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	)	

COMMENTS OF THE PUBLIC INTEREST SPECTRUM COALITION

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February 28, 2011

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On behalf of the Public Interest Spectrum Coalition ("PISC")[1], we are pleased to submit these comments regarding the Commission's Notice of Inquiry (the "*Notice*") on "Promoting More Efficient Use of Spectrum Through Dynamic Spectrum Use Technologies."[2]

I. INTRODUCTION AND SUMMARY

PISC applauds the Commission for issuing the *Notice*, and for initiating this inquiry, as the first steps toward fulfilling two recommendations in the National Broadband Plan "to accelerate the development of opportunistic use technologies and expand access to additional spectrum."[3] The Plan recommended that the Commission promote the development of dynamic spectrum access technologies and governance mechanisms by "allow[ing] opportunistic radios to operate on spectrum currently held by the FCC" and by "initiat[ing] a proceeding that examines ways to extend the geo-location database concept, currently being implemented in the TV bands,

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[1] For purposes of these Comments, PISC includes the organizations Benton Foundation, Free Press, Media Access Project, New America Foundation, and Public Knowledge.

[2] In the Matter of Promoting More Efficient Use of Spectrum Through Dynamic Spectrum Use Technologies, ET Docket No. 10-237, *Notice of Inquiry*, 25 FCC Rcd 16632 (2010) ("*Notice*").

[3] *Connecting America: The National Broadband Plan*, Recommendation 5.13, at p. 96 (2010) ("NBP" or "Plan"). The National Broadband Plan is available at http://www.broadband.gov/plan/.

to additional spectrum bands that are made available for access by opportunistic radios."[4] PISC concurs with both of these initial steps toward expanded spectrum access and efficiency, and offers these Comments to suggest a broader context for, and additional actions in furtherance of, this critical policy goal. As the *Notice* correctly observes, advances in "cognitive" and "opportunistic" radio technologies can help "ensure that any available spectrum is used as efficiently and productively as possible."[5]

As an initial matter, PISC notes that the gross underutilization of the nation's spectrum resource should be an urgent concern for national broadband policy. Spectrum is not only an immensely valuable and publicly owned resource, but one that is infinitely renewable: every millisecond that a frequency band is not used for communication, that capacity is wasted forever. Despite the abundance of unused spectrum capacity, there is a looming limit to the number of frequency bands below 3 GHz that can be reallocated, by auction or otherwise, to exclusively licensed use. As a result, while the traditional carrier business model will demand more and more exclusive-use spectrum in the short-run to meet surging mobile data demand, it should be equally clear that this model is not sustainable longer term. PISC believes that it is not only impractical, but also ultimately anti-consumer to attempt to meet the growing demand for mobile data consumption primarily through traditional reallocations of exclusively licensed spectrum by auction. Advancing the public interest in promoting pervasive connectivity, innovation, and consumer welfare suggests that the Commission also should lay the groundwork for complementary spectrum access models that focus on enabling shared, dynamic access to unused and underutilized bands. For example, both consumer welfare and spectrum efficiency would be enhanced by cognitive and cooperative devices that enable hybrid networks, which carry most

[4] *Id.*

[5] *Notice* ¶ 1.

mobile data short distances, at low power, over unlicensed or other shared spectrum and through consumer-provisioned backhaul.

A critical step toward making substantially more spectrum capacity available for wireless broadband services and innovation is to determine and disclose how, where, and when this publicly owned resource is currently being used – or not used – by current public agency and private sector licensees. PISC recommends that the Commission, in partnership with NTIA, expand on the user-friendly Spectrum Dashboard to aggregate a more complete, comprehensive inventory of what frequencies are ***actually*** in use, for what purpose, to what extent, with what technology, and at what locations, frequencies and times. Both federal government and private sector assignments and uses should be included in the map and companion data sets. Actual spectrum use measurements in a large and regionally diverse sampling of markets also should be part of the any broadband mapping exercise, ideally as an initial step toward an automated system to monitor spectrum use nationwide.

PISC also submits that the most promising mechanism for freeing up large quantities of spectrum capacity needed for wireless broadband deployments and other innovation is to build on the TV Bands Database concept. While only a limited number of underutilized bands can be cleared of incumbent use and then auctioned, substantially more spectrum capacity can be made available more rapidly by opening unused or underutilized bands to "opportunistic access" on a secondary basis, and subject to band-by-band conditions that protect incumbent services from harmful interference. There appears to be no reason to limit the functionality of the TV Bands Database to the TV band frequencies – and no reason not to add more fallow bandwidth to the "common pool" that is parceled out via the white spaces geo-location and look-up system. If a potentially useful frequency band is not being used at particular locations, times, altitudes, or

angles of reception, then that currently wasted spectrum capacity should be listed in the Database for opportunistic access, subject to whatever power limits and other conditions would be necessary to protect incumbent operations.

PISC proposes that the Commission's next step following this NOI process should be a Notice of Proposed Rulemaking to open access to one or more categories of unused or underutilized spectrum. We assume that opening opportunistic access to unused or underutilized spectrum ultimately must be addressed on a band-by-band basis – although even this approach can prioritize certain categories of spectrum where the approach seems most promising and logical. As the National Broadband Plan recommended, the most immediate category of spectrum that should be made accessible is FCC-held spectrum. Another immediate focus for this effort, in collaboration with NTIA, should be the identification and analysis of federal bands that NTIA has determined cannot be cleared for reallocation by auction, but which could under certain stringent conditions (*e.g.*, exclusion zones, low power limits) be opened for shared access by the private sector. A third category that the Commission should address in a future NPRM is "white space" on licensed bands that have not been built out in substantial portions of the country. Opportunistic access using a geo-location database addresses the vexing problem of valuable licenses that are not built out, particularly in rural areas, by moving to a "use it or share it" condition (rather than a more draconian and rarely enforced "use it or lose it" rule).

II. EXCLUSIVE USE SPECTRUM IS NEITHER A FEASIBLE NOR DESIRABLE MEANS TO SATISFY LONG-TERM MOBILE DATA DEMAND.

One of the great disconnects in telecommunications policy is the gap between claims of a "looming spectrum crisis" and the reality that only a fraction of the nation's prime spectrum capacity is actually in use at most places and times, even in the most congested urban areas. On the one hand, National Science Foundation and other private studies of actual spectrum

occupancy measurements show that even in locales such as Manhattan and Washington, D.C. near the White House, less than 20 percent of the frequency bands below 3.1 GHz are in use over the course of a typical business day.[6] On the other hand, the Commission itself estimates that "mobile data demand is expected to grow between 25 and 50 times current levels within 5 years" and that "the broadband spectrum deficit is likely to approach 300 MHz by 2014."[7]

These two propositions are not contradictory. While unused spectrum capacity is abundant, there is little question that demand for spectrum is on the rise. Government licenses for exclusive use of frequencies compatible with the current business model of commercial wireless carriers thus may appear to be scarce, relative to projections for exploding mobile data demand. And although some ISPs are warehousing spectrum acquired at auction (*e.g.*, cable companies in the AWS bands), or warehousing spectrum in less profitable rural and small town areas, overall there is a limit to the number of frequency bands below 3 GHz that can be allocated or reallocated to exclusive use.

Meeting the increasing demand for mobile data will require a greater focus on shared, dynamic access to unused and underutilized bands. As PISC asserted in its filing in response to

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[6] Mark McHenry, "Dupont Circle Spectrum Utilization During Peak Hours, A Collaborative Effort of The New America Foundation and The Shared Spectrum Company," New America Foundation Issue Brief (2003), *available at* http://www.newamerica.net/files/archive/Doc_File_183_1.pdf; Mark McHenry, "NSF Spectrum Occupancy Measurements: Project Summary," Shared Spectrum Company (Aug. 2005) ("McHenry 2005 Study"), *available at* http://www.sharedspectrum.com/measurements/. McHenry's 2005 study collected frequency use data in six locations along the East coast in 2004 and documented an average total spectrum use of less than 10%. Specific findings over a day-long period included: 3.4% in Great Falls, Virginia; 6.9% in Vienna, Virginia (location 1); 11.4% in Arlington, Virginia; 13.1% in New York City; 1.0% in Green Back, West Virginia; and 11.7% in Vienna, Virginia (location 2). The New York City measurements were taken during a national political party convention (when a far higher-than-average use of law enforcement and federal agency spectrum would be expected), yet the vast majority of the public airwaves still remained unused.

