



June 2020

5G DEPLOYMENT

FCC Needs Comprehensive Strategic Planning to Guide Its Efforts

Accessible Version

GAO Highlights

Highlights of [GAO-20-468](#), a report to congressional requesters

View [GAO-20-468](#). For more information, contact Andrew Von Ah at (202) 512-2834 or vonaha@gao.gov.

Why GAO Did This Study

As the latest generation of mobile communications, 5G networks are expected to provide faster connections to support consumer, industry, and public sector services. While private sector carriers deploy 5G networks, FCC has a role in managing deployment challenges, such as how to allocate low-, mid-, and high-band spectrum for 5G use.

GAO was asked to review 5G deployment challenges. This report examines challenges and the federal government's efforts related to 5G deployment with regard to managing spectrum for 5G and closing the digital divide, among other things. GAO, with assistance from the National Academies of Sciences, Engineering, and Medicine, convened a meeting of 17 experts from academia, industry, and consumer groups; reviewed relevant statutes, literature, and FCC documentation; and interviewed FCC and other relevant federal officials, along with stakeholders that include various localities, wireless carriers, and industry associations.

What GAO Recommends

FCC should develop specific and measurable performance goals with related strategies and measures to: (1) manage spectrum demands for 5G and (2) determine the effects 5G deployment and any mitigating actions may have on the digital divide. FCC indicated that setting spectrum goals could unnecessarily limit its options but did not agree or disagree with GAO's recommendations. GAO continues to believe that well-considered strategic planning would benefit FCC's efforts.

June 2020

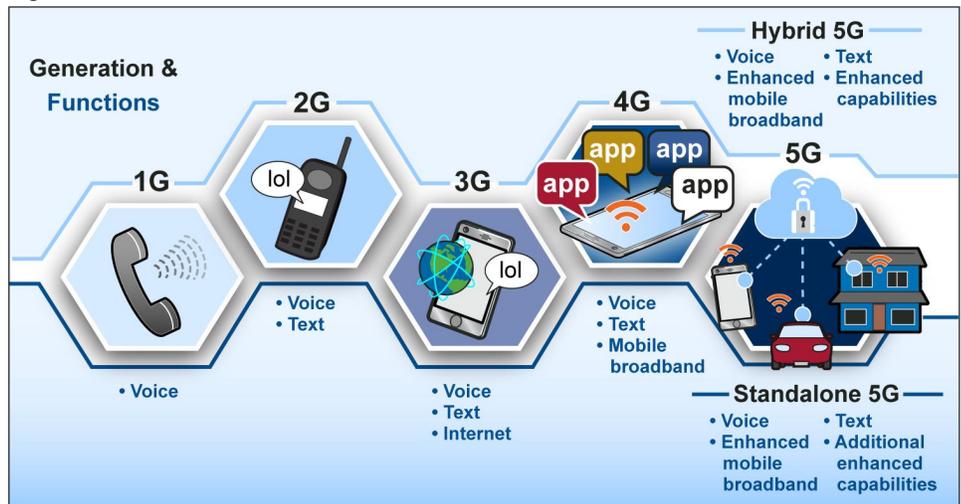
5G DEPLOYMENT

FCC Needs Comprehensive Strategic Planning to Guide Its Efforts

What GAO Found

Approximately every 10 years since the early 1980s, wireless carriers have deployed a new generation of wireless communication technology. This decade is no different, as carriers are now developing and deploying 5G networks, which offer greater speed and higher data capacity than previous generations of mobile wireless networks. Carriers in the United States are currently deploying "hybrid" 5G, which uses 5G technologies in combination with existing 4G networks to improve the networks' speed. In the future, carriers may deploy "standalone" 5G, which relies exclusively on 5G equipment to allow for additional enhanced capabilities (see fig. 1).

Figure 1: Functions of Wireless Communication Generations



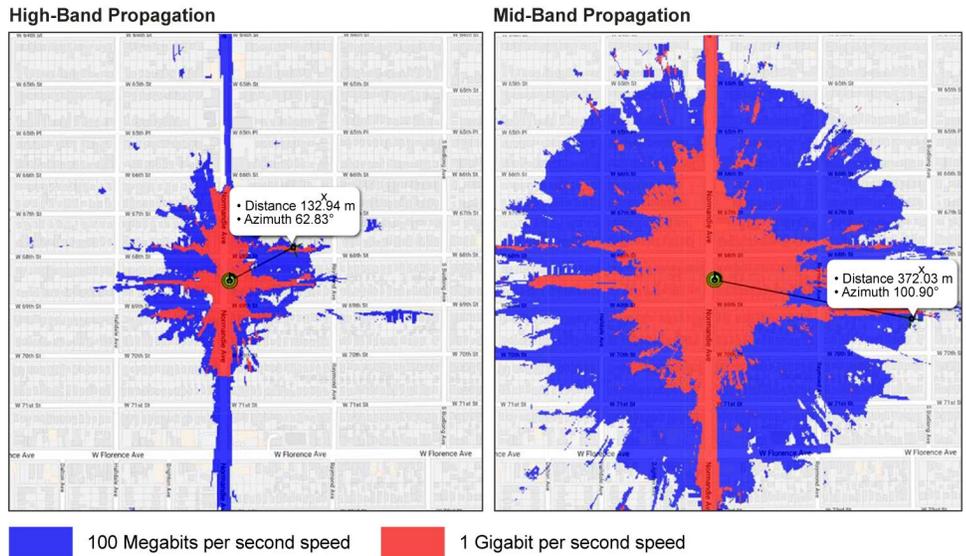
Source: GAO analysis of Congressional Research Service data. | GAO-20-468

Radio frequency spectrum is a finite natural resource used to provide a variety of communication services to businesses and consumers, as well as to federal, state, and local governments. The frequency bands—often referred to as low-band, mid-band, and high-band spectrum—have different characteristics that make them more or less suitable for specific purposes.

Experts GAO convened said that mid-band spectrum is highly congested, leading to an insufficient amount available for carriers to deploy their 5G networks in the United States. The experts stated that to avoid delays in 5G deployment, the commercial sector needs access to more mid-band spectrum.

These experts highlighted the need for mid-band spectrum for 5G due to mid-band's use internationally and because of its properties. Mid-band spectrum allows for higher data capacity than lower bands and can penetrate physical obstacles over long distances—a property known as "propagation"—better than higher bands (see fig. 2).

Figure 2: Comparison of Projected Distance Signals from High-Band and Mid-Band Spectrum Travel from a Single Cell Site in an Urban Environment



Source: GAO analysis of Defense Innovation Board data. | GAO-20-468

The Federal Communications Commission (FCC) has some efforts under way to make additional mid-band spectrum available but so far has primarily made high-band spectrum available for 5G because it is more readily available. Making more mid-band spectrum available to the commercial sector will be challenging, as current mid-band spectrum users include federal government users that may not be able to readily transition to new or less favorable spectrum bands.

FCC's planning document for 5G includes a section on making additional spectrum available but does not clearly identify specific and measurable performance goals or measures to manage the spectrum demands for 5G. Without such strategic planning efforts, FCC will be unable to determine the effectiveness of its spectrum management efforts, particularly related to the congested mid-band spectrum that is critical to 5G deployment.

The experts GAO convened also stated that 5G deployment would likely exacerbate disparities in access to telecommunications services, known as the "digital divide." Specifically, experts as well as stakeholders GAO interviewed said that 5G using high-band spectrum—which allows for high data capacity—is likely to be first deployed in areas already equipped with much of the necessary infrastructure.

Experts said the areas with existing infrastructure are generally urban, densely populated, high-income areas as opposed to rural or low-income areas. Further, within urban settings, experts said that high-band 5G networks are more likely to be deployed in commercially viable areas, including those parts of a city that already are equipped with fiber and power and, presumably, already benefit from the most advanced mobile broadband services available.

FCC has taken steps to address the digital divide, including a recent announcement to make up to \$9 billion in funding available to carriers to deploy 5G in rural areas of the United States. However, FCC has not developed specific and measurable performance goals with related strategies and measures to assess how well its actions are mitigating the added effects 5G deployment will have on the digital divide.

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Abbreviations

5G	fifth generation of mobile communication networks
5G Fast Plan	Facilitate America's Superiority in 5G Technology Plan
FCC	Federal Communications Commission
GHz	gigahertz
GPRA	Government Performance and Results Act
GPRAMA	GPRA Modernization Act of 2010
LTE	Long-term Evolution
MHz	megahertz
MOBILE NOW Act	Making Opportunities for Broadband Investment and Limiting Excessive and Needless Obstacles to Wireless Act
NASEM	National Academies of Sciences, Engineering, and Medicine
NEPA	National Environmental Policy Act of 1969
NHPA	National Historic Preservation Act
NTIA	National Telecommunications and Information Administration

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June 12, 2020

Congressional Requesters

The fifth generation of mobile communication networks (5G) is expected to provide faster connections to support consumer services (e.g., video streaming, autonomous vehicles), industry (e.g., advanced manufacturing), and the public sector (e.g., smart cities). Deployment of 5G could bring new jobs, and potentially billions of dollars in economic benefits, to the United States. In addition, the need for reliable wireless communications takes on new importance to all Americans during times of social distancing, when we must rely on communications networks for such things as distance learning, telework, and telemedicine. However, wireless carriers and governmental bodies throughout the U.S. face several challenges as 5G networks are deployed.

Several federal agencies play a role in enabling the deployment of 5G networks. For example, the Federal Communications Commission (FCC) manages radio frequency spectrum allocation and licensing for nonfederal users, and the National Telecommunications and Information Administration (NTIA), an agency within the Department of Commerce, manages spectrum for federal users. In addition, multiple federal agencies currently occupy and use spectrum that could be well suited for supporting 5G deployment.

