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Congressional Committees

Spectrum Management: Information Technologies for Managing Federal Use

Accessible Version

Radio-frequency spectrum is a scarce natural resource vital to many commercial and government activities.¹ For example, commercial entities use spectrum for wireless services, broadcast television, and other purposes. The federal government uses spectrum for air traffic control, wildfire containment, weather observation, law enforcement, border security, national defense, and more. Spectrum needs have increased and are expected to continue to increase, due to, for example, commercial 5G telecommunications and other new technologies that require additional spectrum.² However, all of the usable spectrum has already been designated for use among federal and nonfederal users.

The Department of Commerce's National Telecommunications and Information Administration (NTIA)—the entity that manages federally allocated spectrum—is responsible for promoting the best and most efficient use of spectrum resources across the federal government, consistent with the needs and missions of federal agencies.³ Individual agencies, which are responsible for assessing their spectrum needs and reporting data to NTIA, also need to manage their spectrum use wisely. NTIA and agencies rely on information technologies (IT)—such as software applications and databases—to manage spectrum use. However, NTIA has recently highlighted that existing IT is out-of-date and hinders spectrum management.

In 2020, the William M. (Mac) Thornberry National Defense Authorization Act for Fiscal Year 2021 (FY21 NDAA) required NTIA and the Department of Defense (DOD), as well as certain covered agencies to be specified by NTIA, to develop plans to modernize their IT for managing

¹In this report, spectrum refers to the radio-frequency spectrum. Frequencies are properties of electromagnetic waves that describe how many wave patterns or cycles pass by in a period of time. Frequency is often measured in Hertz (Hz), where a wave with a frequency of 1 Hz will pass by at 1 cycle per second.

²The term 5G stands for the fifth generation of mobile communications. This next generation of technology promises consumers faster data rates with lower latency, or delays, in transmitting data. It also promises more capacity for a more efficient network.

³47 U.S.C. § 901(b)(2)(U). In managing federal spectrum use, NTIA works with the Federal Communications Commission (FCC), which regulates and manages spectrum for private and nonfederal uses. NTIA and FCC allocate spectrum bands for specific purposes, such as wireless communications and emergency response, and users, such as federal agencies and commercial entities. NTIA assigns spectrum to federal users. Assigning spectrum involves providing federal agencies with an authorization to use specific frequencies. NTIA processes over 90,000 frequency assignments and modifications every year. For additional information on how NTIA manages spectrum, see GAO, *Spectrum Management: NTIA Should Improve Spectrum Reallocation Planning and Assess Its Workforce*, [GAO-22-104537](#) (Washington, D.C.: Jan. 27, 2022).

each agencies' use of spectrum.⁴ NTIA's plan, released in September 2021, highlighted the need to speed frequency assignment processes and enhance the interoperability of different spectrum-related IT systems.⁵ In addition to DOD, NTIA determined that covered agencies would be the 19 member agencies of the Interdepartment Radio Advisory Committee (IRAC).⁶ Plans for covered agencies were due in January 2022.

The FY21 NDAA contains a provision for us to review the current spectrum-related IT of covered agencies.⁷ This report describes (1) the existing spectrum-related IT that covered agencies employ to manage their spectrum use, and (2) the opportunities covered agencies and NTIA identified for improving spectrum management through IT modernization. The FY21 NDAA also contains a provision for GAO to conduct oversight of the implementation of agencies' spectrum-related IT modernization plans.⁸ This topic will be the subject of future GAO work.

To describe existing spectrum-related IT, we reviewed information obtained from the 20 agencies required to develop IT modernization plans (DOD and the 19 IRAC member agencies). For all 20 agencies, we gathered basic information on their spectrum-related IT by reviewing documentation or requesting written information from agency officials. We collected additional details on the spectrum-related IT for 13 agencies through interviews with agency officials responsible for spectrum management. We selected these 13 agencies to ensure we gathered information from agencies with more complex and numerous spectrum-related IT systems and larger historical shares of assigned spectrum, among other factors.

To describe the opportunities that covered agencies and NTIA identified for improving spectrum management through spectrum-related IT modernization, we reviewed NTIA documentation and interviewed NTIA officials, as well as the agency officials described above. Based on an

⁴FY21 NDAA, Pub. L. No. 116-283, § 9203(b), (c), 134 Stat. 3388, 4794-95 (2021). Specifically, the FY21 NDAA required NTIA and each covered agency to develop a plan to modernize each agency's federal spectrum "infrastructure." *Id.* The act defines infrastructure as "information technology systems and information technologies, tools, and databases." *Id.* § 9203(e)(4). For brevity in this report, we use the term "information technologies" or IT to refer to the software, databases, and other tools that comprise this infrastructure.

⁵NTIA, Office of Spectrum Management, *Plan to Modernize and Automate the Infrastructure of NTIA Related to Managing Federal Spectrum Use* (Washington, D.C.: September 2021).

⁶By statute, a covered agency is defined as the Department of Defense as well as any federal entity that the Assistant Secretary of Commerce for Communications and Information, the head of NTIA, determines is appropriate. FY21 NDAA § 9203(e)(1). The IRAC is chaired by NTIA and includes a variety of subcommittees that have specialized functions, including assisting NTIA in assigning frequencies and developing policies for managing federal spectrum use. IRAC consists of 19 agencies: Department of Agriculture, Department of the Air Force, Department of the Army, US Coast Guard, Department of Commerce, Department of Energy, Federal Aviation Administration (FAA), Department of Homeland Security, Department of the Interior, Department of Justice, National Aeronautics and Space Administration (NASA), Department of the Navy, National Science Foundation, Department of State, Department of Transportation, Department of the Treasury, United States Agency for Global Media, United States Postal Service (Postal Service), and Department of Veterans Affairs. For the purposes of this report, we count DOD, Air Force (including Space Force), Army, and Navy (including Marine Corps) as four entities.

