Before the
Federal Communications Commission
Washington, D.C. 20554

In the Matter of	)	
	)	
Promoting More Efficient Use of Spectrum	)	ET Docket No. 10-237
Through Dynamic Spectrum Use Technologies	)	

NOTICE OF INQUIRY

Adopted: November 30, 2010 **Released: November 30, 2010**

Comment Date: [60 days after date of publication in the Federal Register]
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By the Commission: Chairman Genachowski, Commissioners Copps, McDowell, Clyburn, and Baker issuing separate statements.

I. INTRODUCTION

1. Dynamic spectrum access technologies and techniques have the potential to enable more efficient utilization of our nation's precious spectrum resource. While geographic sharing of spectrum is well-established, we are only just now seeing the emergence of technologies that enable "dynamic" sharing – that is, the ability of devices to identify slices of spectrum that are available at that location, whether for a few seconds, a few minutes, a few hours, or a few days. The need to undertake long-term spectrum planning poses a vital strategic and economic challenge for our nation. As we take steps in other proceedings to make more spectrum available, so too we must ensure that any available spectrum is used as efficiently and productively as possible. Advances in technological innovations, such as "cognitive" or "opportunistic" radio technologies, can help address this national challenge. These technologies have the potential to significantly increase the efficiency of spectrum utilization by enabling radios to access and share available spectrum dynamically across different frequencies, thus making more productive use of this valuable resource for the benefit of American consumers. In this Notice of Inquiry (NOI), we seek to promote and facilitate wireless innovation, taking additional steps to ensure that the promise of these advanced radio technologies – as well as the new models of spectrum management techniques that they make possible – can be fully realized and applied across more of the radio spectrum.

2. Specifically, we seek comment on the variety of ways in which dynamic spectrum access radios and techniques can promote more intensive and efficient use of the radio spectrum, and the potential that these technological innovations have for enabling more effective management of spectrum. We first explore the current state of development of dynamic spectrum access technologies, including the technical developments that affect the design and operation of dynamic radios. In particular, we examine the development of spectrum sensing and other dynamic spectrum sharing capabilities and techniques. Next we explore ways in which we can help promote the development of these technologies for use on both a licensed and an unlicensed basis. We inquire whether there are additional steps we should take to improve our "Spectrum Dashboard," a web-based access tool that enables users to determine how spectrum is being used, who holds spectrum licenses around the

country, and what spectrum is available in a particular geographic area.[1] In addition, we seek comment on how spectrum used through secondary market arrangements could employ dynamic spectrum access radios and techniques. We also seek comment on establishment of dynamic access radio test beds and on spectrum bands that might be suitable for dynamic spectrum access. We also examine whether the database access model applicable to unlicensed Television Band Devices might be deployed in other spectrum bands.

II. BACKGROUND

3. The Commission has been providing opportunities for new technologies that promise more efficient and innovative spectrum use for many years for both unlicensed devices and licensed services. For example, the Commission in the mid-1980's adopted flexible rules for spread spectrum technology that ultimately led to the development of the family of 802.11 standards (*e.g.*, Wi-Fi) that today support delivery of broadband services within homes, at hot spots, over community networks, and in conjunction with commercial wireless smart phones. Flexible rules for commercial wireless services led to the development and support of advanced digital technologies such as CDMA and GSM, as well as more recent 3G and 4G technologies such as WiMAX and LTE. We have also encouraged and witnessed the development of technologies such as smart antennas and femto-cells to further improve efficient use of the spectrum.

4. Recently, the Commission has adopted rules to implement dynamic spectrum use with respect to both unlicensed devices and licensed services.

- *5 GHz Unlicensed National Information Infrastructure Band.* In 2003, the Commission made an additional 255 MHz of spectrum available under the Part 15 rules for Unlicensed National Information Infrastructure devices operating in the 5 GHz region of the spectrum based on the use of Dynamic Frequency Selection (DFS).[2] DFS is designed to detect and avoid causing harmful interference to military and weather radar systems that also operate in this band[3]

- *3650-3700 MHz band*. In 2005, the Commission adopted rules to provide 50 megahertz of spectrum in the 3650-3700 MHz band for licensed wireless broadband use.[4] The rules provided for a nationwide license by rule and a registration requirement for specific locations. To ensure that all licensees at all locations have a reasonable opportunity of accessing the spectrum, the Commission required that operations employ contention-based protocols.[5] The Commission stated that it would rely on the wireless industry to develop standards for implementing this

[1] *See* http://reboot.fcc.gov/reform/systems/spectrum-dashboard.

[2] *See* Revision of Parts 2 and 15 of the Commission's Rules to Permit Unlicensed National Information Infrastructure (U-NII) devices in the 5 GHz band, ET Docket No. 03-122, *Report and Order*, 18 FCC Rcd 24484 (2003).

[3] The rules also require the 5.25-5.35 GHz band to incorporate DFS. *See* 47 C.F.R. § 15.407(h)(2). While these rules have generally proven successful, we note that interference to radar operations has occurred. The Commission continues to investigate and work with users and manufacturers regarding these interference events.

[4] *See* Wireless Operations in the 3650-3700 MHz Band, ET Docket No. 04-151, *Report and Order*, 20 FCC Rcd 6502 (2005).

[5] The Commission defined a contention-based protocol as: A protocol that allows multiple users to share the same spectrum by defining the events that must occur when two or more transmitters attempt to simultaneously access the same channel and establishing rules by which a transmitter provides reasonable opportunities for other transmitters to operate. Such a protocol may consist of procedures for initiating new transmissions, procedures for determining the state of the channel (available or unavailable), and procedures for managing retransmissions in the event of a busy channel. *See* 47 C.F.R. § 90.7.

requirement and we note that equipment meeting this requirement is increasingly finding its way into the market.

- *TV White Spaces*. In November 2008, the Commission adopted rules to allow unlicensed radio transmitters to operate in the broadcast television spectrum at locations where that spectrum is not being used by licensed services. The Commission decided to rely on a combination of spectrum sensing and geo-location combined with access to a database of existing spectrum use to determine if a channel is available.[6] In September, 2010, the Commission eliminated the sensing requirement for Television Band Devices that include geo-location/database functions, as petitioners argued that sensing technology was not sufficiently mature for consumer devices and would delay market entry.[7]

With respect to licensed services, we note that the Commission in recent years has promoted flexible use policies – including secondary market policies – that seek to provide licensees with wide latitude to develop and deploy advanced technologies in order to address changing marketplace demands.[8]

5. In a companion Notice of Proposed Rulemaking today, we propose ways to improve our Part 5 Experimental Service.[9] Given the interest and need for increasing spectrum efficiency in the face of spectrum constraints, over the last few years much experimentation has been done in the area of dynamic spectrum use – that is, the use of radios that through a variety of means are aware of their local radio frequency (RF) environment and adjust their operation based on that information. Such radios can exploit available spectrum on a dynamic basis where traditional radios cannot. Our proposals to improve the Part 5 Experimental Service are designed to facilitate research and development of wireless technologies in general and should be particularly important to support the development of dynamic spectrum access technologies and techniques that are the focus of this proceeding.

6. As an initial matter, we note that the terms "dynamic spectrum access radio," "dynamic radio," "cognitive radio," and "opportunistic radio" often have distinct meanings. However, they are used interchangeably herein because we are interested in a broad range of developments in these areas.[10] The International Telecommunication Union-Radiocommunication Sector (ITU-R) Study

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[6] *See* Unlicensed Operation in the TV Broadcast Bands, ET Docket No. 04-186; and Additional Spectrum for Unlicensed Devices Below 900 MHz and in the 3 GHz Band, ET Docket No. 02-380; *Second Report and Order and Memorandum Opinion and Order*, 23 FCC Rcd 16807 (2008). The Commission had previously issued a *First Report and Order and Further Notice of Proposed Rule Making* in this proceeding; *see* 21 FCC Rcd 12266 (2006).

[7] *See* Unlicensed Operation in the TV Broadcast Bands, ET Docket No. 04-186; and Additional Spectrum for Unlicensed Devices Below 900 MHz and in the 3 GHz Band, ET Docket No. 02-380; *Second Memorandum Opinion and Order*, FCC 10-174, released September 23, 2010.

[8] *See, e.g.,* Implementation of Section 6002(b) of the Omnibus Budget Reconciliation Act of 1993, Annual Report and Analysis of Competitive Market Conditions With Respect to Mobile Wireless, Including Commercial Mobile Services, *Fourteenth Report*, 25 FCC Rcd 11407 (2010) at 11566-68, ¶¶ 261, 264; Fostering Innovation and Investment in the Wireless Communications Market, GN Docket No. 09-157; A National Broadband Plan For Our Future, GN Docket No. 09-51; *Notice of Inquiry*, 24 FCC Rcd 11322 (2009) at 11328-29 ¶¶ 26-27.

[9] *See* Promoting Radio Experimentation under Parts 2 and 5 of the Commission's Rules, ET Docket No. 10-236; 2006 Biennial Review of Telecommunications Regulations – Part 2, Administered by the Office of Engineering and Technology (OET), ET Docket No. 06-105; *Notice of Proposed Rulemaking*, adopted November 30, 2010.

[10] None of these terms are defined in the Commission's rules. We also note that these terms are often confused with a "software defined radio" (SDR). However, while a dynamic spectrum access radio will often contain an SDR, an SDR does not necessarily imply this type of radio. IEEE Standard 1900.1 defines SDR as "[a] type of radio in which some or all of the physical layer functions are software defined" and applies to both transmit and receive

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Group 1 has tentatively defined a "cognitive radio system" as one that employs technology that allows the system to: (1) obtain knowledge of its operational and geographical environment, established policies, and its internal state; (2) dynamically and autonomously adjust its operational parameters and protocols according to its obtained knowledge, in order to achieve predefined objectives; and (3) learn from the results obtained.[11] In layman's terms, this describes a radio and network that can react and self-adjust to local changes in spectrum use or environmental conditions to obtain access to spectrum without causing harmful interference. Other groups have developed definitions for "cognitive radio system" as well.[12]

7. While the ITU definition informs as to where technology may ultimately lead, we note that, more simply, dynamic spectrum use can range in variety from simple listen-before-talk (LBT) algorithms to more sophisticated techniques involving spectrum sensing or real-time database look-up schemes. In this way, a radio can take advantage of available spectrum on an ongoing basis as the opportunity presents.

8. As interest in dynamic spectrum access radios continues to grow, many entities are conducting research or taking part in standardization efforts aimed at continued development. An industry group known as the Wireless Innovation Forum[13] has developed a list of capabilities and benefits of such radios.[14] In an attempt to provide some coherence to efforts in this area, in April 2007

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functions. *See* IEEE Standard 1900.1-2008 at 2.9. The Commission's Rules define an SDR as, "[a] radio that includes a transmitter in which the operating parameters of frequency range, modulation type, or maximum output power (either radiated or conducted), or the circumstances under which the transmitter operates in accordance with Commission rules, can be altered by making a change in software without making any changes to hardware components that affect the radio frequency emissions." *See* 47 C.F.R. § 2.1.

