



The Race to 5G: Protecting Taxpayers through Spectrum Auctions



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Introduction

The Federal Communications Commission (FCC) is currently considering whether spectrum critical to the deployment of fifth generation (5G) wireless networks should be sold through a public auction or through a private secondary market transaction. This process began with the July 12, 2018 adoption of a proposed rulemaking on Expanding Flexible Use of the 3.7 GHz to 4.2 GHz Band (Docket 18-122), known as the C-band.¹

If this mid-band spectrum is sold through the normal FCC auction process with strong oversight, the proceeds would go to the taxpayers; incumbent users of the spectrum would be protected; and the spectrum would be used for 5G development and deployment. If it is sold on the secondary market through a private sale, there is no guarantee taxpayers would see any of the revenues generated from the sale; incumbent users are not assured they will be made whole; and there would be limited FCC oversight. Spectrum is unlike any other public asset in terms of its value and strategic importance for the future of the economy and national security.

Since 1994, the FCC has conducted 101 spectrum auctions, which through January 24, 2019, generated \$121,672,180,000 to taxpayers in net winning bids and the awarding of 44,499 licenses. The auction of C-band spectrum could generate an additional \$11 billion to \$60 billion to taxpayers, depending on the amount of spectrum made available for sale.² Given this track record of success, it is difficult to see why any entity other than the FCC should be permitted to conduct the C-band spectrum auction.

According to an April 2, 2019 CTIA report, during the rest of 2019, 5G companies in the U.S. are on schedule to deploy 92 5G networks; South Korean companies will be deploying 48 networks; and the United Kingdom will have 16 networks deployed.³ Leading the development and deployment of 5G networks is critical to keeping the U.S. as the world leader in telecommunications.

On October 25, 2018, the White House issued a Presidential Memorandum on Developing a Sustainable Spectrum Strategy for America's Future. Calling on federal agencies to use spectrum as "efficiently and effectively as possible to help meet our economic, national security, science, safety, and other Federal mission goals now and in the future," the memorandum makes it clear that access to spectrum to enhance the nation's technological capabilities is a critical component to leading the way in next generation technologies, particularly for 5G network deployment.⁴

The FCC's five-year strategy to make more spectrum available for 5G deployment, known as the 5G FAST Plan, is comprised of three components: 1) push more spectrum into the marketplace; 2) update infrastructure policy; and 3) modernize outdated regulations.⁵ As part of this strategy, the FCC held an auction in the 28 GHz band in 2018; has begun the auction for spectrum in the 24 GHz band; and, will be holding auctions in 2019 for the upper 37 GHz, 39

GHz, and 47 GHz bands. On April 12, 2019, the FCC adopted a public notice seeking comment on procedures for the incentive auction of these bands.⁶

The C-band spectrum is currently used to send information via satellites between what are referred to as terrestrial or earth stations by various industries, including the television broadcasting community, communications providers, content providers, and others who would be forced to vacate their use of this space should it be auctioned or otherwise sold. Based on previous auctions, the value of this spectrum could range anywhere from \$11 billion to potentially \$60 billion.

The Benefits of Nationwide 5G Coverage

The 5G network will provide faster data transfer speeds, shorter delays in data, and increased connectivity that will further enhance the use of the Internet of Things (IoT). Just as 4G technologies changed mobile computing, the deployment of 5G will offer faster transmission speeds with lower latency or delays from point to point. This will provide improvements to telemedicine and automotive safety, enhance cybersecurity and data protections, enable the development of new products and services, increase productivity, and allow for the emergence of new industries.⁷

According to a January 2017 study commissioned by Qualcomm, the full global economic effect of the 5G economy will be realized by 2035 and potentially provide 22 million jobs and produce up to \$12.3 trillion in global economic output.⁸

The deployment of 5G networks across the country will require access to millimeter wave spectrum for dense urban communities; mid-band spectrum for metropolitan areas; and low-band spectrum for nationwide coverage, including rural communities. The U.S. has moved forward in auctioning spectrum licenses in the low-band frequencies, as well as in the high-band frequencies. However, the U.S. remains behind other countries, like China and South Korea, in the deployment of mid-band spectrum, where the C-band is located.

