecasting, which seeks to predict how technologies will evolve over time, has developed over many years. During the 1960s, technological forecasting received much attention, and great effort was applied to developing its capabilities. "In 1965, the President charged the National Commission on Automation and Technological Change to examine, among other things, the use of technological forecasting and its potentials for the federal government. The Commission concluded that technological forecasting was little used."^{1/} Also in 1965, the twenty-two nation Organization for Economic Cooperation and Development (OECD) assigned Dr. Erich Jantsch to study technological forecasting. He identified one hundred technological forecasting and planning activities^{2/}, and stated that technological forecasting emerged as a recognized management discipline around 1960.^{3/}

The primary U.S. proponents of technological forecasting have been within the defense community, because of its dependence upon technological advancements. Many of the American leaders in the field have defense backgrounds. The Air Force, Army and Navy all conducted technological forecasting studies during the late 1960s. In 1968, the Navy compiled over six hundred individual forecasts prepared by twenty-three separate R&D activities.^{4/}

Robert Ayres reported in 1969 that

The forecasting of technological as opposed to economic or demographic change is not yet so universally practiced. In part, this lag is due to a belated recognition of the extent of the impact of technological change on society, and in part it is due to a rather widespread notion that technological change is inherently unpredictable.^{5/}

None of these activities, however, dealt specifically with forecasting the development and use of communications technology for the purpose of spectrum planning.

In 1974, Systems Applications, Inc. (SAI) performed a study for the Office of Telecommunications Policy (OTP), NTIA's predecessor, that considered use of market analyses

1/ Technological Forecasting for Industry and Government: Methods and Applications, at xii (J.R. Bright ed.1968).

2/ Id. at xiii.

3/ E. Jantsch, Technological Forecasting in Prospective at 17 (1967).

4/ M.J. Cetron, Technological Forecasting: A Practical Approach at 115 (1969).

5/ R.U. Ayres, Technological Forecasting and Long-Range Planning at 3 (1969).

and demand forecasting to assess more effectively future spectrum requirements.^{6/} It determined that the market analyses then available to OTP were inadequate to produce spectrum demand forecasts. Those market analyses were based primarily upon projected equipment sales and demand for services, with little attempt to discuss their forecasting methods or assumptions. SAI concluded that basing key allocation decisions, solely or primarily, on results, conclusions, on those market reports would be risky. SAI stated that it is unclear whether equipment sales projections represent new spectrum requirements or mere replacement of existing equipment. It also noted that, because other factors, such as system characteristics, usually are not included in market studies, a link to spectrum usage cannot be made. SAI's primary recommendations were to:

1. Establish a program to review market analysis reports and monitor other trade journals for the purpose of extracting forecasting data.
2. Establish a frequency requirements plan supported by annual agency spectrum requirements forecasts. This was to be a statement of federal user frequency needs by band, as a function of time listed for the next 20 years beginning with the present year.
3. Quantify spectrum use for trend analysis.

In a 1976 study for OTP, Sachs/Freeman Associates, Inc. recommended an approach to forecasting that was much more limited than SAI's concept of the federal requirements plan. Sachs/Freeman proposed developing forecasts only for the most congested geographic areas within specific frequency bands.^{7/}

Neither the FCC nor NTIA routinely perform independent forecasts of spectrum requirements, although NTIA has done extensive work on quantifying spectrum use. In specific proceedings, the FCC has used industry-generated forecasts, but it does not have an ongoing program of collecting and reviewing such inputs.

II. Technological Forecasting Methods

As noted in Chapter 6, an understanding of available forecasting techniques, and how and when to apply them, is a major requisite for forecasting.^{8/} Technological forecasts can be based on experience-driven, informed judgments, or on empirical data. In either case, the basis for decisionmaking is structured analysis. Informed judgments, while subject to forecaster error, benefit from the human ability to create or visualize new things. Therefore, they can be applied when no historical data exists, when external factors have an effect much different from previous developments, and when ethical or moral considerations dominate future actions.