[11] Draft Conference Preparatory Meeting Report from the Director, Radiocommunication Bureau, ITU, CPM11-2/1-E, dated August 13, 2010, Section 6/1.19/3, p. 410.

[12] IEEE Standard 1900.1 defines "cognitive radio" as "a type of radio in which communications systems are aware of their environment and internal state and can make decisions about their radio operating behavior based on that information and predefined objectives." *See* IEEE Standard 1900.1-2008 at 2.2. The National Telecommunications and Information Administration, which regulates Federal spectrum use, defines a "cognitive radio system" as "a radiocommunication system that is aware of its environment and internal state and can make decisions about, and adjust, its operating characteristics based on information and predefined objectives." See *Manual of Regulations and Procedures for Federal Radio Management,* May 2010 Revision of the January 2008 Edition, at Section 6.1.1. Chapter 6 ("Definitions and Particulars of Assignments") of the *Manual* is available at http://www.ntia.doc.gov/osmhome/redbook/6_5_10.pdf.

[13] The Wireless Innovation Forum, previously known as the SDR Forum, was established in 1996 as a non-profit mutual benefit corporation dedicated to driving technology innovation in commercial, civil, and defense communications worldwide. *See* http://www.wirelessinnovation.org/mc/page.do;jsessionid=621E726FABC936B7EF9ECA630236D5BC.mc1?sitePageId=98428. The Forum has worked in collaboration with the Institute of Electrical and Electronic Engineers P1900.1 group to establish a definition of software-defined radio that provides consistency and a clear overview of that technology and its associated benefits.

[14] Capabilities include exploiting locally vacant or unused radio channels, or ranges of radio spectrum, to provide new paths to spectrum access; roaming across borders and performing self-adjustment to stay in compliance with all local radio operations and emissions regulations; negotiating as a broker on behalf of the radio user with multiple service providers to give network access best matched to the user needs at the lowest cost; adapting itself without user intervention to save battery power or to reduce interference to other users; making use of location awareness to ensure that radio emissions do not interfere with licensed broadcasters; understanding and following the actions and choices taken by their users to become more responsive and anticipating user needs over time; formulating and issuing queries, one radio to another; executing commands sent by another radio; and fusing contradictory or

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the Institute of Electrical and Electronics Engineers (IEEE) created the IEEE Standards Coordinating Committee 41 (SCC41) on Dynamic Spectrum Access Networks (DySPAN) to oversee the development of the IEEE 1900 series of standards. This effort comprises six working groups tasked with a variety of activities from providing common definitions and explanations of key concepts to developing guidelines for interference and coexistence to developing evaluation methods.[15]

9. We note that Federal agencies also are exploring ways to improve spectrum efficiency. The Commission has participated with the Department of Commerce's National Telecommunications and Information Administration (NTIA) and other Federal agencies in establishing a Spectrum Sharing Innovation Test-Bed (Test-Bed) pilot program to examine the feasibility of increased sharing between Federal and non-Federal users. Planning for this program began in June 2006[16] and in 2008, the Commission designated 10 megahertz of spectrum in the 470-512 MHz band and NTIA designated the 410-420 MHz band for the Test-Bed.[17] Several entities expressed interest in participating in the Test-Bed and evaluation of submitted equipment is ongoing by NTIA.[18]

10. Additionally, the Defense Advanced Research Projects Agency (DARPA) NeXt Generation Communications Program ("XG Program") developed technology and system concepts for military radios to dynamically access spectrum in order to establish and maintain communications. The goal was to demonstrate the ability to access 10 times more spectrum with near-zero setup time; simplify RF spectrum planning, management and coordination; and automatically resolve conflicts in operational spectrum usage. XG technology assesses the spectrum environment and dynamically uses spectrum across frequency, space and time. XG is designed to be successful in the face of jammers and without causing harmful interference to commercial, public service, and military communications systems.[19] In August, 2006, Shared Spectrum Corporation (SSC) performed tests at Fort A.P. Hill which demonstrated three core principals of the XG program: (1) non-interference with legacy systems; (2) setting up and maintaining networks; and, (3) creating capacity where spectrum was not available.[20] At that time, the following issues were identified for continuing work: (1) Integrating XG into network technology; (2) Developing and demonstrating scalability; (3) Addressing a broader class of signals; and (4) Extending the spectrum access logic and algorithms to cover the range and

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complementary information. Benefits include interoperability and coexistence; reduced demand on user; reduced user control burden; greater spectrum efficiency through improved access; improved application interface for communications tasks; dynamic regulatory compliance; radio performance optimization; and user-based cognitive adaptation. *See* SDR Forum Cognitive Radio Definitions and Nomenclature, Approved Document SDRF-06-P-0009-V1.0.0, 10 September 2008, at 8-10.

[15] *See* http://grouper.ieee.org/groups/scc41/index.html.

[16] *See*, respectively, 21 FCC Rcd 7422 (2006) and NTIA Docket No. 060602142-6142-01, published in 71 Fed. Reg. 33282.

[17] *See*, respectively, 23 FCC Rcd 1654 (2008) and NTIA Docket No. 080129095-8096-01, published in 73 Fed. Reg. 6710.

[18] Test-Bed participants include: Adapt4 LLC, Adaptrum Inc., BAE Systems, Motorola Inc., Shared Spectrum Company, and Virginia Polytechnic Institute and State University.

[19] *See* http://www.sharedspectrum.com/technology/darpaxg.html.

[20] *See* http://www.afcea.org/events/spectrum/presentations/2006.12.08%20Marshall%20Spectrum%20Summ%20Panel%20%20Friday.ppt at slide 7.

complexity of Department of Defense operational needs.[21] The XG program ended successfully a few years ago, and the basic technology has continued to be developed as discussed further below.

11. In August 2009, the Commission issued a Notice of Inquiry pertaining to wireless radio services (*Wireless Innovation NOI*).[22] Among other things, the *Wireless Innovation NOI* sought comment on promoting more efficient use of our nation's spectrum resource.[23] It noted that technologies that allow for opportunistic access to spectrum can promote more robust use of the limited spectrum resource, and solicited comment on what the Commission could do to promote the continued development of such technologies.[24] The *Wireless Innovation NOI also* inquired about promoting more intensive use of licensed spectrum, and asked in particular whether it would be helpful to have a database that provides information regarding licensee contact information, as well as spectrum use and availability by geographic area and frequency band.[25]

12. In response to the *Wireless Innovation NOI*, comments were generally supportive of encouraging the use of opportunistic access to spectrum. The SDR Forum stated that it is pleased that the Commission continues to recognize that technologies such as software defined and cognitive radios enable more dynamic and robust use of limited spectrum resources. Accordingly, the SDR Forum urged the Commission to continue to promote the development of these innovative technologies by removing unnecessary regulatory barriers and constraints while, at the same time, ensuring that its technical rules, equipment authorization processes, and enforcement mechanisms fairly and properly safeguard against harmful interference and unauthorized spectrum usage.[26] Comments were mixed regarding establishing a spectrum database, with Google urging the Commission to take the lead on creating a master spectrum database to provide information on spectrum utilization and availability to innovators.[27]

13. Also in August 2009, the Commission initiated a series of broadband workshops to promote an open dialogue between the Commission and key constituents on matters important to broadband implementation. Of particular interest was a September 2009 panel titled "Innovating in Spectrum Access—Technological Advances and Other Approaches to Facilitate More Productive Spectrum Use," in which distinguished researchers discussed the development of radio technologies that enable more dynamic use of spectrum.[28] As discussed below, a number of valuable ideas were set forth, particularly with respect to interference suppression.[29]

14. In March 2010, the *National Broadband Plan* was released.[30] In addition to recommending that significantly more spectrum be made available for broadband use within the next few years, the report underscored the importance of expanding opportunities for innovative spectrum access models made possible by advanced technologies because they enable more efficient use of

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[21] *Id.* at slide 24.

[22] *See* Fostering Innovation and Investment in the Wireless Communications Market, n.8, *supra*.

[23] *Id.* at 11334-11337 ¶¶ 38-47.

[24] *Id* at 11336 ¶ 44.

[25] *Id* at 11335-36 ¶ 43.

[26] *See* SDR Forum comments, GN Docket Nos. 09-51 and 09-157, at 10.

[27] *See* Google comments, GN Docket Nos. 09-51 and 09-157, at 5-6.

[28] *See* Broadband Spectrum Workshop, Third Panel. The transcript of this Workshop is available at http://www.broadband.gov/ws_spectrum.html.

[29] *See* ¶ 25, *infra*.

[30] *See Connecting America: The National Broadband Plan*, Federal Communications Commission, March 2010.

spectrum already available in the marketplace. In particular, the report recommended that the Commission spur further development and deployment of opportunistic uses across more of the radio spectrum. Specifically, the report recommended that the Commission permit opportunistic radios to operate in spectrum it currently holds, and also recommended that the Commission initiate a proceeding that examines ways to extend the geo-location database concept – currently being implemented for Unlicensed Television Band Devices – to other frequency bands.[31] The report noted that certain bands, such as those accommodating satellite uses, are more difficult to protect than other bands, such as those accommodating fixed microwave uses, while asserting that the Commission's new Spectrum Dashboard[32] could eventually enable a more generalized geo-location system, particularly if supplemented with data on spectrum construction and usage.[33] Finally, the report recommended that the Commission evaluate whether we should do more through our secondary market policies to promote access to unused and underutilized spectrum.[34]

15. In October 2010 the Commission held a spectrum summit to highlight the impending shortage of mobile broadband spectrum, its consequences, and possible policy solutions.[35] The summit included participation by industry, wireless carriers, and congressional staff.[36] During a panel discussion, John Chapin, a computer scientist at the Massachusetts Institute of Technology (MIT), noted that because of the exploding demand for spectrum, "shared spectrum will grow from playing a secondary role to playing a critical role in supporting the core business operations and mission critical functions of all spectrum users." He suggested that policy radios, a type of dynamic radio (*see* discussion, *infra*), could increase spectrum efficiency by allowing secondary use of a band at times when the primary user is not fully using the band.[37]

III. DISCUSSION

16. Dynamic spectrum access radios, as well as the new spectrum management techniques that they can enable, hold great promise as we seek to use our nation's available spectrum resources more intensively and efficiently. Ensuring that we can take advantage of these improved efficiencies will be critical as we address a looming spectrum crisis, and can lead to increased spectrum value that spurs additional investment and innovation that can benefit American consumers. We seek to expand the environment in which these advanced technologies and techniques can be developed and improved, and then can be applied across more radio spectrum. Thus, we seek information on these dynamic technologies and on what additional steps the Commission can and should take to encourage, promote, and incentivize their development and use in both unlicensed and licensed spectrum. With data traffic on mobile wireless networks estimated to grow by a factor of thirty-five between 2009 and 2014,[38] there is a critical need for increased efficiency in use of spectrum, as well as the need for additional

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[31] *Id.* at Section 5.6, at 94-96.