On April 3, 2019, Verizon announced the rollout of 5G wireless networks in Chicago and Minneapolis.⁹ AT&T announced it would be adding seven more cities to its 5G network, including portions of Austin, Los Angeles, Nashville, Orlando, San Diego, San Francisco, and San Jose.¹⁰ More companies are expected to follow in additional cities across the country, but without additional mid-band spectrum in the pipeline for 5G deployment, national coverage will be difficult.

Understanding the importance of mid-band spectrum to the future of 5G, on April 12, 2019, FCC Commissioner Jessica Rosenworcel called upon the agency to “flip its priorities and pivot to the mid-band.” The FCC “can start by scheduling an auction in the 3.5 GHz band. We should continue our discussion and engage Congress regarding the 3.7 to 4.2 GHz band. Then we need to explore innovative opportunities for making more efficient use of the 2.5 GHz band.

Finally, we need to continue to press our federal partners to work collaboratively with us to open more mid-band spectrum for new commercial use.”¹¹

She continued, “The truth is, when it comes to mid-band spectrum, we’re not just behind, we are no longer even running the same race as the rest of the world. The good news is that it is not too late to do something about it.”¹²

According to the Small Cell Forum, at least half of the 5G deployments between 2019 and 2022 will require the use of mid-band C-band spectrum between 3.4 GHz and 4.2 GHz.¹³ In its filings on the C-band rulemaking, the C-Band Alliance, a consortium of foreign satellite companies based in Canada, France, and Luxembourg, has asked the FCC for permission to sell licenses in the lower 200 MHz of the 500 MHz spectrum currently located in the C-band on the secondary spectrum market. They claim that they will be able to quickly vacate the lower 200 MHz of spectrum by moving their customers to the upper 300 MHz of the C-band and making the spectrum available for sale to speed the deployment of 5G.

History of Spectrum Auctions

Spectrum management in the U.S. had a rocky beginning. In the early 20th century, spectrum use was unregulated. Following the RMS Titanic tragedy, which raised concerns about congestion and false S.O.S. signals over the airwaves, the Radio Act of 1912 was enacted. This law sought to bring order to radio spectrum by regulating its use and requiring spectrum users to acquire a license to operate from the Department of Commerce.¹⁴ The FCC was created by the Communications Act of 1934 (P.L. 73-416) and tasked with the responsibility of processing applications for spectrum licenses.

By the 1980s, the FCC was overwhelmed with license applications and asked Congress to permit the allocation of spectrum through an alternative means, as spectrum had been given to various radio wave interests without any compensation to the taxpayer, other than negligible application costs, since 1927.¹⁵ From 1983 to 1994, spectrum licenses were awarded through a lottery system. However, this process resulted in random spectrum assignments that made little sense and created a cottage industry of spectrum speculators.¹⁶

In 1993, Congress, for the first time, authorized the FCC to conduct spectrum auctions through the Omnibus Budget Reconciliation Act of 1993 (P.L. 103-66).¹⁷ This authorization was extended by the Balanced Budget Act of 1997 (P.L. 105-33), the Deficit Reduction Act of 2005 (P.L. 109-171), and the DTV Delay Act (P.L. 111-4). The Middle Class Tax Relief and Job Creation Act of 2012 (P.L. 112-96) included the Spectrum Act, which extended the auction authority to the end of fiscal year 2022 and authorized the FCC to conduct a broadcast incentive auction and reverse auction. The Spectrum Pipeline Act provisions of the Bipartisan Budget Act of 2015 (P.L. 114-74) further extended the FCC’s auction authority for an additional 30 MHz of federally-held spectrum identified by the Department of Commerce through FY 2025.¹⁸

Since 1994, the FCC has completed 101 spectrum auctions through either simultaneous multiple-round auctions or modified package bidding, which allows bidders to place bids on groups of licenses. These auctions are open to any eligible company or individual that submits an application and upfront payment. These have raised a combined total of \$121.7 billion for taxpayers.¹⁹ The success of these auctions has enabled more than 100 wireless providers²⁰ to build and improve their networks.

The wireless industry supports more than 4.7 million jobs and contributes \$475 billion annually to the U.S. economy.²¹ Wireless networks have provided tens of millions of Americans access to the latest technology, enabled the development of the app economy, and provided for increased opportunities in education, improved health care outcomes through telemedicine, and greater job creation.

