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 GOOGLE INC.

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TABLE OF CONTENTS

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Google Inc. ("Google") hereby responds to the Commission's *Notice of Inquiry* in the above-captioned proceeding.[1] Google has supported the Commission's ongoing efforts to promote increased efficiency in the use of a scarce public resource, and to make available additional spectrum for a variety of services and applications. We applaud the Commission for seeking to expand on these efforts by promoting and facilitating wireless innovation through dynamic spectrum use technologies.

I. Introduction and Summary

As the *NOI* correctly observes, "dynamic spectrum access technologies and techniques have the potential to enable more efficient utilization of our nation's precious spectrum resource" under both licensed and unlicensed regulatory approaches.[2] Dynamic, opportunistic spectrum access lowers barriers to entry for new competitors and entrepreneurs, fosters innovation through flexible spectrum usage, and encourages efficient usage of a valuable resource.

As an initial matter, Google supports the Commission's inclusive approach to dynamic usage in this proceeding. Rather than a piecemeal examination of technologies such as "dynamic

[1] *In the Matter of Promoting More Efficient Use of Spectrum Through Dynamic Spectrum Use Technologies*, Notice of Inquiry, 25 FCC Rcd. 16632 (2010) ("*NOI*").

[2] *Id.* at ¶¶ 1, 17.

spectrum access radio," "dynamic radio," "cognitive radio," and "opportunistic radio," all of which the *NOI* uses interchangeably,[3] the Commission wisely has opted for a holistic inquiry into "radio[s] and network[s] that can react and self-adjust to local changes in spectrum use or environmental conditions to obtain access to spectrum without causing harmful interference."[4] This approach makes sense. The dynamic access technologies enumerated in the *NOI* are indeed distinct, but examining them simultaneously in a single proceeding is conducive to creating a long-term spectrum plan with consistent policies that will promote greater predictability and innovation in wireless technologies. All dynamic access techniques, although still nascent, promise to increase spectral efficiency and, consequently, the number of users on a particular band, and thus are highly important to continued broadband growth.

As we discuss, the Commission's TV bands white spaces proceeding should serve as a reliable baseline against which to test and build upon dynamic spectrum access rules and policies that could be applied to other bands. Fundamentally, all parties must have an understanding of what, where, and how spectrum is being used. This requires a spectrum inventory that is transparent to users and innovators. This approach was adopted by the Commission in the TV white spaces and should be applied in a more comprehensive fashion to promote dynamic spectrum technologies across all spectrum bands.

We strongly support the identification of spectrum that is or could be made available for dynamic use technologies through a comprehensive spectrum inventory, use of emerging technologies such as real-time databases, improved use of modern propagation models that can define service areas, and other mechanisms. Because such measures will take time, however, we

[3] *See NOI* at ¶ 6.

[4] *Id*.

urge the Commission to act promptly to designate test-bed spectrum for dynamic usage and to identify at least one additional white spaces band. Such a step would signal innovators and investors that the Commission is strongly committed to efficient spectrum use, and result in immediate benefits through testing and experimentation.

We also commend the Commission for its efforts to gather information on the current state of various radio technologies that could make more spectrum available for opportunistic uses. The Commission should take concrete steps to encourage real-time spectrum management techniques, sensing and underlay technologies, and other developments that promote flexible and efficient spectrum usage.

II. The Rules for TV Bands White Spaces Exemplify How Current and Evolving Technologies Can Promote Dynamic and Efficient Spectrum Usage

The Commission's TV bands white spaces proceeding[5] provides insight into effective approaches to promoting dynamic spectrum access opportunities and spectrum management techniques, including identifying available spectrum, making spectrum information transparent, and fostering flexible, market-driven technology solutions. The Commission should view the TV white spaces as a reliable baseline against which to test and build upon dynamic spectrum access rules and policies that could be applied to other bands. Moreover, because the TV white spaces rules provide for competing database administrators, offer unbounded opportunities for device manufacturers, and do not mandate particular technology solutions, they serve as a model for the flexible, market-driven approach that the Commission should follow in this proceeding.[6]

[5] *In the Matter of Unlicensed Operation in the TV Broadcast Bands*, ET Dkt. 04-186, Second Report and Order and Memorandum Opinion and Order, 23 FCC Rcd. 16807 (2008); Second Memorandum Opinion and Order, 25 FCC Rcd. 18661 (2010).