[32] *See* again http://reboot.fcc.gov/reform/systems/spectrum-dashboard.

[33] *See The National Broadband Plan*, Recommendation 5.13, at 95-96.

[34] *Id*. at Recommendation 5.7, at 83.

[35] *See* Spectrum Summit, Oct. 21, 2010. A video of the spectrum summit is available at http://reboot.fcc.gov/video-archives.

[36] Representatives of Intel, Dell, Cisco, Qualcomm, T-Mobile, MIT, and several congressional staff members participated in panel discussions at the spectrum summit.

[37] *See* Comments of John Chapin, MIT, Spectrum Summit, Second Panel, Oct. 21, 2010.

[38] See *Mobile Broadband: The Benefits of Additional Spectrum*, OBI Technical Paper No. 6, Federal Communication Commission Omnibus Broadband Initiative, at 9 (Oct. 21, 2010).

spectrum, not only for mobile wireless networks, but also for a wide variety of RF-based applications and services. Dynamic radios could increase productive use of spectrum.

17. We believe that there are opportunities for use of dynamic spectrum access techniques under both licensed and unlicensed regulatory approaches. Each approach has its benefits and limitations in the context of dynamic spectrum access techniques.[39] We also observe that, as spectrum users seek to make the best and most efficient use of the available spectrum resource, they are increasingly using a combination of unlicensed networks and dedicated licensed networks employing advanced radio devices to meet their spectrum needs. Our objective here is to identify how to make the most efficient use of spectrum to help meet the demand for wireless broadband services, as well as many other applications, under both licensed and unlicensed regulatory approaches.

A. Promoting Advances in Dynamic Spectrum Access Radios

18. We first focus our Inquiry on exploring technical advances in dynamic spectrum access radios, as well as impediments to the more widespread use of these technologies. We believe that more experience with these types of radios is needed before they gain widespread acceptance by spectrum users. Dynamic radios have demonstrated that they can successfully identify available spectrum and avoid causing harmful interference to other spectrum users under certain conditions. However, it appears that further work is needed to show that the technology will function as intended under actual usage conditions in a broad array of radio environments without causing harmful interference to existing spectrum users. Thus, we seek information on the current state of the art in dynamic radios. What is the current state of equipment and system development? What private and public deployments are operational today? What has been the experience with these deployments? Are they operating as expected? Have any unforeseen problems arisen? If so, what actions have been taken to mitigate those problems? What approaches have developers taken with respect to mitigating hidden nodes where shadowing may make it appear that the spectrum is unoccupied when in fact it is being used nearby? Which methods have met with the most success? What solutions are available for dynamic radio operations in the vicinity of (primarily) receive-only sites?

19. Accordingly, we seek any information that commenters believe would be relevant to help us assess how we can best ensure that the public can reap the benefits that dynamic spectrum access radio technology can provide. Below, we solicit comment on a wide variety of specific issues.

20. *Spectrum Sensing*. An important component of dynamic spectrum use could be the inclusion of spectrum sensing capabilities. Sensing permits a dynamic spectrum access radio to detect unused spectrum by autonomously determining current use of a particular frequency. Spectrum sensing techniques can be classified into three categories – transmitter detection, cooperative detection, and interference-based detection. Transmitter detection provides these radios the capability of determining if a signal from a primary user's transmitter is locally present by correlating a known signal with an unknown signal (matched filter detection), measuring signal energy (signal detection), or statistical means (cyclostationary feature detection or some other pattern recognition method). Cooperative detection refers to incorporating information from multiple dynamic users to determine if spectrum is in use by a primary user, and interference-based detection refers to detecting changes in the local noise floor to determine if additional traffic can be tolerated by primary users. What are the criteria for determining available spectrum when employing interference-based detection?

[39] Many parties equate discussion of dynamic spectrum access with the concept of unlicensed overlays. This is at least partly because some prior Commission proceedings dealing with dynamic spectrum access have focused on unlicensed operation. We make clear that, while we are certainly open to exploring situations where an unlicensed overlay may be the best use of a particular spectrum band, such use is not the primary thrust of this proceeding.

21. We seek information on the current state of the art of these various techniques. We note that, with respect to transmitter detection, the Commission observed many challenges in implementing this technique when it tested Television Band Device prototypes in 2008. More specifically, there was much debate regarding the proper threshold level to set for detecting the presence of a signal, there was disagreement over parameters such as measurement bandwidth and dwell time, and we observed a large number of false positive detections when a sensor was in the presence of a strong adjacent channel signal.[40] We request information on advances that have been made to sensing technology since then. What innovations to sensing are contemplated? Are there critical component price points that must be reached for advances to take place? Has there been any industry wide consensus regarding methods of implementing sensing? Have there been studies regarding which sensing methods work best among using matched filters, simple energy detection, or cyclostationary detection or other techniques? Are there ways to generalize sensing requirements, or do they need to be determined band-by-band based on the incumbent services? Advocates for band by band requirements should also address methods for updating sensing algorithms based on usage changes over time. How has filter technology advanced such that false positive detections due to adjacent channel signals can be minimized? Can a common standard for spectrum sensing be developed? What would need to be included in such a standard? How should the detection threshold for spectrum sensing be determined? How can dynamic spectrum access radios avoid adjacent channel interference to incumbent systems? Upon detection, should a minimum frequency offset be established to avoid adjacent channel interference? What factors impact detection time and how do they vary for different incumbent radio services (*e.g*., land mobile systems versus radar systems)?

22. We also seek information on cooperative sensing. Are there systems in place or tests underway today that make use of this technique? If so, what have been the experiences of users in the ability to avoid interference? Are new techniques and algorithms being developed? Have there been studies conducted on the optimum number of sensors and required spacing to adequately cover a given geographic area? How does this change for different environments (*e.g.,* urban, suburban, rural)? How does latency affect the ability of a device to access spectrum under a cooperative sensing regime? Is there a threshold for latency beyond which the information is unreliable? How often does the information need to be updated? Finally, we note that cooperative sensing holds much promise for avoiding hidden nodes. Has there been any real-world experience regarding this? How successful have networks been in this regard? Could additional information describing the radio frequency characteristics of the incumbent systems be used to improve the spectrum sensing capabilities? What information would be needed? How would the information be used?

23. With respect to interference detection, we seek comment on any recent research that has been conducted regarding correlation of a rise in the noise floor with the ability for a device to access a channel. What techniques are best for a device to measure the noise floor? In a rising thermal noise floor environment, what is the implication for channel acquisition? We also seek comment on any research or experiments that have been conducted combining two or more of these techniques. Has such research been conducted? What have been the results?

24. Finally, we request comment on whether we may be able to integrate, in the not-too-distant future, sensing techniques with the techniques that we recently authorized for unlicensed Television Band Devices that include geo-location and database functions as a means for accessing other spectrum bands. As previously noted, in September 2010 we permitted devices operating in the TV bands to rely only on geo-location and a real-time database to determine if a channel is available.

[40] *See* FCC Office of Engineering and Technology *Evaluation of the Performance of Prototype TV-Band White Space Devices, Phase II*, OET Report FCC/OET 08-TR-1005, October 15, 2008. This Report is available (under "Published Reports") at http://www.fcc.gov/oet/projects/tvbanddevice/Welcome.html.

However, it remains to be seen whether such an approach would be sufficient for providing access to other spectrum bands that may present a more variable spectrum environment as compared to the relatively steady-state operation of TV stations. We believe that as sensing technology matures it may be combined with geo-location and database functions to enable access to other spectrum bands. Commenting parties should indicate the time frame in which they believe that sensing techniques will become sufficiently mature to enable these advances.

25. *Interference Suppression*. In the September 2009 Commission Broadband Workshop referenced above,[41] Dr. Bruce Fette, a program manager with the DARPA XG Project's Strategic Technology Office, noted that DARPA followed its XG Program with a "Wireless Network after Next" (WNaN) Program.[42] Dr. Fette stated that the WNaN Program showed that it is important that cognitive radios be able to adapt to interference in their own network and be efficient at managing interference – not only by avoiding it – but also by suppressing it. Dr. Fette argued that it is relevant and appropriate for cognitive radios to understand interference suppression techniques as an important part of their architectural design.[43] We therefore request comment regarding these techniques. What are they and how can they be incorporated into a dynamic spectrum access radio's architectural design. Is there a particular interference suppression technique that is more cost-effective than others? What are the cost trade-offs between interference avoidance and interference suppression?

26. *Propagation Models and other Technical Considerations*. The Commission has relied on the Longley-Rice propagation model to predict the behavior of radio waves for many interference analyses, so that coverage areas may be established for various types of transmitting equipment.[44] In the 2009 Commission Broadband Workshop discussed above, Dr. Joseph Mitola III of Stevens Institute of Technology stated that the Longley-Rice model is inadequate for cognitive radios. Dr. Mitola noted the great variability of radio signal strength in urban areas, and emphasized the importance of three dimensional high-fidelity spatial modeling, as well as temporal modeling to account for differences in daily use.[45] In light of Dr. Mitola's comments, we request comment on what models are best for simulating dynamic radio propagation effects relative to evaluating potential interference to other radio services. We note that the Commission has also used other propagation models, including "R-6602 curves" and "Okumura-Hata" and "COST-Hata" models.[46] Are any of

[41] *See* ¶ 13, *supra*.

[42] *See* Broadband Spectrum Workshop, Third Panel, *supra* n.28, at 146 and 156.

[43] *Id*. at 158.

[44] The Longley-Rice model is a method for predicting the attenuation of radio signals for a telecommunications link over a wide range of frequencies, taking into account terrain, building structures, and other land cover variations. In at least one instance – the Satellite Home Viewer Improvement Act of 1999 – Congress mandated its use. *See* FCC, OET Bulletin Number 72, July 2, 2002.

[45] *See* Broadband Spectrum Workshop, Third Panel, *supra* n.28, at 167-169.