[7] Federal Communications Commission, *Mobile Broadband: The Benefits of Additional Spectrum*, Omnibus Broadband Initiative, Technical Paper No. 6, at pp. 2, 5 (Oct. 2010) ("OBI Paper").

the National Broadband Plan's *Wireless Innovation NOI*,[8] while there is no question that carriers utilizing the existing commercial wireless business model – based on exclusive licensing, very limited spectrum re-use, tower-based hub/spoke channelization, centralized infrastructure and metered billing – may continue to seek out more exclusive-use spectrum in the short-run to meet this demand, it should be equally clear that this model is not sustainable longer term.[9] In the longer term, it is neither cost-effective nor pro-consumer to encourage an ultimately unsustainable model in which mobile data would be transported predominantly over exclusively-licensed airwaves and carrier-provisioned infrastructure.

These Comments first address the problems inherent in relying on dominant carrier business models, then summarize the benefits of the Commission focusing instead on policies promoting the dynamic spectrum access models that are the subject of the instant *Notice*. PISC respectfully submits that the permeation of hybrid and heterogeneous networks are the most feasible solution to the increased demand for mobile data. Both spectrum re-use and backhaul will increasingly be more cost-effective at the edge of the network, closest to the end-user and subject to their control (or, more practically speaking, determined on the fly by software in their device).

A. Exclusive Use Spectrum Alone will Not Absorb Growing Demand

Meeting consumer demand for mobile data will require some combination of four strategies:

- Increased spectrum access
- Smaller cell sizes

[8] In the Matter of Fostering Innovation and Investment in the Wireless Communications Market; A National Broadband Plan for Our Future, GN Docket Nos. 09-157, 09-51, *Notice of Inquiry*, 24 FCC Rcd 11322 (2009) ("*Wireless Innovation NOI*").

[9] *See* Reply Comments of the Public Interest Spectrum Coalition, GN Docket Nos. 09-157, 09-51, at 2 (filed Nov. 5, 2009) ("PISC Wireless Innovation Reply Comments").

- More efficient wireless architectures/technologies
- More effective use of wired backhaul

As noted immediately above, companies utilizing the dominant, existing commercial mobile services business model may seek more exclusive-use spectrum in the short-run, so as to meet peak mobile data demand. Yet, their model is not sustainable in the longer term.

First, while it may be feasible (though politically difficult) to clear incumbents in other services or government users, and thereafter auction for commercial mobile broadband use as much as 300 MHz of spectrum below 3.7 GHz within three-to-five years, there appears to be no economically or politically feasible path to clearing the 800 MHz requested by CTIA.[10] The CTIA projection is based on a 2006 study by the International Telecommunications Union ("ITU"). The futility of meeting projected demand by clearing new bands for auction is highlighted by the fact that the ITU study estimated a considerably higher requirement for markets (such as the U.S.) that aim to sustain sufficient spectrum capacity for three or four competing ISPs in each market. The ITU's total spectrum requirement for three competing networks is 1,980 MHz by 2015 – and 2,240 MHz to support four competitive networks (see Figure 2 below). Clearing the additional 1,700 MHz of spectrum that ITU estimates would be required to sustain robust competition among multiple networks and technologies within the same local area – and with propagation characteristics that ensure quality of service – does not seem feasible within a meaningful time frame. What is more likely to result from a policy premised solely on clearing bands and auctioning more exclusive licenses is a continuation of current trends: a sort of controlled scarcity that releases "just enough" spectrum, and does so at

[10] CTIA Comments, GN Docket Nos. 09-157, 09-51, at vi (filed Sept. 30, 2009); *see also* CTIA, Written *Ex Parte* Communication, GN Docket No. 09-51, at 1 (filed Sept. 29, 2009) ("CTIA Sept. 2009 *Ex Parte*").

costs that deter competitive entry and innovation, while encouraging further industry consolidation and increased market power for the largest providers.

ITU Spectrum Requirements for High-Density Markets

	1 network	**2 networks**	**3 networks**	**4 networks**	**5 networks**
Total Spectrum (MHz)	1720	1760	1980	2240	2500

Source: *ITU, Estimated spectrum bandwidth requirements for the future development of IMT-2000 and IMT-Advanced* (2006).

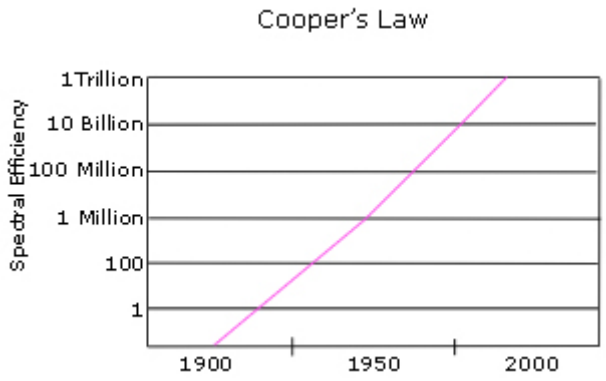
Second, as the Rysavy Research report cited by CTIA observes, although LTE technology will be considerably more spectrum efficient than 3G (EV-DO and UMTS/HSPA), "there are both theoretical and practical limits to spectral efficiency and current systems are approaching those limits."[11]

Third, while the 802.16m (WiMAX) and LTE standards process anticipates further cell-splitting via "relay stations," there are practical limits to how close carriers can bring their owned infrastructure (transmitters and backhaul) to the individual user. According to CTIA data collected by the Commission, during a two-year period after June 2007, total cell sites increased just 14% (from approximately 210,000 to 246,000).[12] As demand for mobile data increases, the industry's cell site bottleneck is a real dilemma. Martin Cooper, leader of the team at Motorola that invented the first mobile phone, has calculated that frequency re-use is responsible for

[11] Rysavy Research, "Mobile Broadband Spectrum Demand," at 19 (Dec. 2008) ("Rysavy Report"), submitted as attachment to CTIA Sept. 2009 *Ex Parte*.

[12] *See* OBI Paper at 12-13, Exh. 8.

roughly 64 times more improvement in total wireless utilization over the past 45 years than any improvement attributable to making more spectrum available.[13]



Cooper writes:

> Of the million times improvement in the last 45 years, roughly 25 times were the result of being able to use more spectrum, 5 times can be attributed to the ability to divide the radio spectrum into narrower slices — frequency division. Modulation techniques . . . take credit for another 5 times or so. ***The remaining sixteen hundred times improvement was the result of*** confining the area used for individual conversations to smaller and smaller areas — what we call ***spectrum re-use***. The importance of spectrum re-use for making more effective use of the spectrum is even greater than reflected in these figures. Frequency division and the various modulation techniques have yielded about as much as we can ever expect. … Shannon's Law teaches us that there is only so much information that can be delivered in a given bandwidth with a given signal-to-noise ratio.[14]

Finally, while more investment in special access can improve the capacity of towers and cells, it will be extremely cumbersome and expensive to bring carrier-provisioned backhaul to each and every carrier cell – and more so if the number of cell sites could plausibly grow in proportion to demand. In its Comments filed in the *Wireless Innovation NOI* docket, AT&T opined that the industry "is going to need more backhaul – a ***lot*** more backhaul. Today 80 to 90 percent of all wireless cell sites are served by legacy copper T1s. . . . There is simply no way that

[13] Martin Cooper, "Cooper's Law," ArrayComm, *available at* http://www.arraycomm.com/serve.php?page=Cooper.