During the FCC's April 12, 2019 monthly meeting, Commissioner Brendan Carr noted that the FCC auction proceedings are "a model for the world."²² He further stated that based on his discussions during his travels to Kenya and other countries, "There is no consensus yet in many of their countries that spectrum should be auctioned let alone schedules for doing so. They asked me to explain why removing restrictions on spectrum is important and why they should strongly consider flexible use."²³

Existing Use of C-Band Spectrum

The space race in the 1950s and early 1960s brought about new innovations for communications and video viewing previously never imagined. Following successful rocket launches in the 1960s, the launch and use of domestic satellites for the distribution of television and communications signals were first proposed. However, it was not until 1974, with the launch of Western Union's WESTAR I, that commercial use of satellites became available. In December 1975, RCA launched its RCA SATCOM F-1. In 1976, the launch of the first COMSTAR series by AT&T and COMSAT allowed 120 transponders to provide 1,500 telephone channels or one TV channel.²⁴

As more communications satellites were launched, the use of the C-band spectrum dramatically increased. Compression technology developed in the 1990s enabled greater use of satellites to transmit audio and video signals to and from terrestrial-based earth stations. According to the International Telecommunication Union (ITU) Constitution, radio frequencies and satellite orbits are limited natural resources, and therefore must be used in a manner that will allow for equitable access.²⁵ Globally, the ITU Radiocommunications Sector (ITU-R) manages radio-frequency spectrum and satellite orbits to ensure a rational, equitable, efficient, and economical use of the radio-frequency spectrum of all radiocommunications systems, including those using satellite orbits.²⁶

By 2014, Eutelsat, Intelsat, JSAT, SES, and Telesat owned half of the more than 300 commercial satellites currently in geosynchronous orbit.²⁷ All except JSAT are members of the C-Band Alliance. The satellites are assigned an orbital slot and allocated use of the C-band

spectrum between the 3.7 MHz and the 4.2 MHz range. They provide access to more than 250 channels of video and 75 audio services to approximately 335,000 subscribers.²⁸

Rights to use the C-band spectrum are governed by a “full-band, full-arc” policy, rather than a range of frequencies being assigned to individual licensees with only one operator holding the rights.²⁹ In other words, satellite earth stations use the entire 500 MHz of the C-band, which allows them to point their satellite dishes in every direction toward every possible geosynchronous satellite. While the rights to use spectrum within the C-band are numerous, they are not clearly defined to one particular user of the spectrum.³⁰

Questions that must be addressed in the FCC’s review of the C-Band Alliance’s proposal include whether it takes into consideration existing use by incumbents in the space, including broadcasters, satellite broadband customers in rural communities, and others who would be forced to vacate their channels to make way for 5G deployment; what is the most appropriate mechanism to balance the need for efficient allocation, public value, and legal durability; whether other non-C-Band Alliance satellite operators would be protected from being forced out of their use of the spectrum by their competitors; and, who would receive the proceeds from a secondary market sale of spectrum owned by the U.S. government. There is also the question of how the satellite companies can sell property they do not own, since they only possess a license to use the spectrum.

In its December 11, 2018 filing with the FCC, the Satellite Industry Association noted the C-band plays an unappreciated role in the daily lives of American consumers by enabling “the media industry to provide broad coverage, near-perfect reliability, and distance insensitive pricing of C-band satellite capacity used to distribute video and audio news, weather, sports, entertaining and religious programming to dense urban centers and small, rural communities alike.”³¹

The nation’s broadcasters, media companies, and other providers, including SiriusXM, DirecTV, and DISH Networks, are heavy users of the C-band to provide content to their customers. Small rural telecommunications providers, like those represented by the Alaskan Telecom Association, often rely exclusively on satellite technology for the provision of basic telephone service, telehealth, and distance learning. These providers have little expectation of the availability of a terrestrial network, especially in remote locations.³²

The C-Band Alliance has received commitments from its members to “undertake, manage, and complete all necessary actions to effectuate” customer migration³³ and has proposed covering the moving expenses of their satellite service customers with 120 percent of the costs of repacking them onto new satellites.³⁴ However, this commitment only applies to members of the C-Band Alliance, and provides little assurance to incumbents using other satellite providers that their video and audio content will continue to be delivered as expected.