[46] R-6602 curves were developed to improve the accuracy of field strength predictions for the TV and FM broadcasting services by taking into account terrain roughness factors. *See* J. Damelin, W. Daniel, H. Fine and G. Waldo, *Development of VHF and UHF Propagation Curves for TV and FM Broadcasting*, FCC, Office of Chief Engineer, Research Div. Report No. R-6602, September 1966. The Okumura-Hata model does not consider actual terrain or clutter in the calculation, but rather computes the path loss as a function of the transmit and receive antenna heights, path distance, radio frequency, and the type of clutter (urban, suburban or open). *See Urgent Communications*, "When Measurements Aren't Feasible", Jay M. Jacobsmeyer, May 1, 2008, available at http://urgentcomm.com/techspeak/radio_measurements_arent_feasible. The Commission recently used this model in the TV White Spaces Proceeding. *See Second Report and Order and Memorandum Opinion and Order*, *supra* n.6, at 23 FCC Rcd 16870-71 ¶ 181. The COST-Hata model extends the Okumura-Hata model to cover a greater range of frequencies. *See* http://sciencestage.com/g/2279533/cost-hata-model.html. The Commission recently used this

(continued....)

these models, or other models, better for different architectures (*e.g*., sensing, cooperative sensing, etc.)? What has been learned regarding assumptions that must be made in using these models for dynamic radios? How have analytical results compared to real-world tests? What improvements can be made to these models? We observe that, with the continuing development of highly sophisticated computer technology, we now have the capability of using more computationally intensive algorithms to produce greater model accuracy. Further, dynamic spectrum access radios permit the combining of more accurate analytical models with actual measurements of spectrum use. Commenters should address the current state-of-the-art regarding propagation models that may be relevant to dynamic radios.

27. It is envisioned that many dynamic spectrum access devices will be used for mobile applications. Unlike analyzing interactions between fixed devices where the locations are known and will not change, the locations and separation distances between mobile devices are unknown, will change continually, and can be relatively short (*e.g.,* on the order of several meters). What propagation loss models should be used for mobile-to-mobile interactions? We note that many existing propagation models default to free-space propagation loss for separation distances below 1 kilometer. Moreover, most propagation models were developed based on measurements that considered antenna heights greater than those used in mobile-to-mobile interactions (*e.g*., one antenna representing a base station). Are existing propagation models appropriate for mobile-to-mobile interactions? If not, what propagation model should be used for these interactions?

28. We are cognizant that, in addition to propagation models, there are a number of technical considerations that are critically important in determining the interference potential of a radio using dynamic spectrum access techniques. For example, once spectrum is deemed available for use at a given location, the potential for interference to other radio services would be considerably different between a 100 milliwatt transmitter and a 100 watt transmitter or between a transmitter operated at ground level or on a tower or tall building. Similarly, the appropriate out-of-band emissions standard might be much more stringent when operating in a band that is adjacent to a service that relies on reception of extremely weak signals. How should we approach development of technical standards for transmitters that employ dynamic spectrum access techniques? Does the complexity of the technical parameters suggest that dynamic spectrum access should, at least initially, focus on several discrete frequency bands to reduce the complexity?

29. *Policy Radios*. A policy radio is a type of dynamic spectrum access radio whose behavior is governed by a set of rules (policies) that are independent of the radio implementation, regardless of whether the radio implementation is in hardware or software.[47] In general, policies are not specific to the particular technologies used by the radio. They may not necessarily specify the waveforms to transmit or the type of filters to use. Instead, they provide a set of rules that the radio must follow in making use of radio spectrum. For example, a policy could specify that a radio may only transmit for two milliseconds in a particular band, may transmit with a maximum power of ten milliwatts in a band, or must avoid causing interference to other radios in a band. What sets policy radios apart from other

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model in the Wireless Communications Service/Satellite Digital Audio Radio Service proceeding. *See* Amendment of Part 27 of the Commission's Rules to Govern the Operation of Wireless Communications Services in the 2.3 GHz Band, WT Docket No. 07-293; Establishment of Rules and Policies for the Digital Audio Radio Satellite Service in the 2310-2360 MHz Frequency Band, IB Docket No. 95-91 and GEN Docket No. 90-357; *Report and Order and Second Report and Order*, 25 FCC Rcd 11710 (2010) at n.315.

[47] *IEEE Standard Definitions and Concepts for Dynamic Spectrum Access: Terminology Relating to Emerging Wireless Networks, System Functionality, and Spectrum Management,* IEEE Std. 1900.1-2008, IEEE Communications Society, 2.6, 3.6.

dynamic radios is that policies may be updated after the radio is in the hands of the end user. This can be important as the use of spectrum bands changes over time.

30. The policies that govern a policy radio's behavior may originate from a number of different sources. Policies could be specified by the Commission or NTIA. Policies may also be created by standards organizations or an industry consortium. Policies governing spectrum in bands that are licensed could be the result of negotiations between the license holder and other stakeholders, such as representatives of dynamic spectrum access radio users or manufacturers. How should policies be developed for these dynamic radios? Who should be responsible for developing these policies? Should the policies be incorporated as part of individual service rules? What is the appropriate hierarchy among the Federal Government, industry, and users of policy radios? If policies are developed by non-governmental entities, should the Commission or other appropriate agencies have the option to review or modify policies before they become effective? What factors should be considered in developing dynamic radio policies? How often should policies be reviewed for possible modification? How do we ensure that dynamic policies are distributed to all devices in a timely manner? What procedures can be used to ensure the distributed polices implemented properly?

31. *Certification, Authorization, Compliance, and Enforcement*. The Commission must approve for public use new RF equipment. Given the dynamic nature of the devices and a wide variety of scenarios under which such devices can operate, it is a challenge to ensure that devices are properly tested for compliance. We therefore request comment on how dynamic radios should be tested for authorization and compliance. Are there compliance models that would permit this equipment to be introduced in a more rapid manner? If so, what are they? Further, if there are instances of interference in the field, our enforcement staff would need to identify and locate the devices. If the devices are dynamically changing their operating parameters, the transient interference makes it difficult to locate the devices that are the source of interference. Are our present enforcement mechanisms sufficient to resolve complaints of interference allegedly caused by dynamic radios? If not, what new mechanism(s) should be put into place? Are there approaches, such as registration in a database, which could be used to help with location of such devices? Should a dynamic spectrum access device be required to transmit a code as part of its transmission containing the FCC license number?

B. Development and Deployment

32. In this section we explore a variety of approaches that the Commission might pursue to advance the development and deployment of services and devices that enable more efficient use of the spectrum through use of dynamic spectrum access techniques. As dynamic spectrum access technologies and techniques evolve, we anticipate that they will create new value chains and business models – many not yet invented. These in turn should stimulate further innovations that enable more effective and efficient use of the spectrum resource. We recognize that many of the questions we raise here have been posed before. However, the technology has continued to develop and approaches that may not have been viable previously may be possible today or in the near future. We also seek comment on several ideas that have not been raised before. Dynamic spectrum access techniques can be applied under both licensed and unlicensed regulatory approaches.[48] Below, we set forth ideas that

[48] We note that in the United States, except for very limited circumstances (*e.g.*, unlicensed PCS), spectrum has not been specifically designated for unlicensed use. Instead, spectrum has been allocated for authorized uses such as fixed or mobile, and unlicensed devices may operate in any band except those identified by rule as "restricted" (*see* 47 C.F.R. § 15.205). Unlicensed device developers tend to gravitate toward bands that have not seen much licensed activity, so they do not have to contend with as many licensed devices. We also note that the Commission's *National Broadband Plan* recommended that the Commission set aside some spectrum solely for unlicensed use. *See National Broadband Plan*, *supra* n.30, Recommendation 5.11, at 94-95.

we believe could spur further development and deployment of dynamic radios under both approaches. We seek comments on how each approach could facilitate the development of dynamic radio access technologies and new spectrum management techniques, and the additional steps that we should take to ensure that our policies and rules facilitate and incentivize more dynamic use of spectrum.

33. *The Commission's Database and the Spectrum Dashboard.* We believe that any analysis of the opportunities for use of dynamic spectrum access techniques to make more efficient use of the spectrum must begin with a good understanding of how the various parts of the spectrum are being used today. We note that several comments to the *Wireless Innovation NOI* proposed that the Commission improve its publicly-accessible spectrum database in ways that make it easier for entities to know what spectrum resource might be available for use, included shared use opportunities.[49] Commenters interested in serving as spectrum brokers or clearinghouses advocated for the availability of database information that could be useful to prospective buyers and sellers of spectrum access in frequency bands and markets across the country, as well as more transparency on the secondary market transactions that had been occurring.[50]

34. Earlier this year, we launched the Spectrum Dashboard to promote greater transparency in spectrum allocation and management. Clear information on our spectrum resource can be crucial to the deployment of new wireless technologies and services. Through the Spectrum Dashboard, we seek to provide spectrum users relevant information pertaining to authorized services across the radio spectrum, including the identity of the entities that hold the spectrum licenses as well as the geographic areas, spectrum bands, and amount of spectrum associated with the licenses. We plan to continue to make improvements over time to the Spectrum Dashboard, including the addition of spectrum leasing information that could help provide additional information on secondary market transactions.

35. We seek comment on how the information we make publicly accessible, including the specific information presented in the Spectrum Dashboard, could be made more useful in promoting more efficient use of the radio spectrum through adoption of dynamic spectrum access technologies. What particular information is most useful in facilitating the sharing of spectrum usage rights between prospective buyers and sellers? How can this information be used to facilitate the deployment of dynamic spectrum access technologies? Should we, for instance, do more to publicize or promote the availability of secondary market mechanisms for obtaining access to spectrum, including through use of opportunistic devices?

36. *Flexible Use Licenses.* We believe that dynamic spectrum access radios, and associated spectrum management techniques, hold great potential for enabling a variety of new types of efficient and innovative spectrum sharing within spectrum bands already licensed under flexible use policies and rules. In adopting flexible use licensing authorizations for commercial spectrum – including policies and rules that facilitate the development of secondary markets – the Commission has sought to remove regulatory barriers and thereby permit more efficient use of licensed spectrum. Among the benefits of these policies is the flexibility that licensees and lessees have in developing and deploying new technologies that help them address changing needs. Under these policies, licensees and spectrum lessees already have wide latitude to adopt and implement spectrum management techniques to manage access to and use of their spectrum, so long as that use is consistent with the applicable rules relating to the spectrum band and the prevention of harmful interference.

37. As a matter of practice, licensees continually devise and update the types of radio devices that they deploy, and improve upon the efficiency of their management of the spectrum use between

[49] *See, e.g.,* Google comments at 6-7; CTIA reply comments at 29; PISC comments at 22.

[50] *See, e.g.*, Key Bridge Global LLC comments at 2-5; Spectrum Bridge comments at 6-9.

and among their users, consistent with the applicable service rules and their respective business models. At the same time, we believe that dynamic spectrum management devices and techniques are likely to create new spectrum management models, and potentially provide additional opportunities for more efficient use of licensed spectrum. Accordingly, we seek comment generally on whether we should take additional steps to enable or promote the use of dynamic radios in spectrum licensed for flexible use. Would further revisions in our flexible use policies be appropriate or necessary in order that we fully realize the promise of these technologies and techniques? Will new business models or new classes of spectrum users develop such that further clarifications or modifications are desirable? How can we best ensure that, on a going-forward basis, our policies and rules are sufficiently flexible to facilitate the development and deployment of these efficiency-enhancing technologies and techniques?