[14] *Id.* (emphases added).

copper T1s can support the huge increases in wireless traffic that are already under way."[15] As with increasing the number of cell sites, it appears impractical and redundant to bring carrier backhaul close to the typical consumer. Exacerbating the shortage of carrier-provisioned backhaul is the fact that the two dominant wireless carriers also dominate the market for special access through their wireline affiliates, which makes it that much more costly and unlikely for smaller national and regional competitors to keep pace.[16] All this is not to suggest that there will not be adequate backhaul capacity for pervasive connectivity; it just won't be primarily carrier-provisioned infrastructure. As high-capacity wireline connections become ubiquitous among both residences and business establishments, consumers will already be paying for backhaul that could be used to offload mobile data traffic at a point far closer to the user than the carrier infrastructure can be sited.

B. The Imperative for Hybrid/Heterogeneous Networks

As high-capacity wireline connections become more prevalent and consumers' ability to purchase "smart" hybrid mobile devices likewise increase, it is neither cost-effective nor pro-consumer to encourage a model in which most mobile data would be transported over expensive licensed airwaves, and through relatively distant carrier-provisioned infrastructure. Instead, this data could and should flow short distances over unlicensed airwaves and consumer-provisioned backhaul. Recent experiments with femtocells, with services such as T-Mobile's @*Home* offering – in which consumers paid an extra fee to have a share of their traffic routed by WiFi

[15] *See* Comments of AT&T Inc., GN Docket Nos. 09-157, 09-51, at 97-98 (filed Sept. 30, 2009) ("AT&T Comments").

[16] *See, e.g.*, Reply Comments of Consumer Federation of America, Consumers Union, Free Press, Media Access Project, the New America Foundation, and Public Knowledge, WT Docket No. 09-66, at 5-6 (filed Oct. 22, 2009) ("Mobile Wireless Competition Reply Comments").

over their own wired Internet connection[17] – and AT&T's deployment of 24,000 free hotspots to encourage its customers to offload mobile data demand over WiFi,[18] all reflect a growing realization that it will be most efficient to re-use spectrum down to the level of the personal cell, while utilizing consumer-provisioned wired connections.

MIT researchers William Lehr and John Chapin describe the economic and engineering logic of this trend toward what they call "hybrid wireless broadband networks." They write:

> A hybrid wireless broadband access service is a high-capacity converged service implemented via multiple overlaid wireless networks, some of which share resources with other systems. . . . [Hybrid networks] combine[ ] multiple spectrum access models, for example dedicated spectrum (exclusively licensed) and shared spectrum (unlicensed). The set of flexible spectrum sharing models we anticipate to appear are collectively referred to as Dynamic Spectrum Access (DSA).
>
> [T]he inherent scarcity of spectrum pushes wireless architectures toward specialization and away from general-purpose designs in the quest for greater spectral efficiency. . . . We see the trend to greater sharing as both inevitable and desirable. However, the rate of increase of sharing and the eventual intensity of sharing and spectrum use depend on appropriate policy choices and research investments.[19]

Thus, commercial mobile services providers – relying as they do on a necessarily limited amount of exclusively licensed spectrum, and shouldering the capital costs for centralized infrastructure – should increasingly act as the "quality of service provider" within a heterogeneous network controlled by consumers at the edge. Consumers will happily pay for remote coverage, for needed mobility (connectivity on the move), or for the transport of latency-sensitive applications. But they should not need to pay an incumbent carrier or intermediary to send the bulk of their mobile data over the publicly-owned airwaves when there is a far more

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[17] *See, e.g.*, "T-Mobile Business Solutions," at http://www.t-mobile.com/Business/Information.aspx?tp=wi_fi_calling&tsp=MobileOffice (visited Feb. 28, 2011).

[18] *See, e.g.*, "Media Kit: AT&T Wi-Fi," at http://www.att.com/gen/press-room?pid=17541 (visited Feb. 28, 2011).

[19] William H. Lehr and John M. Chapin, "Hybrid Wireless Broadband," at 1 (Sept. 2009) *available at* http://www.tprcweb.com/images/stories/papers/LehrchapinTPRC_2009.pdf; see also the earlier companion paper by these same authors, William Lehr and John Chapin, "Divergent Evolutionary Paths for Wired and Wireless Broadband," invited paper presented to Workshop on Wireless Technologies: Enabling Innovation & Economic Growth, Georgetown Center for Business and Public Policy (April 17, 2009).

economic and spectrum-efficient alternative that capitalizes on local control over shared spectrum. Consumer welfare and economic efficiency will be enhanced by cognitive and cooperative devices that default, where feasible, to a local, very low-power network transmitting on unlicensed or other shared spectrum. Indeed, as the availability of more shared spectrum capacity enables the use of more cognitive and cooperative devices, mobile consumers can more readily hop to wireline transit on a P2P basis even when away from open WiFi ports.[20] As Lehr and Chapin opine, wise policy choices will be necessary to facilitate – and not impede – a market evolution toward these more spectrum-efficient and cost-effective hybrid networks.

III. THE NEED FOR A COMPREHENSIVE SPECTRUM INVENTORY AND ACTUAL USE MEASUREMENTS.

A critical step toward making substantially more spectrum capacity available for wireless broadband services and innovation is to determine and disclose how, where and when this publicly-owned resource currently is being used – or not used – by current public agency and private sector licensees. The Commission and the public need to have a more complete, comprehensive inventory of what frequencies are ***actually*** in use, for what purpose, to what extent, with what technology, and at what locations, frequencies and times. Both federal government and private sector assignments and uses should be included in the resulting map and companion data sets. Actual spectrum use measurements in a large and regionally diverse sampling of markets also should be part of any broadband mapping exercise.

[20] PISC Wireless Innovation Reply Comments at 16-17; *see also* Mobile Wireless Competition Reply Comments at 25 (noting that the prospect of paying carriers a premium for femtocells, just so that the customer can ***avoid*** using the carriers' infrastructure, hardly seems like a good deal for consumers).

PISC applauds the Commission for taking the initiative to create a very user-friendly prototype: the Spectrum Dashboard.[21] Clearly there is strong citizen demand even for the basic licensing information that the Dashboard displayed during its beta phase last year.[22] Although the Dashboard so far is limited to a look-up and visualization of the basic licensing information for non-federal bands (*viz.,* the identity of licensees by frequency and geography), it provides a valuable preview of how more comprehensive data on uses of discrete assignments can be made readily accessible through a consumer-friendly, online interface. As the National Broadband Plan recommended, "the spectrum dashboard could eventually provide a data resource to enable a more generalized geo-location system, particularly if supplemented with data on spectrum construction and usage."[23]

PISC member groups have recommended, both in comments submitted in response to National Broadband Plan notices and in Congressional testimony on the Radio Spectrum Inventory Act, that the White House direct a joint NTIA/FCC effort to undertake a comprehensive "Inventory of the Airwaves" that maps and makes publicly available how our public spectrum resource is being utilized in all federal and non-federal bands below 6 GHz, and eventually up to at least 10 GHz.[24]

A more comprehensive inventory and mapping of both federal and non-federal bands would help facilitate expanded access to broadband in at least three ways:

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[21] The FCC's Spectrum Dashboard is publicly available at http://reboot.fcc.gov/reform/systems/spectrum-dashboard.

[22] According to post on the FCC Blog, during its initial 8-month beta period last year, almost 200,000 searches were conducted on the Spectrum Dashboard, roughly 800 per day. James Brown, "Spectrum Dashboard Gets an Upgrade," Official Blog of the FCC (Nov. 18, 2010), *available at* http://reboot.fcc.gov/blog?entryId=998554.

[23] NBP Recommendation 5.13, at 96.