You asked us to identify challenges to deploying 5G and the ways the federal government is addressing those challenges. This report examines challenges and the federal government's efforts related to 5G deployment with regard to: (1) managing spectrum; (2) closing the digital divide (i.e., addressing equity issues); and (3) addressing economic issues.

To address these objectives we reviewed relevant statutes and literature, and FCC and NTIA documentation. We also interviewed FCC and NTIA officials, as well as relevant stakeholders, including wireless carriers and industry associations. Additionally, we issued a brief questionnaire to approximately 150 GAO-identified stakeholders with knowledge of 5G networks (e.g., representatives from the federal government, academia, industry, and consumer groups) to identify challenges to deploying such networks in the U.S. These stakeholders were identified by reviewing previous GAO reports and through background research and were selected to provide a range of perspectives on 5G deployment. We reviewed and consolidated responses. We then convened a one-and-a-

half day meeting of 17 experts from academia, industry, and consumer groups to discuss the challenges identified through the questionnaire, as well as potential actions the federal government could take to address those challenges. We selected these experts with assistance from the National Academies of Sciences, Engineering, and Medicine to obtain a range of perspectives on 5G deployment.¹ We also interviewed four localities about their experiences with 5G deployment, which we selected based on, among other things, cities where wireless carriers have announced they will launch 5G services. The information we obtained from these interviews is not meant to be generalizable to other cities' experiences but is meant to provide illustrative examples of actual 5G deployment. We compared FCC efforts to address 5G deployment challenges to FCC's own strategic goals, relevant leading practices for performance management identified in our prior body of work, and the requirements of the Government Performance and Results Act (GPRA) as enhanced by the GPRA Modernization Act of 2010 (GPRAMA).² See appendix I for a detailed description of our objectives, scope, and methodology, including a list of interviewees.

We conducted this performance audit from February 2019 to June 2020 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

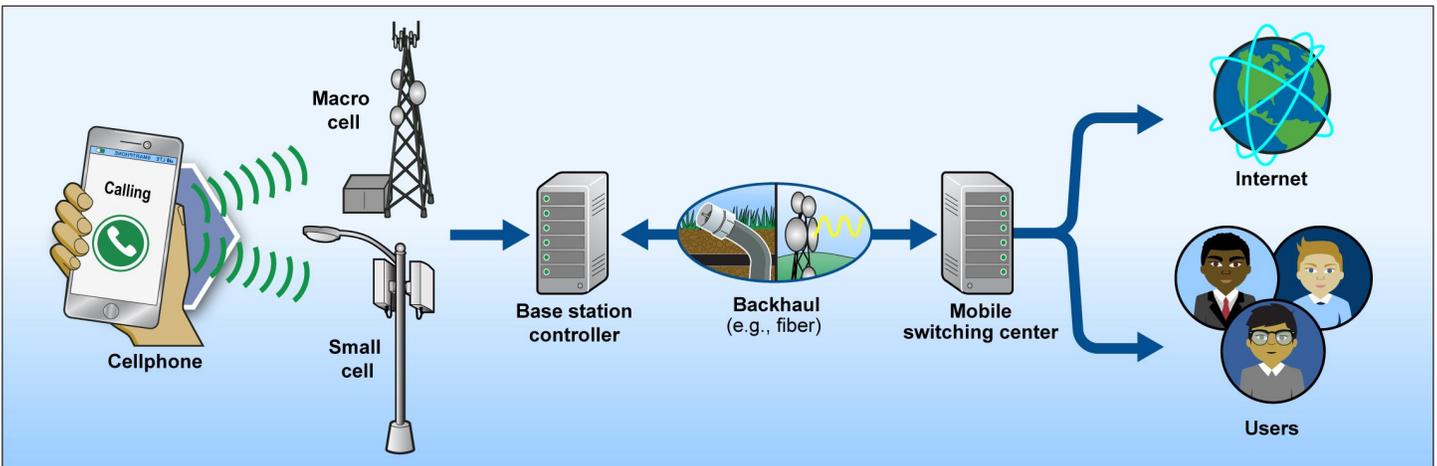
¹This meeting of experts was planned and convened with the assistance of the National Academies of Sciences, Engineering, and Medicine to better ensure that a breadth of expertise was brought to bear in its preparation, however all final decisions regarding meeting substance and expert participation are the responsibility of GAO. Any conclusions and recommendations in GAO reports are solely those of the GAO. A full list of the experts can be found in appendix I.

²Pub. L. No. 103-62, 107 Stat. 285 (1993), as enhanced by Pub. L. No. 111-352, § 3, 124 Stat. 3866, 3867 (2011) codified at 31 U.S.C. § 1115(b)(2), (6). See also, GAO, *Agencies' Strategic Plans under GPRA: Key Questions to Facilitate Congressional Review*, [GAO/GGD-10.1.16](#) (Washington, D.C.: May 1997) and GAO, *Executive Guide: Effectively Implementing the Government Performance and Results Act*, [GAO/GGD-96-118](#) (Washington, D.C.: June 1, 1996). Specifically, we compared FCC's efforts to two leading practices identified in this report: (1) involve stakeholders and (2) produce a set of performance measures at each organization level that demonstrate results, are limited to the vital few, respond to multiple priorities, and link to responsible programs. We selected these practices based on their relevance to FCC's efforts. We excluded 10 other leading practices from our review.

Background

Mobile devices, such as smartphones and tablets, use wireless networks to enable voice and data communications. These wireless networks comprise several components. For example, cell sites—a base station equipped with an antenna—receive and transmit radio signals to mobile devices. In addition to traditional “macro cells,” 5G networks also use smaller wireless infrastructure, known as “small cells,” which can be installed on existing structures, including macro towers, buildings, utility poles, or streetlights. Base station controllers manage communications between the cell site and the mobile switching center, or the “core network.” The core network then directs the communication to landline phones, other cell phones, or the internet. Finally, backhaul facilities, such as fiber optic cables or microwaves, transport the communications (See fig. 1.).

Figure 1: General Overview of Mobile Wireless Network Components



Source: GAO. | GAO-20-468

Cell sites use radio frequency spectrum to receive and transmit radio signals to and from mobile devices. Spectrum is a finite natural resource used to provide a variety of communication services to businesses and consumers, as well as federal, state, and local governments. Businesses and consumers use spectrum for a variety of wireless services including mobile voice and data, Wi-Fi- and Bluetooth-enabled devices, broadcast television, radio, and satellite services. Federal, state, and local governments’ uses of spectrum include national defense, law

enforcement communication, air traffic control, weather services, military radar, and first responder communications.

The frequency bands have different characteristics that make them more or less suitable for specific purposes. For example, different bands have different limits to the amount of information that they can carry, known as “data capacity,” and different levels of ability to effectively penetrate or bend around physical obstacles and cover distances, known as “propagation.” Regarding wireless communication:

- *Low-band* spectrum (generally defined as under 1 gigahertz (GHz)) typically has relatively low data capacity but has propagation characteristics that enable transmission over longer distances and penetration of buildings and other physical barriers better than higher bands.
- *Mid-band* spectrum (generally defined as between 1 GHz and 6 GHz) tends to provide greater data capacity than low bands and has better propagation qualities than higher bands.³
- *High-band* spectrum (generally defined as those above 24 GHz) allows for high data capacity but has relatively limited propagation, to the point that bands at higher frequencies (according to FCC, those above 95 GHz) are most prone to obstruction by natural or manmade objects, such as trees or glass.⁴

In the United States, two federal agencies are primarily responsible for managing spectrum. FCC is the federal agency responsible for allocating spectrum for consumer and commercial purposes (as well as state and local government uses), assigning spectrum licenses to those entities, and making spectrum available for use by unlicensed devices. Licensing assigns frequencies of spectrum, in a specific area, and—generally speaking, according to FCC officials—to a specific entity, such as a telecommunications company. NTIA is responsible for establishing policy on regulating federal spectrum use. NTIA assigns frequencies to government agencies, maintains federal spectrum use databases for those assignments, and oversees, in cooperation with other relevant

³The frequencies between 6 GHz and 24 GHz are referred to as “mid-high” band spectrum. According to NTIA officials, mid-high band spectrum could potentially be used for 5G purposes but most 5G efforts have focused on low-, mid-, and high-band spectrum.

⁴The frequencies above 30 GHz—commonly referred to as “millimeter wave” bands—are a subset of high-band spectrum that allow for especially high data capacity, but can more easily be obstructed by trees and other obstacles.

federal agencies, which spectrum bands reserved for federal government use might be made available for commercial use.

