Economic Impact of Delaying the Deployment of Auction 108 2.5 GHz Licenses

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Executive Summary

Ubiquitous, robust 5G is critical to America's economy and national security. It allows parents to support their families through remote work, kids to access world-class education at a distance, and our service members to stay ahead of emerging threats. These benefits depend on mid-band spectrum. As FCC Chairwoman Jessica Rosenworcel has stated, mid-band "offers an ideal blend of capacity and coverage, this spectrum is key to delivering on the promise of 5G services and ensuring that it reaches as many people as possible. The bottom line is we need mid-band deployment at scale to foster invention in the new 5G spectrum frontier."[1]

The FCC concluded a successful auction for prime, mid-band spectrum last year. Through Auction 108, the FCC offered approximately 8,000 flexible-use county-based licenses for white spaces in the 2.5 GHz band.[2] But nearly 10 months after the auction closed, the FCC has failed to distribute the vast majority of the auctioned licenses, depriving Americans of new or upgraded 5G service. This report estimates the cost of that delay to the economy, jobs, and vulnerable groups.

First, we estimate the loss in consumer welfare—a measure of the value Americans lose by being denied access to this mid-band spectrum and the mobile service and 5G Home Broadband it enables.

- The Auction 108 spectrum that T-Mobile can immediately put to use would generate approximately $28 billion in consumer welfare.[3]
- Including T-Mobile's Auction 108 spectrum for which the company needs to deploy new radios and towers, the spectrum would generate approximately $42 billion in consumer welfare.

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1 Jessica Rosenworcel, "New Frontier of Partnerships", Remarks to the Mobile World, Mobile World Congress, Barcelona, Spain, March 1, 2022, https://www.fcc.gov/document/chairwoman-rosenworcel-remarks-mobile-world-congress-2022, ("New Frontier of Partnerships")

2 FCC, "Auction 108: 2.5 GHz Band," Fact Sheet, Accessed June 3, 2023, https://www.fcc.gov/auction/108, ("Auction 108 Fact Sheet"). *See also*, John Brodkin, "T-Mobile Dominates 2.5 GHz Spectrum Auction to Fill in Network Gaps Across US," arsTechnica, September 2, 2022, https://arstechnica.com/tech-policy/2022/09/t-mobile-dominates-2-5-ghz-spectrum-auction-to-fill-in-network-gaps-across-us/, ("T-Mobile Dominates 2.5 GHz Spectrum Auction").

3 Note that, this consumer welfare figure applies to only STA (Special Temporary Authority) sites.

Second, we estimate lost value to consumers over time, because the longer the delay, the more Americans lose.

- Through June 30, 2023, the regulatory delay has cost Americans approximately $1.3 billion in lost value to consumers.
- For a further three-month delay, *i.e.*, from June 30, 2023 to September 30, 2023, Americans would lose an incremental $750 million.
- For a one-year delay, *i.e.*, from June 30, 2023 to June 30, 2024, Americans would lose an incremental $3 billion.

Third, we estimate a reduction in job creation due to T-Mobile's delayed capex investment in the Auction 108 licenses.

- The creation of over 6,500 wireless industry jobs will be put on hold until the licenses are issued.
- The creation of approximately 17,000 jobs in the overall economy will be put on hold until the licenses are issued.

Finally, we explain the delay's impacts on the spectrum auction system and future spectrum values, and on service to veterans and to educational institutions.

I. Introduction

1. Auction 108, which closed on August 29, 2022, offered approximately 8,000 flexible-use county-based licenses for white spaces in the 2.5 GHz band.[4] The 2.5 GHz spectrum band was originally divided into the Broadband Radio Service (BRS) and the Educational Broadband Service (EBS), and the EBS portion of the band was given to educational institutions in the 1980s.[5] The licenses were granted in 35-mile-radius circles, and later were converted into P35 geographic service area licenses.[6] However, the license circles left irregularly-shaped white spaces in the EBS portion of the band where there was no license, and even in geographies where licenses were granted, not all channels were awarded to licensees.[7] This is the spectrum that was available via Auction 108.[8]

2. This auction was meant to fill in the holes in the 2.5 GHz band and thus to increase the efficiency of high-capacity, broad geography 5G deployment. T-Mobile already owned or leased much of the spectrum in the 2.5 GHz band and the new licenses were attractive to the company because of its existing investment and familiarity with the band.[9] Consequently, T-Mobile won more than 90% of all the licenses sold in Auction 108, with licenses in 2,724 counties (out of 3,143 counties in the U.S.).[10] T-Mobile's winnings cover approximately 83 million pops, primarily in rural areas. And due to the company's existing

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4 "Auction 108 Fact Sheet". *See also*, "T-Mobile Dominates 2.5 GHz Spectrum Auction".

5 FCC, "Broadband Radio Service & Education Broadband Service," Accessed June 4, 2023, https://www.fcc.gov/wireless/bureau-divisions/broadband-division/broadband-radio-service-education-broadband-service.

6 FCC, "Wireless Telecommunications Bureau Announces Changes to the Universal Licensing System (ULS) to Accommodate the Broadband Radio Service and Educational Broadband Service..." DA 05-1818, Released June 28, 2005, https://docs.fcc.gov/public/attachments/DA-05-1818A1.pdf. *See also*, Spectrum Omega, "May 2022 Update – P35 Boundaries," Accessed June 4, 2023, https://specmap.sequence-omega.net/blog/.

7 Note that previously, in Auction 6 when the service was called MMDS, the FCC licensed the irregularly shaped white spaces in the BRS band. *See,* https://www.fcc.gov/auction/6.

8 "Auction 108 Fact Sheet"

9 Linda Hardesty, "T-Mobile Pays $304M to Fill in Holes in Its 2.5 GHz Spectrum," Fierce Wireless, September 1, 2022, Last accessed June 21, 2023, https://www.fiercewireless.com/wireless/t-mobile-pays-304m-fill-holes-its-25-ghz-spectrum

10 "T-Mobile Dominates 2.5 GHz Spectrum Auction"

network investment in the 2.5 GHz band, T-Mobile was ready to turn on much of the spectrum immediately using its already deployed radios.[11]

3. However, 10 months after Auction 108 concluded, the FCC still has not issued licenses to all of the auction winners, depriving Americans of upgraded 5G coverage and capacity.[12] In the intervening period, the Commission's auction authority expired, and although Auction 108 had concluded prior to authority expiring, the Commission stated that it needed time to examine its power to issue the stranded licenses.[13] Various commenters, including four former FCC General Counsels, public interest groups, and representatives of Tribes and rural communities, have argued that the Commission has ample legal authority to issue the licenses.[14] Nonetheless, to expedite the utilization of the spectrum, T-Mobile and other parties have proposed a compromise solution. As a temporary fix, in March 2023, T-Mobile petitioned the FCC for Special Temporary Authority ("STA") to turn on its Auction 108 licenses. The company pointed out that spectrum covering over 50 million people could be turned on immediately and that those families should not be denied upgraded service while the FCC and Congress sort out authority.[15]

4. As it stated in its applications, granting the STAs would "allow T-Mobile to temporarily fill in geographic and spectral voids in its existing coverage in many areas, facilitating the formation of larger contiguous channels and enhancing 5G services with faster speeds and

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[11] Kelley Hill, "T-Mo Asked to be Able to Use New 2.5 GHz Licenses for 5G While the FCC Does its Post-Auction Review," RCR Wireless, October 6, 2022, Last accessed June 21, 2023, https://www.rcrwireless.com/20221006/spectrum/t-mobile-us-wants-to-get-a-jump-on-new-2-5-ghz-use.

