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Report to the Committee on Armed Services, House of Representatives

December 2020

ELECTROMAGNETIC SPECTRUM OPERATIONS

DOD Needs to Address Governance and Oversight Issues to Help Ensure Superiority

GAO-21-64

GAO Highlights

Highlights of GAO-21-64, a report to the Committee on Armed Services, House of Representatives

December 2020

ELECTROMAGNETIC SPECTRUM OPERATIONS

DOD Needs to Address Governance and Oversight Issues to Help Ensure Superiority

Why GAO Did This Study

According to DOD, the EMS is essential for facilitating control in operational environments and impacts operations in the air, land, sea, space, and cyber domains. The pervasiveness of the EMS across warfighting domains means that maintaining or achieving EMS superiority against an adversary is critical to battlefield success.

House Report 116-120 that accompanied a bill for the National Defense Authorization Act for Fiscal Year 2020 included a provision that GAO assess DOD's EMS strategy. This report (1) describes reported threats from peer adversaries; (2) outlines challenges to DOD's superiority in the EMS; and (3) evaluates the extent to which DOD has implemented EMS-related strategies and is positioned to achieve future goals. GAO analyzed 43 EMS studies identified through a literature review, reviewed DOD documentation, and interviewed DOD officials and subject matter experts.

What GAO Recommends

GAO is making five recommendations, including that DOD should identify processes and procedures, reform governance structures, assign leadership for strategy implementation, and develop oversight processes. DOD concurred with the first two recommendations and partially concurred with the last three recommendation. In response to these three latter recommendations, DOD stated that it will take action once the department has developed—and the Secretary of Defense has reviewed—organizational reform recommendations.

View GAO-21-64. For more information, contact Joseph W. Kirschbaum at (202) 512-9971 or kirschbaumj@gao.gov.

What GAO Found

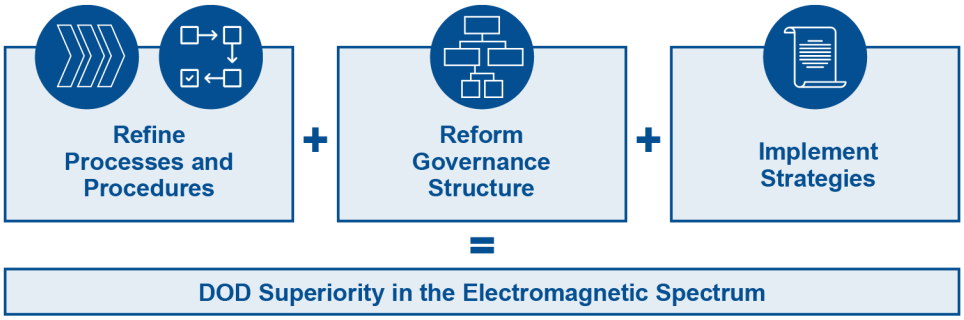
According to studies by the Department of Defense (DOD) and others, near-peer adversaries China and Russia are aware of the importance of the electromagnetic spectrum (EMS) and have taken steps to improve their capabilities to threaten DOD's ability to use and control the EMS. China is taking steps to enhance its capabilities to use the EMS through strategic, organizational, and training advances. Meanwhile, Russian electromagnetic warfare forces, described by the Defense Intelligence Agency as "world class," have demonstrated their effectiveness through successful real-world applications against U.S. and foreign militaries.

Studies by DOD and others have also highlighted internal challenges that may affect the department's ability to ensure superiority, or operational control, in the EMS. These include issues related to:

- Governance and organization,
- Technology acquisition and development,
- EMS operational concepts,
- Spectrum management, and
- Staffing and training.

DOD issued strategies in 2013 and 2017 to address EMS-related challenges, but did not fully implement either strategy because DOD did not assign senior leaders with appropriate authorities and resources or establish oversight processes for implementation. DOD issued a new strategy in September 2020, but the department risks not achieving the new strategy's goals because it has not taken key actions—such as identifying processes and procedures to integrate EMS operations (EMSO) across the department, reforming governance structures, and clearly assigning leadership for strategy implementation. Also, it has not developed oversight processes, such as an implementation plan, that would help ensure accountability and implementation of the 2020 strategy goals. Doing so would help position the department to achieve its EMSO goals (see figure).

Actions to Ensure DOD Superiority in the Electromagnetic Spectrum



Source: GAO analysis of Department of Defense (DOD) information. | GAO-21-64

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Abbreviations

CIO	Chief Information Officer
CFT	Electromagnetic Spectrum Operations Cross-Functional Team
DOD	Department of Defense
EMS	Electromagnetic Spectrum
EMSO	Electromagnetic Spectrum Operations
EW	Electromagnetic Warfare

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December 10, 2020

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

According to the Department of Defense (DOD), without control of the electromagnetic spectrum (EMS)—the natural range of frequencies that support various warfighting functions such as communications, navigation, and weapons usage—DOD risks losing control of the battlefield. DOD conducts specific EMS operations (EMSO)—such as electromagnetic warfare (EW)—but also relies on the EMS for many other uses even as these operations have placed increasingly complex demands on the spectrum.[1] The department's operations in all domains—air, land, sea, space, and cyber—depend on the ability to use and control the EMS. However, technological advances could result in EMS-dependent capabilities being among the first to be targeted in a conflict. According to DOD, adversaries have perceived that the department's reliance on the EMS makes its operations vulnerable. Similarly, a congressional defense task force reported that the EMS-dependent GPS could be a single point of failure for the United States military.[2] Both DOD and the same congressional defense task force have recognized that the United States has not kept full pace with adversaries.[3] For example, according to DOD and independent studies, China and Russia have invested decades in developing capabilities that could degrade DOD's

[1]DOD defines EMSO as coordinated military actions to exploit, attack, protect, and manage the electromagnetic environment. For the purposes of this report, we refer to electromagnetic warfare and its sub-categories as being EMS-related. In 2020, DOD replaced the term "electronic warfare" with the term "electromagnetic warfare." For consistency purposes, we use the updated term except when referring to formal titles that have not changed.

[2]House of Representatives Armed Services Committee, *Future of Defense Task Force Report* (Sept. 23, 2020)

[3]Department of Defense, *The DOD Electronic Warfare Strategy* (2017) (FOUO), and House of Representatives, *Future of Defense Task Force Report*.

operations and affect superiority in the EMS, cyber operations, and other elements of the information environment.[4]

DOD issued EMS-related strategies in 2013 and 2017 and established a working group to position the department for improvements. Further, in September 2020, DOD issued a new EMS strategy to update and consolidate the earlier two. However, as articulated by multiple DOD officials, the department is at a pivotal moment in its ability to address significant EMS management issues. The House Committee on Armed Services has also raised questions about DOD's EMS capabilities in recent years.[5] For example, in the John S. McCain National Defense Authorization Act for Fiscal Year 2019 (hereafter the FY19 NDAA) Congress required DOD to undertake several reforms related to the department's ability to conduct EMSO.[6] The committee reiterated concerns about adversary capabilities and potential threats to DOD's use of the EMS in its September 2020 *Future of Defense Task Force Report.*

For almost 20 years, we have reported on EMS-related threats to DOD operations, DOD's EMS capabilities and ability to compete in the information environment, and U.S. spectrum management.[7] For example, in October 2019, we reported on challenges with how DOD oversees and integrates information-related capabilities, including EMS-related capabilities.[8] We made five recommendations to DOD to improve how it integrates these types of capabilities into operations. In October 2020, the Secretary of Defense designated a Principal Information Operations Advisor and created a temporary cross-functional team to support the advisor. DOD also described future actions that, if taken, will address the intent of some of our recommendations, including conducting a posture

[4]DOD defines EMS superiority as control in the EMS that permits the conduct of operations at a given time and place without prohibitive interference, while affecting an adversary's ability to do the same.

[5]See, for example, H.R. Rep. No. 115-676 at 187 (2018) and H.R. Rep. No. 116-120 at 69 (2019).

[6]Pub. L. No. 115-232, § 1053 (2018).

[7]See Related GAO Products at end of this report for list of EMS-related reports we have issued.

[8]GAO, *Information Operations: DOD Should Improve Leadership and Integration Efforts,* GAO-20-51SU, (Washington, D.C.: Oct. 18, 2019).

review and overseeing implementation of a new strategy for operations in the information environment.

In addition, in August 2019, we reported on the Army's activation of EMS-related units and found that the Army had not fully assessed risk related to the units' activation and was, as a result, experiencing staffing, equipping, and training challenges.[9] We made three recommendations to the Army that it assess these risks. As of September 2020, the Army has conducted risk assessments for two of its new EMS-related units—a Cyber Warfare Support Battalion and an Intelligence, Cyber, EW, and Space detachment—and was in the process of creating those units. In December 2018, we identified both EMS-related weapons and adversaries' EMS capabilities as emerging threats to U.S. national security.[10] We also issued a report about DOD's management and oversight of EW in 2012.[11]

A House report accompanying a bill for the National Defense Authorization Act for Fiscal Year 2020 included a provision that we assess DOD's EMSO.[12] This report (1) describes the reported threats DOD faces from its peer adversaries; (2) outlines the challenges that DOD and other organizations have identified that may affect DOD's ability to ensure superiority in the EMS; and (3) evaluates the extent to which DOD has implemented prior EMS-related strategies and is positioned to achieve the goals of the 2020 strategy.

For this report, we reviewed only unclassified documents because of effects to government operations related to the coronavirus disease 2019 (COVID-19). We interviewed DOD subject matter experts and verified that classified information could provide additional details, but would not significantly change our findings and conclusions.

[9]GAO, *Future Warfare: Army Is Preparing for Cyber and Electronic Warfare Threats, but Needs to Fully Assess the Staffing, Equipping, and Training of New Organizations*, GAO-19-570 (Washington, D.C.: Aug. 15, 2019).

[10]GAO, *National Security: Long-Range Emerging Threats Facing the United States as Identified by Federal Agencies*, GAO-19-204SP (Washington, D.C.: Dec. 13, 2018).

[11]GAO, *Electronic Warfare: DOD Actions Needed to Strengthen Management and Oversight*, GAO-12-479 (Washington, D.C.: July 9, 2012).

[12]H.R. Rep. No. 116-120 at 69 (2019).

For objective one, we performed a literature search to identify and analyze 43 independent assessments, reviews, and studies (hereafter, studies) published from January 2010 through April 2020 issued by DOD, performed on behalf of DOD by organizations such as RAND and the Institute for Defense Analyses, and independent organizations including our prior reports and Congressional Research Service reports.[13] Of these 43 studies, 26 were unclassified DOD and independent studies related to China and Russia's EMS capabilities. For the literature search, we identified key words related to EMS based on DOD doctrine and guidance—such as "electromagnetic spectrum related threat," "electromagnetic spectrum operations," "electronic warfare," "near-peer threats," etc.—and searched for sources that used those terms. We limited our search results to conference papers, scholarly materials and dissertations from military graduate schools, government reports, think tank publications, and legislative materials, such as hearing transcripts. To help ensure we identified relevant studies, we provided DOD the list of studies from our literature review and asked DOD to identify any additional studies they believed would provide us additional information about threats from near-peer adversaries. We also obtained studies from DOD components such as U.S. European Command and U.S. Indo-Pacific Command. The specific studies we identified and used can be found in appendix I.

We also reviewed documentation issued by the Chinese government and provided by U.S. Indo-Pacific Command and other reporting that uses Chinese source documents that describe the goals and intents of the Chinese government. Further, we obtained and analyzed studies sponsored by the Estonian Ministry of Defense and a Ukrainian military official about Russia's demonstrated EMS actions and capabilities. We evaluated the information from the studies for relevant information, and identified examples of EMS threats to the U.S. from China and Russia. As part of our analysis of these studies, we identified three areas where near-peers adversaries are focusing their efforts—recognizing the importance of EMSO-related issues in military strategy, organizing and training military units to focus on and conduct EMSO, and developing EMSO-related capabilities. Because we were restricted to reviewing unclassified documents due to COVID-19 effects on government operations, we were unable to analyze classified details regarding DOD's EMS capabilities or the department's responses to counter China's and

[13]For our literature review, we searched databases such as ProQuest, Scopus, EBSCO, and the Defense Technical Information Center.