⁷Specifically, the FY21 NDAA required a "review of the infrastructure of covered agencies, as such infrastructure exists on the date of" enactment. FY21 NDAA § 9203(d)(1). As stated above, we use the term "information technologies" or IT to refer to the software, databases, and other tools that comprise this infrastructure.

⁸FY21 NDAA § 9203(d)(2).

analysis of this information, we identified general themes, such as the need for enhanced data or analysis capabilities, and categorized opportunities.⁹

We conducted this performance audit from May 2021 to February 2022 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.

In summary, we found that:

- **Agencies use a variety of IT systems to manage spectrum use.** NTIA provides IT systems, such as software, databases, and engineering tools, to agencies so that they can participate in NTIA's spectrum management processes such as the process for assigning spectrum. All covered agencies rely in part on NTIA-provided IT. Additionally, most covered agencies—DOD and the Federal Aviation Administration (FAA), in particular—augment NTIA-provided IT with some additional spectrum-related IT that meets their unique mission needs.
- **Many of the officials we interviewed broadly agreed that IT modernization could provide a range of opportunities for improving spectrum management.** These opportunities largely relate to (1) improving current spectrum management processes by addressing some limitations in existing spectrum-related IT and (2) facilitating the potential for greater spectrum sharing. As NTIA begins implementing its September 2021 plan, and covered agencies release their own modernization plans in 2022 and begin to implement them, whether these plans will include actions to pursue these opportunities is not yet clear.

Background

NTIA has a range of processes for managing agencies' spectrum use. Most notably, NTIA assigns spectrum to federal agencies, providing them with authorization to operate in defined frequency bands.¹⁰ This process is intended to prevent interference between different users.¹¹ For example, the spectrum assignment process enables agencies to operate their spectrum-dependent systems under specified conditions—such as DOD's training exercises within the U.S. involving remote operation of weapons systems—without causing interference to or receiving interference from domestic wireless telecommunications.

NTIA makes frequency assignments (i.e., authorizes agencies to use spectrum) through a multistep process: agencies make an initial request for spectrum; NTIA electronically processes the request and checks for errors, such as formatting mistakes in the request; and members of the IRAC Frequency Assignment Subcommittee review the requests for possible objection, and, potentially, resolve disputes between agencies. Among other spectrum management activities, NTIA also certifies the spectrum-dependent equipment (e.g., communication devices that rely

⁹We characterize the results of our 13 interviews with the following indefinite quantifiers: "some" refers to 3-6 agencies, "many" to 7-10 agencies, and "most" to 11-12 agencies.

¹⁰See 47 U.S.C. § 902(b)(2)(A). These authorizations allow agencies to use specific frequencies at specific locations under specified technical parameters.

¹¹Harmful interference may occur when interference from one user's transmissions seriously degrades, obstructs, or repeatedly interrupts another user's transmissions because the two transmissions' frequencies are the same or adjacent to each other and occur at the same time in the same area. Prior to submitting a frequency request, agencies may use various IT systems to check for potential interference.

on spectrum to transmit a signal) that federal agencies acquire. This helps ensure that the equipment conforms to federal spectrum standards and can operate in available spectrum.¹² NTIA, however, has observed that the spectrum-related IT systems that support some spectrum management processes are cumbersome and impede innovation. For example, NTIA has described existing systems for conducting interference analysis as “antiquated” and labor intensive.¹³ NTIA and others have suggested that as spectrum becomes more congested, increased spectrum sharing—in which more than one user operates in the same frequencies—provides an innovative way to manage spectrum more efficiently. Agencies can share spectrum through a variety of technical and procedural techniques, such as geographic separation of equipment and use of directional antennas. We have previously reported that limitations in existing IT systems do not readily enable agencies to collect or share the kinds of time and location data on their spectrum use that are needed to identify sharing opportunities.¹⁴

Covered Agencies Rely on Various Information Technologies to Manage Their Spectrum Use

NTIA provides covered federal agencies with multiple software applications, databases, and other spectrum-related IT systems to manage spectrum, two of which are central to NTIA’s spectrum management processes and among the most widely used.

- Spectrum XXI is the primary platform that supports the process by which agencies request spectrum frequency assignments from NTIA. All but one of the 20 covered agencies use it.¹⁵ Agencies can also use engineering tools available within Spectrum XXI to identify potential interference and conduct other analyses needed to assess the agencies’ spectrum use.
- The Equipment Location-Certification Information Database (EL-CID) is also central to how most agencies participate in the equipment certification process.¹⁶ NTIA provides agencies with spectrum certifications before development or procurement of major radio spectrum-dependent systems to ensure radio frequencies can be made available for the systems. Agencies use EL-CID to submit and track certification requests and other tasks related to this certification.

See enclosure I for a summary of NTIA-provided systems and for information on which agencies use them.

¹²NTIA, “Chapter 5,” *Manual of Regulations and Procedures for Federal Radio Frequency Management* (Redbook) (September 2017 rev.). NTIA also has other roles related to spectrum management, including supporting U.S. representation at international radio-frequency conferences. For the purposes of this report, we focus on NTIA’s spectrum management role related to spectrum assignment and equipment certification.

¹³NTIA, FY2021 Budget as Presented to Congress (Washington, D.C.: February 2020).

¹⁴[GAO-22-104537](#).