^{6/} M. Drubin, G.P. Mandanis, P. Stanek, The Use of Demand Forecasting in Spectrum Management, (SAI), OTP Contract No. TP3AC001 Wash., D.C. (Sept. 1974).

^{7/} Sachs/Freeman Associates, Inc., Research Study on Spectrum Planning - OTP RFP 76-3, Hyattsville, Md., at 2 (1976).

^{8/} See also Bright, supra note 1, at 151-152.

Empirically based forecasts apply statistical methods and regressive analysis to quantified data. Such forecasts may result in estimates of the probability of an event's occurrence. These forecasts have their own drawbacks. Since they are based on data from past conditions, they are unable to warn the forecaster of radically changed circumstances. Also, selection of the data on which to base a forecast is extremely important.

There are two approaches to using forecasts, whether derived through informed judgments or empirical methods. These two approaches are known as exploratory and normative forecasting. Exploratory techniques report and analyze anticipated developments. They begin with the current status of, and past developments in, a given technology, and postulate the future of the technology. Normative methods start with a future desired technological state and work backward to the present, determining developments and innovations that are required. We describe below several different techniques for both exploratory and normative forecasting.^{9/}

A. Exploratory Forecasting

1. Genius forecasting

"Genius" forecasting is the type of forecasting with which most people are familiar. The leading expert in a field is consulted to provide a forecast. This method is risky, because the expert's knowledge, though vast for one person, may be limited compared to a group's, and one individual's false concepts or biased viewpoint are unchecked.

In spectrum management, the variety of spectrum uses implies that if "genius" forecasting were to be used in spectrum planning, experts from each of the services would have to be involved. Having one expert provide a single general forecast would not be adequate to support any decision. If, however, individual forecasts were made for each service, the task of querying the experts, and compiling and interpreting responses would be large. Of course, private sector user groups and IRAC members could be queried. The benefits are bound to be moderate because of the method's reliance on a single expert's judgment for each service. Aside from providing forecasts, experts could evaluate other forecasts. Forecasts for individual services are written from time to time in radiocommunications journals and may be useful.

2. Polls and committees

The use of polls or committees for forecasting can decrease the dangers of genius forecasting, because reliance on several sources can reduce errors. A simple technique would be to poll experts. The results of the poll -- that is, the majority or "average" response, form the basis the overall forecast. Alternatively, forecasting based on the face-to-face interactions of committees attempt to take advantage of small group decision theory, the synergism of group interactions, and the greater risk-taking characteristics of face-to-face groups where responses are often spontaneous, not carefully and cautiously scripted. The committee knowledge combines the individual knowledge, and more factors can be considered. However, face-to-face groups have several disadvantages, including the existence of dominant individuals, idea

^{9/} These methods are drawn in general from J. Martino, Technological Forecasting for Decision Making (1983) and B. Twiss, Managing Technological Innovation (1974), but the terms can commonly be found within other references on the subject of technological forecasting.

reinforcement through repetitive discussion, and group pressures that mask the input of a deviant or dissident member with correct data.

For spectrum forecasts, NTIA or the FCC could bring together a group of experts for forecast through polls or committees. There is much expertise within the radiocommunications field from which to obtain such forecasts. As noted above, the IRAC and industry user groups are two ready sources of predictions. A notice of inquiry could also be used for polling, though the quality and quantity of responses would be variable.

One variation of committee forecasting, the "Delphi" technique, was developed at Rand Corporation to overcome difficulties in the dynamics of face-to-face groups. This method combines polling with committee feedback. Questionnaires are submitted to a committee or panel of recognized experts. The results are consolidated, and, together with statistical characterizations of the responses, are submitted to the experts. The panel is then asked to revise their predictions, if desired, in the light of the initial results. Their revised predictions and the reasons for any deviation from those of the group are collected. These responses again are examined and the results are sent to the panel for another round, and so on. Delphi provides the benefits of a committee without the pressures of group interactions. Participants can shift views, based upon other's inputs, without losing face. Delphi provides for anonymity, numerous iterations, controlled feedback, and statistical group response. Success comes once the answers reach stability, not consensus.

