Before the
Federal Communications Commission
Washington, DC 20554

In the Matter of:	)	
	)	
International Comparison and Consumer Survey Requirements in the Broadband Data Improvement Act	)	GN Docket No. 09-47
	)	
A National Broadband Plan for our Future	)	GN Docket No. 09-51
	)	
Inquiry Concerning the Deployment of Advanced Telecommunications Capability to All Americans in a Reasonable and Timely Fashion, and Possible Steps to Accelerate Such Deployment Pursuant to Section 706 of the Telecommunications Act of 1996, as Amended by the Broadband Data Improvement Act	)	GN Docket No. 09-137

To: The Commission

REPLY COMMENTS OF ALCATEL-LUCENT ON NBP PUBLIC NOTICE #6, SPECTRUM FOR BROADBAND

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SUMMARY

The world of mobile broadband services is just beginning to show its potential as millions of new devices and users enter the marketplace. Ubiquitous broadband is a platform agnostic concept that is rapidly becoming a reality where converged networks create a seamless experience for consumers. The market demands, and service providers must offer, a broadband world where mobility is no longer a trade-off but simply a different means to access the applications and services of choice.

This new, exciting world of ubiquitous broadband, regardless of platform, is challenged by a rapid increase in bandwidth consumption with a corresponding absence of new spectrum to meet this demand. Service providers need to employ all available means, including effective network management tools and new spectrum, in order to meet this exponential growth in demand and the quality expectations of consumers.

In its comments, Alcatel-Lucent provides the Commission with its view of the demand challenges in the wireless space, what spectrum bands are best positioned to support mobile wireless broadband, and some of the leading issues in maximizing the value of this spectrum. Alcatel-Lucent looks forward to working with the Commission to address the spectrum challenges facing the mobile broadband market.

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REPLY COMMENTS OF ALCATEL-LUCENT

Alcatel-Lucent welcomes this opportunity to respond to the Federal Communications Commission's ("Commission") sixth Public Notice of the National Broadband Plan seeking "focused comment on the sufficiency of current spectrum allocations … for purposes of the Commission's development of a National Broadband Plan."[1]

As the leading provider of broadband access solutions worldwide, Alcatel-Lucent is deeply involved in the research, development, and production of many innovative wireless networking technologies, including technologies that improve spectral efficiency. The following submission expands on the Reply Comments submitted by

[1] Comment Sought on Spectrum for Broadband, NBP Public Notice #6, GN Docket Nos. 09-47, 09-51, 09-137 (rel. Sept. 23, 2009) ("*Spectrum Notice*").

Alcatel-Lucent in the Commission's Notice of Inquiry regarding Innovation and Investment in the Wireless Communications Industry on November 5, 2009.[2]

Q1. WHAT IS THE ABILITY OF CURRENT SPECTRUM ALLOCATIONS TO SUPPORT NEXT-GENERATION BUILD-OUTS AND THE ANTICIPATED SURGE IN DEMAND AND THROUGHPUT REQUIREMENTS?

As recognized by Chairman Genachowski and the Broadband Task Force, the spectrum pipeline is drying up and a spectrum crisis threatens the future of ubiquitous mobile wireless broadband in the United States.[3] Growth in deployment and usage of devices such as smart phones, eReaders and netbooks over 3G networks doubled from 2006 to 2008, generating a rapid increase in bandwidth consumption from data-intensive applications.[4] As devices continue to proliferate and machine-to-machine connectivity is realized on 4G networks,[5] on a global scale, mobile data traffic is expected to increase approximately 1700% from 2008 to 2013.[6] This explosion in capacity demand will expose the fact that the current spectrum allocation for mobile wireless broadband in the United States is inadequate to support the expected demand.

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[2] Alcatel-Lucent Reply Comments in Fostering Innovation and Investment in the Wireless Communications Market, *Notice of Inquiry*, GN Docket No. 09-157 (rel. Aug. 27, 2009) ("*Notice of Inquiry*").

