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	)	

To: The Commission

RESPONSE OF xG TECHNOLOGY, INC.

By its attorneys:

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SUMMARY

xG Technology, Inc. ("xG" or "the Company") fully supports the Commission's goals of making more spectrum available to support the exploding demand for fixed and mobile voice, video and data services. As the Commission has noted in the past, unlicensed spectrum allocations have spurred rapid innovation and the delivery of a wide range of new technologies and applications – due primarily to its flexible use rules and the ability to use this spectrum free of charge.

The Company applauds the Commission for its vision and work to bring forth other creative policies that help make additional spectrum available via geo-databases, opportunistic use and dynamic spectrum access using cognitive radio technologies. The early success of TV white spaces demonstration projects is a testament to that vision, as well as the capacity of industry to innovate when given access to shared spectrum resources.

To maximize the benefits of these newly available resources, the Company cautions the Commission against taking a one size fits all approach to its dynamic spectrum access policies and service rules. In particular, rural areas should not be subject to the same power and antenna height limitations as those that may be necessary for more populated urban areas. Today's location-aware and cognitive radios can easily follow different rural or urban service rules - while effectively guarding primary or other protected spectrum users from interference. By making the deployment of rural wireless broadband systems more economical for service providers, the Commission can help industry better realize the goals set out in the National Broadband Plan.

For similar reasons, policies developed for opportunistic use and dynamic spectrum

access should also remain flexible – taking into account the level of sensing and cognitive capabilities that advanced radios systems like the Company's xMax® network are already demonstrating today and that are certain to improve over time. The Company strongly urges the Commission to develop flexible spectrum use policies and rules that are focused on a desired set of outcomes, and not to dictate specific technologies or methodologies that radios must follow to achieve them. This will enable industry to develop and deploy new innovations that leverage the best ideas found in database-driven spectrum access, cognitive/sensing radios, or a combination of these and other emerging techniques and technologies.

By developing flexible policies that stress objectives and outcomes over prescribed methodologies, a wide range of consumer, enterprise and public safety benefits can be realized at minimum cost and maximum benefit.

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xG Technology, Inc. ("xG" or "the Company"), by its attorneys and pursuant to Section 1.415 of the Commission's Rules, respectfully submits the following responses to the Commission's *Notice of Inquiry* on promoting more efficient use of wireless spectrum through dynamic spectrum use technologies (the "*Dynamic Spectrum Access NOI*").

STATEMENT OF INTEREST

xG is a developer of a broad portfolio of wired and wireless communications intellectual property, including cognitive radio networks.[1] During the past year, the Company has successfully deployed cognitive cellular mobile radio test networks in Fort Lauderdale, Florida and rural Arkansas using the unlicensed 900 MHz band. More recently, the U.S. Army awarded xG a contract to conduct laboratory and field tests of its xMax® cognitive cellular network for potential use by military forces. Under the terms of the contract, the Company has delivered xMax® equipment to the Fort Monmouth, N.J., lab facility for the Army's Communications-Electronics Research, Development, and Engineering Center (CERDEC). In addition, the Company will install and provide training for the Army to operate a multisite xMax® system over a large part of the U.S. Army's Fort Bliss Desert Training areas. The Company has commercialized its technology through a range of spectrum-agnostic, cognitive radio solutions

[1] To avoid any potential misunderstanding, xG notes that the Company is not affiliated with the DARPA NeXt Generation Communications Program ("XG Program") discussed at ¶ 10 of the *Dynamic Spectrum Access NOI*.

that enable commercial service providers and public safety entities to deliver a wide range of fixed and mobile wireless services using licensed and/or unlicensed spectrum.[2]

COMMENTS

To begin, xG applauds the Commission for initiating its timely inquiry into dynamic spectrum access technologies. The National Broadband Plan calls for the FCC to make 500 megahertz of spectrum newly available for broadband use within the next ten years, including 300 megahertz between 225 MHz and 3.7 GHz. The Company believes that cognitive radio technology, combined with flexible spectrum access policies and rules, will play a vital role in meeting this ambitious goal. With respect to the use of dynamic spectrum access technologies in rural areas, the Company urges the Commission to move quickly to adopt policies and rules that maximize technical flexibility for rural operations and that embrace its earlier public interest findings from the *Rural Spectrum Access Report and Order*.[3] Relaxing maximum transmit power and antenna height limitations in rural areas for spectrum bands identified for dynamic spectrum use will encourage business opportunities and spur competition by reducing the cost of serving sparsely populated rural areas. Enabling dynamic access technologies in this manner will provide direct economic benefit to rural areas and it will help the Commission to achieve policy goals that are central to the National Broadband Plan.