[12] Mike Dano, "T-Mobile's Latest 5G Spectrum Purchases Stuck in Limbo," Light Reading, March 20, 2023, Last accessed June 21, 2023, https://www.lightreading.com/5g-and-beyond/t-mobiles-latest-5g-spectrum-purchases-stuck-in-limbo/d/d-id/783923, ("T-Mobile's Latest 5G Spectrum Purchases Stuck in Limbo

[13] Monica Allenven, "Former FCC Leaders Push Congress to Renew Auction Authority," Fierce Wireless, May 24, 2023, last accessed June 21, 2023, https://www.fiercewireless.com/wireless/former-fcc-leaders-push-congress-renew-auction-authority. *See also*, FCC, "Chairwoman Rosenworcel Statement on Expiration of FCC Spectrum Auction Authority," issued on March 10, 2023, https://www.fcc.gov/document/chairwoman-rosenworcel-expiration-spectrum-auction-authority. *See also*, FCC, "FCC Leadership Renews Call to Restore Spectrum Auction Authority," Issued on April 18, 2023, https://docs.fcc.gov/public/attachments/DOC-392666A1.pdf

[14] Letter to P. Michele Ellison, General Counsel, FCC, March 23, 2023, https://www.jenner.com/a/web/e32ms32xaUDSdv4qRruD9P/fcc-auction-authority.pdf.

[15] T-Mobile, "Application for Special Temporary Authority," T-Mobile 2.5 GHz STA Cover Letter filed with the FCC, March 24, 2023, https://www.fcc.gov/ecfs/document/1032447052096/1, ("T-Mobile's Application for Special Temporary Authority"). See also Neville Ray, "More 5G for More Americans," T-Mobile Blog, April 6, 2023, last accessed June 2119, 2023, https://www.t-mobile.com/news/network/more-5g-for-more-americans, ("More 5G for More Americans").

more capacity" and since "much of the spectrum covered by this request is in 'white spaces' – locations where there are spectral or geographic holes between T-Mobile's licensed spectrum" it means that "T-Mobile can quickly initiate use of the spectrum with little to no infrastructure deployment to serve the public."[16] Although STAs would not provide T-Mobile with the licenses it acquired and paid for, they would enable the company to promptly offer upgraded services to more than 50 million individuals covered by T-Mobile's existing network, which is ready to light up the spectrum.

5. Prior analyses have demonstrated the cost of delay in making spectrum available and the FCC has made the availability of spectrum a priority.[17] With a majority of the low-band spectrum already allocated to commercial mobile uses, the Commission has made large amounts of mid-band and millimeter wave (mmW) spectrum available over the past 5 years. For 5G, the spotlight has been on mid-band frequencies, and the Commission has explicitly made provisions for accelerated availability of such spectrum, as observed in the C-Band spectrum auction where bidders could pay a premium for expedited clearing of frequencies.[18] Chairwoman Jessica Rosenworcel, in her remarks to the 2022 Mobile World Congress, stated that mid-band spectrum was critical for 5G and that the U.S. should pivot to mid-band spectrum, as "it offers an ideal blend of capacity and coverage, this spectrum is key to delivering on the promise of 5G services and ensuring that it reaches as many people as possible. The bottom line is we need mid-band deployment at scale to foster invention in the new 5G spectrum frontier."[19]

6. Because of the band's propagation and T-Mobile's existing infrastructure investment, Auction 108 seemed especially suited to bridging the digital divide in rural America quickly. At the beginning of Auction 108, Chairwoman Rosenworcel noted that "[t]he 2.5 GHz band auction can help deliver on the promise of 5G services and ensure that it reaches as many people as possible. The 2.5 GHz band spectrum provides an opportunity to fill in some of

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[16] "T-Mobile's Application for Special Temporary Authority", Attachment A.

[17] "Effective Spectrum Pricing: Supporting better quality and more affordable mobile services," GSMA Spectrum, February 2017, last accessed June 21, 2023, https://www.gsma.com/spectrum/wp-content/uploads/2017/02/Effective-Spectrum-Pricing-Full-Web.pdf

[18] Monica Alleven, "Intelsat, SES: C-band clearing on schedule," Fierce Wireless, January 21, 2021, last accessed June 21, 2023, https://www.fiercewireless.com/operators/intelsat-ses-c-band-clearing-schedule.

[19] "New Frontier of Partnerships"

the critical 5G gaps in rural America."[20] Consistent with the Chairwoman's aspiration, T-Mobile's President of Technology explained that the company has already deployed the necessary towers and radios to utilize this spectrum across numerous regions in the country, and if granted the STAs, T-Mobile would be able to swiftly activate services in many of these markets within a matter of days.[21]

7. In this report, we discuss the costs to society of delaying the grant of STAs and more broadly the delay in granting all of the licenses won by T-Mobile in Auction 108. We estimate the loss in spectrum value, the loss of producer and consumer surplus, the loss of near-term job creation, and the reduced 5G service to anchor institutions and certain vulnerable segments of the population.

II. The Cost of Delaying Spectrum Availability

A. Background

8. Regulatory delay that prevents new goods and services from becoming available in a timely manner leads to societal losses. The economic literature on the impact of regulatory delay on society suggests that prolonged regulatory delays can have detrimental effects on various aspects of the economy. Jerry Hausman, in his 1997 paper on the cost of delay in mobile phones, showed that regulatory delays often lead to large losses in consumer surplus that "cannot be regained in subsequent periods" and there can be large "consumer welfare losses from past regulatory delays."[22] The introduction of any new goods or services can lead to significant gains in consumer welfare. A possible way to estimate the costs from regulatory delays is to calculate the loss to consumers as a result of the delayed introduction of new goods and services. Hausman estimated the loss in consumer welfare from the delayed introduction of voice messaging services in 1990, due to regulatory delay. He estimated that

[20] FCC, "FCC Announces Next 5G Mid-Band Spectrum Auction to Start on July 29," News Release, Released March 21, 2023, https://docs.fcc.gov/public/attachments/DOC-381557A1.docx.

[21] Neville Ray, "More 5G for More Americans," T-Mobile Blog, April 6, 2023, last accessed June 21, 2023, https://www.t-mobile.com/news/network/more-5g-for-more-americans, ("More 5G for More Americans").

[22] Jerry A. Hausman, "Valuing the Effect of Regulation," 1997, pp. 35, 36.

the consumer welfare gain in 1994 alone, from the introduction of the service, was $1.27 billion, implying that a ten-year regulatory delay had cost society billions of dollars.[23] Similarly, a delay in the introduction of cellular telephone services decreased consumer welfare by almost "$100 billion in total, with more than $25 billion lost in a single year."[24]

9. In general, regulatory delays can discourage investment and hinder economic growth. When regulatory processes are protracted, businesses may postpone or abandon investment decisions due to uncertainty and increased costs. This can lead to reduced capital expenditure, lower productivity gains, and slower economic expansion. Regulatory delays can have implications for job creation and the labor market, and uncertainty caused by unnecessarily long regulatory processes can deter businesses from expanding their workforce or creating new jobs. Such delays can also have significant effects on consumer welfare and the quality of services. Delays in regulatory processes may delay the introduction of new and improved products and services, limiting consumer choices and potentially resulting in higher prices.

