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Exhibit 3

Declaration of David E. Borth

A Review of Various Technical Issues Raised in the Verizon Wireless Spectrum Transactions with SpectrumCo and Cox TMI Wireless

and

An Assessment of SpectrumCo's Efforts to Develop Its AWS Spectrum

DECLARATION OF DAVID E. BORTH

1. I am Dr. David E. Borth. I am an independent consultant and a Professor of Electrical and Computer Engineering at the University of Illinois-Chicago, where I joined the faculty in January 2012. Prior to my current work, I was employed by Motorola, Inc. ("Motorola") for 30 years. At Motorola, I served in a number of roles, including 25 years in its central research labs, eventually becoming Corporate Vice President and Director of Wireless Access Research for Motorola Labs. I also served as Chief Technology Officer and Director of Advanced Technology for the Government and Public Safety business of Motorola (now Motorola Solutions), where I was involved in the application of LTE to the Public Safety 700 MHz band.

2. I am the author or co-author of more than 25 papers and five books. I also am the inventor or co-inventor of more than 30 patents. I have served on a number of National Research Council panels, the FCC Technical Advisory Council, and the Department of Commerce Spectrum Management Advisory Committee. I am a Fellow of the IEEE and was elected to the National Academy of Engineering. My full CV is attached to this declaration.

3. I have been asked by counsel for SpectrumCo, LLC ("SpectrumCo") and Cellco Partnership d/b/a Verizon Wireless ("Verizon Wireless") to provide independent expert opinions on the subjects discussed in this declaration. In preparing this declaration, I have relied on my professional experience and the knowledge I have gained through 30 years of experience as a wireless engineer and corporate executive with a leading cellular handset and base station equipment provider, and on my experience in the design, development, and deployment of cellular systems, including the deployment of LTE systems. I have also relied on information

provided by SpectrumCo and Verizon Wireless, and on books, reports, and papers on the topics described herein.

4. I have reviewed the applications for FCC consent to the proposed spectrum license assignments from SpectrumCo and Cox TMI Wireless, LLC ("Cox Wireless") to Verizon Wireless, including the declarations by William H. Stone, Verizon's Executive Director of Network Strategy (Exhibit 3 of the Public Interest Statement attached to each application) (the "Dec. 2011 Stone Declarations"), as well as Mr. Stone's supplemental declaration, which is Exhibit 2 to the March 2, 2012 Joint Opposition to Petitions to Deny and Comments in WT Docket No. 12-4 (the "Supplemental Stone Declaration"). I have had in-depth discussions regarding the substance of the Dec. 2011 Stone Declarations and the Supplemental Stone Declaration with Mr. Stone and other Verizon Wireless engineers. I also have reviewed the December 16, 2011 declaration of Robert Pick, Chief Executive Officer of SpectrumCo (Exhibit 4 of the Public Interest Statement attached to the Verizon Wireless-SpectrumCo application) (the "Pick Declaration"), and interviewed Comcast personnel who have devoted significant time and attention to SpectrumCo matters.

5. This declaration is divided into two parts. Part I analyzes a number of technical issues that have been raised in connection with the proposed spectrum license assignments from SpectrumCo and Cox Wireless to Verizon Wireless and provides an independent assessment of the methodology employed and the conclusions reached by Verizon Wireless in its decision to purchase Advanced Wireless Services ("AWS") licenses from SpectrumCo and Cox Wireless. Part II of this declaration reviews the steps that SpectrumCo has taken to date with respect to the

122 AWS licenses it holds and assesses the technical and engineering conclusions SpectrumCo has reached with respect to the licenses.

6. As detailed in Part I of this declaration, I have concluded that (1) in light of the rapidly growing demand for mobile broadband, Verizon Wireless has used appropriate tools to project the demands that such use will increasingly place on its network; (2) Verizon Wireless uses a reasonable and appropriate methodology to assess capacity constraints on its network in light of existing spectrum resources and has reasonably concluded that data traffic volumes will outstrip capacity in 2013 in some areas and in 2015 in many more, creating a need to acquire additional spectrum; (3) other methods for expanding network capacity – such as cell splitting, use of femto cells, offloading data traffic to WiFi networks, refarming existing spectrum, and deployment of LTE small cells – alone are insufficient to meet the projected demand; and (4) the alternative capacity-enhancing approaches suggested in petitions to deny, including software defined radios, mesh networking, channel bonding, use of unlicensed frequencies, and deployment of distributed antenna systems (DAS), are not viable solutions to address the increase in demand.