With these thoughts in mind, the Company is pleased to offer the following responses to the Commission's *Dynamic Spectrum Access NOI*:

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[2] Further information about the Company can be found at www.xgtechnology.com.

[3] *See* Facilitating the Provision of Spectrum-Based Services to Rural Areas and Promoting Opportunities for Rural Telephone Companies to Provide Spectrum-Based Services, WT Docket No. 02-381, *Report and Order and Further Notice of Proposed Rulemaking*, 19 FCC Rcd 19078 (2004) (*Rural Spectrum Access Report and Order*).

I. Information on the Current State of the Art in Dynamic Radios and Current System Deployments

In its NOI, the Commission seeks information on the current state of the art in dynamic radios, the current state of equipment and system development, and reports from private and public deployments that are operational today.[4]

The Company is pleased to report that it has been demonstrating two cognitive cellular mobile radio systems for about a year. One system covers a 32-square mile area in Fort Lauderdale, Florida while the other operates in rural Arkansas. These systems operate in the unlicensed 900 MHz band under Part 15 rules and have successfully demonstrated cognitive concepts such as avoiding interferers, making fast seamless channel and cell jumps and using interferer mitigation tools at the receiver, while delivering toll quality mobile VoIP service. This project has resulted in many discoveries by the Company that define ways to share spectrum with non-cognitive users while using highly congested "junk" spectrum to deliver very high QOS real time voice and data. The Company believes that cognitive systems should operate very similarly to the rules for the unlicensed 900 MHz band, augmented by the spectrum authorization schemes that are the subject of this *NOI*.

II. Promoting Advances in Dynamic Spectrum Access Radios

The Commission correctly observes that the inclusion of spectrum sensing capabilities could be an important component of dynamic spectrum use.[5] The ability to detect and avoid other spectrum users will allow commercial and public safety licensees to maximize the efficiency of their networks and it will allow the Commission to maximize the utility of shared-use spectrum bands. However, deployment of spectrum sensing technology in the real world

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4 *Dynamic Spectrum Access NOI* at ¶ 18.

5 *Dynamic Spectrum Access NOI* at ¶ 20.

can be very complex, and if the Commission's experience with the TV White Spaces proceeding is any indication, it may be extremely difficult for industry and regulators to reach consensus on common standards that would allow the use of spectrum sensing in licensed spectrum bands.

The Company believes that spectrum sensing makes the most sense when the technology is deployed in shared-use bands. When so deployed, the FCC should be mindful of allowing maximum technical flexibility to promote innovation and to maximize beneficial spectrum use. In this regard, the Company believes that flexible spectrum sharing rules, conjoined with simple noise floor measurement should be good enough. If a device is aware of its location, if it has a basic internal database of expected primary users and if it can listen for those users, this should be sufficient to authorize initial operation. Upon initial operation, an end user device could download more specific and up-to-date primary user information and use that to validate its right to transmit, or potentially choose a more acceptable frequency.

The *NOI* also seeks comment on whether the Commission may be able to integrate, in the not-too-distant future, sensing techniques with the techniques that it recently authorized for unlicensed Television Band Devices that include geo-location and database functions as a means for accessing other spectrum bands.[6] The Company supports the integration of databases with spectrum sensing techniques, since database tools can be used to identify appropriate "domains" (*i.e.*, spectrum bands that are best suited for use at any given time or location) for dynamic spectrum use.

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[6] *Dynamic Spectrum Access NOI* at ¶ 24.

III. Suggestions with Respect to Policy Radios

With respect to policy radios, the Commission has asked for comment on appropriate procedures for setting dynamic spectrum access policies and the appropriate hierarchy among the federal government, industry, and end users.[7] The Company respectfully offers the following suggestions:

When determining the "how and who" of policy development for opportunistic use and dynamic spectrum access, the goals of various stakeholders must be considered. In this case, the policies should be developed to:

- promote efficient spectrum sharing, higher overall spectrum utilization, and maximum public value;
- minimize interference caused by users of policy radios to the primary spectrum users;
- minimize interference between policy radio users; and
- encourage (and if needed enforce) cooperation and "fairness" among authorized users of the spectrum.

By breaking down the goals that policies are created to support, it becomes apparent that different aspects of the overall policy set could more effectively be developed by taking a distributed approach to policy definition. For example, the Commission has the largest stake in policies that promote high spectrum utilization, public good and economic benefit. Policies that support these goals would be appropriate for the FCC (or other agencies with similar goals) to create.

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[7] *Dynamic Spectrum Access NOI* at ¶ 30.

