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**SPECTRUM
MANAGEMENT**

**Preliminary Findings on
Federal Relocation Costs
and Auction Revenues**

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Physical Infrastructure Issues



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Highlights of [GAO-13-563T](#), a testimony before the Subcommittee on Strategic Forces, Committee on Armed Services, U.S. Senate

Why GAO Did This Study

Radio frequency spectrum is the resource that makes possible wireless communications. Balancing competing industry and government demands for a limited amount of spectrum is a challenging and complex task. In 2006, FCC completed an auction of spectrum licenses in the 1710-1755 MHz band that had previously been allocated for federal use. As part of an effort to make additional spectrum available for commercial use, DOD assessed the feasibility of relocating 11 major communication systems from the 1755-1850 MHz band. In September 2011, DOD found that it would cost about \$13 billion over 10 years to relocate most operations from the 1755-1850 MHz band.

GAO was asked to review the costs to relocate federal spectrum users and revenues from spectrum auctions. This testimony addresses our preliminary findings on (1) estimated and actual relocation costs and revenue from the previously auctioned 1710-1755 MHz band, (2) the extent to which DOD followed best practices to prepare its preliminary cost estimate for vacating the 1755-1850 MHz band, and (3) existing government or industry forecasts for revenue from an auction of the 1755-1850 MHz band. GAO reviewed relevant reports; interviewed DOD, FCC, NTIA, and Office of Management and Budget officials and industry stakeholders; and analyzed the extent to which DOD's preliminary cost estimate met best practices identified in GAO's *Cost Estimating and Assessment Guide (Cost Guide)*.

View [GAO-13-563T](#). For more information, contact Mark L. Goldstein at (202) 512-2834 or goldsteinm@gao.gov.

April 24, 2013

SPECTRUM MANAGEMENT

Preliminary Findings on Federal Relocation Costs and Auction Revenues

What GAO Found

Actual costs to relocate federal users from the 1710-1755 megahertz (MHz) band have exceeded the original \$1 billion estimate by about \$474 million as of March 2013, although auction revenues appear to exceed relocation costs by over \$5 billion. Actual relocation costs exceed estimated costs for various reasons, including unforeseen challenges and some agencies not following the National Telecommunications and Information Administration's (NTIA) guidance for preparing the cost estimate. In contrast, the Department of Defense (DOD) expects to complete relocation for about \$275 million or approximately \$80 million less than its \$355 million estimate. According to DOD officials, the relocation of systems from this band has been less expensive than originally estimated because many systems were simply re-tuned to operate in the adjacent 1755-1850 MHz band. The auction of the 1710-1755 MHz band raised almost \$6.9 billion in gross winning bids. NTIA expects agencies to complete the relocation effort between 2013 and 2017; therefore, final net auction revenue (auction revenue less relocation costs) may change.

DOD's preliminary cost estimate for relocating systems from the 1755-1850 MHz band substantially or partially met GAO's best practices, but changes in key assumptions may affect future costs. Adherence with GAO's *Cost Guide* helps to minimize the risk of cost overruns, missed deadlines, and unmet performance targets. GAO found that DOD's estimate substantially met the comprehensive and well-documented best practices. For instance, it included complete information about systems' life cycles and documentation for the majority of systems was sufficient. However, not all programs had evidence of cost-influencing ground rules and assumptions, and some of the source data were insufficient. GAO also determined that DOD partially met the accurate and credible best practices. For example, DOD applied appropriate inflation rates and its estimated costs generally agreed with its 2001 cost estimate for this band. However, DOD did not develop a confidence level, making it difficult to determine if the costs considered are the most likely costs, and DOD only completed some sensitivity analyses and risk assessments at the program level for some programs. DOD officials said that changes to key assumptions could substantially change its costs. Most importantly, decisions about which spectrum band DOD would relocate to are still unresolved. Nevertheless, DOD's cost estimate was consistent with its purpose—informing the decision to make additional spectrum available for commercial wireless services.

No government revenue forecast has been prepared for a potential auction of licenses in the 1755-1850 MHz band, and a variety of factors could influence auction revenues. One private sector study in 2011 forecasted \$19.4 billion in auction revenue for licenses in this band, assuming that federal users would be cleared and the nationwide spectrum price from a previous auction, adjusted for inflation, would apply to this spectrum. The price of spectrum, and ultimately auction revenue, is determined by supply and demand. The Federal Communications Commission (FCC) and NTIA jointly influence the amount of spectrum allocated to federal and nonfederal users (the supply). The potential profitability of a spectrum license influences its demand. Several factors would influence profitability and demand, including whether the spectrum is cleared of federal users or must be shared.