Russia's EMS capabilities. Instead, we requested and received verification from DOD subject matter experts that our unclassified analysis was accurate.

For objective two, we obtained and analyzed 32 unclassified DOD and independent studies identified through the literature review described above. Of these 32 studies, 15 were also reviewed as part of our previously described analysis of EMS threats from China and Russia, while the other 17 were not part of that analysis. To help ensure we identified all relevant studies, we provided DOD the list of studies we identified during our literature review and asked DOD to identify any additional studies they believed would provide us additional information about the department's EMSO challenges. We also requested and received studies from the office of the DOD Chief Information Officer (CIO), the EMSO Cross-Functional Team (CFT), Joint Staff, U.S. European Command, U.S. Indo-Pacific Command, and U.S. Strategic Command. Given that our objective was to identify challenges DOD and others have reported, we did not independently validate the findings from the studies. DOD officials told us that classified documents and studies could provide additional context for DOD's responses to the EMS-related challenges these studies identified, but changes in government operations due to COVID-19 limited our ability to review classified information. In lieu of conducting classified research and independently validating the findings from the studies, we provided DOD subject matter experts with our overall analysis of the challenges from the studies. These subject matter experts concurred with our overall analysis.

We used a data collection instrument to collect and analyze the studies' focus, key findings, and recommendations (when applicable). For each study, one analyst independently reviewed and assessed information for each study using a structured data collection instrument. A second analyst reviewed the data collection instrument, comparing it to the original study, verifying the instrument's accuracy, and adding any additional information the second analyst deemed necessary. We then entered the contents of the data collection instruments in a database. We analyzed the information to identify common themes and content, and synthesized results into general categories of challenges. Information on the studies and their EMS-related recommendations for DOD can be found in appendix II. In addition to our analysis of the studies, we met with and collected information from officials from the CIO, the CFT, Joint Staff, and U.S. Strategic Command.

For objective three, we obtained and analyzed an additional 66 unclassified DOD strategy, policy, and doctrine documents for DOD EMSO that applied department-wide or to specific DOD components, including the military services, to understand what documentation guides EMS-related activities. DOD components told us they have additional classified strategy, policy, and doctrine documents, but we did not review those and focused our work on DOD's actions related to the unclassified documents. We used a data collection instrument for each document to determine its topic, objectives, and recommendations (when applicable), and compared these unclassified documents to identify commonalities and differences. We also obtained and analyzed information related to DOD's implementation of its department-wide EMS-related strategies from 2013 and 2017.

To evaluate the extent to which DOD is positioned to achieve the goals of the 2020 strategy, we compared the steps and actions DOD has taken to leading practices for sound strategic management planning, which identified key elements for implementing strategy.[14] We met with and collected information from officials whose organizations had responsibilities for the 2013 and 2017 strategies, including the CIO, the Under Secretary of Defense for Acquisition and Sustainment (representing the EW Executive Committee), the Defense Spectrum Organization, and the CFT. We obtained and analyzed four draft versions of DOD's 2020 EMS strategy as well as the final September 2020 strategy, and interviewed officials from the CFT, CIO, Joint Staff, and Office of the Undersecretary of Defense for Acquisition and Sustainment about the intended purpose of the strategy and DOD's plans for implementing it. In addition, we reviewed DOD's actions regarding the EMS-related strategies in light of our prior work on other DOD strategies, such as DOD's cyber strategy.

In addition, to assess whether DOD had taken actions to position itself to implement the new 2020 strategy, we analyzed DOD's enactment of congressional EMSO reforms from Section 1053 of the FY19 NDAA. For

[14]We used all the key elements identified in GAO, *Military Readiness: DOD Needs to Incorporate Elements of a Strategic Management Planning Framework into Retrograde and Reset Guidance*, GAO-16-414 (Washington, D.C.: May 13, 2016). This report drew upon other prior work on leading practices for sound strategic management planning, including: GAO, *Managing for Results: Critical Issues for Improving Federal Agencies' Strategic Plans*, GAO/GGD-97-180 (Washington, D.C.: Sept. 16, 1997; and GAO, *Defense Logistics, Actions Needed to Improve the Marine Corps' Equipment Reset Strategies and the Reporting of Total Reset Costs*, GAO-11-523 (Washington, D.C.: Aug. 4, 2011).

this analysis, we obtained and analyzed information from the CFT, CIO, and U.S. Strategic Command about actions DOD has taken or identified as potential actions that might address the statute's provisions. We interviewed officials from all of these components to obtain additional information and perspective. We compared this information to the content DOD included in its September 2019 and July 2020 reports to Congress about the department's progress in implementing the statutory provisions.

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

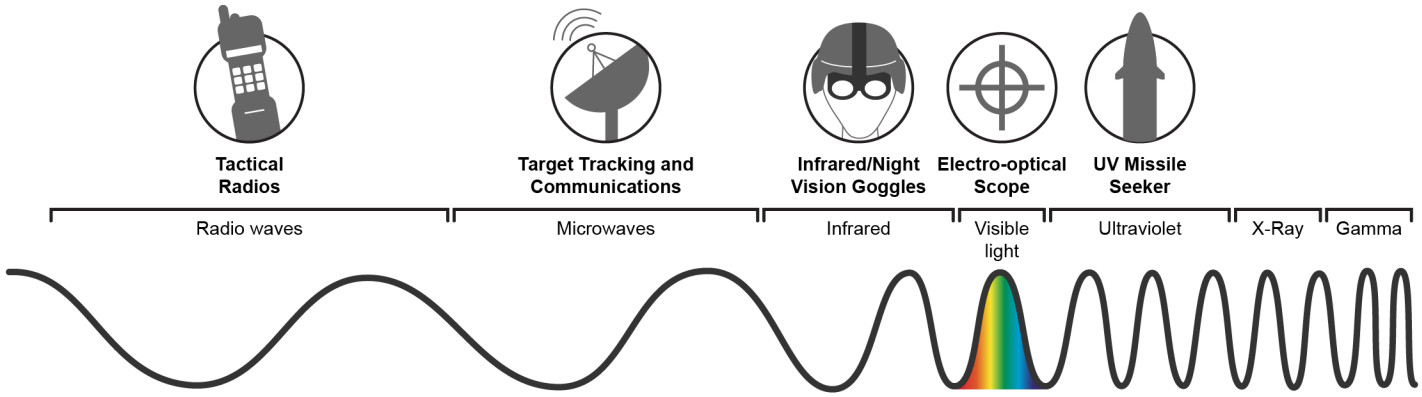
Background

Overview of the Electromagnetic Spectrum, Military Uses, and EMS Superiority

The EMS is the range of all frequencies of electromagnetic radiation that consist of oscillating electric and magnetic fields characterized by frequency and wavelength and subdivided into frequency bands. The EMS is governed by physics, influenced by technology, and a common medium depended upon by society.

There are a number of applications that use the EMS. For example, use of the spectrum includes AM and FM radio transmissions, position, navigation and timing applications, and supporting networks for mobile phones. DOD considers the EMS "a maneuver space" that is essential for facilitating control within the operational environment and where U.S. forces compete with adversaries as well as neutral parties for access and control. DOD uses the EMS to support a range of applications such as tactical radios, target tracking, and night-vision goggles, among other uses (see figure 1).

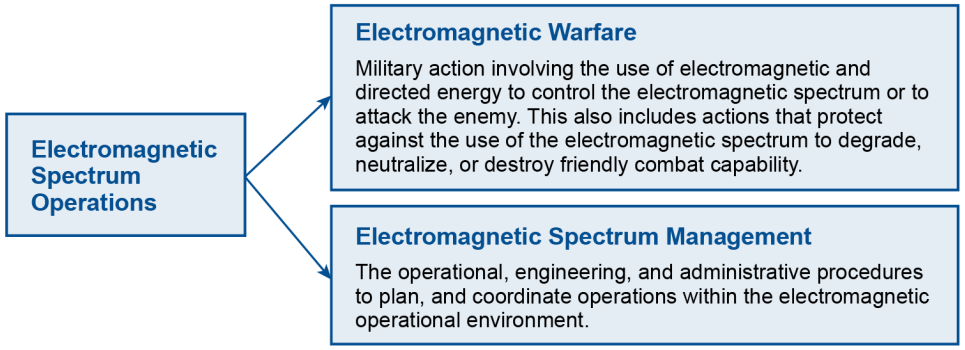
Figure 1: The Electromagnetic Spectrum and Department of Defense Applications



Source: GAO analysis based on Department of Defense information. | GAO-21-64

DOD defines EMSO as coordinated military actions to exploit, attack, protect, and manage the electromagnetic environment.[15] As shown in figure 2, EMSO includes EW (i.e., the use of electromagnetic and directed energy to control the electromagnetic spectrum or to attack adversaries) and electromagnetic spectrum management.

Figure 2: Electromagnetic Spectrum Operations Are Composed of Two Coordinated Efforts



Source: GAO analysis of Department of Defense information. | GAO-21-64

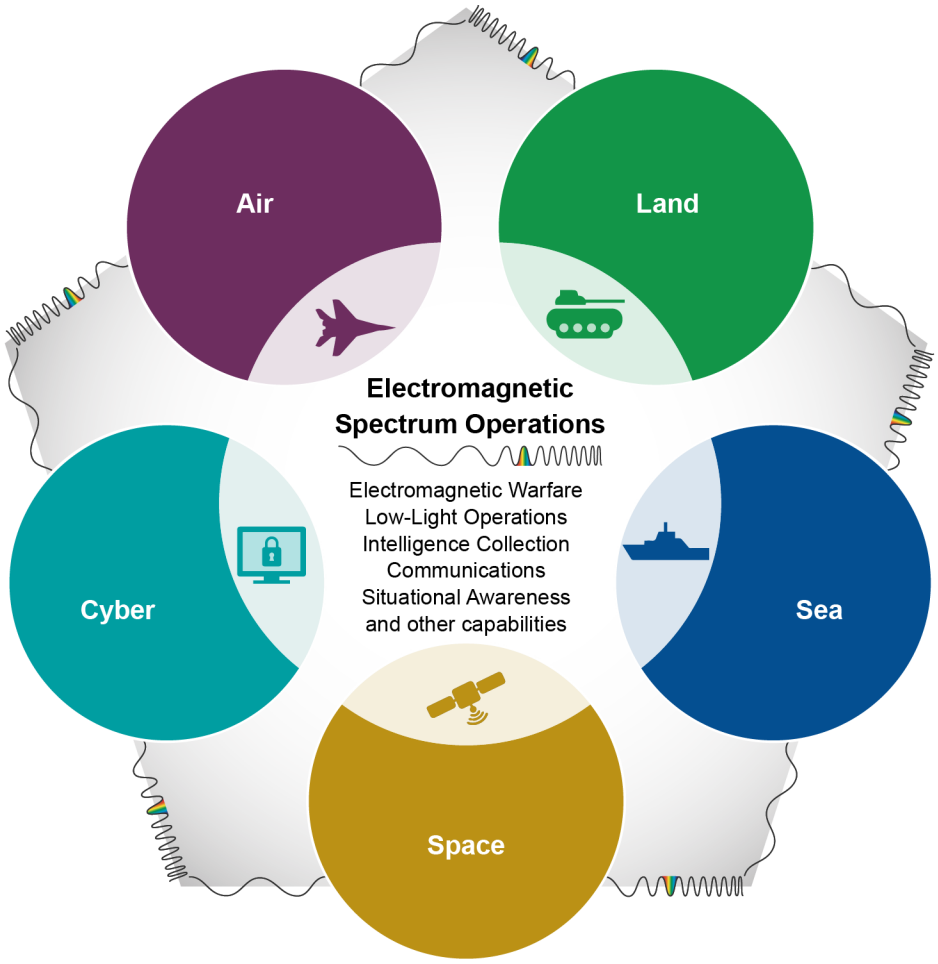
[15]Chairman of the Joint Chiefs of Staff, Joint Publication 3-85, *Joint Electromagnetic Spectrum Operations* (May 22, 2020).