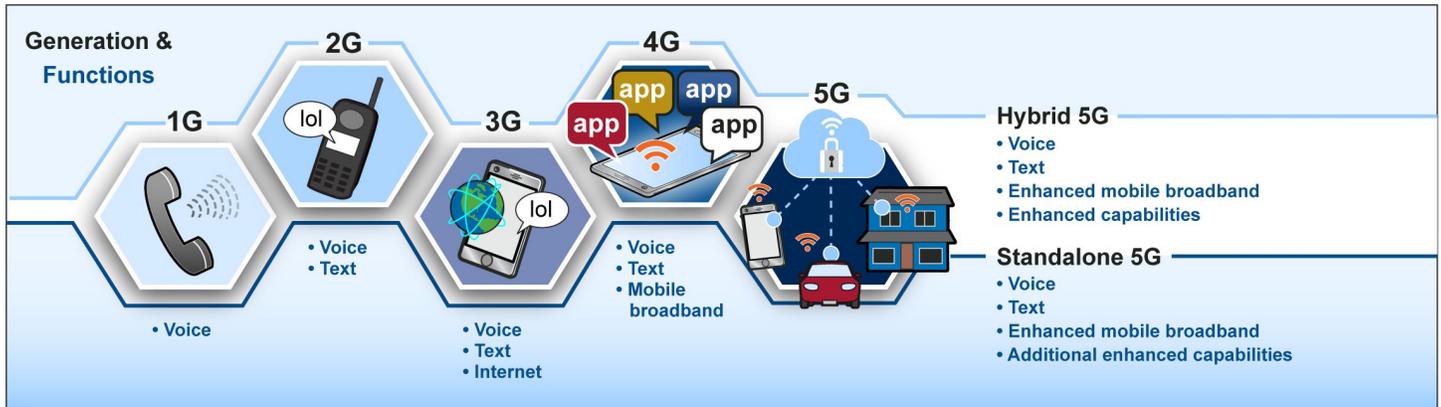
Approximately every 10 years since around the early 1980s, wireless carriers have deployed a new generation of technology, and each development has changed how people and businesses use mobile communication. These technologies can bring greater speed and capabilities to mobile networks and can provide new revenue streams for carriers and economic gains for national economies. For example, a trade organization representing carriers reported that U.S. leadership in developing and deploying 4G brought in significant economic benefits, adding billions of dollars to the U.S. economy.

The carriers we spoke with are currently developing and deploying 5G networks, which will allow for enhanced mobile broadband, offering greater speed and higher data capacity than previous generations of mobile wireless networks. Carriers in the United States are currently deploying 5G as “hybrid” 5G, which uses 5G technologies in combination with existing 4G networks to improve the networks’ speed by enhancing the technology that connects a user device to a core network.⁵ In the future, carriers that want to deploy “standalone” 5G will have to replace their existing 4G network infrastructure with new 5G equipment to enhance the core network. The new, standalone 5G networks will allow for additional enhanced capabilities, such as lower “latency,”⁶ and will be better able to support other advanced use cases (see fig. 2).

⁵Throughout this report, we use the term “4G” to refer to long-term evolution (LTE) services. LTE is an industry standard that is part of the fourth generation of wireless telecommunications technology.

⁶“Latency” refers to the amount of time it takes for data to travel from a device, such as a smartphone or computer, to a server and back again.

Figure 2: Functions of Wireless Communication Generations



Source: GAO analysis of Congressional Research Service data. | GAO-20-468

Carriers have thus far deployed limited 5G services as hybrid 5G networks in the United States, and are taking different approaches with regard to spectrum use for 5G. For example, some carriers told us that they are relying on low-band spectrum for their 5G network. Other carriers are using high-band spectrum in limited locations. In both cases, customers need to purchase new 5G-capable smartphones to use these hybrid 5G networks.

In general, telecommunications networks, including mobile networks, provide important economic and educational opportunities to communities, but different socioeconomic groups and groups in different geographic areas have historically received different levels of access to telecommunications services, leading to a disparity called the “digital divide.” A number of factors explains the digital divide. For example, as we have reported in the past, rural areas tend to have conditions—such as low population density or difficult terrain—that can increase the costs for carriers to deploy and maintain networks.⁷ Furthermore, lower-income households may have access to the necessary infrastructure for service but may not be able to afford the service.

⁷GAO, *Broadband: Additional Stakeholder Input Could Inform FCC Actions to Promote Competition*, [GAO-17-742](#) (Washington, D.C.: Sept. 19, 2017).

FCC Lacks Comprehensive Strategic Planning to Guide Spectrum Policy for 5G Deployment

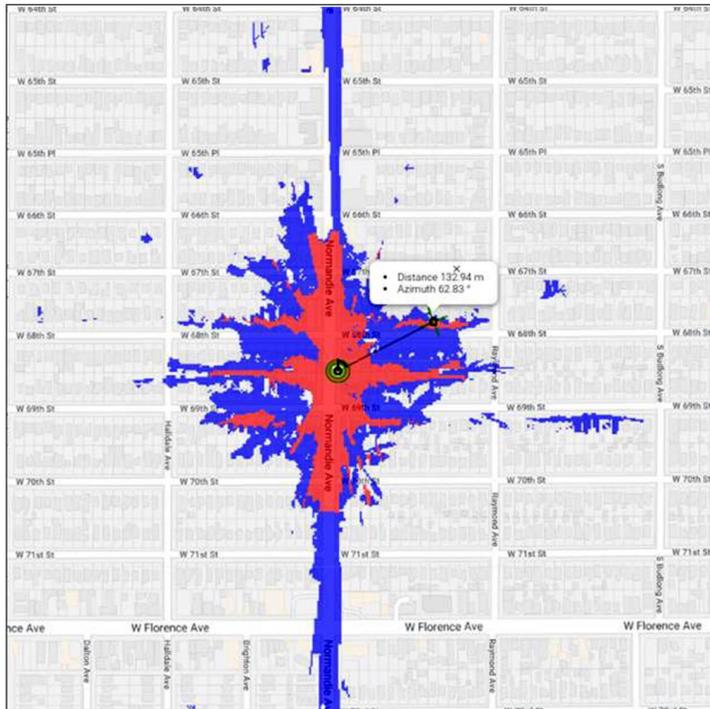
Experts Identified Availability of Mid-Band Spectrum as a Key Deployment Challenge

Experts we convened told us that the lack of sufficient access to mid-band spectrum is a key challenge to deploying 5G, noting that mid-band spectrum is particularly important for 5G deployment because of its network characteristics and potential to be interoperable with other 5G networks worldwide. Experts stated that the availability of mid-band spectrum to carriers in the United States is not yet sufficient to meet carriers' needs for 5G network deployment because of existing congestion within the band.

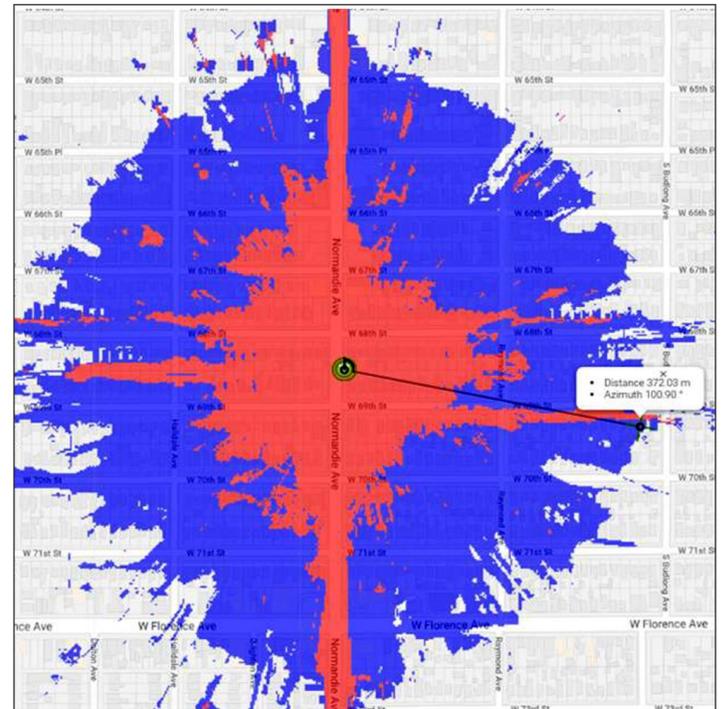
Experts stated that carriers will need a mix of low-, mid-, and high-band spectrum when deploying 5G networks because of the network characteristics unique to each spectrum band. For example, one expert noted that mid-band spectrum provides 5G network characteristics that cannot be achieved using solely low- or high-band spectrum. Signals using mid-band spectrum have better propagation (i.e., ability to effectively penetrate or bend around physical obstacles and cover distances) than signals using high-band spectrum (see fig. 3) and carry more data than low-band spectrum.

Figure 3: Comparison of Projected Distance Signals from High-Band and Mid-Band Spectrum Travel from a Single Cell Site in an Urban Environment

High-Band Propagation



Mid-Band Propagation



- 100 Megabits per second speed
- 1 Gigabit per second speed

Source: GAO analysis of Defense Innovation Board data. | GAO-20-468

Global harmonization of spectrum, or the use of the same spectrum bands among countries around the world, helps ensure that 5G devices will work across countries. Countries that harmonize spectrum for 5G may benefit by making international travel and communication more convenient. For example, consumers from countries that deploy 5G using the same spectrum bands will have the benefit of roaming across networks. Spectrum harmonization also creates economies of scale that can reduce the costs of manufacturing wireless devices and deploying network equipment. Countries, including the United States, have identified specific frequencies in mid-band spectrum that may be used for 5G.

However, experts told us that, as currently allocated, mid-band spectrum is highly congested, leading to an insufficient amount available for carriers to deploy 5G networks in the United States. According to NTIA officials,

current mid-band spectrum users—known as “incumbents”—include federal government users that have primary access rights to the spectrum and face challenges in readily transitioning to new or less favorable spectrum bands. For example, agencies’ existing technologies may be designed specifically for their existing spectrum bands. Additionally, according to FCC officials, it is becoming increasingly challenging to relocate federal users out of a spectrum band entirely and into a new band due to a variety of factors, including concerns about potential interference as well as greater spectrum use in recent years. According to experts, large consecutive portions of spectrum will be necessary for commercial users deploying 5G networks. Using smaller or non-consecutive portions of spectrum may limit the capability of the network.

