Spectrum Policy Task Force

REPORT

ET Docket No. 02- 135

November 2002

Federal Communications Commission

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I. Introduction

The Spectrum Policy Task Force is pleased to report to the Commission its findings and recommendations with regard to improving the way that the electromagnetic radio spectrum is "managed" in the United States. Chairman Powell established the Task Force in June 2002 to assist the Commission in identifying and evaluating changes in spectrum policy that will increase the public benefits derived from the use of radio spectrum. The creation of the Task Force initiated the first ever comprehensive and systematic review of spectrum policy at the FCC.

The Task Force is a team of high-level, multi-disciplinary professional FCC staff – economists, engineers, and attorneys – from across the Commission's Bureaus and Offices. The Task Force's mission is to:

- Provide specific recommendations to the Commission for ways in which to evolve the current "command and control" approach to spectrum policy into a more integrated, market-oriented approach that provides greater regulatory certainty, while minimizing regulatory intervention; and

- Assist the Commission in addressing ubiquitous spectrum issues, including interference protection, spectral efficiency, effective public safety communications, and international spectrum policies.

As Chairman Powell stated when announcing the formation of the Task Force, the government has an almost impossible task in trying to keep pace with the ever-increasing demand for spectrum and the continuing advances in wireless technology and applications. In this fast-moving world, the Commission cannot rely on outmoded procedures and policies. While the Commission has recently made some major strides in how spectrum is allocated and assigned in some bands, principally through flexible rules and competitive bidding, spectrum policy is not keeping pace with the relentless spectrum demands of the market. The Task Force has begun the process of reexamining 90 years of spectrum policy to ensure that the Commission's policies evolve with the consumer-driven evolution of new wireless technologies, devices, and services. The Task Force hopes and expects that this Report will serve as a catalyst for further advancement of spectrum policy at the FCC.

Process. On June 6, 2002, the Spectrum Policy Task Force released a Public Notice seeking comment on existing spectrum policies and recommendations for possible improvements.[1] The Public Notice set forth specific questions related to spectrum policy to give detailed information to the public about the issues the Spectrum Policy Task Force planned to review. Commenters were not limited to responding to these questions, however, and were encouraged to comment on all spectrum-related issues.

[1] "Spectrum Policy Task Force Seeks Public Comment on Issues Related to Commission's Spectrum Policies," *Public Notice,* ET Docket No. 02-135 (rel. June 6, 2002).

The questions raised in the Public Notice were divided into five categories: (1) Market-Oriented Allocation and Assignment Policies; (2) Interference Protection; (3) Spectral Efficiency; (4) Public Safety Communications; and (5) International Issues. Specifically, with respect to market allocation and assignment policies, the Task Force requested comment on the relative effectiveness of the approaches the Commission has employed for facilitating optimal spectrum use and their applicability across different bands with different incumbents' rights. Questions on interference protection addressed the ramifications of technological limits on radio operation, particularly with regard to control of the interference between radio systems and what constitutes acceptable interference. Spectral efficiency questions focused on how to promote and measure efficiency. The Task Force also sought comment on how best to preserve and protect the ability of public safety entities to do their important jobs in light of the increasing spectrum demands. Finally, with respect to international issues, the Task Force sought guidance on the international spectrum coordination process and what role international considerations should play in spectrum policy. ET Docket No. 02-135 was established to collect comments in response to the Public Notice.

Parties filed over 200 comments. These comments were submitted by numerous types of entities, including: manufacturers of electronics, software, infrastructure, and wireless technology; wireless Internet service providers (WISPs), including those providing wireless broadband to rural areas, and other unlicensed spectrum operators; radioastronomy; satellite/broadcast; consumer groups and individual consumers; other wireless providers, including fixed wireless and land mobile; academics, economists, and scientists; commercial mobile radio services (CMRS) providers; radio (including private radio operators, public, and commercial radio) and TV; public safety and government; consultants, journalists, and telecommunications services brokers; engineers; energy/transportation; and telecommunications companies, including rural telephone companies.

The Task Force held numerous information meetings as well as four public workshops: Experimental Licenses and Unlicensed Spectrum, August 1st; Interference Protection, August 2nd; Spectrum Efficiency, August 5th; and Spectrum Rights and Responsibilities, August 9th. Approximately 75 panelists and outside moderators participated. These panelists represented a cross-section of interested parties: manufacturers/product vendors; think tanks, academia, consulting, and financial services; wireless CMRS carriers, other licensed operators, and frequency coordinators; satellite/broadcast; attorneys; WISPs and other unlicensed wireless services; government; public safety; radio/TV; and consumer groups.

The Task Force created the following four working groups: Interference Protection, Spectrum Efficiency, Spectrum Rights and Responsibilities, and Unlicensed and Experimental. The working groups reviewed and analyzed all of the comments and statements made in the workshops. From this information, the Working Groups drafted

reports summarizing the comments submitted and setting forth findings, conclusions, and recommendations.[2]

The Task Force's web site, http://www.fcc.gov/sptf, contains information related to the proceedings, including: the Task Force's mission statement, a link to all public comments, transcripts of the four public workshops and agendas, a calendar of spectrum policy events, spectrum policy speeches, links to government-sponsored spectrum-related web sites, and contact information (including telephone and e-mail address) for the Task Force.

II. Executive Summary

Task Force Major Findings and Recommendations

- Advances in technology create the potential for systems to use spectrum more intensively and to be much more tolerant of interference than in the past.
- In many bands, spectrum access is a more significant problem than physical scarcity of spectrum, in large part due to legacy command-and-control regulation that limits the ability of potential spectrum users to obtain such access.
- To increase opportunities for technologically innovative and economically efficient spectrum use, spectrum policy must evolve towards more flexible and market-oriented regulatory models.
- Such models must be based on clear definitions of the rights and responsibilities of both licensed and unlicensed spectrum users, particularly with respect to interference and interference protection.
- No single regulatory model should be applied to all spectrum: the Commission should pursue a balanced spectrum policy that includes both the granting of exclusive spectrum usage rights through market-based mechanisms and creating open access to spectrum "commons," with command-and-control regulation used in limited circumstances.
- The Commission should seek to implement these policies in both newly allocated bands and in spectrum that is already occupied, but in the latter case, appropriate transitional mechanisms should be employed to avoid degradation of existing services and uses.

Spectrum Use

- Preliminary data and general observations indicate that many portions of the radio spectrum are not in use for significant periods of time, and that spectrum use of

[2] Each Working Group has submitted a report in ET Docket 02-135. These reports can be found at http://www.fcc.gov/sptf/.

these "white spaces" (both temporal and geographic) can be increased significantly.

- Additional information and measurement is needed in order to more accurately quantify and characterize spectrum usage.

The Case for Spectrum Reform

- Increasing demand for spectrum-based services and devices is straining longstanding and outmoded spectrum policies.

- As a result, it is important to evolve from current spectrum policies, which reflect an environment made up of a limited number of types of operations, to policies that reflect the increasingly dynamic and innovative nature of spectrum use.

- The Commission should also strive, wherever possible, to eliminate regulatory barriers to increased spectrum access.

Common Elements of Spectrum Policy

- No single regulatory model can or should be applied to all spectrum, but there are certain common elements that the Commission should incorporate into its spectrum policy regardless of the regulatory model that is used.
    - Maximum feasible flexibility of spectrum use by both licensed and unlicensed users.
    - Clear and exhaustive definition of spectrum users' rights and responsibilities.
    - Policies that account for all potential dimensions of spectrum usage (frequency, power, space, and time).
    - Incentives for efficient spectrum use.
    - Policies that encourage grouping of spectrum "neighbors" with technically compatible characteristics.
    - Periodic review and revision of spectrum rules to account for technological advances and other changes.
    - Efficient and reliable enforcement mechanisms to ensure regulatory compliance by all spectrum users.

Interference Avoidance

- Interference management has become more difficult because of the greater density, mobility and variability of radio frequency (RF) emitters. Interference management becomes even more problematic when and if users have been granted increased flexibility in their spectrum use. As a result, the complexity of predictive interference models has increased dramatically, and is expected to increase even more in the future.

- The Commission should adopt, where feasible, a more quantitative approach to interference management based on the concept of "interference temperature."
    - The interference temperature metric would establish maximum permissible levels of interference, thus characterizing the "worst case" environment in which a receiver would be expected to operate.
    - Different threshold levels could be set for each band, geographic region or service.
    - These thresholds should be set only after review of the condition of the RF environment in each band. To that end, the Task Force recommends that the Commission undertake a systematic study of the RF noise floor.

- The Commission should consider applying receiver performance requirements for some bands and services, either through incentives, regulatory mandates, or some combination of incentives and mandates.

Spectrum Rights Models

- Based on the principle that "one size does not fit all" in spectrum policy, the Commission should consider a balance among three general models for assigning spectrum usage rights:
    - "Exclusive use" model. A licensing model in which a licensee has exclusive and transferable flexible use rights for specified spectrum within a defined geographic area, with flexible use rights that are governed primarily by technical rules to protect spectrum users against interference.
    - "Commons" model. Allows unlimited numbers of unlicensed users to share frequencies, with usage rights that are governed by technical standards or etiquettes but with no right to protection from interference.
    - "Command-and-control" model. The traditional process of spectrum management in the United States, currently used for most spectrum within the Commission's jurisdiction, in which allowable spectrum uses are limited based on regulatory judgments.

- The Commission should expand the use of both the exclusive use and commons models throughout the radio spectrum.
    - The exclusive use model should be applied primarily but not exclusively in bands where scarcity is relatively high and transaction costs associated with market-based negotiation of access rights are relatively low.
    - The commons model should be applied primarily but not exclusively in bands where scarcity is relatively low and transaction costs are relatively high.
    - The commons approach also has potential applicability in the creation of "underlay" rights in spectrum for low-power, low-impact applications, *e.g.*, for operations below an established interference temperature threshold.

- Command-and-control regulation should be reserved only for situations where prescribing spectrum use by regulation is necessary to accomplish important public interest objectives or to conform to treaty obligations.

- Dedication of spectrum in conformity with international harmonization considerations is sometimes appropriate to foster internationally ubiquitous services and economies of scale.
- Spectrum currently set aside for public safety use should remain subject to the command-and-control model to ensure provision of essential life-and-safety services. At the same time, because of the variability of public safety use, public safety users should have flexibility to lease spectrum capacity during lower-use periods to commercial users.
- Broadcast spectrum should remain subject to the current regulatory model, which is based on statutory public interest objectives. Over the longer term, the Commission should periodically reevaluate its broadcast spectrum policies.

- With the exceptions noted above, existing spectrum that is subject to command-and-control regulation should be transitioned to the more flexible exclusive use and commons models to the greatest extent possible. In determining whether and how to transition legacy command-and-control bands to more flexible rights models, the Commission should consider several alternative approaches, and should focus first on initiating transition in those bands where additional flexibility will provide the greatest benefits at the least cost.

Promoting Access to Spectrum

- The Commission should, where feasible, seek to designate additional bands for unlicensed spectrum use to better optimize spectrum access and provide room for expansion in the fast-growing market for unlicensed devices and networks.

- In licensed spectrum bands, the Commission should pursue secondary markets policies that encourage licensees to provide access for "opportunistic" uses above the interference temperature threshold through leasing of spectrum usage rights.
  - The Commission should also explore the possible use of government-granted "easements" for some opportunistic uses in new spectrum bands, but should be sensitive to the potential impact of this approach on planning and investment by licensed users.

- The Commission should explore ways to promote spectrum access and flexibility in rural areas, including flexible regulation of power levels, secondary markets mechanisms to encourage leasing of spectrum usage rights in rural areas, and consideration of rural issues in defining geographic licensing areas.

- Experimental spectrum uses should be encouraged through improvements to the experimental licensing frequency coordination process and dissemination of more information identifying bands that are particularly suitable for experimental applications.

III. Current State of U.S. Spectrum Policy

A. Regulatory Background

Statute. Domestic U.S. spectrum policy and regulation began 90 years ago. Largely as a consequence of the communications failures associated with the sinking of the Titanic, the Federal government established control of the electromagnetic spectrum.[3] The Radio Act of 1912 established the principle that no one could use spectrum without a federal license and a series of spectrum policy principles that continue to the present. The Radio Act of 1927 established the Federal Radio Commission and set forth as its intent to "maintain the control of the United States over all the channels of interstate and foreign radio transmission; and to provide for the use of such channels, but not the ownership thereof." The 1927 Act provided that the new Commission shall, "as public convenience, interest, or necessity requires" classify radio stations, prescribe the nature of the service, assign bands of frequencies or wave lengths and determine the power, time, and location of stations and regulate the kind of apparatus to be used. Licenses were to be granted by the Commission for a limited duration (three years for broadcast licenses and five years for all others), but all federal government stations were to be assigned by the President.

Seven years later, the Communications Act of 1934 abolished the Federal Radio Commission and transferred the authority for spectrum management to the newly created Federal Communications Commission.[4] The 1934 Act brought together the regulation of telephone, telegraph, and radio services within a single independent federal agency. The 1927 Radio Act was absorbed largely intact into Title III of the 1934 Act.

From 1934 to the early 1990s, Congress enacted many amendments to Title III, but there were no fundamental changes to the core provisions that can be traced back to the 1912 and 1927 Acts. However, two noteworthy additions to the 1934 Act inserted in 1983 by Congress are section 7[5] and section 307(e).[6] Section 7(a) establishes that it is the policy of the United States "to encourage the provision of new technologies and services to the public" and that anyone who opposes a new technology or service will have the

[3] The first international radio conference took place in 1903, followed by another in 1906. The second conference adopted a convention requiring receipt of priority distress calls from ships and created the first two radio frequency service categories: general public service in the 187-500 kHz band and long-range or other services for assignment in other frequencies. Additional international spectrum conferences have been held under the auspices of the International Telecommunications Union (ITU) on a regular basis and are now called World Radiocommunication Conferences (WRC). From a domestic spectrum policy standpoint, the outcome of the WRCs have a direct impact on U.S. allocation issues as the WRC Final Acts constitute treaty agreements requiring ratification by the United States Senate. The Commission implements the Final Acts through the rulemaking process.

[4] 47 U.S.C. § 151 *et seq*.

[5] 47 U.S.C. § 157.

[6] 47 U.S.C. § 307(e).

burden of demonstrating that the proposal is inconsistent with the public interest. In addition, section 307(e) provides that the Commission, "notwithstanding any licensing requirement established in this Act," may "by rule authorize the operation of radio stations without individual licenses" in certain services.

In 1993, Congress amended Title III of the 1934 Act to authorize the Commission to assign licenses through competitive bidding.[7] The 1993 Act also required the transfer of certain amounts of spectrum from federal government use to commercial use,[8] amended Section 332 of the 1934 Act with regard to the regulatory treatment of commercial and private mobile radio services, and required the Commission to collect regulatory fees from licensees and other Commission regulatees.[9]

The Telecommunications Act of 1996 added Section 336 to the 1934 Act to provide for broadcast spectrum flexibility and authority to collect certain additional fees.[10] The 1996 Act also eliminated the cap on license terms for non-broadcast licenses in Section 307(c) of the 1934 Act. In the Balanced Budget Act of 1997, Congress expanded the Commission's auction authority, provided for the transfer of additional spectrum from federal government use and granted the Commission explicit authority to allocate electromagnetic spectrum so as to provide flexibility of use.

Administrative. Although the communications statutes (and treaties) discussed above are generally implemented and enforced by the FCC, other federal agencies, including the Department of Commerce, through the National Telecommunications and Information Administration (NTIA), and the Department of State, also play important roles in developing spectrum policy. Until recently, spectrum policy at the administrative agency level, especially at the FCC, was generally formulated on a band-by-band, service-by-service basis, typically in response to specific requests for particular service allocations or station assignments. This *ad hoc* approach has garnered criticism over the years.

It does not appear that any general spectrum management review or comprehensive planning has taken place at the FCC. It was not until the 1990s that specific efforts were made to examine policies surrounding spectrum management in the United States on a more comprehensive basis. First, in December 1989, NTIA began a "Comprehensive Policy Review of Use and Management of the Radio Frequency Spectrum." This review was the first major examination of fundamental spectrum policy objectives and issues by NTIA since its organization in 1978. In 1991, NTIA issued its Report, "U.S. Spectrum Management Policy: Agenda for the Future," which made a

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[7] Section 309(j) was further amended in the Balanced Budget Act of 1997. In the Open-Market Reorganization for the Betterment of International Telecommunications Act of 2000 (ORBIT Act), the Congress passed legislation excluding spectrum used for international and global satellite services from assignment through auctions.

[8] *See* 47 U.S.C. § 923.

[9] *See* 47 U.S.C. § 159.

[10] 47 U.S.C. § 336.

number of significant recommendations, some of which ultimately led to legislation being enacted as part of the 1993 Budget Act.

In the 1990s, while the FCC continued with an *ad hoc* approach to spectrum allocations and policy, significant efforts in the area of broader spectrum policy review by the Commission took three forms: (1) implementation of competitive bidding authority; (2) *en banc* hearings before the full Commission; and (3) policy statements. As noted above, Congress provided the Commission authority to use competitive bidding for licensing certain classes of spectrum users and uses. While much of the implementation of these statutory changes took place on a service-by-service basis, in 1994 the Commission established the general framework for auctions across all services.[11] The Commission also completed other more comprehensive proceedings to implement changes to Sections 332 and 309(j) of the Communications Act.[12]

In March 1996 and April 1999, the Commission held two *en banc* hearings on Spectrum Management.[13] Information presented at the hearings provided insight from industry and academia on their views of how the Commission's spectrum management responsibilities should evolve. Two key focus areas emerged: (1) promoting greater efficiency in spectrum use and (2) making more spectrum available. Flexibility was also emphasized for both allocations and service rules. Other key suggested initiatives included: negotiated interference; new spectrum efficient technologies; innovative and streamlined assignment mechanisms; a more active secondary market; and more unlicensed spectrum.

In November 1999, the Commission issued a Policy Statement on "Principles for Reallocation of Spectrum to Encourage the Development of Telecommunications Technologies for the New Millennium."[14] The Commission has also convened a Technological Advisory Committee to provide expert advice to the Commission on how to respond to rapid advances in technology, with a particular focus on spectrum management.[15]

In November 2000, after holding a public forum on secondary markets in radio spectrum usage rights, the Commission concurrently adopted a Policy Statement, "Principles for Promoting Efficient Use of Spectrum by Encouraging the Development of

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[11] *See* Implementation of Section 309(j) of the Communications Act - Competitive Bidding, PP Docket No. 93-253, Second Report and Order, 9 FCC Rcd 2348 (1994).

[12] *See* Implementation of Sections 3(n) and 332 of the Communications Act Regulatory Treatment of Mobile Services, GN Docket No. 93- 252, Second Report and Order, 9 FCC Rcd 1411(1994).