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Chairman Udall, Ranking Member Sessions, and Members of the Subcommittee:

Thank you for the opportunity to be here today as the Subcommittee examines the Department of Defense's (DOD) requirements for radio frequency spectrum.¹ As you know, DOD requires spectrum to support military operations, testing, and training at home and around the world. For example, DOD has dramatically increased its use of unmanned aerial systems in support of overseas missions; these systems require spectrum to transmit volumes of critical intelligence, surveillance, and reconnaissance data, leading to an increase in DOD's demand for spectrum. Similarly, as the demand for and use of smart phones, tablets, and other wireless devices continues to grow, commercial requirements for spectrum are expanding as well, with important implications for economic growth. Thus, balancing competing industry and government demands for a limited amount of spectrum, today and in the future, is a challenging and complex task.

In June 2010, the administration issued a presidential memorandum directing the National Telecommunications and Information Administration (NTIA) to collaborate with the Federal Communications Commission (FCC) to make available a total of 500 MHz of federal and nonfederal spectrum for wireless broadband within 10 years.² As part of this effort, DOD studied the feasibility of relocating military systems from the 1755-1850 MHz band,³ which is ideally suited to enabling highly mobile, yet reliable communication links for commercial and federal users. Relocating to other parts of the radio frequency spectrum means that many of these

¹The radio frequency spectrum is the part of the natural spectrum of electromagnetic radiation lying between the frequency limits of 3 kilohertz (kHz) and 300 gigahertz (GHz). Radio frequencies are grouped into bands and are measured in units of Hertz, or cycles per second. The term kHz refers to thousands of Hertz, megahertz (MHz) to millions of Hertz, and GHz to billions of Hertz. The Hertz unit of measurement is used to refer to both the quantity of spectrum (such as 500 MHz of spectrum) and the frequency bands (such as the 1755-1850 MHz band).

²See, Memorandum for the Heads of Executive Departments and Agencies, *Unleashing the Wireless Broadband Revolution*, 75 Fed. Reg. 38387 (June 28, 2010).

³Within the United States, this band is allocated exclusively to the federal government, particularly for defense purposes, such as military tactical communications, air combat training, and space systems.

military systems would need to be redesigned. In addition, few other comparable spectrum bands are available that can effectively support the federal operations currently in the band. In September 2011, DOD estimated that the cost to relocate most military systems from the 1755-1850 MHz band would be about \$12.6 billion over 10 years.

My statement today discusses our ongoing review, requested by the Senate Committee on Armed Services, of federal agencies' spectrum relocation costs and auction revenues. Our review focuses on (1) the differences between estimated and actual federal relocation costs, and revenue from the auction of the 1710-1755 MHz band; (2) the extent to which DOD followed best practices to prepare its preliminary cost estimate for vacating the 1755-1850 MHz band and the limitations, if any, of its analysis; and (3) what government or industry revenue forecasts exist for an auction of the 1755-1850 MHz band, and what factors, if any, could influence the actual auction revenue. To determine the estimated and actual federal relocation costs, and revenue from the auction of the 1710-1755 MHz band, we reviewed annual progress reports for the 1710-1755 MHz transition published by NTIA and spectrum auction data published by FCC as of December 2012.⁴ We limited our analysis to the Advanced Wireless Services-1 (AWS-1) auction involving the 1710-1755 MHz band; this is the only spectrum auction involving federal agencies, including DOD, with significant, known relocation costs.⁵ To assess whether the cost of vacating the 1755-1850 MHz band is sufficiently captured in DOD's preliminary cost estimate, we assessed DOD's preliminary estimate against GAO's *Cost Estimating and Assessment Guide (Cost Guide)*, which has been used to evaluate cost estimates

⁴To assess the reliability of the relocation cost and auction revenue data, we reviewed documentation related to the data, compared the data to other sources, including government reports, and discussed the data with FCC and NTIA officials. We determined that the FCC and NTIA data were sufficiently reliable for our purposes.

⁵There have been other auctions involving the relocation of federal government agencies. For example, the National Oceanic and Atmospheric Administration (NOAA), Air Force, and National Science Foundation previously operated systems in the 1670-1675 MHz band. The estimated cost to relocate these systems was \$35-55 million for NOAA and \$515,000 for the Air Force. See NTIA, *Spectrum Reallocation Final Report: Response to Title VI – Omnibus Budget Reconciliation Act of 1993* (Washington, D.C.: February 1995). FCC auctioned the band in April 2003, and the auction generated \$12.6 million. Final relocation costs are unclear.

across the government;⁶ these best practices help ensure cost estimates are comprehensive, well-documented, accurate, and credible. To identify any limitations affecting DOD's estimate, we also interviewed DOD officials responsible for developing the department's preliminary cost estimate. To identify any government or industry forecasts of revenue from a future auction of the 1755-1850 MHz band and any factors that would affect the value of spectrum licenses, we reviewed academic, government, and public policy literature. We also interviewed officials from the Congressional Budget Office (CBO) and the Office of Management and Budget (OMB), and stakeholders with knowledge of spectrum licensing issues, including industry and policy experts. We are conducting our work 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. We plan to issue our final report on this work in May 2013.