¹⁵DOD—including Air Force, Army, and Navy—is a unique case regarding Spectrum XXI. DOD initially developed Spectrum XXI in the 1990s and continues to use a DOD-specific implementation of this software. DOD officials explained that these DOD-specific systems provide additional levels of detail and the security features needed for handling classified information, among other functionality needed for DOD’s global mission. NTIA provides Spectrum XXI to federal agencies through a government use agreement with DOD. Further, while FAA uses Spectrum XXI for limited purposes, it relies on another system, WebAFM, developed in-house and described further below, for the majority of its spectrum management activities.

¹⁶DOD uses NTIA’s EL-CID to access some information but also relies on a different internal system, called Stepstone, for equipment certification purposes that works within another overarching DOD system.

We found the majority of covered agencies (15 of 20) supplemented NTIA-provided systems with other systems that provided additional analytic capabilities or data, often because of unique needs related to the agency's mission.¹⁷ DOD and FAA rely on more systems than other agencies. In particular:

- DOD officials explained that DOD uses over 20 supplemental spectrum-related IT systems to meet unique mission or operational requirements, such as software platforms and databases designed to support global operations. For instance, the Joint Ordnance Electromagnetic Environmental Effects Risk Assessment (JOERAD-O) database contains classified technical information about spectrum equipment to protect against potentially dangerous interactions between the equipment and, for example, weaponry with spectrum-sensitive triggers. See enclosure II for more information on DOD's systems.
- FAA officials said that FAA has 11 key additional IT systems related to spectrum management to support its mission. For example, FAA's Web Automated Frequency Manager (WebAFM) enables engineering analysis to protect frequencies needed for air-to-ground communications and air navigation. See enclosure III for more information on FAA's key systems.
- Ten of the 20 other covered agencies also use additional spectrum-related IT systems acquired from third parties or developed internally. For example, some officials we interviewed said their agencies supplement analytic tools in Spectrum XXI with commercial systems (i.e., HTZ Warfare and Spectrum E) that provide alternative methods for analyzing how spectrum-dependent equipment may perform if deployed. According to officials we interviewed, some agencies also maintain their own databases with information about their spectrum-dependent equipment because they need more detailed information than what is available in NTIA systems due to unique aspects of their mission. For example, the NASA Electronic Radio Database System (NERDS) contains data specific to NASA's equipment related to the agency's terrestrial and space missions. See enclosure IV for additional information about the systems these 10 agencies use.

Some of the officials we interviewed found their current spectrum-related IT systems generally functional, while recognizing difficulties or inefficiencies in some aspects of how the systems work. For example, some officials explained that their agency's existing spectrum-related IT enabled them to get needed frequency assignments, but that some steps took more staff effort than they would like. On the other hand, officials from several agencies, including the Postal Service and the US Coast Guard, did not note any problems in existing spectrum-related IT. Similarly, we have previously reported that several IRAC member agencies view NTIA's spectrum assignment process positively and believe that NTIA generally has the necessary data to effectively make spectrum assignments.¹⁸

Agency officials from NTIA and DOD, however, identified significant limitations of these systems. NTIA officials explained that almost all the systems it provides to agencies, including Spectrum XXI, are increasingly dated and therefore difficult to enhance or support. Without ongoing updates to these systems, the officials expressed concerns that cybersecurity vulnerabilities would increase, putting the spectrum management process at risk. DOD officials expressed a need to increase the speed by which spectrum management decisions are made;

¹⁷Five agencies—Department of State, Postal Service, United States Agency for Global Media, US Coast Guard, and Veterans Affairs—reported using NTIA's spectrum-related IT exclusively.

¹⁸[GAO-22-104537](#).

these decisions may be slowed by limitations in the spectrum-related IT systems used to conduct the analysis that underpins the decisions.

Agency Officials and NTIA Identified Opportunities for Modernizing IT That Could Improve NTIA Processes and Facilitate More Spectrum Sharing

Officials for covered agencies identified spectrum-related IT modernization opportunities that could (1) improve current spectrum management processes and (2) facilitate greater sharing of spectrum in the future, among other benefits.

Improve current spectrum management processes. Many officials we interviewed agreed that IT modernization presents opportunities to make NTIA's spectrum management processes more efficient in the following ways.

- **Increased automation.** NTIA's existing administrative process for assigning spectrum is highly dependent on manual reviews of frequency assignment requests. An official from the Department of the Interior said that personnel must take the time to manually input raw data from different sources, increasing the risk of human error. Some officials we interviewed suggested automating some of these specific processes. A Department of Homeland Security official said that automating the process for assigning frequencies, potentially incorporating artificial intelligence, would help NTIA process requests faster by reducing or eliminating the need for human review.
- **Improved data and analysis standards.** Many officials told us more precise data and analysis standards would improve spectrum management. NTIA officials explained that NTIA's computer code for frequency assignments is over 20-years old. Additionally, existing spectrum-related IT limits the amount and type of data that can be collected, stored, and used for frequency assignments. This is because, in part, the data standards currently in place were developed decades ago using paper-punched cards that could hold limited digital data. DOD officials similarly described efforts to improve DOD's current spectrum-related IT by, for example, creating a new joint spectrum data repository and other tools that make spectrum information more readily available across DOD components. In addition, a DOJ official said that standardized engineering software, for tasks like analyzing the source of harmful interference, would help minimize time-consuming cross-agency discussion and issue resolution.
- **Enhanced cybersecurity.** Some agency officials told us that enhancing cybersecurity by addressing current vulnerabilities was an opportunity for improvement. For example, officials from two agencies said due to cybersecurity concerns they have not been able to use newer, commercially developed analysis software that is better at identifying available frequencies than Spectrum XXI.