[13] *See* "Commission Announces Panelists, Agenda for *En Banc* Hearing on Spectrum Policy," *Public Notice,* DA 96-190 (rel. Feb. 14, 1996) and "FCC Announces Panelists for *En Banc* Hearing on Spectrum Management," *Public Notice* (rel. Apr. 1, 1999).

[14] "Principles for Reallocation of Spectrum to Encourage the Development of Telecommunications Technologies for the New Millennium," *Policy Statement,* 14 FCC Rcd 19868 (1999).

[15] *See* "Report of First Meeting of the Technical Advisory Council" (April 30, 1999), which can be found at: http://www.fcc.gov/oet/tac/report990430.pdf.

Secondary Markets,"[16] and a Notice of Proposed Rulemaking, "Promoting Efficient Use of Spectrum through Elimination of Barriers to the Development of Secondary Markets."[17] The Policy Statement enunciated general goals and principles for the further development of secondary markets in spectrum usage rights, while the Notice proposed concrete steps the Commission might take to implement that policy with respect to wireless radio services and satellite services. Other countries have undertaken similar reviews of spectrum management policies and practices.[18]

B. Spectrum Use

Preliminary data and general observations indicate that portions of the radio spectrum are not in use for significant periods of time. To assess actual spectrum use, the FCC's Enforcement Bureau measured spectrum use below 1 GHz in Atlanta, Chicago, New Orleans, San Diego, and in a Washington, DC suburb during various periods in July 2002.[19] These preliminary measurements indicate that, while some bands are heavily used – such as those bands used by cellular base stations – many other bands are not in use or are used only part of the time. Thus, there may be opportunities for spectrum-based devices to operate in both the temporal white spaces – those resulting from variability in the operations of existing spectrum users over time – and the geographic white spaces – those resulting from the geographic separation of existing spectrum users.

These data offer a useful starting point, and, indeed, confirm some long-held views regarding actual spectrum usage. More information, however, is needed in order to quantify and characterize spectrum usage more accurately so that the Commission can adopt spectrum policies that take advantage of these spectrum white spaces. Currently, no federal agency or other organization systematically measures temporal spectrum use.

Also, it is generally understood that certain types of spectrum users, such as the public safety community, have significant variability in their spectrum use and, as such, much of their allocated spectrum lies fallow during non-peak periods. For example, the Task Force received some usage data regarding a particular police dispatch channel in

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[16] "Principles for Promoting Efficient Use of Spectrum By Encouraging the Development of Secondary Markets," *Policy Statement,* 15 FCC Rcd 24178 (2000).

[17] "Promoting Efficient Use of Spectrum through Elimination of Barriers to the Development of Secondary Markets," *Notice of Proposed Rulemaking,* WT Docket No. 00-230, 15 FCC Rcd 24203 (2000).

[18] For example, Canada and administrations in Europe have recently carried out extensive and comprehensive reviews of their spectrum policies. In the United Kingdom, the government commissioned an "independent review" of radio spectrum management in the U.K. by Professor Martin Cave, who participated in one of the Task Force's workshops. Professor Cave's report was published in March 2002 and made 47 wide-ranging recommendations on the future management of radio spectrum. The U.K. government published its response to the report on October 15, 2002, accepting nearly all of the report's recommendations. *See* http://www.spectrumreview.radio.gov.uk.

[19] The Spectrum Efficiency Working Group Report contains a more detailed discussion of these preliminary measurements.

New York State.[20] These data indicate that, for the measurement period, typical channel occupancy was less than 15%, while the peak usage was close to 85%.

Spectrum above 50 GHz is also not heavily used because, until recently, radio technology has not been sufficiently advanced to use this portion of the spectrum. For example, developments in millimeter-wave technologies – that is, technologies that can effectively propagate pencil-beam like signals – have made higher spectrum bands, such as those above 70 GHz, possible for use.[21] The potential uses for these technologies include high-speed wireless local area networks, broadband access systems for the Internet, point-to-point communications, and point-to-multipoint communications.

In light of the preliminary FCC measurements, the acknowledged variability of some types of licensed spectrum users, and the recent advances in technology, the Task Force concludes that there is evidence to suggest that spectrum use can be increased significantly.

C. Spectrum Reform Considerations

Over the years, as it considered various allocation and service proposals for parts of the spectrum, the Commission has taken into account any number of "public interest" considerations. For example, in determining whether to reallocate spectrum for another use or to change particular service rules, the Commission has considered the reliance interests of existing spectrum users, including their investments and reasonable expectations, in order to make sure any transition to new uses is equitable. Other important factors that have come into play are the benefits (and harms) of allocations to national security and emergency preparedness. It is important to ensure that critical defense systems do not risk exposure to harmful interference and to provide adequate spectrum resources to public safety entities. In making spectrum policy in certain proceedings, especially those involving spectrum used for global satellite systems, the Commission also has ensured that spectrum coordination among countries allows for adequate domestic and international operations. Access to specialized services for persons with disabilities has also been an important concern addressed in numerous proceedings. As a final example of its public interest considerations, the Commission's policies surrounding spectrum allocated for broadcasting service, especially in the context of the conversion from analog to digital television, have taken into account localism and access to free-over-the-air television.

IV. Spectrum Policy Reform: The Time is Now

The Spectrum Policy Task Force believes that the time is ripe for spectrum policy reform. Increasing demand for spectrum-based services and devices are straining longstanding, and outmoded, spectrum policies. The overarching goal of effective

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[20] *See* Comments of Statewide Wireless Network, New York State Office for Technology.

[21] *See* In the Matter of Allocations and Service Rules for the 71-76 GHz, 81-86 GHz and 92-95 GHz Bands, WT Docket No. 02-146, 17 FCC Rcd 12182 (2002).

spectrum policy is to maximize the potential public benefits to be derived through spectrum-based services and devices. The Task Force believes that the Commission can and should modify current spectrum policy through increased flexibility in order to achieve this goal. This section of the Task Force's report discusses why spectrum policy reform is needed.

A. Explosive Demand for Spectrum-Based Services and Devices

There has been a dramatic increase in overall demand for spectrum-based services and devices, accompanied by particular demand for mobile and portable spectrum-based applications. This is true for both traditional, licensed services and for services offered through unlicensed devices. This increased demand is propelled by a host of factors: the economy has moved towards the communications-intensive service sector, the workforce is increasingly mobile, and consumers have been quick to embrace the convenience and increased efficiency of the multitude of wireless devices available today.

While the Task Force recognizes the societal trends that have contributed to the increased demand for spectrum-based services and devices, it is also difficult to make accurate projections of future demands. Historically, both industry and Commission projections for spectrum use have significantly and consistently underestimated the need for additional spectrum and the public's utilization of new technologies and applications. One illustrative example is the explosive growth in consumer demand for mobile wireless services. In 1994, the Commission allocated spectrum based on a projection of 54 million domestic mobile services users for the year 2000. By the year 2000, however, there actually were approximately 110 million mobile services users.[22]

Advances in technologies have significantly increased the diversity of service offerings and have also qualitatively improved existing services, thereby increasing consumer demand for spectrum-based services and devices. For example, advances in spread spectrum techniques have spawned significant consumer demand for associated applications. Spread spectrum technology – which spreads the energy of a radio signal over a bandwidth that is greater than that required to transmit a particular signal[23] – was originally developed for military applications and the Commission first approved its use for commercial applications was first approved by the Commission in 1985. While this technology has been used for cordless telephones for some time, advances in this technology, coupled with developments of industry protocols for its use, such as Bluetooth and Wi-Fi, have contributed to the surging demand for wireless devices that

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[22] *See* Implementation of Section 6002(b) of the Omnibus Budget Reconciliation Act of 1994, Annual Report and Analysis of Competitive Market Conditions with Respect to Commercial Mobile Services, Sixth Report, FCC 01-192, 16 FCC Rcd 13350 (2001) at 21.

[23] The Commission's rules define "spread spectrum systems" as follows: "A spread spectrum system is an information bearing communications system in which: (1) Information is conveyed by modulation of a carrier by some conventional means, (2) the bandwidth is deliberately widened by means of a spreading function over that which would be needed to transmit the information alone. (In some spread spectrum systems, a portion of the information being conveyed by the system may be contained in the spreading function.)" *See* 47 C.F.R. § 2.1.

enable computer and data networking through wireless local area networks (WLANs). Consumers are increasingly demanding wireless computer and data networking because most businesses and many homes now have multiple computers, and, as a result, users often find it desirable to install local area networks to share resources, such as printers, scanners and broadband or dial-up Internet connections. Indeed, developing a local area network using wireless unlicensed devices can be a cost-attractive mobile alternative to wired networks.

New technologies also often enhance existing spectrum-based services and devices, thereby contributing to increased consumer demand. Third generation, or advanced wireless services, will have better packet data control and higher-speed transmission rates than current second generation technologies. For consumers, these technological advances translate into a wider diversity of potential service offerings, particularly Internet and wireless data services, which can be delivered at faster rates. The projected growth in this area is significant – some analysts predict that wireless mobile data traffic will eventually eclipse mobile voice traffic.

Not only is the overall demand for spectrum-based services and devices steadily increasing, because the applications are increasingly dynamic, they are adding even more strain to current spectrum policies. Among other things, they present increasingly complex interference management issues. For example, the same frequencies are used by cordless phones and 802.11b Wi-Fi devices. Because these devices often change locations during their operations and their use is often in close proximity to one another, the technical geometries or parameters that determine interference vary accordingly as well. Using typical worst case predictive interference models would significantly reduce the potential of these devices to operate. As a result, it is important to evolve from current spectrum policies, which reflect a spectrum world made up of a limited number of types of operations, to policies that reflect the increasingly dynamic and innovative nature of spectrum use.

B. Technological Advances: Enabling Changes in Spectrum Policy

While technological advances are contributing to the increased diversity of spectrum-based consumer applications and, consequently, their use is resulting in more demand for spectrum, technological advances are also providing some potential answers to current spectrum policy challenges. Some recent and significant technological advances include the increased use of digital technologies and the development of software-defined radios.

Growth in the use of digital spectrum-based technologies not only increases the potential throughput of information, it also has potentially significant ramifications for interference management. Digital signals are inherently more robust, and resistant to interference, than analog signals. Moreover, digital signal processing techniques, such as coding and error correction, are more effective at rejecting interfering signals. Thus, spectrum policies can and should reflect this increased ability to tolerate interference. Moreover, given the increased ability of new technologies to monitor their local RF environment and operate more dynamically than traditional technologies, the predictive

models used by the Commission can be updated, and perhaps eventually replaced, by techniques that take into account and assess actual, rather than predicted, interference.

Software-defined radios are a significant technological advancement illustrating how technological advances can enable more intensive spectrum use. Unlike traditional radios, in which technical characteristics are fixed at the time of manufacture and cannot subsequently be modified, operating parameters in software-defined radios (such as the operational frequency and modulation type) are determined by software. The fact that these parameters are determined by software means that a software-defined radio can be programmed to transmit and receive on many frequencies and to use any desired modulation or transmission format within the limits of its hardware design. A software-defined radio can also be programmed to receive different types of radio signals on varying frequencies. Often technologies such as software-defined radios are called "smart" or "opportunistic" technologies because, due to their operational flexibility, software-defined radios can search the radio spectrum, sense the environment, and operate in spectrum not in use by others. By operating in so-called white – or unused – spaces in the spectrum, software-defined radios can enable better and more intensive use of the radio spectrum.

Historically, due in large part to technological limitations in radio performance, the Commission's spectrum policies have parceled – or assigned – spectrum according to particular operational frequencies and geographic areas of operations. Smart technologies, such as software-defined radios, potentially allow operators to take advantage of the time dimension of the radio spectrum. That is, because their operations are so agile and can be changed nearly instantaneously, they can operate for short periods of time in unused spectrum. The Commission's current policies do not take into account the time dimension of spectrum use. In addition, the Commission's current policies do not allow new technologies to take advantage of geographic white space. In order to be responsive to these increased technological capabilities, the Commission's spectrum policies can and should remain technology agnostic, but they should not be technology antagonistic. As a result, the Commission should strive, wherever possible, to eliminate regulatory barriers to increased spectrum access.

C. Increased Access: Mitigating Scarcity of Spectrum Resource

Due to the growth in demand for spectrum-based services, many spectrum users seek additional spectrum and it now appears as though spectrum demand is outstripping spectrum supply. Indeed, most prime spectrum has already been assigned to one or more parties, and it is becoming increasingly difficult to find spectrum that can be made available either for new services or to expand existing ones. As noted above, in connection with its spectrum policy inquiry, the Task Force reviewed preliminary data regarding spectrum usage. While additional, and more comprehensive, spectrum measurements can and should be undertaken to improve the understanding of actual spectrum use, preliminary measurements show that significant spectrum capacity remains untapped. Thus, if the Commission were to permit greater access to the radio spectrum, the effects of the physical scarcity of the spectrum resource could be minimized.

Improving access to the spectrum can be achieved through permitting current licensees greater flexibility. Often a licensee has variable needs and therefore does not use its spectrum for particular periods of time. At the same time, due to restrictions based in Commission policies, licensees are usually unable to make their spectrum available to others, even if a market exists to do so. While this concept will be addressed in greater detail, *see infra* Section VIII, granting licensees additional flexibility to make their licensed bands available to others would increase access to the spectrum and, correspondingly, minimize the impact of spectrum scarcity.

Another significant reason that spectrum may be underutilized, as noted earlier, is that the Commission's regulations do not reflect and capitalize upon the significant advancements made in spectrum-based radio technologies. Because new, smart technologies can sense the spectrum environment and because they have the agility to dynamically adapt or adjust their operations, increasing access to the spectrum for smart technologies, such as software-defined radios, can improve utilization, through more efficient access, of the radio spectrum without detriment to existing spectrum users.

In the near term, the Commission should consider adopting policies that increase opportunities for access to the radio spectrum through granting additional flexibility. The Commission also may want to consider options for increasing the benefits derived from the radio spectrum by providing incentives for technologies that improve the throughput of information.

Eventually, it may be possible that spectrum access is fully optimized for certain bands and locations (that is, that the spectrum is not only fully licensed but also heavily used.) At that point in time, the Commission may need to focus solely on promoting improved throughput of information. In the interim, however, to ensure that existing services can continue to grow to accommodate marketplace needs, and that new services have a chance to take hold and grow, it is important that the Commission continue to optimize and facilitate access to and use of the radio spectrum.

V. Key Elements of New Spectrum Policy

To facilitate the Commission's goal of promoting access to and use of radio spectrum, the Task Force recommends that the Commission evolve its spectrum policy toward more flexible and market-oriented spectrum policies that will provide incentives for users to migrate to more technologically innovative and economically efficient uses of spectrum. As discussed below, there is no single regulatory model that can or should be applied to all spectrum to accomplish these goals, but there are certain common elements that should be incorporated into the Commission's general approach to spectrum policy regardless of the regulatory model that is used. These elements also inform the Task Force's approach to interference, spectrum rights, and spectrum access discussed in subsequent sections of this report. Specifically, the Commission should seek to meet the following fundamental objectives in spectrum policy:

- Allow for maximum feasible flexibility of spectrum use by both licensed and unlicensed users;

- Clearly and exhaustively define spectrum users' rights and responsibilities;
- Account for all potential dimensions of spectrum usage (frequency, power, space, and time);
- Provide incentives for efficient spectrum use;
- Encourage grouping of spectrum "neighbors" with technically compatible characteristics;
- Provide for periodic review and revision of spectrum rules to account for technological advances and other changes; and
- Establish efficient and reliable enforcement mechanisms to ensure regulatory compliance by all spectrum users.

A. Maximizing Flexibility of Spectrum Use

As a general proposition, flexibility in spectrum regulation is critical to improving access to spectrum. In this context, "flexibility" means granting both licensed users and unlicensed device operators the maximum possible autonomy to determine the highest valued use of their spectrum, subject only to those rules that are necessary to afford reasonable opportunities for access by other spectrum users and to prevent or limit interference among multiple spectrum uses. Flexibility enables spectrum users to make fundamental choices about how they will use spectrum (including whether to use it or transfer their usage rights to others), taking into account market factors such as consumer demand, availability of technology, and competition. By leaving these choices to the spectrum user, this approach tends to lead to efficient and highly-valued spectrum uses. In most instances, a flexible use approach is preferable to the Commission's traditional "command-and-control" approach to spectrum regulation, in which allowable spectrum uses are limited based on regulatory judgments.

Of course, as discussed further below, there are some necessary limits to the degree of flexibility that can be afforded to any single spectrum user. For example, clear technical rules (*e.g.* power limits, interference standards) remain necessary in all spectrum bands in order to facilitate co-existence of multiple spectrum uses in common and adjacent bands.[24] In addition, there are limited instances in which regulating spectrum use on a command-and-control basis may continue to be necessary to achieve certain public interest objectives.[25] Finally, the degree of flexibility that is afforded to particular spectrum users should take into account the importance of promoting reasonable access to spectrum for other potential users.[26]

Even with these limitations, however, the potential exists for the Commission to significantly increase the amount of flexibility that is afforded to spectrum users in much of the spectrum that it regulates. The Commission should seek to avoid rules that restrict spectrum use to particular services or applications, so long as the user operates within the

[24] *See* Section VI, *infra*.

[25] *See* Section VII, *infra*.

[26] *See* Section VIII, *infra*.

technical parameters applicable to the particular band in question. Furthermore, these technical parameters should themselves be limited to those that are necessary to define the user's RF environment in terms of maximum allowable output and required tolerance of interference.

Such flexibility can be implemented under more than one regulatory model for defining spectrum usage rights. As discussed further below, the Task Force advocates expanding the future use of two alternative regulatory models – one based on awarding exclusive spectrum usage rights and the other on creating unlicensed spectrum "commons" – both of which are premised on the concept of flexible use.[27] Under either model, the Commission should give spectrum users maximum possible autonomy in the following areas:

- Choice of uses or services that are provided on spectrum. Spectrum users should have the maximum possible flexibility to decide how spectrum will be used, *e.g.,* whether to provide commercial services or to use spectrum for private, internal needs, so long as they comply with the general parameters applicable to the band (including any applicable power limits or interference limits).

- Choice of technology that is most appropriate to the spectrum environment. Spectrum users should be allowed to choose the technology that is best-suited to their proposed use or service. They should be allowed adapt their technology to their particular spectrum environment, *e.g.,* to use lower power in spectrum-congested areas and higher power in less-congested (*e.g.,* rural) areas.

- Right to transfer, lease, or subdivide spectrum rights.[28] An efficient secondary markets regime should be in place to facilitate the negotiated movement of spectrum rights from one party to another. In more narrowly-defined services (*e.g.,* public safety), spectrum users should have the ability to lease excess capacity for other uses through time sharing of spectrum or other mechanisms.[29]

B. Clear and Exhaustive Definition of Spectrum Rights and Responsibilities

While commenters and workshop participants were vocal about their desire for more flexible rights, they were equally interested in firmness and clarity in the rules they are required to follow. Most commenters and workshop participants also agreed with the proposition that spectrum users' rights and obligations are often not defined with sufficient clarity under the FCC's current rules. An overarching principle eventually

[27] *See* Section VII, *infra*.