FCC Has Taken Actions to Increase Spectrum Availability

According to FCC officials, FCC has taken several actions to make additional spectrum available for carriers planning to deploy 5G networks. Some examples of FCC’s actions to make low-, mid-, and high-band spectrum available for 5G deployment include:

- **Low-Band:** FCC concluded an auction in 2017 for low-band 600 megahertz (MHz) spectrum licenses, assigning 70 MHz for licensed wireless operations. Such spectrum auctions allow FCC to use competitive bidding to choose from among two or more applications for a spectrum license.
- **Mid-Band:** FCC issued a Report and Order in July 2019 that made spectrum licenses within the 2.5 GHz band accessible to nonfederal users.⁸
- **High-Band:** FCC held its first auctions for high-band 5G spectrum in the 24 GHz and 28 GHz bands in 2018 and 2019. FCC also began an auction of 3,400 MHz of spectrum in the upper 37, 39 and 47 GHz bands in December 2019; bidding in this auction concluded on March 5, 2020.

FCC officials told us that they are aware that mid-band spectrum will be particularly important for 5G deployment despite congestion amongst federal users in this spectrum range. FCC is taking steps to make some additional mid-band spectrum available. For example, in February 2020, FCC announced that it had adopted new rules to auction 280 MHz of mid-

⁸In the *Matter of Transforming the 2.5 GHz Band*, Report and Order, 34 FCC Rcd 5446 (2019).

band spectrum, which can be used for 5G purposes. This spectrum, (3.7 to 3.98 GHz) is currently being used primarily by satellite operators. In March 2020, FCC released a public notice seeking comment on procedures to be used for the auction of this spectrum, which is currently scheduled to begin on December 8, 2020. As another example, according to FCC, in April 2020 FCC provided for expanded Wi-Fi use in 1,200 MHz of spectrum in the 6 GHz band. Such advanced Wi-Fi networks, FCC told us, will be capable of working hand-in-hand with commercial networks to enable robust 5G device broadband connectivity and may be able to help alleviate commercial wireless network congestion. Other activities, according to FCC, include: (1) opening a proceeding in the 3.1 to 3.55 GHz band to consider potential shared use between federal operations and flexible use commercial services; and (2) authorizing a private entity to deploy a low-power terrestrial nationwide network in certain frequencies that will make available additional spectrum for advanced wireless services, including 5G.

FCC and NTIA also developed a spectrum-sharing framework in the 3.5 GHz band that will increase the availability of this mid-band spectrum targeted globally for 5G. This framework separates users into three hierarchical “tiers,” giving differing priority access to the spectrum (3.55 GHz to 3.7 GHz, also known as the “Citizens Broadband Radio Service”) depending on the user’s tier. The first tier includes incumbents, such as federal users (e.g., U.S. Navy radar systems) and a number of commercial users. These users receive first priority and protection from all other users. Tier two users—referred to as “Priority Access Licensees”—are, according to FCC, wireless users that obtain licenses at auction or, following the auction, via secondary markets. These users, which can include wireless carriers, have access to the same mid-band spectrum when a tier one user is not using the spectrum, but FCC officials said these users will need to move to another frequency when a nearby tier one user accesses the same frequency. Third tier users access the band as available.

FCC officials stated that this spectrum-sharing framework will allow for increased spectral utilization of mid-band spectrum in a band like 3.5 GHz and that individual users (e.g., the public using mobile devices) will not notice any difference in their network connection. According to FCC officials, the technology supporting this spectrum-sharing framework is now authorized for full commercial deployment. They also said that FCC certified administrators in January 2020 to coordinate this framework, which will allow for full commercial operation, and that FCC has scheduled to begin auctioning licenses for tier two users on July 23, 2020.

Other federal agencies are also involved with managing spectrum in the United States. For example, NTIA, which manages federal spectrum use, is working with FCC on the technical design and implementation of the spectrum-sharing framework discussed above. NTIA is also seeking to identify additional spectrum for 5G, in conjunction with FCC. According to FCC, some of the most useful portions of mid-band spectrum are already occupied by a federal incumbent and FCC is limited in its ability to make this spectrum available for commercial use. According to NTIA officials, the agency is focused on meeting the spectrum requirements set forth in the Making Opportunities for Broadband Investment and Limiting Excessive and Needless Obstacles to Wireless Act (MOBILE NOW Act) of 2018,⁹ which requires NTIA and FCC to prepare a report by 2022 identifying potential spectrum for future use. For example, NTIA is currently studying the feasibility of spectrum sharing in the 3.45 to 3.55 GHz band.

Overall, FCC's efforts, in conjunction with NTIA, to date have primarily made more high-band spectrum available for 5G purposes. According to the Department of Commerce's 2019 *Annual Report on the Status of Spectrum Repurposing*, 84 percent (4,950 MHz out of 5,863 MHz) of the spectrum made available by FCC and NTIA has been within high-band.¹⁰ According to the report, 12 percent (709 MHz of 5,863 MHz) of the spectrum FCC and NTIA have made available has been within mid-band. NTIA officials said there has been more of a focus on repurposing high-band spectrum because there is a far greater amount of this spectrum available for use and fewer incumbent users within this spectrum. Further, NTIA officials stated that these amounts are a snapshot as of the time the 2019 report was issued and the ratios will change, as additional spectrum is made available. Other recent FCC actions, including those described above, may make more mid-band spectrum available in the future. For example, FCC told us that it has a number of active proceedings that could make additional mid-band spectrum available to commercial users.

⁹Pub. L. No. 115-141 div. P, tit VI, §§ 601-623, 132 Stat. 348, 1097 (2018).

¹⁰U.S. Department of Commerce, *Annual Report on the Status of Spectrum Repurposing*, (Washington, D.C.: August 2019).

FCC's Plan to Guide 5G-Related Efforts Is Missing Key Elements of Strategic Planning

To guide its 5G-related efforts, including spectrum management, FCC has developed its *Facilitate America's Superiority in 5G Technology Plan (5G FAST Plan)*. This Plan includes three "key components: (1) pushing more spectrum into the marketplace; (2) updating infrastructure policy; and (3) modernizing outdated regulations."¹¹ According to FCC officials, the *5G FAST Plan* represents FCC's strategy for supporting 5G, and these key components are FCC's broad strategic goals for 5G.

However, FCC has not laid out in the *5G FAST Plan* how it will implement and assess progress toward the three key components. Our past work on strategic planning has identified related leading practices.¹² These include identifying: (1) specific and measurable performance goals to show progress toward broad strategic goals; (2) the activities (also known as strategies) the agency will take to make progress toward its goals; and (3) related performance measures to assess actual progress made toward the performance goals.

Although FCC's *5G FAST Plan* notes actions or strategies FCC has taken regarding managing spectrum for 5G, it does not clearly identify specific and measurable performance goals and related measures for spectrum management related to 5G deployment. For example, the plan notes that FCC's actions on the 2.5 GHz, 3.5 GHz, and 3.7 - 4.2 GHz bands could make up to 844 MHz available for 5G, but these strategies are not related to any identified performance goals or measures. Without such strategic planning efforts, it is unclear if these actions will be sufficient to address the challenges experts raised about the lack of mid-band spectrum for 5G. Additionally, establishing performance goals and measures would

¹¹FCC, *The FCC's 5G FAST Plan*, (Washington, D.C.: Sept. 28, 2018), accessed December 19, 2019, <https://docs.fcc.gov/public/attachments/DOC-354326A1.pdf>.

¹²Although GPRAMA's requirements apply at the departmental level (e.g., FCC), we have previously stated that they can serve as leading practices at other organizational levels, such as component agencies, offices, programs, and projects. See, for example, GAO, *Environmental Justice: EPA Needs to Take Additional Actions to Help Ensure Effective Implementation*, [GAO-12-77](#) (Washington, D.C.: Oct. 6, 2011). See also, [GAO/GGD-10.1.16](#) and [GAO/GGD-96-118](#). See also Pub. L. No. 103-62, 107 Stat. 285, as enhanced by Pub. L. No. 111-352, § 3, 124 Stat. 3866, 3867, codified at 31 U.S.C. § 1115(b)(2), (6).

allow FCC to assess its spectrum management strategies and track the progress it is making toward its goals.

Further, according to FCC officials, the priorities noted in the *5G FAST Plan* were not developed with outside entities, such as NTIA or other relevant stakeholders, including carriers.¹³ Leading practices, as identified in our previous work, show that successful organizations base their strategic planning, to a large extent, on the interests and expectations of their stakeholders, which could include other federal agencies, Congress, and others.¹⁴ Thus, involving stakeholders in the strategic planning process helps ensure that the agency's efforts are targeted at the highest priorities.

According to FCC officials, it can be difficult to set goals for specific amounts of spectrum to be made available because of, in part, the fast-changing nature of the telecommunications industry. While we recognize that setting such goals, measures, or strategies may be difficult, our past work on strategic planning has found that there is no more important element in results-oriented management than an agency's strategic planning effort.¹⁵ This effort is the starting point and foundation for defining what the agency seeks to accomplish, identifying the strategies it will use to achieve desired results and then determining how well it succeeds in reaching results-oriented goals and achieving objectives. Proactively developing performance goals, strategies and measures—with the involvement of relevant stakeholders—to manage spectrum demands associated with 5G deployment would help ensure that sufficient amounts of spectrum in consecutive portions are made available to avoid delaying the deployment and limiting the capabilities of 5G networks. Additionally, by incorporating these key elements into its strategic planning for 5G, FCC would be able to assess its progress in

¹³NTIA—in collaboration with FCC and other agencies—is drafting a National Spectrum Strategy in response to a Presidential Memorandum. According to the memorandum, the National Spectrum Strategy is to include legislative, regulatory, or other policy recommendations to, among other things, increase spectrum access for all users and create flexible models for spectrum management. *Presidential Memorandum on Developing a Sustainable Spectrum Strategy for America's Future*, (Washington, D.C.: Oct. 25, 2018).