Facilitate spectrum sharing. Some agency officials we interviewed recognized that increasing demand for more spectrum would likely necessitate increased spectrum sharing in the future, and said that existing spectrum-related IT is not sufficient to support the change. They recognized that spectrum-related IT modernization could help address this challenge. Officials from some agencies said that improving spectrum sharing requires automating processes and improved data, as noted above. Some officials also said modernizing the data collection capability of NTIA's IT would enable the kind of precise analysis they need to realistically identify spectrum-sharing opportunities. A DOD official said he hoped that modernization would include enhanced data to help DOD create a spectrum management approach that is more

agile and dynamic, and allows for more sharing.¹⁹ DOD also noted that operational and national security considerations could, in some cases, prevent DOD from providing the level of information required for optimal spectrum sharing. FAA officials said that modernizing spectrum-related IT in light of new and emerging sharing technologies is more important than ever. They specifically noted that spectrum-related IT modernization could improve federal agencies' use of spectrum—and, thus, enhance the availability of spectrum to nonfederal users—but that the safety of life aspects of FAA's mission present challenges in sharing spectrum, independent of spectrum-related IT modernization.

NTIA's vision for modernization touches on some similar opportunities as those identified by officials we interviewed from covered agencies. As some agency officials identified cybersecurity concerns with commercial systems, NTIA officials likewise identified cybersecurity vulnerabilities in NTIA's IT as their most pressing modernization concern. Subsequently, they envision automating some frequency assignment requests, improving the speed of the current assignment and certification processes, and implementing new data and analysis standards, which could decrease agencies' need for supplemental IT and potentially lead to financial savings. The modernization plan, from September 2021, identifies improvements in similar areas. NTIA officials said the modernization plan includes foundational data and functionality to facilitate spectrum sharing in the future, but that new sharing solutions (e.g., time-based sharing) are not included in the current scope of IT modernization.

As NTIA implements its modernization plan and covered agencies release their own modernization plans in 2022, whether these plans will include actions to pursue the opportunities for improvement described above is not clear. GAO will conduct future oversight of the implementation of agencies' IT modernization plans consistent with a provision in the FY21 NDAA.²⁰

Agency Comments

We provided a draft of this report to NTIA and the covered agencies for review and comment. These agencies provided technical comments only, which we incorporated as appropriate.

We are sending copies of this report to the appropriate congressional committees and the Secretaries or Administrators of the covered agencies discussed in this report. In addition, the report is 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. The following staff made key contributions to this report: Sally Moino (Assistant Director); John Stambaugh (Analyst-in-Charge); and Gary Guggolz. Also contributing to this report were: Tommy Baril; Saar Dagani; Melanie Diemel; Philip Farah; Lois Hanshaw; Andrea Levine; Hugh Paquette; Amy Rosewarne; Andrew Stavisky; Janet Temko-Blinder; Hai Tran; and Alwynne Wilbur.

¹⁹DOD officials noted that some of its spectrum-management IT are not related to domestic spectrum use and are therefore outside the scope of their modernization effort.

²⁰FY21 NDAA § 9203(d)(2).

A handwritten signature in black ink, appearing to read "Andrew Von Ah". The signature is fluid and cursive, with a long horizontal stroke at the end.

Andrew Von Ah
Director, Physical Infrastructure

Enclosures – 4

List of Committees

The Honorable Jack Reed
Chairman

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

The Honorable Maria Cantwell
Chair

The Honorable Roger F. Wicker
Ranking Member
Committee on Commerce, Science, and Transportation
United States Senate

The Honorable Adam Smith
Chairman

The Honorable Mike Rogers
Ranking Member
Committee on Armed Services
House of Representatives

The Honorable Frank Pallone, Jr.
Chairman

The Honorable Cathy McMorris Rodgers
Republican Leader
Committee on Energy and Commerce
House of Representatives

Enclosure I: Covered Agencies' Spectrum-Related Information Technologies Provided by the National Telecommunications and Information Administration

Covered agencies rely on a wide range of information technologies (IT) to support their management of spectrum. The National Telecommunications and Information Administration (NTIA) provides multiple IT systems to agencies for various spectrum management purposes (see table 1 for brief descriptions of these systems).

Table 1: Description of Information Technologies the National Telecommunications and Information Administration (NTIA) Provides Agencies to Support Spectrum Management

| Name of information technology | Description |
|--|--|
| Spectrum XXI ^a | Software platform agencies can use to submit requests to NTIA for radio-frequency assignments and to conduct frequency engineering analyses. Analysis capabilities include assessing potential transmission interference between users and frequency transmission propagation (i.e., how far a transmission will travel). Spectrum XXI provides an access platform to the Government Master File, NTIA's record of all federal frequency assignments, which enables agencies to access data on which agencies operate frequencies. |
| Equipment Location-Certification Information Database (EL-CID) | Database system that electronically processes agencies' requests to NTIA to certify their spectrum-dependent equipment (i.e., equipment, such as transmitters on aircraft, which send a signal). |
| IRACnet | Online portal that provides members of the Interdepartment Radio Advisory Committee with access to NTIA information needed for committee proceedings. |
| Data Capture and Forwarding system | System that consolidates, manages, and provides initial data validation for frequency proposals on NTIA's unclassified network. |
| Spectrum Transition Tool | System that is needed by agencies that are relocating spectrum-dependent systems from one band to another; used to report annually to NTIA on the status of relocation. |
| Microcomputer Spectrum Analysis models | Older system for agencies to conduct signal propagation and communication engineering. Some of the models have been integrated into Spectrum XXI. |
| Voice of America Coverage Analysis Program | One of many signal propagation models NTIA shares with agencies as part of its research and development activities. ^b |

Source: GAO analysis of agencies' information. | GAO-22-105221

^aThe Department of Defense uses a DOD-specific implementation of Spectrum XXI that was developed internally rather than the version provided to agencies by NTIA. Officials from the Department of State indicated they do not use Spectrum XXI. NTIA officials explained they input frequency assignment requests into Spectrum XXI on State's behalf.