Background

The radio frequency spectrum is the resource that makes possible wireless communications and supports a vast array of government and commercial services. DOD uses spectrum to transmit and receive critical voice and data communications involving military tactical radio, air combat training, precision-guided munitions, unmanned aerial systems, and aeronautical telemetry and satellite control, among others. The military employs these systems for training, testing, and combat operations throughout the world. Commercial entities use spectrum to provide a variety of wireless services, including mobile voice and data, paging, broadcast television and radio, and satellite services.

In the United States, FCC manages spectrum for nonfederal users under the Communications Act,⁷ while NTIA manages spectrum for federal government users and acts for the President with respect to spectrum management issues as governed by the National Telecommunications

⁶GAO, *GAO Cost Estimating and Assessment Guide: Best Practices for Developing and Managing Capital Program Costs*, [GAO-09-3SP](#) (Washington, D.C.: March 2009).

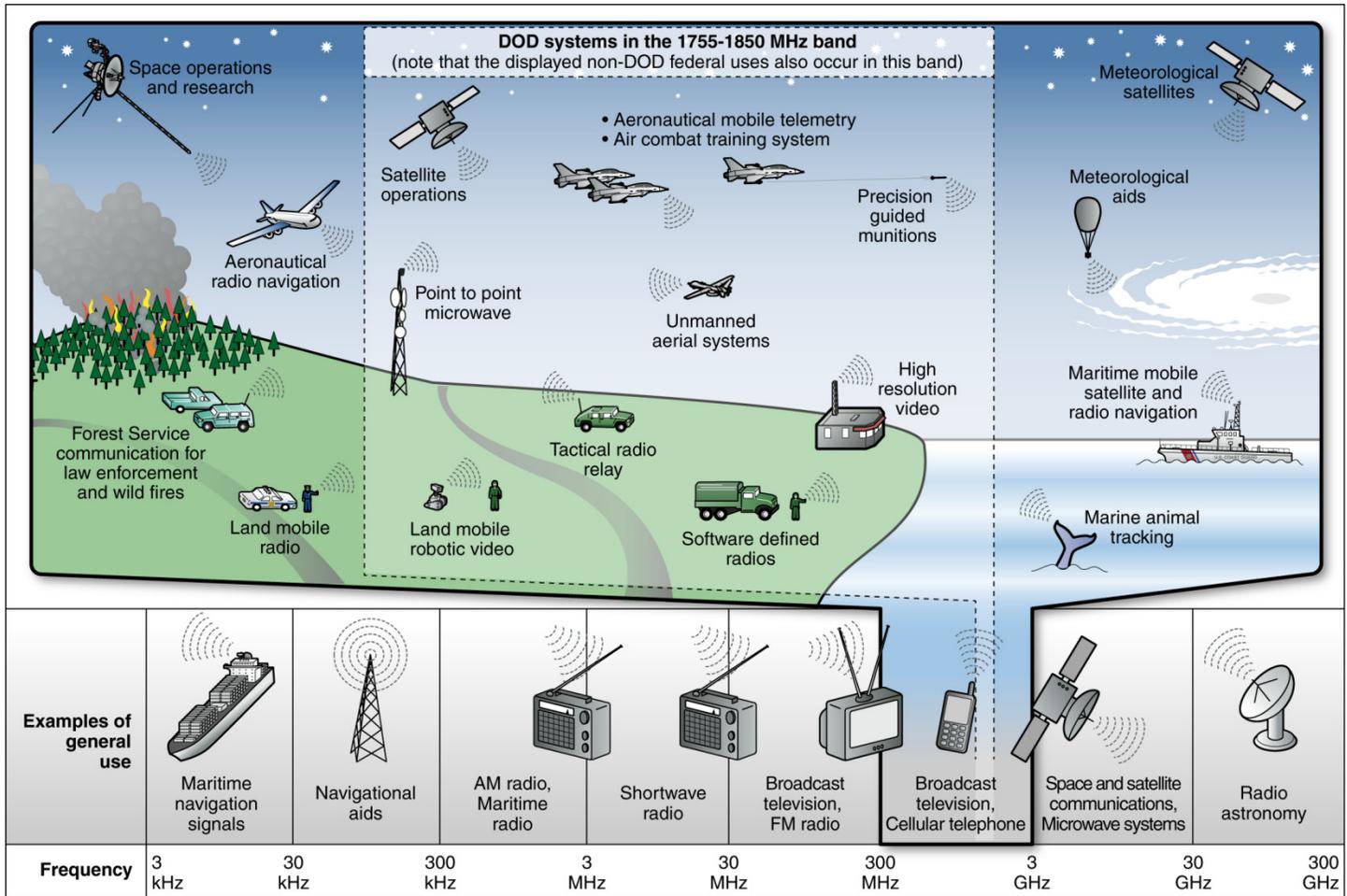
⁷Communications Act, 47 U.S.C. § 309.

and Information Administration Organization Act.⁸ FCC and NTIA, with direction from Congress and the President, jointly determine the amount of spectrum allocated for federal, nonfederal, and shared use. FCC and NTIA manage the spectrum through a system of frequency allocation and assignment.