[28] Where spectrum is made available on a commons basis, spectrum usage rights are non-exclusive, and therefore new users do not depend on the transferability of such rights to obtain access to the spectrum. Nonetheless, there is no reason to restrict the transferability of such rights.

[29] *See* Section VII.C.2, *infra*.

emerged: all spectrum users require clear rules governing their interactions with the Commission and other spectrum users. Regardless of how or to whom particular rights are assigned, ensuring that all rights are clearly delineated is important to avoiding disputes, and provides a clear common framework from which spectrum users can negotiate alternative arrangements.

To provide this framework, the Commission must clearly define the following basic spectrum rights parameters for all licensed and unlicensed spectrum uses:

1. Designated frequency range and bandwidth;
2. Geographic scope of right to operate;
3. Maximum RF output, both in-band and out-of-band; and
4. Interference protection, *i.e.* the maximum level of noise/interference that the spectrum user must accept from other RF sources.[30]

Also, to ensure that rights are exhaustively assigned, the rules should be written to define spectrum rights in terms of spectrum uses that are excluded, prohibited, or limited. Thus, the Commission's approach should be that licensees and unlicensed users are allowed to do anything not explicitly prohibited by the Communications Act, the Commission's rules, Commission orders, licenses or authorizations, rather than the presumption being that anything not affirmatively authorized requires a rule change or waiver before it can be done.

The first three of the parameters listed above essentially define the scope of the maximum allowable RF output of a given spectrum use in terms of frequency, bandwidth, space, and power. These are typically defined with relative clarity in the FCC rules using objective criteria, *e.g.,* licensing area borders, antenna height, and transmitter power limits, etc.[31] However, the fourth criterion (interference protection) is distinct because it pertains to the universe of outside RF sources (in band and out-of-band) that may cause interference to the spectrum user. Because all of these sources may not be known or anticipated, capturing this variable is more difficult. Indeed, commenters and workshop participants almost uniformly cited the FCC's interference rules as the prime example of rules that are not clearly defined. A common refrain was that the FCC rules speak of the right to be protected from "harmful interference," but this term is not defined in technical terms, making objective measurement difficult.[32] To address these issues, the

[30] In the case of unlicensed uses and in some shared licensed bands, interference protection rights are "defined" as a nullity, *i.e.,* spectrum users have no interference protection rights.

[31] As discussed in the next section, however, there are ways in which the rules governing these dimensions of spectrum use can be refined. *See* Section V.C, infra.

[32] Obviously, this is not an issue for bands in which spectrum users have no interference protection, *e.g.*, unlicensed bands. Moreover, in licensed bands, the establishment of maximum power and emission levels at the geographic and spectrum borders of each licensed spectrum block provides a form of interference regulation, because each licensee knows in advance the maximum output that it is required to accept from co-channel and adjacent channel licensees that are subject to these rules. This approach only works, however, if all of the potential RF emitters are known and subject to defined RF output limits. It works less

Commission needs to define interference rights more clearly on a prospective basis. The Task Force discusses possible ways to accomplish this in Section VI below.

C. Accounting for All Dimensions of Spectrum Use

The Task Force also analyzed the benefits of parceling out spectrum using variations in frequency, space, power, and time to maximize the use of spectrum. In the past, the Commission has recognized and licensed spectrum primarily by defining spectrum rights in terms of the first three dimensions. The Task Force found that new technological developments are changing the way in which each of these spectrum dimensions is used. In addition, new technology now permit the Commission to increasingly consider the use of time, in combination with frequency, power, and space, as an added dimension that could permit more dynamic allocation and assignment of spectrum usage rights.

Frequency or bandwidth requests have long been the mainstay of the spectrum allocation and licensing process. Parties file applications with the Commission seeking allocations for a particular service and licensing in a specific bandwidth based on the type of service they envision providing. This process requires all interested parties to evaluate the applicant's proposal through filings at the Commission. The Commission is then required to make a determination as to the desirability of the allocation and rules for the service, including the appropriate bandwidth for a particular licensee. Several technological trends are now affecting this traditional paradigm, however. First, the development of spread spectrum technology has increased demand for contiguous broadband spectrum allocations. Second, technology is making increased use of higher frequencies, *e.g.,* bands above 50 GHz, that previously were considered to have limited utility. Finally, the development of frequency-agile technology has created the potential for development of services and uses that are not tied to specific frequency bands.

Space and power are related but slightly different dimensions that define the geographic scope of spectrum use for spectrum management purposes. The Task Force found that the Commission should expand the ability of spectrum users to partition their geographic service areas, or space, so that portions of their service areas that would otherwise lay fallow could potentially be put to use.

The Task Force also found that spectrum use can be improved is by permitting transmitter power levels to be adjusted to match the environment of the transmitter and the intended service area. For example, maximum power levels could be increased in rural areas so that service can be provided over larger areas at lower cost. In congested urban areas, where high transmitter power levels on one frequency can often adversely impact the use of other frequencies, the Commission should look towards enabling the use of lower power transmissions. For example, high-power digital television broadcasters could be permitted to operate single frequency low-power distributed

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well where output rules for different spectrum uses are established at different times or the rules do not account for unanticipated technologies.

transmission systems within their present service areas. Other site-licensed services could be provided similar flexibility. The Commission could also consider whether it should offer incentives for reducing transmitter power (such as an increased interference protection).

The Task Force also recommends that the Commission seek methods for fostering technologies, such as advanced antennas and system design techniques, that maintain as close to uniform power flux density signal levels as possible throughout a service area. As discussed in the Spectrum Efficiency Working Group and Interference Protection Working Group Reports, these technologies could avoid interference between users, and could provide for greater spectrum reuse.

Finally, with respect to power, the Task Force concluded that the Commission also should promote the co-location of high power transmitters. In general, interference between services is often less likely when the signal strengths from the services are similar; co-location of high power transmitters helps ensure comparable signal strengths throughout the service areas.

To better account for use of spectrum in the time dimension, the Task Force also recommends that the Commission examine methods for promoting technologies that will facilitate time-sharing of spectrum between multiple users. For example, the Commission should consider permitting traditionally-narrow services, such as public safety, to lease excess capacity to other services. The Commission should also consider whether the use of trunking technology, where several users automatically share frequencies, should be expanded, Time divided or aggregated use of spectrum is becoming a necessity in order to meet the burgeoning demand with limited opportunities for allocating new services. The Task Force also recommends that the Commission consider methods for allowing access to spectrum with typically low utilization on an interruptible basis, *i.e.*, allowing the interruptible use of otherwise authorized spectrum when it is not being used by the primary licensee but requiring the user to suspend operations when the primary licensee is transmitting. This type of opportunistic use along with the technology for such use should be studied to determine whether it can be authorized without interfering with the established rights of licensees or whether licensees are in the best position to evaluate such use.

Cutting across the four dimensions of spectrum management discussed above is the concept of whether to allow spectrum licensees to lease access to other spectrum users in one or more of these dimensions under a secondary markets approach, or whether to create regulatory "easements" in one or more of these dimensions that allow users access on a conditional, non-interfering basis. One possibility discussed below is to permit unlicensed systems or devices to operate at very low power up to a defined interference temperature limit [33] Another issue discussed below is whether and how to facilitate access to spectrum by "opportunistic" frequency-agile devices that can take advantage of spectrum "holes" in time and frequency without interfering with other

[33] *See* Section VI, *infra*.

operations in the bands they utilize.[34] The Task Force recommends that the Commission investigate these concepts and the possible parameters for allowing such increased use of the spectrum.

D. Promoting Efficiency

The Task Force identified three variations on and definitions for the term "efficiency," as applicable to spectrum management: spectrum efficiency, technical efficiency, and economic efficiency. Spectrum efficiency occurs when the maximum amount of information is transmitted within the least amount of spectrum. Technical efficiency occurs when inputs, such as spectrum, equipment, capital, and labor, are deployed in a manner that generates the most output for the least cost. Economic efficiency occurs when all inputs are deployed in a manner that generates the most value for consumers. The Task Force found that spectrum and technical efficiency are components of economic efficiency, but that measuring spectrum and technical efficiency does not necessarily provide any meaningful information with respect to economic efficiency.

The Task Force also attempted to develop a methodology for measuring spectrum efficiency. It concluded that while it is generally easiest to assess technical efficiency on a per-device basis in terms of bits/seconds/hertz, after reviewing the comments and the record, it was neither possible nor appropriate to select a single, objective metric for comparing spectrum efficiency across different radio services. Any metric would, inherent in its assumptions, provide advantages to one service or another. In addition, measuring technical efficiency does not provide any information with respect to economic efficiency.

The Task Force concluded that the Commission can best promote economic efficiency by providing spectrum users with flexibility of spectrum use and ease of transferability in order to allow maximization of the value of the services provided. Flexibility provides incentives for economically efficient use and discourages economically inefficient use by ensuring that spectrum users will face the opportunity cost of their spectrum use. In most instances, the application of flexible service rules and efficient secondary market mechanisms are the best means of achieving this goal. The Task Force recognized that there may be situations where the Commission finds it necessary to promote spectrum or technical efficiency (as opposed to economic efficiency) in order to promote particular public interest goals. However, in those instances, where marketplace forces may be inadequate, *e.g.,* in spectrum that is allocated for government use, alternative mechanisms such as user fees should be considered to stimulate improvements in efficiency. In addition, to the extent that wireline or hybrid technologies may be efficient alternatives to existing use of radio spectrum in some instances, Commission policy should promote the use of such alternatives whenever appropriate. It should be noted that the Task Force recommends that the Commission conduct a cost-benefit analysis as part of the spectrum management process and that,

[34] *See* Section VIII.B, *infra*.

while the analysis will often favor market-oriented approaches, there are instances where the analysis will support regulation.

E. "Good Neighbor" Incentives

In addition to improving access to spectrum through flexible use policies, as discussed above, it may be desirable, where possible, to group technically compatible systems and devices in close spectrum proximity. One of the challenges presented by permitting additional flexibility within assigned spectrum is the potential for incompatible adjacent systems. For instance, low-power systems or devices with a high sensitivity to interference could be grouped with similar systems, and systems or devices with high power could be placed elsewhere. System or device spectrum incompatibility can require additional constraints in the form of guard bands, consuming valuable spectrum, or expensive filtering systems to avoid adjacent band interference. The Task Force believes that the Commission should consider making spectrum policy decisions encouraging like systems or devices to be grouped in spectrum "neighborhoods" with like systems. At the same time, it is important to be mindful of the importance of allowing flexible use of spectrum.

The Task Force recommends that the Commission rely primarily on its general spectrum management authority to consider whether future allocations should be grouped based on mutually-compatible technical characteristics. Specifically, such a "good neighbor" policy would group future systems or devices by specifying comparable maximum levels of power and compatible interference protection levels. For existing services, flexible use policies could create the incentive for spectrum-based systems or devices to migrate to compatible bands based on marketplace forces. In some limited instances, however, there may be particular types of systems or devices, public safety for example, that require more direct regulatory intervention (*e.g.,* through creation of guard bands or other direct regulation of out-of-band interference) because the marketplace may not independently encourage such compatibility. In addressing those issues, however, the Commission should be careful not to compromise or undermine the overall concept of flexible use. Over time, the Commission could consider whether the tightening of out-of-band emission limits in services would obviate the need for allocations to be grouped.

F. Periodic Review of Rules

The Task Force recommends that the Commission consider adjusting its regulations on a periodic basis to prevent rules that are calibrated to older technologies from inhibiting access by newer, more efficient technologies that develop over time. For instance, as discussed below, it may be possible to adjust interference standards over time based on technological advances. Public Workshop participants, as well as parties that commented on the Public Notice, generally agreed that it would be useful to set term limits on Commission rules so that the rules would be revisited automatically on a periodic basis.

While the Task Force concludes that the Commission should subject spectrum regulations to periodic re-evaluation, it is also important that such reevaluation occur at

sufficiently spaced intervals so as not to undermine the stability of current spectrum users' business plans and investment. The Task Force continues to believe that a level of certainty regarding one's ability to continue to use spectrum, at least for some foreseeable period, is an essential prerequisite to investment, particularly in services requiring significant infrastructure installation and lead time. Therefore, any periodic reevaluation of rules, and any resulting implementation of new rules, should be on a predetermined schedule, *e.g.,* every 5 to 10 years. Specific timetables for review of rules need not be the same for all services, devices, and spectrum bands, but can vary based on such factors as service provider and customer investment requirements, apparent public expectations, and anticipated speed of technological development. In addition, periodic review of rules to accommodate new technologies should be distinguished from the license renewal process, which focuses on licensee qualifications and compliance with Commission rules. Thus, licensees in bands that are subject to periodic review should nonetheless be entitled to a strong renewal expectancy if they meet the renewal criteria set forth in the Commission's rules.

G. Enforcement

The Task Force believes that in order for the Commission to be able to meet the increasingly complex spectrum management demands being presented by the enormous growth in spectrum use, the Commission must devote sufficient resources to monitoring spectrum use and enforcing the spectrum management rules. The Task Force recommends that the Commission undertake an examination of its field offices' and monitoring facilities' needs and consider providing additional funding and resources to accommodate the spectrum management proposals made in this Report. In addition, the Commission should ensure that it has sufficient resources to independently obtain critical spectrum management data for decision makers and the ability to implement the proposals discussed in this Report. In addition, the Commission may want to seek a review and possible increase in its statutory forfeiture authority in order to provide additional incentives for spectrum users to comply with the Commission's rules.

Recommendations:

- Permit broad, highly flexible use within technical parameters of the allocation.
    - Permit traditionally narrow services to lease excess capacity to other services.
- Investigate rule changes that enable the lowering of permitted power in urban areas and the increasing of permitted power in rural areas.
    - Permit high-power digital television broadcasters to operate single frequency low power distributed transmission systems within their present service area.
    - Promote the co-location of high power transmitters.
- Foster technologies for uniform signal strength generation throughout a service area
- Consider user fees or other steps to stimulate improvements in efficiency when marketplace is inadequate.
- Promote shift to hybridizations with wireline delivery whenever appropriate.
- Group future allocations based on mutually-compatible technical characteristics (power flux density and sensitivity to interference), and improve the out-of-band interference performance of transmitters and receivers over time so as to reduce the need for this kind of grouping.
- Conduct periodic evaluations of allocation parameters with respect to evolving technology and uses.
- Time-limit spectrum rights and subject them to periodic review.
    - Every 5 to 10 years, review spectrum rights and obligations, interference criteria, and definitions, and modify if appropriate.
    - But spectrum users should be entitled to rely on rules remaining constant between periodic reviews.
    - Licensees should still have strong renewal expectancy.
- Ensure that the Commission has sufficient resources to independently monitor and enforce spectrum management rules, including possible increase in statutory forfeiture authority.

VI. Interference Avoidance

A. Interference Challenges[35]

As the Commission considers how to provide opportunities for an ever-increasing array of spectrum-based technologies and services, one recurring and often thorny issue is how to protect users against harmful interference.[36] Ensuring adequate interference protection has been a key responsibility of the Commission since inception and continues to be one of its core functions. Section 303(f) of the Communications Act of 1934, as amended, directs the Commission to make regulations "it may deem necessary to prevent interference between stations" as the public interest requires. Sufficient interference protection is a necessary and fundamental building block in any spectrum policy. Indeed, without adequate interference management, new spectrum-based services could be prematurely thwarted and, correspondingly, mature services might not be able to reach their full potential.

Managing interference has always been challenging. Despite the fact that the Commission has had extensive, and generally successful, experience in managing interference issues, these issues have been increasing in technical difficulty and prevalence due to the changing RF environment generated by new devices and new technology. Interference management requires more than determining the ways in which to engineer around potential degradation to a radio signal. Rather, interference management necessarily involves technical and economic tradeoffs. For example, although requiring licensees to use more selective rather than more sensitive receivers may improve interference management because such receivers are less vulnerable to adjacent channel interference, it may also increase the cost of the communications systems by requiring more infrastructure.[37]

This already challenging issue has become even more difficult as a result of the increasingly intensive use of the radio spectrum. There are now fewer and fewer opportunities to allocate unused spectrum for new services and, correspondingly, fewer and fewer bands in which interference is not a significant issue. Interference management has become more difficult because of the greater density, mobility and variability of RF emitters and because users have been granted increased flexibility in

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[35] For a more extensive discussion, *see* Interference Protection Working Group Report section entitled "Future Challenges Warranting Consideration of New Interference Protection Paradigms."

[36] "Interference" is defined as follows, according to the Commission's rules: "The effect of unwanted energy due to one or a combination of emissions, radiations, or inductions upon reception in a radio-communication system, manifested by any performance degradation, misinterpretation, or loss of information which could be extracted in the absence of such unwanted energy." 47 C.F.R. § 2.1. "Harmful interference" is defined as follows: "Interference which endangers the functioning of a radionavigation service or other safety services or seriously degrades, obstructs, or repeatedly interrupts a radiocommunication service operating in accordance with these [international] Radio Regulations." 47 C.F.R. § 2.1.

[37] Generally, selectivity is achieved by adding filters to the front end of a receiver, and these usually increase the receiver noise figure – decreasing its sensitivity to RF signals.

their spectrum use. As a result, the complexity of predictive interference models has increased dramatically. Whether a user operates a fixed or mobile communications system affects the technical variables required to assess interference. Many types of mobile emitters have very low signal levels. Although the energy radiated by a single emitter might not be likely to cause harm, the cumulative emissions of secondary/unlicensed emitters and out-of-band emissions of primary licensed emitters and emitter types (radio telemetry, unlicensed devices, cell phones, etc.) could result in interference and, thus, must be considered. Technological changes in a communications system – for example, the type of waveform used to transmit a particular signal – also affect assessments of interference. As a result, comprehensive interference predictive analyses are not always possible, calling into question the adequacy of the Commission's current interference framework to manage increasingly congested RF environments in the future.

Commenters and participants in the public workshop were divided on the need for new definitions of what constitutes acceptable interference and harmful interference. Some appreciated the flexibility attendant with the Commission's current case-by-case approach. Others, frustrated by what they see as the uncertainty associated with such an *ad hoc* approach, advocate the adoption of more quantitative measures for interference management. These parties contend, for example, that the current definition of *harmful interference* is subjective and does not reflect modern technology and communications markets. On balance, the Task Force concludes that the current general definitions of interference sufficiently address the broad operational and technical characteristics of the many communications services contained in the Commission's Rules. Rather, in lieu of suggesting that the Commission change or refine its definitions related to interference management, the Task Force believes that quantitative metrics can be used to augment and clarify the application of existing definitions.