7. As detailed in Part II of this declaration, I have concluded that SpectrumCo did everything a reasonably diligent new entrant AWS licensee might be expected to do within the first third of its license term and took meaningful steps to develop, use, and identify long-term business plans for the spectrum. I have reviewed the circumstances surrounding SpectrumCo's analysis of the AWS spectrum as set out in the Verizon Wireless-SpectrumCo Public Interest Statement and the Pick Declaration, and further concluded that SpectrumCo reasonably determined that 20 MHz of AWS spectrum was not enough to fulfill the long-term business

plans of its owners, given the fact that SpectrumCo would have been a new entrant constructing a greenfield mobile wireless network intended to provide both voice and advanced data services.

Part I - A Review of Various Technical Issues Raised in the Verizon Wireless Spectrum Transactions with SpectrumCo and Cox TMI Wireless

8. **Factual Background.** As explained in the Supplemental Stone Declaration, the Verizon Wireless network provides voice, data and mobile broadband services using the 1x (digital), 3G (EVDO), and 4G (LTE) technologies. Verizon Wireless' digital and EVDO services are provided over its spectrum licenses in the cellular (850 MHz) and PCS (1.9 GHz) bands, where all voice traffic and most data and SMS traffic are currently carried.[1]

9. Verizon Wireless launched its 4G LTE network in December 2010, using its 700 MHz Upper C Block licenses. Verizon Wireless has announced that it will cover essentially all of its existing nationwide 3G footprint with LTE by mid-year 2013.

10. Verizon Wireless also holds spectrum licenses in the AWS band[2] in the eastern United States (20 MHz (2 x 10 MHz)), and has plans to deploy LTE service over that spectrum at cell sites where data demands are highest, and over the next few years at the majority of its cell sites in the eastern part of the country.

11. **Verizon Wireless Projections of Data Demands on Its Network.** Data traffic on the Verizon Wireless network has nearly doubled in each of the past five years, with the pace of

[1] *See* Supplemental Stone Declaration ¶ 6.

[2] The AWS-1 band consists of two paired spectrum bands: 1710-1755 MHz and 2110-2155 MHz.

growth accelerating over the past two years.[3] AT&T has recently also reported a doubling in wireless data traffic on the AT&T cellular network from 2010 to 2011.[4] Furthermore, Cisco recently released its latest Visual Networking Index, which details the same phenomenon globally.[5] The Supplemental Stone Declaration updates the figures provided in the Dec. 2011 Stone Declarations, confirms that the rapid growth in broadband traffic on the Verizon Wireless network is continuing, and projects traffic levels into the future.[6]

12. The use of historical data to project future trends is the appropriate way to make such projections, and Mr. Stone's projections regarding the rapid increase in broadband data demand that will be imposed on the Verizon Wireless network are consistent with both industry trends and Verizon Wireless' experience. In my expert opinion, the projections of data demand made by Mr. Stone are reasonable and provide an appropriate foundation upon which to make assessments as to spectrum planning.

13. **Verizon Wireless' Assessment of Capacity Constraints.** In my experience, I have found that wireless carriers must continually assess whether their spectrum holdings are sufficient to meet their needs. As noted in the Supplemental Stone Declaration, Verizon

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[3] *See* Dec. 2011 Stone Declarations ¶ 6.

[4] *See* John Donovan, Senior Executive Vice President – Technology and Network Operations, AT&T, "Wireless Data Volume on Our Network Continues to Double Annually," AT&T Innovation Space Blog (Feb. 14, 2012), available at http://www.attinnovationspace.com/innovation/story/a7781181.

[5] Cisco observes that "[g]lobal mobile data traffic grew 2.3-fold in 2011, more than doubling for the fourth year in a row" and predicts that such traffic "will increase 18-fold between 2011 and 2016." CISCO VISUAL NETWORKING INDEX: GLOBAL MOBILE DATA TRAFFIC FORECAST UPDATE, 2011–2016 (Feb. 14, 2012), available at http://www.cisco.com/en/US/solutions/collateral/ns341/ns525/ns537/ns705/ns827/white_paper_c11-520862.html.

[6] *See* Supplemental Stone Declaration ¶¶ 11-13.

Wireless is no different. Indeed, Verizon Wireless assesses its spectrum capacity on a market-by-market, cell site-by-cell site, and even cell sector-by-cell sector basis, taking into account the mix of spectrum capacity and elements of demand both across the network and within individual markets.[7] This kind of sector-by-sector analysis, which is necessary because capacity overloads occur in individual sectors and not just in individual cells, enables Verizon Wireless to gain a deep understanding of the capacity constraints of its network and their effects on customers, and is an appropriate way to do network planning.