Delphi techniques have several difficulties. The social interactions in a small face-to-face group that may have positive effects are missing. Moreover, the questionnaire assumes considerable importance, since questioner bias must be avoided. The proper questions must be asked, and specific quantifiable and unambiguous terms must be used. The selection of the Delphi committee is also important. If people not truly expert in the field are selected, meaningless information will be obtained.

Martino states that, while no study has validated a Delphi forecast, the results of analysis of Delphi methods have shown that when an expert opinion is needed, Delphi is a good way of getting it.^{10/} In addition, he reports that study results indicate that a panel of 15 members, if truly representative of the "expert community" on some topic, is unlikely to produce forecasts that differ markedly from those of another panel of experts of the same size.^{11/} Therefore, Delphi appears to produce the most "repeatable" forecasts based on informed judgments. The Delphi approach, if applied separately to each type of spectrum use, would require a significant expenditure of resources to develop, complete, and analyze questionnaires. The initial start-up time and cost, as well as the ongoing support would be higher than for other intuitive methods. However, the greatest difficulty in this approach will be commitment of time by the study team.

^{10/} Martino, *supra* note 9, at 24.

^{11/} *Id.* at 25-26.

3. Growth curves and trend extrapolation

Growth curves and trend extrapolation make use of past developments in a technology or technological area to plot future events. Martino describes these as follows:

Forecasting by growth curves requires fitting a mathematical formula for a growth curve to a set of historical empirical data.^{12/}

Once the product or service objectives are known, knowledgeable persons should be asked to identify characteristics of the product or service which have been, or can be improved. The characteristics should be as broad as possible so that a minimum number will encompass the objectives, but they must be capable of quantification and measurement.

* * *

When agreement has been reached on the principal parameters that are identified with progress, 'demand' factors related to the parameters should be listed for subsequent regression analysis. . . . This should be followed by the selection of a structured set of parameters which contribute to progress in the principal parameters.

* * *

Once the present level of capability has been determined, the next step should be the gathering of capability data as far back towards the origins of the selected parameter as possible, but at least as far into the past as the forecast plans to extend into the future.^{13/}

Several different types of growth curves with associated equations have been applied to technological forecasting, and specific curves can be selected depending on the appropriate variables, the constraints to development, and whether those constraints are physical or technological. Furthermore, since this type of forecast depends upon steady state conditions in the environment within which the technology is developed, one must determine the sensitivity of the variables to changes in the outside world.

Technology use often grows exponentially, followed by an asymptotic approach as the limits of the technology are reached. This results in a sigmoid, or "S" shaped growth curve as shown on the following page in figure 1.

^{12/} Id. at 57.

^{13/} Bright, supra note 1, at 62-63, 64.

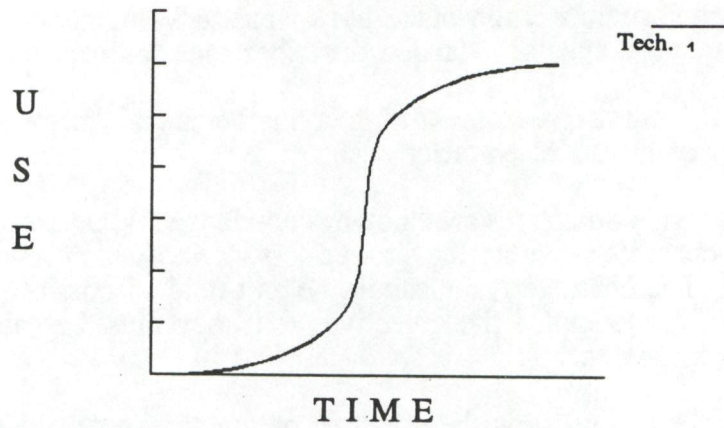


Figure 1 Common growth trend for technology use.

New technologies often are being developed even as the use of existing technologies grows rapidly. Figure 2 portrays the growth of three successive technologies. Since new capabilities that are developed continue to improve system capabilities, the progression from technology to technology could result in a capability improvement trend that can also be projected, as shown in Figure 3.