10. Spectrum is a finite resource, and its availability is crucial for expanding and improving wireless networks. The spectrum for 5G deployment is particularly critical, and can have short and long term effects on the economy. Delaying 5G spectrum deployment means delaying the rollout of new technologies, which rely on specific frequency bands to deliver high-speed and low-latency connectivity.[25] This can impede network expansion and hinder the ability of service providers to meet the increasing demand for data and connectivity. For T-Mobile, in addition to expanding coverage, spectrum is necessary for accommodating the growing number of connected devices and supporting data-intensive applications under 5G. The 2.5 GHz spectrum will enable the company "to offer home internet service over our 5G network to millions of underserved consumers."[26] When 5G spectrum deployment is delayed, it can lead to network congestion and decreased capacity, resulting in slower speeds, dropped calls, and degraded user experiences. As more devices come online and data consumption continues to rise, the delay in deploying additional spectrum can strain existing networks and limit their ability to handle increased traffic. For the 2.5 GHz spectrum

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[23] Jerry A. Hausman, "Valuing the Effect of Regulation," 1997, pp. 3.

[24] Jerry A. Hausman, "Valuing the Effect of Regulation," 1997, pp. 3.

[25] McKinsey & Company, "What is 5G?" October 7, 2022, last accessed June 21, 2023, https://www.mckinsey.com/featured-insights/mckinsey-explainers/what-is-5g.

[26] "More 5G for More Americans"

in question, the regulatory delay will impose constraints on T-Mobile's network capacity for almost a quarter of the country.[27]

11. Spectrum deployment for 5G services will also enable innovation in the telecommunications space by providing a foundation for developing new technologies and services. A delay in 5G spectrum deployment can impede innovation as it restricts the ability of businesses to leverage new spectrum bands for research, development, and experimentation. For instance, postponing the deployment of mid-band spectrum for 5G could slow down the development of applications and use cases that rely on its unique characteristics, such as the combination of coverage and capacity.

12. Overall, delaying spectrum deployment can have far-reaching consequences. The telecommunications industry plays a vital role in economic growth and productivity. Delaying spectrum deployment can have negative economic consequences by hampering the ability of businesses to adopt advanced digital technologies and limiting their competitiveness. It can also impact job creation and investment in the telecommunications sector. Moreover, delays in network expansion and innovation can hinder the emergence of new industries and services that rely on robust and high-speed connectivity.

13. We project that the Auction 108 licenses at issue would have a far-reaching impact on Americans'—and especially rural Americans'—5G service. Based on the geographies of licenses won and tower location data, we estimate that T-Mobile could cover approximately 83 million Americans with its Auction 108 licenses once fully deployed. As stated previously, more than 50 million Americans are within range of an existing T-Mobile deployment that would use Auction 108 licenses. In other words, more than one-seventh of the U.S. population could experience immediate, upgraded 5G service if the FCC issues STAs.

14. T-Mobile relies heavily on the 2.5 GHz band to provide 5G Home Internet, and we find that the license delay is denying in-home broadband service, or a new competitor for that service, to millions of households. T-Mobile's 5G Home Internet is a type of fixed wireless access (FWA) service. FWA is often used to provide broadband internet access to areas where traditional wired infrastructure is difficult or costly to deploy, and a delay in deploying FWA can result in limited or no broadband access for the affected regions. This can hinder economic growth, limit educational opportunities, and impede access to essential services for individuals and businesses. Additionally, delaying fixed wireless deployment can result

[27] *See infra* Table 1.

in increased costs for infrastructure development in the long-run. As the population and demand for connectivity continue to grow, the need for broadband infrastructure will persist, and delaying FWA deployment may require alternative solutions such as costly expansion of wired networks, fiber optic deployments, or satellite services. According to T Mobile, 3 million homes will not either have coverage or enhanced capacity through T-Mobile's FWA if the Auction 108 licenses are not granted.

15. We have described the overall negative effects on the economy from the delay in granting Auction 108 licenses. In the next section, we directly estimate the overall loss in consumer welfare due to the regulatory delay, as this gives a holistic picture of the economy-wide impact of delaying the STAs and licenses.

B. Quantifying the Loss in Consumer Welfare from Regulatory Delay

16. Changes in consumer welfare provide valuable insights into the impact of various regulatory policy decisions on consumers. In this instance, the regulatory delay in granting the STAs/ licenses can result in a significant loss of consumer welfare. In this section, we discuss our methodology for estimating this loss, starting with a timeline for T-Mobile's deployment plans if the regulatory delay were not present.

17. We consider three groups of physical infrastructure for T-Mobile's deployment of its Auction 108 spectrum. First, are the currently deployed sites that would use the new licenses. Because the physical infrastructure already exists, those licenses can be deployed immediately and without significant cost. Second, are sites that need to be built but already have been contemplated in T-Mobile's network build plan. Third, are sites that may be deployed beyond T-Mobile's current build plan. Those include sites that must be deployed to satisfy the FCC's license conditions. We conservatively assume 50% pops coverage in those areas and a less dense build.[28]

[28] For the purpose of our analysis, we assume that STAs sites would be deployed by December 2022 in the ordinary course of business, and the planned sites would have been deployed about seven months after the closing of Auction 108, around March 2023. For greenfield sites, we assume the time frame would be around March 2024.

18. To calculate the loss of consumer welfare, we first calculate the aggregate consumer welfare that can potentially be generated from deploying the 2.5 GHz spectrum, and then we calculate the portion of this that is lost due to regulatory delay.

1. Calculating the Aggregate Consumer Welfare

19. In order to estimate the aggregate consumer welfare, we need three components: (i) an estimate of consumer welfare generated for every $/MHz-pop of spectrum value, (ii) the variation of this value across geographies, and (iii) the amount of spectrum and population affected by the regulatory delay.

- *Per Unit Consumer Surplus:* We use the conceptual framework outlined in the Bazelon and McHenry (2015) paper to calculate an approximate loss in consumer welfare if there are delays in availability of the 2.5 GHz spectrum licenses.[29] In quantifying the consumer surplus generated from the deployment of the 2.5 GHz band, we use the 10-1 and 20-1 ratio between producer surplus and consumer welfare. For the Auction 108 white spaces, we believe that the 3.45 GHz auction is a good comparable for T-Mobile's 2.5 GHz spectrum. [30] Based on this and the observation that consumer welfare is 10 to 20 times the value of the producer's surplus, the per MHz-pop consumer welfare generated in between $7.33/MHz-pop and $14.66/MHz-pop.