[24] *See* Testimony of Michael Calabrese before the House Subcommittee on Telecommunications, Hearing on the Radio Spectrum Inventory Act and CSEA Reform Act (Dec. 15, 2009); *Ex Parte* Comments of New America Foundation, GN Docket No. 09-29, at 2-3 (filed Mar. 25, 2009); Comments of the New America Foundation, Public Knowledge and Media Access Project, GN Docket No. 09-51, at 20 (filed June 8, 2009).

- First, more complete and transparent frequency-by-location data that includes current states of deployment and technologies in use will improve the functioning of secondary markets for spectrum license transfers and leasing. In that regard, PISC supports the *Notice*'s proposed addition to the Dashboard of spectrum leasing information.[25]

- Second, it will provide better information on incumbent uses of – and obstacles to clearing or sharing for – some drastically underutilized bands, so that they can be made more available for private sector use.

- Third, it will reveal the far greater number of frequency bands that could be made available for opportunistic access in discrete geographic areas, at certain times of day or year, or at certain altitudes or directions of arrival (azimuth, elevation).

Rural areas would be the most likely and immediate beneficiaries of measuring in this comprehensive fashion the nation's spectrum utilization. Wireless remains the most cost-effective and rapid means by which to bring broadband access to rural residents. It will quickly become clear that particular frequency bands are either completely unused or grossly underutilized in many rural markets. An online map of spectrum utilization on a localized basis (such as by Rural Service Area and Metropolitan Statistical Area) would provide the Commission with the information it needs either to reallocate spectrum or to open frequencies for non-interfering use by rural broadband providers, as well as for wireless innovation more broadly. Already, thousands of locally-grown Wireless Internet Service Providers ("WISPs"), Rural LECs, public utilities, NGOs and local governments are utilizing wireless technology in on unlicensed spectrum to bring wireless broadband to unserved and underserved rural areas across the country. A substantial obstacle that these small and local providers face in attempting to expand and scale-up their networks is access to additional spectrum.

Although it is understandable that the Commission's Spectrum Dashboard initially consists of a compilation and visualization of its own licensing databases, the longer-term effort

[25] *See Notice* ¶ 34.

to facilitate both more active secondary markets ***and*** the sort of opportunistic Dynamic Spectrum Access that PISC supports in these Comments will require more detailed deployment and technical disclosure on how licensees and federal users actually utilize each spectrum assignment (*e.g.*, if they utilize it at all, where, how, when, and with what technologies).

Information limited to the identity of a licensee of a frequency by geography is somewhat useful – and yet it reveals virtually nothing about the actual utilization of that spectrum, or, conversely, the availability of that spectrum capacity for opportunistic use. Current information on build-out, the location of fixed-site transmitters and receivers, technologies in use, and actual transmit power levels, are all basic data that the Commission needs to obtain profile of the spectrum environment and the availability of unused capacity in a particular geographic area.

It is important to bear in mind that a band of frequencies can be underutilized, and potentially shared, on a number of different dimensions. Retired NTIA engineer Robert Matheson described seven dimensions that define the potential capacity of a given band of spectrum – and the potential for dynamic, or flexible, spectrum usage rights – as illustrated below:

Electrospace Model: Dimensions of Spectrum Sharing[26]

Quantity	*Units*	*No. of Dimensions*
Frequency	kHz, MHz or GHz	1
Time	seconds, hours, months	1
Spatial Location	latitude, longitude, altitude	3
Angle of Arrival	azimuth, elevation angle	2

[26] Robert J. Matheson, "Flexible Spectrum Use Rights," *Journal of Communications and Networks*, 158-59 (June 2006), *available at* http://www.its.bldrdoc.gov/pub/ntia-rpt/05-418/05-418_matheson.pdf.

While this model describes what may be considered the theoretical potential for squeezing the maximum communications capacity out of a band of spectrum, it also highlights the inefficiency of today's two-dimensional spectrum "zoning" policies. Even without relying on the relatively expensive technologies required to share underutilized bands along many simultaneous directions, it is clear that with today's technology, a competent inventory of the airwaves would reveal sufficient data to allow policymakers to facilitate more efficient use of currently wasted spectrum capacity.

The Importance of Actual Spectrum Occupancy Measurements. It is also important that any spectrum mapping initiatives measure the actual and ongoing spectrum use at a large and diverse sample of rural, urban, and suburban locations around the nation. Any inventory of spectrum assignments should be augmented by actual spectrum use measurements – and, eventually, a system of spectrum use monitoring – that can provide a more nuanced window into how, when, where, and to what extent bands are ***actually*** in use. Both government and private sector assignments and uses should be included in such measurements.

The NTIA compiled actual spectrum measurement studies in a number of locations in the mid-1990s, but has measured little in recent years. Indeed, one of the recommendations of the Presidential Task Force on spectrum policy in 2004 was a call for "spot compliance checks" and "signal measurement surveys" to check the accuracy of NTIA's records and provide the information needed to "evaluate the utility of underutilized spectrum."[27]

[27] The Task Force was part of the Spectrum Policy Initiative initiated by President Bush in 2003 and led by NTIA. *See* U.S. Department of Commerce, "Spectrum Policy for the 21st Century–The President's Spectrum Policy Initiative: Report 1, Recommendations of the Federal Government Spectrum Task Force," ¶ 7(June 2004), at http://www.ntia.doc.gov/reports/specpolini/presspecpolini_report1_06242004.htm; *see also* National Telecommunications and Information Administration, "Presidential Memorandum on Spectrum Policy for the 21st Century" (May 2003), *available at* http://www.ntia.doc.gov/frnotices/2004/PresMemoonSpectrumPolicy.htm.

There are proven methods for efficiently aggregating usage data across a wide range of frequencies and at relatively low cost. For example, Ofcom, which regulates spectrum and communications in the United Kingdom, completed in 2009 a nationwide study by mounting measurement equipment on the roofs of vehicles used by a UK-wide sales force. The mobile monitors aggregated data over a period of five months on frequency bands from 10 MHz to 5 GHz.[28] In the U.S., a nationwide fleet service – such as the Postal Service – could aggregate continuous measurements, downloading the data automatically by WiFi each evening. Another method, currently being field-tested by at least one U.S. firm, involves continuous monitoring over wide areas by a meshed network of inexpensive sensors (less than $1000 per unit) that could be mounted on the roofs of public buildings. Any of these methods could provide a cost-effective way to measure actual spectrum utilization, thereby aiding in efforts to identify additional spectrum available today for opportunistic use and dynamic spectrum access.

IV. THE COMMISSION SHOULD BUILD ON THE TV BANDS DATABASE CONCEPT TO FACILITATE PRODUCTIVE USE OF FALLOW SPECTRUM.

Based on recommendations in the National Broadband Plan, PISC submits that both the Commission and NTIA have focused primarily on reallocating underutilized spectrum for exclusive licensing. However, there is considerably more underutilized spectrum in bands in which it is either not practical to relocate incumbent users or in which that would likely take many years. Unused spectrum capacity in these bands can be made available more rapidly by developing more explicit conditions for opportunistic access on a secondary basis, pursuant to requirements that the secondary user avoid causing harmful interference to the incumbent use. It is increasingly clear that a variety of "smart radio" technologies (*e.g.*, geo-location, sensing, and

[28] Ofcom, "Capture of Spectrum Utilisation Information Using Moving Vehicles," at v (Mar. 2009), *available at* http://stakeholders.ofcom.org.uk/binaries/research/technology-research/vehicles.pdf .

dynamic frequency selection) and spectrum management tools (*e.g.*, the forthcoming TV Bands Database) will support such dynamic and shared use of a large number of underutilized federal and non-federal bands alike, with little risk of interference to incumbents. Indeed, the Commission's Spectrum Policy Task Force Report recognized this opportunity even in 2002:

> Preliminary data and general observations indicate that many portions of the radio spectrum are not in use for significant periods of time, and that spectrum use of these "white spaces" (both temporal and geographic) can be increased significantly. . . .
>
> Often technologies such as software-defined radio are called "smart" or "opportunistic" technologies because, due to their operational flexibility, software-defined radios can search the radio spectrum, sense the environment, and operate in spectrum not in use by others. . . . That is, because their operations are so agile and can be changed nearly instantaneously, they can operate for short periods of time in unused spectrum.[29]

A. Opening Access to Additional "White Spaces" is Feasible and Would Serve the Public Interest

The most promising mechanism for making substantial new portions of the spectrum available for wireless broadband deployment and other innovation is to expand on the TV Bands Database. The Commission's Office of Engineering and Technology has initiated the process to certify as many as nine competing but coordinated database providers to facilitate the automated identification of available "white space" channels in the TV band when such channels are not in use in discrete geographic locations in the nation's 210 local TV markets. Under the *Second MO&O a*dopted unanimously by the Commission last September,[30] both fixed and mobile broadband devices will be allowed to operate on an unlicensed basis on unused TV channels provided that the devices have GPS and the capability to periodically check an online database of available TV channel frequencies in that discrete geographic location.