¹⁴[GAO/GGD-96-118](#).

¹⁵[GAO/GGD-10.1.16](#).

managing spectrum, particularly the congested mid-band spectrum that is important to 5G deployment.

FCC Lacks Comprehensive Strategic Planning to Mitigate the Likelihood of 5G to Widen the Digital Divide

Experts Warned That 5G Deployment Would Likely Widen the Digital Divide

Experts we convened told us that 5G deployment, especially high-band 5G networks, will likely widen the existing digital divide, particularly between urban and rural areas, as well as within urban areas. Experts and stakeholders told us that 5G using high-band spectrum is likely to be first deployed in areas already equipped with much of the necessary infrastructure (i.e., fiber and power). Experts said these areas are generally more urban, densely populated, high-income areas as opposed to rural or low-income areas. Stakeholders told us that rural areas will see 5G deployed mostly on lower frequencies, on which signals can propagate further but which cannot carry the same bandwidth (i.e., data throughput) as higher frequencies can. Within urban settings, experts said that high-band 5G networks are more likely to be deployed in commercially viable areas, including those parts of a city that already are equipped with fiber and power and, presumably, already benefit from the most advanced mobile broadband services available. For example, an expert representing the wireless industry stated that only about 10 percent of the District of Columbia would receive 5G services using high-band spectrum, as it would be cost-prohibitive for the carriers to install 5G using this spectrum beyond that 10 percent of the city.

Experts told us that individuals without access to 5G networks will not be able to take advantage of the use cases that 5G promises, including the high-speed connections offered by enhanced mobile broadband. Experts stated that this situation will greatly affect, among other things, the economic and educational opportunities that 5G promises to make possible. We have previously reported on the digital divide, or the varying levels of access to technologies such as internet and wireless services among different socioeconomic groups, as well as groups in different

geographic areas.¹⁶ For example, as we have reported in the past, rural areas tend to have conditions—such as low population density or difficult terrain—that can increase the costs for carriers to deploy and maintain networks in those areas.¹⁷ Furthermore, lower-income households may be located in areas with access to the necessary infrastructure for certain services but may not be able to afford them. The challenge for some households to afford the most advanced mobile communications services would become worse if carriers charge more for 5G services.

An Expert’s Perspective on the Digital Divide

“Employers who want to ensure that their workforce has access to 5G, or their factory floor has access to 5G, won’t locate in communities that don’t have those services, thereby exacerbating the existing digital divide.”

Source: GAO meeting of experts. | GAO-20-468

FCC Has Efforts to Close the Digital Divide but Has Not Developed Specific and Measurable Performance Goals and Related Strategies and Measures

FCC has taken steps to address digital divide issues, with some of these efforts potentially affecting the digital divide as it relates to 5G deployment. For example, according to FCC officials, FCC issued a recent order approving a merger between two mobile carriers that included certain service requirements to increase 5G access nationwide. FCC told us that the merged company will face significant financial penalties if it fails to meet these requirements.

Additionally, FCC has established financial support that may be used for 5G-related efforts. The Universal Service Fund provides financial support to carriers through different programs, each targeting a particular group of telecommunications carriers or consumers. For example, one of these programs, the High Cost Program, provides support in rural or remote areas where the customer base is relatively small and the cost of

¹⁶GAO, *Broadband Internet: FCC’s Data Overstate Access on Tribal Lands*, [GAO-18-630](#) (Washington, D.C.: Sept. 7, 2018).

¹⁷GAO, *Broadband: Additional Stakeholder Input Could Inform FCC Actions to Promote Competition*, [GAO-17-742](#) (Washington, D.C.: Sept. 19, 2017).

installing infrastructure is high.¹⁸ According to FCC officials, the support provided by the Universal Service Fund can evolve over time to address emerging technologies, including 5G. For example, the officials stated that in response to recent hurricanes in the Caribbean, the Universal Service Fund is currently being used to support deployment of fiber and power in parts of Puerto Rico and the U.S. Virgin Islands, which will help support future deployment of 5G in those areas.

Further, in December 2019, the FCC Chairman announced his intention to establish the “5G Fund,” which would make up to \$9 billion in Universal Service Fund support available to carriers to deploy 5G services in rural areas of the United States. In April 2020, FCC issued a Notice of Proposed Rulemaking and Order seeking comments on the framework for the 5G Fund and on approaches to identifying eligible areas for support.¹⁹

Although FCC’s actions could help address the digital divide, its existing planning documents for 5G do not include key elements that would allow FCC to understand the effects of these efforts as they relate to 5G deployment. Neither FCC’s strategic plan for 2018 through 2022 nor its *5G FAST Plan* include specific performance goals—or related strategies and measures—that would allow FCC to assess the effectiveness of its efforts to close the digital divide associated with 5G deployment. For example, FCC’s strategic plan for 2018 through 2022 includes a strategic goal and performance goals to close the digital divide, but the performance goals are not specific or measurable. Further, neither the strategic plan nor the *5G FAST Plan* include specific performance measures regarding the effects of 5G on the digital divide. Moreover, while FCC’s strategic plan states that a strategy to help close the digital divide is that it will set rules to encourage and facilitate the development of 5G networks, the strategy is not associated with specific performance goals or measures regarding the effects of 5G on the digital divide. Additionally, the *5G FAST Plan* identifies a number of current and future strategies for FCC but does not include specific performance goals or measures that would allow it to understand what those strategies are

¹⁸The High Cost Program provides support to networks capable of providing voice and broadband service, both fixed and mobile, to rural, insular and high cost areas that carriers would otherwise not serve and where there is no competition from other carriers at rates comparable to urban areas.

¹⁹*In the Matter of Establishing a 5G Fund for Rural America Universal Service Reform – Mobility Fund*, FCC 20-52 (April 23, 2020).

intended to achieve and the effects those strategies are having on the digital divide as 5G networks are deployed.

These omissions are contrary to leading practices of results-oriented organizations identified in previous GAO work. These leading practices call for performance goals and related strategies and measures, as we previously described.²⁰ Such leading practices, as previously noted, include identifying: (1) specific and measurable performance goals to show progress toward broad strategic goals; (2) the activities (also known as strategies) the agency will take to make progress toward its goals; and (3) related performance measures to assess the results of the strategies and actual progress made toward the performance goals.²¹

FCC officials said that they are focusing on reducing the digital divide and have set high-level goals, but have not established goals specific to 5G. However, by establishing specific and measurable performance goals for 5G with related strategies and measures, FCC will have greater assurance that it has properly planned actions to effectively address the likely adverse effects on the digital divide as 5G networks are deployed. For example, specific goals for 5G will help FCC assess the effectiveness of its recent decision to make \$9 billion in Universal Service Fund support available to carriers to deploy 5G services.

The High Cost of 5G Infrastructure May Affect 5G Deployment

Experts Identified Economic Issues as a Key Challenge

Experts told us that deploying 5G infrastructure will be very costly for carriers. According to international standards established for 5G networks, to support all the new capabilities of 5G, carriers will need to replace their 4G core networks with new 5G equipment.²² These standalone 5G networks will provide new capabilities such as ultra-reliable low latency communications that could enable the development of

²⁰GAO/GGD-10.1.16 and GAO/GGD-96-118.

²¹Pub. L. No. 103-62, 107 Stat. 285, as enhanced by Pub. L. No. 111-352, § 3, codified at 31 U.S.C. § 1115(b)(2), (6). See also, [GAO/GGD-10.1.16](#), [GAO-12-77](#), and [GAO/GGD-96-118](#).

²²3rd Generation Partnership Project, Technical Report 21.915 V15.0.0 (September 2019).

new, more advanced use cases. In the meantime, carriers are currently deploying hybrid 5G, which uses existing 4G network infrastructure, but they still must make some upgrades to their 4G equipment and in some instances, deploy additional cell sites, such as small cells, to provide hybrid 5G service. These small cells can be installed on existing structures, such as buildings or streetlights. See figure 4 for examples of small cells.

Figure 4: Examples of Small Cells



Source: CTIA. | GAO-20-468

Some carriers are deploying 5G using low-band spectrum, which is much less costly to deploy because carriers can use their existing 4G cell towers. However, low-band spectrum does not enable the same data speeds as other types of 5G. As discussed previously, the United States has made a large amount of high-band spectrum available for 5G. The use of such spectrum increases the cost of 5G infrastructure deployment because it requires more small cell installations. Experts suggested that, because of the increased costs, carriers may limit deployment of high-band 5G network equipment to high-density areas such as sections of cities or stadiums. Moreover, a recent Defense Innovation Board report referenced a preliminary study that indicated that carriers would have to install approximately 13 million base stations, at a cost of approximately

\$400 billion, to deliver 5G service using this high-band spectrum to 72 percent of the population.²³

In addition to installing the actual cell site equipment, each small cell site has costs associated with it:

- **Fiber:** Experts told us that fiber deployment is critical to the success of 5G. They noted that getting enough fiber in place to support the large increase in small cells will require a massive infrastructure deployment. For example, experts stated that currently there is not enough fiber in the ground in most places to support 5G. The fiber network must also have the capacity to handle the increased traffic from 5G. Experts told us that the new fiber needed for 5G will be costly to install, both in urban and rural areas. For example, installing fiber in urban areas can be costly due to local rules and difficulty accessing the right-of-way. In rural areas, fiber deployment costs are high because carriers must install fiber over longer distances to reach customers.
- **Power:** In addition to fiber, new cell sites also require a power source. While some small cells are being installed on light poles that have an existing power source, an expert noted that sometimes these are only powered on at night. Another expert noted that carriers may need to install back-up power sources, in case of a power outage.
- **Permitting:** When installing a new cell site, carriers generally must seek approval from the federal, state, or local government that controls the right-of-way or property where the cell site is to be located. This may require carriers to pay permitting fees or meet certain aesthetic requirements. Experts told us that the fact that different cities have different permitting regimes drives up the cost to build infrastructure. For example, experts told us that making sure small cells meet different localities' requirements for design, dimension, and other aesthetic requirements is difficult for carriers and could slow deployment. However, other experts noted that these local permitting processes enable local governments to ensure 5G is being deployed in such a way that would benefit their citizens. For example, according to a report by the National League of Cities, San Jose, California created a tiered pricing structure to encourage

²³Defense Innovation Board, *The 5G Ecosystem: Risks and Opportunities for DoD*, (Washington, D.C.: April 2019).

carriers to cover more of the city.²⁴ The city plans to use some of the revenues from this permitting process to help close the digital divide in the city, for example by allowing people to check out devices at libraries.