[3] Julius Genachowski, Chairman, Federal Communications Commission, *America's Mobile Broadband Future*, Remarks at International CTIA WIRELESS I.T. & Entertainment at 4 (Oct. 7, 2009) *available at* http://hraunfoss.fcc.gov/edocs_public/attachmatch/DOC-293891A1.pdf. See also the National Broadband Plan Status Update during the FCC's September 29, 2009 Meeting, Slide 66

[4] *Mobile Broadband Spectrum Demand*, Rysavy Research, Page 6, (Dec. 2008) *available at* http://www.rysavy.com/Articles/2008_12_Rysavy_Spectrum_Demand_.pdf

[5] For example, the LTE Connected Car illustrates how 4G/Long Term Evolution (LTE) mobile broadband access technology is poised to bring a host of new applications and services to the automobile that are not possible today with current wireless technologies. *See* Alcatel-Lucent's development of the LTE Connected Car concept, *available at* http://www.ngconnect.org/ecosystem/connected-car.htm.

[6] Alcatel-Lucent, "The Effect of Regulations on Innovations and Technical Efficiency of Networks" (Slide 6), at 3G Americas/CTIEL Seminar: "Spectrum Requirements for Broadband Deployment," November 9, 2009.

In light of the exponential growth in wireless user demands, the Commission will need to allocate additional spectrum for commercial mobile services. With additional licensed spectrum – ideally below 1 GHz, but up to 4 GHz – for mobile wireless broadband network deployment, and above 4 GHz for licensed point-to-point microwave radios to provide wireless backhaul, operators will be able to deploy more robust, highly managed and efficient, heterogeneous wireless networks (i.e., layered networks that include microcells, pico cells and femto cells, utilizing higher frequency bands up to 4 GHz to add capacity, in addition to macrocells utilizing lower frequency bands to provide further coverage). With the ability to realize increased coverage and capacity over macro cellular as well as micro cellular infrastructure, mobile wireless broadband operators will be able to provide consumers with a truly mobile, high-bandwidth experience they expect today and in the future.

A. How should the Commission think about the capacity of existing allocations and their ability to support growth in wireless broadband?

It is important to consider how to quantify the way electromagnetic signals can convey information, and to identify the elements that set the upper boundaries to wireless information transmission. Often, the term spectral efficiency is used to describe how many bits of information are conveyed by each Hertz of spectrum for a given radio system. Spectral efficiency is a very useful metric for capturing the communication efficiency of a given transmitter-receiver pair, and it shows that present technologies are

very close to the theoretical Shannon limit. This fact leaves little room for significant additional spectral efficiency improvements in the future.[7]

However, the supply economics of wireless connectivity is not only linked to how many bits per Hertz can be conveyed, but also the number of radio transmitters (base stations) needed to cover the demand of a given area. In order to quantitatively evaluate wireless network economics, like in all market evaluations, a careful look at supply and demand is in order. Looking at spectral efficiency alone, lower frequency spectrum with better propagation characteristics offers significant advantages. However, one must also look beyond spectrum efficiency and consider the number of radios needed to cover the demand of a given area. In doing so, we observe that in most urban environments, the challenge is network capacity; that is, the ability to satisfy the demand generated by the large number of users per square kilometer.

The best way to establish a framework to assess spectrum economics is by an extension of the spectral efficiency concept that we will call Radio Data Flux Density, RDFD or *F*. We will define this as the bit-rate per Hertz per square kilometer per transmitter, or mathematically as:

$$F = \frac{[bps]}{[Hz][km^2][trasmitter]}$$

where $[bps]$ is expressed in bits per second and $[trasmitter]$ represents the number of transmitters, and thus helps us assess the number and type of radio sites. With RDFD we quantify within a single variable (F) the bit-rate, the spectrum, the surface covered, and the number of transmitters (sites), thus providing all the technical and economic

[7] Alcatel-Lucent Reply Comments in Fostering Innovation and Investment in the Wireless Communications Market, *Notice of Inquiry*, GN Docket No. 09-157 (rel. Aug. 27, 2009) ("*Notice of Inquiry*").

information needed to assess the usefulness of a wireless network at a given spectrum allocation condition.

To characterize the supply side of wireless connectivity, we need to consider the channel size and the number of wireless data sources per square kilometer, so from RDFD, we can deduct the available connectivity Supply Density, *S*, as follows:

$$S = F \times B \times T = \frac{[bps]}{[km^2]}$$

where *B* is the channel bandwidth and *T* is the number of transmitters (connectivity sources) and *F* is the above mentioned flux density, RDFD.

