SOLVING THE CAPACITY CRUNCH

Options for Enhancing Data Capacity on Wireless Networks

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EXECUTIVE SUMMARY

Is massive spectrum reallocation urgently needed to address the capacity concerns of wireless carriers? The simple answer is no.

Many wireless carriers and their trade associations argue that the FCC must make hundreds of megahertz of spectrum available for wireless broadband in order to keep pace with customers' growing mobile data demands. But this is not so. Capacity problems can be addressed in numerous ways that do not involve spectrum. So while additional spectrum is a tool that can help relieve congestion on mobile networks, the current rush to reallocate is not necessary.

At some point in this policy debate, the word "capacity" began to be used nearly synonymously with the word "spectrum." The conflation of these terms has led to a disproportionate emphasis on spectrum reallocation as a solution to capacity constraints although it is merely one method of achieving that result. Indeed, additional spectrum is not the most effective alternative for increasing data capacity. Over the past four decades, spectrum reuse strategies have been over 60 times more useful in increasing data capacity when compared to spectrum assignments. Greater spectral reuse is an available and effective means of addressing wireless congestion, particularly when combined with a variety of other non-spectrum alternatives. So if numerous alternatives exist, is there really a spectrum *crisis*? The answer is self-evident.

The counterfactual "spectrum crisis" claim is particularly troubling because it is now being used to justify radical spectrum policy that could cause significant disruption for consumers. Fueled by statements in the National Broadband Plan prepared at the FCC, many are accepting the premise that federal government intervention is necessary to address an impending "spectrum crisis." There is ample evidence to the contrary.

This paper analyzes widely available public data and demonstrates that the "spectrum crisis" is factually revisionist. Wireless carriers do not suffer from a nationwide spectrum crisis; they face a capacity crunch in a limited number of locations. And there are a variety of tools at carriers' disposal for addressing capacity concerns. However, policymakers have not adequately explored these tools. As such, this paper demonstrates the need for a more comprehensive, quantitative and data-driven analysis of capacity-generating techniques that do not simply conform to foregone conclusions about the need for widespread spectrum reallocation.

- Section I establishes that claims of a "*spectrum crisis*" lack a convincing factual basis.
- Section II details some of the actions that carriers and the FCC can take to enhance the capacity of wireless networks.
- Section III demonstrates that several near-term spectrum sources exist.

➢ THERE IS SCANT EVIDENCE SUPPORTING THE ALLEGED "SPECTRUM CRISIS."

The factual basis for the "spectrum crisis" claim is underwhelming. For example, the answer to the fundamental question of how much spectrum mobile carriers need remains uncertain. It appears that the notion of a need for large-scale spectrum reallocation to address a shortage of mobile spectrum is based on questionable assumptions designed to achieve a

particular result. Tellingly, the central justification to reallocate significant amounts of spectrum came several months *after* the release of the FCC's National Broadband Plan. Even then, key pieces of data contradicting the Commission's conclusion were not analyzed in the FCC's technical paper.

- **CARRIERS AND THE COMMISSION HAVE VARIOUS, MEANINGFUL ALTERNATIVES TO ENHANCE NETWORK CAPACITY.**

Many parties overstate the extent of the capacity problem, on the one hand, and understate the availability of solutions, on the other hand. These parties fail to recognize the unrelenting pace of wireless innovation. The "spectrum crisis" is premised on false assumptions about the wireless industry's technological stagnation. In fact, wireless innovations are not a thing of the past, and the free market is as robust as ever—providing carriers with various options to address capacity concerns:

- Deploying innovative network technology upgrades that will promote spectral efficiency;
- Establishing pricing and other fair-use policies to lessen network congestion;
- Migrating voice traffic to Internet Protocol;
- Leveraging consumer infrastructure such as femtocells and wi-fi;
- Investing in infrastructure to enhance capacity through the deployment of Multi-Antenna Signal Processing (smart antennas), picocells, modernizing network architecture, Distrubted Antenna Systems, upgraded backhaul, sectorization and cell splitting;
- Prioritizing latency senitive data packets;
- Employing caching;
- Utilizing channel bonding; and
- Encouraging the development of bandwidth sensitive applications and devices.

In addition, the FCC can take concrete actions, within its current mandate and existing authority, that will not skew market forces and will help relieve network congestion and make better use of spectrum, including:

- Reclaiming hundreds of megahertz of spectrum from speculators and warehousers;
- Concluding and publicly releasing a comprehensive spectrum inventory;
- Increasing licensee flexibility; and
- Establishing receiver standards.

- **OTHER SPECTRUM SOURCES SHOULD BE MADE AVAILABLE.**

  Spectrum is a valued natural resource. Thus, the FCC should rapidly move spectrum into productive commercial use by:

  - Licensing unassigned spectrum bands languishing in the Commission's "pipeline;"
  - Reallocating government spectrum identified by the National Telecommunications and Information Administration (NTIA) as suitable for commercial use; and
  - Improving the secondary market for spectrum.

The Executive Summary of the National Broadband Plan explains that: "The plan is in beta, and always will be. Like the Internet itself, the plan will always be changing—adjusting to new developments in technologies and markets, reflecting new realities, and evolving to realize the unforeseen opportunities of a particular time." Thus, the time has come for the Commission to take an in depth and impartial look at quantifying the impact of non-spectral solutions on the capacity constraints of wireless networks and determine whether that data should alter the Plan's recommendations. While this paper provides numerous capacity-enhancing alternatives, several more exist. Many of these techniques individually have a significant impact on network congestion. The cumulative effect of these solutions will easily meet demands on wireless network capacity. Therefore, the Commision should fully examine all of the alternatives that will lead to greater wireless capacity and be cautious as it examines reallocation as a policy solution. Spectrum is not the cure all for data capacity needs and impulsive regulatory action will only yield unintended (and likely irreversible) consequences.

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I. A "SPECTRUM CRISIS" IS NOT SUPPORTED BY THE FACTS

As John F. Kennedy famously explained, "When written in Chinese, the word 'crisis' is composed of two characters—one represents danger and the other represents opportunity." The purported solution of reallocating large swaths of spectrum presents an opportunity for wireless carriers to gain access to long-coveted spectrum. After all, there is nothing like a "crisis" to help one obtain what would ordinarily be out of reach. However, this supposed "crisis" also presents the significant dangers of uninformed regulatory action, market disruption and unintended consequences.

A. A "Crisis" with Great Timing

The so-called "spectrum crisis" has its roots in the aftermath of the American Recovery and Reinvestment Act of 2009 (Recovery Act).[1] As part of the Recovery Act, the FCC was required to "analyze mechanisms for ensuring broadband access by all people of the United States; provide a detailed strategy for achieving affordability and maximum usage; and include a plan for use of broadband to advance national purposes such as education, health care, energy, and public safety."[2]

With passage of the Recovery Act, wireless carriers advanced a spectrum reallocation agenda at the FCC by claiming that increasing wireless congestion had resulted in a "looming spectrum crisis" that must be cured by significantly increasing the amount of spectrum available for mobile broadband.[3] This lobbying effort was belied by the fact that most of the major carriers had yet to make full use of portions of prior spectrum assignments, including most of the 150 MHz auctioned by the FCC in 2006 and 2008, and those that had started had not completed their build out.

In response to the Recovery Act, on March 16, 2010, the FCC released "Connecting America: The National Broadband Plan" (Broadband Plan or Plan), which concludes that an additional 500 MHz of spectrum should be made available for mobile broadband within the next 10 years, with 300 MHz to be made available between 225 MHz and 3.7 GHz within the next five years.[4] Central to reaching the five-year goal of the Plan was a proposal to reallocate 120 MHz of Ultra High Frequency (UHF) spectrum from television broadcasting to wireless broadband.[5]

The Broadband Plan itself did little to justify the conclusion that the reallocation was necessary. The Plan initially cited forecasts submitted by just three entities (Cisco Systems, Coda Research, and Yankee Group) predicting increases in future traffic as evidence of the impending "spectrum crisis."[6] It was not until October of 2010, some seven months after release of the Broadband Plan, that the FCC issued a report purporting to explain the Plan's claim that additional mobile broadband spectrum was desperately needed.[7] (*See section 1.C* below *discussing the flaws in the FCC's technical analysis and the unreliable nature of some of its source data.*) Thus, this policy decision appears to have been made in a classic cart-before-the-horse way. And it is all the more alarming that wireless carriers and the FCC appear to have discounted all the evidence that contradicts the "impending spectrum crisis" conclusion.[8] This paper demonstrates the need for a more comprehensive, quantitative and data-driven analysis on capacity-generating techniques that do not simply conform to foregone conclusions about the need for widespread spectrum reallocation.

B. The Amount of Spectrum that Mobile Carriers Claim to Require Is Little More than a Wish List

There is no denying that the corporate imperative of mobile wireless carriers is to obtain as much spectrum as they can. However, the fact that wireless carriers cannot find a unified voice on the amount and timing of their spectrum needs suggests that this advocacy is more strategic gamesmanship than factual reality.

It is clear that CTIA and its members were overreaching in claiming that mobile innovation hinged on that industry acquiring an additional 800 MHz of spectrum in six years.[9] Simply put, the wireless industry attempted to dress up a "want" as a "need." In this case, the amount of spectrum requested by the wireless industry was so far out of bounds that the Broadband Plan, without explanation, concluded that the Commission should make 40 percent less spectrum available and do so at a significantly slower pace, adding an additional four years. One would imagine that were the "spectrum crisis" real and were it truly "vital for [the wireless] industry to secure at least 800 MHz of additional spectrum within the next six years,"[10] the Commission's significant downward revision of the request would lead to loud protests in the form of angry op-eds and a push for a legislative fix. Instead, the wireless industry welcomed it with open arms.[11] And why not? CTIA appears to have deployed the old strategy that "if you shoot for the moon and miss you will be among the stars." As explained below, the figures presented by the National Broadband Plan are similarly overstated as they fail to measure meaningfully several capacity management alternatives.

Spectrum management should not be driven by demands like a proverbial Christmas wish list. Any parent will confirm that wants do not rise to the level of needs, much less crises.

The debate concerning the "need" for 800 MHz of spectrum has nearly drowned out the real question—whether a spectrum-centric solution should be the immediate focus to address wireless broadband capacity needs. Spectrum and capacity are not synonymous terms. While mobile carriers are concerned about capacity shortfalls in a limited number of locations, these concerns should not and cannot be addressed with a singular focus on spectrum. Instead, technological advances and localized solutions represent the best long-term solutions to address capacity constraints.

A decade ago, CTIA petitioned the FCC to stop granting spectrum to the mobile satellite services industry and reallocate existing MSS spectrum "to more efficient users of spectrum."[12] With striking similarity to the current debate, then CTIA CEO Tom Wheeler stated "The question is: Will we have the concrete on which the new information superhighway rides?" He then continued, "I'm sad to say that it is an issue very much in doubt. There is no single issue more important than whether or not there is sufficient spectrum for wireless data. It's half time, and we're down a bunch."[13] As it turned out, no reallocation occurred, MSS providers obtained more spectrum, the information superhighway did not experience a "concrete crisis," and Lightsquared, an MSS licensee, now seeks to deploy a spectrally efficient 4G network that "represents more than $7 billion of new investment, with the potential to create more than 100,000 new private-sector jobs within five years."[14] This history illustrates that aggressive reallocation demands by the wireless industry that would hobble the maturation/evolution of other services must be questioned by regulators.

The true need for additional spectrum to address capacity needs is unknown because neither advocates for spectrum reallocation nor the FCC have attempted to quantify comprehensively the impact of non-spectrum alternatives. This paper respectfully submits that the Commission should take a step back, fully document the impact of non-spectrum alternatives on wireless data capacity and then focus its efforts on solutions that will have the most meaningful effect on increasing wireless capacity.