- *Allocation* involves segmenting the radio spectrum into bands of frequencies that are designated for use by particular types of radio services or classes of users. (Fig. 1 illustrates examples of allocated spectrum uses, including DOD systems using the 1755-1850 MHz band.) In addition, spectrum managers specify service rules, which include the technical and operating characteristics of equipment.

⁸Pub. L. No. 102-538, title I, 106 Stat. 3533, codified as amended at 47 U.S.C. ch. 8.

Figure 1: Examples of Allocated Spectrum Uses and DOD Systems Using the 1755-1850 MHz band



Source: GAO.

- Assignment**, which occurs after spectrum has been allocated for particular types of services or classes of users, involves providing users, such as commercial entities or government agencies, with a license or authorization to use a specific portion of spectrum. FCC assigns licenses within frequency bands to commercial enterprises, state and local governments, and other entities. Since 1994, FCC has used competitive bidding, or auctions, to assign certain licenses to

commercial entities for their use of spectrum.⁹ Auctions are a market-based mechanism in which FCC assigns a license to the entity that submits the highest bid for specific bands of spectrum. NTIA authorizes spectrum use through frequency assignments to federal agencies. More than 60 federal agencies and departments combined have over 240,000 frequency assignments, although 9 departments, including DOD, hold 94 percent of all frequency assignments for federal use.

Congress has taken a number of steps to facilitate the deployment of innovative, new commercial wireless services to consumers, including requiring more federal spectrum to be reallocated for commercial use. Relocating communications systems entails costs that are affected by many variables related to the systems themselves as well as the relocation plans. Some fixed microwave systems, for example, can use off-the-shelf commercial technology and may just need to be re-tuned to accommodate a change in frequency. However, some systems may require significant modification if the characteristics of the new spectrum frequencies differ sufficiently from the original spectrum. Specialized systems, such as those used for surveillance and law enforcement purposes, may not be compatible with commercial technology, and therefore agencies have to work with vendors to develop equipment that meets mission needs and operational requirements.

In 2004, the Commercial Spectrum Enhancement Act (CSEA) established a Spectrum Relocation Fund,¹⁰ funded from auction proceeds, to cover the costs incurred by federal entities that relocate to new frequency assignments or transition to alternative technologies.¹¹ The auction of spectrum licenses in the 1710-1755 MHz band was the first with relocation costs to take place under CSEA. Twelve agencies previously operated communication systems in this band, including DOD. CSEA

⁹Not all licenses are assigned via auctions. For example, in some frequency bands, FCC authorizes unlicensed use of spectrum—that is, users do not need to obtain a license to use spectrum. Rather, an unlimited number of unlicensed users can share frequencies on a noninterference basis. Thus, the assignment process does not apply to the use of unlicensed spectrum.

¹⁰47 U.S.C. § 928.

¹¹Eligible relocation expenses are those costs incurred by a federal entity to achieve comparable capability of systems, regardless of whether that is achieved by relocating to a new frequency assignment or utilizing an alternative technology. 47 U.S.C. § 923(g)(3).

designated 1710-1755 MHz as “eligible frequencies” for which federal relocation costs could be paid from the Spectrum Relocation Fund.¹² In September 2006, FCC concluded the auction of licenses in the 1710-1755 MHz band and, in accordance with CSEA,¹³ a portion of the auction proceeds is currently being used to pay spectrum relocation expenses.¹⁴

In response to the President’s 2010 memorandum requiring that additional spectrum be made available for commercial use within 10 years, in January 2011, NTIA selected the 1755-1850 MHz band as the priority band for detailed evaluation and required federal agencies to evaluate the feasibility of relocating systems to alternative spectrum bands. DOD provided NTIA its input in September 2011, and NTIA subsequently issued its assessment of the viability for accommodating commercial wireless broadband in the band in March 2012.¹⁵ Most recently, the President’s Council of Advisors on Science and Technology published a report in July 2012 recommending specific steps to ensure the successful implementation of the President’s 2010 memorandum.¹⁶ The report found, for example, that clearing and vacating federal users from certain bands was not a sustainable basis for spectrum policy largely because of the high cost to relocate federal agencies and disruption to the federal missions. It recommended new policies to promote the sharing of federal spectrum. The sharing approach has been questioned by CTIA—The Wireless Association and its members,¹⁷ which argue that cleared spectrum and an exclusive-use approach to spectrum

¹²47 U.S.C. § 923(g)(2).