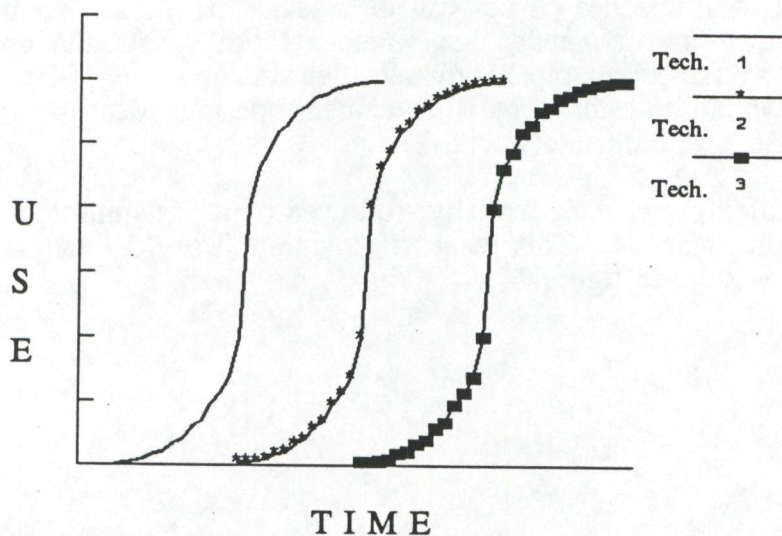


Figure 2 Successive growth trend for new technologies.

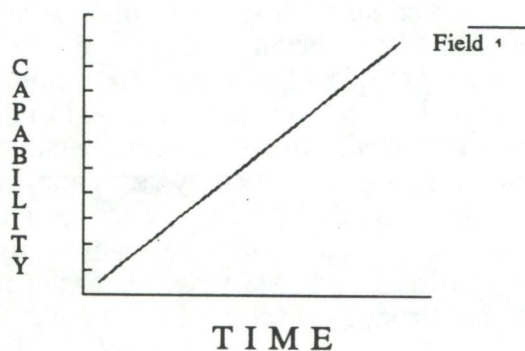


Figure 3 Capability improvement trend.

A spectrum-related example of this type of growth might be seen in a band where three successive technologies are introduced that enable the use of narrower and narrower bandwidths. Each technology experiences significant growth as it is implemented. Growth slows as the band fills, but with the introduction of each technology, channel splitting occurs. Therefore, if the capability were measured in channels per MHz, a continuous increase is experienced. Similarly, as bands have become congested with specific types of communications users, new technology has often resulted in increases in information rates, thus greater communications capacity. Through these types of trends, it could be possible to predict future capability levels before the technologies themselves are on the drawing board.

In the past, NTIA has limited its trend analysis to such specific tasks as the straight line extrapolation of assignment counts, thereby determining what the counts would be in five years if past trends continued. However, changes within equipment characteristics may alter the meaning of those counts. For instance, continuous growth in the use of a band could lead to an erroneous conclusion that the band is getting more congested, while technical improvements may have cut system transmission bandwidths, actually resulting in less congestion. Thus, trend analysis must be based upon data that can shed light upon what is occurring in spectrum use.

GTE comments favorably on the use of trends for specific services when forecasters adequately identify relevant parameters. It cites CCIR Interim Working Party (IWP) 8/13 efforts to forecast future public land mobile telecommunications as excellent work.^{14/} The FAA reports success using historical data on air traffic growth to predict the need for channels in the aeronautical bands.^{15/} NYNEX supports trend analysis, yet feels that "[i]naccuracies occur when forecasts fail to address macro-environmental components such as the economy, population,

^{14/} GTE Comments at 17-18.