AN INSATIABLE DESIRE TO DISPLACE OTHER SPECTRUM LICENSEES

THEN — MSS. *"The question is: Will we have the concrete on which the new information superhighway rides? I'm sad to say that it is an issue very much in doubt. There is no single issue more important than whether or not there is sufficient spectrum for wireless data. It's half time, and we're down a bunch."* CTIA CEO Tom Wheeler (2001).

NOW — Broadcasters. *"It is vital for our industry to secure at least 800 MHz of additional spectrum by 2015 at the very latest. Wireless spectrum is our industry's backbone and it is what allows us to continue to innovate and create new mobile apps, products and services. Without this additional spectrum, our industry will cease to provide U.S. consumers with the most innovative and most competitive mobile offerings."* CTIA CEO Steve Largent (2009).

C. The Analysis Underpinning the FCC's Technical Paper on the "Spectrum Crisis" Presents an Inaccurate and Incomplete Picture

OBI Technical Paper No. 6 attempts to provide "technical analysis to validate the need for additional mobile broadband spectrum in the near-term."[15] The report includes a significant disclaimer upfront: "The goal of this analysis is not to reach definitive numeric findings of spectrum need and economic benefit, but to make a reasonable demonstration that mobile data demand is likely to exceed capacity under current spectrum availability in the near-term."[16] While the Commission explains that "the inherent uncertainty of any forecast of the future" precludes a definitive numeric finding, it is the weaknesses in the OBI methodology that makes it an inappropriate tool for making long-term decisions about reallocating spectrum.

Foremost, the use of an incremental analysis skews the data in favor of the paper's ultimate conclusion. Incremental analysis is a short-term decision-making technique used to determine the cost difference between alternatives. The OBI paper does not adequately examine the cost benefit of several alternative solutions for meeting capacity demands, including many that were discussed in the

National Broadband Plan. These include the use of femtocells, prioritization, caching, channel bonding, the effect of increased allocation transparency, deployments on spectrum currently in the FCC pipeline, improvements in the secondary spectrum marketplace, and deployments that leverage unused spectrum that is identified and made available following a comprehensive spectrum inventory—all of which could significantly impact how much new spectrum is needed. Thus, by ignoring key issues that drive data demand and supply, the OBI paper is skewed toward a pre-ordained decision. Its conclusions are therefore biased and unreliable.

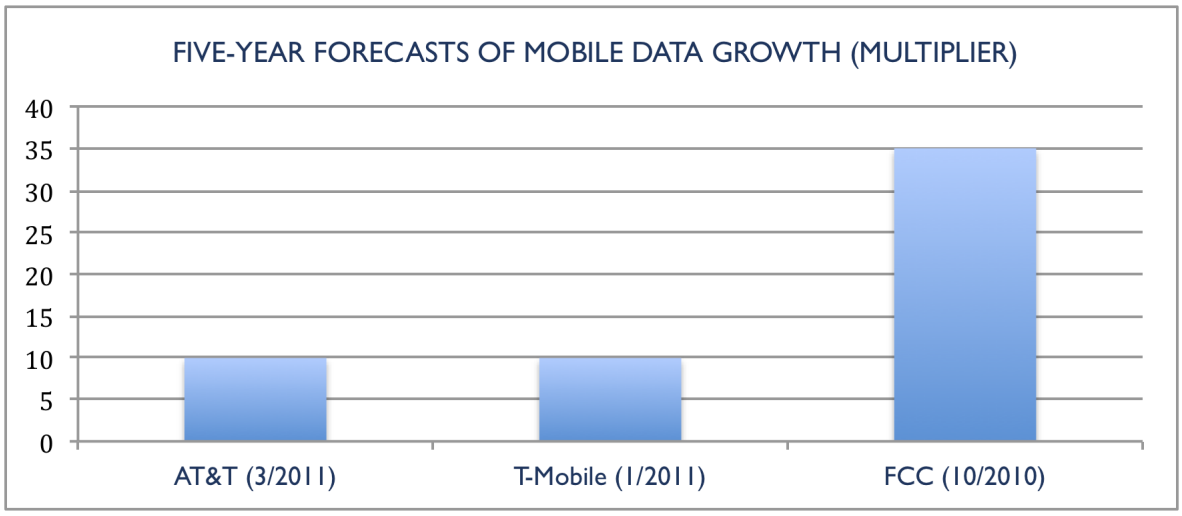
Second, in those instances where the paper acknowledges that certain factors will result in a downward adjustment to its ultimate conclusion, such adjustments appear to be overly modest.[17] For example, the paper concludes that in the face of significant data growth, carriers will respond with a mere 7% compound annual growth rate in the number of deployed cell cites.[18] In addition, the report concludes that it will take five years for spectral efficiency to double.[19] This, however, would represent a significant and perhaps unprecedented throttling of air-interface spectral-efficiency improvements, as it is estimated that the "rate of improvement in use of the radio spectrum for personal communications has been essentially uniform for 104 years" with "efficiency doubling every two-and-a-half years."[20] In addition, despite the substantial efficiency gains that Long Term Evolution (LTE) will bring to the handling of voice traffic (as explained below), OBI Technical Paper No. 6 concludes that the amount of spectrum required to provide voice services will remain completely unchanged for the next five years.[21]

AT&T predicts 8-10 times of data growth between 2010 and 2015 and T-Mobile forecasts that data will have 10 times of growth in 5 years. Yet, the Commission's assessment that 275 MHz of spectrum is needed to meet mobile data demand is premised on data growth of 35 times between 2009 and 2014.

Third, the Paper relies on suspect data. In arriving at its conclusion, OBI Technical Paper No. 6 relies heavily on forecast data from Cisco that is both wildly optimistic about data growth and unscientific. In a blog entry entitled, *Should a Sales Brochure Underlie US Spectrum Policy?,* Steven Crowley states that "[t]here is overlap between the people who prepare the forecast and the people responsible for marketing Cisco's line of core-network hardware to service providers. The forecast is used to help sell that hardware. Put simply, it's a sales brochure."[22]

In contrast, the Yankee Group's forecast of mobile data traffic by 2014 is approximately half that of Cisco. And the Yankee Group forecast (the most conservative estimate relied on by the Commission in the Paper) is considerably higher than forecasts recently released by both AT&T[23] and T-Mobile.[24] AT&T predicts 8-10 times of data growth between 2010 and 2015 and T-Mobile forecasts that data will have 10 times of growth in 5 years.[25] Yet, the Commission's assessment that 275 MHz of spectrum is needed to meet mobile data demand is premised on data growth of 35 times between 2009 and 2014.[26]

FIGURE 1: Data Growth Disparity



Fourth, the Commission's study incorrectly assumes that all future cell sites will be deployed for the purpose of adding capacity. Such an assumption is inconsistent with the fact that a significant portion of current cell sites were deployed simply for coverage in rural and suburban areas and are unlikely to require additional spectrum in the future due to flat demand and gains obtained through the deployment of spectrally efficient technologies. Recent commentary assesses the impact of this methodological error and concludes:

- "The FCC's *own analysis* shows that the incremental spectrum demand by 2014 is reduced from 275MHz to between 117MHz and 227MHz;"
- "The cost of deploying extra cell sites to serve this demand (the FCC's definition of 'economic value,' assuming a cost of $550K per cell site) is reduced from $120B to between $33B and $85B;"
- "Only 60K-155K additional cell sites are needed to meet demand, compared to the 99K that the FCC's model estimates will be deployed anyway in the next 5 years;" and
- To meet demand "[t]he annual growth in the number of base stations would increase from 7% … to between 10% and 15% ... which is not significantly out of line with the 12% growth in base stations that occurred in 2009, according to the FCC's own figures."[27]

Finally, there has not been critical examination of the assumptions that go into the forecasts upon which OBI Paper No. 6 relies. In particular, the paper appears to be premised on the highly suspect assumption that the high demand curve for mobile data will not slow. While smartphone growth is significantly increasing now, it will no doubt plateau and slow. It has been widely accepted for decades that the process of technological adoption over time is typically illustrated as a classic normal

distribution or "bell curve" where a phase of rapid adoption ends in slowed adoption as the product matures or new technologies emerge.[28]

As recently reported, Cisco now projects that U.S. mobile growth will drop by more than half by 2015.[29] As Dave Burstein, Editor of DSL Prime, explains: "The growth is clearly not exponential."[30] Mr. Burstein went on to say "Every CFO and engineer has to plan carefully for the network upgrades needed, but the numbers certainly don't suggest a 'crisis.'"[31] Jon Healey of the Los Angeles Times Editorial Board similarly explains that "Much of the growth in the demand for bandwidth has come from two parallel forces: a new type of smartphone (epitomized by the iPhone) encourages people to make more use of the mobile Web, and more people are switching from conventional mobile phones to these new smartphones. Once everyone has an iPhone, an Android phone or the equivalent, much of the growth goes away."[32] AP Technology writer Peter Svensson echoes this concern and explains "AT&T's own figures indicate that growth is slowing down now that smartphones are already in many hands."[33] Thus, the assumption that data demand will continue to grow unabated is deeply flawed.

II. THERE ARE NUMEROUS ALTERNATIVES THAT WOULD BOOST WIRELESS NETWORK CAPACITY

The official wireless industry position is that FCC regulatory involvement inhibits the "virtuous cycle" of innovation and competition: "the FCC appears focused on micromanaging the wireless industry, which will erode this virtuous cycle that benefits America's wireless consumers."[34] That is why it is puzzling that the "spectrum crisis" argument is built on the flawed premise of the wireless industry's technological stagnation[35] and the *necessity* of regulatory intervention.[36] In essence, CTIA and its members are now claiming that market forces and innovation are insufficient to address the growth of mobile data services and that the FCC must step in to correct this market failure. By simultaneously decrying government interference generally yet calling for it to "solve" this "crisis," the wireless industry is demonstrating that more spectrum is a want, not a need.

When pressed by investment analysts and shareholders, the mobile wireless industry is less sanguine about whether the "spectrum crisis" is real. In an April 2010 interview, Verizon CEO Ivan Seidenberg answered a question about the reallocation of broadcasters' spectrum by stating "Confiscating the [TV] spectrum and repurposing for other things, I'm not sure I buy into the idea that that's a good thing to do" and adding "I think the market's going to settle this."[37] Other carriers appear to agree. Sprint has stated that estimates of a spectrum shortage "may overstate the true need for more spectrum allocations" because "advances in technology can effectively help increase spectrum supply, thereby moderating the need for new allocations."[38] Similarly, T-Mobile's Chief Technology Officer, Neville Ray, has stated, "[t]here is a host of ways to tackle the growth that is coming. It's not just all about spectrum. It's clearly part of the story, but we are less worried about that in the near term."[39] Mr. Ray also noted "[w]e have gone from a world where devices were ahead of the network to a world where the network is ahead of the device."[40] And with the recent announcement that AT&T seeks to purchase T-Mobile, AT&T claims that the transaction would quickly provide "the spectrum and network efficiencies necessary ... to address impending spectrum exhaust in key markets."[41]

"There is a host of ways to tackle the growth that is coming. It's not just all about spectrum. It's clearly part of the story, but we are less worried about that in the near term." T-Mobile Chief Technology Officer, Neville Ray (Jan. 18, 2011)

In addition, those closely watching the market do not appear convinced of a demonstrated need for additional spectrum. Notably, an exhaustive 52-page international study conducted by Merrill Lynch's global equity research team in February of 2010 concludes that there is no overwhelming need for additional spectrum assignments and "reject[s] the carrier capex bear case (i.e., that mobile data growth and capex will outstrip carrier revenues)."[42]

Moreover, there is marketplace evidence that mobile data demands cannot be addressed simply through the acquisition of more and more spectrum. Clearwire's financial statements contend that it has the "largest spectrum position of any wireless service provider in the United States, with holdings exceeding more than 46 billion MHz-POPs."[43] The company claims to hold "approximately 140 MHz of spectrum on average across its national spectrum footprint and approximately 160 MHz of spectrum on average in the largest 100 markets in the United States."[44] Indeed, Clearwire has so much excess spectrum that it is attempting to sell portions of its spectrum holdings in order to finance and expand its network. Although Clearwire has an enviable spectrum position and has tacitly recognized that it has more spectrum than it needs, it appears that customers have been experiencing problems with the network's ability to adequately handle data traffic. Recently, 15 Clearwire customers initiated a class action law suit over the company's data throttling practices, accusing Clearwire of not delivering advertised "high-speed Internet" services to customers and charging them termination fees when they cancel because of poor service.[45] Clearwire's experience vividly demonstrates the importance of network investment to address growing data demand.

