



## **FROM PROPOSAL TO DEPLOYMENT: THE HISTORY OF SPECTRUM ALLOCATION TIMELINES**

*To Re-Allocate the Additional 350 MHz of Licensed Spectrum Needed by 2019,  
Policymakers Must Act Now*

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Bringing new spectrum into the hands of wireless operators to provide broadband services to U.S. consumers takes a significant amount of time. The legislative and regulatory process for the AWS-3 auction began in 2002, the auction ended earlier this year, and commercial deployment is not expected to begin for another two years.

By 2019, the U.S. will see a 78-fold increase in wireless data use over the 2010 level.<sup>1</sup> Taking into account additional infrastructure and increased spectral efficiencies, CTIA has calculated the amount of additional licensed spectrum – over 350 MHz – necessary by the end of the decade to meet this explosion in mobile data.<sup>2</sup>

Yet after the broadcast incentive auction, the traditional licensed spectrum pipeline is empty. The ability of the U.S. to remain the

global leader in wireless depends upon the ability of the government to provide operators with sufficient licensed spectrum over the next five years and beyond – a point echoed by FCC Chairman Tom Wheeler recently when he noted that spectrum will play a major role “in determining who will be the international leader for 5G broadband networks.”<sup>3</sup>

The 350 MHz target is daunting. A review of previous reallocation efforts shows that it takes, on average, 13 years to reallocate spectrum for wireless use. This underscores the urgency of beginning this process today.

There is reason for optimism that we can work collaboratively to shrink that timeline. The wireless industry is ready to quickly deploy spectrum once airwaves are auctioned or reallocated. Government partners have streamlined their procedures.

SPECTRUM	BANDS	FIRST STEP	AVAILABLE FOR USE	FIRST DEPLOYMENT	APPROXIMATE TIME LAG
Cellular	824-849; 869-894 MHz	1970	1981	1983	13 years
PCS	1850-1920; 1930-2000 MHz	1989	1995	1995	6 years
EBS/BRS	2496-2690 MHz	1996	2006	2009	13 years
SMR	817-824; 862-869 MHz	1995	2012	2013	18 years
700 MHz	698-748; 746-806 MHz	1996	2009	2010	14 years
AWS-1	1710-1755; 2110-2155 MHz	2000	2006	2008	8 years
WCS	2305-2315; 2345-2355 MHz	1997	2012	2015	18 years
AWS-3	1695-1710; 1755-1780; 2155-2180 MHz	2002	2015	2017 (estimated)	15 years
AWS-4	2000-2020; 2180-2200 MHz	2003	2012	2017 (estimated)	14 years
600 MHz	TBD	2014	2016 (estimated)	TBD	TBD

The timelines can be accelerated both pre- and post-auction, as the experience with certain bands – PCS, AWS-1, and the upcoming incentive auction – illustrates. But it is incumbent upon policymakers to take that first step, to begin the process as soon as possible.

## **THE DAUNTING HISTORICAL TIMELINES TO REALLOCATE SPECTRUM FOR WIRELESS**

***On average, it takes over 13 years to get spectrum into the hands of consumers.***

The National Broadband Plan catalogued the length of time past spectrum reallocation efforts have taken.<sup>4</sup> The FCC measured the reallocation process starting from the initial Order to the granting of the licenses or the auction's closing.<sup>5</sup> While illustrative of the timeline, as a practical matter, this underestimates the total time by discounting the often lengthy time required to get to an Order.

Nonetheless, the table on the previous page represents an update of the FCC's data to capture additional spectrum bands reallocated since 2010 and notes when service was first deployed – not just when the spectrum was available for use.

The data show that the process of reallocating spectrum for wireless has taken between six and 18 years – on average 13 years – from FCC Order to first deployment.

This timing challenge dates back to the original cellular bands. The FCC adopted its First Report in 1970, began accepting applications for licenses in 1975, and licensed the first cellular system in 1982.<sup>6</sup> Commercial service began when Ameritech

Mobile Communication launched its network in Chicago on October 13, 1983.<sup>7</sup> In the years since, the timelines to reallocate spectrum have not improved with any consistency, as the lengthy AWS-3 process demonstrates.

The policy implication of these facts and the 13-year average is clear: we must begin now to identify the 350 MHz of licensed spectrum to meet the increase in wireless traffic expected in 2019 and beyond.

Some suggest these challenges necessitate a departure from the goal of clearing spectrum for wireless services. However, such delays are not new,<sup>8</sup> spectrum's quality as a finite resource is not a recent development,<sup>9</sup> and these lengthy timelines are not constrained to mobile wireless services.<sup>10</sup> Licensed spectrum made the U.S. the global leader in wireless, and lessons learned from recent spectrum reallocation efforts can provide the path for future efforts.

We cannot rest at the turn of the decade either, as new innovations will continue to increase the demand for wireless data. Carriers are already exploring new technologies, and 4G LTE usage will continue to grow well beyond 2020.<sup>11</sup> Some projections estimate that the Internet of Things may connect up to 50 billion devices by the end of the decade.<sup>12</sup>

Furthermore, countries around the world are looking to 5G not merely as a wireless technology, but as a key input for economic growth. When and how we introduce 5G in the United States depends in part on whether we keep our spectrum policy as forward-looking as our industry.

**THE TIME LAG IN THE DEPLOYMENT OF NEW LICENSED SPECTRUM IS IMPACTED BY A MULTITUDE OF FACTORS**

*The Critical Role of Congress.* Congress first provided the FCC with the authority to conduct spectrum auctions in 1993. One of the primary goals in granting the Commission that authority was “more efficient spectrum management.”<sup>13</sup>

A review of spectrum allocations for wireless since 1993 finds that additional Congressional involvement was necessary for the majority of the spectrum allocated for wireless voice and mobile data services over the past 23 years.