According to DOD, the EMS is essential for facilitating control within the operational environment and impacts all domains—air, land, sea, space and cyber—and portions of military operations. Thus, according to DOD, it needs to control the spectrum to support warfighting functions or it risks losing control of the battlespace.[16] Other military capabilities across warfighting domains require use of the electromagnetic spectrum. These include such things as signals intelligence on adversary transmissions, information operations that affect adversary decision-making, and command and control functions that link communications between U.S. forces (see figure 3). DOD has testified on the importance of the electromagnetic spectrum and highlighted threats from potential adversaries, such as China and Russia.[17]

[16]For example, we have previously reported that communications with friendly forces and the detection, identification, and targeting of enemy forces, among other tasks, rely upon DOD's ability to remain superior and operate unhindered in the EMS. GAO-12-479.

[17]For example, during testimony in March 2018 before the Committee on Senate Armed Services, U.S. Indo-Pacific Command leadership discussed actions China has taken to degrade or deny other countries use of the electromagnetic spectrum and their pursuit of counter-space, directed energy and jamming capabilities among other areas. *Pacific Command Budget, Before S. Comm. On Armed Services,* 115th Cong. (2018) (statement of Admiral Harry B. Harris Jr., U.S. Navy Commander U.S. Indo-Pacific Command).

Figure 3: DOD's Use of the Electromagnetic Spectrum across Warfighting Domains



Source: GAO analysis of Department of Defense (DOD) information. | GAO-21-64

The pervasiveness of the EMS across all warfighting domains means that ensuring superiority against an adversary is critical to battlefield success. DOD defines EMS superiority as control in the electromagnetic spectrum that permits the conduct of operations at a given time and place without prohibitive interference, while affecting an adversary's ability to do the same.[18] Furthermore, according to DOD, freedom of maneuver and action

[18]Chairman of the Joint Chiefs of Staff, Joint Publication 3-85.

within the EMS are essential to U.S. and multinational operations to achieve tactical, operational, and strategic advantage.

DOD Organizational Responsibilities for EMSO

Within DOD, multiple components have roles and responsibilities related to EMSO and enabling EMS superiority. The secretaries of the military departments are responsible for training and equipping forces for EMSO and geographic combatant commands are responsible for including joint and coalition use of the EMS in operational planning. The following officials and components have department-wide EMS responsibilities:

- The CIO reports directly to the Secretary of Defense and is the principal staff assistant responsible for matters related to the EMS, including responsibility for spectrum management, among other things.[19] This role includes responsibilities for providing DOD policy, oversight, and guidance for all EMS-related matters, and leading DOD's management and use of the EMS.
- The Under Secretary of Defense for Acquisition and Sustainment is the principal staff assistant responsible for issues related to EMS-dependent system acquisition and sustainment. This role includes responsibility for overseeing the acquisition of EW major defense acquisition programs and EW capabilities of other major defense acquisition programs. The Under Secretary is also responsible for publishing plans and procedures to guide interoperability of EW systems with other spectrum-dependent systems to include smaller EW programs and rapid acquisition capabilities, in coordination with the CIO.[20] The Office of the Under Secretary of Defense for Acquisition and Sustainment is responsible for coordinating the DOD EW Executive Committee, as discussed below.[21]
- The Secretary of Defense established the CFT consistent with sections 918 and 1053(c) of the John S. McCain NDAA for Fiscal

[19]10 USC § 142 (b)(1)(F) and Department of Defense Directive 5144.02, *DOD Chief Information Officer (DOD CIO)* (Nov. 21, 2014) (incorporating change 1, Sept. 19, 2017).

[20]Department of Defense Directive 3222.04, *Electronic Warfare (EW) Policy*, (Mar. 26, 2014) (incorporating change 2, Aug. 31, 2018).

[21]Additionally, the Under Secretary of Defense for Research and Engineering is responsible for establishing DOD policies on, and supervision of, research and engineering of EMS-dependent systems for operations in electromagnetic environments, and the Director, Operational Test and Evaluation is responsible for issuing guidance and procedures for testing of EMS-dependent system operational effectiveness, operational suitability, and survivability within electromagnetic environments.

Year 2019 (FY19 NDAA).[22] The CFT is responsible for 1) identifying EMSO gaps in capability, capacity, personnel, training, experimentation, and resourcing; 2) identifying requirements and plans to address these gaps; 3) developing a roadmap with plans to address the gaps; and 4) updating the EW strategy, among other things.[23] The Vice Chairman of the Joint Chiefs of Staff is responsible for overseeing the CFT.

- The EW Executive Committee was established in 2015 in response to a Defense Science Board recommendation.[24] In establishing the committee, the Deputy Secretary of Defense directed the committee to focus on EW strategy, acquisition, operational support and security (EW, as previously described, is a subset of EMSO.) This high-level committee—co-chaired by the Under Secretary of Defense for Acquisition and Sustainment and the Vice Chairman of the Joint Chiefs of Staff—is responsible for providing senior oversight, budget harmonization, and advice on EW to DOD senior leaders. The committee also transferred some responsibilities, such as the EW strategy implementation, to the CFT upon the CFT's formation.
- The Vice Chairman of the Joint Chiefs of Staff, in addition to co-chairing the EW Executive Committee and overseeing the CFT, is responsible for overseeing implementation of the 2017 DOD EW strategy.[25]
- U.S. Strategic Command, according to DOD's EMS enterprise policy that was issued in September 2020, has the responsibility for coordinating with other DOD component heads to identify and prioritize joint EMSO requirements, establishing and maintaining a joint EMSO organization, assisting the combatant commands and military departments in planning, executing, and assessing joint EMSO across all domains, and designating representatives to

[22]Pub. L. No. 115-232, §§ 918 and 1053 (2018).

[23]Department of Defense, Secretary of Defense Memorandum, *Establishment of the Electromagnetic Spectrum Operations Cross Functional Team* (Feb. 2, 2019).

[24]Department of Defense, Defense Science Board, *21st Century Military Operations in a Complex Electromagnetic Environment* (July 2015).

[25]Department of Defense, Secretary of Defense Memorandum, *Establishment of the Electromagnetic Spectrum Operations Cross Functional Team*.

participate in the EW Executive Committee for capabilities developed for EMS-related activities.[26]

Overview of DOD EMS Strategies

Since 2013, DOD has issued three department-wide strategies related to the EMS. All three of these strategies provide direction—goals and objectives—to help DOD address and improve EMS-related challenges, such as focusing the department on increasing capabilities, training forces for operations, and organizing governance to remain superior in the EMS.

- **2013 Strategy, *Department of Defense EMS Strategy: A Call to Action*.** This strategy stated the department needed to "act now to ensure access to the congested and contested electromagnetic environment of the future."[27] The strategy presented a framework for how DOD should rapidly adapt to the changing spectrum environment and to assess and respond to spectrum regulatory changes. It emphasized advancing promising spectrum-dependent technologies, along with improving the integration of DOD spectrum activities, improving the ability to assess and respond to spectrum regulatory changes, and addressing associated policy and governance.
- **2017 Strategy, *The DOD Electronic Warfare Strategy*.** This strategy directed the DOD EW enterprise to deliver decisive capability advantages by organizing, training, and equipping forces to be offensively focused, poised to gain and ensure EMS superiority, and unified in their efforts.[28] DOD issued this strategy after a Defense Science Board report highlighted the insufficient attention paid to EW by all services at all levels for over two decades—an approach, according to the strategy, that would not work for the future.[29]
- **2020 Strategy, *Department of Defense Electromagnetic Spectrum Superiority Strategy*.** This strategy consolidates and updates the previous two strategies into a strategy that embraces an enterprise

[26]Department of Defense Directive 3610.01, *Electromagnetic Spectrum Enterprise Policy* (Sept. 4, 2020).

[27]Department of Defense, *Department of Defense Electromagnetic Spectrum Strategy: A Call to Action* (Sept. 11, 2013).

[28]Department of Defense, *The DOD Electronic Warfare Strategy* (2017) (FOUO).

[29]Department of Defense, Defense Science Board, *21st Century Military Operations in a Complex Electromagnetic Environment* (July 2015).

approach to ensure EMS superiority.[30] According to the strategy, it also aligns DOD EMS activities to the objectives of the 2017 National Security Strategy, the 2018 National Defense Strategy, and national economic and technology policy goals.[31] DOD issued this strategy in September 2020.

Studies That We Reviewed Reported China and Russia Have Taken Steps to Challenge U.S. Control of the EMS

While DOD recognizes the importance of EMS superiority in a joint warfighting environment, so too have potential near-peer adversaries, China and Russia, that have taken steps to improve their ability to use the EMS during conflict. These steps, based on the studies we reviewed, include (1) strategy development, (2) using EMS-dependent capabilities in training and combat settings, and (3) developing specific capabilities.

Studies Reported That China Has Incorporated EMS Dominance as a Key Enabler against the United States

First, in 2019, a DOD report to Congress that addresses Chinese military strategy highlighted that Chinese leadership believes that information dominance in the electromagnetic spectrum and denying its use to adversaries is necessary to take and maintain an advantage in combat.[32] The report also found that China is focusing on defending against long-range attack from forces that seek to challenge China in the Pacific Ocean and developing electromagnetic and information-domain capabilities, among other areas.

Drawing heavily on Chinese source documents, a 2018 RAND study further characterized China's strategic military approach as one that emphasizes "comprehensive dominance" in traditional domains (air, land, and sea) as well as space, cyber, psychological warfare, and the

[30]Department of Defense, *Department of Defense Electromagnetic Spectrum Superiority Strategy* (Sept. 28, 2020).

[31]The strategy refers to the White House, *National Security Strategy of the United States* (December 2017); Department of Defense, *Summary of the 2018 National Defense Strategy of the United States of America* (2018); White House, *Presidential Memorandum on Developing a Sustainable Spectrum Strategy for America's Future* (Oct. 25, 2018).

[32]Department of Defense, Office of the Secretary of Defense, *Annual Report to Congress: Military and Security Developments Involving the People's Republic of China 2019* (May 2, 2019).

electromagnetic spectrum.[33] The study notes that dominance across domains is framed by Chinese military theory that victory is predicated on successfully waging "system destruction warfare" to paralyze or destroy an enemy's systems.[34] The theory further contends that integrated combat forces should be used in system versus system operations that feature information dominance, precision strikes, and joint operations, according to the RAND study.

China's words and actions indicate they are moving beyond the theoretical to the practical. In a 2019 report to Congress, DOD noted that Chairman Xi Jinping has articulated a strategic vision to create a force that dominates all networks, uses information operations to control a conflict in its early stages, and that enables China's ability to perform in the electromagnetic spectrum as part of joint military operations.[35] The DOD report also recognized China's strategic vision by noting that China emphasizes EW dominance by suppressing, degrading, disrupting, or deceiving enemy electronic equipment. This includes targeting adversary systems that operate in radio, radar, microwave, infrared, and optical frequency ranges, as well as computer and information systems.

Second, China has taken steps toward the realization of that strategic vision. Specifically, China has formed new military units, such as the People's Liberation Army Strategic Support Force, to achieve dominance of the EMS, according to the RAND and Institute for National Strategic Studies reports.[36] This effort involves centralizing space, cyber, EW capabilities and potentially psychological warfare. A 2019 Center for Strategic and Budgetary Assessments study found China has also begun to practice, evaluate, and improve the use of EMS-related capabilities through training events where units jam or confuse communications, sensors, and satellite navigation systems and conduct anti-jamming

[33]RAND Corporation, *Systems Confrontation and System Destruction Warfare: How the Chinese People's Liberation Army Seeks to Wage Modern Warfare* (Santa Monica, CA: 2018).

[34]RAND Corporation, *Systems Confrontation and System Destruction Warfare.*

[35]Department of Defense, Office of the Secretary of Defense, *Annual Report to Congress: Military and Security Developments Involving the People's Republic of China 2019* (May 2, 2019).