Rather than take a myopic view of spectrum needs, the Commission should recognize that radio network throughput is a function of a variety of factors including spectral efficiency, available spectrum and spectrum reuse. As explained below, the real choice here is between throwing more spectrum at the perceived problem, with the potential of unintended consequences, and insisting that carriers use a myriad of proven tools to address capacity concerns before reallocating large swaths of spectrum.

A. Before Claiming a "Spectrum Crisis" Exists, Carriers Should Leverage Available Marketplace Solutions

Cellular systems are designed so that each cell uses radio frequencies only within its boundaries. Thus, frequency reuse allows for the repeated use of the same spectrum across a cellular system, with little potential for interference. The reuse of frequencies is what enables a cellular system to increase capacity and handle a large number of calls with a limited amount of radio spectrum. Thus, the magic of cellularized systems is not so much the spectrum itself (as many have led us to believe) but the underlying engineering that makes efficient use of the spectrum.

According to wireless pioneer Martin Cooper, spectrum reuse has been over 60 times more effective than additional spectrum assignments in increasing data capacity.

It is difficult to overstate the importance of frequency reuse. Wireless pioneer Martin Cooper, who led the team at Motorola that developed the first handheld mobile phone, calculates that frequency reuse is responsible for a "sixteen hundred times improvement" in spectral efficiency in the last 45 years while additional spectrum assignments in the same time frame has improved spectral efficiency by a factor of "25 times."[46] Put another way, spectrum reuse has been over 60 times more effective than additional spectrum assignments in increasing data capacity. Moreover, network density is a key benefit touted

by AT&T concerning its proposed acquisition of T-Mobile: "[a]t closing, AT&T will immediately gain cell sites equivalent to what would have taken on average five years to build without the transaction, and double that in some markets. The combination will increase AT&T's network density by approximately 30% in some of its most populated areas, while avoiding the need to construct additional cell towers."[47]

Recent analyses, however, appear to discount the "host of ways" that carriers have to "tackle the growth that is coming."[48] The National Broadband Plan contends that "[i]n the absence of sufficient spectrum, network providers *must* turn to costly alternatives, such as cell splitting, often with diminishing returns."[49] In addition to failing to recognize the extraordinary effectiveness of frequency reuse,[50] the assertion is inaccurate—there are numerous less costly demand management approaches, as explained below. Moreover, the undue concern with the expense of certain infrastructure investments places the Commission in the inappropriate role of a central planner that determines the best manner is which private industry should allocate resources.

In addition, a focus on spectrum reallocation alternatives for generating capacity exacerbates existing powerful disincentives for carriers to address capacity shortfalls through technology and infrastructure investment. The Economist describes one of these powerful disincentives as follows:

> The cheapest way to increase capacity is to add more spectrum or to move a network to a lower frequency, which allows radio waves to penetrate walls more easily. So operators tend to lobby governments for more and better spectrum before investing in expensive kit. [51]

While the Economist suggests that adding spectrum is the cheapest way to add capacity, it may be more accurate to say it is the easiest way to accomplish that goal. Additional spectrum does not require development of new technology (for which the carriers are dependent on a limited number of manufacturers who have little motivation to invest large amounts of money to create new technology that will reduce the market for their products). In addition, technologies that result in more capacity per base station and per cell means fewer base stations and fewer cells and new deployment strategies.

Yet another reason carriers opt for more spectrum, consciously or not, is that "ownership" of spectrum is concomitant with exclusivity. When one acquires exclusive rights to spectrum, that spectrum is not available to others that might compete.[52] Thus, policy that rewards or encourages network infrastructure investments (rather than continuous additional spectrum assignments to the same entities) will help avoid congestion issues and, at the same time, serve to enhance the competitive landscape for wireless broadband services.

The "spectrum crisis" argument gives little, if any, credit to the pace of wireless innovation. But, wireless network improvements in recent years demonstrate that technology does not stand still. There is no reason to expect that the trend of wireless innovation will dissipate or even slow.

The Commission should recognize these disincentives as it moves forward on the Broadband Plan—public policy is not served by reallocating hundreds of megahertz of spectrum to make it cheaper and easier for wireless carriers to preserve high profit margins, rather than make additional investments in their networks. Moreover, as CTIA explains, the predominant factor leading to data demands

outpacing supply is *localized* congestion.[53] Therefore, any analysis of the "spectrum crisis" should weigh the relative cost/benefit of localized solutions, as discussed below.

1. Upgrading Network Technology

The "spectrum crisis" argument gives little, if any, credit to the unrelenting pace of wireless innovation. In fact, wireless network improvements in recent years demonstrate that technology does not stand still. There is no reason to expect that the trend of wireless innovation will dissipate or even slow. A review of the advances in spectral efficiency bears this out.

- First-generation cellular services using the AMPS standard had limited spectral efficiency.
- 2.75G networks almost *doubled* first generation efficiency using GSM+EDGE technology.
- 3G networks nearly *quadrupled* 2.75G efficiency using CDMA2000 1x EV-DO Rev. A.
- 3.5G networks employing HSDPA *more than doubled* 3G efficiency.[54]

Most wireless operators have widely deployed 3G networks and are implementing upgrades along the 3GPP High Speed Packet Access (HSPA) Evolution path,[55] particularly in urban coverage areas. Within the 3G upgrade path, upgrade costs can be very low for carriers that have relatively current equipment, enabling software or card upgrades. AT&T and Verizon Wireless are migrating directly to the highly spectrally efficient fourth generation LTE technology. LTE has received considerable attention because it allows a peak download speed of 100 megabits per second (Mbps) on mobile phones and is spectrally efficient, resulting in significant capacity gains. Assuming spectral efficiency advances stay on their current trajectory, there will be significant (and to-date insufficiently examined) capacity gains for mobile carriers.

2. Adopting Fair Use Policies

Unlike voice services, wireless data usage is marked by a small percentage of users generating disproportionate amounts of traffic. AT&T estimates that 3% of their smartphone users generate nearly 40% of total smartphone data traffic.[56] Much of the extreme data use involves video and streaming audio, which are both data intensive.

While unlimited data plans on mobile phones were once the standard, there is now more focus on using pricing as a network management tool. As AT&T Operations President John Stankey put it, "I don't think you can have an unlimited model forever with a scarce resource. More people get drunk at an open bar than a cash bar."[57] In the past year, AT&T and Virgin Mobile abandoned unlimited data plans. In 2010, T-Mobile announced that it would employ data throttling and slow the download speeds of customers that use more than five GB of data each month.[58] And Bloomberg reported on March 1, 2011 that "Verizon Communications Inc. will stop offering unlimited data plans for Apple Inc.'s iPhone as soon as this summer and switch to a tiered pricing offering that can generate more revenue and hold the heaviest users in check."[59] Usage-based smartphone data plans substantially reduce per-user data traffic. As a result, data growth is likely to slow over time. And companies, including Cisco, are marketing products to carriers to help make tiered data plans easier to implement and help carriers "increase the monetization of their networks."[60] Despite these

developments, many of the projections underpinning the "spectrum crisis" claim fail to take into consideration that fair use policies are increasingly serving as a network management tool.

3. Migrating Voice to Internet Protocol

Voice traffic remains a disproportionate user of network capacity, largely because it is handled much less efficiently than data. By some estimates, data traffic is handled 10 times more efficiently than voice.[61] Thus, carriers will obtain dramatic efficiency gains by migrating voice traffic from circuit-switched to packet-based/VoIP. Notably, LTE does not support existing circuit-switched voice and SMS services. While VoIP has become more popular over mobile data networks via over-the-top services like Skype, no operator has deployed a carrier-grade VoIP service to replace 2G circuit-switched voice services. This will soon change. Forbes reports that Verizon is aiming to offer Voice over LTE or VoLTE in 2012 and AT&T will do so in 2013.[62] VoLTE is the new name of One Voice, an initiative made up of dozens of vendor and service provider supporters seeking to back a common standard for voice over LTE. With a voice over LTE standard in place, LTE systems will see significant reductions in spectrum needs.

4. Leveraging Consumer Infrastructure

To date, the spectrum crisis debate has not sufficiently analyzed how carriers' ability to leverage consumer infrastructure will impact spectrum needs. Currently, carriers leverage consumer assets through traffic diversion to femtocells and by offloading mobile Internet traffic onto wi-fi. Cisco explains that "Globally, 31 percent of smartphone traffic was offloaded onto the fixed network through dual-mode or femtocell in 2010."[63] With more and more carriers adopting these techniques, it is likely that the percentage of mobile data that is diverted will grow significantly.

- **Femtocells**: A femtocell is a small cellular base station typically designed for use in a home or business. The devices connect to the service provider's network via broadband and allow mobile operators to make improvements to both coverage and capacity, especially indoors. Femtocells also reduce both capital expenditures and operating expenses because, among other things, backhaul is done over a consumer's broadband connection. T-Mobile recently announced plans to offer a femtocell device in 2011.[64] With this announcement, all the major wireless companies have adopted this strategy, as AT&T,[65] Sprint,[66] and Verizon[67] already provide femtocell service to consumers. It is likely that femtocell use will grow considerably in the future because approximately 70 percent of mobile device usage is indoors.[68] During the Mobile World Congress in Barcelona in February 2011, Simon Saunders, Chairman of the Femto Forum highlighted the likely growth of femto cells by explaining that a year ago "all commercial deployments of femtocells were residential, but now about one-third are corporate."[69]

- **Wi-fi**: Another consumer-driven response to alleviate strain on wireless networks is the offloading of mobile Internet traffic onto wi-fi hot spots. In order to fully leverage this network management technique, AT&T has become the largest wi-fi hot-spot provider in the world, with more than 24,000 wi-fi locations nationwide.[70] AT&T has also purchased service providers like Wayport and is investing in its own outdoor wi-fi networks, including one

located in Times Square.[71] In addition, AT&T encourages greater wi-fi use by waiving a $2.95 wi-fi charge for two hours for customers at McDonalds' 11,000 restaurants and at other popular locations like Starbucks and Barnes & Noble.[72] Device manufacturers have also responded to the carriers' desire to leverage wi-fi-capable devices. It is estimated that nearly four in five smartphone devices *already* contain wi-fi chipsets.[73] Therefore, while these devices are touted as contributing significantly to the surge in data usage, they are being deployed with a built-in solution to help manage demand. As Mark Lowenstein noted in *BusinessWeek*: "Two years ago, all carriers thought wi-fi was a threat, now it's a lifeline."[74] And while wi-fi is already playing a significant role in managing wireless network capacity needs,[75] this proven solution is absent from the "spectrum crisis" debate, and is not even mentioned in the Commission's technical analysis.