14. Verizon Wireless makes use of an internally-developed capacity and spectrum planning tool known as the Verizon Planning Instrument ("VPI") to monitor and evaluate capacity needs on its LTE and EVDO networks. Projected data levels are used to determine the impact on service levels and customer experience on the LTE network.[8] Through experience gained from operating an LTE network, Verizon Wireless has empirically observed the data throughput that a fully loaded LTE cell site sector can support given the amount of spectrum employed and still maintain the speeds expected by all customers.[9] (Verizon Wireless considers LTE speeds of 5-12 Mbps downstream and 2-5 Mbps upstream as the goal for its customers.)

15. The following analysis verifies the figures provided by the VPI regarding the maximum traffic limit of an LTE cell site sector. Assume an LTE system (3GPP Release 8) is deployed in paired 10 MHz blocks of spectrum (i.e., 2 x 10 MHz). An often quoted number for the peak downlink data rate in an LTE sector operating in 10 MHz of spectrum is 86 Mbps assuming 2x2

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[7] *See* Supplemental Stone Declaration ¶ 15.

[8] *See id.* ¶¶ 19-20.

[9] *See id.* ¶¶ 21-23.

MIMO (multiple input-multiple output (antenna system)).[10] In reality, this assumes the sector is isolated from all other sectors (i.e., no cochannel interference), 2x2 MIMO is operational, and no error correction coding has been applied – meaning there is no rate reduction due to the FEC (Forward Error Correction) coding. If the sector is now assumed to be operating in a realistic cellular environment with cochannel interference from the neighboring sectors and the performance is averaged over the entire sector, the average sector throughput is reduced to 16.7 Mbps.[11] At the data speeds that Verizon Wireless provides LTE service to its customers, total sector throughput on a per-hour basis will necessarily be lower. I therefore conclude that the cell site sector capacity thresholds employed in the Supplemental Stone Declaration are reasonable given the assumed data speeds.

16. In the Supplemental Stone Declaration, the cell site sector capacity limit derived under the VPI is applied to particular cell site sectors in 18 markets using actual data traffic figures from YE 2011 and data traffic projections for YE 2013 and YE 2015. The maps supplied with the Supplemental Stone Declaration indicate, based on projected traffic, the specific cell site sectors in which traffic volumes are expected to exceed current capacity, causing customers to experience degradation in the speed and quality of data services. At YE 2011, after one year operating its LTE network, Verizon Wireless had no spectrum constraints in any of the markets selected. Beginning in YE 2013, however, many sectors will begin to become spectrum

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[10] *See* Motorola White Paper, REALISTIC LTE PERFORMANCE: FROM PEAK RATE TO SUBSCRIBER EXPERIENCE, dated 2010, available at http://business.motorola.com/experiencelte/lte-depth.html; NGNM Alliance, GUIDELINES FOR LTE BACKHAUL TRAFFIC ESTIMATION, dated July 3, 2011, available at http://www.ngmn.org/home.html

[11] It should also be noted that LTE is a packet based system. In any packet system, as the throughput of the system approaches the capacity of the link, the queuing delay in processing packets increases significantly, thereby degrading the user experience. James F. Kurose and Keith W. Ross, COMPUTER NETWORKING, THIRD EDITION, Pearson/Addison Wesley (2005), at 256.

constrained (yellow) with some severely constrained (red). By YE 2015, many cell sites sectors will be severely constrained (red).[12]

17. My independent review of the capacity constraint analysis set forth in the Supplemental Stone Declaration leads me to conclude that the methodology employed therein to determine whether data volumes would exceed cell site sector capacities is sound and provides a reasonable basis upon which to conduct spectrum planning. This is precisely the type of analysis that a reasonable and responsible wireless carrier would be expected to engage in so as to ensure the future viability of its network. In my opinion, taking into account the alternative capacity-enhancing measures that Verizon Wireless states that it will invest in (see discussion below), the VPI accurately projects areas where Verizon Wireless customers are likely to experience substantial degradation in the speed and quality of data services absent the addition of spectrum. In short, taking into account the inadequacy of those other measures to meet the projected demand, my expert opinion is that Verizon Wireless will not be able to continue to meet its LTE service goals unless it is able to acquire additional spectrum.

18. **Capacity-Enhancing Measures Currently Employed by Verizon Wireless.** The Supplemental Stone Declaration notes that Verizon Wireless' LTE network development plans assume that cell site sector capacity limits will increase over time from the adoption of the LTE Advanced standard and the deployment of LTE small cells.[13] It also identifies other approaches, aside from acquiring additional spectrum, to address capacity demand that either already have

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[12] *See* Supplemental Stone Declaration ¶¶ 30-37. In markets where Verizon Wireless currently holds AWS spectrum, the maps double the data thresholds for marking a cell site sector yellow or red.