The Task Force believes that, although the Commission's rules and processes for managing interference have historically been effective in many bands, current interference management approaches and tools need to be reexamined. As supported by the record and described in greater detail in the report of the Interference Protection Working Group, the rapidly changing technology and RF environment will challenge the continued effectiveness of such current approaches as predictive interference modeling, technology compatibility testing, and spectrum use decisions based on a qualitative knowledge of the local environment. Moreover, given the increasing flexibility in the types of spectrum-based services and, correspondingly, more intensive use of the radio spectrum, the Task Force believes that the Commission should adopt, wherever feasible, a more quantitative approach to interference management or quantitatively augment its existing rules. Quantitative standards reflecting real-time spectrum use would provide users with more certainty and, at the same time, would facilitate enforcement.

B. Adopting Quantitative Standards: Interference Temperature

The Task Force recommends that, as a long-term strategy, the Commission shift its current paradigm for assessing interference – based on transmitter operations – toward operations using real-time adaptation based on the actual RF environment through interactions between transmitters and receivers. In general, it is the ability of a receiver to select and receive a particular signal that determines whether the signal has been degraded by interference. The environment in which the receiver operates should be considered; *i.e.*, the total amount of undesired power – generated by other emitters and noise sources – that is present at the receiver. Thus, the Commission's rules should specify a more accurate measure of interference that takes into account the cumulative summation of all the undesired RF energy available to be captured by a particular receiving antenna for delivery to the receiver.

To achieve this objective, as well as to transition interference management to more accurate real-time measurements, the Task Force recommends that the Commission adopt a new metric, "interference temperature," to quantify and manage interference. The interference temperature measures the RF power available at the receiving antenna per unit bandwidth.[38] Conceptually, as illustrated in Figure 1, interference temperature

[38] The idea of an interference temperature as a measure of the "noise" power in a particular band and location is synonymous with the concept of antenna temperature: the "equivalent temperature of the power received at an antenna." *See,* for example, Wolfram Research at http://scienceworld.wolfram.com/physics/AntennaTemperature.html. Antenna temperature is a component of the total noise temperature of a receiver system, which also includes the thermal noise generated within the receiver.

Interference temperature, expressed in units of degrees Kelvin, can be calculated as the power received by an antenna in watts divided by the associated RF bandwidth in Hertz and a term known as Boltzman's Constant (equal to 1.3807 watt-sec/°Kelvin). Alternatively, interference temperature can be calculated as the power flux density available at an antenna in watts per meter squared multiplied by the effective capture area of the receiving antenna in meters squared divided by both the associated RF bandwidth in Hertz and Boltzman's constant. An "interference temperature density" can also be defined as the interference temperature per unit area, expressed in units of °Kelvin per meter squared, and calculated as the interference temperature divided by the effective capture area of the receiving antenna. This quantity could be measured for particular frequencies using a reference antenna and, thereafter, would be independent of receiving antenna characteristics.

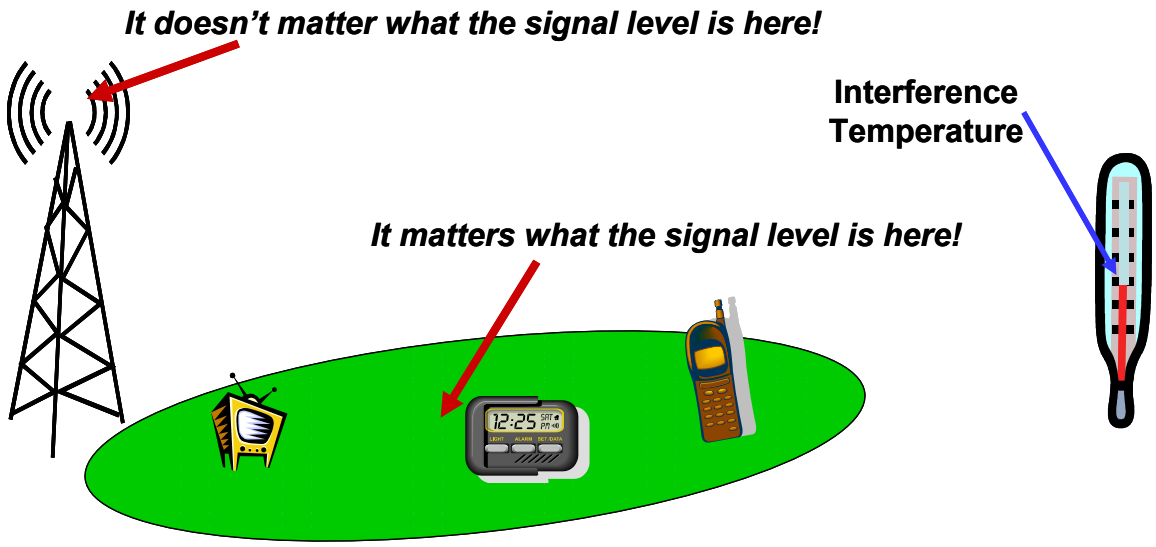

Figure 1

measurements would be taken at various receiver locations to estimate the real-time condition of the RF environment. The degree of certainty of the estimate of the environment would depend on such factors as transmitter signal ranges, uniformity of signal levels over an area, the density of temperature measuring devices and the sharing of the data taken by nearby devices; *e.g.,* through "*ad hoc* cooperative wireless networks." Measuring devices could be designed with the option to include or exclude the energy contributions of particular signals with known characteristics; for example, the emissions of subscribers of licensees assigned the spectrum on an exclusive basis in a particular geographic area.

The Commission could use the interference temperature metric to establish maximum permissible levels of interference, thus characterizing the "worst case" environment in which a receiver would be expected to operate. Different threshold levels could be set for each band, geographic region or service, and these thresholds should be set after the Commission has reviewed the condition of the RF environment in each band. This review should include actual spectrum measurements of the RF noise/interference floor. In addition to obtaining better data regarding the noise floor, the Commission should adopt a standard methodology for measuring the noise floor. Further, the Task Force recommends that the Commission create a public/private partnership for a long-term noise (interference temperature) monitoring network and for the archiving of data, for use by the FCC and the public.

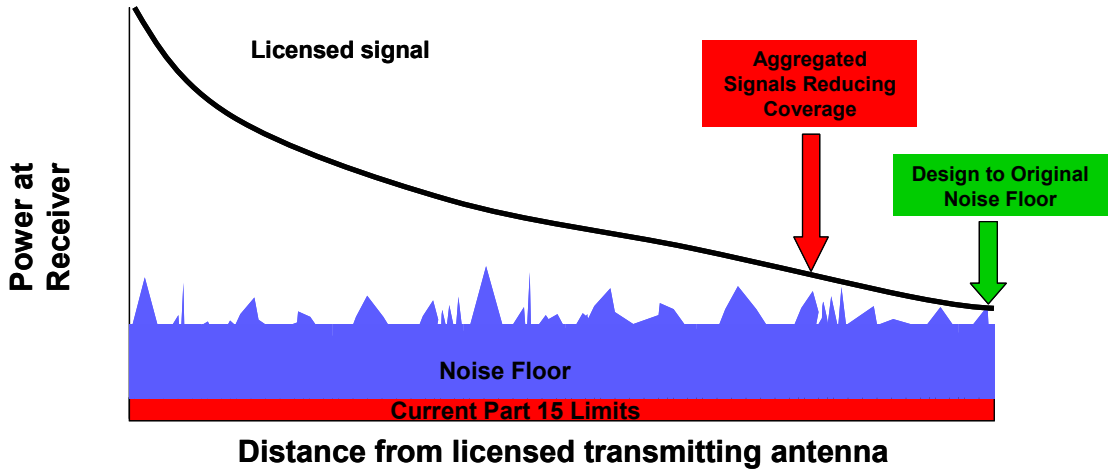

Figure 2

Figures 2 and 3 illustrate significant benefits of capping the permitted interference temperature. Figure 2 depicts a possible scenario resulting from the current open ended nature of the RF noise floor. A communications system has been designed to operate to a distance from the transmitting antenna at which the signal strength approaches the level of the noise floor that existed when the system was established. Over time, the noise floor can rise unpredictably – this due to additional interfering signals, perhaps including out-of-band emissions from new users and further aggregation of unlicensed devices. As a result, signal coverage can be degraded without warning. Additional interfering signals will progressively worsen coverage. Figure 3 modifies the scenario by placing an interference temperature cap over the service area.

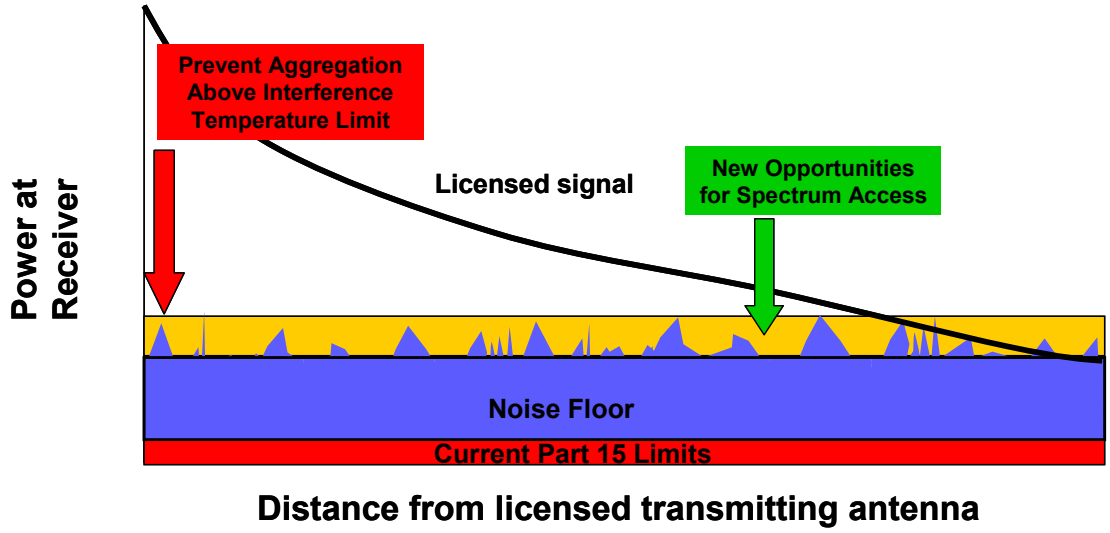

Figure 3

The Task Force believes that two key benefits will result from the application of the interference temperature metric: First, licensed spectrum users will obtain certainty with regard to the maximum permissible level of aggregated noise, or interference, in their band. The interference temperature would quantify the level of acceptable

interference in a particular band. For example, any transmissions from other sources that increase the noise level above the interference temperature would be considered "harmful interference" in accordance with Commission rules. Second, to the extent that the interference temperature in a particular band is not reached, other users (*e.g.*, unlicensed devices) could operate in the same band – with the interference temperature serving as the maximum cap on the potential RF energy they could introduce in the band. This would thus increase access to the band for other users or devices.

Interference temperature sensory and control mechanisms could be used to maintain both in-band and out-of-band emissions within permissible limits. For example, a low power unlicensed RF device could be designed to scan its particular frequency band before transmitting. Its built-in "thermometer" would record interference temperature data and compute the appropriate statistical aggregate value. The device would then project the increase in interference temperature due to its operation over its nominal range. This value would be compared with the permissible limit. If its operation would exceed the limit, the device's controller could execute an appropriate response such as reducing power, switching to a different transmit frequency (if available) or, perhaps, continuing the scanning/sensing process to locate an opportune time to transmit. The technology now exists to build such sensory control systems. Automated transmitter power control, for instance, is used in certain types of wireless and satellite communications systems. Cordless telephones also adapt to the environment by selecting an unused frequency.

Interference temperature mechanisms would serve in conjunction with existing out-of-band emissions on adjacent frequencies. In the future, however, it is possible that interference temperature mechanisms could serve as an alternative to out-of-band emissions limitations. Indeed, depending on spectrum use characteristics and the severity of emission limits, some users might find the temperature sensory control approach to be more economical than expensive transmitter filtering. It could also permit operation at higher power levels in areas or frequency bands with low interference temperature levels.

In sum, where it could be applied, the interference temperature metric, in conjunction with sensory control systems, could significantly enhance interference management. Incumbents would be provided greater certainty regarding the maximum permissible level of interference in their particular bands. Interference temperature limits would also provide a "worst case" characterization of the RF environment and, thus, establish benchmarks for communications equipment and system designers; *i.e.*, the limits could assist designers in balancing the numerous technical and economic tradeoffs involved in radio system planning. Effective enforcement of these interference temperature limits is also an essential component of this concept, in order to ensure successful interference management. Finally, continuous monitoring of the interference temperature would enable the Commission to maintain current data on the RF environment.

C. Additional Methods of Interference Control

In addition to interference temperature, there are several other ways in which the Commission can improve interference management. As noted earlier, Commission regulations for controlling interference set forth permissible technical operational parameters for transmitters. Receiver robustness generally has not been taken into account in Commission regulations. On those occasions when it has been necessary to consider receiver quality, the Commission either applies a set of worst case receiver parameters or uses general receiver characteristics for its analyses.[39] This transmitter-centric policy is not necessarily efficient in today's spectrum environment.

Most parties support the need for the development of receiver standards or guidelines, or, in the alternative, minimum receiver performance requirements. Indeed, many of the parties asserted that, from a purely technical standpoint, interference susceptibility, as well as increased spectrum efficiency is highly dependent on the quality and selectivity of the receiver used. Parties supporting receiver standards assert that such standards would promote spectrum sharing and system interoperability, and would provide common performance parameters that all equipment manufacturers must achieve. A few opposing parties assert that receiver standards could stifle innovation and could present administrative and enforcement challenges. Even those parties opposing receiver standards support, in varying degrees, the adoption of minimum receiver performance requirements.

The Task Force recommends that the Commission consider applying receiver performance requirements, either through incentives, regulatory mandates, or some combination of incentives and mandates. The Task Force generally prefers the use of voluntary receiver performance requirements, over mandatory standards. Thus, while receivers could be manufactured that do not meet the voluntary performance requirements, the Commission would not protect users of such receivers against interference resulting from failure to meet the performance requirements. Voluntary receiver performance requirements could be promoted through industry groups, or incentives could be developed for the use of advanced receivers. Receiver performance requirements may be particularly appropriate when the marketplace does not adequately promote receiver performance (*e.g.,* when the service provider does not control the manufacturing of the receivers). Receiver performance requirements also may serve as a useful transition mechanism for interference management until the Commission is able to implement interference temperature thresholds for particular bands. While the Task Force believes that the Commission currently has the requisite statutory authority to promulgate receiver performance standards, it also recommends that legislation more explicitly granting such authority be enacted. Also, it would be useful to conduct a study to evaluate receiver performance in the current RF environment.

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[39] For example, the Commission adopted provisions for interim interference protection of analog signals in the Multipoint Distribution and Instructional Television Fixed Services from a new service in an adjacent frequency band. In so doing, the Commission assumed a typical numerical value for a key interference rejection characteristic of the receiving equipment, based on information provided by a manufacturer of that equipment. *See Memorandum Opinion and Order* in GN Docket No. 96-228 (1997).

With the coming advances in technology, the Task Force does not believe that minimum receiver performance requirements would necessarily stifle innovation. In the future it is expected that, to a considerable extent, interference problems will be eliminated or adequately mitigated by flexible software solutions built into the receiver; for example, software-controlled filter responses. Further, it is likely that, in the future, manufacturers will design receivers with a more reliable expectation of the environment. On balance, the Task Force believes that the potential benefits of minimum receiver tolerances – whether through Commission mandates or incentives – outweigh the risk that such actions could stifle innovation.

There are many other steps that the Task Force recommends that the Commission should take to control interference. These include:

- Promoting the increased use of automated transmitter power and frequency control – such as the long-term sensory control mechanisms suggested in conjunction with the interference temperature metric and, in the near-term, increased use of automated transmitter power control that would adjust the power to match the amount that is actually needed to provide service; for example, in point-to-point microwave systems.

- Promoting the use of advanced antenna technology and system design techniques that would enhance the uniformity of transmitted signal strength levels through a service area.

- Consider the tightening of out-of-band emission limits over time, so that widely disparate uses of the spectrum can have less interference impact on each other.

- Harmonizing the references to interference in the Commission's regulations:

    - to ensure a consistent understanding of the impact of interference qualifiers such as *harmful*, and to remove or clarify undefined terms such as *objectionable;*

    - to improve the consistency of technical terms and units related to interference management.

- Developing technical bulletins that explain the Commission's interference rules for all radio services – with web site access to not only a particular service's interference rules, but also with links to related information contained elsewhere in the Commission's rules.

- Developing a "best practices" handbook – a compendium of available information broadly relating to interference management, which could include, for example:

    - current industry guidelines for coordinating spectrum use;

- steps that could be taken to resolve interference problems;
- a discussion on how to best use FCC databases and related tools.

D. Transition

As an additional interference management paradigm for the long-term, and to augment current approaches, the Commission should pursue use of the interference temperature metric, in conjunction with self-enforcing sensory control mechanisms. The Commission should also consider developing a program to test the concept on a limited basis. The Task Force recognizes that there are hurdles that must be overcome before the interference temperature metric could serve as a useful management tool. Foremost among these is the need to acquire data on the RF noise floor for different frequency bands and geographic regions. To that end, the Task Force recommends that the Commission undertake a systematic study of the RF noise floor.

Moreover, in addition to obtaining requisite data regarding the noise floor, there are many factors that the Commission would need to consider before setting an interference temperature for a particular band. Some potential factors that may be considered are: (1) nature and extent of incumbency; (2) the nature and types of the services (for example, the criticality of services like public safety); (3) the susceptibility of services and existing equipment to interference; (4) state of development of technology; and (5) propagation characteristics.

In the near term, the Commission should consider establishing receiver performance requirements to supplement its transmitter-centric interference management approaches. Use of modern receiver filtering and related digital system processing techniques could enhance interference management in the near-term, while the interference temperature concepts are being developed. Receiver improvements could also facilitate interference mitigation and more efficient spectrum use in situations in which the interference temperature approach would be inapplicable; *e.g.,* as a safeguard against "blanketing" interference.[40] The Task Force recommends that the Commission pursue receiver performance issues in a *Notice of Inquiry*.

[40] Blanketing interference occurs when an undesired signal on a frequency different than that of the desired signal is sufficiently strong to overpower the front end amplifier stage of a receiver, thereby preventing proper operation of the receiver.