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[29] "For mobile wireless services, economists estimated that the total social benefits from licensed spectrum are at least 10 to 20 times the direct economic value of the spectrum." *See* Coleman Bazelon and Giulia McHenry, "Mobile Broadband Spectrum: A Vital Resource for the Economy," Prepared for CTIA, May 11, 2015, p. 1, https://api.ctia.org/docs/default-source/default-document-library/brattle_spectrum_051115.pdf, ("Mobile Broadband Spectrum")

[30] The 3.45 GHz spectrum was also encumbered, with more than 25% of the licenses encumbered, covering more than 41% of the available MHz-pops. Additionally, flexible use terrestrial mobile operations were allowed at full power in this band for the unencumbered areas, and power levels were the same as those adopted in the C-Band (3.7 GHz) auction. Thus, we use the net national average price for 3.45 GHz spectrum (Auction 110) as the per MHz-pop value of the producer's surplus generated by T-Mobile's Auction 108 2.5 GHz spectrum. This is the net average price based on both Category 1 and Category 2 blocks and 2010 pops. *See* Sasha Javid, "Post-Auction Analysis for Auction 110 (2500 MHz Band), Bitpath, Accessed June 4, 2023, https://www.sashajavid.com/FCC_Auction110.php, ("Sasha Javid Auction 110 Analyses"). *See also,* Kelly Cole & Scott Bergmann, "The 3.45 GHz Auction: A Resounding Success and the Third-Highest Grossing Auction Ever," CTIA Blog, November 17, 2021, https://www.ctia.org/news/the-3-45-ghz-auction-a-resounding-success-and-the-third-highest-grossing-auction-ever. *See also,* FCC, "FCC Opens 100 Megahertz of Mid-Band Spectrum for 5G," Second Report and Order, Order on Reconsideration, and Order of Proposing Modification, Adopted March 18, 2021, ¶16 https://docs.fcc.gov/public/attachments/FCC-21-32A1.docx

- *Variation Across Geographies:* When valuing the consumer welfare generated by the spectrum, we have to account for the relative value of spectrum in different geographies where the towers are located. We use the relative value of geographies from a recent comparable auction to calculate a geographic relative value index (RVI).[31] This RVI is then used in conjunction with the national average per MHz-pop consumer welfare to calculate the consumer welfare at the geographic license level.[32] In this case, we use the relative value of partial economic area (PEA) licenses from the recent auction of C-Band spectrum and FCC Auction 107, and apply it to the spectrum T-Mobile gained in Auction 108. We calculate these relative values from the unaccelerated licenses (i.e., blocks A, B, and C in most licenses and blocks B and C in 46 of the first 50 PEAs).[33]
- *Amount of Population Affected:* For the currently deployed and planned sites, T-Mobile's internal propagation modeling provides an estimate of the population served by each individual tower. For those sites for which we do not know population coverage, we use the average population covered across the same county or, if necessary, across similar counties. For counties in which T-Mobile's 2.5 GHz build plan does not yet contemplate new infrastructure, we conservatively calculate the base spectrum value under the 50% pops covered buildout requirement.[34]

20. Using the above calculation, we estimate that the **aggregate consumer welfare generated** from deploying the 2.5 GHz spectrum is between:

    - **For STAs:** approximately **$19 billion - $37 billion**, with an **average** of approximately **$28 billion** of consumer welfare created.

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[31] Relative Value Index characterizes within-auction license values relative to the auction national average price. Formally, the RVI for license i in auction j is equal to

$$RVI_{ij} = \frac{License\ Price_i}{License\ Size_i * License\ Area\ Pop_i} \Big/ \frac{Aggregate\ Auction\ Proceeds_j}{Total\ Bandwidth_j * Total\ Auction\ Pop_j}$$

See Coleman Bazelon, Paroma Sanyal, Yong Paek and Ryan Taylor, "Understanding Spectrum Prices in Recent Upper Mid-Band FCC Auctions," TPRC 2022, p. 3, August 3, 2022, https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4178817.

[32] The RVI for each site is multiplied with the national average per MHz-pop consumer welfare to obtain the value of the consumer welfare generated at the site level.

[33] FCC, "Auction 107: 3.7 GHz Service," last accessed June 21, 2023, https://www.fcc.gov/auction/107.

[34] T-Mobile will likely have greater coverage, but as a conservative assumption for the total cost of delay, we assume that T-Mobile would cover 50% of the population in every county, consistent with the FCC's minimum four-year buildout.

- **All T-Mobile's Auction 108 Portfolio** : approximately **$28 billion - $56 billion**, with an **average** of approximately **$42 billion** consumer welfare created.

TABLE 1: AGGREGATE CONSUMER WELFARE ESTIMATES: LOW AND HIGH RANGE VALUES

Category	Avg. MHz Added [1]	Est. Pops Covered [2]	Consumer Welfare Low Range [3]	Consumer Welfare High Range [4]	Average Consumer Welfare [5]
STA Sites	72.9	52,289,582	$18,589,249,820	$37,178,499,640	$27,883,874,730
Planned Sites	77.7	24,702,299	$9,280,032,066	$18,560,064,131	$13,920,048,098
Greenfield Counties (50% Pops)	68.1	1,001,827	$266,872,199	$533,744,398	$400,308,298
Total		77,993,708	$28,136,154,084	$56,272,308,168	$42,204,231,126

Sources and Notes: Brattle Calculations.

2. Calculating the Loss in Consumer Welfare

21. For the loss in consumer welfare due to the regulatory delay, the most straightforward approach focuses on the time value of money. This simple framework suggests that since a good is more valuable today than it is in the future, all else equal, there is an opportunity cost to introducing a good at a later date. To calculate this cost there are three primary inputs: (i) the value of consumer welfare - the welfare realization being delayed is the consumer welfare that could be created from deploying the spectrum within a reasonable time from the close of the auction (STAs or entire portfolio), (ii) the period of delay - the estimate of delay in deployment in months or years because of the regulatory delay, and (iii) the discount rate – this is used to calculate the net present value of the loss.

i. Consumer Welfare when STAs or Entire Portfolio Licenses are Granted without Delay

22. As explained earlier, for STAs this varies between $19 - $37 billion and for the entire portfolio it varies between $28 - $56 billion.

ii. Discount Factor

23. To estimate the cost of delay, we discount the expected auction receipts on a monthly basis. For this exercise we use the average of annual cost of capital for the telecom (wireless) sector

according to publicly available data by business sector in the United States, adjusted to a monthly rate.[35] We use the average cost of capital ("WACC") for 2022, 7.8%, to estimate a forward-looking discount factor of 0.63% per month.[36] Since the consumer welfare calculation is based on the producer surplus generated by deploying the 2.5 GHz spectrum, using the WACC to discount the consumer welfare is appropriate. The cost of the delay is the difference between the consumer welfare value at the closing of the auction and the discounted value at various time periods of regulatory delay.

iii. Quantifying the Amount of Delay

24. In general, it takes between 1-2 years to deploy a new spectrum band, as new cell site infrastructure needs to be built, new radios sourced and other network investment needs to be made before the band can be deployed.[37] However, for an existing band, such as the white spaces in 2.5 GHz, the spectrum can be used immediately on the towers that already have the legacy 2.5 GHz deployed. From T-Mobile, we understand that the STA sites could have been deployed soon after the auction, while the planned and greenfield sites would take longer. For the STA sites we assume that in the ordinary course of business, they could have been deployed by December 31, 2022. For the planned sites, we assume that they would require 3 more months, i.e., be deployed by March 30, 2023, and the greenfield sites would be deployed by March 31, 2024. Our estimated lost value calculation thus begins from the date of assumed deployment under business-as-usual conditions, i.e., without any regulatory delay.

[35] Aswath Damodaran, "Cost of Equity and Capital (US)", NYU Stern, January 2023, accessed June 21, 2023, https://pages.stern.nyu.edu/~adamodar/New_Home_Page/datafile/wacc.html, ("Cost of Equity and Capital (US)").

[36] Cost of Equity and Capital (US). We use datasets updated as of 1/2021, 1/2022, and 1/2023. A monthly discount factor *R is* calculated from a yearly cost of capital *C* as $R = (1 + C)^{1/12} - 1$.