Efficient and Effective Sale

With respect to a private entity being able to conduct a sale of spectrum on the secondary market rather than the FCC, some might instinctively conclude that the satellite companies would be able to complete the transactions faster and more efficiently. But, that does not consider the complex steps and experience needed to conduct a spectrum auction or significant legal uncertainty involved in a private sale.

A secondary market sale of the spectrum would require the FCC to allocate the spectrum to the C-Band Alliance through its rulemaking and approval process. Incumbents would need to be reassigned to their new designations in the upper 300 MHz of spectrum, and the spectrum would then need to be repacked for private sale after incumbents have been relocated. This process could take just as long, if not longer than an FCC auction. But, even if it may seem faster, the taxpayers will still not benefit from the sale of their assets, as the proceeds would admittedly be divided among the four foreign-owned satellite companies that comprise the C-Band Alliance.

The FCC has a long history of conducting spectrum auctions and is on track to make more spectrum available in the next few years. The 2017 broadcast incentive auction yielded \$19.8 billion in revenue and provided \$10.05 billion for winning broadcast bidders and more than \$7 billion to the U.S. Treasury for deficit reduction.³⁵ This auction repurposed 84 MHz of spectrum (70 MHz for licensed use and another 14 MHz for wireless microphones and unlicensed use), providing even greater experience in repacking and reallocating spectrum for sale through a government-run auction. By contrast, while the C-Band Alliance is positioned to know what entities are currently using its members' satellites and what spectrum bands they may be using under the full-band, full-arc framework, they do not have the underlying experience needed to conduct a spectrum sale.

In addition, a private sale of spectrum in the C-band would undoubtedly be delayed by court challenges that have already been noted by companies that feel they would be excluded from the bidding process.³⁶

Other Non-CBA Aligned Satellite Operators

In its initial comments filed on October 29, 2018, the C-Band Alliance claimed that the four satellite operators that comprise the alliance "represent virtually all of the C-band service providers in the continental United States ("CONUS")."³⁷ However, this assertion is refuted in a December 11, 2018 filing critical of the C-Band Alliance proposal by a group of small satellite operators (SSOs) who noted that, "the self-styled 'C-Band Alliance' ('CBA') of the four largest U.S. C-band satellite operators proposes to exclude the SSOs from compensation for the reduction in value of C-band assets that would result from a partial reallocation, while nevertheless claiming a right to the exact same compensation for the CBA's own members. The CBA's incoherent and anticompetitive exclusion of its rivals is emblematic of a larger issue with the CBA proposal. As the record demonstrates, the CBA has failed to account for the interests

not just of competing satellite operators, but also of its own customers and U.S. taxpayers as well.”³⁸

The SSOs also raise concerns about the potential for antitrust law violations that could occur if the C-Band Alliance or any other private entity becomes the “facilitator” for the sale of the C-band spectrum on the secondary market.³⁹ These arguments tie closely to the fact that the C-band spectrum is not owned by the satellite operators. It is licensed for their use by the FCC on finite agreements, many of which expire in the mid-2020s.⁴⁰

Proceeds from Secondary Market Sales

The value of the 200 MHz of spectrum proposed for sale by the C-Band Alliance could, according to Laurie Davidson, a satellite equity analyst at Deutsche Bank, generate as much as \$11 billion in gross receipts.⁴¹ The American Cable Association has estimated that the full 500 MHz of C-band spectrum could be worth up to \$60 billion to wireless carriers.⁴² By comparison, the AWS-3 spectrum auction of 65 MHz of Advanced Wireless Services spectrum generated nearly \$45 billion in gross bids for the U.S. government,⁴³ \$7 billion of which was dedicated to build the FirstNet first responder network.⁴⁴

In most instances, the secondary market is used when a licensed owner of spectrum no longer has a use for the spectrum license, and sells it in a private transaction, subject to FCC approval. For example, in 2011, Verizon purchased spectrum from cable television operators valued at \$3.6 billion.⁴⁵ The sellers acquired the spectrum in a government auction in 2006 and therefore owned the rights to the spectrum being acquired.

Secondary markets rely on clearly-defined property rights. The individual or company selling the item has purchased and thereby owns the property, giving them authority to sell it on the secondary market.