38. *Secondary Market Mechanisms.* In its secondary market policies and rules, the Commission has sought to further enable more dynamic access and use of spectrum by licensees and spectrum users. Specifically, the Commission has established procedures to facilitate access to spectrum across various dimensions (*e.g.,* frequency, space, and time) employing advanced technologies.[51] In the *Secondary Markets Second Report and Order*, the Commission took additional steps to facilitate the development of spectrum usage arrangements that employ advanced technologies that can more efficiently share use of licensed spectrum.[52] In particular, the Commission clarified that licensees and spectrum lessees may enter into a wide variety of "dynamic" spectrum leasing arrangements that enable users to share use of the licensed spectrum based on the particular parameter and arrangements that the licensee and spectrum lessee(s) have agreed upon.[53] The Commission also permitted licensees to make spectrum available to individual users or groups of users through "private commons" arrangements.[54] These secondary market policies and rules are intended to facilitate the use of advanced technologies, including "smart" or "opportunistic" devices, that have the potential to increase access and use of underutilized or unused licensed spectrum.[55] As further improvements in these technologies come along, we anticipate that licensees and spectrum users will find ways to employ these secondary market mechanisms.

39. Under our policies for dynamic spectrum leasing arrangements, a licensee and spectrum lessee may enter into arrangements in which use of the same frequencies in the same geographic area is shared between both the licensee's and spectrum lessee's users by employing opportunistic devices. For instance, a licensee could enter into a spectrum leasing arrangement that gives one spectrum lessee access to the spectrum on a priority basis, while also leasing use of the same spectrum to another spectrum lessee on a lower-priority basis, with the requirement that the lower-priority spectrum lessee employ certain opportunistic technology to avoid interfering with the priority spectrum lessee. The

[51] *See* Promoting Efficient Use of Spectrum Through Elimination of Barriers to the Development of Secondary Markets, WT Docket 00-230, *Report and Order and Further Notice of Proposed Rulemaking,* 18 FCC Rcd 20604 (2003) (*Secondary Markets First Report and Order*); *Erratum,* 18 FCC Rcd 24817 (2003); *Second Report and Order, Order on Reconsideration, and Second Further Notice of Proposed Rulemaking,* 19 FCC Rcd 17503 (2004) (*Secondary Markets Second Report and Order*); *Third Report and Order,* 22 FCC Rcd 7209 (April 11, 2007) (*Secondary Markets Third Report and Order*); *see also* 47 C.F.R. §§ 1.9001 *et seq.* (Subpart X rules concerning "Spectrum Leasing").

[52] *See Secondary Markets Second Report and Order*, 19 FCC Rcd at 17545-54 ¶¶ 85-99.

[53] *Id*. at 17546-48 ¶¶ 88-90 (explaining that "a variety of dynamic forms of spectrum leasing arrangements" are permitted, and providing a number of illustrative, but non-exhaustive, examples of permissible dynamic forms of spectrum leasing utilizing advanced technologies).

[54] *Id.* at 17549-53 ¶¶ 91-99; *see also Secondary Markets Third Report and Order*, 22 FCC Rcd at 7209-12 ¶¶ 3-9 (discussing rules applicable to "private commons" arrangements).

[55] *See Secondary Markets Second Report and Order*, 19 FCC Rcd at 17545-54 ¶¶ 85-99.

flexibility provided under our dynamic spectrum leasing rules also permits arrangements that could facilitate opportunistic use by parties operating at the same power level and under similar technical parameters as the licensee, or they could promote such use at lower power levels.[56] With the continuing evolution of dynamic spectrum access radios, we might expect that licensees and spectrum lessees would have the technical capability to avail themselves of the opportunities afforded by dynamic spectrum leasing arrangements. What are the barriers to such arrangements? Why haven't licensees and spectrum lessees been entering into such arrangements to date? Is the technology sufficiently developed to enable the sharing of spectrum pursuant to these arrangements? Have business models developed for which such arrangements would be mutually beneficial to both the licensee and spectrum lessee? Do commenters anticipate that parties will be entering these arrangements in the near future? What additional steps should the Commission take to facilitate and encourage these arrangements?

40. In establishing the private commons option, the Commission sought to provide additional means for opportunistic uses of licensed spectrum. Under this mechanism, licensees can make licensed spectrum available on an equal basis to multiple users that employ advanced technologies to meet their particular needs. For instance, a licensee may permit peer-to-peer communications by other users employing devices in a non-hierarchical network arrangement that does not utilize the licensee's network infrastructure. The licensee authorizes other users to operate on the licensed frequencies employing particular devices that meet technical parameters specified by the licensee. The technical parameters for these devices, in turn, enable users to operate in a manner designed to minimize interference concerns relating to other users in the licensed band so long as the devices comply with the applicable technical requirements and use restrictions under the license authorization itself.[57] We seek comment generally on the role of private commons arrangements as more advanced and dynamic radio technologies are developed. How, if at all, should our equipment certification and authorization processes be adapted? Why haven't licensees and spectrum users entered into any such arrangements to date? Have business models evolved that would make use of this type of arrangement? What additional steps should the Commission take to promote these kinds of arrangements?

41. The Commission also has stated that its general flexible use policies and secondary market mechanisms already provide significant flexibility with regard to the use of dynamic spectrum management techniques. As the Commission noted, these include situations in which a licensee might make its spectrum available on a temporary, as-needed basis, with payments being made as the spectrum is being used (*e.g.,* through a "real-time dynamic auction mechanism").[58] While the Commission to date has declined to address any specific dynamic spectrum management technique or business model that has been suggested, it has underscored that the flexible use policies generally are designed to permit these types of arrangements so long as their implementation is consistent with the applicable service rules.[59] Some parties commenting on the *Wireless Innovation NOI* request that the Commission clarify that specific dynamic spectrum management techniques, such as "real-time dynamic auction mechanisms," are permissible under the Commission flexible use and spectrum leasing policies.[60] We reiterate here that our rules provide wide latitude with respect to these types of

[56] *Id*. at 17547-48 ¶¶ 88-89.

[57] *Id*. at 17549-53 ¶¶ 91-99; *see also Secondary Markets Third Report and Order*, 22 FCC Rcd at 7209-12 ¶¶ 3-9 (discussing rules applicable to "private commons" arrangements).

[58] *See* Service Rules for the 698-746, 747-762, and 777-792 MHz Bands, WT Docket No. 06-150, *Second Report and Order*, 22 FCC Rcd 15289 (2007) at 15734-15380 ¶¶ 231-248 ("*700 MHz Band Second Report and Order*"). Google had sought clarification generally as to whether such dynamic spectrum management techniques are permissible in the commercial 700 MHz band. *See id.*

[59] *Id.* at 15378-15380 ¶¶ 241-248.

[60] *See, e.g.*, Google Comments at 11.

arrangements. We also invite comment on whether there are specific aspects of our existing policies and rules that actually impede or prohibit a licensee from employing some kinds of dynamic spectrum techniques, and if so, how our policies should be revised.

42. *Unlicensed and Licensed Uses.* Spectrum users are increasingly using a combination of unlicensed networks and dedicated licensed networks, often employing advanced radio devices, to access different spectrum for broadband services. What different types of complementary spectrum models have developed, and what kinds of models are anticipated in the future? How should these developments, and the emergence of converged wireless networks, inform our spectrum policies? What steps should we take to facilitate use of different spectrum bands and network architectures?

43. *Identifying Frequency Bands Suitable for Dynamic Access Use*. We invite comment as to what spectrum bands might be most appropriate for use of dynamic spectrum access techniques. We note that there are a number of licenses that were offered in various auctions where there were no winning bids or where licenses were ultimately returned to the Commission. Might we provide access to this spectrum for some period of time, such as two or three years, before offering that spectrum for re-auction? This could provide sufficient time to build systems and gain experience with multiple parties sharing the same spectrum using dynamic spectrum access techniques. Once the spectrum is re-auctioned, the operator of the dynamic spectrum access system would have to vacate the spectrum, unless the conditions of the re-auction permitted the operator to stay.

44. What other spectrum might be suitable for use based on dynamic spectrum access? We are cognizant that in many cases spectrum can be put to its highest valued use by reallocating a frequency band for a new service, relocating the existing service to another band or alternative communications technology, and auctioning the band. In other cases, traditional sharing techniques based on geographic separation or frequency coordination may yield the highest valued use of the spectrum. However, relocation of existing services to other spectrum may not always be feasible and traditional sharing techniques may not make the most efficient use of the spectrum, particularly for services that do not operate continuously, leaving the spectrum available for others to use part of the time. It appears that dynamic spectrum access techniques might be best suited to such situations. Are there underutilized non-Federal, Federal, or shared Federal/non-Federal bands where we might make more efficient use of the spectrum through use of dynamic spectrum access techniques? We observe that using a Federal or shared band would require coordination with NTIA, and inquire whether there could be potential benefits – such as a greater amount of spectrum and diversity of use – to both Federal and non-Federal users from using a combined Federal/Non-Federal band or a shared band. Is there a process that we could establish where the FCC, NTIA, and relevant stakeholders could collaborate to identify such spectrum and speed the testing and introduction of dynamic spectrum access technology?

45. In considering appropriate spectrum bands, we observe that new concepts and technologies are opening the door to fresh thinking about spectrum. Radio services have generally required access to a specific contiguous band of frequencies available nationwide. While this is likely to remain the predominant model for spectrum access for the foreseeable future, we are seeing the emergence of technologies that allow non-contiguous spectrum to be bonded or joined together such that what might have previously been thought of as "scraps" can be woven together to provide viable communications capacity. Certain services may be viable using such techniques, provided one is reasonably certain that sufficient scraps are available to draw upon, or that these techniques are used as a complement to increase capacity for services that have nationwide access to spectrum in other bands. This is particularly relevant to dynamic spectrum access techniques where the available slices of spectrum may be constantly changing. We recognize that there are major technical hurdles to applying such concepts. For example, if the scraps are too far apart in the spectrum, it may not be feasible to design a receiver and antenna with suitable characteristics to cover all of the bands. What is the minimum usable size of the scraps? Would there be any difference in the performance of a dynamic

spectrum access device that uses scraps as compared to contiguous spectrum? We invite comment on this issue, as well as inviting comment more generally as to the role dynamic spectrum access techniques might play in increasing spectrum capacity.