[36]RAND Corporation, *Systems Confrontation and System Destruction Warfare.* Costello, John and Joe McReynolds. Center for the Study of Chinese Military Affairs, Institute for National Strategic Studies, National Defense University. *China's Strategic Support Force: A Force for a New Era.* (Washington, D.C.: 2018).

operations.[37] According to DOD, these types of exercises test understanding of EW weapons, equipment, and performance, and also enable users to improve confidence in their ability to operate effectively in a complex electromagnetic environment as well as test and validate EW weapons.

Third, China can use a range of EMS-related applications to challenge other militaries. For example, a 2019 Defense Intelligence Agency report identified that China is acquiring technologies to improve counter-space capabilities.[38] According to the report, this includes the development of anti-satellite capabilities, including research and development of directed-energy weapons and satellite jammers, and an antisatellite missile system that it tested in July 2014. The Defense Intelligence Agency also found that Chinese electronic countermeasure units are equipped with a range of modern, ground-based EW systems capable of targeting large portions of the electromagnetic spectrum. These units use high, very high, and ultra-high frequency, radar, and unmanned aerial vehicle jamming systems to support forces. According to a draft U.S. Indo-Pacific Command report, China has worked toward developing improved capabilities through a combination of increased spending and the theft of technologies across more than two decades.[39]

Russia Has Developed "World Class" EMS Capabilities According to Studies We Reviewed

First, a 2019 Defense Intelligence Agency assessment of Russian military strategy and capabilities describes Russia's EW forces as "world-class," and in coordination with traditional military means, capable of destroying adversary command, control, communications, and intelligence capabilities.[40] According to a 2019 RAND study, Russia has made significant investments in EW and delivered advanced systems to ground

[37]Clark, Bryan, Whitney Morgan McNamara, and Timothy A. Walton. Center for Strategic and Budgetary Assessments. *Winning the Invisible War: Gaining an Enduring U.S. Advantage in the Electromagnetic Spectrum.* (Washington, D.C.: 2019). This report was prepared at the request of the Defense Technical Information Center.

[38]Department of Defense, Defense Intelligence Agency, *China Military Power: Modernizing a Force to Fight and Win,* DIA-02-1706-085 (2019).

[39]According to a draft DOD report, Chinese military investment grew 620 percent between 1996 and 2015. Combined with the theft of technology, China has rapidly narrowed military disparities with the United States. Department of Defense, U.S. Indo-Pacific Command, *Spinning a Better Kill Web: Preparing the Joint Force to Counter Chinese Networked Warfare* (April 2, 2020) (Draft).

[40]Department of Defense, Defense Intelligence Agency, *Russian Military Power: Building a Military to Support Great Power Aspirations*, DIA-11-1704-161 (2017).

forces that are intended to jam Very High Frequency radio and GPS.[41] A report sponsored by the Estonian Ministry of Defense, a North Atlantic Treaty Organization member, found that Russian ground forces have built EW into their brigade structure, which means that the Russian Ground Forces do not move or conduct operations without EW support.[42] The report also found that advances in EW will allow Russian forces to jam, disrupt and interfere with North Atlantic Treaty Organization member communications, radar, unmanned aerial vehicles and other assets. Furthermore, the report concluded that Russia may view the EMS as an area of weakness for North Atlantic Treaty Organization members and that changes to policy, capabilities, organization and training, among other areas, are needed to take the initiative if conflict occurs.

Second, Russian forces may be benefiting from a significant increase in training and experience. According to a 2017 Center for Strategic and Budgetary Assessments report, that experience has been gained from real-world operations where forces in Ukraine and Syria have gained practical experience in EW, leading to improvements in Russia's ability to command the EMS.[43] For example, a Ukrainian military official noted that Russia was able to successfully jam GPS and cellular communications as well as perform electromagnetic attacks on communications devices in eastern Ukraine. The Congressional Research Service has noted that EW in Syria against U.S. forces was very aggressive and that communications systems were routinely knocked down.[44]

Third, Russia may also be one of the best perpetrators of electromagnetic counter-space warfare according to a 2020 Center for Strategic and International Studies assessment on space threats. Russia's counter-space warfare capabilities were noted by the assessment to include jamming and imitating satellite signals in conflict zones, nearby territories,

[41]RAND Corporation, *The Future of the Russian Military: Russia's Ground Combat Capabilities and Implications for U.S.-Russia Competition* (Santa Monica, CA: 2019).

[42]McDermott, Roger N. International Center for Defense and Security, *Russia's Electronic Warfare Capabilities to 2025: Challenging NATO in the Electromagnetic Spectrum* (Tallinn, Estonia: September 2017).

[43]Center for Strategic and Budgetary Assessments, *Recognizing the Electromagnetic Spectrum as an Operational Domain* (Dec. 22, 2017). The report was prepared at the request of the Department of Defense, Office of the Secretary of Defense Acquisition, Technology and Logistics.

[44]Congressional Research Service, *U.S. Airborne Electronic Attack Programs: Background and Issues for Congress* (May 14, 2019).

and within its own borders.[45] The center's 2019 report from the previous year highlighted several space-related threats emanating from Russia to include directed energy weapons, electromagnetic pulse weapons, and radio frequency jamming.[46] However, according to a Center for Strategic and Budgetary Assessments report, despite these technological advancements, the Russian military faces significant challenges in fielding next generation EMS technologies and training personnel to operate them due to an aging, corrupt, and inefficient industrial base and a force that is dependent on conscripts.[47]

DOD officials from multiple components told us they recognize the importance of the EMS in a potential conflict, and that China and Russia have spent decades improving their EMS capabilities. The officials stated that the department is taking steps in response to the threats that China and Russia could pose, but could not provide details at an unclassified level. However, the officials stated that DOD's 2020 EMS strategy provides an opportunity to address how the department considers and manages the EMS given adversaries' advances.

DOD and Other Organizations Have Identified Multiple Challenges to Ensuring DOD's EMS Superiority

DOD officials told us that EMS-related challenges have been studied extensively for more than a decade, and we identified 32 unclassified studies that described such challenges.[48] More than half of these studies were published or commissioned by DOD—including studies by the Institute for Defense Analysis and the Center for Strategic and Budgetary Assessments—while others included our prior reports and Congressional Research Service reports. DOD officials we interviewed echoed many of the same challenges the studies covered, such as challenges related to DOD's EMS governance, outdated EMS capabilities, increased congestion and competition in the spectrum, and shortages of staff with

[45]Center for Strategic and International Studies, The Aerospace Security Project, *Space Threat Assessment 2020* (Washington D.C.: March 2020).

[46]Center for Strategic and International Studies, *Space Threat Assessment 2019.*

[47]Clark, Bryan, Whitney Morgan McNamara, and Timothy A. Walton. *Winning the Invisible War*.

[48]See Appendix I for the full list of studies we reviewed, and Appendix II for a list of the studies' recommendations. We reviewed only unclassified documents because of the effects on government operations related to the coronavirus disease 2019 (COVID-19). We interviewed DOD subject matter experts to verify that classified information would not change our findings and conclusions.

EMS expertise, among others. The studies stated that the challenges, if not addressed, could undermine DOD's competiveness in the EMS.

- **Dispersed governance of the EMS:** Responsibilities for the EMS are dispersed throughout DOD, involving many different DOD components, according to the studies we reviewed and officials' statements in interviews. Specifically, DOD policy and other guidance documents place responsibilities for EMS-related issues with various officials: the CIO, Under Secretary of Defense for Acquisition and Sustainment, multiple Joint Staff directorates, U.S. Strategic Command, the CFT, EW Executive Committee, the military services, and the Vice Chairman of the Joint Chiefs of Staff.

  DOD officials from multiple offices with EMS duties identified a lack of central coordinating authority as a major challenge to effective EMS governance. An official from the CFT said that EMS-related duties are spread across the department and there is a need for a DOD official that can be held responsible for EMS issues. Multiple studies pointed out this issue, with the Institute for Defense Analysis stating "the multiplicity of accountable officials and organizations means that, in practice, nobody is accountable for addressing the EMS as a whole and the Secretary has nowhere to turn for decisive action."[49]

- **Full-time responsibilities are located at lower organizational levels:** In a September 2019 report to Congress, DOD stated that initial studies of the department's organizational structure, staffing, and authorities found that the Office of the Secretary of Defense is challenged by a lack of a full-time position at a high enough rank level to provide overall guidance and unity of effort across the department.[50] While there are multiple senior-level leaders, such as general or flag officers, who focus on daily operations in the physical domains (air, land, sea, and space) and cyber domain—domains that are dependent on the EMS—DOD identified only one full-time one-star general officer serving as a branch chief to focus on department-wide EMSO.[51]

[49]Institute for Defense Analysis, *Independent Assessment of EMS Enterprise Organizational Alternatives,* (Alexandria, VA.: 2019), 4.

[50]Department of Defense, *Report on FY 2019 NDAA Section 1053: Guidance on the Electronic Warfare Mission Area and Joint Electromagnetic Spectrum Operations* (Sept. 30, 2019).

[51]In addition, there is a one-star general officer that serves as the Deputy Director of the CFT, a temporary organization.

In addition, senior-level DOD officials responsible for department-wide EMS management are assigned many non-EMS-related responsibilities. For example, the Vice Chairman of the Joint Chiefs of Staff, a four-star general officer, is DOD's Senior Designated Official for the CFT, but has numerous other responsibilities. Those who focus on EMS-related issues full-time are most often located at lower organizational levels within DOD. For example, although the CIO has responsibility for advising the Secretary of Defense on EMS matters as the principal staff assistant for EMS, the highest-ranking position we found in CIO primarily focused on EMS was vacant from 2018 through November 2020, according to a CIO official. According to a CIO organizational chart, it is supposed to be a Senior Executive Service position, but DOD had a temporary Acting Director at the O-6 level during those two years.

- **Outdated capabilities:** Our 2012 report on airborne electronic attack acquisitions, as well as a study by the Center for New American Security and an internal DOD assessment, stated that some of DOD's EMS-related technology is outdated, and DOD's acquisition process may hinder the fielding of innovative technology.[52] These studies reported that DOD is using legacy systems, or is modernizing outdated systems, instead of innovating new technologies. Some capabilities remain fundamentally unchanged in design since they were fielded decades ago and studies cautioned that some systems are facing technical obsolescence and operational stresses.

  Several studies offered recommendations for areas of innovation to address some of these gaps, such as leveraging advances in artificial intelligence to enable faster real-time decision making. CIO and Joint Staff officials stressed the importance of developing agile and dynamic technology to support DOD's EMS superiority goals.

- **Lengthy acquisition process:** Joint Staff and U.S. Strategic Command officials identified the lack of a DOD-wide acquisition strategy that ensures interoperability for EMS-related capabilities as a challenge. For example, a U.S. Strategic Command official described issues with interoperability between legacy and new systems. In addition, a Joint Staff official said that the acquisition process tends to be composed of disparate efforts across different organizations within

[52]Davis, Thomas M., David Barno, and Nora Bensahel. Center for New American Security. *The Enduring Need for Electronic Attack in Air Operations,* (Washington, D.C.: 2014). GAO, *Airborne Electronic Attack: Achieving Mission Objectives Depends on Overcoming Acquisition Challenges*, GAO-12-175 (Washington, D.C.: Mar. 29, 2012). U.S. Department of Defense. U.S. Indo-Pacific Command. *Spinning a Better Kill Web.*

DOD. For example, the military services typically have separate development and acquisition processes for EMS-related capabilities.

We have previously found that in the case of some EW capabilities, the services generally fund their own priorities when facing budget situations in which they have to choose between funding their own, service-specific research priorities and funding department-wide priorities.[53] DOD officials at the Defense Intelligence Agency and U.S. Indo-Pacific Command said that the services' authority and responsibility for equipping forces can hinder effective integration of EMS-related capabilities across the joint forces.