^{15/} FAA Comments at 5.

natural resources and technology," and "[w]hen applying historical forecasting to spectrum use forecasting, one must... be sensitive to the limitations of this approach."^{16/}

Growth curves and trends could be applied to diverse aspects of spectrum use. First, however, quantifiable factors must be determined from which trends can be established. Band occupancy or congestion on a geographical basis are two prominent factors. Forecasting when spectrum in a specific location will get congested would help to notify spectrum managers when action needs to be taken to institute spectrum conservation techniques or guidelines. Computer-driven calculations of spectrum use, supplemented by occupancy measurements, would be useful in this approach. Other factors that could be used in decisionmaking are forecasts of technical characteristics such as system bandwidths or data rates. Just as computer capacity has improved, bandwidths have narrowed and data rates increased in some radio communications fields, reducing the need for spectrum.

Many types of trend analysis require a great deal of time and resources, including developing and implementing supporting computer software. If trend analysis were to be applied to spectrum services, many of the services would require different criteria and the data needed to evaluate some types of systems may not be readily available in data files. However, once a trend is developed for each band or service, continuation of the process should not be difficult.

4. Precursor analysis

Precursor analysis theoretically improves upon trend analysis through the forecaster's knowledge of factors that lead or cause trends. Unlike trend analysis, which assumes that what has happened in the past will continue in the future, precursor analysis expressly recognizes that developments in one technology often depend upon preceding developments in another. Clearly, many of the improvements in communications technology have followed related activities in computer technology development. For instance, increased interest in hand-held personal communications systems may be related to the decreases in memory chip size that permit portability.

Precursors probably exist within the different radiocommunications services, but they need to be identified, service by service. Many of the precursor activities may not be related strictly to the technical aspects of a particular development. For example, economic factors can greatly effect users' interest in new technologies.

The basis for precursor analysis -- the identification of related events within the radiocommunications field -- should be a daily ongoing effort by spectrum managers. However, due to continual political, social, and economic changes, precursors themselves may change over time. For example, the importance of developments in defense capabilities, often seen as precursors of civil technology improvements, may decrease in an era of lessened international tensions.

5. Analogies

Through the use of analogies, forecasting conclusions from historical developments of an earlier but similar technology are drawn. Reasoning from comparable situations can aid

^{16/} NYNEX Comments at 50-51.

prediction. For example, one could seek to compare the original growth of broadcast television with the possible future growth of advanced television. In this type of forecasting, only general trends in a developing technology can be predicted. Even so, a similarity to another situation does not necessarily mean that the results will be the same.

Application of analogies to radiocommunications is extremely difficult, both because of the advanced technologies involved and the fact that the social, economic and political factors that affect communications have changed rapidly during the last decades, making reliance on analogies risky. Moreover, analogies can be criticized on analytic grounds because they often rely on informed judgment that can vary among forecasters. For these reasons, within spectrum management in particular, the general conclusions drawn from analogies could be informative, but would probably not be decisive for allocation decisions, and therefore, may not be useful as a predictive tool.

6. Analytical causal models

Analytical causal models take trend extrapolation, growth curves and analogies one step further by including relationships among other factors and other trends, and projecting the resulting interactions.

Causal models have two shortcomings that they share with trend extrapolation, growth curves, and analogies: they are based on observations of behavior, but do not provide essential reasons for explaining the behavior of a technology or technologies; and they are based on data that necessarily will contain errors.

Similar to precursor analysis, analytical causal models place significant demands on forecasters to determine what causal relationships exist. However, such causal relationships must be considered in decision processes if all of the implications of decisions are to be understood. The use of these models in predicting trends would be a long term project that would require substantial additional resources.

7. Technology Tracking^{17/}

Technology tracking is a system of monitoring information on specific areas that affect or lead technology growth and change. New developments and trends can then be examined. The empirically-based techniques discussed previously rely on the rational extension of historical trends. They make no provision for forecasting such events as a technological breakthrough, though precursor analyses depend on such factors. As Martino notes, "Examination of breakthroughs shows that there were many precursor events that would have made it possible to forecast the eventual development of technology."^{18/} Therefore, true early warning signals must be separated from the "noise". A properly designed system will minimize the number of false signals identified and give proper recognition to consequential signals.

^{17/} In technological forecasting literature, this is referred to as "monitoring" but to differentiate between this concept and "monitoring" of spectrum occupancy through measurements, we have selected the term "technology tracking."