5. Enhancing Carrier Infrastructure

> *"AT&T and other wireless operators could double the amount of capacity they supply with current spectrum by investing more in new wireless equipment on existing cell towers." Wall Street Journal (April 4, 2011) (quoting American Tower CEO James Taiclet).*

At least part of the capacity crunch is temporary: before the sizable increase in data demand, some carriers had underinvested in their networks, but now many are adding more backhaul and optimizing their networks for data.[76] Also, many carriers are moving from lower capacity 3G networks to 4G networks that are more efficient and cheaper to operate. There are many available network investments that address congestion. In fact, James Taiclet, Chief Executive Officer of American Tower Corp., a large independent owner and operator of cell sites, has indicated that "AT&T and other wireless operators could double the amount of capacity they supply with current spectrum by investing more in new wireless equipment on existing cell towers."[77] Mr. Taiclet, whose company operates around 38,000 towers, notes that "our tower sites are about 50% loaded on average," and in big cities such as New York and Boston, "tower sites are loaded 60% to 75% on average."[78]

- **Multi-Antenna Signal Processing**: In conventional wireless communications, a single antenna is used at the source, and another single antenna is used at the destination. Such systems are vulnerable to problems caused by multipath effects. Multipath effects occur when an electromagnetic field is met with obstructions such as hills, canyons, buildings, and utility wires, and wavefronts are scattered and take many paths to reach the destination. The late arrival of scattered portions of the signal causes problems such as fading, cut-out and intermittent reception, reduction in data speed, and an increase in the number of errors. Multi-Antenna Signal Processing (MAS), commonly referred to as smart antennas, uses an array of antennas and enormous processing power at each base station site to concentrate the transmitted signal directly to the user handset antenna and perform the ask and listen process in a similarly concentrated matter. Further, MAS technology avoids transmitting energy to other receivers in the same cell and avoids listening to other handsets in that cell. As a result, it is possible to use the same radio channel (*i.e.* same frequency and time slot) several times more efficiently within the cell than with other technologies. MAS technology is

commercially available and has been used in hundreds of thousands of base stations deployed in 20 countries for over 10 years.[79]

- **Picocells:** A picocell is a small cellular base station typically covering a small area, such as an office or, more recently, a single aircraft. In wireless networks, picocells are typically used to extend coverage to indoor areas where outdoor signals do not sufficiently reach, or to add network capacity in areas with concentrated phone usage, such as train stations. Picocells can even be deployed in areas with limited space, for example, lampposts. And even while the first long-term evolution macrocells had yet to go live in the US, vendors were "already hard at work on the pico- and femtocells that will eventually augment those wide-area 4G networks."[80]

- **Modernized Network Architecture:** Alcatel Lucent has gone beyond the picocell and has created a brand new network architecture based on small cubes that can fit in the palm of your hand. Alcatel Lucent's architecture, known as lightRadio, which recently won first place for its category in the CTIA Emerging Technology Awards,[81] "will quickly expand network capacity, lower operating costs, reduce energy consumption and bring connectivity to everyone around the world."[82] lightRadio departs from antiquated network designs by breaking the base station into its component elements and distributing its intelligence throughout the network. lightRadio is small enough to be deployed virtually anywhere, which allows it to benefit greatly from its independence from tower infrastructure as "roughly half of the power from cell towers' base stations is lost before it makes its way up to the antennas at the top of the tower."[83] In addition, the antennas' directional beams can be shifted to maximize their potential, based on live data. It is estimated that the smart technology and power efficiency of lightRadio "can help cut carriers' operating costs in half."[84] And the best is likely yet to come. As the saying goes "competition breeds innovation." It is doubtful that competitors will sit idly by and let Alcatel Lucent redesign the network architecture for wireless broadband without developing other bandwidth-boosting alternatives.

- **Distributed Antenna Systems:** A Distributed Antenna System, or DAS, is a network of smaller, spatially separated antenna nodes connected to the communications network.[85] In essence, a single antenna radiating at high power is replaced by a group of low-power antennas to cover the same area. DAS networks are effective in areas with difficult topography, structural impediments, or in locations where it is not optimal to build a traditional macro cell. The benefits of DAS were recently explained by Michael Schweder, President of New Jersey AT&T, when AT&T announced that it had expanded its mobile broadband coverage at the host stadium of the 2014 Superbowl—New Meadowlands Stadium in East Rutherford, New Jersey: "We've significantly ramped up our wireless investments to enable an experience that offers New Jersey consumers better speed, reliability and availability where they need it the most."[86] AT&T is demonstrating that it can execute on enhancing capacity (without additional spectrum) even in a challenging RF environment where ten of thousands of people are congregated for several hours in a limited geographic area. In fact, the AT&T press release points to more and more targeted infrastructure investments as "AT&T will focus on continuing to enhance its wireless network forecasting capabilities to

better predict usage trends and build network capacity to always stay one step ahead of customer need."[87]

- **Upgraded Backhaul**: Backhaul refers to transporting traffic between distributed sites and more centralized points of presence. Throughout the United States, wireless operators are beginning to migrate their base stations away from copper transport to fiber-based transport. Fiber-based transport provides a natural, scalable migration path and provides wireless operators with greatly enhanced service reliability and congestion management. As *Wireless Week* explains, "demand for mobile data has been a boon to backhaul providers that are doing a brisk business helping carriers solve the capacity crunch."[88] This trend, however, is not factored into recent "spectrum crisis" analyses or the Commission's technical rationale.
- **Sectorization**: Another way to increase subscriber capacity of a wireless network is to replace the omni-directional antenna at each base station with several (usually three or six) sector antennas with 120 or 60-degree openings. Each sector can be considered a new cell, with its own channel set of frequency channels. The use of directional sector antennas allows denser frequency reuse. In addition, sectorization is less expensive than cell splitting because it does not require the acquisition of new base station sites.
- **Cell Splitting**: Cell splitting is required when there is demand for greater capacity than an individual cell can offer. The cell size is reduced to cover a smaller area and the number of cell sites is increased. Cell splitting is perhaps the most expensive means of capacity creation because it requires significant infrastructure and planning approvals. However, several factors are leading to decreased costs: (1) urban/suburban sites can be located on rooftops, rather than towers; (2) radio equipment has become much smaller than in the past, with simpler requirements for enclosures and support, power and installation; and (3) new sites are increasingly shared, either under carrier network sharing agreements or through third party tower companies.

6. Packet Prioritization

Congestion can be effectively addressed by managing the inspection and prioritization of packets at critical points in the network. Routers generally inspect and forward packets practically instantaneously. But when a router is inundated, data packets are temporarily queued in the router's memory. If the memory becomes full, the router "drops" some of the packets. And if the sending computer doesn't get a timely response, it attempts to resend the data. This process consumes capacity and deteriorates quality of service because some data (for example video) is particularly sensitive to these delays. In such situations, carriers may prioritize the packets and allow latency-sensitive data to get to the head of the queue. In the extreme case, packet prioritization can save lives: "in wireless networks in the absence of network management, bandwidth intensive applications and other spectrum uses would have the potential to prevent or degrade the use of the voice service that consumers rely upon – and in the case of E-911, rely upon in emergency situations."[89] But, in reality, wireless carriers have significant degrees of freedom to employ packet prioritization. While the FCC has determined that entities providing fixed broadband Internet access services "shall not unreasonably discriminate in transmitting lawful network traffic over a consumer's broadband Internet

access service,"[90] no such provision applies to wireless carriers. And it is now evident that "service providers are beginning to adopt more sophisticated and varied traffic management strategies."[91]

7. Caching

Edge caching is the temporary storage of frequently accessed data on servers that are located close to end users. By moving content closer to consumers, edge caching helps service providers avoid the latency that occurs as packets traverse longer distances across the network. Caching works particularly well with content that uses a significant amount of bandwidth and does not change frequently, for example, a popular YouTube video like "Baby" by Justin Bieber, which recently became the first YouTube video to earn a half billion views.[92] Employing edge caching lightens network traffic and improves end user performance. Caching is a familiar concept as corporate intranets and computer operating systems boost performance by utilizing basic caching techniques.

In a related development, on February 15, 2011, IEEE announced that the IEEE Standards Association (IEEE-SA) Standards Board approved the development of draft standard IEEE P2200 – Standard Protocol for Stream Management in Media Client Devices.[93] IEEE P2200 will enable the delivery of rich media content such as high-definition or 3D video, games, music, books, and magazines to portable devices by preemptively leveraging local storage and intelligent content caching. The High Quality Mobile Experience (HQME) Steering Committee explains that an open HQME standard "would alleviate the growing demand on the network"[94] and accelerates delivery to mobile devices. This, of course, would be welcome news to consumers: the HQME website invites consumers to "consider a mobile experience with virtually no time lost to buffering or loading."[95]

8. Channel Bonding

Channel bonding is a technique that uses noncontiguous spectrum channels in a contiguous manner. For example, with channel bonding, four MHz HSPA channels (5 MHz each) can be utilized in a manner similar to a full 20MHz channel. This places downward pressure on spectrum requirements because channel bonding increases the usefulness of slivers of spectrum and avoids the difficult (and expensive) task of amassing large swaths of contiguous spectrum. Moreover, channel bonding boosts data output. When Nokia Siemens Networks demonstrated channel-bonding of an 800MHz channel and a 2.6GHz channel, the result was a 90% increase in data rates and propagation characteristics of the more desirable 800MHz channel.[96]

9. Encouraging the Development of Bandwidth-Sensitive Applications and Devices

Carriers often portray themselves as victims of the applications running on their networks. However, there is a new trend to actively manage the bandwidth consumption of mobile applications. Forbes reports: "AT&T has begun notifying developers when their applications hog bandwidth. The carrier has a team that runs software programs to check the efficiency of the applications that run on its network, . . . If an app takes up, say, two times more bits than it needs to, the developer gets a call and advice on how to revise it."[97] Rysavy Research explains: "applications that are designed specifically for bandwidth-constrained networks can consume significantly less data than those that are not."[98]

Similarly, devices that are designed with bandwidth conservation in mind use much less data. Rysavy Research demonstrates that there is an urgent need to ensure that devices that access wireless networks do so efficiently. In a recent white paper, Rysavy Research explains that with "a 1024 byte message with no attachment, BlackBerry communicated a total of 1251 bytes whereas iPhone iOS communicated 39625. This represents a 39625 divided by 1251, or 31.7 times efficiency advantage of BlackBerry over iPhone."[99] This means that retrieving a simple attachment-free email message takes almost 32X as much data across the network when using an iPhone as compared to a Blackberry. In addition, the Rysavy Research Paper documents several other examples of inefficiency at the device level.[100] So while there has been significant public discussion about the "bandwidth-intensive" nature of smartphones driving the "spectrum crisis," Rysavy Research demonstrates that a significant portion of those bandwidth needs are the result of devices that are not optimized for a capacity-constrained data channel.

Addressing excessive bandwidth consumption at its source will no doubt have a positive impact on relieving network congestion.

B. The Commission Itself Must Take a More Active Role in Promoting Efficient and Intensive Use of Spectrum

The Commission has a statutory obligation to promote the efficient and intensive use of the electromagnetic spectrum.[101] This is hardly a congressional afterthought, as the provision was incorporated into the legislation that granted the FCC its auction authority. While there is no one

definition of 'intensive" use, clearly dormant spectrum fails any variant of the definition. As explained below, the Commission should expeditiously conclude its spectrum inventory and determine how these national assets can be put to better use.

1. *Far Too Much of the Nation's Spectrum Is Either Underutilized or Occupied by Spectrum Warehousers*

There are two factors that significantly impact the intensive and efficient use of spectrum. First, there are many underused bands. In a 2005 National Science Foundation spectrum usage study conducted in New York City over several months[102] (including the summer of 2004 when the Republican National Convention was in town) researchers noted that, on average, only about 5.2 percent of the available spectrum from 30 MHz to 3000 MHz was being used at any given time. And, at peak times, the total spectrum usage in New York City was just 13 percent. The Commission should make the investment in compiling better data by committing to analyze the actual level of spectrum usage. As Google has recommended: "the Commission should acknowledge that any discussion of promoting wireless innovation and investment must begin with accurate data about the current extent of spectrum utilization."[103]

Second, there are many bands in which the licensees are warehousing rather than building systems to service consumers. In Auction 66 for AWS-1 licenses, "Verizon Wireless spent $2.8 billion for (unused) AWS licenses"; "AT&T (then Cingular) spent $1.3 billion for AWS frequencies"; and "cable operators spent $2.4 billion for (currently unused) AWS licenses."[104] These bidding groups account for $6.5 billion in unused AWS-1 spectrum. Worse still, it is estimated that carriers are collectively sitting on $15 billion in spectrum licenses, with AT&T alone warehousing licenses worth $10 billion.[105] In fact, 70-90% of AT&T's spectrum capacity is unused.[106] Verizon Wireless is on record at the Commission that it "does not plan to deploy its Lower A Block spectrum in the near term."[107] Elsewhere, Clearwire is now looking to make billions off undeveloped spectrum licenses after obtaining leases covering 85% of the 2.5 GHz band.[108] Undeployed spectrum has a profound impact on the overall capacity of wireless networks.