Recommendations:

- Quantify acceptable levels of interference through "interference temperature" concept (long-term objective).
- Obtain better data regarding noise floor:
    - Adopt standard method for measuring noise floor.
- Create a public/private partnership for long term noise (interference temperature) monitoring network and archiving of data for use by FCC and public.
- Include minimum receiver performance requirements in regulation (either through (1) additional incentives, (2) mandates, or (3) some combination of incentives and mandates) to be used until can migrate to "interference temperature" regulatory scheme and to be used for the long term where use of interference temperature would be inapplicable; *e.g.,* for systems in which licensees do not have control over receivers.
- Move to interference-limited policies.
- Issue Notice of Inquiry to characterize current and future receiver environments and to explore issues to consider, such as, minimum performance parameters and protection for legacy receivers.
- Award contractual study to evaluate receiver performance in current environment.
- Promote voluntary receiver performance requirements through industry groups.
- Consider incentives for use of advanced receivers.
- Promote transmitter enhancements for interference control: (a) foster technologies that enhance uniform signal levels throughout a service area; (b) promote greater use of automated transmitter control systems; and (c) consider tightening out-of-band emission limits over time.
- Improve communications on interference issues with public.
    - Harmonize interference language in FCC rules and affected international rules.
    - Ensure consistent and appropriate use of interference terminology.
    - Develop technical bulletins that explain interference rules for all radio services.
    - Develop best practices handbook.
- Add language to the Act expressly allowing the Commission to establish rules or performance requirements for receivers.
- "Interference temperature" concept should form the basis for better defining interference rights.
- Accompany clearer interference definition with effective enforcement.

VII. Spectrum Usage Models

A. Comparison of Alternative Spectrum Usage Models

The Task Force examined the Commission's spectrum policies and rules in relation to three general models for assigning spectrum usage rights:

- "Command-and-control" model. The traditional process of spectrum management in the United States, currently used for most spectrum within the Commission's jurisdiction, allocates and assigns frequencies to limited categories of spectrum users for specific government-defined uses. Service rules for the band specify eligibility and service restrictions, power limits, build-out requirements, and other rules.

- "Exclusive use" model. A licensing model in which a licensee has exclusive and transferable rights to the use of specified spectrum within a defined geographic area, with flexible use rights that are governed primarily by technical rules to protect spectrum users against interference. Under this model, exclusive rights resemble property rights in spectrum, but this model does not imply or require creation of "full" private property rights in spectrum.

- "Commons" or "open access" model. Allows unlimited numbers of unlicensed users to share frequencies, with usage rights that are governed by technical standards or etiquettes but with no right to protection from interference. Spectrum is available to all users that comply with established technical "etiquettes" or standards that set power limits and other criteria for operation of unlicensed devices to mitigate potential interference.

There is, of course, some overlap among these models as well as variations that combine elements of each. For example, spectrum users that are regulated on a command-and-control basis may have some of the same rights as spectrum users who are subject to the exclusive use model (*e.g.,* exclusive and transferable rights, interference protection). Moreover, spectrum that is subject to the exclusive use or commons model may nonetheless be subject to some degree of command-and-control restriction (*e.g.,* limiting usage based on international allocation restrictions). Nonetheless, the key distinction between the command-and-control approach and the other two models is that the former typically imposes significantly greater usage restrictions on spectrum (and sometimes on the eligibility of spectrum users), thereby restricting flexibility of spectrum use to a far greater degree than either of the other two models.

Commenters and participants in the workshops generally criticized the costs and inefficiencies imposed on spectrum users and the public by command-and-control regulation, and argued that these costs could be substantially reduced by moving from

command-and-control regulation to more flexible, market-oriented approaches, whether under an exclusive use model, a commons model, or a combination of the two. Some commenters, however, argued in favor of retaining a command-and-control approach for certain services (*e.g.,* public safety) on the grounds that exclusive reliance on market-based spectrum usage models would undervalue or thwart the provision of such services. Moreover, while most commenters and workshop participants favored expanded application of flexible, market-oriented spectrum policies, there was a significant split between those who favored an exclusive use approach and those who favored a commons approach.

Commenters who favored the exclusive use model argued that it promotes economic efficiency because its key characteristics – clearly defined rights, exclusivity, flexibility, and transferability – are necessary for efficiently allocating any scarce resource among competing uses. They also argued that without exclusive rights and interference protection, spectrum users would face uncertainty and would lack the incentive to invest in new technologies or services. These parties also tended to express skepticism regarding the commons approach, contending that a spectrum commons would result in overuse, interference, and underinvestment.

Supporters of the commons model argued that this approach leads to greater technological innovation and spectrum efficiency than an exclusive use approach. Because no spectrum is exclusively held, spectrum commons users have incentive to create spectrally efficient frequency-hopping technologies, whereas licensed spectrum typically sits idle when the license-holder is not transmitting. Furthermore, proponents of an open, commons approach claimed that spectrum scarcity might actually be reduced under such a regime because of the efficiency-enhancing possibilities and fundamentally different spectrum demands of new system architectures such as mesh networks. Commenters also contended that even in spectrum that was otherwise subject to an exclusive use approach, a commons approach should be used to create "underlay" rights for low-power, non-interfering devices.

Despite this split, most commenters and workshop participants supported the proposition that in spectrum policy, "one size does not fit all," and that the Commission should therefore strike a balance between the exclusive rights and the commons models. For example, many commenters suggested that granting flexible exclusive use rights to spectrum users did not preclude the Commission from imposing some regulatory limitations on use, analogous to zoning restrictions that are placed on property owners by local governments. Other commenters argued that unlicensed spectrum should not be seen as a complete replacement for licensed spectrum, but that some spectrum should be set aside for unlicensed use in the same manner than some land is set aside for public parks.

The Task Force agrees with the consensus view expressed by participants in this process that "one size does not fit all" in spectrum policy. An examination of the exclusive use and commons models as they have been applied to date suggests that each model has encouraged different equally beneficial types of technical and economic

efficiencies. In broadband PCS, for example, licensees have developed centrally managed wireless networks that cover large geographic areas and accommodate large numbers of mobile customers. The licensing of multiple users has also led to significant competitive benefits in the CMRS market. More recently, the designation of bands for open access by Part 15 devices has fostered the emergence of "smart" low power devices that can support sophisticated applications such as peer-to-peer networking. This has resulted in a significant surge of economic investment in these services or devices use over the last several years.

The Task Force therefore recommends that the Commission base its spectrum policy on a balance of the three basic spectrum rights models outlined above: an exclusive use approach, a commons approach, and (to a more limited degree) a command-and-control approach. It is further recommended that the Commission fundamentally alter the existing balance among these models – which is dominated by legacy command-and-control regulation – by expanding the use of both the exclusive use and commons models throughout the radio spectrum, and limiting the use of the command-and-control model to those instances where there are compelling public policy reasons. Thus, to the extent feasible, the Commission should identify more spectrum for both licensed and unlicensed uses under flexible rules, and should transition existing spectrum that is subject to more restrictive command-and-control regulation to these models to the greatest extent possible, as discussed in Section D below.

In proposing to reshape the balance among the three models, the Task Force recognizes that the models themselves are not pure and mutually exclusive approaches to spectrum management, but rather are representative approaches on a broader continuum that may be subject to variation in particular instances. Thus, for any given spectrum band or proposed use, the Commission may find it beneficial to incorporate elements from more than one model. For example, as discussed further below, spectrum that is licensed under an exclusive use approach could also be subject to an "underlay" easement that is available to low-power unlicensed devices using a commons approach. Similarly, services that require some dedication of spectrum on a command-and-control basis (*e.g.,* public safety) may benefit from partial application of the exclusive-use model to enable them to lease spectrum capacity to others when it is not otherwise needed. As a general matter, however, the Task Force believes that there is considerable room to move from the largely *ad hoc* regulation of particular bands that has evolved historically to a more consistent and comprehensive application of these models across the radio spectrum as a whole. If these models are consistently applied in all Commission spectrum policy decisions, it has the potential to significantly reduce the artificial scarcity of spectrum that currently exists as a result of barriers to access. This approach will have the beneficial effect of reducing the cost of obtaining exclusive spectrum rights in the market and will also help to alleviate congestion of spectrum that is made available on a commons basis, thus mitigating the risk of the "tragedy of the commons" – oversaturation resulting in inefficient use.

B. Application of Exclusive Use and Commons Models

The recommendation to move towards greater reliance on exclusive use and commons models requires that the Commission determine the appropriate balance between these two models. Ultimately, wherever there are competing uses for a resource – that is, wherever there is scarcity – some mechanism must exist for allocating that resource. A mechanism based on markets, such as an exclusive use model, will be most efficient in most cases. However, government may also wish to promote the important efficiency and innovation benefits of a spectrum commons by allocating spectrum bands for shared use, much as it allocates land to public parks.

There are a number of variables that may be relevant to this determination with respect to any particular band, but the Task Force believes that the key factors to be considered are (1) spectrum scarcity, and (2) transaction costs associated with moving spectrum from less efficient to more efficient use. In this context, "spectrum scarcity" means the degree to which particular spectrum is subject to competing demands for use so that the demand exceeds the current supply; and "transaction costs" means the expenditure of time and resources required for a potential spectrum user to obtain the spectrum access rights from one or many parties necessary to its proposed spectrum use.

1. Factors Favoring Exclusive Use Model

The exclusive use model should be applied to most spectrum, particularly in bands where scarcity is relatively high and transaction costs associated with market-based negotiation of access rights are relatively low. The exclusive use model is appropriate because where spectrum is subject to competing demands, and therefore more likely to have a high market value, this approach creates the strongest incentives for parties to put spectrum to its highest valued use. In addition, where rights and responsibilities are clearly defined and effectively enforced, the characteristics of this model – *e.g.*, exclusivity, flexibility, and transferability – generally provide a clear framework for market-based assignment and negotiation of access rights among spectrum users, thereby limiting transaction costs.

These variables suggest that in the lower portion of the radio spectrum, particularly bands below 5 GHz, the Commission should focus primarily, though not exclusively, on using the exclusive use model. The propagation characteristics in this portion of the spectrum (which can support a wide variety of high- and low-power, fixed and mobile uses), combined with the high level of incumbent use (including government as well as non-government uses), result in a large number of competing demands for a relatively small amount of available spectrum. These factors tend to weigh in favor of an exclusive use approach with flexible rules because it provides a mechanism for spectrum users to choose among the full range of technically feasible spectrum use options based on market forces. Moreover, the typical transaction costs associated with negotiation of access rights tend to be relatively low in relation to the value of this spectrum.

Even in situations where usable spectrum is scarce but transaction costs are potentially high, the exclusive use model still may be most appropriate, though other

variables may also come into play. The presence of high transaction costs means that some transfers of spectrum will not occur, and some valuable uses therefore will not appear in the market. However, wherever scarcity exists, there will be competing claims to the resource, and the exclusive use model is most effective at balancing these competing claims. Moreover, the greater the scarcity, the greater will be the incentive for parties to find ways to overcome these high transaction costs. In contrast, as discussed below, a commons approach may be less effective in cases of high scarcity, despite its advantages in addressing high transaction costs.

Finally, while these factors weigh in favor of applying the exclusive use model under the above-described circumstances, it should be emphasized that they do not preclude the introduction of unlicensed "underlays" into exclusive use bands. As discussed below, the criteria that favor use of the commons model apply to potential underlay uses of spectrum below the interference temperature threshold, and may apply in some cases to opportunistic uses above the threshold, depending on the nature of the proposed use.

2. Factors Favoring Commons Model

The commons model should be applied to significant portions of the spectrum, particularly in bands where scarcity is low and transaction costs associated with market mechanisms are high. The commons approach makes increased access possible by replacing the negotiation of spectrum access rights among rights holders and prospective users with a commons model governed by user protocols and etiquette. These protocols promote efficiency through spectrum sharing, typically by requiring commons to operate at low power for a short time in limited areas, which allows multiple users to operate on the same spectrum. This approach also promotes technological innovation by providing a spectrum environment in which to develop new technologies. Users do not pay for access to the spectrum, so they will channel their investment exclusively into developing robust technology that can function in this environment and continue to function as the environment grows more congested.

Where both spectrum scarcity and transaction costs are low, the commons model again may be the most appropriate, though this situation is less clear. Under these circumstances, the presence of low transaction costs would add to the efficiency-creating characteristics of the commons. On the other hand, it also is possible that the exclusive use model would provide comparable benefits, as the price will be close to zero if spectrum is abundant. With low transaction costs as well as low price, interested users should have unrestricted access to the spectrum they need.

The variables described above tend to tilt in favor of expanded use of the commons model in higher spectrum bands, particularly above 50 GHz, based on the physical characteristics of the spectrum itself. In these bands, the propagation characteristics of spectrum preclude many of the applications that are possible in lower bands (*e.g.,* mobile service, broadcasting), and instead favor short-distance line-of-sight operation using narrow transmission beams. Thus, these bands are well-suited to accommodate multiple devices operating within a small area without interference.

Moreover, administering these uses on an individualized licensed basis would involve very high transaction costs.

The Task Force does not advocate the wholesale conversion of all spectrum to a commons approach as some commenters appear to advocate. Although the commons model is in many ways a highly deregulatory "Darwinian" approach, as its proponents point out, productive use of spectrum commons by unlicensed devices, particularly in lower spectrum bands, typically requires significant regulatory limitations on device transmitter power that preclude many other technically and economically feasible spectrum uses that rely on higher-power signal propagation over longer distances, or that require greater protection from interference. In addition, some commons proponents themselves state that setting aside additional spectrum for use on a commons basis is not essential to the continued success of unlicensed technology because the technological capability exists to prevent congestion from occurring in existing unlicensed bands.

This does not, however, mean that only higher band spectrum should be subject to a commons approach. The record shows that the Commission's dedication of some lower band spectrum to unlicensed uses, *e.g.,* 2.4 GHz, is yielding significant technological and economic benefits in the form of low-power short-distance communications and emerging mesh network technologies that should be further encouraged. The Task Force therefore recommends that the commons model continue to be applied selectively to other lower spectrum bands.

In addition, the commons approach has potential applicability in the creation of underlay rights across the entire range of spectrum for low-power, low-impact devices. To the extent that the Commission establishes "interference temperature" rules for particular bands, as discussed in Section VI above, the spectrum environment that is created below the temperature threshold has the characteristics that weigh most heavily in favor of the commons approach: low scarcity due to technical restrictions on the power and operating range of devices and high transaction costs associated with negotiating access. Therefore, the commons approach should presumptively be used for operations below the interference temperature threshold. In addition, the commons model may be appropriate for some opportunistic, non-interfering uses of exclusively licensed spectrum above the interference temperature threshold, although this approach raises more significant challenges. These issues are presented in greater detail in Section VIII.B., below, in the discussion of secondary markets and government-granted easements.

An important caveat must accompany any recommendation for a commons model: although there are indications that technology can go a long way to forestall scarcity concerns, if scarcity eventually does arise in particular spectrum bands in the future, then the commons model may need to evolve to address the problem. Because there is no price mechanism in the commons model to use as a tool for allocating scarce resources among competing users, there is always the risk that free access will eventually lead to interference and over-saturation, *i.e.,* the "tragedy of the commons." These problems can be overcome to some extent through regulatory guidance, requirements such as power and emission limits, and sharing etiquettes. But if actual spectrum scarcity

still occurs, rights may need to be redefined and market mechanisms (*e.g.,* band managers) introduced because without them there are insufficient incentives to avoid overuse.

C. Limited Use of Command and Control

The command-and-control model should be applied only in situations where prescribing spectrum use by regulation is necessary to accomplish important public interest objectives or to conform to treaty obligations. With respect to the command-and-control model, as noted above, the Task Force recognizes that continued use of this approach may be required in situations where prescribing spectrum use by regulation is necessary to accomplish compelling public interest objectives. However, such objectives should be carefully defined, and the amount of spectrum subject to a command-and-control regime should be limited to that which ensures that those objectives are achieved. Many spectrum users will claim that they warrant special consideration and thus deserve exemption from any reform of their service allocation rules. It is therefore critical to distinguish between special interest and the public interest, establishing a high bar for any service to clear prior to receiving an exemption.

In general, command-and-control regulation should be reserved only for spectrum uses that provide clear, non-market public interest benefits or that require regulatory prescription to avoid market failure. For example, radioastronomy may need to have dedicated, protected spectrum bands for the foreseeable future, due to its highly sensitive applications and the fact that its benefits accrue to society as a whole and only over the long run. Public safety and critical infrastructure may also require dedicated spectrum at particular times to ensure priority access for emergency communications. Other areas where limited use of command-and-control may be justified include international/satellite, public safety, and broadcasting, which are discussed in greater detail below.

Subject to these exceptions, the Commission should eschew command-and-control regulation, and legacy command-and-control bands should be transitioned to more flexible rules and uses to the maximum extent possible (whether under the exclusive rights or the commons model). The Task Force's recommendations with respect to transition mechanisms are discussed in greater detail in Section D, below.

1. International and Satellite Issues

A number of commenters stressed that the United States should make a better effort to harmonize its spectrum management policies and allocations with those of the rest of the world, when possible. To the extent domestic policies and allocations complement international decisions, U.S. consumers and businesses will reap important benefits such as more international roaming and better economies of scale with regard to equipment manufacturing. These commenters also pointed out that while the satellite, maritime, aeronautical, public safety and radioastronomy services have long required and benefited from extensive international coordination, terrestrial services like third generation wireless and radio local area network (*e.g.,* Wi-Fi) services are also becoming increasingly ubiquitous requiring the same level of international coordination.

Other parties commented on the importance of the Commission considering how spectrum-based services and devices using spectrum that has international treaty implications are affected by spectrum use models, often reducing the amount of flexibility available to users domestically. It was stated, for example, that the Commission should take account of the effect that interference caused by licensees offering newly flexible services would have on existing cross-border interference agreements with Canada and Mexico. The Task Force also noted that spectrum used for satellite services typically requires extensive international and global coordination under the International Telecommunication Union's Radio Regulations, inherently limiting a licensee's flexibility. Commenters asserted that a broader regional perspective on spectrum management by the Commission could speed deployment of services to U.S. consumers by resolving cross-border coordination and regional policy issues earlier.

The Task Force also noted that in the Open-Market Reorganization for the Betterment of International Telecommunications Act of 2000 (ORBIT Act), the Congress passed legislation excluding spectrum used for international and global satellite services from assignment through auctions. In order to provide more flexibility in allocating and licensing spectrum used for satellite services, the Task Force recommends that the Commission consider a statutory proposal for Congress that would assess and re-examine Section 647 of the Orbit Act to consider permitting, but not requiring, the Commission to utilize competitive bidding to resolve mutually exclusive applications for global and international satellite services.

Conclusions/recommendations. International considerations must be taken into account in two ways:

- First, because regional and world wide harmonization of band use can have significant advantages both in terms of truly ubiquitous services and economies of scale, in developing domestic spectrum policies and allocations, the Commission should consider the potential impact on international objectives, among other objectives.

- Second, U.S. consumers could benefit from improved (*i.e.,* quicker and more flexible) spectrum management coordination with the United States' regional neighbors, especially Canada and Mexico.