[37] Melissa Arnoldi, "Ready to Launch: How 2 Years of 5G Trials is Preparing Us for Commercial Deployment," AT&T Blog, April 10, 2018, last accessed June 21, 2023, https://about.att.com/innovationblog/two_years_of_5g_tria.

TABLE 2: COST OF DELAY

		Low Range		High Range			
STA/License Grant Date	**Delay in Months**	**Aggregate Lost Consumer Welfare**	**Monthly Lost Consumer Welfare**	**Aggregate Lost Consumer Welfare**	**Monthly Lost Consumer Welfare**	**Average Value of Delay**	**% Lost Consumer Welfare**
[A]	[B]	[C]	[D]	[E]	[F]	[G]	[H]
31-Mar-23	3	$345,669,525	$115,223,175	$691,339,050	$230,446,350	$518,504,287	1.9%
30-Jun-23	6	$857,474,686	$171,673,016	$1,714,949,373	$343,346,031	$1,286,212,030	3.1%
30-Sep-23	9	$1,359,762,764	$170,080,195	$2,719,525,529	$340,160,389	$2,039,644,146	4.9%
31-Dec-23	12	$1,852,710,730	$168,507,099	$3,705,421,460	$337,014,198	$2,779,066,095	6.6%
31-Mar-24	15	$2,336,492,264	$166,953,454	$4,672,984,527	$333,906,907	$3,504,738,395	8.4%
30-Jun-24	18	$2,816,240,340	$167,073,162	$5,632,480,680	$334,146,324	$4,224,360,510	10.0%
30-Sep-24	21	$3,287,067,438	$165,542,229	$6,574,134,877	$331,084,458	$4,930,601,158	11.7%

Sources and Notes: Brattle Calculations. Column [H] refers to the high range, however, the percentages for the low range are very similar.

25. From Table 2, we estimate that **lost consumer welfare** from deploying the 2.5 GHz spectrum for various delay scenarios:

- The aggregate cost of delay so far, through the end of June 2023, totals approximately $858 million - $1.7 billion, for an average of almost $1.3 billion lost in consumer welfare to date.
- For a further 3 month delay, from June 30, 2023 to September 30, 2023, the additional loss of consumer welfare is approximately between $503 million - $1 billion, for an average loss of around $750 million.
- For a further 1 year delay, from June 30, 2023 to June 30, 2024, the loss is approximately between $2 billion - $4 billion, for an average loss of almost $3 billion.
    - Monthly Loss
        - Currently, the FCC's delay is costing the economy between $172 million and $343 million per month in welfare loss, for an average loss of around $258 million.
        - Similar amounts of monthly loss to consumer welfare will continue as the delay continues.

C. Effect of Regulatory Uncertainty

26. Aside from the traditional risks that businesses face in any industry, such as uncertainty about future demand, regulated industries face heightened uncertainty from unknown future regulatory actions.[38] In the telecommunications industry, regulatory uncertainty can decrease spectrum value because there is some probability that future cash flows are negatively affected, or eliminated altogether, as the FCC has the right to revoke a license.[39] Moreover, additional risk from regulations increases the cost of debt, as the likelihood of default rises.[40] Thus, regulatory delay that increases future expectations about adverse regulatory events increases regulatory uncertainty and can negatively impact the sector.

27. In prior work, Bazelon (2012) examined the impact of increased regulatory uncertainty, through the possibility of revocation of a license, on the market value of spectrum[41]. Beyond the impact on T-Mobile's Auction 108 licenses, the events that have caused the delay in issuing those licenses risk injecting more uncertainty for all spectrum license holders. That T-Mobile has paid for these licenses, but is not enjoying the use of them, raises questions for all license holders about their ability to productively use the spectrum they are licensed. Ultimately, market perceptions will be molded by how long the current delay takes to resolve, and how it is resolved. For example, by issuing STAs while the ultimate licensing authority is resolved by Congress, the FCC would send a strong signal that it would do whatever it can to make sure licensees are able to enjoy the rights they are entitled to.

28. The impact of regulatory uncertainty can be significant. Bazelon (2012) measured the impact on future cash flows of potential license revocation and found that the impact on spectrum value was greater than proportional to the chance of license revocation.[42] Although we do

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[38] Coleman Bazelon, "Cost of Regulatory Risk for Wireless Spectrum Values", The Brattle Group, August 23, 2011, https://www.brattle.com/wp-content/uploads/2017/10/7933_cost_of_regulatory_risk_for_wireless_spectrum_values_bazelon_aug_23_2011.pdf.

[39] Coleman Bazelon, "Implications of Regulatory Inefficiency For Innovative Wireless Investments," Prepared for LightSquared, Filed at the FCC Filed with Comments In Opposition of Lightsquared Inc. IB Docket No. 11-109, DA 12-214, March 15, 2027, p. 7, ("Implications of Regulatory Inefficiency For Innovative Wireless Investments").

[40] Implications of Regulatory Inefficiency For Innovative Wireless Investments, p. 7.

[41] Implications of Regulatory Inefficiency For Innovative Wireless Investments, p. 9.

[42] Implications of Regulatory Inefficiency For Innovative Wireless Investments, p. 15.

not know yet what will be the ultimate impact on marketplace perceptions from this current delay in issuing T-Mobile's Auction 108 licenses, even a small impact can have a large effect on spectrum value. Just a fraction of one percent increase in the uncertainty of the security of the right to use a spectrum license can decrease the license's value by 1% or more. The current stock of FCC licenses is easily worth more than $1 trillion.[43] Consequently, a 1% (or multiple thereof) decrease in the value of spectrum is more than $10 billion (or multiple thereof) in value lost.

III. Effect of Delaying the Grant of T-Mobile's Auction 108 License Portfolio and STAs on Jobs, Anchor Institutions and Vulnerable Population

A. Effect on Jobs

29. The introduction of 5G technology will have both direct and indirect effects on the labor market. One of the most significant impacts is the emergence of new employment opportunities stemming from the capabilities of 5G, including innovative applications, services, business models, and overall business growth. But the immediate and direct demand for new jobs will primarily arise from the additional labor needed to construct and deploy the 5G network infrastructure.

30. Currently, the U.S. wireless industry supports about 250,000 wireless jobs and sources estimate that 5G could generate as many as 4.6 million jobs economy-wide in the U.S.[44] In

[43] Brattle Internal Estimate.

[44] "Wireless Telecommunications Carriers in the US - Employment Statistics 2004–2029", updated March 27, 2023, last accessed June 21, 2023, https://www.ibisworld.com/industry-statistics/employment/wireless-telecommunications-carriers-united-states/ See also, Enrique Duarte Melo, Antonio Varas, Heinz Bernold, and Xinchen Gu, "5G Promises Massive Job and GDP Growth in the US," Prepared in Collaboration with CTIA, February 2021, p. 4, https://api.ctia.org/wp-content/uploads/2021/01/5G-Promises-Massive-Job-and-GDP-Growth-in-the-US_Feb-2021.pdf.

fact, China has experienced a nine-fold increase in 5G-related jobs.[45] Thus, a delay in 5G deployment, due to unavailability of T-Mobile's 2.5 GHz spectrum would have a significant negative impact on new job creation.