[13] *See id.* ¶ 24.

been deployed, will be deployed, or are not feasible.[14] I would like to comment further on several of these approaches, and on Mr. Stone's conclusion that, while these measures will have some impact, they will be inadequate to meet the projected demands.

19. Cell splitting. As the capacity of a particular macro cell site is exceeded, the cell may be split – that is, additional cell sites using the same frequency planning are added in addition to a given cell to provide coverage over a particular area. Theoretically, for an N=1 frequency reuse plan such as that used in LTE systems,[15] each additional cell site provides a capacity equivalent to the original site. Thus capacity is enhanced without requiring any new spectrum. This attribute of cellular systems has been used for many years as new wireless carriers came on board, initially with a minimal footprint followed by a built-out system. The drawback of cell splitting is that as more and more sites are placed close together, the benefits derived from adding a site decline relative to the costs associated with building an additional site and the time required to actually locate a new base station. Furthermore, the actual capacity improvement in dense systems within a small geographic area is limited to a capacity improvement in the 3 sectors at adjacent cell sites that face the newly-added cell. In addition, if an entire area is capacity limited (such as is the case for the projected data traffic growth in the 3 cities analyzed in the Supplemental Stone Declaration as well as in several others shown in the maps attached to that declaration), then cell splitting is not an acceptable choice from a cost and time viewpoint. As noted in the Supplemental Stone Declaration, Verizon Wireless does deploy split cells in situations where doing so is effective and practical to meet increased demand.[16] In my judgment,

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[14] *See id.* ¶¶ 39-49.

[15] A system with an "N=1 frequency reuse plan" reuses all frequencies in every sector of every cell.

[16] *See* Supplemental Stone Declaration ¶ 43.

Verizon Wireless has reasonably concluded that the benefits that can be derived from cell splitting are limited and that, to address widespread increases in data demand, adding additional spectrum at cell site sectors is both much more cost effective and faster than widespread cell splitting.

20. Use of femto cells. For users in some locations (e.g., office and apartment buildings), high speed access to the carrier network can be accomplished through the use of a femto cell. This is a low power eNodeB that is located in the customer premises and that uses the carrier's authorized frequencies to communicate with the user's devices but uses an Internet connection to the carrier to carry the traffic to and from the user to the carrier network. With careful planning, interference to the larger macrocell network is minimized while locally enhancing the network capacity without requiring any additional spectrum. The emphasis here is on the term locally; an individual user or very small group of users operating in the same building may indeed enjoy higher data speeds because of the Internet connection to the carrier network, but the overall impact on total network capacity is quite limited. I therefore agree with Mr. Stone's conclusion that, because they can only offload a small fraction of any sector's traffic, femto cells "will never be able to meet the skyrocketing demand ...."[17]

21. Offloading data traffic to Wi-Fi. Most smartphones today also have Wi-Fi capability. By relying on the high availability of Wi-Fi networks and hotspots, user data traffic may be sent to and from the carrier network via Wi-Fi without making use of the carrier's spectrum. High speed data may thus be offloaded from the carrier's cellular network. Consumers today regularly

[17] *Id.* ¶ 45.

make use of this capability for significant downloads of data, and, in fact, Verizon Wireless has already factored in this behavior into its data traffic projections.[18]

22. As noted in the Supplemental Stone Declaration, Wi-Fi networks make use of unlicensed spectrum and are therefore subject to interference that can degrade the Wi-Fi access point capacity.[19] For this and other reasons, Verizon Wireless has decided not to automatically push its customers off of its EVDO and LTE networks, but rather gives them the choice to use third-party Wi-Fi. Verizon Wireless does deploy its own Wi-Fi networks to handle special traffic situations during special events and in venues like stadiums.[20] From my own experience in wireless systems, I concur with the viewpoint of Verizon Wireless. Wi-Fi networks can provide some level of additional capacity, but their operation is outside the control of any wireless carrier and therefore could cause users to suffer a degraded experience compared to that offered by Verizon Wireless. I believe that Verizon Wireless' decision not to force its customers onto Wi-Fi networks is a reasonable one.