¹³47 U.S.C. § 928(d)(1), appropriates from the Spectrum Relocation Fund such sums as may be required to pay authorized relocation or sharing costs. See, also 47 U.S.C. § 928(c).

¹⁴This auction included licenses in the 1710-1755 MHz and 2110-2155 MHz bands. In August 2008, FCC held a second auction of the licenses that were not sold in the first auction.

¹⁵NTIA, *An Assessment of the Viability of Accommodating Wireless Broadband in the 1755-1850 MHz Band* (Washington, D.C.: March 2012).

¹⁶Executive Office of the President, President’s Council of Advisors on Science and Technology, *Report to the President: Realizing the Full Potential of Government-Held Spectrum to Spur Economic Growth* (Washington, D.C.: July 2012).

¹⁷CTIA-The Wireless Association is an international nonprofit membership organization that has represented the wireless communications industry since 1984. Membership in the association includes wireless carriers and their suppliers, as well as providers and manufacturers of wireless data services and products.

management has enabled the U.S. wireless industry to invest hundreds of billions of dollars to deploy mobile broadband networks resulting in economic benefits for consumers and businesses.

Some Agencies Underestimated 1710-1755 MHz Band Relocation Costs, Although Auction Revenues Appear to Exceed Those Costs

Some Federal Agencies Underestimated Relocation Costs

Actual costs to relocate communications systems for 12 federal agencies from the 1710-1755 MHz band have exceeded original estimates by about \$474 million, or 47 percent, as of March 2013. The original transfers from the Spectrum Relocation Fund to agency accounts, totaling over \$1 billion, were made in March 2007. Subsequently, some agencies requested additional monies from the Spectrum Relocation Fund to cover relocation expenses. Agencies requesting the largest amounts of subsequent transfers include the Department of Justice (\$294 million), the Department of Homeland Security (\$192 million), the Department of Energy (\$35 million), and the U.S. Postal Service (\$6.6 million). OMB and NTIA officials expect the final relocation cost to be about \$1.5 billion compared with the original estimate of about \$1 billion. Total actual costs exceed estimated costs for many reasons, including unforeseen challenges, unique issues posed by specific equipment location, the transition timeframe, costs associated with achieving comparable capability, and the fact that some agencies may not have properly followed OMB and NTIA guidance to prepare the original cost estimate. NTIA reports that it expects agencies to complete the relocation effort between 2013 and 2017.

Although 11 of the 12 agencies plan to spend the same amount or more than they estimated, DOD expects to complete the 1710-1755 MHz transition for about \$275 million, or approximately \$80 million less than its cost estimate. DOD's cost estimates, some made as early as 1995, changed over time as officials considered different relocation scenarios with differing key assumptions and their thinking evolved about the

systems that would be affected, according to DOD and NTIA officials. Cost estimates to relocate military systems from the late 1990s and early 2000s ranged from a low of \$38 million to as much as \$1.6 billion, depending on the scenario. DOD's final cost estimate to relocate from the band was about \$355 million. DOD officials told us that the relocation of systems from the 1710-1755 MHz band has been less expensive than originally estimated because many of its systems were simply re-tuned to operate in the 1755-1850 MHz band.

Auction Revenues Appear to Exceed Agency Relocation Costs

The auction of the 1710-1755 MHz band raised almost \$6.9 billion in gross winning bids from the sale of licenses to use these frequencies.¹⁸ This revenue minus the expected final relocation costs of approximately \$1.5 billion suggests that the auction of the band will raise roughly \$5.4 billion for the U.S. Treasury. As mentioned above, NTIA reports that it expects agencies to complete the relocation effort between 2013 and 2017; therefore, the final net revenue amount may change. For example, the Department of the Navy has already initiated a process to return almost \$65 million to the Spectrum Relocation Fund.

DOD's Preliminary Cost Estimate Substantially or Partially Met GAO's Identified Best Practices, but Changes in Assumptions May Affect Future Costs

¹⁸Although the AWS-1 auction of spectrum licenses raised \$13.7 billion, the portion of the auction proceeds associated with the transferred government spectrum amounted to almost \$6.9 billion and was deposited in the Spectrum Relocation Fund.

DOD's Preliminary Cost Estimate for Relocating from the 1755-1850 MHz Band Substantially or Partially Met GAO's Identified Best Practices

DOD's Office of Cost Assessment and Program Evaluation (CAPE)¹⁹ led the effort to prepare the department's preliminary cost estimate portion of its study to determine the feasibility of relocating its 11 major radio systems from the 1755-1850 MHz band. To do so, CAPE worked closely with cost estimators and others at the respective military services regarding the technical and cost data needed to support the estimate and how they should be gathered to maintain consistency across the services. The services' cost estimators compiled and reviewed the program data, identified the appropriate program content affected by each system's relocation, developed cost estimates under the given constraints and assumptions, and internally reviewed the estimates consistent with their standard practices before providing them to CAPE. CAPE staff then reviewed the services' estimates for accuracy and consistency, and obtained DOD management approval on its practices and findings. According to DOD officials, CAPE based this methodology on the cost estimation best practices it customarily employs.