^{18/} Martino, supra note 9, at 134.

COMSAT and others support review of R&D activities within both government and private sectors in order to identify future requirements.^{19/} The Navy recommends R&D monitoring, or tracking, as a source of forecasting data for technology development.^{20/} Foreign research and development also requires coverage. NSF states that R&D monitoring in the field of radio astronomy could provide links to new developments; however, it believes that attempting to link such monitoring to prediction of marketplace demand for radiocommunications in general would be very difficult.^{21/}

A systematic method of monitoring literature in a specific technological area could be established. The information gained would then have to be examined for relevance and significance and catalogued for reference. The 1974 SAI study mentioned earlier recommended tracking of market analyses and trade journals.^{22/} One advantage of this method is that it requires limited resources and can be accomplished by engineers as well as by professional forecasters.^{23/}

Tracking of trade publications for data related to spectrum use should be an ongoing part of spectrum management. At the very least it should be occur through staffwide circulation of journals; a better arrangement would be through designation of a staff member to perform such tracking. Such a staff member would be responsible for ordering trade literature, determining its utility, and preparing reports. This staff member could also maintain contact with relevant research groups within the federal agencies, and the private industry.

8. Cross Impact Matrices

Developments in one technology can directly affect another. For example, as noted above, advances in computer chip design can result in more efficient radio systems. A major issue in technological forecasting involves predicting the interaction of technologies and the effects of such. There are three dimensions of interaction: The "mode" of the interaction - whether the interaction enhances or decreases the likelihood of another event; the "force" of the interaction - whether there is a strong or weak influence; and the time lag of the interaction - the degree of immediacy and duration of the effect.^{24/} The cross impact matrix method takes these dimensions into account. As Twiss states, there are five steps to creating and using a cross impact matrix:

1. Determine technology-related events being forecast.
2. Assign probabilities to and likely dates of the events' occurrence using Delphi, trend extrapolation, or another technique.

^{19/} COMSAT Comments at 50-52.

^{20/} U.S. Navy Comments at 4.

^{21/} NSF Comments at 21.

^{22/} SAI, supra note 6, at 108.

^{23/} B. Twiss, supra note 9, at 91.

^{24/} Martino, supra note 9, at 327.

3. Determine the interactions between the events, i.e., the mode, the force and the time lag.
4. Generate a future state of the technology by simulations to determine if an event has occurred and then modifying the probability, and expected time of the remaining events in accordance with step 3 above.
5. Perform step 4 many times.^{25/}

If any one or more of the events occur in many of the possible futures developed, one can assume there is a very good likelihood that it will, in fact, occur. The many repetitions necessary imply that a computer is required to best use the cross impact matrix. Although cross impact matrices account for the impact of one technology or another, they often are based on the forecaster's intuition in assigning the degree of interaction among the technologies and are thus open to error.

Since there are many different types of spectrum-based equipment, applications, and services that have fundamental similarities, their impact on one another should be assessed in any approach to spectrum forecasting. However, the development of a computer-aided process like a cross impact matrix approach would require substantial resources.

B. Normative Forecasting

As stated earlier, normative forecasting involves determining what technologies or situations are desirable at a particular time, then backtracking to determine what must occur and when, in order to reach the desired point. Thus, normative forecasting is "needs-" or "goal-" oriented, and results in directive action. Therefore, if spectrum congestion is predicted using one or more of the techniques discussed above, normative forecasting could be used to define a desire outcome and approach to resolving the congestion.

Techniques used in normative forecasting of particular interest in spectrum management are relevance trees; morphological analysis; and mission flow diagrams. These tools are similar in that they each involve determination of some goal or the prediction of a negative situation, such as spectrum congestion. The normative approach is completed by analyzing the technological achievement required to meet the goal or to produce a more desirable situation.