Similarly, policies (and associated protocols and technologies) that maximize cooperation and sharing of spectrum resources among various users and product offers might be better addressed by industry. Industry policies would need to be consistent with (and subject to) to the foundational policies and rules developed by the Commission. Industry policies could be developed through established standards bodies or industry associations. Some examples may include the IEEE 802.11af task group as well as the Wireless Innovation Forum. The FCC should retain oversight responsibility to ensure that policies developed by industry are evenhanded and do not unduly favor incumbent interests or discriminate against innovative companies or new technologies.

These policies could be included as part of individual service rules as was done with TV White Spaces. However these rules could be added separately from the service rules particularly when previously allocated bands become available for opportunistic use, or when spectrum licensees and policy radio users are able to form a mutually beneficial leasing arrangement.

There is a wide range of factors to consider when developing policies. These include the possibility that the radios under the policies' control may have different capabilities, sensing and flexibility in responding to and adapting to conditions that keep them in compliance with policy objectives. That is, policies should help define a set of goals for spectrum use and not how a particular radio or system should meet those goals. Indeed, policies adopted for a particular spectrum band may vary depending upon the specific capabilities of the radios or systems being deployed in that band. For example, radios with specified cognitive capabilities (*i.e.*, devices that are able to sense interference, to dynamically change channels and/or to adjust power as a way to avoid interference with other users) could be subject to a less prescriptive set

of policies and rules than radios that lack these capabilities. The Commission should avoid taking a "one size fits all" approach to policy requirements within a radio band and instead support policies that consider emerging capabilities found in cognitive and software defined radios (SDRs).

As radio technology continues to evolve, the Commission should review its policy rules based on requests from spectrum licensees and industry so that polices remain only as prescriptive as needed and are appropriately relaxed so that users can take advantage of new radio capabilities as they emerge.

Methodologies of policy distribution to radios should similarly take into account the nature of the radio, spectrum, application, and the policies themselves. More specifically, the dynamic aspects of the policy (location-based, time of day, interference thresholds, power levels, etc.), specific aspects of the radio (mobile or fixed, high or low power, urban or rural location), aspects of the spectrum (propagation characteristics, licensed or unlicensed, etc.) should determine the distribution requirements. For example, TV White Spaces radios must contact the database and supply the database with the radio's geo-location information in order to get an approved channel list before the radio can start transmitting. The radio must also recheck with the database at least every 24 hours or when it changes locations.

While this is appropriate for situations where radio or spectrum availability can change on a highly dynamic basis, it may be overly burdensome and costly for radios that are deployed in fixed locations, operate at low and/or fixed transmit power or operate in stable frequency allocations. In this case, appropriate policies could be incorporated into the radio system at the time of manufacture or installation.

IV. Promoting the Use of Dynamic Spectrum Access Radios for Spectrum Licensed under Flexible Use Policies and Suggestions to Promote Broadband Service in Rural Areas

xG agrees with the Commission that dynamic spectrum access radios and associated spectrum management techniques hold great potential for enabling highly efficient spectrum use and the possibility of innovative spectrum sharing arrangements within spectrum bands that are already licensed pursuant to the Commission's flexible use policies and rules.[8] These policies allow licensees and spectrum lessees wide latitude to utilize new technologies and implement new spectrum management techniques so long as that use is consistent with applicable service rules and others are protected from harmful interference.

However, to promote the use of dynamic radios in spectrum that is licensed for flexible use, the Commission can do more to facilitate the economic deployment and use of these technologies. xG strongly believes that the Commission's policies and rules should take into consideration the environment in which opportunistic and dynamic use systems will be deployed. In particular, radio systems deployed in rural areas should not be subject to the same restrictions as those deployed in urban areas. Case in point – antenna heights and maximum transmit power allowed for TV White Spaces operations are currently the same no matter where the White Space system is deployed. While these restrictions may be appropriate for urban, suburban or rural deployments near the edge of the exclusion zones, the Commission's rules need to be more flexible and allow additional tower height and/or transmit power for rural deployments that are large distances from exclusion zones. Relaxation of rules for remote rural areas not only makes sense from a technical standpoint, but it also would support more cost effective and faster rollout of wireless rural broadband connectivity. The Company therefore

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[8] *Dynamic Spectrum Access NOI* at ¶ 36.