Experts' Perspectives on Permitting Costs

“There are several thousand municipalities in the United States, each of which has different paperwork, processes, and payment mechanisms for siting small cells, which increases 5G deployment cost and time and inhibits the rollout of the networks.”

“5G deployment requires many more small cells than 4G required macro cells, thereby increasing the reliance on public right-of-ways. As a result, we have seen cities restricted from charging market rates for permitting. However, cities play a really crucial role in ensuring that the deployment of these technologies and the use of public right-of-ways is coupled with public interest obligations.”

Source: GAO meeting of experts. | GAO-20-468

Carriers' current financial condition will also affect how they deploy 5G, including where and what type of networks they deploy. Experts noted that carriers in the United States may not currently have the capital required to fund large-scale deployments of 5G due, in part, to the costs of recent business decisions. Additionally, an expert mentioned that carriers would likely only be able to afford to deploy high-band spectrum in small sections of cities. Another expert predicted that carriers may not replace existing 4G equipment until it becomes less reliable over time, leading to a more comprehensive roll-out of 5G in 6 to 8 years. A representative from a carrier said that while it did not anticipate any additional revenue from 5G deployment, carriers still must deploy 5G because to not do so would place their companies at extreme risk of losing large numbers of customers, potentially eroding their revenue base.

²⁴National League of Cities, *Municipal Action Guide: Small Cell Wireless Technology in Cities*, (Washington, D.C.: August 2018).

Experts' Perspectives on Economic Challenges to 5G Deployment

“Most of the major carriers in the United States aren't in great financial shape. They've leveraged up and have made acquisitions into new spaces. ...The challenge for these carriers is do they have the billions of dollars required for another large-scale capital program, or do they just sort of put it out there because it's good PR.”

“Right now, from an economic standpoint, there isn't a strong case for making this enormous investment in 5G and it feels like it's more of a defensive play by carriers.”

Source: GAO meeting of experts. | GAO-20-468

Experts also noted that consumers are not always willing to pay more for 5G service, which reduces carriers' ability to recoup their deployment investments. For example, one expert questioned whether consumers in the United States were willing to pay anything more for 5G, and another noted that carriers are currently charging the same price for 5G and 4G service. Additionally, experts told us that there is no clear use case currently developed for 5G in the United States, besides enhanced mobile broadband. The 5G use cases often cited, such as remote surgery or autonomous vehicles, are unlikely to be developed in the near future. Without such use cases, they said, carriers lack a strong business case for deploying 5G. Other experts noted, however, that 4G use cases—such as social media or ride sharing apps—did not exist when carriers started to deploy 4G, but were developed after 4G was in place. Similarly, experts predicted that 5G use cases would be developed after 5G networks were available in the United States.

FCC and Others Have Taken Some Steps to Reduce Deployment Costs

To help reduce the cost of deploying 5G infrastructure, FCC has taken steps to expedite the permitting and review of small cells. For example, FCC issued a Programmatic Agreement for the Collocation of Wireless Antennas, which reduces the regulatory approval process for collocating small cells that are on existing infrastructure, such as utility poles.²⁵ In

²⁵Collocation Nationwide Programmatic Agreement, as amended, 47 C.F.R. Part 1, Appendix B.

addition, FCC adopted an order and declaratory ruling regarding state and local government reviews of small cell applications, which set parameters for fees and time frames for these reviews.²⁶ This Order went into effect in January of 2019; however, it is currently being challenged in federal court.²⁷

FCC also adopted an order that, among other things, exempted the construction of small cells from compliance with federal historic preservation and environmental review that were applied to large macro towers.²⁸ A recent federal court decision, overturned the exemption and the FCC repealed the section of the order.²⁹

In addition to the steps FCC has taken to limit regulatory and permitting costs, experts suggested that carriers could consider sharing their network infrastructure to reduce their capital expenditure for deploying 5G. Through infrastructure sharing agreements, two or more carriers share infrastructure such as radio antennas or fiber to deliver service to users. This sharing reduces deployment costs for carriers and allows them to deploy in areas where the costs would normally be prohibitive, such as rural areas. Such sharing agreements can increase choices for consumers, as more carriers can afford to operate in areas they would not normally be able to. FCC officials said that industry is already moving toward greater shared infrastructure and FCC's efforts are designed to promote it. However, such sharing agreements may have the potential to decrease competition, if not well monitored. In addition, a carrier may not be willing to share infrastructure with other carriers for fear of losing its competitive advantage. For example, according to a report by the Body of

²⁶*Accelerating Wireless Broadband Deployment by Removing Barriers to Infrastructure Investment*, Second Report and Order, 33 FCC Rcd 3102 (2018) (*Second Report and Order*).

²⁷City of San Jose, v. FCC, No. 19-70144 (9th Cir.).

²⁸*Accelerating Wireless Broadband Deployment by Removing Barriers to Infrastructure Investment, Declaratory Ruling and Third Report and Order*, 33 FCC Rcd 9088 (2018). The reviews are mandated under the National Historic Preservation Act (NHPA), Pub. L. No. 89-665, codified at 54 U.S.C. §§ 300101-307108, and the National Environmental Policy Act of 1969 (NEPA), Pub. L. No. 91-190, codified at 42 U.S.C. §§ 4321-4370m.

²⁹*United Keetoowah Band of Cherokee Indians v. FCC*, 933 F.3d 728 (D.C. Cir. 2019). However, the court did uphold FCC's limitations on upfront fees. *In the Matter of Accelerating Wireless Broadband Deployment by Removing Barriers to Infrastructure Investment*, 2019 WL 5088796, WT Dkt No. 17-79 (F.C.C. Oct. 8, 2019) (stating that "deployments of small wireless facilities are subject to review to the same extent as larger wireless facilities pursuant to the NHPA and the NEPA.").

European Regulators,³⁰ a carrier that is the only one offering service in a certain area could lose competitive advantage and not be rewarded for its investments in the area under a sharing agreement.

Infrastructure sharing is common in other countries; the same report by the Body of European Regulators found that carriers in 14 European countries had active sharing agreements with joint deployment in place. For example, in Spain, some carriers share their mobile networks in areas with fewer than 175,000 inhabitants. According to the report, 5G will further incentivize network sharing, as carriers need to deploy more small cells and fiber. Experts told us, however, that such sharing agreements were uncommon in the United States. Instead, carriers typically install their own network infrastructure, leading to overlapping networks and higher overall deployment costs. FCC officials said they recognize the benefits of infrastructure sharing, especially for 5G, but said that the decision about whether to share infrastructure is ultimately up to each carrier. Officials noted that carriers will use their own economic and engineering analysis in determining how to deploy 5G.

Conclusions

5G networks could create significant economic benefits for the United States, as companies develop products and technologies to access 5G's new capabilities. Carriers currently face challenges to deploying 5G, however, which could delay or even limit the United States' opportunity to realize those benefits. FCC has taken a number of actions regarding 5G deployment, but it has not clearly developed specific and measurable performance goals and related measures—with the involvement of relevant stakeholders, including NTIA—to manage the spectrum demands associated with 5G deployment. This makes FCC unable to demonstrate whether the progress being made in freeing up spectrum is achieving any specific goals, particularly as it relates to congested mid-band spectrum. Additionally, without having established specific and measurable performance goals with related strategies and measures for mitigating 5G's potential effects on the digital divide, FCC will not be able to assess the extent to which its actions are addressing the digital divide or what actions would best help all Americans obtain access to wireless networks.

³⁰Body of European Regulators for Electronic Communications, *BoR (18) 116 BEREC Report on Infrastructure Sharing*, (June 14, 2018).

Recommendations for Executive Action

We are making the following two recommendations to FCC:

The Chairman of FCC should develop, in coordination with NTIA and other relevant stakeholders, specific and measurable performance goals—with related strategies and measures—to manage spectrum demands associated with 5G deployment. (Recommendation 1)

The Chairman of FCC should develop specific and measurable performance goals—with related strategies and measures—to determine the effects 5G deployment and any mitigating actions may have on the digital divide. (Recommendation 2)

Agency Comments and Our Evaluation

We provided a draft of this report to FCC and NTIA for review and comment. FCC provided written comments, which we have reprinted in appendix II. FCC and NTIA also provided technical comments, which we incorporated as appropriate throughout our report.

In its written comments, FCC neither agreed nor disagreed with our recommendations. FCC described the challenges associated with developing performance goals for managing the spectrum demands associated with 5G deployment. Specifically, FCC stated that such goals could limit the options available to manage spectrum demands. Instead, FCC stated that it adopts specific and measurable performance goals—with related strategies and measures—during ongoing rulemakings, which allow FCC to establish engineering, economic, or other technical outcomes.