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[29] Spectrum Policy Task Force, ET Docket No. 02-135, *Report*, at 3-4, 14 (Nov. 2002).

[30] Unlicensed Operation in the TV Broadcast Bands, Additional Spectrum for Unlicensed Devices Below 900 MHz and in the 3 GHz Band, ET Docket Nos. 04-186, 02-380, *Second Memorandum Opinion and Order,* 25 FCC Rcd 18661 (2010) ("*Second MO&O*"); *see also* Unlicensed Operation in the TV Broadcast Bands, *Second Report and Order and Memorandum Opinion and Order*, ET Docket Nos. 04-186, 02-380, 23 FCC Rcd 16807 (2008).

There appears to be no reason to limit the functionality of the TV Bands Database to the TV band frequencies – and no reason not to add more fallow bandwidth to the "common pool" that is parceled out via the TV Bands Database. If a potentially useful frequency band is not being used at particular locations, times, altitudes, or angles of reception, then that currently wasted spectrum capacity could at a minimum be listed in the Database for opportunistic access, subject to whatever power limits and other conditions would be necessary to avoid harmful interference to sensitive incumbent operations.[31] The Commission's access rules for TV white space anticipate the use of frequency-hopping, multi-band radios, which are increasingly common and affordable in commercial mobile systems. Device makers and service providers would simply choose from an expanded Database the combination of frequencies most appropriate to their needs. Devices (whether fixed access points or mobile handsets) would scan for and select to utilize the clearest frequency from among those to which they can be tuned.

Although device costs might seem to be higher for such networks or services dependent on cognitive, frequency-hopping radios, the low spectrum costs would presumably be an offset. Certainly, that trade-off between the ability to use unlicensed spectrum with somewhat more expensive equipment and/or a potentially lower quality of service is what has allowed thousands of WISPs and community wireless providers to serve rural and other underserved areas. Just as unlicensed and lightly-licensed bands have proven a boon to both wireless innovation and broadband availability, opening more and more underutilized bands for shared and opportunistic access is likely as well to both benefit consumers and keep policy a step ahead of the need to accommodate mobile data demand at affordable prices.

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[31] *See* Michael Calabrese, "Ending Spectrum Scarcity: Building on the TV Bands Database to Access Unused Public Airwaves," New America Foundation, Wireless Future Working Paper #25 (June 2009), *available at* http://www.newamerica.net/files/nafmigration/Calabrese_WorkingPaper25_ EndSpectrumScarcity.pdf; Kevin Werbach, "Castle in the Air: A Domain Name System for Spectrum," *Northwestern University Law Review*, Vol. 104, at 613 (2010), *available at* http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1557244.

Another emerging development that points toward both the usefulness of a "stockpile" of unused spectrum and its benefit for consumers and competition is the possibility that multiple carriers – as well as other services needing wireless connectivity – could share a common network infrastructure. For example, investment analysts at Credit Suisse have recently been reporting on the "transformative" impact of a proposed "network-sharing model [that] would lower barriers for new entrants, potentially leading to retail pricing pressure."[32] Under the scenario they describe, a single nationwide 4G network "with multimode base stations and software defined radios would make infrastructure sharing possible."[33] In their view, other carriers would share network operating costs, but bring their own spectrum. "This could result in over 350 MHz of spectrum … being consolidated on a single network," they speculate, with participants offering both direct retail and wholesale services.[34] While PISC has no special insight into whether this particular business model is viable, the point is that under a network-sharing scenario that some industry analysts consider both technically feasible and financially superior, it would be possible for an incumbent or new entrant to make shared or opportunistic use of available spectrum in a particular area, even on a temporary basis, without the need to build out infrastructure dependent on exclusive or long-term access to that particular frequency band. And the more overall spectrum capacity that is available – from licensed, unlicensed and shared access – the more likely consumers will enjoy higher-capacity connections at lower prices.

Just because a frequency band is not fully or frequently utilized in a particular geographic area – which is what the McHenry/NSF spectrum measurements indicate – does not mean it is

[32] Jonathan Chaplin, Tom Champion, Nick Karzon, "Network Sharing Could Be Transformative," Credit Suisse, Equity Research Comment, at 1 (Feb. 23, 2011).

[33] *Id.*

[34] *Id.* at 2-3.

not serving its assigned purpose, or that its incumbent users can be relocated. Many military bands in particular are assigned for mission-critical training and emergency purposes that are episodic or geographically limited in nature. Yet, while in many such cases "clearing" a band of its current licensee and reassigning it exclusively to private sector licensees cannot be justified, there is nevertheless tremendous communications capacity that could be used productively at no cost or harm to the incumbent – just as the military today shares several radar bands with unlicensed users of low-power unlicensed devices.[35]

At the same time, even a band that would register as "occupied" over the course of a day or week may still have tremendous unused spectrum capacity. For example, certain bands needed by the Department of Defense in relation to air defenses or radar might be useable at very low power close to ground level, particularly with exclusion zones around receive sites or other sensitive areas – all of which could condition a band available only to cognitive radios through a governance mechanism like the TV Bands Database.

B. Unique Advantages of a Dynamic Spectrum Access Database

Building on the TV Bands Database (or "TVBD") has a number of other distinct advantages, particularly if such a database is utilized for opportunistic access:

- **No Permanent Assignments, No Stranded Users**

First, the "assignment" of bands for opportunistic access need not be permanent, or even long-term. At any time, a band can be added, or withdrawn, or limited to use in a particular geographic area or at a particular time of day. Under the TV white space rules, the Commission reserves the option to license additional TV stations, thereby removing a previously vacant channel from the TVDB in that particular local market. Opportunistic access presumes that

[35] *See* Michael J. Marcus, "New Approaches to Private Sector Sharing of Federal Government Spectrum," Wireless Future Program Issue Brief #26, New America Foundation (June 2009).

devices will increasingly be multi-band and capable of frequency hopping. Unlike in exclusively licensed bands, where it is expensive and time-consuming to upgrade or clear existing users, no white space devices need to be tied to a particular frequency. Bands can be opened or closed for sharing – nationally, regionally, or locally – and even on short notice, without "stranding" any users, legacy devices, or infrastructure. In the future, the Commission may even want to go further than it did in the rules conditioning unlicensed access to TV White Space channels by prohibiting single-frequency radios, and requiring at least that broadband devices sold to the general public be capable of operating on multiple bands, so that there is little risk a device can be rendered obsolete if a particular band is pulled from database (or is no longer available for that type of device).