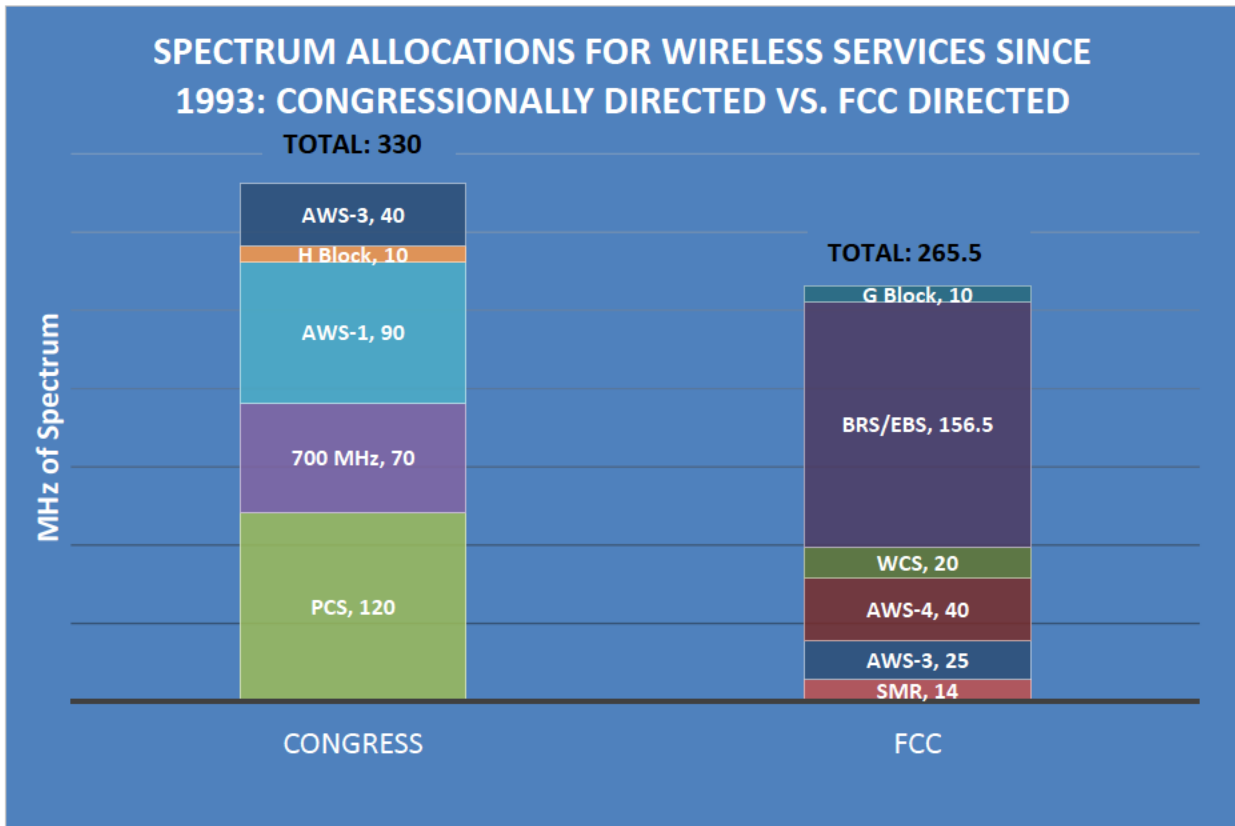
As the chart below illustrates, Congress directed the Commission to auction 55 percent of the licensed spectrum made available for wireless broadband since

1993. For example, Congress played a key role in the PCS,<sup>14</sup> AWS-1,<sup>15</sup> 700 MHz,<sup>16</sup> H-Block and AWS-3 auctions.<sup>17</sup>

Congress also plays a critical oversight role to keep auctions and allocations on track. The need for continued Congressional involvement underscores the difficulty in bringing spectrum for wireless broadband to auction, and adds time to those efforts.

*The Critical Role of the Administration.* Today, the federal government has sole or primary use of between 60-70 percent of spectrum suitable for wireless broadband.<sup>18</sup> Given this fact, every Administration plays a key role in coordinating agencies’ efforts before, during, and after spectrum reallocation efforts.<sup>19</sup>

The Obama Administration deserves credit on this front, including for a series of



Presidential Memoranda and Executive Orders that have emphasized this issue across a host of executive departments, agencies, and offices and helped set the stage for progress on spectrum.<sup>20</sup>

Since 2010, the Administration has spearheaded efforts to re-allocate 135 MHz for mobile broadband.<sup>21</sup> As spectrum bands are considered and once bands are reallocated, such support is critical.