We reviewed DOD's preliminary cost estimation methodology and evaluated it against GAO's *Cost Guide*, which also identifies cost estimating best practices that help ensure cost estimates are comprehensive, well-documented, accurate, and credible. These characteristics of cost estimates help minimize the risk of cost overruns, missed deadlines, and unmet performance targets:

- A *comprehensive* cost estimate ensures that costs are neither omitted nor double counted.
- A *well-documented* estimate is thoroughly documented, including source data and significance, clearly detailed calculations and results, and explanations for choosing a particular method or reference.
- An *accurate* cost estimate is unbiased, not overly conservative or overly optimistic, and based on an assessment of most likely costs.
- A *credible* estimate discusses any limitations of the analysis from uncertainty or biases surrounding data or assumptions.

¹⁹The Director of Cost Assessment and Program Evaluation (CAPE) is a principal staff assistant and advisor to the Secretary of Defense and Deputy Secretary of Defense in the Office of the Secretary of Defense.

DOD officials developed the preliminary cost estimate as a less-rigorous, “rough-order-of-magnitude” cost estimate²⁰ as outlined by NTIA, not a budget-quality cost estimate. Because of this, we performed a high-level analysis, applying GAO’s identified best practices to DOD’s cost estimate and methodology, and did not review all supporting data and analysis.

Overall, we found that DOD’s cost estimate was consistent with the purpose of the feasibility study, which was to inform the decision-making process to reallocate 500 MHz of spectrum for commercial wireless broadband use. Additionally, we found that DOD’s methodology substantially met the comprehensive and well-documented characteristics of reliable cost estimates, and partially met the accurate and credible characteristics.²¹

- **Comprehensive—Substantially Met:** We observed that DOD’s estimate included complete information about systems’ life cycles, an appropriate level of detail to ensure cost elements were neither omitted nor double-counted, and overarching study assumptions that applied across programs. However, some programs did not list all the discrete tasks required for relocation, and not all the individual programs had evidence of cost-influencing ground rules and assumptions.
- **Well-documented—Substantially Met:** We found that management reviewed and accepted the estimate, the estimate was consistent with the technical baseline data, and documentation for the majority of programs was sufficient that an analyst unfamiliar with the program could understand and replicate what was done. However, the documentation also captured varying levels of detail on source data and its reliability, as well as on calculations performed and estimation

²⁰The rough-order-of-magnitude estimate is typically developed to support “what-if” analyses, and is helpful in examining differences in high-level variation alternatives to see which are most feasible. Because it is developed from limited data and in a short time, it should never be considered a budget-quality cost estimate.

²¹GAO’s *Cost Guide* includes five levels of compliance with its best practices. Not Met: Provided no evidence that satisfies any of the characteristic. Minimally Met: Provided evidence that satisfies a small portion of the characteristic. Partially Met: Provided evidence that satisfies about half of the characteristic. Substantially Met: Provided evidence that satisfies a large portion of the characteristic. Fully Met: Provided complete evidence that satisfies the entire characteristic.

methodology used, some of which were not sufficient to support a rough-order-of-magnitude estimate.

- **Accurate—Partially Met:** We found that DOD properly applied appropriate inflation rates and made no apparent calculation errors. In addition, the estimated costs agreed with DOD's prior relocation cost estimate for this band conducted in 2001.²² However, no confidence level was specifically stated in DOD's cost estimate to determine if the costs considered are the most likely costs, which is required to fully or substantially meet this characteristic.
- **Credible—Partially Met:** We observed that DOD cross-checked major cost elements and found them to be similar. However, some sensitivity analyses and risk assessments were only completed at the program level for some programs, and not at all at a summary level.²³ Performing risk assessments and sensitivity analyses on all projects and at the summary level is required to fully meet this characteristic, and is required on a majority of projects and at the summary level to substantially meet this characteristic.

As the Assumptions Supporting DOD's Cost Estimate for Relocating from the 1755-1850 MHz Band Change, Costs May Also Change

Even though DOD's preliminary cost estimate substantially met some of our best practices, as the assumptions supporting the estimate change over time, costs may also change. According to DOD officials, any change to key assumptions about the bands to which systems would move could substantially change relocation costs. Because decisions about the time frame for relocation and the spectrum bands to which the various systems would be reassigned have not been made yet, DOD based its current estimate on the most likely assumptions, provided by NTIA, some of which have already been proven inaccurate or are still undetermined. For example:

²²CAPE compared the overall cost estimate using constant fiscal year 2011 dollars with DOD's 2001 cost estimate for relocating from the same band (Department of Defense, *Investigation of the Feasibility of Accommodating the International Mobile Telecommunications (IMT) 2000 Within the 1755-1850 MHz Band* (February 9, 2001)), adjusting for changes in the types and quantities of the systems, and demonstrated that the two estimates are within 5 percent of each other.