The slow pace of deployment on these spectrum bands is inconsistent with the spirit of 47 U.S.C. § 309(j)(4)(B), which was implemented to prevent stockpiling or warehousing of spectrum by licensees or permittees.[109] Build out requirements must be more closely related to the commercial reality of how long it takes to commence wireless operations in order to avoid situations where spectrum assets are not aggressively deployed. With the bands identified above and many other bands underutilized, the claims of immediate crisis are significantly overstated. Thus, there is no need to rush to oust current licensees (e.g., broadcasters) from spectrum without a full understanding of the extent of underutilized spectrum.

The fact that there is no "crisis" for more spectrum can also be seen in public statements of certain wireless licensees. After the AWS-1 auction, Brian Roberts, CEO of Comcast, summed up his deployment plans by stating, "I don't think we have to rush out and do something. I think there's optionality for anyone that owns facilities."[110] More recently, Time Warner Cable's Chief Operations Officer, Rob Marcus, was quoted in the January 28, 2011 edition of Communications Daily as stating that his company "has no plans to sell, lease or use its AWS spectrum licenses."[111] Dish Network CEO Charlie Ergen indicated on a November 2010 earnings call with investment analysts that "one of the better things we did was that we resisted the temptation to go out and try to build [the spectrum] out and spend more money on build out before we know where we want to go." He also explained the value of speculating on spectrum without a business plan: "if we can figure out a way to use it, that's good. If we can't somebody else will own it."[112]

BIDDING VS. BUILDING

- *"I don't think we have to rush out and do something. I think there's optionality for anyone that owns facilities." — Brian Roberts, CEO of Comcast (summing up his deployment plans following the AWS-1 auction).*
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2. *The FCC Should Complete and Publicly Release a Comprehensive Spectrum Inventory Before Taking Unprecedented Regulatory Actions*

There has been considerable FCC and congressional attention focused on the concept of a spectrum inventory. There can be little doubt that the FCC cannot, at the same time, promote "efficient and intensive use of the electromagnetic spectrum" and remain unaware of the full extent of spectrum utilization.

On July 14, 2010, FCC Chairman Julius Genachowski sent a letter to Senator John Rockefeller, Chairman of the Senate Commerce Committee, publicly announcing that such an inventory is underway.[113] In light of the longstanding calls for an inventory, it is a widely recognized hope that the FCC will complete and publicly release a comprehensive inventory in the near term, which should include data and measurement of actual spectrum use. And although Chairman Genachowski has indicated that the Commission has concluded a "baseline" inventory,[114] much remains unknown about the breadth of that process. For example, does the baseline FCC inventory include frequencies between 300 Megahertz and 6.5 Gigahertz, as does the pending Reforming Airwaves by Developing Incentives and Opportunistic Sharing (RADIOS) Act, introduced by Senators Kerry and Snowe on March 2, 2011?[115] Does the baseline inventory include as detailed an inquiry as proposed in the RADIOS Act? Notably,

> *"While an inventory of both federal and non-federal spectrum would not answer all of our questions, it would provide decision makers at the FCC, NTIA and Congress a clearer, more detailed and up-to-date understanding of how spectrum is currently being used and by whom—data essential to sound policy decisions and spectrum management."* Senator Olympia Snowe (2011).

the RADIOS Act requires additional studies beyond the inventory, including a spectrum survey/ measurement study that looks at spectrum occupancy and use.[116]

While it is commendable that the FCC has produced the Spectrum Dashboard and License View, these tools are much more limited than the spectrum inventory proposed in the RADIOS Act. Moreover, the Commission's Spectrum Dashboard, by its own terms, "does not constitute the official licensing records for the Commission"[117] and "the FCC makes no representations regarding the accuracy or completeness of the information maintained in the Spectrum Dashboard."[118] The Commission's disclaimer that the Spectrum Dashboard is designed for "informational purposes" and that users of License View "are cautioned that this system does not necessarily constitute the complete record"[119] demonstrates the need for an official spectrum inventory done in a comprehensive manner.

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Senator Olympia Snowe recently reiterated to the Commission the importance of using the spectrum inventory as a mechanism for analyzing the need for additional regulatory interventions: "While an inventory of both federal and non-federal spectrum would not answer all of our questions, it would provide decision makers at the FCC, NTIA and Congress a clearer, more detailed and up-to-date understanding of how spectrum is currently being used and by whom—data essential to sound policy decisions and spectrum management."[120] The spectrum inventory is a diagnostic tool and as such it should logically come before any reallocation proceeding. The breadth of the undertaking represented by the National Broadband Plan militates against a rush to "treatment" without adequate diagnosis. Regulatory action that precedes the spectrum inventory's granular data would likely lead to uninformed, premature, and wasteful decision-making. In fact, CTIA supports the concept of a comprehensive spectrum inventory and previously described it as a "good first step."[121]

3. The FCC Should Increase Licensee Flexibility

FCC licensees should have the flexibility to innovate and respond to market demands and technological breakthroughs. In fact, licensee flexibility is a theme in the National Broadband Plan: "Flexibility of use enables markets in spectrum, allowing innovation and capital formation to occur with greater efficiency. More flexible spectrum rights will help ensure that spectrum moves to more productive uses, including mobile broadband, through voluntary market mechanisms."[122] But the concept of flexible use must go beyond these statements. As former FCC Chairman Reed Hundt stated, "As discussed in virtually all FCC statements, but only put into practice in certain circumstances, the FCC should not place artificial use restrictions on the licensees. Licensees should be allowed to compete to provide whatever service they think will serve consumer demand provided that they do not cause undue interference to other spectrum users."[123] As the Commission has acknowledged the importance of flexibility, it should examine the extent to which additional licensee flexibility would impact spectrum availability.

Granting spectrum licensees broad flexibility would allow the marketplace to respond to the needs of wireless carriers. Wireless carriers, for example, could then more easily enter into lease agreements with other licensees for use of their spectrum to provide mobile broadband.[124] Indeed, as economists and policy analysts have increasingly come to agree, flexible rights for spectrum licensees, coupled with a vibrant secondary market for those rights, are the most efficient ways to repurpose spectrum (rather than any form of administrative reallocation).[125] The Commission should explore ways to reduce restrictions on licensee flexibility as another method of ensuring that spectrum is put to its most productive use.

4. The Commission Should Adopt Receiver Standards

Historically, the Commission has regulated the interfering potential of transmitters in order to avoid unacceptable levels of radio interference.[126] Increasingly, however, interference occurs due to inadequate receiver performance rather than the function of transmitters.[127] Nevertheless, the Commission has generally not adopted minimum receiver standards in order to help define when an entity is entitled to protection from interference. In contrast, the National Telecommunications and Information Administration has established "receiver standards for most Federal users of the radio spectrum."[128] Recently, NTIA urged the Commission to look closely at receiver standards as part of its inquiry on dynamic spectrum use technologies.[129]

Receiver standards are needed for commercial networks to ensure the intensive use of spectrum. Without standards, the nation's spectrum resources are wasted due to protracted rulemakings whenever parties seek to introduce services in a band adjacent to incumbent operations due to concerns about harmful interference. As IEEE explained to the Commission last year: "there is no controversy that the AWS-3 band (2155-2175 MHz) is vacant, yet commercial access to this band has been blocked for several years because of harmful interference [claims] and the lack of definitive findings on the issue: various sides have offered different criteria for defining harmful interference."[130] Similarly, in 2011, receiver standards have again been a source of significant debate following the Commission's evaluation of Lightsquared's conditional request for waiver of the Ancillary Terrestrial Component rules.[131] And while the Commission has recently concluded that "responsibility for protecting services rests not only on new entrants but also on incumbent users themselves, who must use receivers that reasonably discriminate against reception of signals outside their allocated spectrum,"[132] adopting rules to that effect is the best means of ensuring intense use of the nation's spectrum assets.

III. OTHER SOURCES OF SPECTRUM ARE MORE READILY AVAILABLE

A. The Commission Should Immediately Address a Significant Portion of the Spectrum Demand Equation by Assigning Spectrum that Is Languishing in Its "Pipeline"

The FCC has spent considerable time and energy focusing on external solutions (reallocation of spectrum from one industry segment to another) to the supposed "spectrum crisis." But, it must also be diligent in taking actions that only it can perform—licensing spectrum bands that have been

languishing for years at the Commission. While the National Broadband Plan and the "Broadband Action Agenda" pledged to issue orders in 2010 related to several unassigned bands, that did not occur.[133]

- **AWS-3 block spectrum at 2155-2175 MHz** — The FCC designated this spectrum block for Advanced Wireless Services in 2005, ordered the relocation of incumbents in 2006, issued a Notice of Proposed Rulemaking in 2007 and sought comment on draft service rules in a Further Notice of Proposed Rulemaking in 2008. The FCC, however, did not fulfill its pledge to issue final service rules in 2010.[134]

- **H block spectrum at 1915-1920 MHz and 1995-2000 MHz and J block spectrum at 2020-2025 MHz and 2175-2180 MHz** — In 2004, the FCC designated these blocks for broadband and advanced wireless services and initiated a rulemaking proceeding on service rules. The FCC issued a Further Notice in 2008 to refresh the record. The FCC, however, did not fulfill its pledge to issue service rules in 2010.

- **700 MHz D block at 758-763 MHz and 788-793 MHz** — The FCC unsuccessfully attempted to auction this spectrum block in 2008, in an attempt to form a public/private partnership with the licensee of the adjacent public safety block and create a nationwide public safety broadband network. The FCC sought comment on potential modifications to the D block rules in 2008. However, the Commission did not fulfill its pledge to issue service rules in 2010.

Therefore, in each of these three unassigned spectrum bands, the FCC failed to complete its work on longstanding proceedings with mature records developed over a number of years. The fact that these bands still remain unassigned demonstrates that there are no pressing exigencies that should prevent the FCC from fully examining non-spectrum capacity-generating alternatives (as suggested in Section II.A above) or concluding a comprehensive spectrum inventory (as suggested in Section II.B above) before pressing ahead with reallocation and other spectrum management decisions that would greatly benefit from this additional relevant data.

The FCC has spent considerable time and energy focusing on external solutions to the supposed "spectrum crisis." But it must also be diligent in taking actions that only it can perform—licensing spectrum bands that have been languishing for years at the Commission. While the National Broadband Plan and the "Broadband Action Agenda" pledged to issue orders in 2010 related to several unassigned spectrum bands, that did not occur.

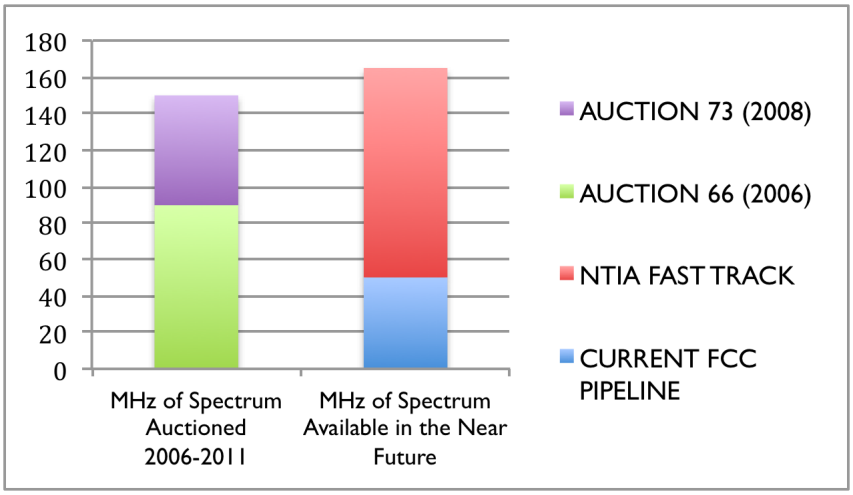
B. The FCC Should Immediately License Underutilized Spectrum Previously Identified by NTIA

Last year, NTIA undertook a "fast-track review" to identify spectrum bands that could be reallocated for commercial use. The NTIA Fast Track Evaluation Report recommends that a total of 115 megahertz be made available for wireless broadband use within five years.