46. Another possibility for dynamic spectrum access use is to allow unlicensed operations in the bands above 38.6 GHz.[61] While there is some amateur radio, fixed microwave, ISM (industrial, scientific, and medical equipment), RF devices, and satellite uses of this Extremely High Frequency spectrum, most bands above 38.6 GHz are very lightly utilized or lie fallow. Therefore, the potential for interference to other services from dynamic radio use of this spectrum would appear to be limited. We note, in particular, that the 57-64 GHz band is used by Part 15 unlicensed wireless systems, and is viable for high capacity, short distance communications. We could require users in the bands above 38.6 GHz to employ dynamic access technology or techniques, such as relying on geo-location and, if feasible, sensing techniques, combined with access to a database of existing spectrum use to determine if a channel is available; other technology or techniques also would be considered. Although we would initially provide for unlicensed use only, we could eventually allow for licensed use of the spectrum once operators devise sufficient means to share the spectrum without causing interference to each other. This tiered approach could encourage investment by providing a path for some interference protection and certainty within the band. Accordingly, we specifically request comment of the feasibility of using spectrum above 38.6 GHz for dynamic spectrum access use, including the types of device applications are envisioned for use.

47. *Test-Beds for Developmental Purposes*. One idea for enabling further development and deployment opportunities for dynamic radios is to create one or more test-beds where such radios can operate subject to real world conditions. To establish test-beds, we could identify frequency bands and geographic areas where dynamic radios could operate. Although participants would typically operate in the test-beds under experimental authorizations, we could establish "ground rules" to facilitate the development of dynamic radio technologies in the designated bands and geographic areas. We seek comment on where and how we might permit these test-beds to be established. As previously noted, we have implemented a Spectrum Sharing Innovation Test-Bed in conjunction with NTIA in the 400-500 MHz spectrum range, using both Federal and non-Federal spectrum, and inquire whether there may be lessons to learn from that experience that could assist us in implementing a Federal/non-Federal dynamic radio test-bed. For example, are there incentives that we can offer that would encourage greater participation in such a test-bed than has occurred in the Spectrum Sharing Innovation Test-Bed? Could DARPA, the National Science Foundation (NSF), or another Federal agency assist in providing funding of a dynamic radio test-bed?

48. *Real-Time Databases*. An alternative approach for enabling dynamic spectrum use is to extend the concepts underlying the rules for Television Band Devices to additional spectrum bands. Under such a system, devices would rely on a real-time database to obtain up-to-the-minute information on spectrum availability for any given location. Commenters should address whether they believe this concept is practical for other bands. If so, they should identify in which bands they believe such a system could work and provide details on how it would work. Commenters should keep in mind that this approach was pursued in the TV bands under the premise that most facilities needing protection (*e.g*., TV stations, cable headends, wireless microphones) are generally fixed. Accordingly, computing the respective protection zones is relatively straightforward. We seek comment on whether such an approach would also work in fixed microwave bands. How might such an approach be instituted in these bands? Should the Commission consider promoting such an approach, and if so, how? Are there other candidate bands? How would a real-time database be

[61] Currently, unlicensed operations are now allowed in some portions of the spectrum above 38.6 GHz. *See* 47 C.F.R. § 15.205.

maintained so that it contains up-to-date information? Similarly, we seek comment on whether and how such an approach would work in highly mobile bands.

49. We also seek comment on whether such an approach could work in satellite bands, including bands characterized by both geostationary satellite orbit (GSO) and non-geostationary satellite orbit (NGSO) usage. Additionally, we seek comment on whether different rules would need to be imposed for satellite up-link versus down-link bands. If so, what are these differences? We note that extending the Television Band Device concept to these bands could be extremely challenging. The governing database would need to either know the location and target area of all satellites and, possibly – for NGSO systems – the location of the satellites as they move relative to the surface of the earth, as well as all mobile or fixed earth stations, both transmitting and receive-only, at any given time; or be able to predict with a high degree of accuracy and confidence the location of mobile stations. We therefore inquire whether development of such a database is feasible. Could such an approach be implemented in a cost-effective manner? If the database could not determine the exact location of all mobile stations at any given time, what degree of predictive accuracy would be required? Could this predictive accuracy be readily calculated in advance? How could non-registered receive-only earth stations be protected?[62] Could international coordination problems arise, if this approach were implemented?

50. *Real-time Spectrum Monitoring*. Another means to promote dynamic spectrum use may be through real-time spectrum monitoring. In the *Wireless Innovation NOI*, the Commission asked questions regarding whether there are any steps it could take to regularly monitor, measure, and report spectrum use.[63] The Commission further described its vision of developing a low-cost standard package of sensors and measurement systems that could be deployed throughout the country to create a real-time spectrum monitoring network, similar to weather monitoring equipment atop schools and other buildings that have been put in place in recent years to comprise local weather networks. Data collected could be useful for the Commission and other parties in identifying available frequency bands.[64] Generally, we seek comment on whether such a system of monitoring equipment could be deployed at a reasonable cost. Should such a network be administered by the U.S. Government or the private sector? If the private sector, how should the collected information be disseminated? For example, should a fee be charged? Could a low-cost sensor be developed to effectively detect the presence of weak radio signals? How would a system of sensors perform in urban areas or in areas where there is irregular terrain? Additionally, we seek comment on the reliability of the output of the sensors used to measure spectrum use.

51. In comments to the *Wireless Innovation NOI*, Key Bridge Global LLC states that it has developed a low cost distributed spectrum monitoring solution that is currently being tested and measuring spectrum use in the Washington DC metro area.[65] If this, or similar systems are implemented across a metropolitan area,[66] real-time data could be fed into a spectrum database that

[62] Section 25.131(b) of the Commission's Rules permits registration of receive-only earth stations operating in the fixed-satellite service operating with U.S.-licensed satellites in order to protect them from interference from terrestrial microwave stations in bands shared co-equally with the fixed service. However, there are several satellite bands which are not shared with the fixed service and registration is not permitted. Since the location of these earth stations is unknown, sharing with dynamic spectrum uses could be more difficult in these bands.

[63] *See Wireless Innovation NOI*, n.8, *supra*, at 11336-37 ¶ 47.

[64] *Id.* at 11336, n.50.

[65] *See* Key Bridge Global LLC comments, GN Docket Nos. 09-51 and 09-157, at 6.

[66] Monitoring equipment would need to be widespread to accurately measure all spectrum use and to avoid problems with hidden nodes.

could be queried by devices for accurate information on available spectrum at any given time. Radios, based on the data, could then choose the best available band for their intended application. Such a scheme would essentially take the TV White Spaces concept a step beyond the registration-for-protection model we have today, as devices would get real-time information regarding available channels.

52. Under such an approach, we seek comment on how measurements should be accomplished for different bands. We note that incumbent users in various bands offer services that run the gamut from simple AM or FM radio transmissions to complex radar signals and advanced communications protocols as well as signal strengths that can vary several orders of magnitude. Often, systems must be monitored and measured differently depending on their band of operation and their intended mission. What requirements would need to be imposed on equipment for monitoring spectrum usage? Should there be standard settings for detection (*e.g.*, resolution bandwidth, dwell time on any given frequency, type of detector, etc.)? What type of deployment geometries must be used for various areas? How should the information be collected to allow for changes over a period of time? How many monitoring stations would be needed to cover an urban, suburban, or rural area, or to eliminate (or minimize) the possibility of hidden nodes? If monitoring is used to create predictive models for spectrum usage at any given location and time, what type statistics must be reported? What time frame is needed for obtaining statistically relevant results? What steps can be implemented to ensure that all dynamic devices receive real-time spectrum information? What criteria should be established for determining whether an incumbent system is present? For example, if an incumbent system transmits only once or twice a week because it is monitoring a channel that transmits emergency messages, how can that system be accounted for?

53. A further extension of this concept would be for devices, using real-time monitoring data, to not only determine the best radio path, but to also determine the best technical parameters (*e.g.,* power, bandwidth, etc.) for ensuring successful communications. Is such a scheme possible? What are the decision points for determining the various operating parameters? How could rules be developed to allow such usage? Should such a system apply to both licensed services and unlicensed devices? Would there be any benefit in the FCC and NTIA developing a set of "Best Practices" to be used in performing spectrum monitoring?

54. *Use of Dynamic Spectrum Access Radios by the Public Safety Community*. We believe that there may be considerable opportunity for dynamic spectrum access radios to be used by the public safety community and within public safety frequency bands. We also note the potential for reconfigurable radios to alleviate many of the interoperability issues associated with public safety spectrum use. Additionally, we observe that many public safety radios currently rely on an older push-to-talk (PTT) protocol. Can dynamic spectrum access radios be deployed in a seamless manner to replace existing public safety radios, including PTT radios? If such a process would not be seamless, are there some public safety bands that would be better candidates than others for an initial transition to dynamic spectrum access radios? We seek comment on all issues related to the potential use of dynamic spectrum access radios by the public safety community and within public safety frequency bands.

55. *FCC Participation in Technology and Standards Development.* FCC staff has actively participated with organizations and in events sponsored by various groups focused on dynamic spectrum access techniques. For example, FCC staff recently participated in the NSF workshop on spectrum efficiency and access, with dynamic spectrum access techniques a principal focus of discussion towards possible grant funding from NSF.[67] FCC staff has also participated in and helped to organize recent international and domestic IEEE DySPAN conferences that focused on developing

[67] *See* http://www.nsf.gov/funding/pgm_summ.jsp?pims_id=503480.

the science of dynamic spectrum access.[68] Recently, the Institute of Telecommunications Sciences, in collaboration with NTIA, conducted an international symposium on advanced radio technologies (ISART) in which the FCC participated.[69] Members of the FCC engineering staff have spoken about dynamic spectrum access at a variety of other conferences and workshops. Is there more that the Commission can do through its participation in the technical community to help advance this technology and help identify and remove any regulatory barriers? For example, are there working groups or forums that the Commission can participate in, sponsored by Federal agencies or industry, related to dynamic spectrum access techniques?

56. *Harmful Interference, Spectrum Rights and Receiver Standards.* We appreciate that there are a variety of other issues relative to the viability of dynamic spectrum access techniques, including such issues as how to define harmful interference, rights and responsibilities of incumbent users of the spectrum, and receiver standards. However, we observe that these issues are not confined to questions related to dynamic spectrum access, but rather are more general issues related to spectrum policy. We do not address those issues here, but may consider these and other relevant points in a future proceeding.

57. *Conclusion*. Dynamic spectrum technologies and techniques have the potential to create new opportunities for all spectrum users, thereby expanding consumer benefits. We solicit comment on how to create incentives to facilitate dynamic spectrum use. Is there a particular regulatory paradigm or specific rules that we should adopt? For example, could we facilitate the use of dynamic radio technology by encouraging or mandating sharing among certain services? What incentives would spur development of dynamic spectrum use among licensed services? Do developers of unlicensed devices have an economic incentive to adopt dynamic radio technology, or is regulatory intervention necessary? Are there actions that the Commission can take that could spur development, testing, and deployment of dynamic radios? Are there particular dynamic radio technologies that have more potential than others that the Commission should encourage or mandate? In addressing these questions, commenters should indicate whether they believe that the Commission can promote economically, as well as technically, efficient[70] use of spectrum by establishing new rules or policies regarding dynamic radios.