23. Refarming existing spectrum that Verizon Wireless currently holds. As noted above, Verizon Wireless currently holds spectrum and provides services in several bands: 1X and 3G services in the cellular (850 MHz) and PCS (1.9 GHz) bands, LTE in the upper C block 700 MHz. It will also support LTE in the AWS spectrum that Verizon Wireless holds in the eastern United States. Thus, the only spectrum bands in use that might potentially be refarmed for

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[18] *See id.* ¶ 46. Verizon Wireless includes Wi-Fi chipsets in all of its smartphones and allows its customers to use Wi-Fi networks

[19] *See id.*

[20] *Id.*

deployment of LTE by Verizon Wireless are the cellular and PCS spectrum bands in which Verizon Wireless holds licenses.

24. At the present time, even though data traffic is moving to LTE, overall traffic on the Verizon Wireless EVDO network also continues to grow.[21] A very large number of devices therefore will continue to operate using EVDO as customers will choose not to transition. Furthermore, EVDO supports certain types of machine-to-machine devices that are not easily upgraded. Hence it is reasonable for Verizon Wireless to continue to operate its EVDO network for many years beyond 2015. This is not at all unusual in the wireless industry; even though the wireless carriers would like to transition their customers to the latest spectrally efficient technology, a significant percentage of customers will choose not to upgrade. Some earlier examples of this include the availability of analog AMPS cell systems long after the entire transition of the cellular industry to digital[22] and the availability of D-AMPS (IS-54/IS-136) cell systems long after the move to higher speed digital cellular systems.[23]

25. An additional issue with refarming spectrum is the availability of enough contiguous frequencies to permit reconfiguration of EVDO cell sites to LTE cell sites. While the current LTE standards permit channelization from 1.4 MHz to 20 MHz (with corresponding FDD paired spectrum), in order to offer data rates that would be minimally acceptable under Verizon Wireless' standards, an LTE system must operate with at least 10 MHz (2 x 5 MHz) of spectrum. Since EVDO operates on paired 1.25 MHz channels, at least 4 (or more to allow for adjacent system interference from EVDO signals) contiguous channels of PCS spectrum must be free in a

[21] *See id.* ¶ 13 (graph).

[22] AMPS went into service in 1983 and was formally retired in most of the U.S. by February 2008.

[23] D-AMPS was standardized in 1990 and was retired from service in most of the U.S. by 2009.

sector in order for a successful conversion to an LTE system. Verizon Wireless in due course will be able to free up this amount of PCS spectrum only on a piecemeal basis and only in the more lightly loaded cells.[24] Hence refarming may be a good idea in theory, but it will take a significant amount of time to even partially implement and perhaps a very long time to fully implement. Based on the above, in my view the refarming of spectrum currently licensed to Verizon Wireless therefore provides no solution to the capacity constraints that the company's network will begin to feel within a relatively short time.

26. **Alternative Capacity-Enhancing Approaches Identified in the Petitions to Deny.** A few parties challenging the proposed spectrum license assignments have suggested that, instead of acquiring the AWS spectrum licenses, Verizon Wireless should invest in additional potential methods to address spectrum limitations.[25] Some of these alternatives have already been addressed immediately above. The others will be addressed technology by technology below.

27. Software defined radios. Software defined radios are radios in which the air interface and operating frequency and/or the user applications interface are controlled via software. Many existing radio architectures now use software defined radio technology although often times this feature is hidden from the user. While software defined radios can form the basis for a complete system that might someday realize higher capacity levels, they cannot provide a direct impact to help enhance the capacity of an already fully-developed wireless network like Verizon Wireless'.

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[24] *See* Supplemental Stone Declaration ¶ 48.

[25] *See* Petition to Deny filed by Free Press, WT Docket No. 12-4 (filed Feb. 21, 2012); Petition to Deny filed by Public Knowledge, Media Access Project, New America Foundation, Benton Foundation, Access Humboldt, Center for Rural Strategies, Future of Music Coalition, National Consumer Law Center, and Writers Guild of America, West, WT Docket No. 12-4 (filed Feb. 21, 2012).

28. Mesh networking. Mesh networking is a type of radio system architecture whereby each transceiver or node in the system serves not only as a transceiver for an individual user but also as a relay node in the overall network to relay transmissions from other users to other nodes in the network. Mesh networks have been utilized for military systems and for Wi-Fi networks. Usually these networks are single frequency systems so that each node can hear all adjacent nodes. While mesh networking can provide improved connectivity among nodes in wireless networks, it often does this at the expense of increased delay and congestion within the network. It can be shown that the capacity of an entire mesh network grows as more nodes are added to the network, but the throughput per node decreases with an increase in the number of nodes in the network. Thus, the use of mesh networks can actually degrade the throughput made available to individual users as more nodes are added to the network. In my opinion, therefore, mesh networking is not an appropriate method to enhance cellular system capacity.