- Radio transmitters on weather balloons, as well as for weather satellites, currently use the first spectrum band identified by the NTIA, ranging from 1695 to 1710 MHz. This band can be used for commercial broadband services by establishing exclusion zones that prevent commercial services from interfering with government operations.
- NTIA also identified the 3550 to 3650 MHz band that is used mostly by the Department of Defense for high-power radars. According to NTIA, this spectrum can be safely licensed for broadband "outside certain coastal areas and test and training areas."

On January 19, 2011, NTIA officially requested that the FCC "take the necessary regulatory actions to make available for wireless broadband" 15 MHz at 1695 to 1710MHz, and 100 MHz at 3550 to 3650 MHz. NTIA's rapid progress in identifying bands that could be transitioned to commercial broadband use provides the Commission with another 115 MHz of available spectrum.[135] As illustrated in Figure 2, below, when combined with the 50 MHz of spectrum currently in the Commission's pipeline (as discussed above), the FCC will have at its disposal just as much spectrum as was auctioned in the past five years. The Commission should expedite the licensing of all these bands.

FIGURE 2: "Five Years" Worth of Wireless Broadband Spectrum . . . Pending Assignment



C. The Commission Should Help Facilitate the Success of the Secondary Market

Carriers are also able to increase their spectrum holdings through secondary market transactions. Over a decade ago, when the concept of the secondary spectrum market was formulated, it was envisioned by the FCC as a means of addressing increased demands for wireless services: "We continue to believe that an effective way to make unused spectrum held by existing licensees available to others may be through secondary markets."[136]

A few notable transactions that leveraged the secondary market include:

- In 2007, AT&T purchased licenses for 12 MHz of broadband-capable spectrum from Aloha Partners for $2.5 billion.[137] AT&T's purchase covers196 million U.S. residents, including 72 of the 100 largest markets in the U.S.

- In 2010, investment firm Harbinger Capital Partners completed an acquisition of mobile satellite telecom provider SkyTerra Communications. Taking into account outstanding debt and securities, the deal was valued at more than $1.8 billion.[138]

- In 2010, AT&T signed a $1.93 billion deal with Qualcomm to buy spectrum licenses covering more than 300 million people nationwide in the lower 700-megahertz band.[139]

Despite these and other examples, the National Broadband Plan states, "[w]hile the FCC currently has rules that enable secondary markets, the record is mixed."[140] The Plan concludes that by the end of 2010 "the FCC should identify and address barriers to more productive allocation and use of spectrum through secondary markets."[141] This is not the first time the FCC has sought to enhance the secondary market rules. In 2004, the FCC issued a rulemaking in which it explained that the Commission would "continue to explore additional steps that could further enhance secondary markets and increase the efficient use of spectrum and the availability to the public of innovative wireless services."[142]

Six years after the FCC obtained a record in response to its initial rulemaking seeking to strengthen secondary markets, the Commission in 2010 issued yet another report questioning whether the secondary markets were working adequately. Reports asking questions are not enough. The FCC must do all it can to encourage secondary market transactions. As economist Jeffrey Eisenach explained to the House Subcommittee on Communications, Technology and the Internet, Committee on Energy and Commerce:

> Rather than trying to engage in a one-time repurposing exercise (which would, indeed, take a decade or more), the Commission would do better to focus on implementing reforms that would allow spectrum to move dynamically – that is, continuously – to its highest valued uses, in response to changes in markets and technologies.[143]

The secondary market proceedings should be brought to a quick close and the FCC should revise its rules to permit robust use of this critical spectrum management tool. In addition, the FCC should further encourage the use of the secondary marketplace by adopting meaningful build out requirements and appropriate enforcement mechanisms, including specific license forfeiture procedures for licensees failing to utilize their spectrum in a timely manner. Doing so will significantly promote the secondary market, ultimately get spectrum in the hands of parties that seek to use it and allow consumers to reap the benefit of greater competition.

IV. CONCLUSION

In the final analysis, the impending "spectrum crisis" is not real. In fact, it includes all the elements of a bestselling science fiction novel. First, the story seamlessly merges reality and fantasy. Second, the tale includes dire predictions about the future if, and only if, the worst-case scenario were to happen concerning a long list of variables. Third, the account ignores all simple solutions in favor of a dramatic conclusion. And, of course, there is a manufactured *enemy*. In this case, many seem to indirectly and incorrectly believe that free over-the-air broadcasting is the enemy of mobile broadband. But this debate masks the fact that there are other spectrum resources available and that carriers and the FCC have meaningful alternatives to manage the increased demand for data services.

In reality, broadcast and broadband can and should be complementary—projections show that the large amounts of future demand for mobile broadband will be for mobile video,[144] and broadcasting (with its point to multipoint distribution system) is the most efficient way to distribute video (especially video wanted by significant numbers of viewers). This only serves to underscore the importance of the Commission fully investigating and quantifying the impact of all capacity-generating alternatives, including permitting all licenses sufficient flexibility to leverage technological breakthroughs to help deliver the type of mobile services that U.S. consumers deserve.

* * *

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ENDNOTES

[1] American Recovery and Reinvestment Act of 2009, Pub. L. No. 111-5, § 6001(k)(2)(D), 123 Stat. 115, 516 (2009) (Recovery Act).

[2] *Id.*

[3] CTIA Written Ex Parte Communication, GN Docket No. 09-51 at 13 (Sept. 29, 2009).

[4] Connecting America: The National Broadband Plan, Recommendation 5.8, p.86 (FCC, 2010) (Broadband Plan).

[5] Broadband Plan, Recommendation 5.8, p.86.

[6] *Id.* Notably, the Cisco Forecast, which is among the three reports relied on by the Commission to support the claim of massively increased spectrum demand, is based on *global* use.

[7] FCC Staff Technical Paper, Mobile Broadband: The Benefits of Additional Spectrum (FCC, October 2010) (OBI Technical Paper No. 6). While the OBI paper claims that it provides "additional technical analysis to validate the need for additional mobile broadband spectrum in the near-term," no previous engineering analysis on this topic was issued by the agency. *Id* at 2.

[8] *See* "The Emporer's New Spectrum Crisis," available at http://www.tvnewscheck.com/article/2010/04/12/41368/the-emperors-new-spectrum-crisis (discussing a blog post by Edward Lazarus, FCC Chief of Staff, entitled "The Record Is Clear: America Needs More Spectrum," which claims that the National Broadband Plan record shows "overwhelming" agreement that the U.S. needs more broadband spectrum despite considerable comments in the record that take a contrary position). The blog is available at http://blog.broadband.gov/?entryId=358488. More recently, Chairman Genachowski has suggested that spectrum still not used but compliant with FCC build out regulations did not contribute to any perceived lack of available spectrum even though certain licensees have admitted (several years after winning licenses auction) that they still have no plans to deploy (*See* http://www.dslreports.com/shownews/FCC-Boss-Spectrum-Hoarding-Illusory-113223). The Chairman also indicated that there was no need to conduct a long envisioned comprehensive spectrum inventory that would provide data about spectrum occupancy and usage ("FCC on Spectrum Inventory: Already Did It," The Hill (Mar. 16, 2011) available at http://thehill.com/blogs/hillicon-valley/technology/150197-fcc-on-spectrum-inventory-already-did-it). On April 12, 2011 at the 2011 NAB Show in Las Vegas, Chairman Genachowski characterized arguments that challenge the notion of a spectrum crunch as "distractions" and claimed that "some have argued that there's no spectrum crunch – but the data couldn't be clearer." While the data shows increased use of mobile data by consumers, this paper demonstrates that data demand has been somewhat exaggerated and, in any event, when placed in context with the many alternative mechanisms available, increased data demand does not necessarily mean more spectrum assignments are required.

[9] "With more than 276 million subscribers in the U.S., it is vital for our industry to secure at least 800 MHz of additional spectrum within the next six years." "Without this additional spectrum, our industry will cease to provide U.S. consumers with the most innovative and most competitive wireless offerings in the world." Statement of Steve Largent, President and CEO, CTIA (December 15, 2009) (emphasis added) (Largent Statement). *See also* CTIA Comments, GN Docket Nos. 09-157, 09-51, at vi (filed Sept. 30, 2009).

[10] *See* Largent Statement.

[11] "CTIA and our member companies are extremely pleased" about the FCC's and the broadband team's focus on making available "500 MHz of spectrum for broadband within 10 years, of which 300 MHz should be made available for mobile use within 5 years." Statement of Steve Largent, President and CEO, CTIA (March 15, 2010).

[12] Petition for Reconsideration of the Cellular Telecommunications & Internet Association, ET Docket Nos. 00-258 and 95-18; IB Docket No. 99-81 (filed Oct. 15, 2001).

[13] "Cut MSS Spectrum Loose, Says CTIA," Connected Planet (May 22, 2001) available at http://connectedplanetonline.com/news/telecom_cut_mss_spectrum/ (last visited April 14, 2011).

[14] Statement of Julius Genachowski, Chairman, FCC (July 20, 2010).

[15] OBI Technical Paper No. 6 at 2.

[16] *Id.*

[17] *Id.* at Exhibit 10.

[18] *Id.* at 17.

[19] *Id.* at Exhibit 10.

[20] This technological progression has been coined "Cooper's Law." *See* http://www.arraycomm.com/serve.php?page=Cooper

[21] OBI Technical Paper No. 6 at Exhibit 10.

[22] See http://stevencrowley.com/2011/03/29/should-a-sales-brochure-underlie-us-spectrum-policy/

[23] *See* http://www.att.com/Common/about_us/pdf/INV_PRES_3-21-11_FINAL.pdf

[24] *See* http://www.download-telekom.de/dt/StaticPage/97/67/90/tmo-invday11.pdf_976790.pdf

[25] *Id.* T-Mobile predicts 60% CAGR from 2009-14 or 10 times growth in 5 years.

[26] OBI Technical Paper No. 6 at 9. It is also notable that the Commission relied on an arithmetic mean of the three forecasts when it should have utilized a geometric mean, which would have led to a more modest growth rate.

[27] See http://tmfassociates.com/blog/2010/10/22/analyzing-the-spectrum-crisis-can-the-fcc-add-up/ (emphasis added).

[28] For a well respected and often cited discussion of this phenomenon *see* Bohlen, Joe M.; Beal, George M. (May 1957), "The Diffusion Process", *Special Report No. 18* (Agriculture Extension Service, Iowa State College)**1**: 56–77 available at http://www.soc.iastate.edu/extension/presentations/publications/comm/Diffusion%20Process.pdf

[29] Cisco Visual Networking Index: Global Mobile Data Traffic Forecast Update, 2010-2015.