- **No Bands Need Lie Fallow**

Second, building on the TVBD model provides the Commission the flexibility to make spectrum available on a temporary basis when it otherwise would be wasted simply because there is no alternative to the virtually all-or-nothing ethos of long-term exclusive licensing. For example, for years the Commission has struggled with the issue of how best to reallocate the very sparsely used AWS bands at 2155 – 2180 MHz. With a geo-location database in place, any fallow band could be listed for immediate access – and then de-listed (or restricted in additional ways) if and when a new licensee is selected and builds out. There seems to be no reason that FCC-held spectrum in particular should lie fallow in the future, when instead it can be made available for at least temporary, opportunistic use.

- ***"Use it or Share It"***

Third, opportunistic access using a geo-location database addresses the vexing problem of valuable licenses that are not built out, particularly in rural areas, by moving to a "use it or

share it" model (rather than a more draconian and rarely enforced "use it or lose it" rule).[36] For example, there are PCS, AWS, and EBS frequency blocks that the current licensees are not using productively – and that they may never build out, for economic reasons, in rural and small town areas. These unused frequencies could be made available to local broadband providers, such as small rural WISPs, RLECs, and community networks, on an opportunistic basis. In addition to expanding available spectrum capacity, this would have the additional benefit of making licensee build-out and spectrum usage more transparent, especially if these frequencies were available for opportunistic use up until such time as a licensee or lessee actually builds out and commences operations – not merely until such time as a licensee expresses an intention to enter into a lease. As noted above, multi-radio base stations and cognitive radio technologies increasingly make it possible for operators to share network infrastructure and/or make use of a spectrum band without being dependent on its constant or continued availability. Such advances would be a boon for rural broadband deployment in particular, since those are the areas with the most valuable spectrum lying fallow.

- **Access to Each Band Can be Subject to its Own Unique Conditions**

Another distinct advantage of a geo-location database is that access to different bands can be subject to different (and changeable) operating rules. There is no need for one-size-fits-all access to spectrum available for opportunistic use. Each listed frequency band can carry its own "rules of the road" with respect to maximum signal power, out-of-band emissions, or even the times of day or angle of transmission allowed. This would permit the Commission, where appropriate, to establish conditions that protect incumbent services, not only on the same

[36] While the "use it or share it" approach fosters many benefits, there still may be situations in which a long-term failure to build out should indeed result in loss of a license under rules similar to those imposed on certain 700 MHz Band commercial licensees.

frequency, but on adjacent frequencies. It also would allow the Commission to foster innovation with respect to new network architectures – such as conditioning access to some bands on more spectrum-efficient cooperative mesh protocols, rather than on the standard 802.11 contention-based protocols.[37] The TV Bands Database will demonstrate a simple version of this capability. For example, while both fixed and mobile devices will receive lists of available TV channels based on geo-location, the mobile devices will be limited to far lower power levels on all channels, while the fixed devices will not be permitted to transmit on channels immediately adjacent to licensed TV stations.

This ability to use a dynamic Database to condition access to different bands in different ways also means that opportunistic access does not necessarily require "unlicensed" access under the sort of Part 15 rules that apply to TV White Space or the 2.4 GHz band. Certain bands could be open access, yet require "registration" (similar to the lightly-licensed 3650-3700 band today), or even permit a "reservation" that would preclude conflicting uses in the location and for the period needed. Other bands could be open for leased access on a licensed basis – whether longer-term or on a micro-payment basis – by allowing the use of the geo-location Database as a mechanism to implement secondary market arrangements.

Both federal and non-federal bands should be added to the Database, with access to each band subject to conditions that are tailored to avoid harmful interference to existing, licensed use. For example, the ability to share military radar bands on an opportunistic basis is technically very different than sharing a band used primarily for fixed services, such as satellite or point-to-point microwave links, or a trunked land mobile radio system. One feature that facilitates the Pentagon's willingness to allow dynamic sharing of radar frequencies in the 5 GHz band is that

[37] *See* Comments of Powerwave Technologies Inc., GN Docket Nos. 09-157, 09-151, at 11-13 (filed Sept. 24, 2009).

unlike television reception, radar poses no "hidden node" challenge to spectrum sensing and Dynamic Frequency Selection technologies, because the transmitter and receiver are co-located. In a fixed service band, by contrast, sensing may be less reliable than simply calculating the availability of frequencies in discrete locations based on the listing of protected transmit sites.

- **Any 'Tragedy of the Commons' Can Readily be Avoided**

Finally, the database permission approach also could ensure that there is never a "tragedy of the commons" on a particular band. For example, the database could give permission to access certain bands only in exchange for micro-payments to certain licensees that need to be compensated for offering opportunistic access (*e.g.*, as an incentive or compensation for a licensee's investment in more interference-resistant receivers, or for other affirmative measures to facilitate shared access). Payments would be tantamount to user fees and could be collected upfront (as FCC device certification fees) or on an ongoing, real-time basis. With respect to a feared "tragedy of the commons," transmitters seeking a list of permitted channels could also be required to report back the frequency they choose to use and the duration of their transmission. On certain bands devices could be required to incorporate sensing and to share that "environmental" data as well. While utilizing the geo-location database to perform such functions would require a virtually real-time database, TV Bands Database providers have indicated that it would be technologically feasible to add that capability as needed and, indeed, some providers already contemplate offering value-added services along these lines.

Eli Noam first suggested micro-payments as a safeguard against potential congestion on the most desirable bands (or in the highest demand markets, such as New York or L.A).[38] More

[38] Eli Noam, "Yesterday's Heresy, Today's Orthodoxy, Tomorrow's Anachronism: Taking the Next Step to Open Spectrum Access," 41 *Journal of Law & Economics* 765-90 (1998), *available at* http://www.citi.columbia.edu/elinoam/articles/SPECTRM1.htm; *see also* Eli Noam, "Taking the Next Step Beyond Spectrum Auctions: Open Spectrum Access," *IEEE Communications,* Vol. 33(12) (Dec. 1995).

recently, Google's Rick Whitt has suggested that web-based technologies could now support a real-time auction of frequency slots on an automated and fairly low-cost basis, just as Google conducts real-time auctions matching advertisers to search terms: "In the same way, an auction could be performed for a radio transmission in a pertinent place and time to determine the economic value the market would support for that transmission."[39] Commission staff also have demonstrated theoretically that efficiency can be improved if "a given band of spectrum is treated as a common pool resource in the absence of excessive spectrum congestion, but is treated as an excludable private good in the presence of such congestions."[40]

Nevertheless, while micro-payments could be useful as a prophylactic against extreme congestion, there is no reason the Commission should assume that such congestion is inevitable. While spectrum capacity certainly could become constrained in absolute terms in our wireless future, we are nowhere near that point. With the vast majority of the spectrum capacity below 3.1 GHz unused, even in New York City at any particular time, the only near-term risk of congestion would be the result of the Commission failure to move quickly or aggressively enough to stock the proposed TV Bands Database (or a similar frequency clearinghouse) with underutilized frequencies.

Nor should spectrum incumbents expect to be "bribed" for relinquishing any supposed rights to squat on fallow spectrum. While the actual use of a band by a licensee or its lessee should be protected against interfering use, the mere ***potential*** for a licensee to lease its unused capacity on secondary markets should not preempt or block opportunistic access. Today, most prime spectrum could be leased (and certainly most of it is underutilized) – but very little is in

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[39] Richard S. Whitt, Google *Ex Parte* filing, WC Docket No. 06-150, App. A, at 6 (filed May 21, 2007); *see also* Google Inc. Comments, GN Docket No. 09-157, at 11 (filed Sept. 30, 2009).

[40] Mark M. Bykowski, *et al.*, "Enhancing Spectrum's Value Through Market-informed Congestion Etiquettes," FCC/OSP Working Paper Series No. 41 (Feb. 2008).

fact leased. The Communications Act specifies that licensing is temporary and that it does not contemplate granting exhaustive rights to the spectrum capacity assigned with any band. By law, what is licensed is the temporary right to use the designated frequency to the extent needed to provide a communications service that serves the public interest. Unused spectrum capacity on any band, in any location, remains public property and subject to new conditions that the Commission determines will serve the public interest.