29. Channel bonding. Channel bonding groups together various available frequencies in a wireless system to form a bonded channel of the required bandwidth. Unused frequencies are therefore put to use. This requires the air interface to be highly reconfigurable at the expense of added system complexity. For an LTE system, this also requires that two sets of bonded channels are formed – one for the uplink, the other for the downlink. Furthermore, since the bonded channel is made up of disparate and not contiguous frequencies, special care must be paid to channel sounding and synchronization as well as interference from adjacent OFDM carriers.

30. The need to bond channels typically can arise when a wider bandwidth is required for a higher data rate, in which event channel bonding can artificially create such a wider carrier

bandwidth. While in this case the technology is potentially useful, it does not increase either the peak spectrum efficiency of the sector or the actual coverage spectrum efficiency of a loaded sector.

31. Use of unlicensed frequencies. In addition to the Wi-Fi bands at 2.4 GHz and at 5 GHz, in the U.S. there are a number of other unlicensed frequencies available for deployment of unlicensed services at 902-928 MHz, 1920-1930 MHz, the TV white space spectrum, and selected other frequency bands, in addition to those frequency bands where low power part 15 devices may be deployed. The reasons supplied in the Supplemental Stone Declaration for Verizon Wireless' decision not to force customers onto Wi-Fi networks apply with equal force to these other unlicensed frequency bands. Verizon Wireless has stated a desire to ensure that its customers receive the highest possible quality and reliability. Given that unlicensed bands are shared bands with all sorts of possible uses, the quality and reliability of using these frequencies cannot be guaranteed. Thus, unlicensed frequencies should not be relied upon to enhance system capacity.

32. Next generation standards. As has been the trend in the cellular standards arena, future standards often improve upon the performance of older standards. Such is the case with LTE. The first release of LTE, 3GPP Release 8, was superseded by further system improvements in 3GPP Release 9, which remained backward compatible. In April 2011, the standard for 3GPP Release 10 was set. 3GPP Release 10 addresses the next evolution of LTE known as LTE Advanced. LTE Advanced offers enhanced performance over LTE in two ways – the first by using more spectrum (up to 100 MHz); the second by using this spectrum more efficiently. The improvement in spectral efficiency (and a corresponding increase in spectral capacity) is

expected to be made possible by enhanced downlink MIMO transmission through an increase in the number of antennas in both the eNodeB as well as in the user equipment – up to 8 antennas in each. However, there are limitations in the number of antennas that can be practically deployed. At the cell site, the number of antennas is constrained by aesthetics, wind loading, cabling, antenna mast mechanical limits, and local zoning issues, among other issues. In the user equipment, it is very difficult to locate more than 2 independent antennas within the space constraints of today's physically shrinking user equipment – handsets, tablets, dongles. Furthermore, the MIMO gains expected with the added antennas may not fully be realized because of the close proximity of antennas to each other in a given sector antenna mast or in the user equipment. For these reasons and because of the current uncertainty associated with the timeline of the rollout of equipment for LTE Advanced, it is unlikely in my opinion that an LTE Advanced system rollout will obviate the need for additional spectrum before system capacity is exceeded in many sectors of the Verizon Wireless LTE system.

33. Deployment of Distributed Antenna Systems (DAS). Distributed Antenna Systems replace a single antenna radiating at high power with a group of multiple antennas, each radiating at low power to cover the same area as the high power antenna. One version of a DAS is a leaky coax antenna system – a type of technology that has been used for years to cover tunnels, transit stations, etc. The essential aspect of DAS is that it is used to provide improved coverage of an area that might not otherwise be covered by an existing conventional cell system. So deploying distributed antenna systems will not make a contribution to enhancing system capacity but may improve system coverage.

Part II - An Assessment of SpectrumCo's Efforts to Develop Its AWS Spectrum

34. This section of the declaration reviews the steps SpectrumCo has taken with respect to the 122 AWS licenses it holds and assesses the technical and engineering conclusions SpectrumCo has reached with respect to the licenses. This review has been conducted in furtherance of the application SpectrumCo and Verizon Wireless have filed with the FCC to assign SpectrumCo's AWS licenses to Verizon Wireless.

35. Based on the analysis set forth below, I have reached the following conclusions:

- SpectrumCo did everything a reasonably diligent new entrant AWS licensee might be expected to do within the first third of its license term and took meaningful steps to develop, use, and identify long-term business plans for the spectrum.
- As described in the Verizon Wireless-SpectrumCo Public Interest Statement and the Pick Declaration, SpectrumCo reasonably determined that 20 MHz of AWS spectrum was not enough to fulfill the long-term business plans of its owners, given the fact that consumer broadband demand was increasing dramatically, and that SpectrumCo would have been a new entrant constructing a greenfield mobile wireless network intended to provide both voice and advanced data services.