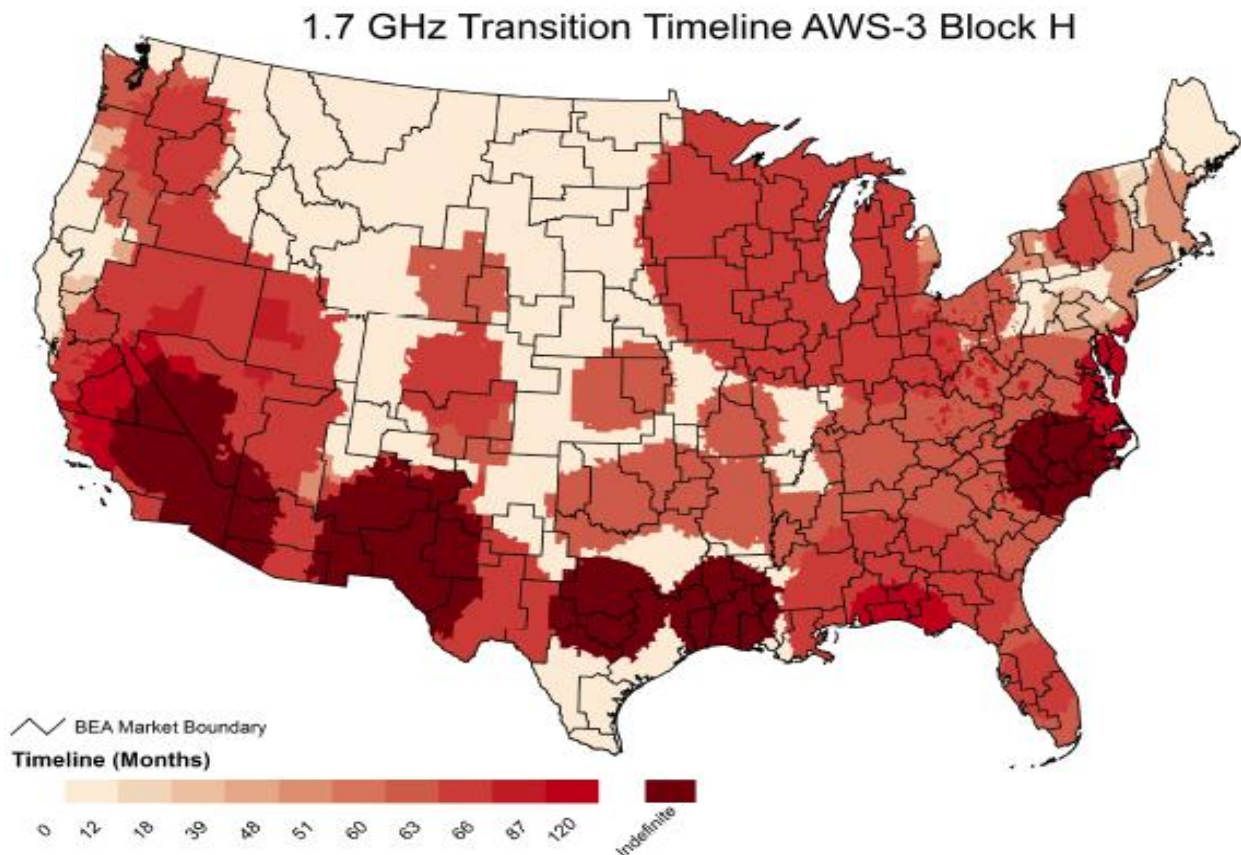
In the AWS-1 band, 12 different agencies had to cease operations of their systems before relocating in new bands.<sup>22</sup> In the 1755-1850 MHz band, the lower 25 MHz of which was auctioned earlier this year, 19 different federal agencies had operations.<sup>23</sup>

Without Administration backing and commitment, spectrum reallocations efforts may lag even further behind.

**Clearing Existing Users.** Once spectrum is auctioned or re-allocated, existing systems in those spectrum bands need to be cleared, either relocated or retuned. Finding a new home for relocated incumbents is critical to ensure that important mission-critical services remain operational for government agencies.

The process of clearing incumbents, especially federal government incumbents is always an arduous undertaking, and one that can take years and cost billions. For instance, winning licensees of 700 MHz spectrum, auctioned in 2008, faced “a process that took several years and had multiple delays.”<sup>24</sup>

The map below illustrates the estimated post-auction transition timelines associated with a portion of AWS-3 spectrum.<sup>25</sup>



In addition, multiple federal agencies frequently occupy a given spectrum band, complicating the clearing process. Three years after the 2006 AWS-1 auction, many federal agencies had not completed clearing their operations from the band, delaying the deployment of mobile broadband services.<sup>26</sup>

Final AWS-1 relocation costs are expected to total approximately \$1.5 billion, and NTIA estimates that the relocation of users in the AWS-1 band will not be complete until 2017, over a decade after wireless carriers placed their winning bids.<sup>27</sup>

**Technical Issues.** A range of issues must typically be resolved – frequently through standards-setting processes – before wireless carriers and equipment manufacturers consider deployment in new spectrum bands.

The reliance on marketplace-driven, industry-based standards setting can aid the deployment of new wireless services. However, bringing the consensus-driven standards process to a successful conclusion can add time to the process of getting more spectrum in the hands of wireless consumers. The work of the initial LTE standards, for instance, began in 2004 and was not finalized until 2008.<sup>28</sup>

Furthermore, international harmonization, achieved through entities such as the ITU, has economic (increased economies of scale), technical (better management of interference), and social (lower barriers to market entry) benefits.

Once a new spectrum band has been reallocated, technical issues for each specific band must be planned and

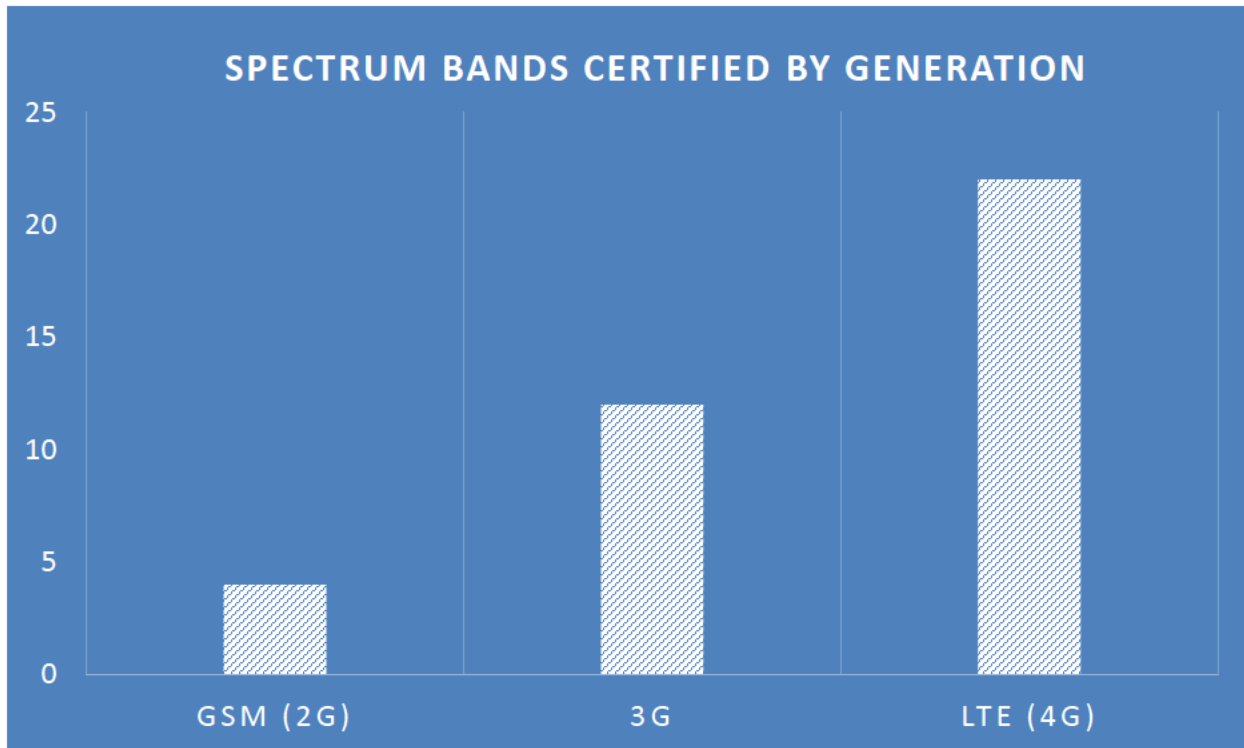
validated, such as “power levels, band classes, frequency allocations ..., compatibility of network equipment and other aspects of networking” in order “to facilitate communications on a global basis.”<sup>29</sup>