31. To calculate the impact of the delay on jobs we use a capex multiplier from existing literature on the economic impact of 5G on the U.S. economy.[46] Prior research suggests that for every $1 million in capex in the wireless industry, there are approximately 3.5 wireless jobs created and 9 overall jobs, inclusive of the wireless jobs.[47] Based on our estimate of incremental capex for the Auction 108 spectrum, a delay in deploying the spectrum delays the creation of over 6,500 wireless jobs and approximately 17,000 total jobs in the U.S.[48]

B. Lack of Improved Broadband Access to Anchor Institutions

32. Anchor institutions are typically large organizations or facilities that play a vital role in their communities, such as hospitals, universities, and libraries. Aside from the direct loss in value, a regulatory delay in deploying the 2.5 GHz spectrum can affect connectivity to these institutions. It is important to note that the impact of slower 2.5 GHz deployment on anchor institutions will vary depending on the specific institution, the level of broadband access available, and whether the institution subscribes to T-Mobile service directly. However, in general, slower broadband can impede anchor institutions' ability to effectively serve their communities, limit access to essential resources, and hinder progress in various areas. Slower broadband deployment can exacerbate existing inequalities and contribute to a digital divide. Disadvantaged communities, including those served by anchor institutions,

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[45] Minghe Hu, "China Sees Ninefold Increase in Number of 5G-related Jobs with Demand for Talent Far Outstripping Supply," Southern China Morning Post, October 21, 2019, last accessed June 21, 2023, https://www.scmp.com/tech/big-tech/article/3033837/china-sees-ninefold-increase-number-5g-related-jobs-demand-talent-far.

[46] James E. Prieger, "An Economic Analysis of 5G Wireless Deployment: Impact on the U.S, and Local Economices," ACT: The App Association, February 2020, https://actonline.org/wp-content/uploads/ACT-Report-An-Economic-Analysis-of-5G-FINAL.pdf, ("An Economic Analysis of 5G Wireless Deployment").

[47] "An Economic Analysis of 5G Wireless Deployment", Table 7, p. 39.

[48] We estimate 6,650 direct jobs and 16,910 total jobs delayed. *See "*An Economic Analysis of 5G Wireless Deployment", Table 7, p. 39.

may have limited access to online resources and opportunities, further marginalizing them in the digital age.

33. To understand the potentially affected institutions, we use a combination of T-Mobile's cell-site location data and population coverage to estimate the geographic coverage of white space licenses at every tower location. We then map the educational institutions and libraries that are located in that footprint. This allows us to calculate the number of these institutions that are potentially affected by the regulatory delay, and we are also able to quantify the number of students that may be impacted using enrollment data.

1. U.S.-Wide Impact

34. To investigate the impact of the regulatory delay, we analyzed publicly available data on educational institutions in the United States.[49] Specifically, we looked at colleges and universities, public schools, private schools, and libraries.[50] As previously mentioned in the report, these are important anchor institutions and broadband connectivity is critical infrastructure for these institutions. As we have observed in the past several years, the Commission has made digital equity one of its primary goals, and closing the homework gap has been at the forefront of that effort.[51] The delay would have a detrimental impact on the student population, impeding its access to reliable internet connectivity and causing disruptions in the learning process.

35. In Table 3, we show the number of educational facilities impacted by the regulatory delay and show how many students would potentially be affected.[52] Note that these are calculated based on the STA and planned sites and hence will undercount the affected institutions and the student population as we have not accounted for the greenfield sites. In column 2 and 3 of Table 3, we show the impact of delay on spectrum deployment for only

[49] Integrated Post Secondary Education System (IPEDS) for the Homeland Infrastructure Foundation-Level Data (HIFLD) database, data last updated on December 10, 2022, last accessed June 21, 2023, https://gii.dhs.gov/HIFLD, ("HIFLD database").

[50] HIFLD database.

[51] FCC, "Homework Gap and Connectivity Divide," last accessed June 21, 2023, https://www.fcc.gov/about-fcc/fcc-initiatives/homework-gap-and-connectivity-divide.

[52] In order to calculate total enrollees affected, we look at the columns "TOT_ENROLL" in the colleges and universities data and "ENROLLMENT" in the data for public and private schools. In the datasets used for this analysis, it should be noted that there are duplicate observations. To address this, we group the data by variables expected to uniquely identify a facility and retain only the first instance within each group.

the STA sites. We observe that a significant number of colleges and universities, public schools, private schools, and libraries will be adversely affected. In total, almost 35,000 educational facilities may be potentially impacted. For STA sites only, the number of enrollees affected is over 15 million. In columns 4 and 5, we show the impact across the currently contemplated Auction 108 plan. For that group of cell sites, over 40,000 educational facilities and over 16 million enrollees are affected. Figure 2 provides a visual representation.

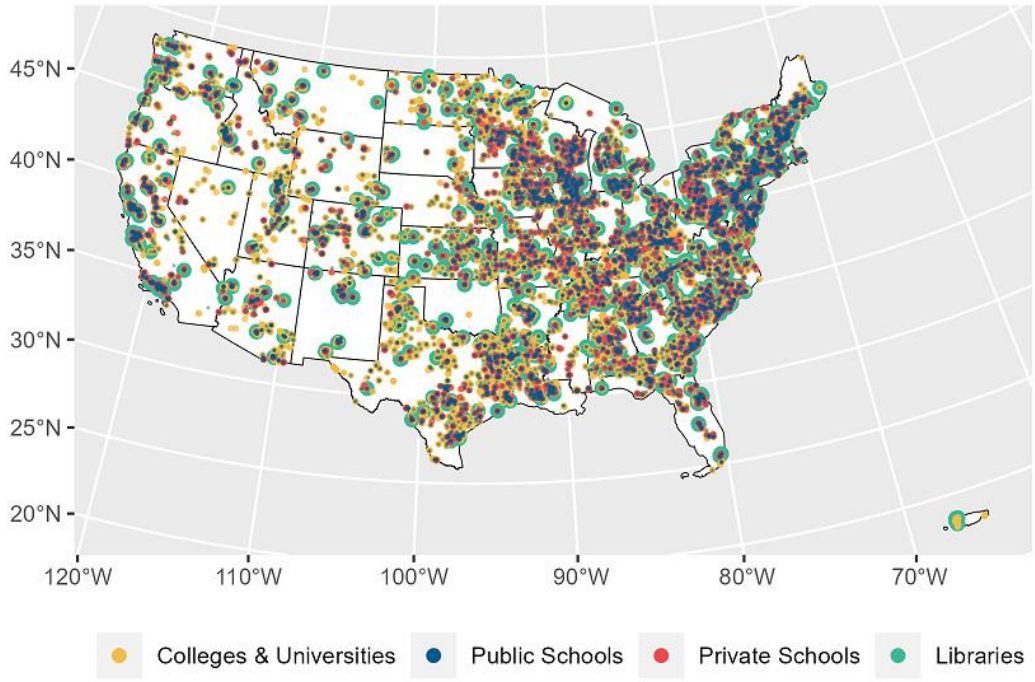
TABLE 3: EDUCATIONAL INSTITUTIONS AFFECTED BY THE DELAY IN SPECTRUM DEPLOYMENT

Type	**STA Sites**		**All Sites (POR and STA)**		**Greenfield Counties**	
	Count	*Enrollees Affected*	*Count*	*Enrollees Affected*	*Count*	*Enrollees Affected*
[1]	[2]	[3]	[4]	[5]	[6]	[7]
Colleges and Universities	1,522	4,516,161	1,639	4,727,125	48	84,770
Private Schools	4,346	606,469	4,996	659,971	123	8,251
Public Schools	23,541	10,153,985	27,691	11,364,912	1,405	274,379
Libraries	5,556	--	6,625	--	377	--
Total	**34,965**	**15,276,615**	**40,951**	**16,752,008**	**1,953**	**367,400**