1. Relevance trees

Relevance trees are used for those developments in which levels of complexity or a hierarchy are apparent. For example, the development of pollution-free cars could have several possible solutions (electricity, emission controlled gas, or diesel), each having several functions to be performed and several solutions for each function. The relevance tree is constructed by identifying all conceivable solutions and subsolutions to a given problem. The probability of success associated with each branch of the tree is then determined using exploratory forecasting techniques. The "optimum" solution makes use of these results in the light of organization goals and constraints.

^{25/} Twiss, supra note 9 at 91.

2. Morphological Analysis^{26/}

Morphological analysis is used when a problem can be broken into independent parts. The elements of the system are first listed. Then "solutions" for each element -- that is, the ways each element can be accomplished, are defined. Finally, one selects desirable solutions and evaluates the technology required for each. Some solutions, of course, can be rejected because of conflicts with other solutions. The remaining solutions can then be established as goals for the technologies involved.

Morphological analysis and relevance trees can be used in evaluating similar situations. The elements of the morphological analysis correspond to relevance tree functions, while the most basic "branches" of the relevance tree correspond to components of the elements in the morphological model.

3. Mission Flow Diagrams

Mission flow diagrams were initially developed to analyze certain types of military missions, hence the name. They can be used for the analysis of sequential processes where alternate approaches are possible. All possible routes or sequences to accomplish each task are listed. The significant steps in each route are listed. The difficulties and costs associated with each path and possibly alternative routes can be identified. Once the difficulties have been identified, performance requirements for the technologies involved can be used as normative forecasts.

III. Conclusions

The approaches discussed here are evaluated generally in Chapter 6. A thorough but balanced approach to spectrum forecasting at NTIA and the FCC is recommended. Major parts of such a program would include:

1. Expert input;
2. Trend analysis; and
3. Technology Tracking.

^{26/} "Morphological" means having to do with an organism's structure and form.

APPENDIX H

SPECTRUM MANAGEMENT TRAINING REQUIREMENTS

Figure 1, shows that since 1980, the number of frequency assignments made at both NTIA and the FCC have increased.^{1/} NTIA authorized 46.1% more stations in 1989 than in 1980; the FCC authorized 52.9% more in 1988 than in 1980. Thus, it is clear that radio systems are more numerous today than they were in 1980. They have also become more complex during this period. Spectrum management decisions involve complex and highly technical applications of radio technology. Successful decisions require detailed analysis of the impact of proposed policy options on the ability of others to use the spectrum, including detailed engineering estimates of new and existing systems to determine the effects of various interference signals, the propagation of electromagnetic waves, and how various interfering signals affect the ability of the user to understand the intended signal. Successful spectrum management decisions balance the technical ramifications of these issues with their inherent social and policy values. Thus, the optimum engineering solution may have to be modified because of economic, legal, and policy considerations.

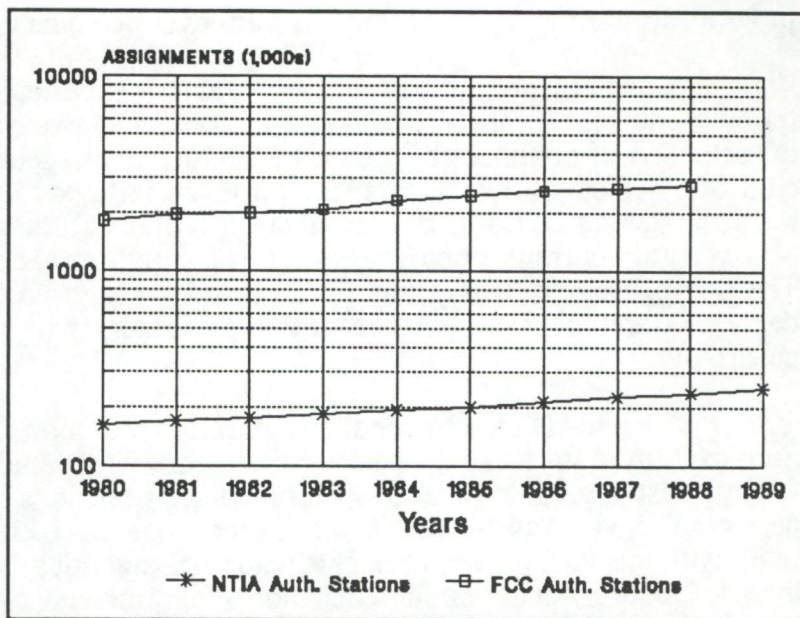


Figure 1 Growth in FCC Licenses and NTIA Assignments.