urges the Commission to move quickly to adopt policies and rules that maximize technical flexibility for rural operations and that embrace its earlier public interest findings from the *Rural Spectrum Access Report and Order.*[9] Relaxing maximum transmit power and antenna height limitations for all spectrum bands that have been identified for dynamic spectrum use will encourage business opportunities and spur competition by reducing the cost of serving sparsely populated rural areas. Enabling dynamic access technologies in this manner will provide direct economic benefit to rural areas and it will help the Commission to achieve policy goals that are central to the National Broadband Plan.

xG respectfully submits that the Commission has already made the necessary public interest findings in the context of its *Rural Spectrum Access* proceeding (WT Docket No. 02-381), and it has already developed a suitable baseline definition for "rural areas" – counties (or equivalent) with a population density of 100 persons per square mile or less, based upon the most recently available Census data – that it can use for purposes of implementing its dynamic spectrum use regulatory policies. The Commission has found that definitions based on county boundaries are easy to administer and understand, population data based on county boundaries are widely available to the public, and county boundaries rarely change.[10] This definition encompasses 2,331 U.S. counties with a total population of approximately 60 million people. These figures, based on the 2000 Census, correspond to approximately 72 percent of all U.S. counties and 21 percent of the total U.S. population.[11]

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[9] *See* Facilitating the Provision of Spectrum-Based Services to Rural Areas and Promoting Opportunities for Rural Telephone Companies to Provide Spectrum-Based Services, WT Docket No. 02-381, *Report and Order and Further Notice of Proposed Rulemaking*, 19 FCC Rcd 19078 (2004) (*Rural Spectrum Access Report and Order*).

[10] *Rural Spectrum Access Report and Order* at ¶ 11.

[11] *Id.*

V. Unlicensed and Licensed Spectrum Use Models

The Commission recognizes that spectrum users are increasingly using a combination of unlicensed networks and dedicated licensed networks to access different spectrum for broadband services. Accordingly, the *NOI* seeks comment on what different types of complementary spectrum models have been developed, and what kinds of models might be anticipated in the future.[12]

xG is a developer and provider of cognitive cellular radio solutions that currently operate in an unlicensed frequency band. The Company has had a keen interest in opportunistic use of licensed spectrum bands to enhance and extend the capabilities of its xMax® cognitive cellular network equipment. The Company is designing its xMax® cognitive cellular radio solution to offer a scalable range of equipment solutions for licensed, unlicensed and complementary spectrum applications. Significantly, the benefits of complementary spectrum use are not limited to commercial carriers, but also encompass a wide variety of wireless system operators and applications.

There are a number of applications that the Company envisions for xMax® and other cognitive technologies in mixed licensed/unlicensed operations including:

- Rural broadband access, low-cost mobile cellular systems (for mobile voice, messaging, data and video delivery over a single network);
- Supplementing public safety, emergency response and other first responder wireless communications;
- Smart Grid communications for electric utilities, that are needed for modernization and increased efficiency/conservation of power generation, distribution and load-balancing;
- Machine to machine (M2M) communications and enabling the "Internet of things;"

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[12] *Dynamic Spectrum Access NOI* at ¶ 42.

- Smart City networks and applications including traffic and security video monitoring, telemetry and environmental monitoring, mobile workforce support, public broadband delivery (access point back-haul, or direct wireless access over WS enabled xMax®); and
- Wireless bandwidth capacity offload for both public and private commercial networks.

As the Commission is well aware, major mobile network operators are actively leveraging unlicensed spectrum and technologies (*e.g.* Wi-Fi) to offload significant data traffic from their licensed spectrum networks. TV White Spaces flexible use spectrum has also garnered significant attention and has been used to demonstrate its efficacy in delivering a wide range of services including rural broadband, smart city and smart grid applications.

These examples should mold Commission policy in a very clear way. Unlicensed and flexible use spectrum not only plays a vital role in supporting traditional consumer applications, such as cordless phones and wireless LANs, but it also provides a complementary capability to a wide range of business, public safety and other networks. Therefore, additional unlicensed spectrum allocations are both warranted and needed to promote new innovations in technology, business models and competition, as well as efficiently providing added capabilities and capacities to licensed spectrum operations

VI. Test Beds for Developmental Purposes

The Commission believes it may be appropriate to create one or more test beds where dynamic radios can operate subject to real world conditions. The FCC's designated test beds would identify frequency bands and geographic areas where dynamic radios could operate, and establish "ground rules" to facilitate the development of dynamic radio technologies.[13]

[13] *Dynamic Spectrum Access NOI* at ¶ 47.

The Company agrees with the Commission that the need for developmental test beds is paramount. In this regard, the Company may want the flexibility to augment its experimental testing to include cognitive radio systems operating in other designated bands, under rules that can support mobile cellular broadband services. The TV White Spaces rules currently in effect are too restrictive in that mobile devices are very power limited and the sensing rules are too restrictive, especially in rural areas where the risk of primary user interference is minimal.