The studies also stated that DOD's lengthy acquisition and development process affects DOD's ability to ensure superiority in the EMS. According to a 2019 study by the Institute of Defense Analysis, "piecemeal acquisition of stand-alone communications and EW systems within large and lengthy platform acquisition programs has not provided the speed, agility, and operational integration needed."[54] Other studies, such as a 2015 Defense Science Board report and two separate studies by the Center for Strategic and Budgetary Assessments, echoed these concerns.[55] To address the lengthy acquisition process, a study by the Center for New American Security recommended a separate "rapid acquisition system" for EW capabilities to avoid fielding capabilities that have already become obsolete since their design.[56]

- **Absence of a holistic, overarching EMS operational concept:** EMS-related studies identified the need for a cohesive approach to ensuring EMS superiority, instead of trying to match enemy capabilities one-for-one. In 2015, the Defense Science Board reported that trying to mitigate every potential EW vulnerability is an enormous undertaking.[57] The board's report recommended that DOD adopt a more balanced strategy that puts U.S. adversaries on the defensive. A

[53]GAO-12-175.

[54]Institute for Defense Analysis. *Independent Assessment*, 2.

[55]Department of Defense, Defense Science Board, *21st Century Military Operations.* Clark, Bryan, Whitney Morgan McNamara, and Timothy A. Walton. Center for Strategic and Budgetary Assessments. *Winning the Invisible War.* Center for Strategic and Budgetary Assessments. *Recognizing the Electromagnetic Spectrum*.

[56]Davis, Thomas M., David Barno, and Nora Bensahel. *The Enduring Need for Electronic Attack*, 10.

[57]Department of Defense, Defense Science Board, *21st Century Military Operations.*

2019 Center for Strategic and Budgetary Assessments study had a similar conclusion, stating that the U.S. should seek to exploit areas of advantage, such as relationships with allies, instead of trying to solve every capability gap.[58]

Studies and officials from multiple EMS-related DOD organizations stated that DOD should treat the EMS as a space where U.S. forces compete with adversaries and neutral forces for access and control, rather than a utility.[59] Specifically, the Center for Strategic and Budgetary Assessment concluded in a 2017 report that DOD's operational concepts treated the EMS more as a utility that is only relevant when U.S. forces use it, which hampers the ability of U.S. forces to effectively engage in the EMS.[60] The CFT's Deputy Director echoed this in public statements in May 2020, stating that "it's [the EMS] viewed as a utility and [it] is assumed that it can be accessed at will" despite being critically important for joint functions.[61]

- **Increased competition and congestion in the spectrum:** Studies and officials from multiple EMS-related DOD organizations described how the EMS is becoming increasingly congested—as more users compete for access—and also contested as adversaries advance their EMS operational capabilities. For example, commercial demands for spectrum, such as 5G, have increased competition for spectrum. Additionally, a 2020 report by the CIO stated that additional crowding in the spectrum increases the amount of unintentional interference.[62]

  Spectrum auctions and re-allocations have decreased the amount of spectrum available for military uses, according to officials from CIO,

[58]Clark, Bryan, Whitney Morgan McNamara, and Timothy A. Walton. *Winning the Invisible War.*

[59]DOD refers to this type of space as a "maneuver space."

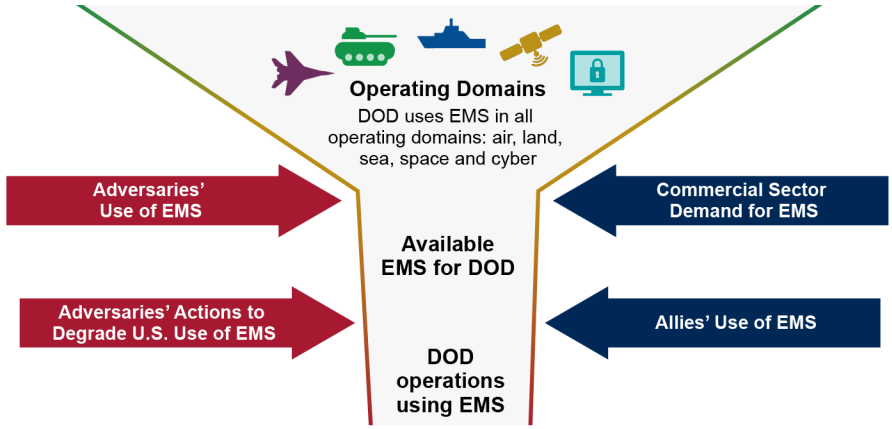
[60]Center for Strategic and Budgetary Assessments. *Recognizing the Electromagnetic Spectrum as an Operational Domain.* (Washington, D.C.: 2017).

[61]Lopez, C. Todd. "As in Other Domains, U.S. Use of Electromagnetic Spectrum is Contested." *Defense News.* Defense.gov. (2020).

[62]Department of Defense, Office of the Chief Information Officer, *Information Paper: Expanded Office of the Secretary of Defense Level Responsibilities Necessary for the Full Range of Electromagnetic Spectrum (EMS) Activities within the Department of Defense.* (Jan. 20, 2020).

U.S. Strategic Command, and Joint Staff.[63] These officials agreed that this shrinking availability of spectrum is a challenge for DOD's EMSO. For example, U.S. Strategic Command officials stated that the selling of additional spectrum to the commercial sector effectively shrinks the amount of spectrum in which the military can train and operate. In addition, CIO officials said that adversaries' and allies' EMS requirements are competing for the same portions of the spectrum during operations, which could result in a loss of communications or other critical spectrum-dependent functions. Further, according to DOD officials from two components, there are issues with interoperability between spectrum management systems that can make it difficult to allocate spectrum for joint operations. (See figure 4).

Figure 4: Increased Competition for Electromagnetic Spectrum (EMS) Decreases Availability for DOD Use



Source: GAO analysis of Department of Defense (DOD) information and non-DOD information. | GAO-21-64

[63]For example, the Secretary of Defense criticized the Federal Communications Commission's 2020 decision to approve the Ligado Network's application to create a cellular network by repurposing a portion of radio spectrum adjacent to that used by GPS. The Secretary of Defense asserted that the decision will degrade the effectiveness and reliability of GPS. See Esper, Mark. "The FCC's Decision Puts GPS at Risk; Its effect will be to undermine U.S. national security and disrupt commerce and daily life." *Wall Street Journal* (May 5, 2020). The Chairman of the Federal Communications Commission claimed that DOD had ample opportunity to submit evidence prior to their decision, which included strict conditions to ensure that GPS operations continue to be protected by harmful interference. See Pai, Ajit V. *Letter to Adam Smith, Chairman of the House Committee on Armed Services*. May 26, 2020.

- **Issues with electromagnetic battle management:** Studies stated that current electromagnetic battle management—actions taken to monitor, assess, and plan operations in the EMS environment—practices may be insufficient in light of increased commercial and military use of the spectrum. The studies also highlighted deficiencies in DOD's traditional models of advance planning for spectrum use and allocation as insufficient to effectively function in the electromagnetic environment. A DOD official confirmed that the department does not use its predominant electromagnetic battle management system to adjust spectrum allocations in real time.
- **Shortages of staff with EMS expertise:** DOD also faces shortages of staff with EMS expertise, according to studies and DOD officials who focus on the EMS. The U.S. Air Force's Electromagnetic Defense Task Force 2018 annual conference report found that institutional knowledge of electromagnetic warfare has "atrophied" in the department.[64] Multiple DOD officials who work on EMS issues echoed this in interviews, with an official from the CFT stating that the department lacks a formally defined, sustained, and commonly understood EMS workforce, hindering its ability to outpace near-peer competitors.
- **Challenges for EMS training:** Studies reported that existing training procedures and ranges are often insufficient to prepare warfighters to operate in a degraded EMS environment. For example, one study from the Center for Strategic and Budgetary Assessment pointed out that the services conduct training for EMSO, but this training does not generally reflect the most advanced level of adversaries' capabilities, despite some improvement.[65] U.S. Strategic Command officials also made this point and added that training procedures typically incorporate operating in a degraded electromagnetic environment only for part of the exercise, instead of being fully integrated throughout.

  Several studies mentioned deficiencies in training ranges, such as outdated infrastructure, and challenges to conducting realistic open-air testing and training, such as operational security. Multiple studies

[64]Department of Defense, U.S. Air Force Air University, *Electromagnetic Defense Task Force 2018 Report.* (Maxwell Air Force Base, Alabama: 2018), 5. The Electromagnetic Defense Task Force is an annual summit of EMS experts sponsored by the U.S. Air Force Air University to discuss vulnerabilities and threats to the United States and its allies and explore mitigation strategies regarding national security challenges in the EMS.

[65]Clark, Bryan, Whitney Morgan McNamara, and Timothy A. Walton. *Winning the Invisible War.*

and CFT and U.S. Strategic Command officials recommended realistic, virtual training as a way to address these challenges.

Based on several DOD reports and our interviews with DOD officials from multiple components, we found that DOD recognizes these challenges. DOD officials told us that many of their actions related to these challenges are classified, but some of the studies we reviewed reported actions at an unclassified level. For example, in its 2020 report to Congress, DOD stated its intention to develop an EMSO investment strategy to align EMS efforts across the department.[66] This report also described a recently completed effort to identify solutions to DOD's EMS training deficiencies.

DOD Did Not Fully Implement Prior EMS-Related Strategies and Is at Risk of Not Achieving Long-Term EMSO Goals

DOD issued two department-wide EMS-related strategies in 2013 and 2017, and published a third strategy in September 2020. The three strategies provide direction to help DOD improve EMSO and EMS-related issues. However, the department did not fully implement the 2013 and 2017 strategies and is at risk of not achieving the goals of the 2020 strategy because DOD has not taken critical governance and oversight actions such as those Congress established in section 1053 of the FY19 NDAA to support DOD EMS. Specifically, DOD has not (1) issued process and procedures to integrate EMSO across the department, (2) proposed and implemented governance reforms, (3) assigned a senior official with appropriate authority to oversee strategy implementation, and (4) articulated oversight processes for strategy implementation.

DOD Did Not Fully Implement Its 2013 or 2017 EMS Strategies

In 2013 and 2017, DOD issued two EMS-related strategies. Both of these strategies provide direction—goals and objectives—to help DOD address and improve EMS-related issues and challenges, such as focusing the department on increasing capabilities, training forces for operations, and organizing governance to ensure superiority in the EMS. DOD officials whose offices were responsible for implementing the prior strategies stated that the strategies helped influence how DOD thought about the spectrum, but the department did not achieve all of its goals.

- **2013 DOD EMS Strategy.** This strategy stated the department needed to "act now to ensure access to the congested and contested

[66]Department of Defense, *Second Report on Section 1053(d)(4) of the John S. McCain National Defense Authorization Act for Fiscal Year 2019, Guidance on the Electronic Warfare Mission Area and Joint Electromagnetic Spectrum Operations* (July 2020).

electromagnetic environment of the future."[67] The strategy presented a framework for how DOD should rapidly adapt to the changing spectrum environment and to assess and respond to spectrum regulatory changes. Its three goals emphasized advancing promising spectrum-dependent technologies, along with improving the integration of DOD spectrum activities, improving the ability to assess and respond to spectrum regulatory changes, and addressing associated policy and governance.

According to an official from the office of the CIO, some department components took actions related to the strategy. For example, DOD established an EMS Technology Working Group in support of the goals outlined in the strategy. This group was responsible for measuring the progress of DOD's EMS technology development, and is co-chaired by officials from the office of the CIO and the Defense Spectrum Organization. DOD officials noted that the strategy was successful at driving culture change and the way the department thought about the spectrum, but not all components took action. Specifically, DOD subsequently identified 23 recommendations that the department believed DOD components should take to achieve the 2013 strategy's goals. However, as of the last recommendation status report in January 2019 (i.e., more than 5 years after the strategy was issued), only three of 23 recommendations derived from the strategy had been completed.

- **2017 DOD EW Strategy.** This strategy was issued after a Defense Science Board report highlighted the insufficient attention paid to EW by all services at all levels during the past 25 years—an approach, according to the strategy, that would not work for the future.[68] The strategy directed the DOD EW enterprise to deliver decisive capability advantages by organizing, training, and equipping forces to be offensively focused, poised to gain and ensure EMS superiority, and unified in their efforts.[69] However, DOD did not fully implement the 2017 strategy.