Moreover, spectrum management problems do not respect national boundaries. Thus, spectrum management decisions also often involve international agreements through diplomatic negotiations in the international forums of the ITU and among neighboring countries. Because of this interchange of technical and policy development requirements, it is unusual to find individuals with the background necessary to perform spectrum management in industry or government.

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^{1/} See R.J. Mayher and F. Wentland, *Spectrum Management Structure and Regulations in the U.S. - Do We Need a Change in the Twenty First Century?*, Conference Record, IEEE International EMC Symposium, Washington, D.C., Aug. 1990.

If the spectrum management community is to respond to increased needs for access to the spectrum in a timely and effective manner, NTIA, the FCC, and users require highly trained spectrum managers.^{2/}

Recognizing this problem as long ago as 1975, the director of the Office of Telecommunications Policy (OTP) established a Government-Wide Career Development Program for Radio Spectrum Management Personnel. The primary objective of this program was to attract, develop, and retain personnel required to meet the present and future staffing requirements in the spectrum management fields. From 1975 to 1983, OTP and then NTIA conducted this program to train entry level interns, mid-level personnel and senior spectrum managers.

The intern program provided a training experience composed of formal seminars and training courses, informal discussion periods, and work assignments. The program involved the selection of nominees by various IRAC member agencies and formalized training requiring complete dedication of the nominee on a full-time basis for a period of one year. An IRAC member agency could also take advantage of some of the training opportunities offered by NTIA for its current employees without committing them to a full-time, year-long program. The Intern Program was primarily designed for high-potential recent college graduates with a degree in the physical sciences or engineering, with particular emphasis in physics and electronics.

OTP and NTIA also conducted programs for more experienced spectrum managers. The mid-level program was for spectrum managers who demonstrated the potential and motivation for successful performance in spectrum management positions at higher grade levels. Each person selected by an IRAC member agency was placed in a development program commensurate with the agency requirements and the individual needs. These learning experiences included both formal training/education programs and rotational assignments. An Individual Development Plan was written yearly for each selectee. The senior program was designed for those persons who demonstrated potential and motivation for higher level responsibilities. Each person selected by an IRAC member agency was placed in a 1-year planned program of learning experience including both training/education and developmental on-the-job training (possibly rotational assignments) within the IRAC organization. This program included appropriate managerial training, preparation for and attendance at appropriate international conferences and other training to provide each individual with the maximum of technical broadening and update.

Of the training programs, the intern program was the most effective since new qualified personnel were sought, trained and brought into the spectrum management community. The mid-level program continues to train approximately fifty personnel each year in a one or two week seminar. The senior level program was the least successful because of the difficulty of arranging appropriate courses and on-the-job training in specific organizations for key senior spectrum managers. The intern and the senior level parts of the program were canceled in 1983 due to a lack of funding, which prevented NTIA from offering the programs and made it difficult for the agencies to guarantee the interns positions after a year's training and in developing a suitable curriculum for senior spectrum managers.

^{2/} Several commenters note that the FCC and NTIA have insufficient staff to prevent crisis management and to permit timely and comprehensive responses to the study, planning and oversight of the spectrum. See, e.g., APCO Comments at 2-3 and LMCC Comments at 65.

The need for the training of personnel is more critical today than it was when the earlier NTIA/OTP training program started, because of the increased complexity of managing the spectrum and the aging of the current agency staffs, with few replacements entering this field.

Thus, NTIA will continue the mid-level program as currently configured, will seek to develop new low-cost training opportunities, such as seminars and work shops for mid-level and senior spectrum managers, and will investigate the practicality of re-establishing, with other Federal agencies and the private sector, the intern/entry-level and senior level training programs.