**Network Equipment, Chipset, and Handset Design and Manufacture.** After the standards setting process concludes, handset and equipment manufacturers “must design and manufacture network equipment and chipsets that can function over a certain band of spectrum.”<sup>30</sup>

As more spectrum bands come into use and as more devices are produced for use throughout the world, manufacturing those handsets and network equipment grows more complicated. The iPhone 6 supports up to 20 LTE bands, seven more than the iPhone 5.<sup>31</sup> As the chart on the following page illustrates, every successive wireless technology generation operates in a greater number of spectrum bands.<sup>32</sup>

The technical intricacies of network gear and handsets are not limited to device and equipment manufacturers. Wireless carriers spend significant time to ensure device and network compatibility with new spectrum bands. Indeed, “it may take a few years before a carrier can put a new spectrum band to use with a new generation of technologies.”<sup>33</sup>

The U.S. Department of Justice recently acknowledged this fact, stating, “Carriers must engage in years of planning and development before spectrum acquired at auction can be put to use to benefit consumers,” and noting that “once a carrier has certainty about which specific licenses it will be awarded, the carrier must then



begin the process of ensuring that its customer devices and network equipment can communicate on those frequencies.”<sup>34</sup>

**Interference Testing.** Before wireless services are deployed on new spectrum bands, they must undergo rigorous testing to ensure that the deployments do not cause interference to users in other bands. And as more services are packed into spectrum bands, the need to be good neighbors to adjacent users takes on greater importance.

For example, the 700 MHz A-Block had well-documented interference issues, due to Channel 51’s location directly adjacent to the downlink band for the 700 MHz A-Block. That interference threat caused a delay in the use of the band for mobile broadband.

Furthermore, effective pre-deployment network testing requires an interference-free environment. For instance, drive tests

and optimization are standard components of the network deployment process. Carriers must be able to conduct this testing in the frequency environment for commercial services, not spectrum impaired by interference.

**Cell Site Deployment and Modifications.** At the same time, cell sites need to be built or modified to handle new frequencies. For instance, “towers may need additional antennas, filters, or backhaul to support new spectrum bands,”<sup>35</sup> which means re-negotiating tower leases and possibly strengthening the structure to accommodate the increased tower load.

The FCC has taken laudable steps to reduce regulatory burdens for infrastructure deployment.<sup>36</sup> Yet that process can remain expensive and time-consuming.

For instance, an FCC report noted in the context of the incentive auction that

“[n]egotiations with site and tower owners ... are unpredictable in length and may cause uncertainty in the timing of the process.”<sup>37</sup> One company has described “wireless siting permit issues [that] are so prevalent that [the carrier] has had to bring or defend more than 300 lawsuits in state and federal courts.”<sup>38</sup>

Even on federal and Tribal lands – subject to a 2012 Executive Order designed to facilitate wireless broadband infrastructure deployment<sup>39</sup> – carriers face antenna siting difficulties.

The Department of Defense, for instance, has some of the most expensive lease terms – well above market rates – and a lengthy wireless application review process.<sup>40</sup> Leases to place new sites on lands regulated by the Bureau of Land Management and the National Park Service can take up to three years to negotiate.<sup>41</sup>

In a recent opportunity to comment on some of the structural barriers to broadband deployment, wireless carriers noted the continued impact associated with administrative burdens on wireless siting on federal and Tribal lands<sup>42</sup> – which represent approximately 30 percent of U.S. land mass.

For all tower sites, radios, antennas, backhaul, site modifications, permitting, and lease modifications are factors which

**“[W]e need to increase the spectrum pipeline. We have, of course, a big auction on the horizon that involves choice airwaves in the 600 MHz band. But we need to think beyond this one auction now. We need to find ways to speed the process of repurposing more spectrum for mobile broadband use.”**

**– FCC Commissioner  
Jessica Rosenworcel**

contribute to the time lag between a spectrum reallocation proposal and deployment.

#### **THE AWS-3 BAND: A CASE STUDY**

Clearing spectrum will always present challenges, but as the following case study illustrates,

those obstacles can be overcome with hard work and a multi-stakeholder commitment to collaboration.

The AWS-3 auction also underscores that such efforts take time. Indeed, the history of the AWS-3 auction stretches back to 2001, when NTIA evaluated the potential of reallocating the 1710-1850 MHz band.<sup>43</sup>

A brief recap: Following the 2001 NTIA report, the FCC allocated various portions of the 2155-2180 MHz band as AWS-3 spectrum in a series of orders dating back to 2002.<sup>44</sup> One of the goals throughout this continued refinement of the upper band was to create large, contiguous blocks of internationally harmonized spectrum.