Therefore, even without waiting for license renewal, the Commission can at any time permit use of the otherwise wasted spectrum capacity on a non-interfering basis. Indeed, as Eli Noam wrote over a decade ago, the government has an obligation not to create any unnecessary barriers to citizen communication, particularly over government-controlled conduits such as the airwaves that are intrinsically a public forum:

> [S]pectrum access is traffic control, not real estate development. It's about flows, not stocks. . . .
>
> The emergence of technologies that make it possible for multiple users of spectrum to cohabit and move around frequencies has profound effects. It is not just that it is arguably a more efficient system . . . But, more importantly, it is *constitutionally* the stronger system. . . . Electronic speech is protected by the First Amendment's Free Speech Clause. Therefore the state may abridge it only in pursuance of a "compelling state interest" and through the "least restrictive means" that "must be carefully tailored to achieve such interest."[41]

C. Priorities and Process to Identify and Condition Unused or Underutilized Bands for Opportunistic Access

As noted above, the combination of current cognitive radio technologies (*e.g.*, geo-location, sensing, dynamic frequency selection) and spectrum management tools (*e.g.*, the TV Bands Database, beaconing, device testing/certification) should enable the initiation of a band-by-band process of identifying the most underutilized bands of useful spectrum and determining the conditions governing access by third parties. PISC proposes that the Commission's next step

[41] Noam, "Yesterday's Heresy," *supra* note 38.

following this *Notice* and the review of comments thereon should be to issue a Notice of Proposed Rulemaking, proposing to open access to one or more categories of unused or underutilized spectrum. We assume that permitting opportunistic access to unused or underutilized spectrum ultimately must occur on a band-by-band basis – although even this approach could prioritize certain categories of spectrum in which opportunistic access seems most promising and logical (*e.g.*, FCC-held spectrum and certain federal bands that cannot be cleared for reallocation to exclusive commercial use).

At the outset, PISC reiterates its contention that frequency bands that are intensively and efficiently in use – such as the bands used for CMRS – are the least suitable candidates for spectrum band sharing, except possibly in geographic areas that are not built out. In comments filed in response to the National Broadband Plan's *Wireless Innovation NOI*, certain industry commenters, including CTIA and AT&T, made strenuous arguments against opportunistic access to the bands for which CMRS providers hold licenses.[42] AT&T characterizes cognitive radio access to fallow capacity as "forced spectrum sharing," improperly assuming that the managed use of unused capacity on a non-interfering basis would somehow impose a burden on the licensee. Regardless, these concerns are a red herring vis-à-vis bands occupied by CMRS providers. There are many hundreds of MHz of high-quality spectrum in other bands, far more lightly used and better suited to opportunistic access, than are the PCS and other bands used by the commercial wireless industry.

The most obvious category of spectrum that should be made accessible, as recommended in the National Broadband Plan, is FCC-held spectrum. Another immediate focus for this effort, in collaboration with NTIA, should be the identification and analysis of federal bands that NTIA

[42] *See* AT&T Comments at 75-86; CTIA Comments, GN Docket Nos. 09-157, 09-51, at 80-82 (filed Sept. 30, 2009).

has determined cannot be cleared for reallocation by auction, but which could, under stringent conditions (*e.g.*, exclusion zones, power limits) be opened for shared access by the private sector. A third category that the Commission should address in a future NPRM is "white space" on licensed bands that have not been built out in substantial portions of the country. Some of the prime spectrum auctioned over the past decade remains fallow, particularly in many rural and small town areas, and at least conditional and temporary access to that spectrum capacity should be considered as part of this effort.

- ***FCC-Held Spectrum***

One of the two actions recommended by the National Broadband Plan "to accelerate the development of opportunistic use technologies" called on the Commission to "allow opportunistic radios to operate on spectrum currently held by the FCC (such as certain license areas where spectrum was not successfully auctioned)."[43] PISC concurs that opportunistic access to still-unassigned spectrum in multiple bands, even if temporary, could provide what the Plan termed a "technical 'sandbox' for . . . innovation in cognitive technologies (including frequency hopping) that take advantage of the ability to operate in different frequency bands . . . ."[44] There seems to be no reason that FCC-held spectrum cannot be considered – immediately and collectively – for opportunistic access, subject to whatever technical conditions are required on a band-by-band basis to protect incumbent uses from harmful interference.

The Plan used the example of "spectrum not successfully auctioned." Yet, as noted above with respect to the 2155-2180 MHz band – which has remained unassigned for years – PISC believes that FCC-held bands scheduled or intended for auction or other reassignment by license also should be listed in the TV Bands Database for opportunistic access by market area

[43] NBP Recommendation 5.13, at 96.

[44] *Id.*

until such time as any licensee actually operates a service. It would be an unnecessary waste of spectrum to pull a band such as 2155-2180 out of use nationwide if (as is likely) the capacity actually will not be used in certain geographic areas for a number of years after assignment.

- ***Federal Bands that Can Accommodate More Secondary, Shared Use***

Nowhere is spectrum underutilization more evident than in many of the bands reserved for use by the federal government itself.[45] According to NTIA's Office of Spectrum Management, federal agencies have exclusive use of 18.1% (629 MHz) of the "beachfront" frequencies between 225 and 3700 MHz, while non-federal users have exclusive licenses to 30.4% (1058 MHz). The remaining 51.5% is shared, with federal use primary and private sector use secondary.[46] Spectrum measurement studies, such as the Shared Spectrum measurements sponsored by the National Science Foundation,[47] indicate that Federal spectrum bands between 225 and 400 MHz, 902 and 1850 MHz (particularly 1755 to 1850 MHz), and smaller bands at 108 – 174 and 400 – 450 MHz, appear virtually unused in most areas at most times, particularly in the more densely populated areas of the country that are most likely to experience insufficient capacity for the future demand for wireless broadband data services. While most of these bands could not be cleared and reallocated because they serve national security and other functions, they undoubtedly could be shared far more intensively on a conditional basis by taking advantage of cognitive radio technologies, sensing, and geo-location techniques.

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[45] For an overview and discussion of the utilization of federal spectrum and policy recommendations for reallocation of this underutilized spectrum, *see* Victor Pickard and Sascha D. Meinrath, "Revitalizing the Public Airwaves: Opportunistic Unlicensed Reuse of Government Spectrum," Wireless Future Working Paper #26, New America Foundation (June 2009), published subsequently in *International Journal of Communications* 3 (2009), at 1052-1084, *available at* http://www.community-wealth.org/_pdfs/articles-publications/municipal/article-pickard-meinrath.pdf.

[46] *See* Karl Nebbia, Director, NTIA Office of Spectrum Management, presentation to the Commerce Spectrum Management Advisory Committee (CSMAC) (Dec. 9, 2009).

[47] *See the* McHenry 2005 Study, which collected frequency use data in six locations along the East coast in 2004 and documented an average total spectrum use of between 0 and 3% at rooftop level across hundreds of MHz of federal spectrum.