²³A sensitivity analysis examines how changes to key assumptions and inputs affect the estimate. A risk assessment identifies the factors underlying an estimate that might be uncertain and the risks they pose to the estimate.

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- **Relocation bands:** According to DOD officials, equipment relocation costs vary depending on the relocation band's proximity to the current band. Moving to bands further away than the assumed relocation bands could increase costs; moving to closer bands could decrease costs. In addition, congestion, in both the 1755-1850 MHz band and the potential bands to which its systems might be moved, complicates relocation planning. Also, DOD officials said that many of the potential spectrum bands to which DOD's systems could be relocated would not be able to accommodate the new systems unless other actions are also taken. For example, the 2025-2110 MHz band, into which DOD assumed it could move several systems and operate them on a primary basis, is currently allocated to commercial electronic news gathering systems and other commercial systems. To accommodate military systems within this band, FCC would need to withdraw this spectrum from commercial use to allow NTIA to provide DOD primary status within this band, or FCC would have to otherwise ensure that commercial systems operate on a non-interference basis with military systems. FCC has not initiated a rulemaking procedure to begin such processes.
 - **Relocation start date:** DOD's cost estimate assumed relocation would begin in fiscal year 2013, but no auction has been approved, so relocation efforts have not begun. According to DOD officials, new equipment and systems continue to be deployed in and designed for the current band, and older systems are retired. This changes the overall profile of systems in the band, which can change the costs of relocation. For example, a major driver of the cost increase between DOD's 2001 and 2011 relocation estimates for the 1755-1850 MHz band was the large increase in the use of unmanned aerial systems. DOD deployed these systems very little in 2001, but their numbers had increased substantially by 2011. Conversely, equipment near the end of its life cycle when the study was completed may be retired or replaced outside of relocation efforts, which could decrease relocation costs.
 - **Inflation:** Inflation will drive up costs as more time elapses before the auction occurs.

In addition to changing assumptions, the high-level nature of a rough-order-of-magnitude estimate means that it is not as robust as a detailed, budget-quality lifecycle estimate, and its results should not be considered or used with the same confidence. DOD officials said that for a spectrum-band relocation effort, a detailed, budget-quality cost estimate would normally be done during the transition planning phase once a spectrum

auction has been approved, and would be based on specific auction and relocation decisions.

No Government Revenue Forecasts Exist for a Potential Auction of the 1755-1850 MHz Band, and a Variety of Factors Could Influence Auction Revenues

Federal Agencies Have Not Produced a Revenue Forecast for the 1755-1850 MHz Band

No official government revenue forecast has been prepared by CBO, FCC, NTIA, or OMB for a potential auction of the 1755-1850 MHz band licenses, but some estimates might be prepared once there is a greater likelihood of an auction. Officials at these agencies knowledgeable about estimating revenue from the auction of spectrum licenses said that it is too early to produce meaningful forecasts for a potential auction of the 1755-1850 MHz band. Moreover, CBO only provides written estimates of potential receipts when a congressional committee reports legislation invoking FCC auctions. OMB officials said NTIA, with OMB concurrence, will transmit federal agency relocation cost estimates to assist FCC in establishing minimum bids for an auction once it is announced.²⁴ OMB would also estimate receipts and relocation costs as part of the President's budget. OMB analysts would use relocation cost information from NTIA to complete OMB's estimate of receipts.

Although no official government revenue forecast exists, an economist with the Brattle Group, an economic consulting firm, published a revenue forecast in 2011 for a potential auction of the 1755-1850 MHz band that

²⁴FCC calculates minimum bids for spectrum auctions typically based on bandwidth and license-area population. Bidders for specific licenses must put forth opening bids that match or exceed the minimum bid to be in contention.

forecasted revenues of \$19.4 billion for the band.²⁵ We did not evaluate the accuracy of this revenue estimate. Like all forecasts, the Brattle Group study was based on certain assumptions. The study assumed that the 1755-1850 MHz band would be generally cleared of federal users. It also assumed the AWS-1 average nationwide price of \$1.03 per MHz-pop as a baseline price for spectrum allocated to wireless broadband services,²⁶ and that the 1755-1780 MHz portion of the band would be paired with the 2155-2180 MHz band, which various industry stakeholders currently support. The study assumed that the 95 MHz of spectrum between 1755 and 1850 MHz would be auctioned as part of a total of 470 MHz of spectrum included in 6 auctions sequenced 18 months apart and spread over 9 years with total estimated net receipts of \$64 billion. In addition, the study adjusted the price of spectrum based on the increase in the supply of spectrum over the course of the six auctions,²⁷ as well as for differences in the quality of the spectrum bands involved.