[6] Of course, the Commission should continue to review its antenna height, out-of-band emission, and other technical rules to ensure that they provide sufficient flexibility to enable TV white spaces

As we discuss below, for dynamic spectrum use technologies to succeed there first must be a thorough understanding of where spectrum is available for the technologies to operate. The TV white spaces database model functions as a limited form of spectrum inventory by storing a complete list of protected users. A comprehensive inventory of all allocated spectrum will be necessary to more fully realize the benefits of dynamic use technologies.

Similarly, transparent access to information about spectrum is a critical driver of improvements in efficient spectrum use, and in investment and innovation. By consolidating substantial information about ongoing and planned spectrum use and making the information publicly available and searchable,[7] the TV white spaces databases provide a model of transparency.

Furthermore, swift progress toward fully-deployed TV white spaces systems underscores why it is essential for the Commission to identify and make available additional spectrum bands for unlicensed use. The rapid evolution of technologies made possible by unlicensed access to spectrum enables testing without the threshold requirements of licensing. Such low barriers to entry in turn will lead to greater investment in portions of the spectrum that otherwise would remain fallow or minimally used. The Commission should look to add to the inventory of unlicensed spectrum managed by the TV white spaces database by promptly identifying at least one other band that has similar characteristics to the TV bands.

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technologies to reach their fullest potential. *See* Google Inc. Response to Petitions for Reconsideration at 3-4, 6, ET Dkt. 04-186 (Feb. 24, 2011).

[7] *See* 47 C.F.R. § 15.715(i).

III. The Commission Should Increase Spectrum Available for Dynamic Usage

As highlighted in the *NOI*, the Commission has taken steps in recent years to foster dynamic spectrum use in several discrete spectrum bands, with great success.[8] As demand for broadband services and applications continues to grow, however, it is critical that additional spectrum be made available. In particular, unused spectrum should be reallocated and made available to users on both licensed and unlicensed bases. Spectrum being used inefficiently, or not at all, should be made available for dynamic access, through geographic and time-based spectrum sharing, wideband low-power underlays, and other innovative technologies.

A comprehensive and authoritative spectrum inventory would facilitate identification of candidate spectrum bands, as we discuss below. Because conducting such an inventory will take time, however, Google urges the Commission to act promptly to designate test-bed spectrum for dynamic usage. Such a step would signal innovators and investors that the Commission is strongly committed to efficient spectrum use, and would allow immediate testing.

A. A Comprehensive Spectrum Inventory Is Needed to Identify Spectrum for Dynamic Use

Google has consistently stated that a database identifying current spectrum usage and availability is critical for effective spectrum planning and policy.[9] A comprehensive inventory of Federal and non-Federal spectrum usage conducted by the Commission and the National Telecommunications and Information Administration ("NTIA") is thus a necessary step in

[8] *See, e.g., NOI* at ¶ 4 (noting that in 2003, the Commission made available 255 MHz in the 5 GHz band for unlicensed operations based on the use of Dynamic Frequency Selection; in 2005, the Commission made available the 3650-3700 MHz band for wireless broadband use on a "license by rule" basis; and in 2008, the Commission adopted rules allowing unlicensed radio devices to operate on unused television broadcast spectrum).

[9] *See, e.g.*, Comments of Google Inc. at 7, GN Dkt. 09-157 (Sept. 30, 2009) ("Google Wireless Innovation Comments").

identifying spectrum that already is or that could be made available for use by opportunistic technologies. To the extent feasible, the inventory should measure the effective utilization of licensed and allocated spectrum so that the Commission and NTIA, with input from stakeholders, can make informed decisions regarding bands suitable for reallocation and dynamic access.

B. Transparency of Spectrum Information Will Promote Dynamic Use

Fragmented data unnecessarily increases barriers to entry for potential innovators. Opportunities for dynamic spectrum access will be enhanced by organizing information that the Commission and industry already possess. The Commission's websites and online databases should be reexamined, coordinated, and linked to improve the organization of data regarding license terms and construction requirements, geographic partitioning/disaggregation activities, ownership, affiliations, cell tower registrations, and coverage and build-out data, as well as about unlicensed spectrum availability and the technical rules and limits for each unlicensed and hybrid-licensed band (*e.g.*, power limits, non-interference standards, out-of-band emissions limits, and database coordination requirements).[10] This data should be supplemented with additional information from the spectrum inventory.