36. Acquiring the spectrum was part of an effort by SpectrumCo's owners to explore wireless options for their customers.[26] In this analysis, I describe the steps required for a new entrant to build a greenfield 4G cellular system in the AWS band, and I describe SpectrumCo's efforts to perform those steps. The task facing a new entrant can be broken into three steps: (1) developing the spectrum; (2) provisioning the spectrum – the process of matching the available spectrum to customer demand; and (3) designing and constructing a greenfield network.

37. **Developing the Spectrum.** As is sometimes the case when the FCC reallocates a spectrum band, the AWS spectrum was in use by incumbent licensees at the time it was

[26] *See* Pick Declaration ¶ 2.

reallocated and auctioned. These incumbent licensees must be moved out of the band before the band can be repurposed by the successful bidders, but this process can only take place after licenses are issued for the auctioned spectrum. Prior to the AWS auction, the 2.1 GHz portion of the AWS paired allocation contained approximately 5700 fixed microwave service (FS) systems and 205 broadband radio service (BRS) systems. There also were myriad federal government users operating in the 1.7 GHz portion of the AWS paired allocation. Many of these federal government users are still in the AWS band. The rules for the AWS service call for a mandatory negotiation period of up to two years for non-public safety FS systems and up to three years for public safety FS systems.[27] Note that the need to identify, negotiate, and relocate incumbent users is critical to making the spectrum commercially usable, but adds to the time needed to start up a new system operating in the AWS spectrum. In fact, the FCC's rules provide AWS licensees an additional five years for construction beyond the license period that is typically provided to mobile wireless licensees because of the additional time it was anticipated to take to clear the band.[28]

38. At the time that SpectrumCo acquired the AWS licenses in 2006, SpectrumCo created a template of a possible national network that it could create with the AWS spectrum. It then identified a number of incumbent microwave links that would need to be cleared in order to implement the template national network. SpectrumCo spent more than $20 million to clear or

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[27] *See* 47 C.F.R. §§ 27.1111, 27.1132, *et seq.*

[28] *See Service Rules for Advanced Wireless Services in the 1.7 GHz and 2.1 GHz Bands*, Report and Order, 18 FCC Rcd 25162, ¶ 70 (2003) (The Commission established an initial license term of 15 years for licensees in the AWS-1 band, agreeing with commenters who argued that the need to clear the band and relocate incumbents warranted a longer-than-usual initial license term.).

confirm the clearance of more than 500 incumbent wireless point-to-point microwave links in the geographic area covered by SpectrumCo's AWS licenses.[29]

39. **Provisioning the Spectrum.** After spectrum obtained at auction is cleared of incumbents, a licensee must determine how to use the spectrum based on a number of factors:

(a) Is the new network to be used for voice, data, or both?

(b) What are the issues associated with the frequency of the band? How is the maximum cell size determined, and what is the total number of cells required to be used to build out a system?

(c) What air interface technology should be used? If voice is part of the wireless network, how is voice handled?

(d) What are the current and projected amounts of data per customer?

(e) What is the projected customer base for this new network?

(f) For (a) through (e), what bandwidth of spectrum is expected to be required, what are the spectrum bandwidth projections for the future and how do we solve future bandwidth demands?

40. Consumer demand drives network development decisions, and, as noted in the Public Interest Statement,[30] consumer demand has shifted to broadband. From the plethora of data available in a number of recent reports from the FCC, Cisco, CTIA, and others[31] it is clear that

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[29] *See* Pick Declaration ¶ 3.

[30] *See* Verizon Wireless-SpectrumCo Application, FCC File No. 0004993617 (filed Dec. 16, 2011), Public Interest Statement at 7-9.

[31] *See, e.g.*, Federal Communications Commission, Connecting America: The National Broadband Plan, 2010, available at http://www.broadband.gov/plan/; Federal Communications Commission, "Mobile Broadband: The Benefits of Additional Spectrum", dated October 2010, available at http://transition.fcc.gov/Daily_Releases/Daily_Business/2010/db1021/DOC-302324A1.pdf; CISCO VISUAL NETWORKING INDEX: GLOBAL MOBILE DATA TRAFFIC FORECAST UPDATE, 2011–2016 (Feb. 14, 2012), available at http://www.cisco.com/en/US/solutions/collateral/ns341/ns525/ns537/ns705/ns827/white_paper_c11-520862.html.

data from smartphones, tablets, and dongles, as well as new applications[32] for these types of devices, are driving the traffic on cellular networks today and will continue to do so into the foreseeable future. In order to support growth in broadband demand, a new entrant's greenfield wireless network must be engineered for optimal high-speed data transmission.

