Spectrum Policy Task Force

REPORT

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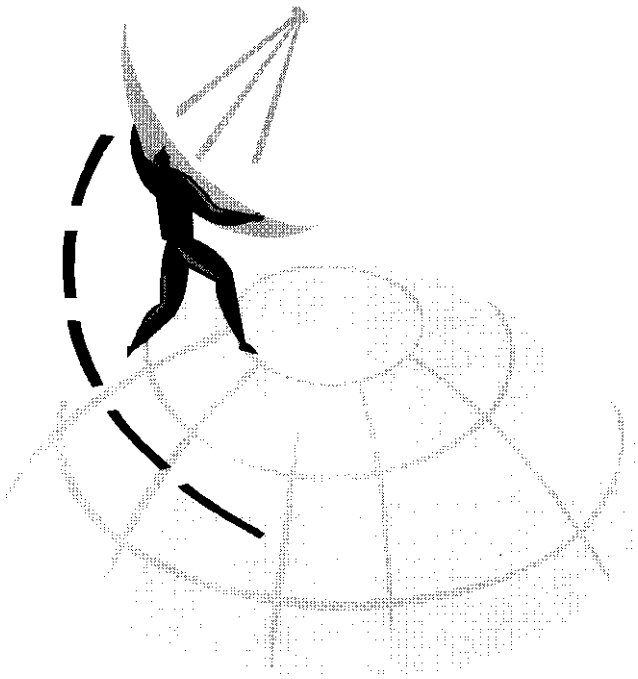

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I. Introduction

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 hands, 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.' 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; energyltransportation; 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 9''. 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.*

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:/lwww.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 hut with no right to protection from interference.
    - "Command-and-controy 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 hands 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 he 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 ofpriority distress calls from ships and created thc first two radio frequency service categories: general public service in the 187-500 kHz hand 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] 47U.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? 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." 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] **See47** 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." 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." 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."" 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 41 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** httu://www.suectrumview.radio.eov.uk.

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

New York State." 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** Stale 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

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

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

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

technical parameters applicable to the particular hand 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 he 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 he 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

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[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.'* To address these issues, the

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[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 Cornmission 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,

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