  While the EW Executive Committee was responsible for implementing the strategy, the committee's actions had limited success. For example, in response to the strategy calling for an EW workforce,

[67]Department of Defense, *Department of Defense Electromagnetic Spectrum Strategy 2013: A Call to Action*.

[68]Department of Defense, Defense Science Board, *21st Century Military Operations in a Complex Electromagnetic Environment* (July 2015).

[69]Department of Defense, *The DOD Electronic Warfare Strategy* (2017) (FOUO).

each service established officer and enlisted communities that include EW expertise, but generally as part of a larger community or in conjunction with cyber operations. These efforts are widely divergent in terms of their degree of emphasis on EW. A 2019 DOD-contracted assessment described the progress made in general, but did not track specific actions to implement the strategy. DOD officials confirmed that the department made limited progress in implementing the 2017 strategy prior to the 2018 enactment of section 1053(d)(2) of the FY19 NDAA that directed the EW Executive Committee, in coordination with the CFT, to update the 2017 strategy.[70]

DOD Has Not Yet Taken Key Governance and Oversight Steps to Help It Achieve Long-Term EMSO Goals

DOD officials we interviewed recognize that action is necessary and the 2020 strategy updates and consolidates the 2013 and 2017 strategies into a new document. The 2020 strategy seeks to align EMS resources, capabilities, and activities across DOD to support core national security objectives while remaining mindful of the importance of U.S. economic prosperity. Additionally, according to the strategy, DOD believes the strategy lays the foundation for a robust EMS enterprise, prepares EMS professionals to leverage new technologies, and focuses on strengthening alliances to achieve the department's vision of freedom of action in the EMS.

Based on our analysis, DOD risks not achieving these goals because DOD has not taken key governance and oversight actions. Specifically, the department has not (1) issued processes and procedures to integrate EMSO across the department, (2) proposed and implemented governance reforms, (3) assigned a senior official with appropriate authority to oversee long-term strategy implementation, or (4) articulated oversight activities that would help ensure accountability and strategy implementation.

DOD Has Not Established Processes and Procedures to Integrate the Department's EMSO Efforts

The first key governance action not taken that places DOD's goals at risk is establishing processes and procedures for integrating EMSO efforts. In the FY19 NDAA, Congress directed DOD actions to enhance the department's ability to conduct EMSO. Section 1053 of this legislation required the Secretary of Defense to 1) establish processes and

[70]Pub. L. No. 115-232, § 1053(d)(2) (2018). The House Armed Services Committee expressed concern that since the 2017 strategy was released, subsequent efforts to strengthen, modernize, and create synergy of effort across the department related to the joint EMSO enterprise may have stagnated within the military services, the Office of the Secretary of Defense, and the Office of the Chairman of the Joint Chiefs of Staff. H.R. Rep. No. 115-676 at 187 (2018).

procedures to develop, integrate, and enhance the EW mission area and the conduct of joint EMSO in all domains across the department; and 2) ensure that such processes and procedures provide for integrated defense-wide strategy, planning, and budgeting with respect to the conduct of such operations, including activities conducted to counter and deter such operations by malign actors.[71] The Secretary of Defense delegated this responsibility to the Vice Chairman of the Joint Chiefs of Staff as the senior designated official overseeing the CFT.[72]

However, we found that DOD had not taken action to establish the required processes and procedures. Specifically, current DOD guidance provides procedures for managing spectrum support operations, but the guidance does not address the processes and procedures required by section 1053.[73] In commenting on a draft version of this report, DOD said that the department had established processes and procedures in a recent DOD directive and Joint Publication 3-85.[74] However, our analysis found that these documents did not cover all of the elements of the processes and procedures required by section 1053. The DOD directive establishes policy and assigns responsibilities to specific DOD officials; however, the directive does not itself provide the required processes and procedures. Joint Publication 3-85 does establish some of the processes and procedures. However, joint publications do not apply to every DOD component, such as CIO and other Office of the Secretary of Defense organizations, and this publication does not describe budgeting for joint EMSO, both required characteristics for the processes and procedures in section 1053.

[71]Pub. L. No. 115-232, § 1053(a)(1-2) (2018). Section 1053 refers to the term EW, which is a subset of EMS operations. DOD decided to broaden the scope in its response to the law by applying the requirements to all of its EMSO.

[72]Department of Defense, Secretary of Defense Memorandum, *Establishment of the Electromagnetic Spectrum Operations Cross Functional Team* (Feb. 2, 2019).

[73]DOD Instruction 4650.01 contains department-wide procedures for management and use of the electromagnetic spectrum but the procedures are limited in scope and do not develop, integrate, and enhance the electronic warfare mission area and the conduct of joint EMSO as required by section 1053. Department of Defense, Chief Information Officer, DOD Instruction 4650.01, *Policy and Procedures for Management and Use of the Electromagnetic Spectrum* (Jan. 9, 2009) (incorporating change 1, Oct. 7, 2017).

[74]Department of Defense Directive 3610.01, *Electromagnetic Spectrum Enterprise Policy*; Chairman of the Joint Chiefs of Staff, Joint Publication 3-85.

Additionally, DOD's reports to Congress on developing, integrating, and enhancing EMSO did not describe the section 1053 requirement to establish processes and procedures to develop, integrate, and enhance the EW mission area and conduct of joint EMSO.[75] We also analyzed an internal CFT document used to track implementation of FY19 NDAA requirements and found that the information included did not identify new or existing department-wide processes and procedures. Additionally, in September 2020, a cognizant CFT official told us that establishing the required processes and procedures would be a future effort.

According to the documents we reviewed and the CFT official, DOD has not established the processes and procedures because the CFT plans to include them in an implementation plan for the 2020 strategy. Specifically, the strategy calls for DOD to issue an implementation plan within 180 days of the strategy's September 2020 publication (i.e., no later than March 27, 2021). A CFT official told us that DOD had not begun drafting the implementation plan as of September 2020. Additionally, our analysis of prior EMS implementation plans found that these plans did not accomplish similar intent for processes and procedures. Specifically, we found that the implementation plans for the 2013 and 2017 strategies recommended—but did not establish—actions such as processes and procedures. As such, until DOD identifies the processes and procedures needed to provide for an integrated defense-wide strategy, planning, and budgeting for EMS operations, as required by the FY19 NDAA, DOD is at risk of not fully implementing the goals in the 2020 strategy.

DOD Has Not Proposed and Implemented Governance Reforms

The second key governance action not taken that places DOD's goals at risk is proposing and implementing EMSO governance reforms to the Secretary of Defense. As previously described, multiple studies and DOD officials have identified governance as a major challenge for DOD's EMSO—including dispersed governance across the department and full-time responsibilities being located at lower organizational levels. According to a 2020 DOD report to Congress, the most critical aspects of the 2015 Defense Science Board's recommendations were leadership

[75]Department of Defense, *Report on FY 2019 NDAA Section 1053*, *Guidance on the Electronic Warfare Mission Area and Joint Electromagnetic Spectrum Operations,* (Sept. 30, 2019); Department of Defense, *Second Report on Section 1053(d)(4) of the John S. McCain National Defense Authorization Act for Fiscal Year 2019, Guidance on the Electronic Warfare Mission Area and Joint Electromagnetic Spectrum Operations* (July 2020).

and governance.[76] Congress, likewise, identified concerns about DOD's governance and included a provision in the FY19 NDAA that provided the Senior Designated Official of the CFT with the responsibility for proposing EW governance, management, organizational, and operational reforms to the Secretary of Defense, after review and comment by the EW Executive Committee.[77] The Secretary of Defense memorandum implementing this provision—and identifying the Vice Chairman of the Joint Chiefs of Staff as the Senior Designated Official—directed the Senior Designated Official to propose such reforms to the Secretary of Defense after review and comment by the EW Executive Committee.[78]

In 2019 and 2020, DOD provided reports to Congress on the department's progress in addressing the FY19 NDAA's EMSO requirements. DOD reported that it needs to take additional actions to address governance issues. Specifically, in 2019, DOD reported that the CFT determined the EW Executive Committee aided coordination and was a viable advisory body, but does not provide the required governance envisioned by the Defense Science Board.[79] The 2020 status report to Congress stated that CIO has sufficient authorities to serve as DOD's lead for EMS issues; however, the same report stated that the CFT believed the current CIO structure limits its influence to advance EMS issues within the department.[80]

A CFT official said that CIO did not have enough staff to govern EMSO across the department. According to the 2020 report to Congress, the CIO is examining the appropriate organizational structure within the CIO and the necessary resourcing required in the fiscal year 2022 presidential

[76]Department of Defense, *Second Report on Section 1053(d)(4 of the John S. McCain National Defense Authorization Act for Fiscal Year 2019, Guidance on the Electronic Warfare Mission Area and Joint Electromagnetic Spectrum Operations* (July 2020).

[77]Pub. L. No. 115-232, § 1053(b)(2)(C) (2018).

[78]Department of Defense, Secretary of Defense Memorandum, *Establishment of the Electromagnetic Spectrum Operations Cross Functional Team.*

[79]Department of Defense *Report on FY 2019 NDAA Section 1053, Guidance on the Electronic Warfare Mission Area and Joint Electromagnetic Spectrum Operations*, (Sept. 30, 2019),

[80]Department of Defense, *Second Report on Section 1053(d)(4) of the John S. McCain National Defense Authorization Act for Fiscal Year 2019, Guidance on the Electronic Warfare Mission Area and Joint Electromagnetic Spectrum Operations*. (July 2020).

budget.[81] A CIO official told us that, as of August 2020, DOD had begun the process to provide additional staff for EMS. However, the provision of additional staff for EMS responsibilities in CIO does not constitute governance reforms and it is unclear whether the additional staff within CIO will address the governance challenges identified in the studies we reviewed. Likewise, U.S. Strategic Command determined that additional roles and responsibilities were necessary and is in the process of examining both as part of a separate review of the command's overall structure.[82]

DOD reports to Congress acknowledge that governance issues continue to put DOD's EMSO goals at risk. DOD officials told us that this was the most important issue that DOD needed to address, and the studies identified governance as a major challenge. Yet, as of September 2020, DOD had not proposed reforms to the Secretary of Defense for EMS governance, management, organization, and operations in accordance with the FY19 NDAA provisions. While DOD provided evidence that governance reforms have been discussed at the CIO, CFT, and EW Executive Committee levels, these discussions generally related to studies and assessments rather than formal proposals for action. For example, in April 2019 the EW Executive Committee—responsible for reviewing and commenting on any such proposed reforms—tasked multiple DOD components with preparing information papers for the committee.

In August 2020, officials from the committee told us the department had not formally proposed reforms for the committee's review, as provided by section 1053. Additionally, in February 2020, DOD's Cost Assessment and Program Evaluation office completed an EMS review, but this review focused on EMS resources within CIO and not broader governance reforms. In October 2020, a CFT official told us the CFT had previously discussed potential reforms with the CFT's Senior Designated Official and the EW Executive Committee, but the official was unaware of any further action at higher levels.

The CFT official said that these governance reforms will come about as part of the new 2020 strategy. Our analysis of the 2020 strategy found that it identifies effective EMS governance as a goal, but a strategic goal

[81]Ibid.

[82]According to U.S. Strategic Command officials, DOD was reviewing all of U.S. Strategic Command's responsibilities, of which EMSO is only one portion.

is not the same as specific proposals for reform. Further, as we previously described, DOD made limited progress in achieving the goals identified in the previous two EMS strategies. Without proposing EMS governance reforms, DOD risks not addressing the previously described governance challenges, which could affect DOD's goals for EMS superiority.