Ultimately, the Commission should use these inputs to make available a general database that allows any user with any level of sophistication to determine for a specific geographic location whether particular frequencies are assigned for commercial or non-commercial use and, if so, a point of contact; whether facilities have been constructed; transmitter locations and equipment types; and, importantly, spectrum occupancy data relevant to determining the extent

[10] As with the TV bands, the private sector may play a role in creating databases or other technologies to make this information more accessible to potential innovators and users.

of the entity's spectrum usage. This increased level of transparency will allow both the private sector and the government to engage in a more informed dialogue about whether or not particular spectrum bands are being used efficiently, whether current and future uses could be better accommodated by relocating to other bands, and which bands could or should be reallocated or made available for dynamic use technologies. All of this information in turn will foster additional advancements in spectrum access technologies.

C. The Commission Should Reexamine Propagation Models to Ensure That Spectrum Allocations Are Being Conducted in an Efficient Manner

Google commends the Commission for seeking comment on whether new or different propagation models could reduce barriers to spectrum access while still providing adequate levels of protection from unwanted interference. Because the Commission uses propagation models to define areas of protection and service areas, it is critical that these models be as accurate as possible. Certain propagation models could have the unintended effect of decreasing the amount of spectrum available for dynamic and opportunistic usage. For instance, Google agrees with concerns raised about the Longley-Rice propagation model. As others have asserted, Longley-Rice is inadequate for cognitive radios because of the "great variability of radio signal strength in urban areas" and its "lack of three dimensional high-fidelity spatial modeling, as well as temporal modeling, to account for differences in daily use."[11]

Although at this time Google is not advocating for the use of one particular propagation model over another, we call on the Commission to look to techniques that are appropriate and

[11] *See NOI* at ¶ 26 (citing *Broadband Spectrum Workshop* (2009), Third Panel, statement by Dr. Joseph Mitola III of the Stevens Institute of Technology, at 167-169, *available at* http://www.broadband.gov/ws_spectrum.html ("if you look at the way radios actually propagate, Longley-Rice isn't it," especially in cities)).

tailored to the realities of measurement today (for example, the Okomura-Hata model).[12] Spectrum allocation should not be determined by the methodology that utilizes the most conservative parameters, has been used for the longest period of time, or whose original motivation for use was ease of computation with manual methods in the pre-computer era. Rather, the Commission should accept methods that produce accurate results while reducing barriers to spectrum deployment.[13]

D. Dynamic Spectrum Auctions Provide a Ready and Effective Means to Make Additional Spectrum Available for Dynamic Access

As Chairman Genachowski observed, by allowing "the power of the free market to ensure underutilized spectrum flows to the uses consumers value most in the 21st century . . . [e]verybody wins."[14] Put simply, providers and users are best served by an open, transparent, flexible and market-driven spectrum regime. Google is a strong proponent of any system that provides access to unused spectrum by any lawful secondary user. One example is a dynamic auction mechanism, which would have the important benefit of requiring payment for spectrum use on an as-needed basis, rather than months or years in advance, as under the current system.[15]

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[12] *See NOI* at ¶ 26; Okumura, Y., *et. al., Field Strength and its Variability in VHF and UHF Land-Mobile Radio Service*, Rev. of the Electrical Comm. Laboratory, Vol. 16, Nos. 9-10, 1968.

[13] We note that, when considering decision criteria for secondary transmissions based on interference by secondary users to primary users, an important consideration is the ratio of the transmit powers of the two users. This necessitates an interference model that includes this ratio, likely by considering the distance between the two transmitters.

[14] Prepared Remarks of Chairman Julius Genachowski, "Our Innovation Infrastructure: Opportunities and Challenges," delivered at the NARUC Annual Meeting in Atlanta, GA (Nov. 15, 2010).

[15] As the Commission has confirmed, its flexible use and spectrum leasing rules and policies allow the use of dynamic auction techniques, such as real-time auctions and per-device registration fees. *See NOI* at ¶ 41. *See also* Letter from Richard S. Whitt, Google Inc., to Marlene H. Dortch, Secretary, FCC, at 3-4, WC Dkt. 06-150 (May 21, 2007) (noting that real-time auctions and other market mechanisms can help ensure that a particular slice of spectrum ends up in the hands of the user who values it most at any particular time and place).

In turn, a dynamic auction system may remove barriers to entry and facilitate infrastructure build-outs and service delivery (for example, by leaving more money in the private sector). Pro-consumer benefits of a real-time wholesale platform could include lower retail prices, new service offerings, and more widespread mobile broadband Internet access.

To maximize channel capacity, bands allocated for dynamic spectrum access should be as large as possible. For each available spectrum band, the licensee could bestow the right to transmit an amount of power for a unit of time. Total transmitted power in a given location could be capped, with the cap enforced by measurements made by the devices. The right to transmit on the band could be awarded by auction, potentially managed via the Internet by a central clearinghouse.