In 2010, the National Broadband Plan recommended that government agencies determine if 1755-1780 MHz could be paired with 2155-2180 MHz.<sup>45</sup> NTIA said at the time that commercial access to 1755-1780 MHz wouldn't be possible in the near-term.<sup>46</sup> It was called “a very tough band,”<sup>47</sup> a “tricky area to navigate politically,”<sup>48</sup> and “not viable.”<sup>49</sup>



Nevertheless, in 2012, Congress directed the FCC to auction 2155-2180 MHz and 15 MHz between 1675 and 1710 MHz. Even after Congressional action, however, “no one was sure” that the FCC would move forward with the auction.<sup>50</sup>

“While we’re making progress toward to the Administration’s spectrum goals, we have much more to do. We have no plan beyond 2020 to accommodate mobile growth, and the closer we get, the more daunting the timeline looks.”

– CTIA President and CEO  
Meredith Baker

There is no more traditional licensed spectrum in the pipeline after the incentive auction, and on average it takes 13 years to reallocate or auction and clear spectrum.

The protracted process of freeing up spectrum places

And for good reason. Even the relatively clean 2155-2175 MHz band contained over 1,800 active licenses.<sup>51</sup> Overall, AWS-3 licenses “will have to negotiate coordination agreements with 17 different government agencies regarding 2,500 frequency assignments.”<sup>52</sup>

However, thanks to unprecedented collaboration between federal agencies and industry and strong support from the FCC and NTIA, progress continued. In 2014, the FCC paired the 1755-1780 MHz and 2155-2180 MHz bands together, and added a mobile uplink band at 1695-1710 MHz.<sup>53</sup>

The auction closed earlier this year, and government relocation efforts have already begun, with the earliest commercial deployment expected in 2017. Thus, from NTIA’s report to those bands actually deployed into the hands of consumers, over a decade and a half will have passed by.

## CONCLUSION

This report highlights the urgency necessary in the effort to identify and reallocate licensed spectrum.

the U.S. at risk of losing its wireless broadband leadership. It is critical to move now to identify new bands to enable the continued growth of wireless – for 4G LTE, LTE Advanced, the Internet of Things, and next generation technologies like 5G.

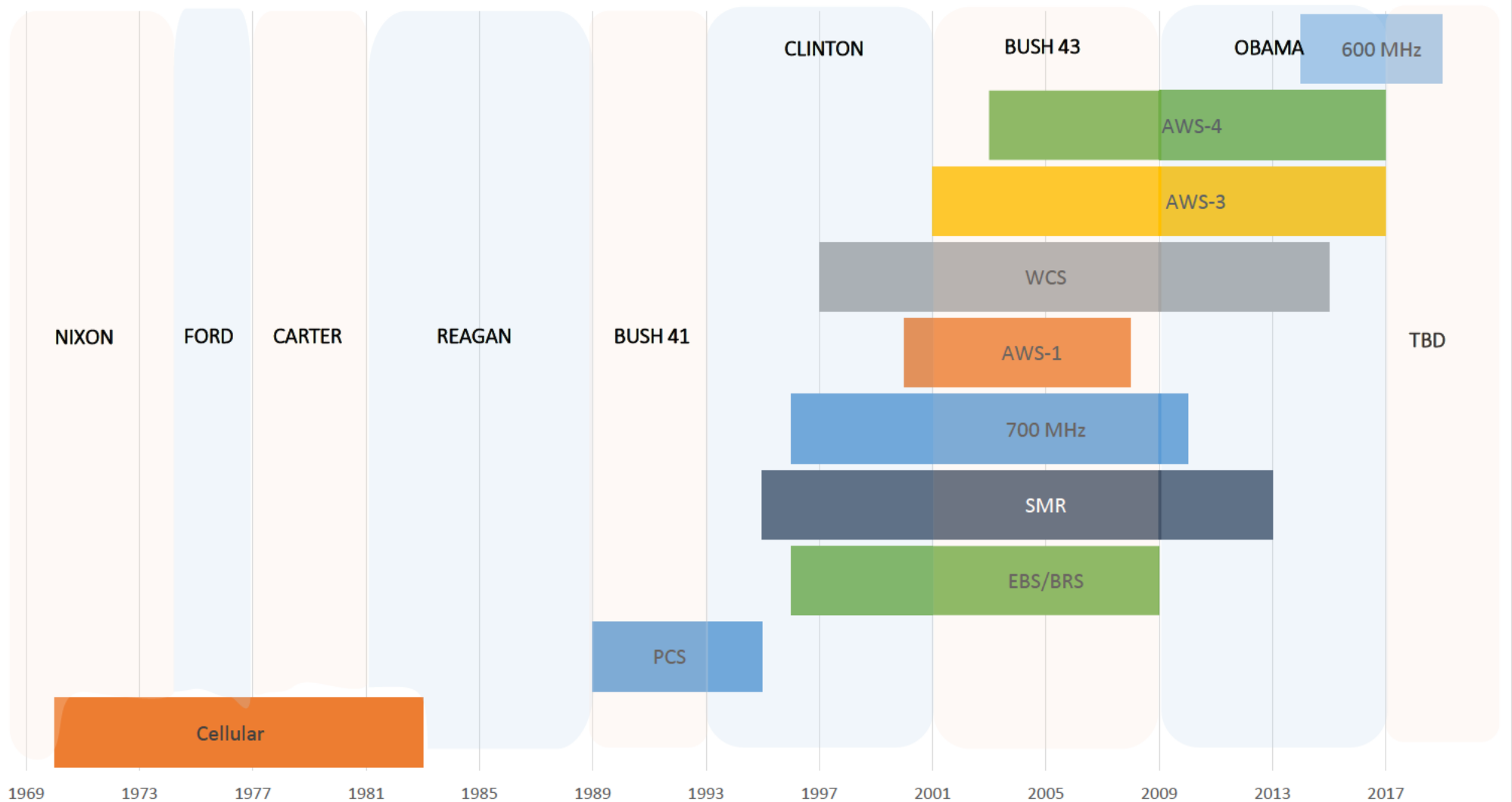
Failure to move quickly will not be felt only by wireless carriers and equipment manufacturers. The continued success of the mobile apps industry, for example – a source of employment for over 750,000 people – depends on more spectrum.