Because of the nature of satellite use of the C-band spectrum, satellite owners are allocated an orbital slot and granted use of the spectrum within the C-band. While they have full-band, full-arc access to the entire 500 MHz of the C-band spectrum and the earth stations using the band, the satellite operators do not have ownership rights to any portion of the C-band. Usage is constrained based on time, geographic area, permitted technology, and purpose. Factors relating to interference also create difficulties in defining property rights with respect to selling this spectrum on a secondary market.⁴⁶

The lack of ownership by the C-Band Alliance is made evident by its request to the FCC to give them the spectrum licenses so they can sell them on the secondary market.⁴⁷ This reinforces the critical fact they neither own the licenses nor have the authority to sell the licenses, but instead are only authorized to use the spectrum through which they transmit their satellite signals.

The C-Band Alliance proposal is reminiscent of a prior attempt to obtain licensed spectrum without reimbursing the federal government. In 2003, Northpoint Technology sought

\$100 million worth of spectrum directly from Congress to provide wireless and satellite services, a giveaway that would have benefitted a company whose only asset was its high-powered connections to the right people in the nation's capital.⁴⁸ Fortunately, this proposed theft of spectrum failed.

Similarly, a private sale by the C-Band Alliance of the lower 200 MHz of spectrum in the C-band would not generate any revenue to the current owners of the spectrum, the nation's taxpayers.

Congressional Interest

Members of Congress, including Sens. Jerry Moran (R-Kan.) and Tom Udall (D-N.M.), and Reps. Tony Cardenas (D-Calif.) and Adam Kinzinger (R-Ill.), have asked the FCC to carefully consider potential interference of new terrestrial users on incumbent operations, and ensure that the incumbents are made whole for costs incurred as a result of any new service or shared uses in the C-band.⁴⁹ The members encouraged the FCC to oversee any reallocation of the spectrum and facility and manage spectrum policy in a manner that promotes the public interest.

On March 15, 2019, Sen. John Kennedy (R-La.) called upon the FCC to ensure that the "process for allocating C-band spectrum for 5G must be fair, open, and transparent." He raised concerns about how fair the C-Band Alliance proposal would be, not only to companies that might wish to bid on the spectrum for deploying 5G networks using mid-band spectrum, but also for the American public to whom this valuable resource belongs.⁵⁰

Sen. Kennedy stated, "A privately managed spectrum sale would give the CBA the means to sell nationwide licenses to the largest wireless carriers, with little concern for competitive carriers and new entrants. This outcome would be particularly harmful for rural America as large wireless carriers may never deploy 5G service in these communities. The CBA's members would also have the incentive to raise prices for their remaining satellite services. This would have a disproportionate impact on rural cable operators and their customers."⁵¹

Conclusion

Keeping the taxpayers first in spectrum auctions means that the FCC should take control of and conduct the auction of the C-band. Any other process risks forgoing between \$11 billion and \$60 billion for taxpayers and failing to add that money to the \$121.7 billion already provided through the 101 FCC-conducted spectrum auctions over the past 25 years. The FCC has the experience, knowledge, and fiduciary responsibility to protect the spectrum's owners. Another entity, like the C-Band Alliance, has none of those attributes.

Access to mid-band spectrum, including portions of the C-band, is critical to a fully integrated nationwide 5G network. Just as 4G revolutionized the use of mobile devices with enormous innovations including the creation of the app economy, mobile commerce, and

health care monitoring devices, 5G will bring new technologies that will deliver enormous economic growth, and strengthen the nation’s agricultural, automotive, education, IoT, manufacturing, and health care capabilities.

If the U.S. government allows foreign-owned satellite companies to sell part of the C-band spectrum in a private auction, there is no guarantee that the buyers in such a sale would feel compelled to use the spectrum for 5G network deployment. In addition, the proceeds from a private sale would be retained by the private entities selling the spectrum, rather than the funds reverting to the taxpayers. Any sale of federally-owned spectrum must be conducted by the FCC in order to generate the best outcome for taxpayers.

It is clear from the filings of the C-Band Alliance that they do not need access to at least 200 MHz of the spectrum in the C-band once their customers are relocated, leaving one to wonder whether more of the 500 MHz spectrum might be repacked for additional 5G use. Therefore, the FCC should review the entirety of the C-band spectrum, ensure continuity of service for existing incumbents using the C-band, reassign and repurpose available spectrum for deployment of 5G, and conduct another spectrum auction, which will reimburse the taxpayers, not foreign-owned satellite operators, for their use of the spectrum.