- In addition, the Commission should assess and re-examine Section 647 of the Orbit Act to consider permitting, but not requiring, the Commission to utilize competitive bidding to resolve mutually exclusive applications for global and international satellite services.

2. Public Safety

The Task Force sought information regarding what spectrum use models the Commission should employ to ensure public safety access to spectrum. Most

commenters and workshop participants who addressed this issue agreed that there are some important differences between the spectrum needs of commercial systems, which require high system capacity to support large numbers of users and applications, and those of public safety systems, which require less average capacity but need very robust and reliable communications, particularly for emergencies. Public safety spectrum users also typically have different funding mechanisms, are inherently more budget-constrained, and have longer equipment replacement cycles than commercial users.

But commenters and workshop participants also suggested that changes in spectrum policy could encourage greater efficiency on the part of public safety providers. For example, some public safety agencies indicated that they are becoming more innovative through creative licensing schemes, such as forming partnerships between state and local agencies and utilities and federal agencies. By sharing costs and spectrum with others, public safety entities have the potential to obtain more technologically advanced wide-area systems than they could afford on their own.

Some spectrum should continue to be dedicated on a command-and-control basis for public safety use. In light of the above considerations, the Task Force recommends that spectrum currently set aside for public safety use remain subject to the command-and-control model. Eventually, if the cost of spectrum is driven down by enhancing access and reducing scarcity, it is possible that public safety users could acquire spectrum in the market on the same basis as non-public safety users, but these conditions do not exist currently and should not form the basis for meeting the core spectrum needs of public safety entities.

At the same time, there is considerable potential for introduction of market-oriented policies that would help rather than burden public safety, and that would allow for more efficient use of spectrum to meet both public safety and commercial spectrum needs. The Commission therefore should explore mechanisms for meeting public safety needs other than through dedication of spectrum on a command-and-control basis.

Public safety users should have flexibility to lease their dedicated spectrum capacity that is available during lower-use periods to commercial users with a "take-back" mechanism when public safety use increases. Public safety spectrum use is typically highly variable, with periods of low traffic and occasional usage "spikes" during certain times of the day or week or during emergencies. Accordingly, there is benefit to be gained from permitting public safety entities to lease some of their spectrum capacity to commercial users during low-use periods, under an arrangement whereby the spectrum can be reclaimed immediately when needed for public safety use. The potential for this type of shared use will increase as smart transmitters and receivers are developed that can be shut down immediately upon command.

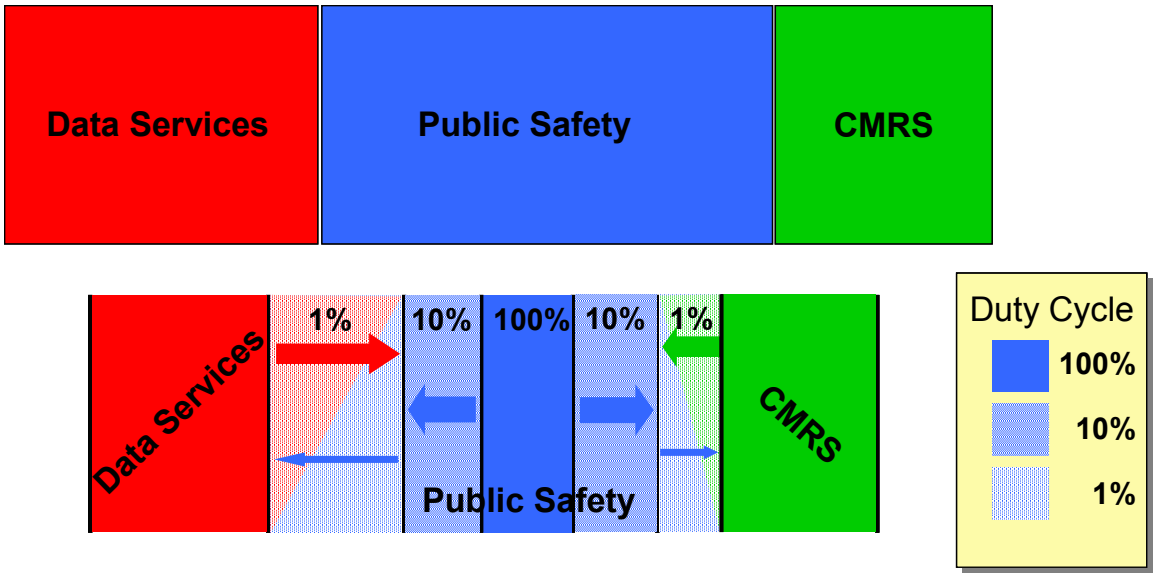

Figure 4

For major regional or national emergencies, additional public safety spectrum needs could be addressed through enhanced easement rights to non-public safety spectrum. In extraordinary national or regional emergencies (*e.g.,* terrorist attack, major natural disaster), public safety providers may require priority access to spectrum resources significantly beyond the amount of spectrum required to handle their normal emergency workload. Because of the extraordinary nature of these events, permanent dedication of spectrum to public safety to meet these contingencies is likely to be highly inefficient. An alternative would be to address these needs through an easement mechanism that would enable public safety users to operate on non-public safety spectrum in such extraordinary emergencies, but to revert to operations on public safety dedicated spectrum when the emergency subsided. *See* Figure 4.

3. Broadcasting

The Commission has traditionally allocated spectrum specifically for broadcast use, based on statutory public interest considerations and the free over-the-air nature of broadcast service. Many commenters argue that these characteristics distinguish broadcasting from other market-based uses of spectrum, and that the Commission should therefore continue to dedicate some spectrum specifically for broadcast use on a command-and-control basis. Other commenters contend that the continued dedication of spectrum for broadcasting, and particularly for commercial broadcasting, is increasingly anachronistic as the public gains access to alternative sources of programming and information from cable television, satellite services, the Internet, and other outlets.

The Task Force concludes that for the time being, there are valid reasons to continue applying the "command-and-control" model to existing broadcast spectrum. Broadcast service is traditionally not subscriber-based; rather, it provides "universal" news, information, and entertainment services to the general public. As such, broadcasting has consistently been a central focus of Congress and the Communications Act, which regulates broadcast content and behavior by placing certain public interest

obligations on broadcast licensees.[41] In addition, localism and diversity of ownership are two important public interest objectives that have been associated with broadcasting to a greater degree than other spectrum uses. Finally, the broadcaster's relative lack of control over receiver equipment affects the rapidity with which technological advances can be introduced into the marketplace and assimilated by consumers – a factor that has complicated the DTV transition.

The transition of broadcast to a digital world, which is already under way, should help to increase the efficiency and flexibility in use of broadcast spectrum. As broadcasters convert to digital, some broadcast spectrum can be recovered for reallocation and reassignment to more flexible uses, as in the case of the 700 MHz band. The Commission has also allowed for some flexible use of broadcast spectrum,[42] and should consider additional ways to allow greater flexibility consistent with broadcasters continuing to meet their core public interest responsibilities. In addition, the Commission can take steps to make "white space" in the broadcast bands available for other uses.

Over the longer term, the Commission should periodically reevaluate its broadcast spectrum policies to determine whether they remain necessary to accomplish the public interest objectives they are intended to promote. In particular, such reevaluation should consider the extent to which the public interest benefits provided by dedication of spectrum to broadcasting under a command-and-control regime can be provided through the application of more flexible, market-oriented spectrum policies. It is likely that there will be a continued need to set aside some spectrum for non-market based broadcast uses, such as non-commercial and educational broadcasting. Assuming that technological advances continue to occur and that scarcity of access to spectrum resources decreases, however, it is equally likely that the continued application of command-and-control policies to commercial broadcasting spectrum could be substantially relaxed, or may not be needed at all, to ensure the public availability from multiple sources, including alternative technologies, of the types of information and programming that commercial broadcasters provide.

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[41] These include requirements that broadcasters provide "reasonable access" to candidates for federal elective office and afford "equal opportunities" to candidates for any public office, children's educational programming requirements, restrictions on airing of indecent programming, and provisions relating to the rating of video programming, and equal employment opportunities rules. *See* 47 U.S.C. § 312(a)(7), 47 C.F.R. §73.1944 (reasonable access); 47 U.S.C. § 315, 47 C.F.R. § 73.1941 (equal opportunities); 47 U.S.C. § 303(b), 47 C.F.R. §§ 73.671, 73.673, 73.3526 (children's educational programming); 18 U.S.C. § 1464; 47 U.S.C. § 303, 47 C.F.R. § 73.3999 (indecent programming); 47 U.S.C. § 303(w) (rating of video programming); 47 C.F.R. § 73.2080 (equal employment opportunities).

[42] Broadcast spectrum can be used for ancillary or supplementary services that do not interfere with the primary broadcast signal, *e.g.*, through use or leasing of the vertical blanking interval to provide telecommunications services. *See* 47 C.F.R. § 73.646. In the digital context, broadcasters may provide ancillary and supplementary services such as subscription television programming, computer software distribution, data transmission, teletext, interactive services, and audio signals so long as such services do not interfere with the required provision of free over-the-air programming. *See* In the matter of Advanced Television Systems and Their Impact upon the Existing Television Broadcast Service, *Fifth Report and Order* at para. 29 (citations omitted). *See also* 47 U.S.C. § 336.

D. Transition Issues

As discussed above, this report recommends that the Commission move towards assigning flexible usage rights in spectrum within its jurisdiction, whether under an exclusive rights or a commons model. However, the practical reality is that most spectrum within the Commission's jurisdiction is already occupied by incumbent spectrum users. Moreover, most of these incumbents are governed by legacy command-and-control regulations that substantially limit allowable uses of the spectrum. Therefore, successful implementation of the recommendations in this report requires the Commission to consider how to migrate away from restrictive legacy licensing regimes to more flexible rights models that create opportunities for new, more efficient and beneficial uses. Specifically, the Commission must determine which bands should be transitioned to expanded flexible rights models and how the transition should be accomplished.

1. General Transition Considerations

In determining whether and how to transition legacy command-and-control bands to more flexible rights models, the Commission should focus first on initiating transition in those bands where additional flexibility will provide the greatest benefits at the least cost. In general, the greatest benefits will be realized in those bands in which the current regulatory regime has led to significant underutilization or inefficient use of the spectrum. However, the Commission must also weigh the potential cost of transition, both in terms of its impact on incumbents and on the public.

Assessing these potential costs and benefits, the Task Force notes that there are some bands where the Commission has already taken steps to implement a flexible rights approach. These include exclusive-use bands that are already licensed under flexible use rules or are allocated for such use (*e.g.,* broadband PCS), and bands that are dedicated for use by Part 15 unlicensed devices (*e.g.,* 2.4 GHz). Because many of the benefits of flexibility have already been realized in these bands, and spectrum uses have developed accordingly, there is not a significant need for fundamental regulatory changes in these bands in the near term. However, to the extent that the Commission enhances flexibility in the long-term as recommended in this report, such changes are potentially applicable to these bands and would likely not impose significant costs in light of the regulatory steps the Commission has already taken.

The Task Force also does not recommend fundamental regulatory changes in the near term with respect to spectrum that is currently dedicated for public safety use, or with respect to currently allocated broadcast spectrum. In the case of public safety, attempting a sweeping transition of existing public safety spectrum to an exclusive use or commons model could be highly costly and disruptive to existing public safety uses, and does not appear to offer countervailing public interest benefits. Nevertheless, the Task Force does recommend consideration of measures discussed above to empower public safety users to make their existing spectrum available for other uses when it is not in use for public safety purposes. In the case of broadcasting, evolution towards greater flexibility is governed for the time being by the statutorily-mandated DTV transition

process, making additional regulatory changes impractical at least until that process is complete.

Implementing a transition may also be difficult in spectrum bands that are currently shared with the federal government, because the Commission cannot regulate federal spectrum uses, and the presence of federal users in such bands may limit the benefits of any flexibility that would be afforded to non-federal spectrum users. However, the Task Force recommends consideration of these bands for transition purposes to the extent that transition would be beneficial, and recommends that the Commission work with NTIA to consider alternatives for introducing greater flexibility and efficiency into federal government uses of spectrum.

In bands that fall outside these categories, the Task Force recommends that the Commission initiate proceedings to begin the transition of its spectrum regulations to allow more flexible uses. Moreover, in the long term, the Commission should consider transitioning to a flexible rights model in all bands throughout the spectrum where such action would further the Commission's spectrum policy goals.

2. Available Transition Mechanisms

Once the Commission identifies particular bands that are suitable for transition, it will need to identify appropriate transition mechanisms. Historically, the Commission has used a number of different transitional mechanisms to move spectrum from narrowly-defined legacy uses to more flexible new uses. In addition, other mechanisms that have not previously been used are also available. Generally, the core issue for all of these transition mechanisms is the treatment of incumbents: Do they remain in the band or are they cleared or relocated? If incumbents are cleared or relocated out of the band, what mechanisms are used? If incumbents remain in the band, does the Commission grant them expanded rights outright or does it use a new licensing vehicle to award expanded rights?

Transition options generally fall into the following categories, though variations and combinations of each are also possible: (1) reallocating a particular band to the flexible rights model, with assignment of the expanded rights to new licensees and the mandatory relocation of incumbents to other bands; (2) allowing incumbents to remain as licensees for those portions in a band that they currently occupy, while assigning "overlay" licenses for additional rights and/or unoccupied "white space" not assigned to incumbents; (3) reallocating and assigning spectrum to new licensees under the flexible rights model, and using voluntary market-based band-restructuring incentives, such as a two-sided auction, to encourage incumbents to clear or restructure the band; or (4) granting expanded, flexible rights to the incumbent licensees already occupying the band. Each of these options is discussed in general below.

a) Expanded rights "overlay" licenses combined with mandatory relocation of incumbents

Under this option, the Commission reallocates a particular band of spectrum to allow for more flexible uses, grants the expanded usage rights under new licenses (generally via auctions) and requires incumbent licensees and the services they provide to clear the band and either cease operating or relocate to other bands. The Commission has used this option in several instances, including broadband PCS.

There are several variations of this option, depending on the conditions that must be met in order for mandatory relocation of incumbents to occur. Under one approach (which was used for broadband PCS), new spectrum licenses are issued under flexible rules while incumbents are required to clear, relocate, or retune to alternative bands by a specified date. In addition, the new licensees may be required to pay the costs of relocating incumbents. Under a more conditional approach (which was adopted for 700 MHz DTV spectrum), incumbents are required to clear or relocate only if and when certain external conditions are met, such that there is no fixed time frame for clearing and relocation. Under this approach, while new licensees are not required to pay the costs of clearing and relocating incumbents, they may pay for voluntary early clearing by incumbents.

b) Expanded rights "overlay" licenses combined with grandfathering of incumbents

Under this option, the Commission grants expanded usage rights under new licenses, which are "overlaid" on top of the incumbent licenses. Incumbents retain their existing rights (including interference and renewal rights) on a grandfathered basis, and are not subject to mandatory band-clearing or relocation.

The overlay option has been used in services such as paging and SMR where the Commission is converting from site-based to geographic-area licensing, there is unlicensed "white space" (geographic areas where incumbents are not currently authorized), and incumbent and potential new uses are generally compatible. Under this option, incumbents can only acquire expanded rights, including the ability to expand their systems beyond their existing site-based contours, by obtaining overlay licenses. Alternatively, new overlay licensees must protect incumbents' existing systems unless they buy the incumbents out.

c) Expanded rights "overlay" licenses combined with voluntary band-clearing/restructuring incentives for incumbents

Under this option, the Commission reallocates restricted spectrum to more flexible use, grants the expanded usage rights under new licenses, and establishes a simultaneous market-based exchange mechanism to encourage voluntary band-clearing or restructuring of the band by incumbents. This mechanism is designed to create incentives for incumbents either to relinquish their licenses and clear the band for new users or to exchange their restricted-use licenses for the expanded rights available under the new license.

The Commission has not employed this option to date, but a number of potential mechanisms have been proposed that could facilitate this type of exchange. For instance, one mechanism that has been suggested is a "two-sided" auction, in which the Commission would auction expanded usage rights to spectrum under new licenses, and incumbents would voluntarily make their spectrum rights in the band available for auction at the same time. Under this approach, incumbents would be eligible to participate in the auction for expanded rights only if they offered their own spectrum licenses for sale in the same auction. Moreover, incumbents would be allowed to "bid" on their own spectrum in addition to spectrum offered by other incumbents and by the FCC. Incumbents who chose not to offer their licenses would retain their incumbent rights, but would not be granted expanded rights. This mechanism provides several incentives to incumbents to offer their spectrum rights for possible exchange. First, if incumbents voluntarily participate, they would immediately have their licenses converted to expanded flexible rights licenses, thus increasing the value of their spectrum usage rights. In addition, incumbents would not be forced to sell their spectrum usage rights to others, although they would face the opportunity cost of not doing so. Finally, incumbents would be able to keep any proceeds from the sale of their rights to others, and could, as well, potentially obtain rights to relocate to other parts of the auctioned band (or other bands altogether) that might be more advantageous to them.

d) Expanded rights granted to incumbent licensees under existing licenses

Under this option, the Commission grants expanded flexible rights directly to incumbents through modification of their existing licenses. Potential new entrants are not able to bid for or otherwise obtain these expanded rights, except by acquiring the licenses from incumbents through the secondary market. This option has been used by the Commission in several bands. For example, in the CMRS Flexibility proceeding, the Commission granted CMRS providers the right to provide fixed in addition to mobile services under their existing licenses.

3. Factors Affecting the Choice of Transition Mechanism

The Commission must consider a number of factors when deciding which transition mechanisms to implement. These factors may vary significantly from band to band, suggesting possible advantages to taking different approaches in different bands.

Major factors in the Commission's evaluation of options include:

- The restrictive nature of licensee rights currently afforded incumbents in the band when compared with the flexibility that would be gained by transitioning to an expanded flexible rights model;
- The types of services currently offered in the band and the potential consumer impact of transitioning to an expanded flexible rights model of licensing;
- The number of incumbents in the band;

- The likelihood that expanded flexibility would lead to rapid changes in the use of the band or instead would have only a gradual impact on existing systems and uses;
- The practical effect on incumbent systems of providing expanded flexibility under a new licensing model (*e.g.,* the potential for new users to co-exist in the band with incumbents);
- The nature and extent of investments made by incumbents in their acquisition of licenses and the building of systems, including whether incumbents have had the opportunity to recoup their investments; and
- The time and transaction costs associated with developing and implementing any particular transition mechanism in a particular band or bands, compared to other transition mechanisms.

New overlay licensing with mandatory relocation. As a preliminary matter, consideration of this option depends on the availability of alternative spectrum that would be suitable for use by incumbent licensees required to relocate. Assuming that alternative spectrum is available, this option may be preferred in cases where band-clearing is likely to be critical because of the technical incompatibility between existing uses by incumbents and prospective uses. However, it is important that the benefits to be obtained through mandatory band-clearing outweigh the costs and time required to complete the relocation of incumbents, and that the relocation be consistent with the Commission's broader spectrum goals for the relocation band.