As other industries, from health to transportation, embrace the wireless platform, spectrum demand will only increase. And the consequences of a spectrum shortage will only escalate.

With serious commitment, the time it takes to reallocate licensed spectrum can be fast-tracked. Let’s get to work.

# APPENDIX A

## Timelines of Spectrum Allocation Efforts



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- <sup>1</sup> Cisco, VNI Mobile Forecast Highlights, 2014 – 2019, [http://www.cisco.com/c/dam/assets/sol/sp/vni/forecast\\_highlights\\_mobile/index.html#~Country](http://www.cisco.com/c/dam/assets/sol/sp/vni/forecast_highlights_mobile/index.html#~Country).
- <sup>2</sup> The Brattle Group, SUBSTANTIAL LICENSED SPECTRUM DEFICIT (2015-2019): UPDATING THE FCC’S MOBILE DATA DEMAND PROJECTIONS (June 23, 2015), [http://www.ctia.org/docs/default-source/default-document-library/bazelon\\_mchenry\\_spectrum-deficit\\_2015-06-23.pdf](http://www.ctia.org/docs/default-source/default-document-library/bazelon_mchenry_spectrum-deficit_2015-06-23.pdf).
- <sup>3</sup> Prepared Remarks of FCC Chairman Tom Wheeler, The Brookings Institution (June 26, 2015), [http://transition.fcc.gov/Daily\\_Releases/Daily\\_Business/2015/db0626/DOC-334141A1.pdf](http://transition.fcc.gov/Daily_Releases/Daily_Business/2015/db0626/DOC-334141A1.pdf).
- <sup>4</sup> Federal Communications Commission, CONNECTING AMERICA: THE NATIONAL BROADBAND PLAN at 79 (2010), <https://transition.fcc.gov/national-broadband-plan/national-broadband-plan.pdf>. Since the Plan’s release, the FCC also completed an auction of the 1.9 GHz PCS H Block in February 2014. Federal Communications Commission, Public Notice, Auction of H Block Licenses in the 1915-1920 MHz and 1995-2000 MHz Bands Closes (Feb. 28, 2014), [https://apps.fcc.gov/edocs\\_public/attachmatch/DA-14-279A1.pdf](https://apps.fcc.gov/edocs_public/attachmatch/DA-14-279A1.pdf).
- <sup>5</sup> Except in the case of the 700 MHz auction that took place in 2008. Incumbents in that band were not required to cease transmissions until June 12, 2009.
- <sup>6</sup> John O. Robinson, Federal Communications Commission, OPP WORKING PAPER SERIES 15, SPECTRUM MANAGEMENT POLICY IN THE UNITED STATES: A HISTORICAL ACCOUNT at 74 (1985), [https://transition.fcc.gov/Bureaus/OPP/working\\_papers/oppwp15.pdf](https://transition.fcc.gov/Bureaus/OPP/working_papers/oppwp15.pdf) (“OPP SPECTRUM POLICY PAPER”).
- <sup>7</sup> Joel West, INSTITUTIONAL CONSTRAINTS OF CELLULAR TELEPHONE SERVICE ON THREE CONTINENTS at 205 (2000), <http://www.joelwest.org/Papers/West2000.pdf>.
- <sup>8</sup> As far back as 1949, an FCC commissioner had sought a spectrum allocation for common carrier mobile radiotelephone – the precursor to the wireless services eventually deployed *34 years later* and the basis for the mobile connected life we enjoy today. OPP SPECTRUM POLICY PAPER at 64.
- <sup>9</sup> The notion of spectrum’s quality as a finite resource is not a recent development either, as a 1985 FCC paper noted: “Scarcity of usable spectrum was already influencing spectrum allocation for land mobile in 1930.” *Id.*, Appendix B at 5.
- <sup>10</sup> Milton Mueller, Cato Institute, Policy Analysis No. 21: Property Rights in Radio Communication: The Key to the Reform of Telecommunications Regulation (1982), <http://www.cato.org/pubs/pas/pa011.html>.
- <sup>11</sup> See Ericsson, ERICSSON MOBILITY REPORT: ON THE PULSE OF THE NETWORKED SOCIETY at 7 (2014), <http://www.ericsson.com/res/docs/2014/ericsson-mobility-report-november-2014.pdf>.
- <sup>12</sup> CTIA, MOBILE CYBERSECURITY AND THE INTERNET OF THINGS: EMPOWERING M2M COMMUNICATIONS at 3 (2014), <http://www.ctia.org/docs/default-source/default-document-library/ctia-iot-white-paper.pdf>.
- <sup>13</sup> Max D. Paglin et al., eds., THE COMMUNICATIONS ACT: A LEGISLATIVE HISTORY OF THE MAJOR AMENDMENTS, 1934-1996 at 26 (1999).
- <sup>14</sup> Omnibus Budget Reconciliation Act of 1993, Pub. L. No. 103-66 (1993); see also Reed E. Hundt and Gregory L. Rosston, ARTICULATING A MODERN APPROACH TO FCC COMPETITION POLICY at X (2013), [https://www.techpolicyinstitute.org/files/hundt\\_rosston\\_articulating%20a%20modern%20approach%20to%20fcc%20competition%20policy.pdf](https://www.techpolicyinstitute.org/files/hundt_rosston_articulating%20a%20modern%20approach%20to%20fcc%20competition%20policy.pdf) (“The FCC did not make the new Personal Communications Service (‘PCS’) spectrum available until Congress passed OBRA ’93. In that act, Congress gave the FCC

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authority to assign licenses via auctions, set stringent timelines for the implementation of the auctions for the PCS spectrum licenses, and created a new regulatory framework for Commercial Mobile Radio Services.”).