Sources and Notes:
[1]: Homeland Infrastructure Foundation-Level Data (HIFLD), last accessed June 9, 2023, https://hifld-geoplatform.opendata.arcgis.com/
[2]—[7]: Brattle Analysis

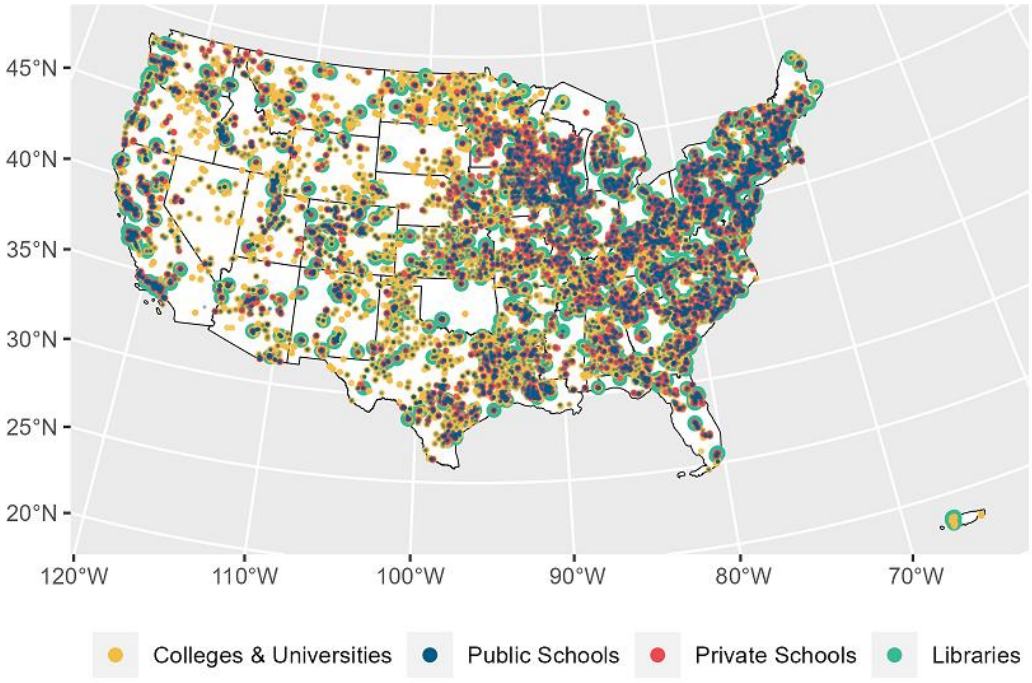
36. Figure 1 shows the educational facilities that lie within the coverage area of the STA sites identified in Table 3. Figure 2 shows the educational facilities within the coverage area of either STA or planned sites.

FIGURE 1: EDUCATIONAL INSTITUTIONS AFFECTED BY REGULATORY DELAY (STA SITES ONLY)



Source: Brattle Analysis.

FIGURE 2: EDUCATIONAL INSTITUTIONS AFFECTED BY REGULATORY DELAY (ALL SITES)



Source: Brattle Analysis

2. Rural-Urban Impact

37. From the table below it appears that there is a fairly significant non-urban impact. Over 50% of the public school students, over 40% of the college students, and over 60% of the libraries potentially being impacted by the regulatory delay are in non-urban areas.

TABLE 4: EDUCATIONAL INSTITUTIONS AFFECTED BY SPECTRUM DELAY BY MORPHOLOGY (ALL SITES)

	Colleges and Universities		Private Schools		Public Schools		Libraries
Morphology	**Enrollees Affected**	**Count**	**Enrollees Affected**	**Count**	**Enrollees Affected**	**Count**	**Count**
[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]
Non-Urban	1,971,847	736	267,247	2527	5,867,957	15,975	4,188
Urban	2,755,278	903	392,724	2,469	5,496,955	11,716	2,637
Total	4,727,125	1,639	659,971	4,996	11,364,912	27,691	6,825

Sources and Notes:
[1]: "APT 700MHz Best Choice for nationwide coverage," ZTE, last accessed June 6, 2023, https://www.gsma.com/spectrum/wp-content/uploads/2013/07/ZTE-LTE-APT-700MHz-Network-White-Paper-ZTE-June-2013.pdf
[2]—[9]: Brattle Analysis; Homeland Infrastructure Foundation-Level Data (HIFLD), last accessed June 9, 2023, https://hifld-geoplatform.opendata.arcgis.com/

C. Veterans Facilities Affected by Delaying 2.5 GHz Deployment

38. We understand that T-Mobile is the primary wireless service provider for the Department of Veterans Affairs (VA). VA hospitals are crucial anchor institutions providing healthcare services to veterans – a vulnerable population for whom such care is critical. VA hospitals increasingly rely on telemedicine to provide healthcare services to veterans, especially those in rural or underserved areas.[53] Slower broadband can hinder the effectiveness of telemedicine, leading to poor video quality, delays, and disruptions in virtual consultations,

[53] VA, "VA Reports Significant Increase in Veteran Use of Telehealth Services," VA News Release, Nov. 22, 2019, last accessed June 21, 2023, https://news.va.gov/press-room/va-reports-significant-increase-in-veteran-use-of-telehealth-services/.

making it challenging for veterans to access healthcare remotely.[54] Additionally, some medical equipment relies on internet connectivity for real-time data transmission, remote monitoring, and software updates. These impacts can collectively result in compromised healthcare quality, delayed treatment, and increased operational challenges for VA hospitals.

39. To quantify the effect on VA facilities, we follow the same methodology as the educational facility analysis above and calculate the number of such facilities that are affected by the regulatory delay.

1. U.S.-Wide Impact

40. Table 5 shows how many VA medical facilities will be affected by the spectrum deployment delay in two scenarios – STA sites only and STA and planned sites.