^bThe NTIA Institute for Telecommunication Services is the research organization of NTIA providing the Voice of America coverage analysis program and other signal propagation models. All other NTIA references in this document refer to the NTIA Office of Spectrum Management.

All covered agencies rely at least in part on NTIA-provided IT. Nearly all covered agencies use Spectrum XXI and most use the Equipment Location-Certification Information Database (EL-CID). Among agencies that do not use these two systems, officials explained they were not necessary to support their specific needs. For example, an agency that uses commercially available equipment may not need to use EL-CID for equipment certification. Other systems provided by NTIA are used by small groups of agencies to support specific functions relevant to them. For example, the Department of Defense and seven other agencies reported using the Spectrum Transition Tool that NTIA provides to manage the reallocation of specific spectrum bands. See figure 1 for information on which systems agency officials reported using.

Figure 1: Covered Agencies That Use National Telecommunications and Information Administration (NTIA) Provided IT to Manage Their Spectrum Use

| Information technology name | Agriculture | Commerce ^a | Defense and military departments ^b | Energy | Federal Aviation Administration | Homeland Security | Interior | Justice | NASA | National Science Foundation | State | Transportation (non-FXA) | Treasury | US Agency for Global Media | US Coast Guard | Postal Service | Veterans Affairs |
|---|-------------|-----------------------|---|--------|---------------------------------|-------------------|----------|---------|------|-----------------------------|-------|--------------------------|----------|----------------------------|----------------|----------------|------------------|
| Spectrum XXI | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ⊘ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Equipment Location-Information Certification Database | ⊘ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ⊘ | ⊘ | ✓ | ✓ | ⊘ | ✓ | ⊘ | ✓ | ✓ |
| IRACnet | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ⊘ | ✓ | ✓ | ✓ | ✓ |
| Data Capture and Forwarding system | ⊘ | ✓ | ⊘ | ✓ | ⊘ | ⊘ | ✓ | ✓ | ✓ | ⊘ | ⊘ | ⊘ | ✓ | ✓ | ⊘ | ✓ | ✓ |
| Microcomputer Spectrum Analysis models | ⊘ | ⊘ | ⊘ | ⊘ | ✓ | ⊘ | ✓ | ⊘ | ⊘ | ⊘ | ⊘ | ⊘ | ⊘ | ⊘ | ⊘ | ⊘ | ⊘ |
| Spectrum Transition Tool | ⊘ | ✓ | ✓ | ✓ | ⊘ | ✓ | ✓ | ✓ | ⊘ | ⊘ | ⊘ | ✓ | ⊘ | ⊘ | ⊘ | ⊘ | ⊘ |
| Voice of America Coverage Analysis Program | ⊘ | ⊘ | ⊘ | ⊘ | ⊘ | ⊘ | ⊘ | ⊘ | ⊘ | ⊘ | ⊘ | ⊘ | ✓ | ⊘ | ⊘ | ⊘ | ⊘ |

✓ = Covered agency usage ⊘ = No covered agency usage

Source: GAO analysis of agency information. | GAO-22-105221

Note: Covered agencies include the Department of Defense and the 19 member agencies of the Interdepartment Radio Advisory Committee.

^aThe National Oceanic and Atmospheric Administration provided information on behalf of Commerce.

^bDefense and military departments are combined in this figure, but are counted as four distinct entities (DOD, Air Force, Army, and Navy) elsewhere in this report. The Marine Corps and Space Force are included within the Navy and Air Force, respectively.

NTIA officials also described two additional NTIA IT systems that support spectrum management.

- **Frequency Management and Reporting System (FMRS).** NTIA uses this system to process and maintain frequency assignments and the Government Master File database. NTIA does not provide this system to federal agencies for their use.
- **FreqCoord.** Federal and nonfederal users rely on this web-based system to coordinate frequency sharing in the 71-76 GHz, 81-86 GHz, and 92-95 GHz bands. The system can identify potential interference and, absent conflicts, transfer frequency requests to the frequency assignment process.

Enclosure II: Department of Defense Spectrum-Related Information Technologies

Multiple components of the Department of Defense (DOD) hold some responsibilities for spectrum management. DOD's Chief Information Officer (CIO) resides within the Office of the Secretary of Defense (OSD). The CIO represents all of DOD at the National Telecommunications and Information Administration's (NTIA) Policy and Plans Steering Group, which advises NTIA on spectrum policy, and is a non-voting observer of the Interdepartment Radio Advisory Committee (IRAC). The CIO also oversees the director of the Defense Information Systems Agency (DISA)—an agency that also includes the Defense Spectrum Organization (DSO). DSO supports spectrum-dependent system acquisition, spectrum planning and operations, such as deconfliction and interference resolution, and develop spectrum management tools and databases, among other activities.

The military departments also hold responsibilities for spectrum management. Spectrum Management Offices within the Air Force, Army, and Navy provide voting representatives on NTIA's IRAC and are the primary point of communication with NTIA for frequency assignments and equipment certification.²¹ Further, spectrum management responsibilities extend to other DOD organizations. For example, under U.S. Army Cyber Command, the U.S. Army Network Enterprise Technology Command (NETCOM) manages tactical-level frequency assignments for deployed equipment that field officers need operational approvals from NTIA to put into use. Likewise, regional spectrum offices for the Navy and Marine Corps, as well as Air Force and Space Force, provide support at the unit and installation levels.