<sup>15</sup> Balanced Budget Act of 1997, Pub. L. No. 105-33 (1997).

<sup>16</sup> Deficit Reduction Act of 2005, Pub. L. No. 109-171 (2006).

<sup>17</sup> Middle Class Tax Relief and Job Creation Act of 2012, Pub. L. No. 112-96 (2012).

<sup>18</sup> Scott Bergmann, AWS-Auction 101, CTIA Blog (Nov. 12, 2014), <http://blog.ctia.org/2014/11/12/aws-3-auction-101/>.

<sup>19</sup> Even in the early days of the FCC when the airwaves were not as crowded, efforts to allocate spectrum took years. For instance, the allocation process for VHF spectrum above 30 MHz took six years. OPP SPECTRUM POLICY PAPER at 57.

<sup>20</sup> See, e.g., The White House, Presidential Memorandum: Unleashing the Wireless Broadband Revolution (June 28, 2010), <https://www.whitehouse.gov/the-press-office/presidential-memorandum-unleashing-wireless-broadband-revolution>; The White House, Presidential Memorandum – Expanding America’s Leadership in Wireless Innovation (June 14, 2013), <https://www.whitehouse.gov/the-press-office/2013/06/14/presidential-memorandum-expanding-americas-leadership-wireless-innovatio>.

<sup>21</sup> CTIA, MOBILE DATA DEMAND: GROWTH FORECASTS MET at 8 (2015), <http://www.ctia.org/docs/default-source/default-document-library/062115mobile-data-demands-white-paper.pdf>.

<sup>22</sup> U.S. Department of Commerce, RELOCATION OF FEDERAL RADIO SYSTEMS FROM THE 1710-1755 MHZ SPECTRUM BAND: EIGHTH ANNUAL PROGRESS REPORT at 2 (2015), [http://www.ntia.doc.gov/files/ntia/publications/eighth\\_annual\\_report\\_1710-1755\\_relocation.pdf](http://www.ntia.doc.gov/files/ntia/publications/eighth_annual_report_1710-1755_relocation.pdf).

<sup>23</sup> U.S. Department of Commerce, AN ASSESSMENT OF THE VIABILITY OF ACCOMMODATING WIRELESS BROADBAND IN THE 1755-1850 MHZ BAND at 6 (March 2012), [http://www.ntia.doc.gov/files/ntia/publications/ntia\\_1755\\_1850\\_mhz\\_report\\_march2012.pdf](http://www.ntia.doc.gov/files/ntia/publications/ntia_1755_1850_mhz_report_march2012.pdf).

<sup>24</sup> Wells Fargo Securities, Wireless Spectrum Primer at 16 (March 25, 2015).

<sup>25</sup> Chris Hardy, Coordinating with Incumbents Critical to AWS-3 Spectrum Success, CommScope (Feb. 3, 2015), <http://www.commscope.com/Blog/Coordinating-With-Incumbents-Critical-to-AWS-3-Spectrum-Success/>.

<sup>26</sup> Comments of T-Mobile USA, Inc., Relocation of Federal Systems in the 1710- 1755 MHz Frequency Band: Review of the Initial Implementation of the Commercial Spectrum Enhancement Act, FCC Docket No. 0906231085-91085-01 (Aug. 21, 2009).

<sup>27</sup> U.S. Department of Commerce, RELOCATION OF FEDERAL RADIO SYSTEMS FROM THE 1710-1755 MHZ SPECTRUM BAND: EIGHTH ANNUAL PROGRESS REPORT at 2 (2015), [http://www.ntia.doc.gov/files/ntia/publications/eighth\\_annual\\_report\\_1710-1755\\_relocation.pdf](http://www.ntia.doc.gov/files/ntia/publications/eighth_annual_report_1710-1755_relocation.pdf).

<sup>28</sup> Verizon, White Paper, LTE: THE FUTURE OF MOBILE BROADBAND TECHNOLOGY at 10 (2009), <http://innovation.verizon.com/content/dam/vic/PDF/LTE%20The%20Future%20of%20Mobile%20Broadband%20Technology.pdf>.

<sup>29</sup> Wells Fargo Securities, Wireless Spectrum Primer at 16 (March 25, 2015).

<sup>30</sup> Wells Fargo Securities, Wireless Spectrum Primer at 16 (March 25, 2015).

<sup>31</sup> Apple, iPhone 6, Connectivity, <https://www.apple.com/iphone-6/connectivity/> (last visited July 1,

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2015).

<sup>32</sup> Global Certification Forum, Current Scope of Certification, <http://www.globalcertificationforum.org/certification/scope/current-scope.html> (last visited July 1, 2015).

<sup>33</sup> Jonathan Nuechterlein, Philip J. Weiser, DIGITAL CROSSROADS: TELECOMMUNICATIONS LAW AND POLICY IN THE INTERNET AGE at 135 (2013).

<sup>34</sup> U.S. Department of Justice, Antitrust Division, Policies Regarding Mobile Spectrum Holdings, WT Docket No. 12-269 (June 24, 2015).

<sup>35</sup> Wells Fargo Securities, Wireless Spectrum Primer at 16 (March 25, 2015).

<sup>36</sup> Federal Communications Commission, *Acceleration of Broadband Deployment by Improving Wireless Facilities Siting Policies*, WT Docket No. 13-238, Report and Order, 29 FCC Rcd 12865 (Oct. 17, 2014).