In order to ensure maximum efficiency gains in the near term and avoid holdout problems, it is preferable under this option for there to be a fixed timetable for mandatory relocation. Furthermore, this option is likely to work best when there are market incentives for new licensees and incumbents to negotiate voluntary relocation agreements, although it may also be appropriate to develop mandatory compensation mechanisms in the event that the voluntary ones prove inadequate.

New overlay licensing with incumbent grandfathering. The "overlay option" generally requires the presence of a significant amount of unlicensed "white space" that would lend itself to an overlay licensing scheme. This option also is likely to work best where there is a limited need to relocate incumbents to other bands and where incumbents have incentives to acquire rights to the surrounding white space, *e.g.,* in bands that are being converted from site-based to geographic area licensing and where incumbent uses and potential new uses are generally compatible. In considering use of this option, the Commission needs to assess the degree of risk that incumbents will hold out against transitioning to more flexible use, which could hinder the Commission's goals of enabling more efficient use of the spectrum.

New overlay licensing with voluntary band-clearing/restructuring. This option has potential advantages when (1) the new flexible rights regime being implemented represents a significant increase in flexibility over the legacy rules, and (2) this expanded flexibility is likely to lead to rapid changes in the market value and the actual use of the spectrum. In such cases, a simultaneous exchange mechanism may be the fastest and

most efficient means of enabling incumbents and potential new spectrum users to restructure and reassign spectrum rights within the band to facilitate new uses. In determining whether to employ this option, the Commission should compare the administrative costs and efficiency of implementing a simultaneous exchange mechanism with that of employing other transition options, particularly the option of granting expanded rights to incumbents discussed below.

Expanded rights granted to incumbents. This option has potential advantages where the practical impact of granting incumbents additional flexibility is limited or is likely to be gradual rather than immediate, in which case it is likely that the operation of secondary markets over time can effectively distribute these flexible rights so that efficiency gains can be achieved. As a practical matter, this option also requires that there be no "white space," *i.e.,* that all spectrum in the band be previously assigned to incumbents (to avoid ambiguity as to who is entitled to additional rights). While granting incumbent licensees additional flexibility may allow for more immediate expansion of the availability of flexible rights licensing models, it also may raise equity issues relating to possible windfalls or unjust enrichment. The larger issue is whether such a policy would encourage parties to make future bids on presumably low-cost spectrum that is allocated for low-value uses and that has no flexibility, then petition for an expansion of those rights after acquiring the license. Accordingly, in considering this option, these equity issues will need to be balanced against the potential gains in administrative efficiency and the potential public benefits of providing additional flexibility to incumbents in the band.

Conclusions/recommendations. The Task Force recommends that the Commission undertake the following:

- Identify encumbered bands licensed under legacy command-and-control regimes that are suitable for transitioning to expanded flexible rights licensing models within the next five years –
    - Set a goal of identifying 100 megahertz of spectrum below 5 GHz for this transition phase.
    - Develop processes for determining which bands provide greatest opportunity for improving efficient use through adoption of expanded flexible rights licensing schemes.
    - Look for band "defragmentation" opportunities (*i.e.*, consolidating narrowband spectrum "slices").

- Choose appropriate transition mechanisms for the different bands being transitioned –
    - Look for bands in which to test different transition mechanisms.
    - Promote policy and legislative changes to facilitate the conducting of two-sided auctions.
    - Encourage migration of compatible technologies into common band groupings.

Recommendations:

- Expand the use of both the exclusive rights and commons models, and move away from the command-and-control model, with limited exceptions.
- Transition legacy command-and-control bands to more flexible rules and uses to the maximum extent possible (whether under the exclusive rights or commons model), with only limited exceptions.
- Assess and re-examine Section 647 of the Orbit Act to consider permitting, but not requiring, the Commission to utilize competitive bidding to resolve mutually exclusive applications for global and international satellite services. Take into account international concerns, including frequency coordination with Canada and Mexico and global harmonization of uses.
- Continue to dedicate some spectrum on a command-and-control basis for public safety use.
- Address additional public safety needs through alternative "safety valve" mechanisms to make spectrum is available to public safety in emergency situations when more capacity is needed.
    - Because some public safety spectrum use is characterized by intermittent "spikes," public safety users should have flexibility to lease spectrum capacity that is available during lower-use periods to commercial users with a "take-back" mechanism when public safety use increases.
    - For major regional or national emergencies, additional public safety spectrum needs should be addressed through enhanced easement rights to non-public safety spectrum.
- Develop more flexible policy for addressing public safety spectrum needs, including leasing/take-back arrangements with commercial users and easement rights to non-public safety spectrum in major emergencies.

Transition Recommendations:

- For new spectrum allocations and the associated spectrum assignments, apply the following basic framework:
    - Base choice of exclusive rights, commons, or command-and-control model in particular bands on factors previously identified.
    - Make underlay rights based on interference temperature a component of new spectrum allocations and assignments.
        - This does not require a constant interference temperature definition across all bands.
    - Clearly define access rights for opportunistic devices whether based on secondary markets, easements, or a combination of the two.
- For encumbered spectrum, identify bands that are suitable for initiating transition within the next five years and develop a transition plan for each band.
    - Set a goal of identifying highly valuable 100 megahertz of spectrum for this transition phase.
    - Look for band "defragmentation" opportunities (consolidating narrowband spectrum "slices" and encouraging migration of compatible technologies into common band groupings).
    - Interference temperature should be specified for most new allocations and associated assignments, and underlay operations.
    - Address underlay/easement rights in transition bands on a going-forward basis (avoid retroactive easements).
- Develop mechanisms to improve efficiency of secondary markets in facilitating transition.
    - Move forward with the Secondary Markets proceeding.
    - Facilitate use of leasing, band managers, and similar mechanisms to promote transition, particularly in multi-use bands.
    - Address spectrum access issues in rural areas.
    - Recommend that Congress amend Section 309(j) of the Act to include an express grant of authority to the FCC to conduct two-sided auctions and simultaneous exchanges.
    - Recommend that Congress amend the Act to authorize the use of auction funds to pay relocation expenses to incumbents.
    - Recommend that Congress eliminate the 2007 expiration date on the Commission's statutory auction authority and grant the Commission permanent auction authority.

VIII. Promoting Access to Spectrum

A. Designating Spectrum Bands for Unlicensed Use

The currently available spectrum for unlicensed operations has spawned a significant market for unlicensed devices and, as a result, the Commission should consider designating additional bands for unlicensed use to better optimize spectrum access. It is estimated that sales of unlicensed consumer devices are more than $2 billion per year. In addition, the growing popularity of computer networking has stimulated a heightened interest in unlicensed technology and one of the fastest growing applications of unlicensed devices is for WLANs. Among the more popular wireless data services are devices that operate in the 2.4 GHz band in accordance with the 802.11b or "Wi-Fi" standards and protocols developed by the Institute of Electrical and Electronic Engineers. Unlicensed devices are also being developed to provide very short-range wireless "personal area" networks (WPANs), such as Bluetooth. The wireless LAN market posted its eighth consecutive quarter of double-digit growth; total growth from 2000 has been over 150 percent.

Much of the spectrum below 50 GHz is available for low-powered unlicensed use. Higher-powered operations are permitted in several bands, however.[43] A significant number of parties stated that additional spectrum should be made available for unlicensed use. And, based on the record, it is generally perceived that the creation of unlicensed bands has been very successful in allowing the rapid introduction of new technology and that additional unlicensed bands would create more such opportunities. However, there was a general lack of information on how the Commission should create such unlicensed bands and what priority they should be given relative to other spectrum requests.

The Task Force finds that, while it is not practical at this point to develop estimates of the optimal amount of spectrum that should be provided for unlicensed operations, it appears that additional spectrum is needed for unlicensed devices. This is particularly true in light of recent trends towards increased use of short distance wireless systems, which use fixed infrastructure to provide end-to-end connectivity. In large area wireless systems, it has been difficult to control mutual interference without entry and technical regulation. As radio ranges become smaller, this justification for licensing becomes less universal. An ever increasing fraction of today's radio applications have ranges measured in yards rather than miles. For new unlicensed bands, access should be controlled by a new type of band manager or frequency coordinator selected by the FCC.

In addition, while there is great interest in making available additional unlicensed spectrum, there is no consensus on how such spectrum should be obtained, especially at frequencies in the lower regions of the spectrum, *i.e.*, at 5 GHz and below. The Industrial, Scientific, and Medical (ISM)/spread spectrum bands were relatively easy to

[43] These bands include: 902-928 MHz; 1910-1930 MHz, 2390-2483.5 MHz, 5150-5350 MHz, 5725-5825 MHz, and 57,000-64,000 GHz.

designate for unlicensed use because the microwave ovens and other ISM equipment using them made these bands of little value to most traditional spectrum users. However, having used this opportunity, there is little "low-hanging fruit" left for unlicensed band use. As it considers any expansion of unlicensed use, the Commission will have to pay careful attention to legitimate concerns of other spectrum users and consider untraditional approaches to obtaining spectrum use. In spectrum above 50 GHz, however, the Task Force recommends that future rulemakings routinely review *de novo* whether licensing is in fact necessary.

The record also indicated that wireless ISPs (WISPs) often experience difficulty in tailoring their communications systems to meet particular needs due to the lack of flexibility in equipment authorizations. For example, WISPs may be unable to change antennas to suit a particular application, even though such change does not alter the operating parameters of the system. In addition, WISPs (and point-to-point systems) should be permitted to increase their power limits in rural areas. The Task Force recommends that the Commission facilitate increased flexibility for both systems and power limits, to the extent possible.

B. Secondary Market Rights and Easements

The record also suggests that the there are ways to improve access to licensed spectrum by new entrants. As technological advances have increased the potential for spectrum to accommodate multiple non-interfering uses, two alternative and possibly complementary approaches have been suggested to facilitate access in licensed bands. Some commenters and Workshop participants advocated reliance on "secondary markets" arrangements involving the lease of spectrum usage rights. Under this approach, licensees would hold the rights associated with determining which potential entrants could have access to the spectrum and under what conditions. Other commenters and Workshop participants advocated allowing open access to licensed spectrum for non-interfering devices through expanded use of government-defined "easements." In the latter case, the Commission, and not the licensee, would establish conditions for user access to the spectrum, and the consent of the licensee would not be required so long as the non-licensee user complied with the conditions.

Commenters disagreed, however, on how to balance these approaches. Proponents of secondary market arrangements asserted that the market can solve most types of access problems if licensees have flexibility and exclusive rights. Secondary markets proponents were also skeptical of the easement approach, arguing that (1) "non-interfering" operation tends to work better in theory than in practice, and (2) even where spectrum is otherwise not being used by the licensee, creating easements for third party access without the licensee's consent could lead to squatter's rights problems. Some commenters also argued that easement rights should not be created on spectrum that has already been licensed by the Commission, contending that incumbent licensees have already built out their systems and made other technical decisions in reliance on being able to control access by third parties that could possibly create harmful interference.

Proponents of easements asserted that requiring negotiation of access rights in the market would not facilitate, and might even inhibit, access by the very technology that is revolutionizing efficient spectrum use, *i.e.,* smart, frequency-agile devices. They pointed out that the Commission currently allows some unlicensed devices to operate in licensed spectrum without the users of those devices obtaining permission from the licensee. Easement proponents also contended that exclusive rights holders will prefer to block access by such devices to protect their investment, and that the only way to open spectrum to new uses is to vastly expand the use of the easement model. They also contended that new technology is sufficiently sophisticated to overcome concerns regarding interference with the licensed user's operations.

The Commission has already taken some steps to initiate and expand access to spectrum. For example, in the Secondary Markets proceeding, the Commission has begun to explore possible market arrangements that would give licensees greater flexibility to authorize others to use otherwise unused portions of their licensed spectrum. The Commission has also used an easement approach in cases such as UWB, but this is still a very limited application compared to the type of easement access that some commenters advocate. As discussed above, developments in new technology such as SDR, frequency-agile radios, and spread spectrum have heightened the importance of the access issue by making multiple dynamic uses of spectrum possible that were not technologically feasible in the past. The Task Force therefore recommends that the Commission develop access models that take this new technological potential into account. At the same time, these models must take into account the need for licensed spectrum users to have flexible and clearly-defined spectrum usage rights that promote efficient and beneficial spectrum use.

Going forward, the Task Force believes that there is room for the balanced and expanded use of both the secondary market and easement approaches to facilitate spectrum access. First, as discussed above, the Task Force recommends that in bands where an interference temperature threshold is established, the Commission use an easement approach to create spectrum usage rights for unlicensed devices that operate below the threshold.[44] An easement approach appears appropriate for these operations because by definition, the licensee is required to accept any RF energy that is created by such devices so long as the threshold is not exceeded.

Second, the Task Force recommends looking primarily at the use of secondary markets, but possibly at some limited use of easements as well, to facilitate access to licensed spectrum for opportunistic, non-interfering devices that operate above the temperature threshold. Under the secondary markets approach, licensees would have broad flexibility to allow secondary uses of their spectrum by devices operating above the interference temperature threshold. Such devices would operate as secondary users based on an agreement with the licensee, which can be negotiated directly with the licensee or through a private intermediary (*e.g.,* band manager or frequency coordinator) that manages the secondary uses on the licensee's behalf.

[44] *See* Sections VI and VII.B, *supra*.

In most cases of potential opportunistic use of spectrum, efficient secondary market mechanisms can be developed that would allow negotiated access at reasonable transactions costs. The secondary markets model takes advantage of the flexibility and adaptability of the market to solve access problems. Because licensees have economic incentives to use spectrum in ways that will yield the highest return to them, they will generally find it advantageous to allow others to use unused portions of their spectrum if they are adequately compensated.

The Task Force does not agree with commenters that contend that making an exclusive licensee the access "gatekeeper" (*i.e.,* requiring potential spectrum users to obtain licensee consent) will inhibit access by new technology, although there may be occasional instances of this type of restrictive behavior. If the rights afforded to licensees are sufficiently well-defined and flexible, and the secondary market mechanism is fast and efficient with low transaction costs, licensees will have ample incentive to negotiate with potential secondary users for such access. It is also important to realize that a secondary markets approach to access by opportunistic devices does not necessarily require the prospective opportunistic user to negotiate individually with each affected licensee: band managers, clearinghouses, and other intermediaries such as clearinghouses can facilitate these negotiated transactions. Thus, the secondary market approach has significant potential to foster opportunistic technologies, such as agile-frequency-hopping radios, software defined radios, and adaptive antennas, at reasonable transaction costs. In fact, it is anticipated that as the access-enhancing potential of these technologies continues to improve, exclusive licensees will often wish to encourage and even develop such technologies in order to provide new services and devices and serve more customers.

To facilitate use of the secondary markets model, it is essential to have in place a flexible and efficient regulatory regime that allows for the negotiation of the necessary access rights and keeps the transaction costs of negotiation low. To further this goal, the Task Force recommends as an essential first step that the Commission take action to adopt rules in the ongoing Secondary Markets proceeding, and that it take additional steps to implement secondary markets to the extent that its current statutory authority allows. In addition, to the extent that statutory constraints continue to exist, the Task Force recommends legislative changes that would provide explicit authority for the Commission to implement a fully flexible approach to secondary markets.

While the Task Force generally recommends that access rights for devices operating above the interference temperature threshold be negotiated through the secondary market, there may be instances where secondary markets work less well because they impose such significant transaction costs on parties that negotiations will not occur. In such cases, the easements model may offer a viable alternative approach. Under this approach, unlicensed devices operating above the interference temperature threshold would be allowed to operate on licensed spectrum on a non-interfering basis subject to specified conditions and with no negotiation with the licensee required. Non-interfering operation would be ensured by allowing operation at a higher power on a not-

to-interfere basis using standard protocols. The FCC or a frequency coordinator would administer and resolve harmful interference issues. By definition, the easements model allows for efficient and low-cost access to spectrum, because the government establishes overall rules and protocols under which any user would be allowed access to the spectrum, and negotiations with individual licensees are not required. The easements model also bears greater consideration than in the past because the increased sophistication of technology allows for the possibility of enhanced spectrum use by third parties on a non-interfering basis with the licensee.

Nevertheless, broad application of the easement approach to operations above the interference temperature threshold presents significant challenges. Because the easement model inherently limits the flexibility afforded to the licensee to some degree, and relies on government to define the scope of the easement, it should be applied cautiously. For example, currently all Part 15 devices are limited to extremely low power levels in order to minimize the possibility of interference. If opportunistic devices are to be authorized at higher powers in the future, this will require regulations or protocols to ensure that such devices have the ability to "listen" before they transmit and to cease transmitting instantly when continued transmission would cause interference. In addition, there is the concern that once unlicensed devices begin to operate in an easement, it may be difficult legally or politically to shut down their operations even if they begin to cause interference or otherwise limit the licensed user's flexibility. Thus, as proponents of the secondary market model note, the potential for "squatter's rights" issues to arise is another potential downside of the easement model that must be addressed.

To address these concerns, the Task Force recommends that in the first instance, the Commission focus on use of the secondary markets model to facilitate access above the interference temperature threshold. Once there has been an opportunity to evaluate the effectiveness of this approach, the Commission can then assess whether there is a need to pursue an easement approach for some types of access. Even then, any decision whether to use an easement approach will require careful consideration of the time, space, and frequency-agility dimensions of the proposed spectrum use. In addition, in making such decisions, the Commission will need to be sensitive to the potential impact of allowing easement-based access by opportunistic devices on the expectations, business plans, and investment made by licensed spectrum users.

C. Access to Spectrum in Rural Areas

The Task Force addressed the issue of whether the Commission's approach to spectrum management should vary in different portions of the spectrum, in different geographic areas, or for different types of uses. Many commenters focused considerable discussion on the issue of rural areas, where spectrum is almost uniformly uncongested even in the most heavily used bands below 3 GHz. Although some parties indicated that the Commission should not adopt different spectrum allocation and assignment policies for different portions of the spectrum or different geographic regions, it was generally recognized that the economic and technical considerations in rural areas are different than in urban areas, and there is some support in the record for applying different rules to spectrum usage in urban and rural areas.

Some advocates for rural interests asserted that rural carriers have difficulty gaining access to spectrum, even though spectrum in rural areas is typically the least congested. Specifically, rural carriers argued that the Commission's tendency to use large geographic licensing regions that encompass both urban and rural areas discourages rural carriers from seeking to acquire licenses. In addition, rural carriers contended that the Commission's partitioning and disaggregation rules do not benefit rural providers because they must incur significant transaction costs to negotiate access to rural spectrum with multiple large carriers that may prefer in any event to retain such spectrum for future use. It was further argued that licensing build-out requirements that are based on population coverage tend to lead to build-out only in urban areas, with rural spectrum going unused.