41. Each spectrum band is unique, and all of the characteristics of a band must be taken into account when designing a network. These factors include propagation characteristics, capacity, and availability of equipment and technology for the band. The AWS band was in its infancy at the time of the auction, and there were many unanswered questions about the spectrum and no off-the-shelf equipment available for use in the band.

42. In late 2006, when SpectrumCo acquired the AWS spectrum, there were several potential air interface technologies for the AWS band. The best way to determine which air interface technology is preferable is to test the available alternatives. Today, the answer is easy – the choice is LTE. The advances in LTE that have occurred since WiMAX was first introduced heavily favor LTE as the choice of technology. But just a few years ago, that "clear choice" was much less clear.

43. SpectrumCo began looking at 4G technologies that (a) could work in the AWS spectrum allocation, and (b) support broadband data. As a company which could only rely upon AWS spectrum (unlike the other major AWS auction winners, all of which were already operating using spectrum in other bands), SpectrumCo had to help drive the technology development in

[32] Willa Plank, "Confessions of an iPhone Data Hog," Wall Street Journal online (Jan. 27, 2012), available at http://online.wsj.com/article/SB10001424052970204624204577183032028581306.html; Marguerite Reardon, "Is Apple's App Store a cellular data hog?," CNET online (Sep. 26, 2011), available at http://news.cnet.com/8301-30686_3-20111803-266/is-apples-app-store-a-cellular-data-hog/.

this band. In January 2007, SpectrumCo embarked on a two-year study to determine the best possible air interface technology for deployment on a new nationwide 4G network operating in the AWS spectrum. At that time, AWS was in the very early stages of development, and there existed many questions about technology, equipment and how the spectrum could best be used. A 4G technology test bed was constructed and operated in King of Prussia, Pennsylvania by SpectrumCo to evaluate the three leading 4G technology candidates at that time: WiMAX, Ultra Mobile Broadband (UMB), and LTE. In 2007, this was a far-reaching undertaking because, although the standard for IEEE 802.16e TDD WiMAX had been approved in that year, the FDD version actually tested was a pre-standard technology. Similarly, 3GPP release 8, which defined the first LTE standard, was not completed until 2009. Leading wireless equipment manufacturers including Alcatel-Lucent, Qualcomm, and Huawei participated with SpectrumCo in the King of Prussia tests. The primary objectives of these tests were to evaluate and compare the performance of certain key attributes of the spectrum and the air interfaces, to determine the readiness of the technology for SpectrumCo deployment, to evaluate the applicability of the technology to the AWS spectrum, and to validate industry claims about the technology.

44. Each 4G technology was subjected to a set of live operational tests. Transmission equipment was installed at several outdoor cell sites, and the sites were connected to create a small-scale wireless network. Prototype handsets were tested with each 4G technology. The amount of time and resources devoted to the King of Prussia tests demonstrates that SpectrumCo was very serious about finding a way to use the AWS spectrum to provide wireless services to consumers.

45. For each 4G technology, SpectrumCo measured a number of key parameters essential to understanding the spectral efficiency, operational efficiency, latency, interference management, data throughput, and handover capability of the technology. For a variety of reasons (clear to everyone today), SpectrumCo determined that LTE was the optimal technology for use in the AWS spectrum. This conclusion was supported by both operational tests at the King of Prussia location and analysis conducted by SpectrumCo. Subsequent to the testing at King of Prussia, SpectrumCo collaborated with Nortel on LTE testing in the AWS band using Nortel's Ottawa Live Air Test system. In support of expanding the AWS ecosystem, SpectrumCo has also made its spectrum available to original equipment manufacturers to develop and test AWS-capable wireless equipment.

46. **Designing and Constructing a Greenfield Network.** Constructing a greenfield LTE network requires the selection of base station and wireless core network vendors. This equipment drives power requirements, space requirements, heating/cooling demands at the remote sites, and network communication requirements. After these vendors are selected, initial wireless network design may begin. Coverage areas are defined by market opportunity, demand, and population, with the goal of addressing all three aspects. With the initial wireless network plan completed, a backhaul plan to support communications to cell sites must be established. Often a backhaul plan consists of non-homogeneous backhaul methods – a mix of fiber/copper/microwave – in order to support a wide range of cell site locations.

47. Finally, before beginning operations, a new entrant must secure handsets and enter into roaming agreements. The key relevant questions for handsets are: which manufacturers will produce handsets for the relevant band, how long before handsets can be designed and delivered,