Across the DOD components, spectrum managers rely on a large number of information technologies (IT) systems to support DOD's global missions. DOD officials explained that components use similar IT systems, but that the tasks required at various levels differ. See table 2 for summary of DOD-specific IT used broadly across the department.

²¹The Navy Marine Corps Spectrum Center within the Department of Navy supports both the U.S. Navy and U.S. Marine Corps. Similarly, the Department of the Air Force spectrum management office supports both the U.S. Air Force and U.S. Space Force.

Table 2: Summary of Selected Information Technologies Employed within the Department of Defense to Manage Use of Radio-Frequency Spectrum

| Name of information technology | Description |
|--|---|
| Joint Spectrum Data Repository (JSDR) | DOD data collection system that houses spectrum-related information and also contains analysis tools. Dashboards allow data analysis, and maps provide worldwide access. |
| End-to-End Supportability System (E2ESS) | A DOD data collection tool and database for spectrum-dependent system data and related information to support DOD business processes and operations, such as coordination with host nations and DOD component spectrum access and allocation planning. |
| Global Electromagnetic Spectrum Information System (GEMSIS) | DOD's program of record for sustaining several DOD capabilities including Spectrum XXI, JSDR, and E2ESS. |
| Spectrum XXI | Software platform used to submit requests to the National Telecommunications and Information Administration (NTIA) for radio-frequency assignments and to conduct frequency engineering analyses. |
| Frequency Resources Records Database (FRRS) | DOD spectrum allocation and frequency assignment database for use worldwide. Maintained by Defense Information Systems Agency's (DISA) Defense Spectrum Organization (DSO). |
| Spectrum Certification System (SCS) database | Legacy DOD database that houses technical information needed for military review and approval of radio-frequency equipment purchased or developed by DOD. Sunset May 2020. Will be replaced by the E2ESS system. |
| Joint Equipment, Tactical and Space (JETS) database | DOD database that houses highly detailed engineering and technical information about DOD radar and other systems that use spectrum. Maintained by DISA-DSO. |
| Joint Ordnance Electromagnetic Environmental Effects Risk Assessment (JOERAD-O) database | DOD classified database that houses technical information about equipment that uses spectrum in complex and dangerous environments. Protects people and systems from potentially dangerous effects the equipment could have on, for example, ordnance fuses. |
| Joint Spectrum Interference Resolution Online (JSIR-O) | DOD classified online portal for reporting on and awareness of spectrum interference incidents. |
| Early Entry Portal (EEP) | DISA/DSO portal to support wireless services entering the 1755-1780 MHz band during the transition of DOD systems from the band. |
| Visualyse | Commercial software for modeling and simulating radio systems, including system planning and interference analysis. |
| Spectrum Technology Testbed Initiative (STTI) | DOD spectrum modeling and simulations software used by DSO to perform spectrum-engineering analysis of DOD's spectrum-dependent systems, such as realistically emulating the electromagnetic battlefield environment, and evaluation of operational implications of transitioning relocated to other bands. |
| Early Entry Portal Analysis Capability (EEPAC) | Software to coordinate spectrum relocations activities with the commercial entities for early access to the 1755-1780 MHz band. |
| Terrain Integrated Rough Earth Model (TIREM) | Modeling software that predicts transmission propagation and loss based on geographic and other factors. |
| Irregular Terrain Model | Model of radio-frequency propagation that predicts distance and variability of signal in time and space. |
| International Telecommunication Union Propagation Models | Models of radio-frequency propagation for various use-case scenarios including space and terrestrial locations and bands. |
| Identify Friend or Foe (IFF TWG Model) | IFF TWG Model is a stand-alone model developed between FAA and the Department of Defense, in collaboration with NTIA, to predict the radio-frequency environment within the 1030/1090 MHz band. |
| DOD Integrated Frequency Deconfliction System | Software for analysis of potential interference based on terrain and equipment characteristics, among other data. |
| NASA, DOD, and Commerce spectrum coordination website | Online document repository to exchange spectrum coordination information. |
| NASA Space Frequency Coordination Group website | Online document repository to support civil space agency coordination. |

Source: GAO analysis of agency information. | GAO-22-105221

Note: DOD officials also identified other spectrum-related IT used within DOD that are unrelated to national spectrum management processes; these are not included in this table.

In addition to the IT systems used broadly across most of DOD and DOD components, the Navy uses some IT systems that are specific to naval operations. Officials we interviewed identified the following such systems:

- **E3 Online.** This online database includes some spectrum information needed for safety functions, such as hazards of electromagnetic radiation to ordnance.
- **Real Time Spectrum Operations (RTSO) database.** This database provides information on systems and frequencies used by other countries needed to facilitate safe naval operations abroad.
- **Spectrum Supportability Integrated Process Portal (SSIPP).** This system handles requests for the Navy's spectrum supportability risk-assessment process.
- **Spectrum Operations for Littoral and Ashore Requirements Exercise Portal (SOLAR XP).** Online platform that helps track spectrum requests, provide users with notifications and reminders, and retrieve data on previously processed requests.
- **Navy AWS-3 Analysis Tool (NAAT).** This customized tool for the Navy coordinates operators in the 1695-1710 MHz band, used for meteorological purposes.

Enclosure III: Federal Aviation Administration Spectrum-Related Information Technologies

Within the Department of Transportation (DOT), the Federal Aviation Administration (FAA) is the largest user of spectrum. Both DOT and FAA have offices responsible for spectrum management, and both are voting members of the Interdepartment Radio Advisory Committee (IRAC).²² FAA manages spectrum use related to aviation.