[30] "Cisco: U.S. Mobile Data Growth Falling 60-80%," DSL Prime (Mar. 29, 2011) available at http://www.dslprime.com/a-wireless-cloud/61-w/4040-cisco-us-mobile-data-growth-falling-60-80

[31] *Id.*

[32] Jon Healey, "Spectrum crisis? What spectrum crisis?" Opinion, LA Times (Apr. 1, 2011) available at http://opinion.latimes.com/opinionla/2011/04/spectrum-crisis-what-spectrum-crisis.html

[33] Peter Svensson, "AT&T Talks of Spectrum Shortage, Yet It Has Plenty," AP (Mar. 21, 2011) available at http://abcnews.go.com/Technology/wireStory?id=13188504

[34] CTIA's Innovation and Advocacy Position Paper is available at http://www.ctia.org/advocacy/policy_topics/topic.cfm/TID/64

[35] LTE technology will be significantly more spectrum efficient than 3G. Nevertheless, the Rysavy Research report contends that "there are both theoretical and practical limits to spectral efficiency and current systems are approaching those limits." *See* CTIA Written Ex Parte Communication, GN Docket No. 09-51 at 1 (Sept. 29, 2009) (attaching Rysavy Research, "Mobile Broadband Spectrum Demand," at 19 (Dec. 2008)) ("Rysavy Report").

[36] *See, e.g.,* Op-ed by CTIA CEO Steve Largent entitled "FCC Not Free Market, Best for Spectrum Auction," (Mar. 21, 2011) available at http://benton.org/node/53499

[37] *See* http://www.cfr.org/publication/21840/conversation_with_ivan_seidenberg.html

[38] Comments of Sprint Nextel Corporation, GN Dockets 09-47, 09-51 and 09-137 at 23 (October 23, 2009).

[39] "T-Mobile's Ray discusses HSPA+ 42, spectrum refarming and backhaul deployment," Fierce Broadband Wireless (Jan. 18, 2011) available at http://www.fiercebroadbandwireless.com/story/t-mobiles-ray-discusses-hspa-42-spectrum-refarming-and-backhaul-deployment/2011-01-18.

[40] *Id.*

[41] "AT&T to Acquire T-Mobile for $39 Billion," CNN Money (Mar. 21, 2011) available at http://money.cnn.com/2011/03/20/news/companies/att_tmobile_deal/index.htm?source=yahoo_quote

[42] "Mobile Data: Traffic Jam Ahead?" — Merrill Lynch Report at 1(released Feb. 2, 2010).

[43] Clearwire Annual Report, Form 10-K at 2 (filed Feb 22, 2011).

[44] *Id.*

[45] "WiMAX Throttling Lawsuit: Clearwire Can't Deliver The Goods," Wired (Mar. 10, 2011) available at http://www.wired.com/epicenter/2011/03/throttling-lawsuit-clearwire/

[46] *See* http://www.arraycomm.com/serve.php?page=Cooper

[47] AT&T to Acquire T-Mobile USA From Deutsche Telekom, AT&T Press Release (Mar. 20, 2011) available at http://www.att.com/gen/press-room?pid=19358&cdvn=news&newsarticleid=31703&mapcode=corporate|financial

[48] *See* http://www.fiercebroadbandwireless.com/story/t-mobiles-ray-discusses-hspa-42-spectrum-refarming-and-backhaul-deployment/2011-01-18

[49] Connecting America: The National Broadband Plan, p.77 (FCC, 2010) (emphasis added).

[50] Rysavy Research, "Mobile Broadband Capacity Constraints And the Need for Optimization" (updated February 24, 2010) at 5 ("Spectrum reuse, which cellular technologies accomplish through the use of the same frequencies over and over in different cells is, in fact, the greatest determinant of overall network capacity.").

[51] "Will the Rapid Growth in Data Traffic Overwhelm Wireless Networks?" — The Economist (Feb. 11, 2010).

[52] *See* Gregory Rose, *How Incumbents Blocked New Entrants in the AWS-1 Auction: Lessons For the Future*, in Spectrum Auction Breakdown: How Incumbents Manipulate FCC Auction Rules To Block Broadband Competition (June 2007), Working Paper 18, available at http://www.newamerica.net/files/WorkingPaper18_FCCAuctionRules_Rose_FINAL.pdf; Gregory Rose; Peter Cramton and Jesse A. Scwartz, "Collusive Bidding in FCC Spectrum Auctions," *Contributions to Economic Analysis and Policy*1:1(2002) available at: http://works.bepress.com/cramton/2

[53] *See* Rysavy Report *at 15.*

[54] Comments of Sprint Nextel Corporation, GN Dockets 09-47, 09-51 and 09-137 at 23-24 (October 23, 2009) (explaining that first-generation cellular services using the AMPS standard had a spectral efficiency of 0.17 bps/Hz. 2.75G networks almost *doubled* first generation efficiency to 0.33 bps/Hz using GSM+EDGE technology. 3G networks nearly *quadrupled* 2.75G efficiency to 1.3 bps/Hz using CDMA2000 1x EV-DO Rev. A. 3.5G networks employing HSDPA *more than doubled* 3G efficiency to 2.88 bps/Hz). While specific figures for spectral efficiency vary from party to party based on definitions and measurements, parties generally agree on the trend toward more efficient networks.

[55] High Speed Packet Access (HSPA) is the set of technologies that defines the migration path for 3G/WCDMA operators worldwide. HSPA, which uses the Frequency Division Duplexing transmission scheme, includes HSDPA (High Speed Downlink Packet Access), HSUPA (High Speed Uplink Packet Access) and HSPA Evolved (HSPA+). *See* http://www.gsmworld.com/technology/hspa.htm

[56] "AT&T: 3% of Wireless Users Eat 40% of Data," Venture Beat (December 9, 2009) available at http://venturebeat.com/2009/12/09/att/

[57] "AT&T's iPhone Mess," Business Week (February 3, 2010) available at http://www.businessweek.com/magazine/content/10_07/b4166034389519_page_3.htm. It is notable, however, that such

techniques are only one tool available to carriers. This can be seen by the fact that AT&T now selectively employs unlimited data plans as a customer retention tool.

[58] " T-Mobile Will Skip Overage Charges, Throttle Data," Phone Scoop (April 26, 2010) available at http://www.phonescoop.com/news/item.php?n=5877

[59] "Verizon Wireless Plans to End Unlimited Data Options for Apple's IPhone," Blooomberg (Mar. 1, 2011) available at http://www.bloomberg.com/news/2011-03-01/verizon-wireless-to-drop-unlimited-iphone-data-plans-cfo-says.html

[60] *See* www.cisco.com/en/US/solutions/collateral/.../brochure_c02-620392.pdf

[61] Each 5MHz HSPA carrier can handle up to 60-70 simultaneous voice conversations (equivalent to 0.5Mbps at 8Kbps). But HSPA handles data at about 1 bit/second/hertz (depending on the release), implying 5Mbps per 5MHz carrier at 100% utilization, or ten times greater efficiency than voice.

[62] "AT&T CTO Says Voice Over LTE Coming In 2013," Forbes (Feb. 15, 2011) available at http://blogs.forbes.com/elizabethwoyke/2011/02/15/att-cto-says-voice-over-lte-coming-in-2013/

[63] Cisco Visual Networking Index: Global Mobile Data Traffic Forecast Update, 2010-2015. Despite the rising popularity of offloading, Cisco's forecast is in part premised on the unlikely notion that there will be less than 2% annual growth in offloading in the United States over the next 4 years. *Id.* at Table 7.

[64] "T-Mobile to Join 3G Femto Fray," available at http://www.lightreading.com/document.asp?doc_id=203288&

[65] Earlier this year, AT&T began mailing coupons for free Microcells to the 7.5 percent of its mobile subscribers who are most likely to have very limited AT&T coverage in their homes. "AT&T May Give Away MicroCells for Weakly Covered Homes," PC World (Jan. 21, 2011) available at http://www.pcworld.com/businesscenter/article/217385/atandt_may_give_away_microcells_for_weakly_covered_homes.htm

[66] "Sprint Begins Offering EV-DO Femtocells," Fierce Wireless (Aug. 20, 2010) available at http://www.fiercewireless.com/story/rumor-mill-sprints-ev-do-femtocells-begin-shipping/2010-08-20

[67] *See* http://www.verizonfemtocell.com/

[68] *See, e.g.*, http://gigaom.com/2010/06/02/att-explains-its-pricing-change-its-all-about-value/

[69] "Femtocells Make their Way into the Office," *Computerworld* (March 7, 2011) available at http://www.computerworld.com/s/article/355071/Femtocells_Make_Way_Into_Enterprises?taxonomyId=75

[70] *See* AT&T Inc. 2010 Annual Statement, Chairman's Letter available at http://www.att.com/gen/investor-relations?pid=19236

[71] "AT&T Offers Times Square Wi-Fi," *Wireless Week* (May 25, 2010) available at http://www.wirelessweek.com/News/2010/05/Carriers-Times-Square-Wi-Fi-ATT/

[72] *See* http://www.mcdonalds.com/us/en/services/free_wifi.html; http://www.starbucks.com/coffeehouse/wireless-internet; http://www.barnesandnoble.com/u/Wi-fi-at-Barnes-and-Noble/379001240/

[73] "Is All Wi-Fi Offload the Same?" Wireless Week (July 11, 2010) available at http://www.wirelessweek.com/Articles/2010/07/Technology-Offload-Wi-Fi/

[74] "AT&T Mulls Plans to Deal with iPhone Data Demand," *BusinessWeek* (December 21, 2009) available at http://www.businessweek.com/technology/content/dec2009/tc20091221_605613.htm

[75] Cisco Visual Networking Index: Global Mobile Data Traffic Forecast Update, 2009-2014, February 9, 2010; Coda Research Consultancy, US Mobile Traffic Forecasts: 2009-2015, 2009 (Cisco Forecast).

[76] "AT&T Addresses 3G Woes With Massive Backhaul Build," Sidecut Reports, http://www.sidecutreports.com/2010/01/06/att-addresses-3g-woes-with-massive-backhaul-build/

[77] "Skepticism Greets AT&T Theory, Telecom Giant Says T-Mobile Deal Will Improve Network Quality, but Experts See Other Options," Wall Street Journal (April 4, 2011) available at http://online.wsj.com/article/SB10001424052748703806304576236683511907142.html

[78] *Id.*

[79] Additional data on MAS performance in deployed systems is available on the ArrayComm Web site. *See* http://www.arraycomm.com/serve.php?page=proof.

[80] "CTIA: Vendors Collaborate on LTE Picocells, Femtocells," Connected Planet Online (Mar. 15, 2010) available at http://connectedplanetonline.com/ctia/2010/news/ctia--vendors-collaborate-lte-0315/

[81] *See* Alcatel-Lucent's lightRadio™ Receives First Place Award in 2011 CTIA E-Tech Competition Honoring Emerging Mobile Technologies, Alcatel-Lucent Press Release (Mar. 24, 2011) available at http://www.alcatel-lucent.com/wps/portal/!ut/p/kcxml/04_Sj9SPykssy0xPLMnMz0vM0Y_QjzKLd4x3tXDUL8h2VAQAURh_Yw!!?LMSG_CABINET=Docs_and_Resource_Ctr&LMSG_CONTENT_FILE=News_Releases_2011/News_Article_002384.xml

[82] *See* http://www.alcatel-lucent.com/features/light_radio/index.html

[83] *See* "The Tiny Cube that Could Cut Your Cell Phone Bill," CNN Money (Mar. 21, 2011) available at http://money.cnn.com/2011/03/21/technology/light_radio/index.htm?iid=HLM

[84] *Id.*

[85] *See* http://www.thedasforum.org/

[86] *See* "AT&T Invests in New Jersey Network to Deliver Most-Advanced Mobile Broadband Experience," AT&T Press Release (Mar. 18, 2011) available at http://www.marketwatch.com/story/att-invests-in-new-jersey-network-to-deliver-most-advanced-mobile-broadband-experience-2011-03-18

[87] *Id.*

[88] "Booming Business for Backhaul," *Wireless Week* (May 3, 2010) available at http://www.wirelessweek.com/articles/2010/05/booming-business-for-backhaul/

[89] Comments of CTIA, In the Matter of Vuze, Inc. Petition to Establish Rules Governing Network Management Practices by Broadband Network Operators, WC Docket No. 07-52 (filed Feb. 13, 2008).

[90] *See* In the Matter of Preserving the Open Internet; Broadband Industry Practices, GN Docket No. 09-191, WC Docket No. 07-52, *Report and Order*, FCC 10-201 at 88 (rel. Dec. 23, 2010).