We acknowledge in our report that setting specific and measurable performance goals, strategies, and measures can be challenging, but continue to believe such strategic planning would benefit FCC's spectrum management efforts. We did not identify what specific and measurable performance goals, strategies, and measures FCC should develop because FCC is in the best position to make such determinations. However, as we describe in our report, FCC still has not engaged in this strategic planning effort. Our past work has found that there is no more important element in results-oriented management than an agency's strategic planning effort. That effort should be the starting point and

foundation for FCC to define what it seeks to accomplish, identify the strategies it will use to achieve desired results, and then determine how well it succeeds in reaching results-oriented goals and achieving objectives.

Related to our recommendation for FCC to develop specific and measurable performance goals to determine the effects 5G deployment and any mitigating actions may have on the digital divide, FCC noted that it is taking regulatory actions and providing funds designed to reduce the digital divide. FCC further said that it remains committed to promoting robust 5G deployment nationwide and, consistent with our recommendation, will continue to explore new ways to evaluate how it may impact efforts to close the digital divide.

As agreed with your offices, unless you publicly announce the contents of this report earlier, we plan no further distribution until 15 days from the report date. At that time, we will send copies to the appropriate congressional committees, the Chairman of the FCC, the Secretary of the Department of Commerce, and other interested parties. In addition, the report will be available at no charge on the GAO website at <https://www.gao.gov>.

If you or your staff have any questions about this report, please contact me at (202) 512-2834 or Vonaha@gao.gov. Contact points for our Offices of Congressional Relations and Public Affairs may be found on the last page of this report. GAO staff who made key contributions to this report are listed in appendix III.



Andrew Von Ah
Director, Physical Infrastructure

List of Requesters

The Honorable James M. Inhofe
Chairman
The Honorable Jack Reed
Ranking Member
Committee on Armed Services
United States Senate

The Honorable Marco Rubio
Acting Chairman
The Honorable Mark R. Warner
Vice Chairman
Select Committee on Intelligence
United States Senate

The Honorable Adam Smith
Chairman
The Honorable Mac Thornberry
Ranking Member
Committee on Armed Services
House of Representatives

The Honorable Eddie Bernice Johnson
Chairwoman
Committee on Science, Space, and Technology
House of Representatives

The Honorable Adam B. Schiff
Chairman
The Honorable Devin Nunes
Ranking Member
Permanent Select Committee on Intelligence
House of Representatives

The Honorable Bill Foster
Chairman
Subcommittee on Investigations and Oversight
Committee on Science, Space, and Technology
House of Representatives

List of Requesters Continued

Letter

The Honorable Richard Burr
United States Senate

The Honorable Mikie Sherrill
House of Representatives

Appendix I: Objectives, Scope, and Methodology

This report examines the challenges, and the federal government's efforts, related to 5G deployment with regard to: (1) managing spectrum; (2) closing the digital divide; and (3) addressing economic issues. These were the top three challenges to 5G deployment identified by the 17 experts we convened.

To identify challenges to 5G deployment, we issued a brief questionnaire to 146 GAO-identified stakeholders with knowledge of 5G networks. These stakeholders included officials from the federal government, as well as representatives from academia, industry, and consumer groups. Stakeholders were identified by reviewing previous GAO reports and through background research and were selected to provide a range of perspectives on 5G deployment. We asked these stakeholders to identify challenges to deploying 5G networks in the U.S. and received 23 responses. We conducted a content analysis to categorize the responses into a final set of 13 challenges. See table 1 for a list of the challenges. Because content analysis relies on the judgment of coders to determine whether qualitative data reflects particular categories, we took several steps to ensure that this judgment remained objective, accurate, and consistent. These steps included using independent coders from two different mission teams within GAO to ensure consistent judgment of categories. The independent coders were in general agreement on the challenges categories. On the basis of this high level of agreement between coders, as well as a review by a third independent analyst, we are confident that our content analysis represents an objective, accurate, and consistent assignment of these coding categories.

Table 1: List of Challenges to 5G Deployment Identified through GAO’s Questionnaire

Challenge	Description
Capability Development	Mobile wireless technologies’ ability to support 5G capabilities
Standardization	Standardization for interoperability of devices and networks
Testing	The status of testing of 5G technologies
Economics	Competition, cost of deployment, consumer demand, and use case maturity
Infrastructure	The installation of 5G network equipment
Laws and Regulations	Laws and/or regulations related to 5G networks
Policy	Policy frameworks regarding deployment of 5G networks
Access	Equitable access and affordability of 5G networks
Education	Customer education and marketing of 5G capabilities
Biological Effects	Perceived health effects of 5G networks
Cybersecurity/Privacy	Cybersecurity and privacy of 5G networks
Licensing	The allocation, management, and availability of spectrum
Techniques and Technologies	Managing shared and unlicensed spectrum

Source: GAO. | GAO-20-468

We then convened a meeting of 17 experts to discuss the above challenges to 5G deployment. Our meeting of experts was held at the National Academies of Sciences, Engineering, and Medicine (NASEM) in October 2019 over one-and-a-half days.¹ Staff from NASEM assisted us in identifying experts for the meeting. To identify the experts appropriate for this meeting, NASEM relied on staff experience and professional judgment drawn from its Computer Science and Telecommunications Board. We selected the final panel of experts in consultation with NASEM staff with the goal of ensuring that a broad range of views was represented from multiple 5G-related areas, such as those of wireless carriers, academia, and consumer and industry groups. See table 2 for a list of the experts that participated in the meeting.

¹Although we discussed cybersecurity and privacy issues during the course of this meeting, these topics were not included in the scope of this report, as there is other ongoing GAO work reviewing related issues. This work is scheduled to be released later in 2020.

Table 2: Participants for GAO’s Meeting of Experts

Phillip Berenbroick, Public Knowledge
Cat Blake, Next Century Cities
Kausik Ray Chaudhuri, Qualcomm
Mark Cooper, Consumer Federation of America
Nicole DuPuis, Gartner (Day one only)
Nada Golmie, National Institute of Standards and Technology
Keith Gremban, University of Colorado Boulder
Dan Hays, PwC
Thomas Hazlett, Clemson University
Milo Medin, Google
Michael Murphy, Nokia – North and South America
Thomas C. Power, CTIA
Dennis Roberson, Illinois Institute of Technology
Douglas Sicker, Carnegie Mellon University
Grant Spellmeyer, U.S. Cellular
Stéphane Téral, IHS Markit Technology
Olivia B. Wein, National Consumer Law Center

Source: GAO. | GAO-20-468

The meeting was moderated by GAO staff who guided the experts through questions about each challenge to 5G deployment. The experts also discussed potential actions the federal government could take to address those challenges and were asked to identify the most significant challenges to 5G deployment. This meeting of experts was planned and convened with the assistance of NASEM to better ensure that a breadth of expertise was brought to bear in its preparation; however, all final decisions regarding meeting substance and expert participation are the responsibility of GAO. Any conclusions and recommendations in GAO reports are solely those of the GAO. The meeting was recorded and transcribed to ensure that we accurately captured the experts’ statements, and we reviewed and analyzed the transcripts as a source of evidence. We edited experts’ quotations from the transcripts for clarity and conciseness to include in this report.

In addition to the experts we spoke to on the panel, we also interviewed 16 stakeholders—as well as officials from the Federal Communications Commission (FCC), the National Telecommunications and Information Administration (NTIA), and the National Institute of Standards and Technology—to further understand the challenges to 5G deployment. We selected these stakeholders based on our prior telecommunications work,

other 5G literature, and recommendations from stakeholders we interviewed to provide a range of perspectives on 5G deployment. Stakeholders were from two universities, four industry associations, five wireless carriers, as well as five local governments and organizations. To identify these local governments, we selected a group of cities to include those where wireless carriers have announced they will launch 5G services, and selected a mix of cities where there was local opposition to 5G, as well as cities with state or local laws regarding small cell permitting. We then selected lower-population density cities in the same states as those cities, using U.S. Census data. To select these cities, we identified the county with the median population density of the state, and then selected the city which holds the county seat. We attempted to contact all the selected cities and were able to schedule and hold interviews with representatives from Los Angeles, California; Jacksonville, Florida; Greenville, Illinois; and Naples, Florida. The information we obtained from these interviews is not meant to be generalizable to other cities' experiences, but is meant to provide illustrative examples of actual 5G deployment. See table 3 for a complete list of stakeholders we interviewed.

Appendix I: Objectives, Scope, and Methodology

Table 3: List of Stakeholders GAO Interviewed

Category	Stakeholder
Academia	Rob Frieden, Professor, Penn State University
	Akbar Sayeed, Professor, University of Wisconsin-Madison
Industry Associations	5G Americas
	CTIA
	NTCA The Rural Broadband Association
	Wireless Infrastructure Association
Local Agencies and Organizations	Greenville, IL, City Management
	Jacksonville, FL, Planning and Development Department
	Los Angeles, CA, Bureau of Street Lighting
	Naples, FL, Collier County Growth Management Department
	National League of Cities
Wireless Carriers	AT&T
	Sprint
	T-Mobile
	U.S. Cellular
	Verizon

Source: GAO. | GAO-20-468

Finally, to assess the federal government’s actions to address challenges to 5G deployment, we reviewed relevant statutes and literature,² along with reports and documents from FCC and the Department of Commerce. For example, we reviewed FCC reports and orders related to 5G networks,³ the Department of Commerce’s Spectrum Repurposing Report,⁴ along with planning reports such as FCC’s *Facilitate America’s Superiority in 5G Technology Plan (5G FAST Plan)* and FCC’s and the

²We searched Scopus and ProQuest for articles about 5G implementation challenges.