58. Much work is being done on advancements in dynamic radio technology, and we believe that this work has already enabled more efficient use of the spectrum resource. However, we recognize that this work is still in its early stages, and that far more efficient spectrum use may be possible in the future. For this to happen, not only must advances continue to be made in the areas of sensing technology, usage algorithms, and cognitive abilities, but regulatory models may need to change. We therefore inquire as to what we can do to best facilitate the use of dynamic radio technology, both from a technical and non-technical perspective.

[68] *See* http://www.ieee-dyspan.org.

[69] *See* http://www.its.bldrdoc.gov/isart.

[70] The term efficiency is used herein to mean making more intensive use of a frequency band. However, while this is clearly desirable from a technical perspective, mandating more intensive use of a band may not always be appropriate, if that leads to lesser total value to the public from use of that band (economic inefficiency). As the Commission noted in a 2002 *Report*: "Economic efficiency occurs when all inputs are deployed in a manner that generates the most value for the public." *See* FCC Spectrum Policy Task Force *Report*, ET Docket No. 02-135 (November 2002), at 21.

IV. PROCEDURAL MATTERS

59. *Paperwork Reduction Act*. This document does not contain proposed information collection(s) subject to the Paperwork Reduction Act of 1995 (PRA), Public Law 104-13. Therefore, it does not contain any new or modified information collection burden for small business concerns with fewer than 25 employees, pursuant to the Small Business Paperwork Relief Act of 2002, Public Law 107-198, *see* 44 U.S.C. 3506(c)(4).

60. *Comments and Reply Comments*. Pursuant to sections 1.415 and 1.419 of our rules, 47 CFR §§ 1.415, 1.419, interested parties may file comments and reply comments on or before the dates indicated on the first page of this document. Comments may be filed using: (1) the Commission's Electronic Comment Filing System (ECFS), (2) the Federal Government's eRulemaking Portal, or (3) by filing paper copies.[71] *See Electronic Filing of Documents in Rulemaking Proceedings*, 63 FR 24121 (1998).

- Electronic Filers: Comments may be filed electronically using the Internet by accessing the ECFS: http://fjallfoss.fcc.gov/ecfs2/ or the Federal eRulemaking Portal: http://www.regulations.gov.

- Paper Filers: Parties who choose to file by paper must file an original and four copies of each filing. If more than one docket or rulemaking number appears in the caption of this proceeding, filers must submit two additional copies for each additional docket or rulemaking number.

  Filings can be sent by hand or messenger delivery, by commercial overnight courier, or by first-class or overnight U.S. Postal Service mail. All filings must be addressed to the Commission's Secretary, Office of the Secretary, Federal Communications Commission.

  - All hand-delivered or messenger-delivered paper filings for the Commission's Secretary must be delivered to FCC Headquarters at 445 12th St., SW, Room TW-A325, Washington, DC 20554. The filing hours are 8:00 a.m. to 7:00 p.m. All hand deliveries must be held together with rubber bands or fasteners. Any envelopes must be disposed of before entering the building.

  - Commercial overnight mail (other than U.S. Postal Service Express Mail and Priority Mail) must be sent to 9300 East Hampton Drive, Capitol Heights, MD 20743.

  - U.S. Postal Service first-class, Express, and Priority mail must be addressed to 445 12th Street, SW, Washington DC 20554.

61. *People with Disabilities*: To request materials in accessible formats for people with disabilities (braille, large print, electronic files, audio format), send an e-mail to fcc504@fcc.gov or call the Consumer & Governmental Affairs Bureau at 202-418-0530 (voice), 202-418-0432 (tty).

62. *Further Information*: For further information, contact Nicholas Oros or Rodney Small, Office of Engineering and Technology, at (202) 418-0636 or (202) 418-2452, respectively; or Paul Murray, Wireless Telecommunications Bureau, at (202) 418-0688; or via the Internet at Nicholas.Oros@fcc.gov, Rodney.Small@fcc.gov, or Paul.Murray@fcc.gov.

[71] *See Electronic Filing of Documents in Rulemaking Proceedings*, 63 FR 24121 (1998).

V. ORDERING CLAUSES

63. Accordingly, IT IS ORDERED, that, pursuant to Sections 4(i), 301, and 303 of the Communications Act of 1934, as amended, 47 U.S.C. §§ 154(i), 301, and 303, this Notice of Inquiry IS ADOPTED.

FEDERAL COMMUNICATIONS COMMISSION

Marlene H. Dortch
Secretary

STATEMENT OF
CHAIRMAN JULIUS GENACHOWSKI

Re: *Promoting More Efficient Use of Spectrum Through Dynamic Spectrum Use Technologies*, ET Docket No. 10-237, Notice of Inquiry; *Promoting Expanded Opportunities for Radio Experimentation and Market Studies under Part 5 of the Commission's Rules and Streamlining Other Related Rules*, ET Docket No. 10-236, *2006 Biennial Review of Telecommunications Regulations—Part 2 Administered by the Office of Engineering and Technology (OET)*, ET Docket No. 06-105, Notice of Proposed Rulemaking.

With these two items, we build on our efforts to use spectrum more efficiently and in ways that deliver the highest value for the American people, and to encourage groundbreaking innovation.

Earlier this year we took steps to unleash spectrum capacity for flexible use, including mobile broadband. We freed up 25 MHz of WCS spectrum, and are tackling 90 MHz in the mobile satellite service band. For the first time in 25 years, we freed up spectrum below 5 GHz for unlicensed use, launching a new platform for innovation that we hope will lead to new services and products as significant as Wi-Fi.

Super Wi-Fi – one of the applications we expect to see from the newly released white spaces spectrum – has been helped and accelerated by FCC experimental licenses. So have new potentially life-saving anti-collision systems in cars. You may have seen the TV ads – this technology requires spectrum, and it was developed using an FCC experimental license. Experimental licensing has also led to important life-saving medical devices.

I'm pleased that today we take steps to improve and expand our experimental licensing program. We are proposing, for example, to ease testing restrictions on universities, research organizations, and other institutions that are developing new services and devices that utilize spectrum. We also propose Innovation Zone licenses, and a new program to speed development of new health related devices that use spectrum – an increasingly exciting area for investment and innovation and for improving health care and reducing costs.

The goal is to accelerate innovation – to reduce the time for an idea to get from the lab to the market. A more extensive experimental licensing program would also help the FCC make smarter, faster decisions, by giving us on-the-ground intelligence on interference issues, and insight into the development of new cutting edge technologies.

Encouraging research and development is vital to our objective of making the U.S. the spawning ground for the great technological advances of tomorrow. Past advances in technology, such as cellular networks and improvements in digital transmission techniques have led to vastly improved efficiency in spectrum use.

Consistent with our focus on maximizing the efficient use of spectrum, we are also beginning today an inquiry on how we can spur new technologies that share spectrum dynamically. Today, spectrum that is allocated can sit idle during time periods when the primary licensee is not using the airwaves. Same for geographic locations. This doesn't make sense given the growing demands on spectrum.

My goal is for these proceedings to be a vehicle for identifying steps we can take to unleash and accelerate new spectrally-efficiency policies and technologies. I'm interested in ideas, for example, to jumpstart secondary markets for dynamic spectrum access. I'm interested in how we can encourage better information on spectrum use, building on our innovative spectrum dashboard, and concretely facilitating opportunistic or auxiliary spectrum uses.

Historically, the U.S. has led the world in spectrum policy innovation. Auctions of licensed spectrum and release of unlicensed spectrum are two key examples of groundbreaking spectrum policy innovation. I believe incentive auctions are a third.

I'd like to set a goal for these proceedings: that it leads to yet another historically significant spectrum policy innovation. I'd like to call for broad participation to meet that goal.

I don't assume that the spectrum management models and policies used today are those that will make the most sense tomorrow, especially given rapidly evolving technologies – both involving dynamic information-based markets and evolving spectrum sensing devices.

I think the opportunity here is not only for the development of new spectrum efficient policies – as important as that is – but also for the development of new spectrally-efficient technologies and products, which we would like to see developed and perfected here in the United States.

The spectrum proceedings today are all vital parts of ensuring that the U.S. leads the world in mobile in the 21st century – promoting economic growth, job creation, and our global competitiveness.

I'd like to thank the staff of the Office of Engineering and Technology, the Wireless Bureau, the Media Bureau, and the Office of General Counsel for their hard work on this item. I'd also like to thank our tireless CTO Doug Sicker for thinking outside the box and working both within the agency and with outside stakeholders to develop two outstanding items.

STATEMENT OF
COMMISSIONER MICHAEL J. COPPS

Re: *Promoting More Efficient Use of Spectrum Through Dynamic Spectrum Use Technologies*, ET Docket No. 10-237, Notice of Inquiry; *Promoting Expanded Opportunities for Radio Experimentation and Market Studies under Part 5 of the Commission's Rules and Streamlining Other Related Rules*, ET Docket No. 10-236, *2006 Biennial Review of Telecommunications Regulations—Part 2 Administered by the Office of Engineering and Technology (OET)*, ET Docket No. 06-105, Notice of Proposed Rulemaking.

Today we launch two important proceedings aimed at maximizing the power and opportunity of our public spectrum resource. The demand for spectrum, as we all know, has never been greater. Unfortunately the laws of physics prevent us from being able to create more of this finite resource. That said, even as we look to free up existing spectrum to meet the needs for wireless broadband, we can and should explore ways to make more dynamic and opportunistic use of the spectrum we have. Given the technology breakthroughs I have witnessed over nearly a decade here at the Commission, I am a strong believer in the creative power of spectrum engineers and innovators—both inside and outside the agency—to help us use our spectrum resource more intensively and efficiently. We need hear from these experts as we move forward with our Notice of Inquiry—making sure we have a complete picture of the dynamic spectrum access tools available and doing what we can do to encourage their development and use.

We also propose today much-need improvements to our system for spectrum experimentation in a separate Notice of Proposed Rulemaking. Many of you have heard my not infrequent exhortations on the need to do more to encourage research and development in this country in order to ensure America's going-forward global competitiveness. Today we make concrete proposals that do just that. We propose to broaden experimental research authorizations for qualified academic and research institutions to afford them greater opportunities to design and implement experiments without the burdens of getting pre-approval each and every time. In a similar vein, we seek to create innovation zones for experimentation that would allow innovators greater flexibility to conduct and modify their spectrum experiments. Nowhere is the potential for RF innovation more exciting than in the area of promoting advances in health care technology—whether restoring mobility to paralyzed limbs or creating advanced body sensor networks. We therefore propose to create a new medical experimental program for hospitals and other healthcare institutions, supervised in conjunction with the U.S. Food and Drug Administration.