[91] "Volubill Research Gives Insight into Mobile Operators' Future Traffic Management Strategies," Volubill Press Release (April 5, 2011) available at http://www.volubill.com/rep-press_releases/ido-91/volubill_research_gives_insight_into_mobile_operators_future_traffic_management_strategies.html. On April 5, 2011, Volubill and Telesperience released a report entitled, "Utilizing offloading and traffic shaping to optimize capacity and deliver commercial success", which reveals the steps mobile network operators are taking to address the capacity crunch caused by the increases in wireless data traffic consumption. Notably, the survey found that 47 percent of operators currently employ traffic shaping and 97 percent plan to by 2013.

[92] http://www.youtube.com/watch?v=kffacxfA7G4

[93] "IEEE Approves Development of IEEE P2200™ Draft Standard to Deliver High Quality Mobile Entertainment (HQME)," IEEE Standards Association Press Release (Feb. 15, 2011) available at http://standards.ieee.org/news/2011/p2200.html

[94] *See* http://www.hqme.org/

[95] *See* http://www.hqme.org/hqme.php

[96] "LTE-Advanced 'Carrier Aggregation' on Commercial Equipment a World First," Nokia Siemens Networks Press Release (Feb. 9, 2011).

[97] "AT&T CTO Says Voice Over LTE Coming In 2013," Forbes (Feb. 15, 2011) available at http://blogs.forbes.com/elizabethwoyke/2011/02/15/att-cto-says-voice-over-lte-coming-in-2013/

[98] Rysavy Research, "Smartphone Efficiency Report" at 3 (January 25, 2011) (Smartphone Efficiency Report) available at http://www.rysavy.com/Articles/2011_01_Smartphone_Efficiency.pdf

[99] Smartphone Efficiency Report at 8.

[100] *See* Smartphone Efficiency Report at 7-12.

[101] 47 U.S.C. § 309(j)(3)(D).

[102] *See* http://www.sharedspectrum.com/papers/spectrum-reports/

[103] *See* Comments of Google, *In the Matter of Fostering Innovation and Investment in the Wireless Communications Market*, GN Docket No. 09-157 at 6 (filed Sept. 30, 2009).

[104] "Phoney Spectrum Scarcity," TechAlps (June 19, 2010) available at http://www.techalps.com/wireless/phoney-spectrum-scarcity.html

[105] *See* http://www.dslreports.com/shownews/FCC-Again-Promises-More-Spectrum-112141?nocomment=1

[106] "70-90% of AT&T's spectrum capacity is unused," DSL Prime (Mar. 22, 2011) available at http://www.dslprime.com/a-wireless-cloud/61-w/4193-70-90-of-atat-spectrum-capacity-unused

[107] Comments of Verizon Wireless, In the Matter of 700 MHZ Mobile Equipment Capability, RM-11592 (Mar. 31, 2010).

[108] "How Craig McCaw Built a 4G Network on the Cheap," Bloomberg Businessweek (May 20, 2010) available at http://www.businessweek.com/magazine/content/10_22/b4180035396063.htm; *see also* "Clearwire Said to Seek Up to $5 Billion in Spectrum Auction," Reuters (Oct. 13, 2010) available at http://www.bloomberg.com/news/2010-10-12/clearwire-said-to-seek-up-to-5-billion-for-spectrum-at-t-sprint-may-bid.html.

[109] 47 U.S.C. § 309(j)(4)(B) requires the Commission to prescribe regulations that "include performance requirements, such as appropriate deadlines and penalties for performance failures, to ensure prompt delivery of service to rural areas, to prevent stockpiling or warehousing of spectrum by licensees or permittees, and to promote investment in and rapid deployment of new technologies and services."

[110] *See* http://www.pff.org/issues-pubs/pops/pop13.32robertsluncheontranscript.pdf

[111] Communications Daily, January 28, 2011.

[112] Charles Ergen, *Dish Network CEO Discusses Q3 2010 Results – Earnings Call Transcript, Q&A Section,* SeekingAlpha.com (Nov. 5, 2010), available at http://seekingalpha.com/article/235177-dish-network-ceo-discusses-q3-2010-results-earnings-call-transcript?part=qanda (last visited March 7, 2011).

[113] Letter from Federal Communications Commission (FCC) Chairman Julius Genachowski to Senator John Rockefeller (July 14, 2010).

[114] "FCC on Spectrum Inventory: Already Did It," The Hill (Mar. 16, 2011) available at http://thehill.com/blogs/hillicon-valley/technology/150197-fcc-on-spectrum-inventory-already-did-it

[115] *See* Reforming Airwaves by Developing Incentives and Opportunistic Sharing Act ("RADIOS Act"), S.455, 112th Cong. (2011).

[116] *Id.*

[117] *See* http://reboot.fcc.gov/reform/systems/spectrum-dashboard/about ("The data and analyses provided in the Spectrum Dashboard are for informational purposes and research assistance only. The Spectrum Dashboard does not constitute the official licensing records for the Commission. Specifically, the FCC makes no representations regarding the accuracy or completeness of the information maintained in the Spectrum Dashboard.")

[118] *Id.*

[119] *See* http://reboot.fcc.gov/license-view/

[120] Letter from Senator Olympia Snowe to FCC Chairman Julius Genachowski (January 12, 2011).

[121] CTIA Written Ex Parte Communication, GN Docket No. 09-51 at 23 (Sept. 29, 2009).

[122] Broadband Plan, Section 5.1 (FCC, 2010).

[123] Reed E. Hundt and Gregory L. Rosston, "Communications Policy for 2005 and Beyond," Stanford Institute for Economic Policy Research (SIEPR Discussion Paper No. 04-07, March 10, 2005) at 9.

[124] *See* "FCC vs. Innovation," The Wall Street Journal (Feb. 12, 2011); *see also In the Matter of Fixed and Mobile Services in the Mobile Satellite Service Bands at 1525-1559 MHz and 1626.5-1660.5 MHz, 1610-1626.5 MHz and 2483.5-2500 MHz, and 2000-2020 MHz and 2180-2200 MHz*, Report and Order, ET Docket 10-142 at ¶ 15 (rel. April 6, 2011) (We agree that applying these spectrum leasing policies and rules will help facilitate efficient and innovative new arrangements for using MSS/ATC spectrum, including in both urban and rural areas.").

[125] *See* Jeffrey A. Eisenach, "Spectrum Reallocation and the National Broadband Plan" (October 2010).

[126] 47 U.S.C. § 301 (requiring that no person transmit radio signals except pursuant to a license granted under the Act); 47 U.S.C. § 302 (empowering the Commission to regulate the interference potential of radio transmitters); 47 U.S.C. § 303 (empowering the Commission to adopt such regulations as it deems necessary to prevent interference between radio stations and to encourage more effective use of radio spectrum in the public interest).

[127] As far back as 2002, the Commission had a record before it demonstrating the need for receiver standards. In summarizing the record at that time, the Spectrum Policy Task Force Report explained, "Most parties support the need for the development of receiver standards or guidelines, or, in the alternative, minimum receiver performance requirements. Indeed, many of the parties asserted that, from a purely technical standpoint, interference susceptibility, as well as increased spectrum efficiency is highly dependent on the quality and selectivity of the receiver used." *See* Spectrum Policy Task Force Report, ET Docket No. 02-135 at 31 (rel. Nov. 15, 2002); *see also* In the Matter of Interference Immunity Performance Specifications for Radio Receivers, Notice of Inquiry, ET Docket No. 03-65 ¶ 1(rel. Mar. 24, 2003) ("Increasingly in recent years, the preemptive effect of minimally performing receivers has been demonstrated, as licensees seek protection for service predicated on the performance of receivers with little tolerance for other signals."); NTIA Report 03-404, Receiver Spectrum Standards, Phase 1 — Summary of Research into Existing Standards at iv (November 2003) available at www.ntia.doc.gov/osmhome/reports/ntia03-404/ntiareport03-404.doc ("In recent years, there have been a growing number of cases of non-cochannel interference that has been caused by inadequate performance of receivers instead of by transmitter performance.").

[128] NTIA Report 03-404 at iv.

[129] Letter from Karl B. Nebbia, Associate Administrator of the Office of Spectrum Management to Julius Knapp, Chief, Office of Engineering and Technology, ET Docket No. 10-237 (Mar. 2, 2011). *See also* "NTIA Urges FCC to Adopt Receiver Standards," NTIA Press Release (rel. Nov 12, 2003) available at http://www.ntia.doc.gov/ntiahome/press/2003/receiverstds_11122003.htm (explaining that "Receiver standards mean less interference and more available spectrum.")

[130] Letter from Evelyn Hirt, President, IEEE-USA to FCC Chairman Julius Genachowski and NTIA Administrator Lawrence Strickling (May 6, 2010).

[131] *See* LightSquared Subsidiary LLC Request for Modification of its Authority for an Ancillary Terrestrial Component, SAT-MOD-20101118-00239, Order and Authorization, 26 FCC Rcd 566, 586-87, at ¶¶ 41-43 (International Bureau, Jan. 26, 2011).

[132] *In the Matter of Fixed and Mobile Services in the Mobile Satellite Service Bands at 1525-1559 MHz and 1626.5-1660.5 MHz, 1610-1626.5 MHz and 2483.5-2500 MHz, and 2000-2020 MHz and 2180-2200 MHz*, Report and Order, ET Docket 10-142 at ¶ 28 (rel. April 6, 2011).

[133] The Commission explained that "[t]he Agenda focuses on 2010 items but discusses 2011 items where appropriate . . ." Broadband Action Agenda at n. 1.

[134] In a January 2010 response to Representative Eshoo's letter expressing concern that AWS-3 had been pending too long, Mr. Genachowski noted: "I want to assure you that establishing service rules for the AWS-3 spectrum remains an important Commission priority. Such rules should aim to put AWS-3 to use as expeditiously as feasible, while ensuring that those rules are consistent with our legislative mandate to develop a comprehensive broadband policy for our nation." In the end, no decision at all was made and the rulemaking was terminated prior to the issuance of a final order.

[135] Letter from Karl B. Nebbia, Associate Administrator of the Office of Spectrum Management to Julius Knapp, Chief, Office of Engineering and Technology (Jan. 19, 2011).

[136] Principles for Promoting the Efficient Use of Spectrum by Encouraging the Development of Secondary Markets, Policy Statement (FCC 00-401) at 5, III-12.

[137] In the Matter of Application of Aloha Spectrum Holdings Company LLC (Assignor) and AT&T Mobility II LLC (Assignee) Seeking FCC Consent For Assignment of Licenses and Authorizations, WT Docket No. 07-265, FCC 08-26 (adopted January 25, 2008).

[138] In the Matter of SkyTerra Communications, Inc., Transferor and Harbinger Capital Partners Funds, Transferee Applications for Consent to Transfer of Control of SkyTerra Subsidiary, LLC, IB Docket No. 08-184, DA 10-535 (adopted March 26, 2010).

[139] "AT&T Agrees to Acquire Wireless Spectrum from Qualcomm," Qualcomm Press Release (Dec. 20, 2010) available at http://www.qualcomm.com/news/releases/2010/12/20/att-agrees-acquire-wireless-spectrum-qualcomm

[140] Broadband Plan, p.77 (FCC, 2010), Recommendation 5.7.

[141] *Id.*

[142] *See* Second Report and Order, Order on Reconsideration, and Second Further Notice of Proposed Rulemaking, ET Docket No. 04-167 (Sept. 2004).

[143] Testimony of Jeffrey A. Eisenach, Ph.D., Before the Subcommittee on Communications, Technology and the Internet, Committee on Energy and Commerce, United States House of Representatives, April 21, 2010.

[144] *See* Cisco Forecast ("Mobile video traffic was 49.8 percent of total mobile data traffic at the end of 2010, and will account for 52.8 percent of traffic by the end of 2011.").