We need a similar parameter to characterize the demand side of wireless connectivity. Having made our network figure of merit dependent on coverage, we have to quantify now the connectivity demand per square kilometer, so we will call this quantity Radio Data Demand Density, RDDD, *D*:

$$D = \frac{[bps]}{[km^2]}$$

To assess the capacity of existing allocations and their ability to support growth in wireless broadband, we need to study the growth path of connectivity Supply Density, *S*, and compare it to the growth path of the connectivity Demand Density, *D*. A network that works properly and fulfills the needs of its subscribers should obey the simple yet often challenging condition:

$$S \geq D$$

Connectivity supply has to be greater or equal to connectivity demand in order to avoid network congestion, frustrated users, saturated call centers, and subscriber churn. In the answer to the next question, we will analyze the quantitative aspect of connectivity

supply and demand considering reasonable demand parameters and assessing the needed infrastructure to fulfill the demand in question.

B. How should the Commission think about the trade-off between more spectrum and greater investment in network infrastructure as means of adding network capacity?

The Commission must consider the connectivity supply possible with a given spectrum band, *S*, and the radio sites necessary to fulfill the connectivity demand, *D*, prompted by the device density per square kilometer in terms of adding network capacity.

	Number of devices per km^2	1,200		
	Primetime bit-rate Mbps	0.778		
	Prime time occupancy	20%		
	Prime time consumption per km^2 in Mbps	186.67		
Total Spectrum			UMTS HSPA+	Advanced LTE
30	Relative spectral efficiency (base of 1 = UMTS)		3	6
	Maximum FDD channel size in MHz	**5**		
	Mbps per sector or TRX		15	30
	Number of sectors per km2		12	6
	Number of 3-sector/cell base stations per km^2		4.1	2.1
60	Relative spectral efficiency (base of 1 = UMTS)		3	6
	Maximum FDD channel size in MHz	**10**		
	Mbps per sector or TRX		30	60
	Number of sectors per km2		6	3
	Number of 3-sector/cell base stations per km^2		2.1	1.0

In looking at the table provided above, we have the supply connectivity for two cases, one with 30 MHz of spectrum and another with 60 MHz of spectrum, both with common features including: a sectorized (3-sectors/cell) radio access network with frequency reuse 3 (the least noisy configuration); and identical connectivity demand – namely, 1,200 devices per square kilometer, where 20% of the devices use the network resources simultaneously at primetime with a throughput of 778kbps (e.g., for MPEG 4

compressed video streaming). Finally, given that signal propagation is not the limiting factor in dense urban environments, capacity of the network is the defining element governing the site count.

Comparing the number of sectorized base station sites needed to address the demand, the site count is dramatically impacted by two factors: one, better spectral efficiency through the use of next-generation Orthogonal Frequency Division Multiplexing ("OFDM") technologies like LTE-Advanced and WiMax; and two, having more spectrum. A carrier operating with 30 MHz of licensed spectrum will have to deploy twice the amount of sites than a carrier operating with 60 MHz of spectrum, significantly impacting the cost of infrastructure deployment. At the same time, this study confirms that doubling the spectral efficiency - from close to 0.75 bps/Hz (EV-DO and HSPA) to 1.0 bps/Hz (WiMax) to 1.5 bps/Hz (LTE)[8] - through the investment in and deployment of advanced, highly managed network infrastructure, such as LTE, is fundamental to the business case for wireless data connectivity. Thus, the capacity constraints that networks are currently facing can be alleviated by allocating more licensed spectrum for commercial mobile wireless broadband, adopting more spectral efficient technologies, such as LTE, and deploying advanced network management tools. As more data-enabled devices enter the market, investments in spectral efficient technologies alone will not suffice to meet the connectivity demand; more licensed spectrum will be fundamental to assure that the American people have access to mobile wireless broadband.

[8] *Mobile Broadband Spectrum Demand*, Rysavy Research, Pages 13-14, (Dec. 2008) *available at* http://www.rysavy.com/Articles/2008_12_Rysavy_Spectrum_Demand_.pdf

C. Do unlicensed devices have adequate access to spectrum that can be used to provide wireless broadband services or as a complement to services provided over licensed spectrum?