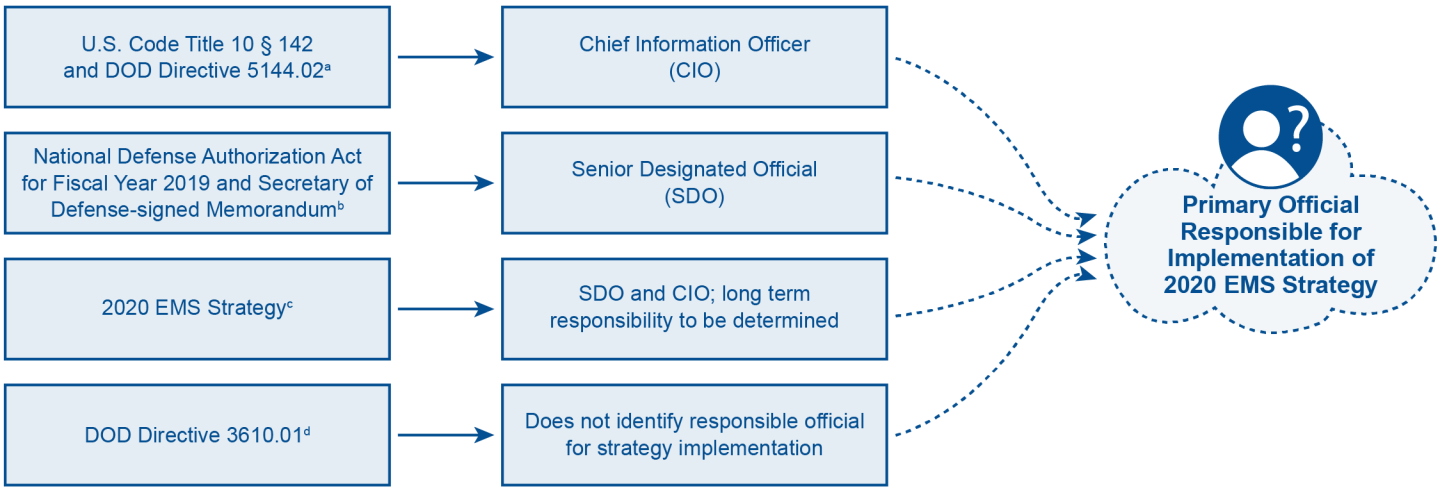
DOD Has Not Clearly Assigned a Senior Official with Appropriate Authority and Resources to Ensure 2020 Strategy Implementation

Another key governance action that DOD has not taken is assigning a senior official with appropriate authority and resources to ensure long-term EMS strategy implementation. DOD documents and officials stated that the department lacked an official with appropriate authority designated to oversee long-term implementation, likely limiting the department in implementing the 2013 and 2017 strategies. We found that DOD is at risk of not achieving the goals articulated in the 2020 strategy because the department has not clearly assigned a senior official with appropriate authority to ensure the strategy's long-term implementation, even though the strategy calls for implementation actions to begin within 180 days of its September 2020 publication (i.e., no later than March 27, 2021).

As shown in figure 5 below, DOD guidance, federal law, and other documents have not consistently identified who is responsible to oversee the strategy's long-term implementation. The lack of clarity in responsibility for overseeing strategy implementation contrasts with the strategy's long-term vision. This vision calls for forces and actions in 2030 and beyond.[83]

[83]The long-term vision in the 2020 strategy aims for forces in 2030 and beyond to be ready to fight and win through the deliberate, institutional pursuit of EMS superiority. Department of Defense, *Department of Defense Electromagnetic Spectrum Superiority Strategy* (September 2020).

Figure 5: Federal Laws and Department of Defense Documents Related to Electromagnetic Spectrum (EMS) Strategy Implementation



Source: GAO analysis of Department of Defense (DOD) information. | GAO-21-64

[a]CIO officials told us that they believe their statutory and department-assigned responsibilities will make the CIO responsible for overseeing strategy implementation.

[b]These documents assign responsibility to the SDO (Vice Chairman of the Joint Chiefs of Staff).

[c]The foreword of the strategy states that the SDO, in partnership with the CIO, will oversee strategy implementation. However, the strategy later states the SDO will oversee strategy implementation only until this responsibility transitions to a permanent governing entity, but does not identify who this permanent governing entity will be.

[d]DOD Directive 3610.01, *Electromagnetic Spectrum Enterprise Policy* (Sept. 4, 2020) assigns responsibilities for enabling EMS superiority, however, this directive does not identify an official responsible for strategy implementation.

It is unclear which of the officials identified in figure 5 above has the authority and resources to organize efforts across many DOD components and ensure they implement the department's strategy and goals. As previously described, governance issues have limited the department's ability to make progress on prior efforts to date. Although the CIO established the EMS Senior Steering Group to coordinate implementation of the 2013 strategy, the group could not ensure action, in part due to lack of authority to task officials from other DOD components, and the group was not sustainable long-term, according to CIO officials. For example, they said officials involved lacked seniority to compel action from other components, and DOD provided the effort only temporary resources.

Similarly, for the 2017 strategy, the EW Executive Committee was responsible for implementing the strategy. However, according to a

February 2019 study conducted on the implementation of the strategy, constraints of the committee's portfolio limited the committee's ability to implement the strategy.[84] The study also found that the committee did not include an official who would be instrumental in implementing the strategy—the Under Secretary of Defense for Personnel and Readiness—thus reducing the committee's ability to improve and integrate the readiness efforts among the services. Further, officials from the Office of the Under Secretary of Defense for Acquisition and Sustainment pointed out that the CIO does not have the ability to influence the services' budgets or compel them to take action for EW or other acquisition programs. As noted above, multiple studies identified acquisition issues as a challenge to ensuring DOD's operational superiority in the EMS.

DOD took a different approach with the 2018 DOD Cyber Strategy, clearly assigning long-term leadership responsibilities with associated authority. According to officials from the Office of the Principal Cyber Advisor, DOD made the Principal Cyber Advisor responsible for and accountable to the Secretary of Defense for ensuring the strategy's implementation. Also, since the Principal Cyber Advisor was established as an enduring position in 2014, the advisor and staff were in a position of authority to oversee implementation and transitions from the 2015 DOD Cyber Strategy to the 2018 DOD Cyber Strategy. The officials said that having a senior DOD official in a position to oversee DOD's efforts across multiple years and strategies enabled the department to more effectively achieve the goals identified in the cyber strategy. In contrast, DOD has not assigned clear responsibility and comparable authority for overseeing long-term EMS strategy implementation because it has not clarified how the previously described DOD guidance, federal law, and other documents affect strategy implementation.

Assigning responsibility to a senior official with the ability to compel action and oversee long-term implementation of the 2020 EMS strategy would help DOD achieve the strategy's goals and help ensure accountability for the implementation of the 2020 strategy. In addition, taking such action early would benefit the official's ability to influence implementation, which

[84]Center for Strategic and Budgetary Assessments, *Electronic Warfare Strategy Implementation Plan Study* (Washington, D.C.: Feb. 15, 2019). This study was commissioned by the office of the Undersecretary of Defense for Acquisition and Sustainment.

the 2020 strategy states will be detailed in an implementation plan within 180 days of issuance.

DOD Has Not Created Oversight Processes That Ensure Accountability for 2020 Strategy Implementation

We have previously reported that gaps in DOD's oversight processes to implement EMS-related strategies created risk to DOD achieving the strategies' outcomes and goals, and the department carrying out its missions effectively.[85] In our work, we found that oversight processes would facilitate strategy implementation and help the department achieve the goals established in strategies related to the EMS. Specifically, our work on DOD information operations—which incorporates some EMS-related capabilities such as EW—found that DOD had similarly made limited progress on implementing a 2016 strategy in part because it lacked oversight processes to facilitate and oversee implementation of the strategy. Such oversight processes would include, among other things, descriptions of how objectives are to be achieved and by when (e.g., in an implementation plan), performance metrics, and regular progress reviews.

DOD EMS officials stated that oversight processes with an implementation plan and leadership involvement would be needed for the 2020 strategy. However, we found that other than the department's intention to issue an implementation plan, DOD has not articulated additional oversight processes that would ensure accountability for implementing the 2020 strategy, placing DOD's goals for EMS superiority at risk. Specifically, a CFT official told us the department intends to fulfill the 2020 strategy's goal of issuing an implementation plan within 180 days of the strategy's publication, and that as of September 2020 the CFT was in the beginning phases of developing the methodology and process for creating the implementation plan.

DOD's experience with the previous EMS strategies demonstrates that the intention of issuing an implementation plan within 180 days does not guarantee the department will do so. The previous strategies also called for such plans, and they were not issued in a timely manner. For

[85]GAO-20-51SU. We recommended that the Secretary of Defense should ensure that the Under Secretary of Defense for Policy and the Chairman of the Joint Chiefs of Staff establish a process that facilitates implementation of DOD's revised strategy for operations in the information environment and hold DOD components accountable for implementing this strategy. In October 2020, the Secretary of Defense designated a Principal Information Operations Advisor and assigned this advisor responsibility for overseeing implementation of a future strategy. We will continue to monitor DOD's actions to determine whether it establishes a process that meets the intent of our recommendation.

example, the 2013 strategy stated that the CIO had already begun development of an action plan. However, that action plan took 2 years to develop, which CIO officials said was in part due to the number of people involved in the effort. Similarly, although DOD officials said they made three separate attempts to create an implementation plan for the 2017 strategy—including one that started before the strategy was issued—EW Executive Committee officials said the committee never approved any of the plans that came from those efforts. The officials said the EW Executive Committee eventually halted efforts on issuing an implementation plan in 2019 after the CFT initiated efforts to issue an updated strategy.

In addition, we found that DOD had not determined other activities to fulfill a potential implementation plan and facilitate meeting the strategy's goals. For example, DOD officials potentially involved in implementation steps told us the department had not identified whether senior leaders would be assigned and accountable for taking action and providing progress reports on status of implementation efforts.

DOD took different steps to assist implementation of the previously-described cyber strategies. According to Office of the Principal Cyber Advisor officials, senior DOD officials overseeing the 2015 and 2018 cyber strategies stated that articulating and establishing a series of oversight processes better positions the department to implement strategies and achieve the department's goals. Specifically, the officials said that the DOD Principal Cyber Advisor established multiple oversight processes in support of the 2015 DOD Cyber Strategy. These oversight processes included (1) the issuance of an overall implementation plan (or individual plans for different sections of the strategy) that identifies specific actions that will be taken and estimated completion dates, (2) assignment of senior DOD leader(s) (e.g., general and flag officers and/or civilian senior executives) who would be held accountable for implementing a specific section of the strategy, and (3) establishing progress reports (e.g., monthly, bimonthly, or quarterly) on the status of the actions identified in the implementation plan(s). The DOD Principal Cyber Advisor was able to use these oversight processes to monitor DOD's progress for the 2015 and 2018 cyber strategies.

Until DOD issues an implementation plan, the 2020 strategy is at risk of encountering similar challenges as with previous strategies. Further, developing oversight processes to facilitate strategy implementation would better position DOD to make measurable progress, fully implement

the 2020 strategy, and achieve the department's future EMS superiority goals.

Conclusions

Studies have shown that adversaries of the United States, such as China and Russia, are developing capabilities and strategies that could affect DOD superiority in the information environment, including the EMS. DOD has also reported that loss of EMS superiority could result in the department losing control of the battlefield, as its EMSO supports many warfighting functions across all domains. DOD recognizes the importance of EMSO to military operations in actual conflicts and in operations short of open conflict that involve the broad information environment. However, gaps we identified in DOD's ability to develop and implement EMS-related strategies have impeded progress in meeting DOD's goals. By addressing gaps we found in five areas—(1) the processes and procedures to integrate EMSO throughout the department, (2) governance reforms to correct diffuse organization, (3) responsibility by an official with appropriate authority, (4) a strategy implementation plan, and (5) activities that monitor and assess the department's progress in implementing the strategy—DOD can capitalize on progress that it has already made and better support ensuring EMS superiority.

Recommendations for Executive Action

We are making five recommendations to DOD.