TABLE 5: VETERANS' MEDICAL FACILITIES AFFECTED BY SPECTRUM DELAY

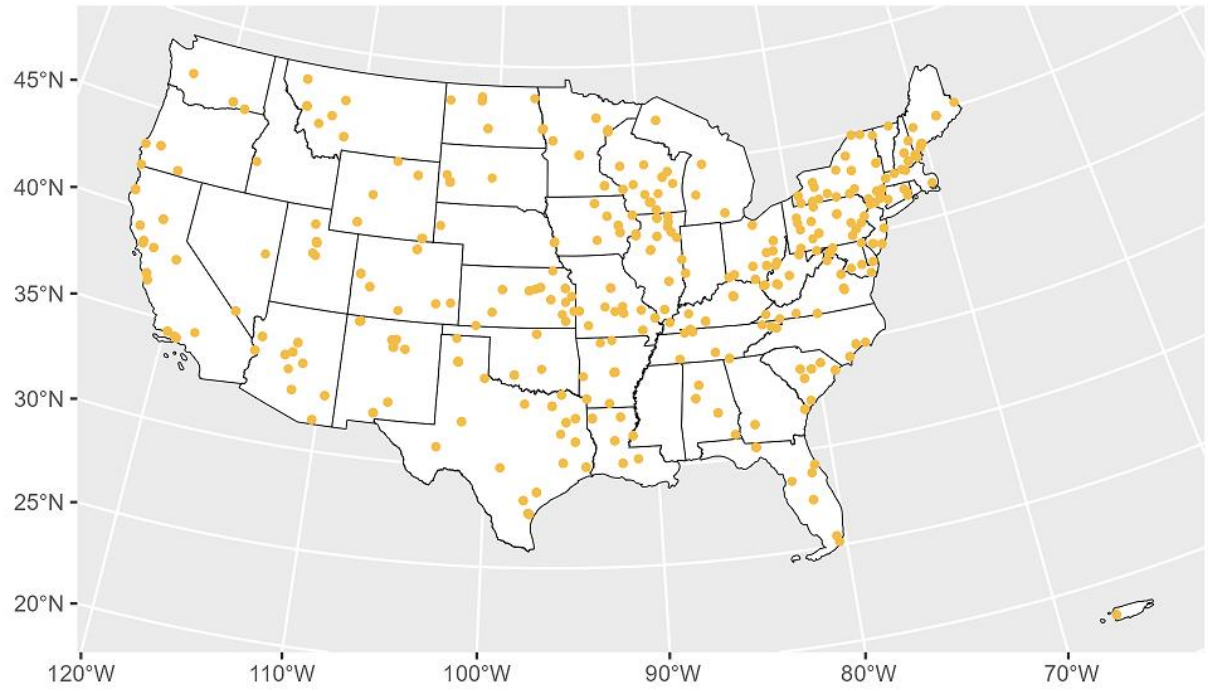
Type	**Count**	
	STA Sites	*All Sites (POR and STA)*
[1]	[2]	[3]
General Medical and Surgical Hospital	84	91
Nursing Homes (Skilled Nursing Facilities)	2	3
Other Outpatient Care Centers	254	298
Total	**340**	**392**

Sources and Notes:
[1]: "Veterans Health Administration Medical Facilities", Homeland Infrastructure Foundation-Level Data (HIFLD), last accessed June 9, 2023, https://hifld-geoplatform.opendata.arcgis.com/datasets/veterans-health-administration-medical-facilities/explore?location=38.837974%2C-76.553386%2C8.95
[2] – [3]: Brattle Analysis.
Also note that 5 General and Medical Surgical Hospitals and 18 Outpatient Care Centers are affected by the spectrum deployment delay in greenfield sites.

[54] Emily Olsen, "Study: Poor Broadband Speed Linked to Lower Video Telemedicine Use Among Veterans," HIMSS, Global Edition, October 17, 2022, last accessed June 21, 2023, https://www.mobihealthnews.com/news/study-poor-broadband-speed-linked-lower-video-telemedicine-use-among-veterans.

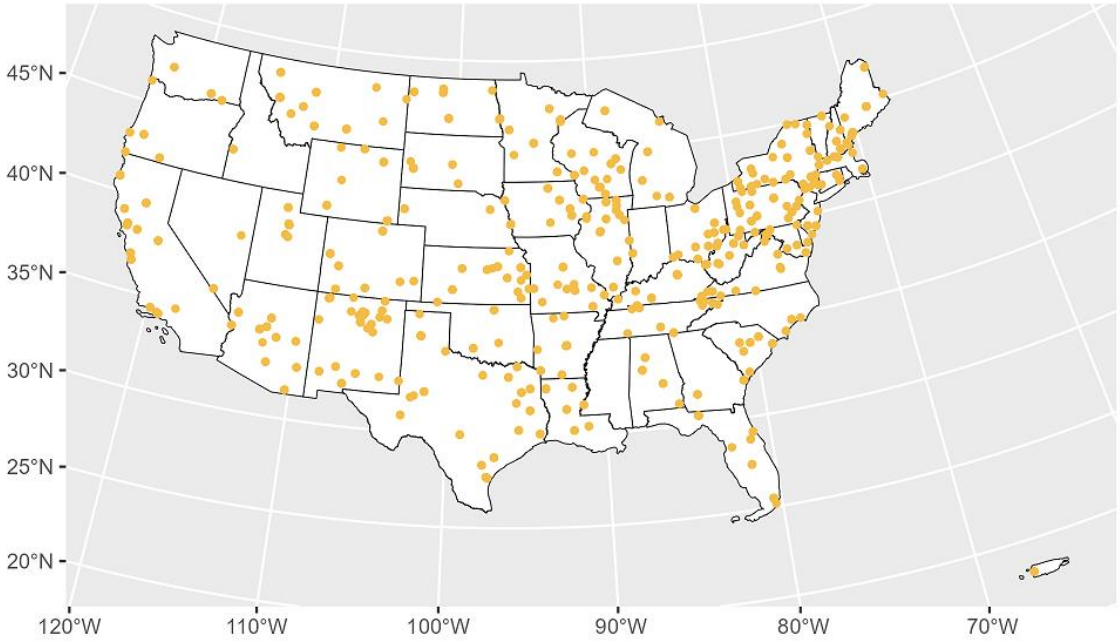
41. In Figure 3, the extensive scale of the impact becomes clear as affected facilities span across the United States. Figure 4 incorporates all the planned build sites in addition to the existing STA sites.

FIGURE 3: VETERANS MEDICAL FACILITIES AFFECTED BY SPECTRUM DELAY (STA SITES)



Source: Brattle Analysis

FIGURE 4: VETERANS MEDICAL FACILITIES AFFECTED BY SPECTRUM DELAY (ALL SITES)



Source: Brattle Analysis

2. Rural-Urban Impact

42. From the table below it appears that there is a fairly significant non-urban impact. Over 50% of the affected VA facilities are in non-urban areas.

TABLE 6: VETERAN'S MEDICAL FACILITIES AFFECTED BY SPECTRUM DELAY BY MORPHOLOGY

Morphology [1]	**Count** [2]
Non-Urban	203
Urban	189

Sources and Notes:
[1]: "APT 700MHz Best Choice for nationwide coverage," ZTE, last accessed June 6, 2023, https://www.gsma.com/spectrum/wp-content/uploads/2013/07/ZTE-LTE-APT-700MHz-Network-White-Paper-ZTE-June-2013.pdf
[2]: Brattle Analysis.

IV. Conclusion

43. Overall, the economic literature highlights the negative consequences of regulatory delays on investment, economic growth, innovation, job creation, consumer welfare, and small businesses. Our study of FCC's delay in issuing Auction 108 licenses shows substantial harm that is consistent with the literature.

We estimate the consumer welfare at risk as follows:

- The Auction 108 spectrum that T-Mobile can immediately put to use would generate approximately $28 billion in consumer welfare, with the possibility of generating up to $37 billion.
- Including T-Mobile's Auction 108 spectrum for which the company needs to deploy new radios and towers, the spectrum would generate approximately $42 billion in consumer welfare, with the possibility of generating up to $56 billion.

We estimate lost consumer value over time as follows:

- Through June 30, 2023, the regulatory delay has cost Americans $1.3 billion in lost value.
- For a further three-month delay, *i.e.*, from June 30, 2023 to September 30, 2023, Americans would lose an incremental $750 million.
- For a one-year delay, *i.e.*, from June 30, 2023 to June 30, 2024, Americans would lose an incremental $3 billion.

We estimate a reduction in job creation due to T-Mobile's delayed capex investment in the Auction 108 licenses as follows:

- The creation of over 6,500 wireless industry jobs will be put on hold until the licenses are issued.
- The creation of approximately 17,000 jobs in the overall economy will be put on hold until the licenses are issued.