Alcatel-Lucent believes there is adequate access to spectrum for unlicensed devices, especially in rural areas, to provide wireless broadband services. However, the unlicensed spectrum should not be viewed as a viable alternative to licensed spectrum for wireless broadband services. Last-mile wireless broadband networks require the interference protection that only exclusive-use licensed spectrum can provide. That said, a significant amount of throughput on 3G/WiFi enabled devices travels over the WiFi connection.[9] The 3G/WiFi enabled device model, of course, is not a truly mobile experience, as consumers are forced to download large files in a stationary environment, perhaps at home or in a coffee shop, over a typically unsecure and unreliable WiFi connection utilizing unlicensed spectrum. As operators move to heterogeneous networks (i.e., layered networks that include microcells, pico cells and femto cells, in addition to macrocells), some of the data currently carried over WiFi will migrate to the highly secure and reliable 3G and 4G mobile networks, potentially increasing the data demand even beyond the presently forecasted levels. Thus, the need for additional licensed spectrum increases.

Q2. WHAT SPECTRUM BANDS ARE BEST POSITIONED TO SUPPORT MOBILE WIRELESS BROADBAND?

The wireless industry is investing in short-term and long-term innovative technological advances in wireless network infrastructure to increase spectral

[9] Alcatel-Lucent Reply Comments in Fostering Innovation and Investment in the Wireless Communications Market, *Notice of Inquiry*, GN Docket No. 09-157 (rel. Aug. 27, 2009) ("*Notice of Inquiry*").

efficiency.[10] However, investments in technologies that boost spectral efficiency will only produce incremental gains in capacity to offer a limited increase in supply that will not meet the expected demand.

In order to facilitate greater capacity for mobile wireless broadband services, the Commission must allocate additional licensed spectrum for mobile wireless providers to combine macro cellular and micro cellular elements into the deployment of robust, heterogeneous mobile wireless broadband networks. With additional spectrum, advanced heterogeneous networks will provide increased connectivity to rural areas over larger, far-reaching macro cellular networks utilizing licensed spectrum in the lower frequency bands with greater propagation characteristics. Additionally, in order to meet capacity demands in more populated, urban areas, the Commission should allocate and license additional spectrum in higher frequency bands between 3 GHz and 4 GHz. Micro cellular elements relying on higher frequency bands and deployed as part of a heterogeneous network will provide increased capacity and densification of mobile wireless broadband networks in urban areas. Although the higher frequency bands lack sufficient propagation characteristics for technically and economically feasible macro cellular networks, the availability of large spectrum blocks provide for ideal circumstances for micro cellular networking utilizing licensed spectrum. Allocating licensed spectrum in the higher frequency bands will allow operators to meet the expected increase in capacity demands in urban areas, where mobile devices will be utilized most.

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[10] Alcatel-Lucent Reply Comments in Fostering Innovation and Investment in the Wireless Communications Market, *Notice of Inquiry*, GN Docket No. 09-157 (rel. Aug. 27, 2009) ("*Notice of Inquiry*").

Q4. WHAT ARE THE KEY ISSUES IN MOVING SPECTRUM ALLOCATIONS TOWARD THEIR HIGHEST AND BEST USE IN THE PUBLIC INTEREST?

Alcatel-Lucent concurs with Chairman Genachowski that the market and consumers, not regulators, are best positioned to determine the highest and best use of spectrum.[11] Exclusive use, flexible licensing, and technology neutrality, and support of a robust secondary market have been policies long endorsed by the Commission that ensure commercial mobile wireless spectrum is used effectively and efficiently, and the Commission should continue to employ this regulatory structure when allocating additional spectrum for mobile wireless broadband services.