A Variety of Factors Could Influence Auction Revenues

Like all goods, the price of licensed spectrum, and ultimately the auction revenue, is determined by supply and demand. This fundamental economic concept helps to explain how the price of licensed spectrum could change depending on how much licensed spectrum is available now and in the future, and how much licensed spectrum is demanded by the wireless industry for broadband applications. Government agencies can influence the supply of spectrum available for licensing, whereas

²⁵Coleman Bazelon, The Brattle Group, Inc., *Expected Receipts From Proposed Spectrum Auctions* (Washington, D.C.: July 28, 2011).

²⁶The unit price of licensed spectrum is typically expressed in terms of dollars per MHz-pop, where MHz-pop is the product of total MHz of a band and population covered by the region of a license. The \$1.03 price represents the current price for AWS-1 spectrum based on the original AWS-1 price adjusted for inflation using the SpecEx Spectrum Index.

²⁷To adjust the price of spectrum for the increased supply, the study used the price elasticity for spectrum. According to the study, wireless broadband spectrum is generally thought to have a price elasticity of around -1.2, which implies that a 1 percent increase in the base supply of spectrum should result in a 1.2 percent decrease in its price.

expectations about profitability determine demand for spectrum in the marketplace.²⁸

Supply. In 2010, the President directed NTIA to work with FCC to make 500 MHz of spectrum available for use by commercial broadband services within 10 years. This represents a significant increase in the supply of spectrum available for licensing in the marketplace. As with all economic goods, the price and value of licensed spectrum are expected to fall as additional supply is introduced, all other things being equal.

Demand. The expected, potential profitability of a spectrum license influences the level of demand for it. Currently, the demand for licensed spectrum is increasing and a primary driver of this increased demand is the significant growth in commercial-wireless broadband services, including third and fourth generation technologies that are increasingly used for smart phones and tablet computers. Some of the factors that would influence the demand for licensed spectrum are:

- *Clearing versus Sharing:* Spectrum is more valuable, and companies will pay more to license it, if it is entirely cleared of incumbent federal users, giving them sole use of licensed spectrum; spectrum licenses are less valuable if access must be shared. Sharing could potentially have a big impact on the price of spectrum licenses. In 2012, the President's Council of Advisors on Science and Technology advocated that sharing between federal and commercial users become the new norm for spectrum management, especially given the high cost and lengthy time it takes to relocate federal users.
- *Certainty and Timing:* Another factor that affects the value of licensed spectrum is the certainty about when it becomes available. Any increase in the probability that the spectrum would not be cleared on time would have a negative effect on the price companies are willing to pay to use it. For example, 7 years after the auction of the 1710-1755 MHz band, federal agencies are still relocating systems. The estimated 10-year timeframe to clear federal users from the 1755-

²⁸The value of a spectrum license, and hence the future price of licensed spectrum at a given auction, depends on many factors, ranging from the physical characteristics of the spectrum that is licensed to the general investment climate and the existence of applicable technology infrastructure. For the purposes of this discussion, we focus only on those supply and demand factors directly influenced by government decisions or wireless companies.

1850 MHz band, and potential uncertainty around that timeframe, could negatively influence demand for the spectrum.

- *Available Wireless Services:* Innovation in the wireless broadband market is expected to continue to drive demand for wireless services. For example, demand continues to increase for smartphones and tablets as new services are introduced in the marketplace. These devices can connect to the Internet through regular cellular service using commercial spectrum, or they can use publicly available (unlicensed) spectrum via wireless fidelity (Wi-Fi) networks to access the Internet.²⁹ The value of the spectrum, therefore, is determined by continued strong development of and demand for wireless services and these devices, and the profits that can be realized from them.

Chairman Udall, Ranking Member Sessions, and Members of the Subcommittee, this concludes my prepared remarks. I am happy to respond to any questions that you or other Members of the Subcommittee may have at this time.

GAO Contacts and Staff Acknowledgments

For questions about this statement, please contact Mark L. Goldstein, Director, Physical Infrastructure Issues, at (202) 512-2834 or goldsteinm@gao.gov. In addition, contact points for our Offices of Congressional Relations and Public Affairs may be found on the last page of this statement. Individuals who made key contributions to this statement include Mike Clements, Assistant Director; Stephen Brown; Jonathan Carver; Jennifer Echard; Emile Ettedgui; Colin Fallon; Bert Japikse; Elke Kolodinski; Joshua Ormond; Jay Tallon; and Elizabeth Wood.

²⁹Wi-Fi networks can permit multiple computing devices in each discrete location to share a single wired connection to the Internet, thus efficiently sharing spectrum.

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