³See, for example, *In the Matter of Accelerating Wireless Broadband Deployment by Removing Barriers to Infrastructure Investment*, Second Report and Order, FCC 18-30 (2018). See, also, *In the Matter of Accelerating Wireless Broadband Deployment by Removing Barriers to Infrastructure Investment, Declaratory Ruling and Third Report and Order*, FCC 18-133 (2018).

⁴U.S. Department of Commerce, *Annual Report on the Status of Spectrum Repurposing*, (Washington, D.C.: August 2019).

Department of Commerce's strategic plans.⁵ In addition, we interviewed FCC and NTIA officials about their efforts to address 5G deployment challenges. We compared FCC efforts to address 5G deployment challenges to its own strategic goals and relevant leading practices for performance management identified in our prior body of work.⁶

We conducted this performance audit from February 2019 to June 2020 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

⁵FCC, *The FCC's 5G FAST Plan*, (Washington, D.C.: Sept. 28, 2018), accessed December 19, 2019, <https://docs.fcc.gov/public/attachments/DOC-354326A1.pdf>. FCC, *Federal Communications Commission Strategic Plan 2018-2022*, (Washington, D.C.) and U.S. Department of Commerce, *U.S. Department of Commerce Strategic Plan 2018-2022*, (Washington, D.C.).

⁶Pub. L. No. 103-62, 107 Stat. 285 (1993), as enhanced by Pub. L. No. 111-352, § 3, 124 Stat. 3866, 3867 (2011) codified at 31 U.S.C. § 1115(b)(2), (6). See also, GAO, *Agencies' Strategic Plans under GPR: Key Questions to Facilitate Congressional Review*, [GAO/GGD-10.1.16](#) (Washington, D.C.: May 1997) and GAO, *Executive Guide: Effectively Implementing the Government Performance and Results Act*, [GAO/GGD-96-118](#) (Washington, D.C.: June 1, 1996). Specifically, we compared FCC's efforts to two leading practices identified in this report: (1) involve stakeholders and (2) produce a set of performance measures at each organization level that demonstrate results, are limited to the vital few, respond to multiple priorities, and link to responsible programs. We selected these practices based on their relevance to FCC's efforts. We excluded 10 other leading practices from our review.

Appendix II: Comments from the Federal Communications Commission



Federal Communications Commission
Washington, D.C. 20554

May 20, 2020

Andrew Von Ah
Director, Physical Infrastructure
Government Accountability Office
441 G Street NW
Washington, DC 20548

Dear Mr. Von Ah:

Thank you for the opportunity to review the Government Accountability Office's draft report, "5G Deployment, FCC Needs Comprehensive Strategy Planning to Guide its Efforts." One of the Commission's top priorities is to ensure that the United States leads the world in wireless innovation. To this end, the FCC is pursuing a comprehensive strategy to Facilitate America's Superiority in 5G Technology (the 5G FAST Plan).

The 5G FAST Plan includes three key components: (1) pushing more spectrum into the marketplace; (2) updating infrastructure policy; and (3) modernizing outdated regulations. As the draft report acknowledges, the Commission has already taken steps, and has ongoing efforts underway, to fulfill these vital components of its strategic 5G planning.

For example, the Commission has already increased availability across low-, mid- and high-band spectrum, including high-band auctions that offered licenses in close to 5,000 megahertz of spectrum over the past 18 months. While we have quickly worked to identify and make available all possible spectrum for 5G purposes, our efforts since 2017 have particularly focused on mid-band spectrum, given its importance to 5G deployments. Recent proceedings have made available up to 547.5 megahertz in the 2.5, 3.5, and 3.7-3.98 GHz bands, and established important mechanisms for spectrum sharing that will inform future mid-band proceedings involving a significant federal incumbent presence. Our recent decision to permit unlicensed use in the 6 GHz band is making up to an additional 1,200 megahertz of key mid-band spectrum available for 5G applications, and the ongoing proceeding in the 5.9 GHz band could further augment the amount of mid-band spectrum.

Although the Commission does not require specific technologies be used in various spectrum bands, it has an interest in ensuring that the American public has access to the latest technology to spur continued economic development. Thus, while the carriers may choose which technologies they deploy, the Commission has been actively working to ensure that new spectrum coming available is favorable for 5G deployments. In further expanding spectrum availability for 5G, the Commission's dual responsibilities in adopting rules and policies through notice and comment processes, and in managing non-federal uses of spectrum, necessitate approaching spectrum allocation and service rule proceedings with an open mind as to what is practically and scientifically achievable. This entails weighing the public record and performing engineering, economic, and technical analyses that play an important role in

Appendix II: Comments from the Federal Communications Commission

determining the outcome of band-specific proposals. Further, because the Commission's authority encompasses non-federal use of spectrum, proposals in bands with federal government equities involve participation and input from NTIA and other federal stakeholders with band-specific proposals.

Because the Commission does not want to prejudge such issues by adopting performance goals prematurely, it generally decides such issues only after it analyzes numerous filings in the record, including hundreds of comments, and engineering and economic studies. In other words, the Commission adopts specific and measurable performance goals (with related strategies and measures) during ongoing rulemakings, once it becomes possible to establish such goals. For instance, during the 3.7-4.2 GHz proceeding, once the record had been developed, Chairman Pai outlined specific, key goals—including making 280 megahertz of spectrum available for flexible use in an FCC-run, public auction, to begin in December 2020. Further, once band-specific policy determinations have been made in individual proceedings, the Commission also establishes specific and measurable performance goals that can be accurately measured by established requirements, such as construction benchmarks and renewal standards, to ensure licensees maximize their use of this scarce public resource. Beyond new licensees, specific and measurable metrics are also established for other affected stakeholders; examples in the 3.7-4.2 GHz context include target deadlines for incumbents electing accelerated relocation and for selecting a relocation payment clearinghouse. Essentially, the resulting product of the Commission's rulemaking process – a Report & Order – becomes the strategic plan for the specific band in question. As a multi-member regulatory agency required to follow notice and comment procedures, this outcome is only achievable after completing a wide-ranging and transparent proceeding involving multiple stakeholders.

Prejudging the engineering, economic, and other technical outcomes of a proceeding through unfounded or artificial benchmarks, as GAO recommends, could have the unintended consequence of limiting the options available to manage federal and non-federal spectrum demands. Indeed, preserving all available options to address federal stakeholder concerns will be increasingly important moving forward, as the vast majority of low-and mid- band spectrum allocated to non-federal uses has already been assigned for flexible uses and federal allocations are present throughout nearly all remaining mid-band 5G spectrum options. We believe the approach described above strikes an appropriate and reasonable balance in preserving flexibility to set policies in furtherance of our strategic goals, and in how they are subsequently evaluated.

As the draft report also recognizes, the Commission has made closing the digital divide a key priority in its 2018-2022 strategic plan. One of the specific strategies identified in the plan designed to achieve this goal involves promoting “a regulatory approach of light-touch regulation, facilities-based competition, flexible use policy, and freeing up spectrum to encourage and facilitate the development of 5G networks.”¹ In addition to the spectrum allocation efforts described above, the Commission has executed this strategy by acting to speed federal, state, and local review of infrastructure deployments, and through continued application of a flexible use spectrum policy which enables licensees to quickly adapt to consumer and network demands in a technology-neutral manner. As noted above, licensees must meet construction benchmarks and renewal standards to demonstrate their performance goal compliance.

Apart from these regulatory actions, there are also multiple funding opportunities in development, such as the Rural Digital Opportunity Fund and a new 5G Fund for Rural America, to address deployment shortcomings in rural areas. These opportunities either incorporate or propose performance and reporting requirements for future recipients, which we anticipate will enable us to assess and identify where

¹ 2018-2022 FCC Strategic Plan at 6.

**Appendix II: Comments from the Federal
Communications Commission**

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Thank you for the opportunity to review GAO's recommendations. We look forward to continuing to engage in a productive dialogue with GAO in the future, so that we can continue to fulfill Congress's statutory objectives for the benefit of the American people.

Sincerely,



Donald K. Stockdale, Jr.
Chief, Wireless Telecommunications Bureau



Kris Anne Monteith
Chief, Wireline Competition Bureau



Ronald T. Repasi
Acting Chief, Office of Engineering and
Technology

Text of Appendix II: Comments from the Federal Communications Commission

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May 20, 2020

Andrew Von Ah

Director, Physical Infrastructure Government Accountability Office

441 G Street NW

Washington, DC 20548

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Chief, Wireless Telecommunications Bureau

Kris Anne Monteith

Chief, Wireline Competition Bureau

Ronald T. Repasi

Acting Chief, Office of Engineering and Technology

Appendix III: GAO Contact and Staff Acknowledgments

GAO Contact

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Staff Acknowledgments

In addition to the contact named above, Keith Cunningham (Assistant Director); Daniel Paepke (Analyst in Charge); Oluwaseun Ajayi; Carol Bray; Vijay D'Souza; Wayne Emilien; Jonathan Felbinger; Richard Hung; Catrin Jones; Michael Krafve; Kaelin Kuhn; Hannah Laufe; Dan Luo; Neelaxi Lakhmani; Brian Mazanec; Jamilah Moon; Cheryl Peterson; Erika Prochaska; Malika Rice; Oliver Richard; Pamela Snedden; Andrew Stavisky; Hai Tran; Christopher Turner; Tatyana Walker; and Michelle Weathers made key contributions to this report.

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