In addition, the Commission should allocate large amounts of contiguous spectrum to facilitate higher throughput rates and promote greater efficiency in order to meet the data connectivity rates orders of magnitude beyond those of today. For this reason, the Commission should consider future spectrum allocations that support configurations up to 2 x 20 MHz to advance the deployment of technologies with peak data rates that exceed 100 Mbps, such as LTE.[12] LTE-Advanced, a future enhancement to the standard providing even higher peak data rates, can both support and benefit from even larger contiguous blocks of spectrum.[13] During the Commission's Broadband Workshop on Spectrum, Alcatel-Lucent and other industry participants indicated that a

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[11] Julius Genachowski, Chairman, Federal Communications Commission, *America's Mobile Broadband Future*, Remarks at International CTIA WIRELESS I.T. & Entertainment at 4 (Oct. 7, 2009) *available at* http://hraunfoss.fcc.gov/edocs_public/attachmatch/DOC-293891A1.pdf

[12] Verizon Wireless, "LTE: The Future of Mobile Broadband Technology," filed with Comments of Verizon Wireless, *Fostering Innovation and Investment in the Wireless Communications Market* ("Verizon Wireless Innovation Comments"), Notice of Inquiry, FCC 09-66 (2009).

[13] Third Generation Partnership Project ("3GPP"), "3GPP Partners Propose LTE-Advanced Radio Technology," press release available at http://www.3gpp.org/3GPP-Partners-propose-IMT-Advanced.

minimum of 80-120 MHz of contiguous spectrum is needed to support multiple licensees deploying technologies such as LTE requiring 2 x 20 MHz for each licensee.[14]

In order to facilitate the allocation of large amounts of contiguous spectrum blocks, the Commission must begin immediately to identify up to 1 GHz of additional spectrum within 5 years, as recommended by the International Telecommunications Union[15] and cited by many comments in this proceeding.

Q5. WHAT IS THE ABILITY OF CURRENT SPECTRUM ALLOCATIONS TO SUPPORT BOTH THE FIXED AND MOBILE WIRLESS BACKHUAL MARKET?

Alcatel-Lucent believes that current spectrum allocations to support the fixed and mobile wireless backaul market are inadequate. Due to the Commission's current rules for frequency coordination and interference protection, the current allocation of spectrum to support wireless backhaul is facing a shortfall because the current frequency planning rules are outdated and based upon technologies less resilient to interference. However, frequency coordination rules cannot be changed overnight. Therefore, in order to meet the current demand for wireless backhaul, the Commission must allocate additional licensed spectrum.

A. Do current spectrum allocations provide enough capacity for wireless backhaul? Should we expand the amount of licensed spectrum that can be used for middle mile or backhaul links to support broadband connectivity?

Given the past and anticipated future proliferation of devices, compounded with the adoption of machine-to-machine mobile wireless broadband connectivity and the data

[14] FCC's Broadband Workshop on Spectrum, September 17, 2009, available at http://www.broadband.gov/ws_spectrum.html.
[15] Estimated Spectrum Bandwidth Requirements for the Future Development of IMT-2000 and IMT-Advanced, Report ITU-R M.2078 (2006) ("ITU Bandwidth Requirements Report") at page 25.

demand discussed above for last mile networks, wireless backhaul also requires more spectrum to meet backhaul capacity demands. The Commission should examine whether the rules for frequency coordination and interference protection in Part 101 are outdated.

Revision of the frequency planning and coordination rules in Part 101, however, should not be taken to extremes. The current regulations have evolved over a 60-year history of point-to-point microwave systems. The rules are therefore designed to protect the existing systems in this band while allowing optimal use of the Part 101 bands. It is doubtful that incumbent operators will be in a position to endure a lower level of performance and path protection provided by the current rules, so it is more advisable to allocate additional spectrum for new, more spectrally efficient technologies. Additionally, it will be difficult – both technically and practically – to expediently change Part 101 frequency planning rules.

It would be better to allocate new spectrum with different rules for coordination. These new bands could take advantage of technologies like OFDM and other modulation types, smart antennas, beam forming, distributed array antennas, etc. which would in turn improve spectral efficiency and frequency planning. Once a sufficient volume of the older technology has been decommissioned, a migration of newer technologies into the existing Part 101 bands could take place to allow more dense location of stations.

CONCLUSION

Alcatel-Lucent agrees with Chairman Genachowski that a spectrum crisis is looming due to the expected increase in user demands, and that a shortage of spectrum could be a threat to the future of wireless broadband service in America. Alcatel-Lucent

fully concurs with the Commission that more spectrum must be allocated to commercial wireless services to address this exponential growth.

Respectfully submitted,

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