Given FAA's stated mission to properly engineer radio frequencies that ensure the safety of flight, the agency has long held NTIA-delegated responsibility for managing frequency assignments related to flight safety. FAA has seven teams within the Spectrum Office with responsibilities for managing and protecting the spectrum assigned to FAA, according to FAA officials. Each team has between seven and 11 staff members. Three of these teams are in FAA's headquarters in Washington D.C.:

- **Spectrum Assignment and Engineering Team.** Performs coverage analysis and assigns aviation frequencies to the military, 19 additional federal agencies, and commercial/industry entities.
- **Spectrum Planning and International Team.** Leads frequency management for civil aviation domestically and internationally. It ensures new aviation systems that use spectrum are introduced safely.
- **Spectrum National Security Team.** Supports classified national defense and security requirements for the Departments of Defense, Justice, Homeland Security, and Energy.

One team, the Spectrum Testing and Engineering Analysis Team, is located at FAA's technical center in New Jersey. The main functions of this team include ensuring spectrum-engineering requirements are met by conducting tests and developing equipment and software used by FAA to research and determine the causes of interference. Three additional teams are in Service Areas for the eastern, central, and western regions of the U.S. Their main functions are to manage FAA spectrum and investigate frequency interference within the Service Area boundaries. FAA relies on a large number of different information technologies (IT) to support spectrum management. See table 3 for a summary of key IT systems.

²²DOT's Office of the Assistant Secretary for Research and Technology handles spectrum management for surface and maritime operating administrations, such as the Federal Highway Administration and the Maritime Administration.

Table 3: Summary of Selected Information Technologies Used by the Federal Aviation Administration (FAA) to Manage the Use of Radio-Frequency Spectrum

| Name of information technology | Description |
|---|--|
| Canadian Coordination (CanCoord) | CanCoord is a web-based application developed by FAA to coordinate frequency assignments with Canada and Mexico. |
| Extended Service Volume Management System (ESVMS) | ESVMS is a workflow, management, and reference database system used to support certain navigational procedures. A subsystem of ESVMS is deployed to support the same functions for the military. |
| FoxHunt | Foxhunt is an application developed by FAA to detect and track radio-frequency interference events. It is deployed in vehicles in the field. |
| Identify Friend or Foe (IFF TWG Model) | IFF TWG Model is a stand-alone model developed between FAA and the Department of Defense, in collaboration with the National Telecommunications and Information Administration (NTIA), to predict the radio-frequency environment within the 1030/1090 MHz band. |
| Internet Radio Coverage Analysis System (IRCAS) | iRCAS is an FAA propagation tool for air-to-ground communication and navigational aids frequency coverage analysis. |
| Spectrum Business Intelligence Tool (S-BIT) | S-BIT is an application developed by FAA to support review of business processes related to spectrum management. |
| Radar evaluation process | This process is a series of steps composed of propagation-modeling tools and technical data from radar field measurements that are used by FAA to protect and assign frequencies for primary radars. |
| Transmitter Compatibility Analysis Tool (TCAT) | TCAT is an engineering-analysis tool developed by FAA to determine potential interference on aviation from military and non-military electronic attack and countermeasure activities. |
| Web Automated Frequency Manager (WebAFM) | WebAFM is a web-based application developed by the FAA as the main platform for spectrum management. It includes engineering models to perform analysis to protect air-to-ground communication and navigational aids frequencies. WebAFM can also be used to conduct interference analysis of pending or proposed frequency assignments. It contains a copy of Government Master File data and is the interface FAA uses to vote on NTIA spectrum agendas and for daily exchanges with NTIA. |
| Web Frequency Transmission Authorization (WebFTA) | WebFTA is a web-based application developed by the FAA for use within FAA to submit requests for new frequencies, update technical information, and access information on approved frequencies processed through WebAFM. This application also provides the frequency transmission authorization (FTA) for every FAA facility and/or system to the end user. |
| Web Frequency Coordination Request (WebFCR) | WebFCR is a public-facing external web-based application developed by the FAA to receive external frequency coordination requests on aviation frequencies. |

Source: GAO analysis of agency information. | GAO-22-105221

Enclosure IV: Other Covered Agencies' Spectrum-Related Information Technologies Developed Internally or from Third Parties

In addition to the information technologies (IT) provided by the National Telecommunications and Information Administration (NTIA), 10 covered agencies use IT systems developed internally or from third parties (see figure 2). (The Department of Defense and Federal Aviation Administration also use additional IT, which is described in prior enclosures.)

Figure 2: Ten Covered Agencies Use Some Additional Information Technologies to Supplement National Telecommunications and Information Administration (NTIA)-provided IT to Support Spectrum Management