Commenters also discussed whether there should be different interference standards for rural and urban areas. Certain parties advocated higher permissible power levels for rural areas on the theory that where there is less congestion, higher permissible power levels would allow for fuller usage of spectrum. Others objected to this idea, arguing that having different rural and urban regimes is impractical because it is not a simple matter to define urban versus rural, as many areas fall somewhere in between and problems may arise when formerly rural areas undergo development. Thus, there was a difference of opinion as to whether different technical rules for rural areas are feasible or desirable.

The Task Force recommends that the Commission explore ways to promote spectrum access and flexibility in rural areas. As a threshold matter, however, it is important to note that the distinction between high- and low-congestion areas does not necessarily require non-uniform rules for the latter, so long as the rules do not artificially cause spectrum congestion or constrain the use of uncongested spectrum. Interference and other technical rules should generally be calibrated to conditions in areas where spectrum is likely to be in the greatest demand and the most congested, which will typically be urban areas. Thus, the obligations of spectrum users to avoid interference should be set at levels suitable for such areas, as should their obligation to accept interference from others. However, these rules should also afford spectrum users the flexibility to operate at higher power in less congested areas, which are typically rural, so long as such higher power operations do not cause interference and do not receive additional interference protection. These same principles should be applied to unlicensed bands so that higher-power operation of unlicensed devices is permitted in less congested areas.

To improve providers' ability to gain access to spectrum in rural areas, the Commission should promote the development of an efficient and flexible secondary markets regime that, in addition to partitioning, facilitates the leasing of spectrum usage rights in rural areas, which would significantly lower transaction costs. The Commission could also consider expanding "easements" on licensed spectrum (as discussed in Section VIII.B. above) in low-congestion areas to allow access, on a non-interference basis, by other spectrum users. Such an approach, however, would require the use of technology

that is capable of measuring the level of spectrum congestion in the area and adjusting power accordingly.

In addition, when licensing by geographic area, the Commission should consider the impact of its rules on access to rural spectrum. In some instances, it may be appropriate to use licensing areas that distinguish between rural and urban areas so that rural interests can more readily acquire spectrum in the areas they serve. However, in other instances, larger spectrum areas may be beneficial to rural interests by allowing licensees to take advantage of economies of scale or scope based on regional or nationwide footprints.

D. Experimental Licensing

Section 303(g) of the Communications Act of 1934, as amended, (the Act) authorizes the Commission to provide for experimental use of frequencies and charges the Commission with encouraging "the larger and more effective use of radio in the public interest."[45] Experimental licenses provide the opportunity for manufacturers, inventors, entrepreneurs, and students to experiment with new radio technologies, new equipment designs, characteristics of radio wave propagation, and new service concepts related to the use of the radio spectrum, which may not otherwise be permitted under existing service rules. In order to encourage innovation, the experimental license rules provide great flexibility with regard to allowable frequency range, power, and emission. However, to protect previously-allocated services, experimental licenses are issued on condition that experimental operations do not cause interference to existing services, and experimental operations are not protected from interference from allocated services.

Only a few parties addressed the topic of experimental licenses. The principal concern of these parties appeared to be potential delay involved in obtaining an experimental license due to interagency frequency coordination and, in particular, difficulties associated with testing systems being developed for government transfer bands and for overseas markets with different allocation plans. Concerns were also raised about the non-interactive nature of the coordination process from the point of view of private entities seeking to experiment with new technologies.

Experimental license applications that request use of spectrum used exclusively by the federal government or shared with the federal government must be coordinated with NTIA to assess any potential interference issues. In practice, NTIA refers such applications to the Interdepartmental Radio Advisory Committee (IRAC), which is composed of all federal agencies that are major spectrum users.[46] Most coordination requests are handled promptly, but some applications remain in the coordination process

[45] *See* Section 303(g) of the Communications Act of 1934, as amended, 47 U.S.C. § 303(g). This discussion is based in part on the NPRM in Docket 96-256, 11 FCC Rcd 20130 (1996). The rules addressing experimental licenses are contained in Part 5 of the Commission's rules. *See* 47 CFR Part 5.

[46] NTIA coordination is actually carried out by the IRAC Frequency Assignment Subcommittee (FAS).

for a considerable period of time and, in some instances, are not resolved after periods in excess of one year.[47]

The Task Force believes that a slight modification in the frequency coordination process may effectively facilitate expeditious resolution of any potential interference issues. A suggestion from the parties, that the Task Force supports, is to permit more direct communications between parties who have applied for experimental licenses and the federal government entities concerned about their pending experimental applications on a more regular basis. The parties suggest that such contacts would allow them to explore possible modifications in their experimental license applications that might lead to mutually acceptable outcomes, such as restricting location, operating power, and operating hours. Although the Task Force recognizes that classification issues related to certain federal government systems may make direct communication impractical in all cases, at least in some instances, communications between the parties is possible and that new procedural and organizational mechanisms should be put in place to improve communications between commercial parties desiring to implement experiments and federal users of the spectrum. To this end, the Task Force recommends that the FCC and NTIA consider implementing a new interface for non-federal government spectrum users with IRAC members to help search for workable compromises for experimental license applications. One possible approach, also suggested by commenters, would be to consider appointing an advocate or ombudsman for the private sector.

In addition, the Task Force believes that it would be helpful to have more information about the use of certain bands for experimentation – particularly government transfer bands -- available to the public. To facilitate experimentation in bands that are designated for transfer to the private sector, perhaps the FCC and NTIA could work together to identify – or pre-clear – some location, frequency, and time combinations where non-federal government spectrum users would be permitted to conduct experiments. These joint FCC-NTIA efforts would greatly facilitate the ability of the private sector to rapidly deploy consumer services in these bands after transfer from federal government use.

E. Transition Issues

As discussed, there are many ways to increase access to the radio spectrum. The Task Force recognizes, however, that these proposed changes cannot, and should not, be implemented without giving serious consideration to the reliance interests of incumbent spectrum users. Thus, for example, while the Task Force believes that it is important to conduct a review to determine which bands may be feasible for unlicensed use, it is equally important to assess and address the expectations of incumbent users in any candidate band.

There are few transition issues implicated in using the general secondary markets model to facilitate access to currently occupied spectrum, because access under this

[47] OET's Experimental Branch has recently instituted a procedure in which new applications that not successfully coordinated in one year are dismissed without prejudice.

model is premised on negotiation with the licensee. Licensed spectrum users would gain greater flexibility, and private negotiations would determine availability of particular spectrum for use by others. To the extent, however, that government-defined easements are contemplated as an alternative to the general secondary markets model, the issue of incumbency would be among the many serious challenges in deciding whether such easements would be appropriate.

Recommendations:

- Consider methods for additional spectrum access for unlicensed devices, which include:
    - Access to new band controlled by a new type of band manager or frequency coordinator.
    - Opportunistic or dynamic use of existing bands – through either cognitive radio techniques to find "white space" in existing bands or use protocols to get out of the way of primary users.
    - Underlay beneath primary users:

        (1) Unlicensed devices operate below acceptable interference level (that is, operate on a non-interference basis with licensees); and/or

        (2) Unlicensed devices can operate at higher powers if negotiate with licensee – negotiations can either take place directly or through private band manager.
- In licensed spectrum bands, pursue secondary markets policies that encourage licensees to provide access for "opportunistic" uses above the interference temperature threshold through leasing of spectrum usage rights.
    - At a later time, after evaluating the effectiveness of secondary markets approach, assess whether there is a need to create government-granted "easements" for some types of access, but consider the potential impact of this approach on planning and investment by licensed users.
- Millimeterwave bands: all future rulemaking for terrestrial use above 50 GHz should include *de novo* review of the merits of licensing.
- Wireless ISPs (WISPs) and point-to-point microwave systems:
    - Facilitate greater flexibility by making it easier for operators to better tailor their equipment for particular application.
    - Increase power limits for WISPs (and point-to-point systems) in rural areas.
    - In general, technical rules should be calibrated to areas where spectrum is in the greatest demand and the most congested, which are typically urban areas.
        - In less congested areas, the rules should not prevent licensees from operating at higher power on a non-interference basis, but licensees operating in such areas should not have expanded interference protection rights or reduced obligations to avoid interference.
        - In unlicensed bands, technical rules should allow for higher-power operation in less congested areas.
    - The Commission should increase incentives and reduce transaction costs on parties seeking access to rural spectrum
        - Geographic licensing areas that distinguish between rural and urban areas may be appropriate in some bands to allow focused bidding on rural areas
        - More important is the development of an efficient and flexible secondary markets regime that facilitates leasing of rural spectrum in all licensed bands
        - The Commission could also consider expanding "easements" on licensed spectrum in rural areas to allow access by other spectrum users.
- Experimental Licensing: Recommend an interface with IRAC members to help search for workable compromises for experimental applications and suggest that NTIA or DOC to appoint an advocate/ombudsman for the private sector.
- Recommend that NTIA and FCC identify some (frequency, location, time) combinations in the transfer bands for experiments that have low risk of interference to Federal systems, "pre-clear" them and announce availability for experiments in a "broad area announcement"-like PN.

IX. Policy Recommendations

The following is a list of the Task Force's specific policy recommendations, which correspond to the recommendations listed at the end of each section. Specific recommendations that would require legislative action are listed in Appendix A.

A. Key Elements of New Spectrum Policy Recommendations

1. Permit broad, highly flexible use within technical parameters of the allocation.
   a. Permit traditionally narrow services to lease excess capacity to other services.
2. Investigate rule changes that enable the lowering of permitted power in urban areas and the increasing of permitted power in rural areas.
   a. Permit high-power digital television broadcasters to operate single frequency low power distributed transmission systems within their present service area.
   b. Promote the co-location of high power transmitters.
3. Foster technologies for uniform signal strength generation throughout a service area.
4. Consider user fees or other steps to stimulate improvements in efficiency when marketplace is inadequate.
5. Promote shift to hybridizations with wireline delivery whenever appropriate.
6. Group future allocations based on mutually-compatible technical characteristics (power flux density and sensitivity to interference), and improve the out-of-band interference performance of transmitters and receivers over time so as to reduce the need for this kind of grouping.
7. Conduct periodic evaluations of allocation parameters with respect to evolving technology and uses.
8. Time-limit spectrum rights and subject them to periodic review.
   a. Every 5 to 10 years, review spectrum rights and obligations, interference criteria, and definitions, and modify if appropriate.
   b. But spectrum users should be entitled to rely on rules remaining constant between periodic reviews.
   c. Licensees should still have strong renewal expectancy.

B. Interference Avoidance Recommendations

9. Quantify acceptable levels of interference through "interference temperature" concept (long-term objective).
10. Obtain better data regarding noise floor:
    a. Adopt standard method for measuring noise floor.
11. Create a public/private partnership for long term noise (interference temperature) monitoring network and archiving of data for use by FCC and public.

12. Include receiver tolerances in regulation (either through (1) additional incentives, (2) mandates, or (3) some combination of incentives and mandates) to be used until can migrate to "interference temperature" regulatory scheme and to be used for the long term where use of interference temperature would be inapplicable; *e.g.,* for systems in which licensees do not have control over receivers.
13. Move to interference-limited policies.
14. Issue Notice of Inquiry to characterize current and future receiver environments and to explore issues to consider, such as, performance parameters and protection for legacy receivers.
15. Award contractual study to evaluate receiver performance in current environment.
16. Promote voluntary receiver performance requirements through industry groups.
17. Consider incentives for use of advanced receivers.
18. Promote transmitter enhancements for interference control: (a) foster technologies that enhance uniform signal levels throughout a service area; (b) promote greater use of automated transmitter control systems; and (c) consider tightening out-of-band emission limits over time.
19. Improve communications on interference issues with public.
    a. Harmonize interference language in FCC rules and affected international rules.
    b. Ensure consistent and appropriate use of interference terminology.
    c. Develop technical bulletins that explain interference rules for all radio services.
    d. Develop best practices handbook.
20. Add language to the Act expressly allowing the Commission to establish rules or performance requirements for receivers.
21. "Interference temperature" concept should form the basis for better defining interference rights.
22. Accompany clearer interference definition with effective enforcement.

C. Spectrum Usage Models Recommendations

23. Expand the use of both the exclusive rights and commons models, and move away from the command-and-control model, with limited exceptions.
24. Transition legacy command-and-control bands to more flexible rules and uses to the maximum extent possible (whether under the exclusive rights or commons model), with only limited exceptions.
25. Assess and re-examine Section 647 of the Orbit Act to consider permitting, <u>but not requiring</u>, the Commission to utilize competitive bidding to resolve mutually exclusive applications for global and international satellite services. Take into account international concerns, including frequency coordination with Canada and Mexico and global harmonization of uses.
26. Continue to dedicate some spectrum on a command-and-control basis for public safety use.

27. Address additional public safety needs through alternative "safety valve" mechanisms to make spectrum is available to public safety in emergency situations when more capacity is needed.
    a. Because some public safety spectrum use is characterized by intermittent "spikes," public safety users should have flexibility to lease spectrum capacity that is available during lower-use periods to commercial users with a "take-back" mechanism when public safety use increases.
    b. For major regional or national emergencies, additional public safety spectrum needs should be addressed through enhanced easement rights to non-public safety spectrum.
28. Develop more flexible policy for addressing public safety spectrum needs, including leasing/take-back arrangements with commercial users and easement rights to non-public safety spectrum in major emergencies.
29. For new spectrum allocations and the associated spectrum assignments, apply the following basic framework:
    a. Base choice of exclusive rights, commons, or command-and-control model in particular bands on factors previously identified.
    b. Make underlay rights based on interference temperature a component of new spectrum allocations and assignments.
        i. This does not require a constant interference temperature definition across all bands.
    c. Clearly define access rights for opportunistic devices whether based on secondary markets, easements, or a combination of the two.
30. For encumbered spectrum, identify bands that are suitable for initiating transition within the next five years and develop a transition plan for each band.
    a. Set a goal of identifying highly valuable 100 megahertz of spectrum for this transition phase.
    b. Look for band "defragmentation" opportunities (consolidating narrowband spectrum "slices" and encouraging migration of compatible technologies into common band groupings).
    c. Interference temperature should be specified for most new allocations and associated assignments, and underlay operations.
    d. Address underlay/easement rights in transition bands on a going-forward basis (avoid retroactive easements).
31. Develop mechanisms to improve efficiency of secondary markets in facilitating transition.
    a. Move forward with the Secondary Markets proceeding.
    b. Facilitate use of leasing, band managers, and similar mechanisms to promote transition, particularly in multi-use bands.
    c. Address spectrum access issues in rural areas.

d. Recommend that Congress amend Section 309(j) of the Act to include an express grant of authority to the FCC to conduct two-sided auctions and simultaneous exchanges.

e. Recommend that Congress amend the Act to authorize the use of auction funds to pay relocation expenses to incumbents.

f. Recommend that Congress eliminate the 2007 expiration date on the Commission's statutory auction authority and grant the Commission permanent auction authority.

D. Promoting Access to Spectrum Recommendations

32. Consider methods for additional spectrum access for unlicensed devices, which include:
    a. Access to new band controlled by a new type of band manager or frequency coordinator.
    b. Opportunistic or dynamic use of existing bands – through either cognitive radio techniques to find "white space" in existing bands or use protocols to get out of the way of primary users.
    c. Underlay beneath primary users:
        i. Unlicensed devices operate below acceptable interference level (that is, operate on a non-interference basis with licensees); and/or
        ii. Unlicensed devices can operate at higher powers if negotiate with licensee – negotiations can either take place directly or through private band manager.
33. In licensed spectrum bands, pursue secondary markets policies that encourage licensees to provide access for "opportunistic" uses above the interference temperature threshold through leasing of spectrum usage rights.
    a. At a later time, after evaluating the effectiveness of secondary markets approach, assess whether there is a need to create government-granted "easements" for some types of access, but consider the potential impact of this approach on planning and investment by licensed users.
34. Millimeterwave bands: all future rulemaking for terrestrial use above 50 GHz should include *de novo* review of the merits of licensing.
35. Wireless ISPs (WISPs) and point-to-point microwave systems:
    a. Facilitate greater flexibility by making it easier for operators to better tailor their equipment for particular application.
    b. Increase power limits for WISPs (and point-to-point systems) in rural areas.
36. In general, technical rules should be calibrated to areas where spectrum is in the greatest demand and the most congested, which are typically urban areas.
    a. In less congested areas, the rules should not prevent licensees from operating at higher power on a non-interference basis, but licensees operating in such areas should not have expanded interference protection rights or reduced obligations to avoid interference.

b. In unlicensed bands, technical rules should allow for higher-power operation in less congested areas.

37. The Commission should increase incentives and reduce transaction costs on parties seeking access to rural spectrum
    a. Geographic licensing areas that distinguish between rural and urban areas may be appropriate in some bands to allow focused bidding on rural areas
    b. More important is the development of an efficient and flexible secondary markets regime that facilitates leasing of rural spectrum in all licensed bands
    c. The Commission could also consider expanding “easements” on licensed spectrum in rural areas to allow access by other spectrum users.
38. Experimental Licensing: Recommend an interface with IRAC members to help search for workable compromises for experimental applications and suggest that NTIA or DOC to appoint an advocate/ombudsman for the private sector.
39. Recommend that NTIA and FCC identify some (frequency, location, time) combinations in the transfer bands for experiments that have low risk of interference to Federal systems, "pre-clear" them and announce availability for experiments in a "broad area announcement"-like PN.

Appendix A: Legislative Recommendations

The Task Force recommends that the Commission consider the statutory proposals detailed below for submission to Congress. These recommendations resulted from a thorough examination of the current statutory structure contained in the Communications Act of 1934, as amended, as well as related laws. They are intended as a blueprint for working with Congress to effectuate a more flexible spectrum policy regime.

- Initiate a review of the potential use of spectrum fees for non-market based spectrum uses. *See* Section V.D.

- Request language in the Communications Act to clarify the scope of the Commission's authority to establish rules or performance requirements for all receivers. *See* Section VI.B.

- Consider amending Section 309(j) of the Communications Act to provide the Commission authority to conduct two-sided auctions and simultaneous spectrum exchanges. *See* Section VII.D.

- Support existing legislative measures that would amend the Communications Act to authorize the use of auction funds to pay relocation expenses to Federal government incumbents and suggest expanding such measures to include non-Federal entities. *See* Section VII.D.

- Undertake a review of Section 310 of the Communications Act to determine the feasibility of providing the Commission with additional flexibility to improve the operation of secondary markets and the processing of other transactions. *See* Section VIII.B.

- Assess and re-examine Section 647 of the Orbit Act to consider permitting, but not requiring, the Commission to utilize competitive bidding to resolve mutually exclusive applications for spectrum used for global and international satellite services. *See* Section VII.C.