VII. Use of Real Time Databases

The *NOI* suggests that an alternative approach for enabling dynamic spectrum may be to extend the concepts underlying the rules for Television Band Devices to additional spectrum bands. Under such a system, devices would rely on a real-time database to obtain up-to-the-minute information on spectrum availability for any given location.[14]

For spectrum and locations that may require opportunistic use systems to avoid interfering with mobile or low powered devices with primary access rights, a combination of real time databases and distributed cognitive sensing (with detect and avoid capabilities) should provide primary users sufficient protections while making unused spectrum capacity available for flexible use.

The Company has demonstrated significant benefit from cognitive capabilities deployed in radio networks in a shared unlicensed band. Cognitive capabilities have enabled the Company to deploy carrier grade services in what is commonly considered "highly saturated" spectrum in the unlicensed 900 MHz band (902 to 928 MHz). Even in the presence of mobile/portable devices, real time interference mitigation and avoidance have allowed the Company to recapture significant bandwidth and greatly increase the total utilization of this

band. The addition of a real time database that informs the cognitive radios' process by providing gross conditions on spectrum availability, would not only potentially increase the radio's access to additional spectrum (even if on a temporary or geographic basis) but also set boundaries on the amounts and locations of spectrum needing to be analyzed – and thus simplify the sensing and computational requirements of the radios.

In summary, the Company sees significant advantages to enhancing cognitive radios with real time spectrum databases. While the databases alone will tell the radios what frequencies, power limits, etc. the radios *can* use, cognitive capabilities in the radios (at the edge of the network) can tell them what frequencies and power they *should* use in order to minimize interference (with primary and secondary users) and maximize total user and network throughput. The combination of these technologies should provide sufficient protections in bands where primary spectrum users are mobile, operate at low-power or are particularly sensitive to interference.

It is worthy to note, however, that using a central database to authorize a radio poses some substantial risk. It is proposed that before any radio can transmit, it must be authorized by a central database. Likewise, the "lease" on that authorization has been proposed to be 24 hours. Let us suppose a success scenario wherein millions of diverse users of such radios come to depend on the communications link or network to conduct ordinary business. A failure of the database, an act of cyber terrorism or maybe even a simple fiber line cut could disrupt access to the database. Within minutes, radios would cease to function across the country. Within 24 hours every single radio would be useless. In such case, at a minimum there must be a backup plan. Perhaps a radio would be allowed to re-authorize itself for some limited number of days

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[14] *Dynamic Spectrum Access NOI* at ¶ 48.

until the database is recovered. Perhaps the radio would fall back to the sensing method, which has been liberalized and simplified to a simple noise floor measurement process. In any case, relying upon only one authorization method would be too risky. This becomes even more apparent when one considers the potential of mass adoption by the public safety community.

VIII. Use of Dynamic Spectrum Access Radios by the Public Safety Community

The Commission believes that there may be considerable opportunity for dynamic spectrum access radios to be used by the public safety community and within public safety frequency bands. It has asked commenters to address whether dynamic spectrum access radios might be deployed in a seamless manner to replace existing public safety radios, including PTT radios.[15]

The Company agrees with the Commission that the public safety community can be greatly served by dynamic spectrum access. Dynamic spectrum access radios can be instantly reconfigured for a variety of existing and new services. PTT protocols are already in use over the Internet and cellular systems and pose no significant challenge to the reconfigurable radio. The Company also believes, based upon its own work, that transitioning to such disparate networks by public safety spectrum users can be seamless.

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[15] *Dynamic Spectrum Access NOI* at ¶ 54.

CONCLUSION

xG agrees that dynamic spectrum access presents a potentially huge economic opportunity in the U.S. for both private and commercial operations as well as the public safety community. However, a "one size fits all" approach to establishing regulations, for the sake of simplicity and ease of administration, would be ill advised especially for rural areas where greater power and antenna heights are needed to adequately cover large areas with low population densities. Sophisticated techniques in location awareness and cognitive radio, currently available, are capable of following different rules for urban and rural areas without causing interference to protected users. In many cases, spectrum sensing rules could be liberalized and often a simple noise floor measurement would be adequate.

Finally, the Commission should establish rules and policies that mandate goals and outcomes without specifying technologies and methodologies for achieving those goals and outcomes. This will foster an environment for innovations that leverage the best ideas in database-driven spectrum access, cognitive/sensing radios, or a combination of these for the greatest cost efficiency and public benefit.

Respectfully submitted,

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