¹ Federal Communications Commission, “In the Matter of Expanding Flexible Use of the 3.7 to 4.2 GHz Band,” GN Docket No. 18-122, Order and Notice of Proposed Rulemaking, Adopted July 12, 2018, <https://docs.fcc.gov/public/attachments/FCC-18-91A1.pdf>.

² Federal Communications Commission, “Auctions Summary: Completed Auctions,” January 24, 2019, <https://www.fcc.gov/auctions-summary>.

³ CTIA, “A National Spectrum Strategy to Lead in 5G,” April 2, 2019, <https://www.ctia.org/news/a-national-spectrum-strategy-to-lead-in-5g>.

⁴ The White House, “Presidential Memorandum on Developing a Sustainable Spectrum Strategy for America’s Future,” October 25, 2018, <https://www.whitehouse.gov/presidential-actions/presidential-memorandum-developing-sustainable-spectrum-strategy-americas-future/>.

⁵ Federal Communications Commission, “The FCC’s 5G FAST Plan,” September 28, 2018, <https://www.fcc.gov/5G>.

⁶ Federal Communications Commission, “Spectrum Frontiers Auction 103, Public Notice – AU Docket No. 19-59,” April 12, 2019, <https://docs.fcc.gov/public/attachments/DOC-356692A1.pdf>.

⁷ PSB Research, “5G Economy Global Public Survey Report,” commissioned by Qualcomm, December 2016, <https://www.qualcomm.com/media/documents/files/psb-public-survey-report.pdf>.

⁸ Karen Campbell, Jim Duffley, Bob Flanagan, Bill Morelli, Brendan O’Neil, Francis Sideco, “The 5G economy: How 5G technology will contribute to the global economy,” IHS Economics & IHS Technology, January 2017, <https://www.qualcomm.com/media/documents/files/ihs-5g-economic-impact-study.pdf>.

⁹ Todd Haselton, “Verizon begins rolling out its 5G wireless network for smartphones,” CNBC, April 3, 2019, <https://www.cnbc.com/2019/04/03/verizon-begins-rolling-out-its-5g-wireless-network-for-smartphones.html>.

¹⁰ Eli Blumenthal, “AT&T expands mobile 5G rollout with seven new cities, total rises to 19,” *USA Today*, April 9, 2019, <https://www.usatoday.com/story/tech/2019/04/09/at-t-expands-5-g-rollout-seven-new-cities-total-rises-19/3409787002/>.

¹¹ Federal Communications Commission, “Statement of FCC Commissioner Jessica Rosenworcel, Re: Incentive Auction of Upper Microwave Flexible-Use Service Licenses in the Upper 37 GHz, 39 GHz, and 47 GHz for Next-Generation Wireless Services, AU Docket No. 19-59,” April 12, 2019, <https://docs.fcc.gov/public/attachments/DOC-356984A4.pdf>.