Bands reserved for federal agency use seem particularly well-suited for opportunistic access for a variety of reasons. Among the reasons are that federal bands are at least nominally controlled by NTIA and, unlike a private sector licensee, the Department of Commerce and other federal users can be expected to balance their own needs with the public interest in expanding available wireless broadband capacity. The military in particular has both very wide bands of spectrum that are unused in most locations on most days – and the ability to enforce priority-in-use over opportunistic private sector users during any emergency that might justify reserving those bands. Indeed, the Department of Defense ("DoD") has done exactly that in the past – opening up extensive military radar bands (most notably in the 5 GHz band) for passive sharing with low-power unlicensed users equipped with "smart radio" technology that is able to sense if radar is operating and vacate the channel in under one second.[48]

One of the biggest obstacles, particularly in the federal bands, is the lack transparency with respect to actual use and the types of systems and technologies that need to be accommodated to facilitate greater private sector access. PISC believes that the Commission should take a far more pro-active role, both under its own powers and in collaboration with the NTIA, to achieve far greater transparency and use of under-utilized federal bands. At the same time, the federal spectrum use review process that NTIA already has under way – as part of the Administration's drive to make a total of 500 additional megahertz of spectrum available for licensed and unlicensed use over the next decade – is structured to identify bands most appropriate for sharing with non-federal users on both a licensed and/or unlicensed basis.[49] PISC

[48] For a brief history of how DoD shares radar bands with the private sector, and a proposal describing how federal agencies can take affirmative steps to facilitate expanded and more efficient band sharing, see Marcus, "New Approaches to Private Sector Sharing of Federal Government Spectrum," *supra* note 35, at 4-6.

[49] U.S. Department of Commerce, "Plan and Timetable to Make Available 500 Megahertz of Spectrum for Wireless Broadband," at 10 (Oct. 2010). This plan states that NTIA's band-by-band evaluation "will include a determination of which bands are best suited for one or more of four repurposing options in order of preference: (1) Exclusive non-

recommends that as NTIA identifies bands as appropriate for shared access – whether on a licensed and/or unlicensed basis – that it open a proceeding as quickly as possible to determine under what conditions (*e.g.*, exclusion zones) and using what technologies and governance mechanisms (e.g., geo-location database permission) it can move ahead to open the band for greater private sector use.

- ***Fallow Commercial Bands in Areas Not Built Out and Not in Use***

A third category of bands that should be prioritized for identification, analysis, and eventual listing in the TV Bands Database for at least temporary access on an area-by-area basis are bands that lie fallow and unused several years after initial assignment. Opportunistic access using a geo-location database can address the vexing problem of highly-desirable spectrum assets (such as those described in Part IV.B above) that are not being used, particularly in rural areas, even after many years. Much of this spectrum is not subject to stringent build-out requirements, and could remain idle for an indefinite period. And although more recent spectrum auctions and grants of flexibility (*e.g.*, the recent LightSquared ATC integrated device waiver for the mobile satellite L Band) have included more stringent build-out requirements, the threat of "use it or lose it" doesn't by itself enable use of the fallow spectrum in the communities that are among the last to be served – even assuming that the licensee will ultimately comply.

Whether or not build-out requirements apply to a licensee, a general license condition that implements a "use it or ***share*** it" rule in geographic areas where spectrum has not been put into active service would at least create an opportunity for the local community and consumers to benefit from third parties making opportunistic (even if temporary) use. These unused

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Federal use (licensed); (2) Federal Shared with non-Federal (licensed); (3) Federal and/or non-Federal use shared with unlicensed; and (4) Exclusive unlicensed." *Id.*; *see also* U.S. Department of Commerce, "An Assessment of the Near-Term Viability of Accommodating Wireless Broadband Systems in the 1675-1710 MHz, 1755-1780 MHz, 3500-3650 MHz, and 4200-4220, 4380-4400 MHz Bands" (Oct. 2010).

frequencies could be made available to local broadband providers, such as local WISPs and community networks, on an opportunistic basis. Assuming that these "white spaces" are added to the TV Bands Database on a geographically discrete basis, there still could be many years of opportunistic use (particularly in rural areas) before a licensee actually builds out and lights up its own operations. And although the opportunistic access would end when the band is pulled from the geo-location database, it could become equally common for the licensee ultimately either to partner with or lease the spectrum (on an exclusive basis) to the operator that has established a viable use for it. This option, combined with the maturation of the TV Bands Database, likely will facilitate more secondary market transactions that are then registered in the Database as licensed (and hence primary) uses of what would otherwise have been warehoused capacity.

Although the pressure of a "use it or share it" condition may incent more rapid deployments by licensees or more active efforts to engage in licensed secondary market transactions, PISC believes that access to unused capacity on a purely opportunistic and non-interfering basis should be unlicensed. This is of course no great departure from the status quo. As the National Broadband Plan reminds us, "[t]he FCC's Part 15 Rules permit unlicensed devices to operate on any spectrum except spectrum specifically designated as restricted."[50] And, as under Part 15, we assume that unlicensed access to bands listed through the geo-location database – or through sensing, or a combination of the two – would be subject to the general conditions that the unlicensed operations cause no harmful interference to licensed operations and accept interference that may be caused by any other operations in the band. A primary advantage of gaining access to a band designated by the Commission for opportunistic access is

[50] NBP at 95.

that the licensed uses of the band (or lack thereof) will be more transparent on a geographically specific basis; and the conditions the Commission attaches to opportunistic access could conceivably be different than the generic Part 15 technical rules in ways that prove more useful to certain services or uses.

While it is difficult to know in advance how much additional activity and market entry will be spurred by opening these three categories of unused or underutilized bands for opportunistic use, considering that spectrum capacity is infinitely renewable from one second to the next, there seems to be little if any downside in following the National Broadband Plan's recommendation to "accelerate the development of opportunistic use technologies and expand access to additional spectrum."[51]

D. Testbeds to Spur Innovation

Finally, the *Notice* asks in paragraph 47 if there are additional options for providing specialized spectrum access for innovation that would augment the Commission's existing practice of granting Special Temporary Authority ("STAs"), or access to the spectrum "Test-Bed" created jointly with NTIA.[52] One possibility would be to open immediately all the bands corresponding to FCC-held licenses for opportunistic access, but with the additional proviso that sponsors of commercial and/or technological trials could apply for waivers of certain limitations on the general use of those bands. For example, although general access to these bands might well be conditioned on GPS capability and authorization by the TV Bands Database (or an alternative geo-location database), for test-bed purposes the Commission could approve sensing-alone in an area where it knows that no licensed or otherwise protected services are operating. As noted above, prime bands such as at 2155-2180 MHz and even the 700 MHz D Block are

[51] *Id.*

[52] See *Notice* ¶¶ 9, 47.

unlikely to be reassigned ***and*** built out across most of the country for many years to come. It seems that significant trials for new network architectures or technologies could take place on these and other "orphaned" bands without disrupting incumbent services or even using limited "test-bed" capacity already set aside for these purposes by the FCC and NTIA.

Opening additional bands overseen by the Commission and NTIA to such use could take place in tandem with expanded opportunistic access to bands managed through the TV Bands Database, as described above. One of the biggest drawbacks to a large-scale trial on bands pending reassignment (such as the D Block or 2155-2180 MHz bands) is that the innovator is not likely to retain access to the band long-term. However, if an innovator built multi-band, cognitive radio capability into its tests, deployed devices could be given permission to access another band (or combination of bands) in the future. This also reflects a virtue of the sort of opportunistic access inherent in the TV Bands database: Not every band available through the geo-location database needs to be subject to the same set of operating rules and protocols; and, moreover, those rules and the devices given permission to access a particular band can evolve over time without "stranding" legacy equipment.

CONCLUSION

PISC applauds the Commission for taking this vital first step toward creating a roadmap for unlocking the veritable "vast wasteland" of unused and underutilized spectrum capacity. As consumer demand for mobile data is projected to continue to outstrip network capacity, the nation will soon run out of high-quality spectrum that can be reallocated for mobile broadband services on an exclusively licensed basis. It is critical that the Commission get ahead of this trend and lay the groundwork to harness dynamic spectrum access technologies to enable more band sharing and opportunistic access to unused capacity on both a licensed and unlicensed

basis. The development of the TV Bands Database offers a unique opportunity for the United States to once again lead the world in developing the next generation of wireless broadband innovation, as well as promote competition, innovation and consumer choice. Just as forward-looking policy enabled the development of WiFi and related unlicensed technologies, the Commission should now lead the way in promoting cognitive radio technologies and opportunistic access to unused spectrum capacity.

Respectfully Submitted,

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February 28, 2011