<sup>37</sup> Widelity, Inc., RESPONSE TO THE FEDERAL COMMUNICATIONS COMMISSION FOR THE BROADCASTER TRANSITION STUDY SOLICITATION at 10 (2013), [https://apps.fcc.gov/edocs\\_public/attachmatch/DA-14-389A2.pdf](https://apps.fcc.gov/edocs_public/attachmatch/DA-14-389A2.pdf).

<sup>38</sup> T-Mobile Comments, Sullivan Decl. at 1-5, *Acceleration of Broadband Deployment by Improving Wireless Facilities Siting Policies*, WT Docket No. 13-238 (March 5, 2014).

<sup>39</sup> The White House, Executive Order – Accelerating Broadband Infrastructure Deployment (June 14, 2012), <https://www.whitehouse.gov/the-press-office/2012/06/14/executive-order-accelerating-broadband-infrastructure-deployment>.

<sup>40</sup> CTIA Comments at 11-12, Broadband Opportunity Council Notice and Request for Comment, Docket No. 150414365-5365-01 (June 10, 2015), <http://www.ctia.org/docs/default-source/Legislative-Activity/150610-ctia-comments-in-response-to-boc-notice.pdf?sfvrsn=0>.

<sup>41</sup> *Id.* at 16-17.

<sup>42</sup> *See, e.g.*, Comments of AT&T at 4, Broadband Opportunity Council Notice and Request for Comment (June 10, 2015), [http://www.ntia.doc.gov/files/ntia/att\\_services\\_inc\\_boc.pdf](http://www.ntia.doc.gov/files/ntia/att_services_inc_boc.pdf).

<sup>43</sup> U.S. General Accounting Office, DEFENSE SPECTRUM MANAGEMENT: MORE ANALYSIS NEEDED TO SUPPORT SPECTRUM USE DECISIONS FOR THE 1755-1850 MHz BAND at 9 (2001), <http://www.gao.gov/assets/240/232102.pdf>. The AWS Third Report and Order reallocated the 2165-2180 MHz band for fixed and mobile services, including AWS. Federal Communications Commission, *Amendment of Part 2 of the Commission's Rules to Allocate Spectrum Below 3 GHz for Mobile and Fixed Services to Support the Introduction of New Advanced Wireless Services, including Third Generation Wireless Systems*, ET Docket No. 00-258, Third Report and Order, Third Notice of Proposed Rulemaking and Second Memorandum Opinion and Order, 18 FCC Rcd 2223 (2002).

<sup>44</sup> Federal Communications Commission, *Amendment of Part 2 of the Commission's Rules to Allocate Spectrum Below 3 GHz for Mobile and Fixed Services to Support the Introduction of New Advanced Wireless Services, including Third Generation Wireless Systems*, ET Docket No. 00-258, Third Report and Order, Third Notice of Proposed Rulemaking and Second Memorandum Opinion and Order, 18 FCC Rcd 2223 (2002); Federal Communications Commission, *Service Rules for Advanced Wireless Services in the 2155-2175 MHz Band*, WT Docket No. 07-195, Notice of Proposed Rulemaking, 22 FCC Rcd 17035 (2007); Federal Communications Commission, *Service Rules for Advanced Wireless Services in the 2155-2175 MHz Band*, WT Docket No. 07-195 et al., Further Notice of Proposed Rulemaking, 23 FCC Rcd 9859 (2008). The 2160-2165 MHz band “was already allocated for non-Federal Government fixed services and mobile services.” Federal Communications Commission, *Service Rules for Advanced Wireless Services in*

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*the 2155-2175 MHz Band*, WT Docket No. 07-195, Notice of Proposed Rulemaking at 7, fn. 13, 22 FCC Rcd 17035 (2007).

<sup>45</sup> Federal Communications Commission, *CONNECTING AMERICA: THE NATIONAL BROADBAND PLAN* at 86 (2010), <https://transition.fcc.gov/national-broadband-plan/national-broadband-plan.pdf>.

<sup>46</sup> Howard Buskirk, *NTIA Eyes 1675-1710 MHz Band to Pair with AWS-3 for FCC Auction*, COMMUNICATIONS DAILY (June 4, 2010).

<sup>47</sup> Howard Buskirk, *Strickling Dashes Hope 1755 MHz Band Could Be Reallocated*, COMMUNICATIONS DAILY (May 4, 2010).

<sup>48</sup> Howard Buskirk, *NTIA's Look at 1755-1850 MHz Band Called Welcome News for Wireless Industry*, COMMUNICATIONS DAILY (Feb. 2, 2011).

<sup>49</sup> *Wireless*, COMMUNICATIONS DAILY (May 26, 2010).

<sup>50</sup> Statement of Chairman Tom Wheeler, *Amendment of the Commission's Rules with Regard to Commercial Operations in the 1695-1710 MHz, 1755-1780 MHz, and 2155-2180 MHz Bands*, GN Docket No. 13-185, Report and Order, 29 FCC Rcd 4610 (March 31, 2014), [https://apps.fcc.gov/edocs\\_public/attachmatch/DOC-326344A2.pdf](https://apps.fcc.gov/edocs_public/attachmatch/DOC-326344A2.pdf).

<sup>51</sup> Federal Communications Commission, *Service Rules for Advanced Wireless Services in the 2155-2175 MHz Band*, WT Docket No. 07-195, Notice of Proposed Rulemaking at 8, 22 FCC Rcd 17035 (2007).

<sup>52</sup> Tammy Parker, *AWS-3 Auction Winners Could Face Lots of Spectrum-Coordination Hitches*, FIERCEWIRELESSTECH (Aug. 20, 2014), <http://www.fiercewireless.com/tech/story/aws-3-auction-winners-could-face-lots-spectrum-coordination-hitches/2014-08-20>.

<sup>53</sup> Federal Communications Commission, *Amendment of the Commission's Rules with Regard to Commercial Operations in the 1695-1710 MHz, 1755-1780 MHz, and 2155-2180 MHz Bands*, Report and Order, GN Docket No. 13-185, 29 FCC Rcd 4610 (2014).