| Information Technology name and description ^a | Agriculture | Commerce ^b | Energy | Homeland Security | Interior | Justice | NASA | National Science Foundation | Transportation (non-FAA) | Treasury |
|---|-------------|-----------------------|--------|-------------------|----------|---------|------|-----------------------------|--------------------------|----------|
| Global Protect VPN: Remote access virtual private network that allows users to connect and work from any location. | ✓ | ✓ | ✓ | ⊘ | ✓ | ✓ | ✓ | ✓ | ✓ | ⊘ |
| HTZ Warfare: Radio network-planning and spectrum-engineering software for the deployment, network optimization, and analysis of tactical military communications. | ⊘ | ⊘ | ✓ | ✓ | ⊘ | ✓ | ⊘ | ⊘ | ⊘ | ⊘ |
| Kiteworks: Platform that automates business processes and provides secure file transfer for many types of data sources. | ✓ | ✓ | ✓ | ✓ | ⊘ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Spectrum-E: Web-based software for spectrum management that incorporates automation and allows user interaction. | ⊘ | ⊘ | ⊘ | ✓ | ✓ | ✓ | ✓ | ⊘ | ⊘ | ✓ |
| Federal Communications Commission (FCC) Universal Licensing System Database: Searchable database that wireless license applicants use for license-related activities. | ⊘ | ✓ | ⊘ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Google Earth: 3D-mapping program providing access to global satellite images. | ⊘ | ⊘ | ✓ | ✓ | ✓ | ⊘ | ✓ | ✓ | ✓ | ✓ |
| Datalinks: Online search system that provides access to FCC and Federal Aviation Administration (FAA) data. | ⊘ | ⊘ | ✓ | ⊘ | ⊘ | ⊘ | ⊘ | ⊘ | ⊘ | ⊘ |
| Department of Defense's (DOD) Integrated Frequency Deconfliction System: Software for analysis of potential interference based on terrain and equipment characteristics, among other data. | ⊘ | ⊘ | ⊘ | ⊘ | ⊘ | ⊘ | ✓ | ⊘ | ⊘ | ⊘ |
| Justice's agenda processing tool: Spreadsheet developed to manage data related to NTIA frequency assignment processes. | ⊘ | ⊘ | ⊘ | ⊘ | ⊘ | ✓ | ⊘ | ⊘ | ⊘ | ⊘ |
| Justice's frequency selection tool: Spreadsheet developed to import Spectrum XXI data and identify clear frequencies. | ⊘ | ⊘ | ⊘ | ⊘ | ⊘ | ✓ | ⊘ | ⊘ | ⊘ | ⊘ |
| Transportation's Tableau tool: Developed with the commercial data analytics platform Tableau to review and evaluate transportation-related frequency bands. | ⊘ | ⊘ | ⊘ | ⊘ | ⊘ | ⊘ | ⊘ | ⊘ | ✓ | ⊘ |
| Transportation's engineering data tools: Developed to conduct frequency analysis and provide engineering data to NTIA and FCC. | ⊘ | ⊘ | ⊘ | ⊘ | ⊘ | ⊘ | ⊘ | ⊘ | ✓ | ⊘ |
| FCC distance and azimuth calculator: Online software to help determine compliance with FCC minimum distance separation requirements between signal transmitter sites. | ⊘ | ⊘ | ⊘ | ⊘ | ⊘ | ⊘ | ⊘ | ⊘ | ⊘ | ✓ |
| itouchMaps: Web-based software for latitude and longitude location. | ⊘ | ⊘ | ⊘ | ⊘ | ⊘ | ⊘ | ⊘ | ⊘ | ⊘ | ✓ |
| MAX.gov: Web-based software maintained by the Office of Management and Budget for secure collaboration among federal employees, staff, and contractors. | ✓ | ✓ | ⊘ | ✓ | ✓ | ✓ | ⊘ | ⊘ | ⊘ | ✓ |
| National Aeronautics and Space Administration (NASA) Electronic Radio Database Systems: Database and software supporting spectrum management and operations. | ⊘ | ⊘ | ⊘ | ⊘ | ⊘ | ⊘ | ✓ | ✓ | ⊘ | ⊘ |
| NASA Space Frequency Coordination Group website: Online Document repository to support civil space agency coordination. | ⊘ | ⊘ | ⊘ | ⊘ | ⊘ | ⊘ | ✓ | ⊘ | ⊘ | ⊘ |
| NASA, DOD, and Commerce spectrum coordination website: Online document repository to exchange spectrum coordination information. | ⊘ | ⊘ | ⊘ | ⊘ | ⊘ | ⊘ | ✓ | ⊘ | ⊘ | ⊘ |
| NASA Frequency Coordination Meeting website: Online document repository for information exchange among three participating civilian space agencies—NASA, JAXA (Japan), and ESA (Europe). | ⊘ | ⊘ | ⊘ | ⊘ | ⊘ | ⊘ | ✓ | ⊘ | ⊘ | ⊘ |
| am Atmospheric Model: A tool for radiative transfer calculations at microwave to sub-millimeter wavelengths. | ⊘ | ⊘ | ⊘ | ⊘ | ⊘ | ⊘ | ⊘ | ✓ | ⊘ | ⊘ |
| Softwright Terrain Analysis Package: Software that models radio-frequency propagation over terrain and other wireless analysis. | ✓ | ⊘ | ⊘ | ⊘ | ✓ | ⊘ | ⊘ | ⊘ | ⊘ | ⊘ |
| Systems Planning Engineering Evaluation Device: Software that uses 3D mapping, mission planning, and interference analysis to simulate and model degradation and interoperability issues. | ⊘ | ⊘ | ✓ | ⊘ | ⊘ | ⊘ | ⊘ | ⊘ | ⊘ | ⊘ |
| Visualyse: Commercial software for modeling and simulating radio systems, including system planning and interference analysis. | ⊘ | ✓ | ⊘ | ⊘ | ⊘ | ⊘ | ✓ | ⊘ | ⊘ | ⊘ |
| MATLAB: Commercial programming and numeric computing platform used to analyze data, develop algorithms, model complex processes, and perform large-scale computations and simulations. | ⊘ | ⊘ | ⊘ | ⊘ | ⊘ | ⊘ | ✓ | ⊘ | ⊘ | ⊘ |
| Web Frequency Coordination Request: Public-facing external web-based application developed by the Federal Aviation Administration to receive external frequency coordination requests on aviation frequencies. | ⊘ | ⊘ | ⊘ | ✓ | ⊘ | ⊘ | ⊘ | ⊘ | ⊘ | ⊘ |

✓ = Covered agency usage ⊘ = No covered agency usage

Source: GAO analysis of agency information. | GAO-22-105221

^aAgencies may also use other generic software, such as spreadsheet or messaging applications that are not included in this figure.

^bThe National Oceanic and Atmospheric Administration provided information on behalf of Commerce. (105221)