The benefits of utilizing market forces to encourage efficient spectrum management are compelling.[16] This approach aligns with the Commission's own "flexible use policies . . . [which] seek to provide licensees with wide latitude to develop and deploy advanced technologies in order to address changing marketplace demands."[17] It also would result in an efficient allocation of resources among various means of transmitting information (including by allowing the market to make economic trade-offs between fiber optic and wireless transmission). Another benefit could be improved, low-cost service in rural areas, where less competition for spectrum would result in fewer bids and thus lower prices.

[16] *NOI* at ¶ 5.

[17] *Id*. at ¶ 4.

IV. The Commission Should Look to Existing Technologies to Optimize Spectrum Utilization

The *NOI* touches on many important technology and policy issues related to dynamic access. Google commends the Commission for its efforts to gather information on the current state of various radio technologies that could further the public interest in making more spectrum available. The technologies discussed below promote the objective of identifying spectrum that could be made available for both licensed and unlicensed use, which the Commission should support to encourage more flexible and efficient spectrum usage.

A. Real-Time Spectrum Management Via a Database

TV bands white spaces utilize a number of enabling technologies that could provide viable starting points for implementing dynamic spectrum use in other bands.[18] One such technology is a real-time database containing information about frequency utilization for any given geographic location, time period, and spectrum band where dynamic access is permitted. With information immediately available through a database, cognitive radio devices would be able to quickly identify and utilize available frequencies. Moreover, real-time databases can be designed to account for all necessary interference protections for existing users. They would be particularly useful for policy radios,[19] allowing secondary use of a band when the primary user is not fully utilizing its allocated spectrum. Real-time databases also would be a key component in implementing dynamic spectrum auctions.

[18] *See NOI* at ¶ 48.

[19] *See id.* at ¶ 29.

B. Spectrum Sensing and Monitoring

A real-time database used in conjunction with geolocation technologies is an important mechanism to manage access to shared spectrum. In adopting the TV white spaces rules, the Commission wisely decided at this time to allow the database to serve as the primary tool for devices to identify available spectrum at a particular location. However, the Commission also left open the future independent use of sensing technology. Because sensing and related technologies such as beacons and cooperative sensing have the potential to make large amounts of spectrum available for shared use, Google strongly supports their development.[20]

For the same reasons, we agree with the Commission that a monitoring network of sensors and measurement systems, external to devices and deployed atop buildings, would encourage dynamic spectrum access by disseminating data about real-time spectrum use and availability.[21] Key to the system of monitors is that the output be open and transparent to all parties, potentially feeding the real-time database. The network could be operated or managed by the public sector, similar to weather monitoring equipment.

We agree with the Commission's assessment that much of the technology is still untested and that many technical issues remain.[22] For this reason, we urge the Commission to proceed with a test-bed, both to determine the value of monitoring networks and to develop and refine technical concepts. Aside from testing equipment, a test-bed has the additional advantage of gathering information about other technical questions, such as appropriate propagation models.

[20] *NOI* at ¶ 18.

[21] *Id.* at ¶ 50.

[22] *Id.* at ¶ 18.

C. Underlays

Google supports efficient spectrum sharing through use of technology. Thus, we urge the Commission to reexamine whether to adopt an interference temperature technique as a means of interference management among competing users, as previously recommended by the Commission's Spectrum Policy Task Force.[23] Low-power wideband underlay transmitters are able to monitor interference temperature and adjust their operations accordingly in order to avoid disruption to other users. Consequently, such transmitters enable spectrum sharing even in bands with no unassigned spectrum, and thus are an important means to facilitate flexible spectrum sharing. As Google has stated previously,[24] an interference temperature approach also would improve the Commission's existing standard of what constitutes potential harmful interference and permit the Commission to provide greater non-interfering access to spectrum in a timely manner.

V. Conclusion

Google applauds the Commission for examining how to promote dynamic spectrum access. We believe that dynamic, opportunistic access will stimulate entry of new competitors and entrepreneurs into the marketplace, advance innovation, and encourage efficient usage of our nation's valuable spectrum resources. We urge the Commission to seize this opportunity to

[23] *See* Federal Communications Commission Spectrum Policy Task Force, *Report of the Interference Protection Working Group* (Nov. 15, 2002), *available at* http://www.fcc.gov/sptf/files/IPWGFinalReport.pdf.

[24] *See* Google Wireless Innovation Comments at 23.

identify spectrum available for dynamic access and to adopt policies to promote widespread usage of that spectrum.

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