¹² *Ibid.*

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- ¹³ Small Cell Forum, “Focus on C-Band spectrum means 5G will be dense from day one,” January 24, 2018, <https://www.smallcellforum.org/blog/focus-c-band-spectrum-means-5g-will-dense-day-one/>.
- ¹⁴ Ben Christopher, “The Spectrum Auction: How Economists Saved the Day,” *Priceonomics*, August 19, 2016, <https://priceonomics.com/the-spectrum-auction-how-economists-saved-the-day/>.
- ¹⁵ Ibid.
- ¹⁶ Ibid.
- ¹⁷ Linda K. Moore, “Framing Spectrum Policy: Legislative Initiatives,” Congressional Research Service, May 18, 2016, <https://fas.org/sgp/crs/misc/R44433.pdf>.
- ¹⁸ Ibid.
- ¹⁹ Federal Communications Commission, “Auctions Summary: Completed Auctions,” January 24, 2019, <https://www.fcc.gov/auctions-summary>.
- ²⁰ CTIA, “The Wireless Industry, Industry Data,” June 20, 2018, <https://www.ctia.org/the-wireless-industry/infographics-library>.
- ²¹ Accenture, “Smart Cities: How 5G Can Help Municipalities Become Vibrant Smart Cities,” April 5, 2018, https://www.accenture.com/us-en/insight-smart-cities?c=strat_accenturestratemediarelations_10245982&n=mrl_0418&#block-how-the-wireless-industry-powers-the-us-economy.
- ²² Federal Communications Commission, “Statement of Commissioner Brendan Carr, Re: Incentive Auction of Upper Microwave Flexible-Use Service Licenses in the Upper 37 GHz, 39 GHz, and 47 GHz for Next-Generation Wireless Services, AU Docket No. 19-59,” April 12, 2019, <https://docs.fcc.gov/public/attachments/DOC-356984A3.pdf>.
- ²³ Ibid.
- ²⁴ David J. Whalen, “Communications Satellites: Making the Global Village Possible,” National Aeronautics and Space Administration, <https://history.nasa.gov/satcomhistory.html>.
- ²⁵ International Telecommunication Union, “Constitution of the International Telecommunication Union, Article 44, Use of the Radio-Frequency Spectrum and of the Geostationary-Satellite and Other Satellite Orbits,” <https://www.itu.int/council/pd/constitution.html>.
- ²⁶ International Telecommunications Union, “Welcome to ITU-R,” <https://www.itu.int/net/ITU-R/index.asp?category=information&rlink=itur-welcome%2525E2%25258C%2525A9=en>.
- ²⁷ Intelstat Retirees and Alumni Association, “Brief History & Future Market Demands for Satellite Industry,” 2014, http://myiraa.com/content/download/2014/IRAA_Presentation_DK_Sachdev.pdf.
- ²⁸ Satellite Broadcaster & Communications Association, “Consumer Satellite Product Overview,” <http://sbca.com/receiver-network/satellite-overview.htm>.
- ²⁹ Mitchell Lazarus, “Fixed Service versus Full-Band, Full-Arc Coordination,” National Spectrum Management Association, May 16, 2017, <https://nsma.org/wp-content/uploads/2017/05/2017-06-nsma-fixed-service-versus-full-band-full-arc-coordination.pdf>.
- ³⁰ Joe Kane, “The FCC’s 3.7 – 4.2 GHz Spectrum Band Proceeding: Key Facts and Analysis,” R Street Policy Study, September 2018, <https://ecfsapi.fcc.gov/file/102675932336/Appendix%20A%20-%20The%20FCC'S%203.7-4.2%20GHz%20Spectrum%20Band%20Proceeding%20Key%20Facts%20and%20Analysis.pdf>.
- ³¹ Federal Communications Commission, “Reply Comments of the Satellite Industry Association, In the Matter of Expanding Flexible Use of the 3.7 to 4.2 GHz Band (GN Docket No. 18-122), Expanding Flexible Use in the Mid-Band Spectrum Between 3.7 and 24 GHz, et al.,” (“FCC C-band rulemaking”), December 11, 2018, <https://ecfsapi.fcc.gov/file/1211075228340/SIA%20Reply%20Comments%20on%20Mid-Band%20NPRM%2011%20Dec%202018.pdf>.
- ³² Federal Communications Commission, “Reply Comments of Alaska Telecom Association on FCC C-band rulemaking” December 11, 2018, <https://ecfsapi.fcc.gov/file/1211095006980/ATA%20Reply%20Comments%20C%20Band%20Reallocation.pdf>.
- ³³ Federal Communications Commission, “Written Ex Parté Communications, GN Docket No. 18-122, Wiley Rein, LLP on behalf of the C-Band Alliance,” April 3, 2019, <https://ecfsapi.fcc.gov/file/10403446622844/CBA%20-%20Customer%20Commitment%20Ex%20Parte%20-%20204-3-19.pdf>.
- ³⁴ John Eggerton, “C-Band Alliance Outlines Compensation for Repack,” Multichannel, April 3, 2019, <https://www.multichannel.com/news/c-band-alliance-outlines-compensation-for-repack>.