Over the years, our Experimental Radio Service program has been a tool that innovators have used to test new and exciting services, many of which we now take for granted. The improvements we propose today look to build upon that success.

Thank you to Julie Knapp and his truly excellent team in the Office of Engineering and Technology, as well as to Ruth Milkman and her impressive Wireless Telecommunications Bureau, for bringing these items to us. I look forward to working with them, as well as my distinguished colleagues, to bring these proceedings to sound and expeditious resolution. The country can reap solid benefits from such action and help us regain competitiveness—and that means jobs—in the global economy.

STATEMENT OF
COMMISSIONER ROBERT M. MCDOWELL

Re: *Promoting More Efficient Use of Spectrum Through Dynamic Spectrum Use Technologies*, ET Docket No. 10-237, Notice of Inquiry; *Promoting Expanded Opportunities for Radio Experimentation and Market Studies under Part 5 of the Commission's Rules and Streamlining Other Related Rules*, ET Docket No. 10-236, *2006 Biennial Review of Telecommunications Regulations—Part 2 Administered by the Office of Engineering and Technology (OET)*, ET Docket No. 06-105, Notice of Proposed Rulemaking.

I am delighted to support both of these actions, and I thank our talented and hard-working Office of Engineering and Technology and Wireless Telecommunications Bureau teams for your diligence and creativity. The American wireless marketplace is dynamic and explosive; it is a world leader in innovation and competition. And it certainly offers one of the brightest rays of growth and opportunity in the American economy.

Given this context, I am pleased that we are starting to do the heavy lifting today – to undertake longer term spectrum planning. As always, I look forward to working with Chairman Genachowski, and all of my colleagues here, to begin the process of putting more spectrum into the hands of consumers.

The notice of proposed rulemaking seeks comment on new ideas to promote innovation and efficiency in spectrum use in our Part 5 Experimental Radio Service (ERS) rules. Our ERS program is a wonderful example of success as evidenced by the variety of new technologies begun as experiments and subsequently deployed as valuable services relied upon by American consumers every day. These successes include: the Personal Communications Service, air-to-ground communications, and new life-changing medical devices, to name just a few.

As an overarching matter, I hope our updated rules will adhere to the Commission's more recent "flexible use" policy. Old style "command and control" (read: prescriptive) rules not only hamper creative entrepreneurs who are in the best position to understand and satisfy consumer demands, they cause spectral inefficiencies as well.

With respect to our notice of inquiry regarding ways to encourage dynamic spectrum use, I have long emphasized that spectral efficiency, and seeking new ideas for dynamic uses, when it comes to undertaking longer term spectrum planning, are crucial in light of the realities that are shaping America's wireless future. In practical terms, even if we could identify 500 megahertz of quality spectrum to reallocate today, the better part of a decade would pass by before we could write proposed auction rules and band plans, analyze public comment, adopt rules, hold an auction, collect the proceeds, clear the bands, and watch carriers build out and turn on their networks for their customers. So, in the meantime, helping innovators create and deploy new technologies to enhance more efficient use of the airwaves has to be a top priority for all of us.

While we sort through the complex issues associated with freeing up more spectrum for the longer term, I look forward to learning more about technologies that will allow wireless providers to take better advantage of the immediate fixes already available in the marketplace. These include more robust deployment of enhanced antenna systems; improved development, testing and roll-out of creative technologies such as cognitive radios; and heightened consideration of the use of femto cells. Each of these technological options augments capacity and coverage, which is especially important for data and multimedia transmissions.

We are at the very beginning of what will surely be a lengthy process. I look forward to giving these and other issues the careful and thoughtful consideration that they deserve.

STATEMENT OF
COMMISSIONER MIGNON L. CLYBURN

Re: *Promoting More Efficient Use of Spectrum Through Dynamic Spectrum Use Technologies*, ET Docket No. 10-237, Notice of Inquiry; *Promoting Expanded Opportunities for Radio Experimentation and Market Studies under Part 5 of the Commission's Rules and Streamlining Other Related Rules*, ET Docket No. 10-236, *2006 Biennial Review of Telecommunications Regulations—Part 2 Administered by the Office of Engineering and Technology (OET)*, ET Docket No. 06-105, Notice of Proposed Rulemaking.

I commend the Chairman for his leadership in promoting the policies put forth in these companion items. If our Nation wants to more effectively compete, we must encourage greater research and development and more efficient spectrum use. Such R&D is not only necessary for the advancement of monumental communication innovations, such as the Internet and the World Wide Web, but it is also critically important to the success of individual businesses and to our overall National economy. A White House study, conducted in September 2009, found that research and development is one of the most important pillars in building a foundation for an economy that could create jobs and drive sustainable growth.

All of the initiatives in the experimental license NPRM encourage greater R&D, which will enable individual entities to do more with their experimental authorizations, facilitate collaboration among industry and academics, and streamline rules. The two initiatives I find particularly noteworthy are the research and medical program experimental radio licenses.

Universities and non-profit research institutions have proven they deserve the enhanced experimental authorizations, reduced oversight, and streamlined application process that the research program license would give. For example, using experimental licenses, research institutions have not only developed ultra-fast, 1 Gigabit per second, research and education broadband networks, but they have also demonstrated public service leadership by advocating that we help connect these networks to anchor institutions in low-income communities.

This recommendation can lead to important short-term and long-term economic benefits. Community connection projects are, by their nature, job intensive, so connecting these research and education networks to low-income communities, can lead to immediate job creation and investment opportunities. For instance, Rutgers University reports, that the Global Environment for Network Innovations (GENI) project, which involves 29 universities, has created hundreds of jobs in New Jersey alone.

The National Broadband Plan also explained how Case Western University's project to connect its ultra fast, 1 Gigabit per second network to homes, schools, libraries and museums in a low-income community in Cleveland, Ohio, is creating jobs. This project is also leading to software and service development for environmental efficiency, health, and many other applications. These are just a few examples of why we should do as much as we can, as quickly as we can, to encourage universities and research institutions to engage in more research and development of communications technologies.

Designing the medical program experimental authorization to promote more test bed facilities for new wireless medical devices could speed the development of important achievements in health care. I thank the Food and Drug Administration and the American Society for Healthcare Engineering for collaborating with us on this initiative. The item encourages researchers and physicians to work with Veterans Affairs facilities and military services, early in the development of these new devices, I am pleased to see. Our Wounded Warriors have made great sacrifices in defense of our Nation, and we owe it to them to create an environment that can lead to faster medical breakthroughs, and help them make the best of their return to civilian life.

The medical program experimental license could also accelerate innovations in telemedicine to further empower both doctors and patients. Advances in video technology and medical broadband applications are allowing physicians to collaborate with their colleagues across the globe, in real time, on difficult cases. For those suffering from long term and chronic illnesses, remote patient monitoring offers greater mobility and independence. Our agency should continue to promote technologies and policies that will give those, in greatest need of medical care, more flexibility in finding the right treatment for them.

The scholarship in today's *Notice of Inquiry* on dynamic spectrum use technologies also sends the proper message that we must encourage more efficient use of spectrum. The *Notice* recognizes that, to best advance these technologies, the Commission must have a clear understanding of how the various parts of the spectrum are being used today. The item then asks detailed technical questions to ensure that we have a comprehensive record on the latest developments in dynamic spectrum technologies. In promoting flexible use policies – such as the leasing of licensed spectrum through the secondary market – the *Notice* presents a cogent analysis of the possible techniques our policies already permit.

I thank Doug Sicker, Julie Knapp, and the other technology evangelists in the Office of Engineering and Technology, the Office of General Counsel, and the Wireless Telecommunications Bureau, for their hard work on these items.

STATEMENT OF
COMMISSIONER MEREDITH ATTWELL BAKER

Re: *Promoting More Efficient Use of Spectrum Through Dynamic Spectrum Use Technologies*, ET Docket No. 10-237, Notice of Inquiry; *Promoting Expanded Opportunities for Radio Experimentation and Market Studies under Part 5 of the Commission's Rules and Streamlining Other Related Rules*, ET Docket No. 10-236, *2006 Biennial Review of Telecommunications Regulations—Part 2 Administered by the Office of Engineering and Technology (OET)*, ET Docket No. 06-105, Notice of Proposed Rulemaking.

This holiday season kicks off a new cycle of fundamental change in the wireless device market. Consumers everywhere are choosing powerful new smartphones. Gartner reports that worldwide smartphone sales grew 96 percent from the third quarter last year, and SNL Kagan projects smartphones accounting for 30 percent of overall mobile phone subscriptions by the fourth quarter of 2010 in the US. Moreover, tablets that use hundreds of times more data than even the most advanced smart phones may well be the stars of this year's giving season. In fact, yesterday's *Wall Street Journal* cites a recent ChangeWave Research survey that found that 9% of holiday shoppers plan to buy an iPad in the next 90 days. I have little doubt that whether smartphone or tablet, these devices will challenge networks as much as they will delight their owners.

I am convinced that our efforts to find additional spectrum to power these devices—and all those that are going to follow—constitute only half the battle to meet the dramatically exploding needs of this country's wireless consumers. We must also promote greater innovation to help use the spectrum we have today—and the spectrum we will allocate tomorrow—as efficiently as possible. The two items we are considering today are a good place to start. In fact, the innovation they will support may well provide the tools we will need to unlock the full potential of the TV broadcast bands.

I am excited about today's item expanding opportunities for radio experimentation. I am a firm believer that we need to support research and development efforts whenever and however we can. Making it easier and more straightforward to conduct real-world research is a natural and straightforward step that we can take. Our action today offers practical support to our nation's inventors by enhancing their ability to test their theories and innovations and streamlining the procedures they must follow to do so. This should help shorten the innovation cycle, which will benefit consumers and operators across the country by reducing the time it will take to get new devices to the market. It will also help maintain our country's leadership in the development of wireless technologies, applications and services.

Dynamic spectrum access is thought by many to be a key technical advance that can substantially improve the way spectrum is used for both commercial and non-commercial services. It is an area where the Department of Defense has shown great leadership and innovation over the years. However, it has proven difficult to apply their research and development in the area of dynamic spectrum access to commercial radio systems. Technical issues have been too complex and costs have been too high.

It is my hope that in issuing the NOI on dynamic spectrum access, we can focus our collective attention on what it will take to overcome these challenges. If we are successful, dynamic spectrum access technologies could become one of the go-to tools operators rely upon to more efficiently manage their commercial spectrum resources. Coupled with an enhanced Spectrum Dashboard and potentially other ways to get information about available spectrum to prospective users, dynamic spectrum access might foster secondary markets for short term, "spot" spectrum transactions—another potentially useful way to manage congestion.

I want to thank the staff for their hard work, which I hope did not include too much time over the Thanksgiving weekend.