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- ³⁵ Federal Communications Commission, “Broadcast Incentive Auction and Post-Auction Transition,” May 9, 2017, <https://www.fcc.gov/about-fcc/fcc-initiatives/incentive-auctions>.
- ³⁶ Caleb Henry, “C-Band Alliance plan will spawn lawsuits, Google, Charter warn,” Space News, February 7, 2019, <https://spacenews.com/c-band-alliance-plan-will-spawn-lawsuits-google-charter-warn/>.
- ³⁷ Federal Communications Commission, “Comments of the C-Band Alliance on FCC C-band rulemaking,” October 29, 2018, <http://www.intelsat.com/wp-content/uploads/2018/10/FCC-NPRM-Comment-Filings.pdf>.
- ³⁸ Federal Communications Commission, “Reply Comments of ABS, HOSPASAT, and EMBRATEL Star One on FCC C-band rulemaking,” December 11, 2018, [https://ecfsapi.fcc.gov/file/1211140941610/SSO%20C-Band%20Reply%20Comments%20\(12-11\).pdf](https://ecfsapi.fcc.gov/file/1211140941610/SSO%20C-Band%20Reply%20Comments%20(12-11).pdf).
- ³⁹ *Ibid.*, p. 19.
- ⁴⁰ Mark Holmes, “Fan of the C-Band? Industry Analyst is Cautious About SES,” *Via Satellite*, October 15, 2018, <https://www.satellitetoday.com/telecom/2018/10/15/fan-of-the-c-band-industry-analyst-is-cautious-about-ses/undefined>.
- ⁴¹ Mark Holmes, “Telesat Joins the Band: What this Means for the C-Band Alliance,” *Via Satellite*, October 4, 2018, <https://www.satellitetoday.com/mobility/2018/10/04/telesat-joins-the-band-what-this-means-for-the-c-band-alliance/undefined>.
- ⁴² Caleb Henry, “C-Band Alliance plan will spawn lawsuits, Google, Charter warn,” *Space News*, February 7, 2019, <https://spacenews.com/c-band-alliance-plan-will-spawn-lawsuits-google-charter-warn/>.
- ⁴³ Federal Communications Commission, “Auction 97: Advanced Wireless Services (AWS-3): Fact Sheet,” January 29, 2015, <https://www.fcc.gov/auction/97/factsheet>.
- ⁴⁴ FirstNet First Responder Network Authority, “The Network,” <https://www.firstnet.gov/network>.
- ⁴⁵ Anton Troianovski, Lauren A.E. Schuker and Greg Bensinger, “Verizon Snaps Up Spectrum,” *The Wall Street Journal*, December 3, 2011, <https://www.wsj.com/articles/SB10001424052970204826704577074103860244794>.
- ⁴⁶ Scott J. Wallsten, “Secondary Spectrum Markets,” *Economists, Incorporated*, Fall 2009, <https://ei.com/economists-ink/fall-2009/secondary-spectrum-markets-by-scott-j-wallsten/>.
- ⁴⁷ Federal Communications Commission, “Comments of the C-Band Alliance on FCC C-band rulemaking,” October 29, 2018, <https://ecfsapi.fcc.gov/file/1029067703990/C-Band%20Alliance%20NPRM%20Comments%2010.29.2018.pdf>.
- ⁴⁸ Al Cors, Jr., “Stealing Spectrum,” *National Review*, September 4, 2003, <https://www.nationalreview.com/2003/09/stealing-spectrum-al-cors-jr/>.
- ⁴⁹ Federal Communications Commission, “Letter from Sens. Jerry Moran (R-Kans.) and Tom Udall (D-N.M.) regarding Expanding Flexible Use of the 3.7 to 4.2 GHz Band,” November 13, 2018, <https://docs.fcc.gov/public/attachments/DOC-355996A2.pdf>; and, Federal Communications Commission, “Letter from Reps. Tony Cardenas (D-Calif.) and Adam Kinzinger (R-Ill.) regarding Expanding Flexible Use of the 3.7 to 4.2 GHz Band, with response from FCC Chairman Ajit Pai,” January 17, 2019, <https://ecfsapi.fcc.gov/file/10222306836318/Letter%20from%20Rep%20Cardenas%20%20et%20al%20and%20Chairman%20Pai%20Response.pdf>.
- ⁵⁰ Senator John Kennedy (R-La.), “U.S. Sen. John Kennedy: Don’t Hurt Rural Communities With Privately-Managed Spectrum Sale,” March 15, 2019, <https://www.kennedy.senate.gov/public/press-releases?ID=72CBD77A-71E0-4B0C-8770-BFCD615B0FE>.
- ⁵¹ *Ibid.*