The Secretary of Defense should ensure that the Vice Chairman of the Joint Chiefs of Staff, as Senior Designated Official of the CFT, identifies the procedures and processes necessary to provide for integrated defense-wide strategy, planning, and budgeting with respect to joint electromagnetic spectrum operations, as required by the FY19 NDAA. (Recommendation 1)

The Secretary of Defense should ensure that the Vice Chairman of the Joint Chiefs of Staff as Senior Designated Official of the CFT proposes EMS governance, management, organizational, and operational reforms to the Secretary. (Recommendation 2)

The Secretary of Defense should assign clear responsibility to a senior official with authority and resources necessary to compel action for the long-term implementation of the 2020 strategy in time to oversee the execution of the 2020 strategy implementation plan. (Recommendation 3)

The Secretary of Defense should ensure that the designated senior official for long-term strategy implementation issues an actionable

implementation plan within 180 days following issuance of the 2020 strategy. (Recommendation 4)

The Secretary of Defense should ensure that the designated senior official for long-term strategy implementation creates oversight processes that would facilitate the department's implementation of the 2020 strategy. (Recommendation 5)

Agency Comments and Our Evaluation

We provided a draft of this report to DOD for review and comment. In written comments, reprinted in appendix III, DOD concurred with two of our recommendations and partially concurred with the remaining three. DOD separately provided technical comments, which we incorporated as appropriate.

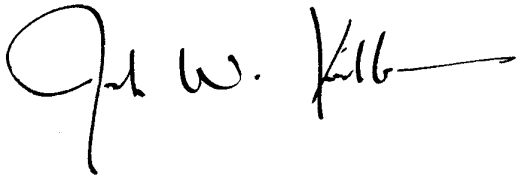
The department concurred with our first two recommendations and discussed steps planned or under way to address them.

The department partially concurred with our three other recommendations relating to assigning clear responsibility to a senior official for the 2020 strategy, including that this official develop an implementation plan for the 2020 strategy and for an oversight process. The department agreed with the intent of each recommendation but stated that it could not provide specifics on implementation until the Secretary of Defense has reviewed potential recommendations for organizational reform that the department is preparing for consideration. With respect to the recommendation on an implementation plan, the department reiterated its intent to issue such a plan within 180 days of the publication of the strategy. DOD did not identify timeframes for developing and proposing organizational reforms. Given the department's challenges in implementing previous EMS-related strategies, we believe that DOD needs to maintain focus on actions necessary to implement the 2020 strategy. If the department finalizes and carries out organizational reform efforts that they are considering and continues to make progress toward the intent of our recommendations, DOD will be better positioned for success in the long term.

We are sending copies of this report to the appropriate congressional committees, the Secretary of Defense, and the DOD components included in the scope of this review. In addition, the report is available at no charge on the GAO website at http://www.gao.gov.

If you or your staff have any questions concerning this report, please contact Joseph W. Kirschbaum at (202) 512-9971 or KirschbaumJ@gao.gov. Contact points for our Offices of Congressional

Relations and Public Affairs may be found on the last page of this report. GAO staff who made key contributions to this report are listed in appendix IV.



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Director, Defense Capabilities and Management

Appendix I: Description of Literature Review and Studies That We Reviewed

To provide additional information on key issues related to electromagnetic spectrum (EMS) operations, we reviewed 43 unclassified studies published in the past 10 years that we determined described China's and Russia's EMS capabilities and/or identified challenges or gaps in the Department of Defense's (DOD) EMS operations, management, and capacities. In cases where the full report was classified, we analyzed the unclassified executive summaries.

"Application of Electronic Warfare on the East of Ukraine: 2018-2019 Experience" (presented at the Association of Old Crows 56th International Symposium and Convention, October 29, 2019).

Bonner, Lt Col E. Lincoln, "Defending Our Satellites: The Need for Electronic Warfare Education and Training." *Air and Space Power Journal*, (November-December 2015).

Bucki, 2nd Lt Elliot. "Flexible, Smart, and Lethal: Adapting U.S. SEAD Doctrine to Changing Threats." *Air and Space Power Journal*, vol. 30, issue 2 (2016).

Center for Strategic and Budgetary Assessments. *Recognizing the Electromagnetic Spectrum as an Operational Domain.* Washington, D.C.: 2017.

Clark, Bryan, Whitney Morgan McNamara, and Timothy A. Walton. Center for Strategic and Budgetary Assessments. *Winning the Invisible War: Gaining an Enduring U.S. Advantage in the Electromagnetic Spectrum*. Washington, D.C.: 2019.

Collins, Col. Liam. "Russia Gives Lessons in Electronic Warfare." *ARMY Magazine*, vol. 68, no. 8 (2018).

Dahm, J. Michael. "Threat-Based Intelligence China: Electronic Warfare" (presented at the Association of Old Crows 56th International Symposium and Convention, October 28, 2019).

Davis, M. Thomas, David Barno, and Nora Bensahel. Center for New American Security. *The Enduring Need for Electronic Attack in Air Operations.* Washington, D.C.: 2014.

Department of Defense, Defense Intelligence Agency, *Challenges to Security in Space*, DIA_F_01403_A (2019).

Department of Defense, Defense Intelligence Agency, *China Military Power: Modernizing a Force to Fight and Win*, DIA-02-1706-085 (2019).

Department of Defense, Defense Intelligence Agency, *Russian Military Power: Building a Military to Support Great Power Aspirations*, DIA-11-1704-161 (2017).

Department of Defense. Defense Science Board. 21st *Century Military Operations in a Complex Electromagnetic Environment*. 2015.[1]

Department of Defense. Defense Science Board. *Defense Applications of 5G Network Technology: Executive Summary.* 2019.[2]

Department of Defense. Defense Science Board. *Summer Study on Capabilities for Constrained Military Operations*. 2016. (U//FOUO)

Department of Defense. Defense Science Board. *Task Force on Military Satellite Communication and Tactical Networking*. 2017.[3]

Department of Defense. Chief Information Officer. *Information Paper: Expanded Office of the Secretary of Defense Level Responsibilities Necessary for the Full Range of Electromagnetic Spectrum (EMS) Activities within the Department of Defense*. 2020.

Department of Defense, Office of the Secretary of Defense, *Annual Report to Congress: Military and Security Developments Involving the People's Republic of China 2019* (May 2, 2019).

Department of Defense*. Report on FY 2019 NDAA Section 1053: Guidance on the Electronic Warfare Mission Area and Joint Electromagnetic Spectrum Operations*. 2019.

Department of Defense. U.S. Air Force Air University, Curtis E. LeMay Center for Doctrine Development and Education. *Electromagnetic Defense Task Force 2018 Report*. Maxwell Air Force Base, AL: 2018.

[1]The full report is classified; our analysis is based on the unclassified summary.

[2]The full report is classified; our analysis is based on the unclassified summary.

[3]The full report is classified; our analysis is based on the unclassified summary.

Department of Defense. U.S. Indo-Pacific Command. *Spinning a Better Kill Web: Preparing the Joint Force to Counter Chinese Networked Warfare*. Honolulu, HI: draft.

Florenzen, Matthew J., Kurt M. Shulkitas, and Kyle P. Bair. "Unmasking the Spectrum with Artificial Intelligence." *Joint Force Quarterly*, vol. 95, no. 4 (2019).

GAO. *Airborne Electronic Attack: Achieving Mission Objectives Depends on Overcoming Acquisition Challenges*. GAO-12-175. Washington, D.C.: March 29, 2012.

GAO. *Defense Management: DOD Should Set Deadlines on Stalled Collaboration Efforts and Clarify Cross-Functional Team Funding Responsibilities*. GAO-19-598. Washington, D.C.: August 20, 2019.

GAO. *Electronic Warfare: DOD Actions Needed to Strengthen Management and Oversight*. GAO-12-429. Washington, D.C.: July 9, 2012.

GAO. *Future Warfare: Army is Preparing for Cyber and Electronic Warfare Threats, But Needs to Fully Assess the Staffing, Equipping, and Training of New Organizations*. GAO-19-570. Washington, D.C.: August 15, 2019.

GAO. *National Security: Long-Range Emerging Threats Facing the United States As Identified by Federal Agencies*. GAO-19-204SP. Washington D.C.: December, 13, 2018.

Gunzinger, Mark A. Center for Strategic and Budgetary Assessments. *Sustaining America's Strategic Advantage in Long-Range Strike*. Washington, D.C.: 2010.

Harrison, Todd et al. Center for Strategic and International Studies. *Space Threat Assessment 2020*. Washington, D.C.: 2020.

Hoehn, John R. Congressional Research Service. *Defense Primer: Electronic Warfare*. Washington, D.C.: 2019.

Hoehn, John R. Congressional Research Service. *Defense Primer: Military Use of the Electromagnetic Spectrum*. Washington, D.C.: 2019.

Hoehn, John R. Congressional Research Service. *Ground Electronic Warfare: Background and Issues for Congress*. Washington, D.C.: 2019.

Hoehn, John R. Congressional Research Service. *U.S. Airborne Electronic Attack Programs: Background and Issues for Congress*. Washington, D.C.: 2019.

Hoehn, John R. Congressional Research Service. *U.S. Military Electronic Warfare Program Funding: Background and Issues for Congress*. Washington, D.C.: 2019.

Institute for Defense Analysis. *Independent Assessment of EMS Enterprise Organizational Alternatives*. Alexandria, VA: 2019.

McDermott, Roger N. International Centre for Defence and Security. *Russia's Electronic Warfare Capabilities to 2025: Challenging NATO in the Electromagnetic Spectrum*. Tallin, Estonia: 2017.

Porche, Isaac R. III, et al. RAND Corporation. *Redefining Information Warfare Boundaries for an Army in a Wireless World*. Santa Monica, CA: 2013.

Radin, Andrew, et al. RAND Corporation. *The Future of the Russian Military: Russian's Ground Combat Capabilities and Implications for U.S.-Russia Competition.* Santa Monica, CA: 2019.

Rugge, Fabio (Ed.). Brookings Institution. *The Global Race for Technological Superiority: Discover the Security Implications*. Milan, Italy: 2019.

Stokes, Major Paul L. and Lt. Col. Barian A. Woodward. "The Cyber Base of Fire: A Combined Arms Approach to Cyber Maneuver." *Marine Corps Gazette,* vol. 102, no. 4 (2018).

Sukman, Lt. Col. Dan. "Seize Initiative with Information Operations." *ARMY Magazine*, vol. 68, no. 11 (2018).

Theohary, Catherine A. and John R. Hoehn. Congressional Research Service. *Convergence of Cyberspace Operations and Electronic Warfare*. Washington, D.C.: 2019.

Weeden, Brian (Ed.) and Victoria Samson (Ed.). Secure World Foundation. *Global Counterspace Capabilities: An Open Source Assessment*. Washington D.C.: April 2020.

William, Ian and Masao Dahlgren. Center for Strategic and International Studies, *More than Missiles: China Previews its New Way of War*. Washington, D.C.: October 2019.

Appendix II: Summary of Recommendations from Studies

A number of studies in our literature review included recommendations on how the Department of Defense (DOD) could address electromagnetic spectrum (EMS)-related challenges. Summaries of these recommendations are in table 1, below. The table also identifies the main EMS-related topics that each study described.

Table 1: Selected EMS-Related Recommendations from Studies Reviewed

Report	Topics Discussed	Summary of Recommendations to the Department of Defense (DOD) related to Electromagnetic Spectrum Operations (EMS)
Bucki, 2nd Lt Elliot. "Flexible, Smart, and Lethal: Adapting U.S. SEAD Doctrine to Changing Threats." *Air and Space Power Journal,* vol. 30, issue 2 (2016).	• Technology and equipment • Doctrine	• Revise DOD's joint suppression of enemy air defenses doctrine in line with advances in integrated air defense systems and tactics.
Center for Strategic and Budgetary Assessments. *Recognizing the Electromagnetic Spectrum as an Operational Domain. Washington, D.C.: 2017.*	• Strategies • Governance and organization • Training	• Establish the EMS as a domain. • Expand membership of the Electronic Warfare Executive Committee (EW EXCOM) with expertise in training, readiness, and policy and give the EW EXCOM direct authority over EW-related policy. • Identify the increasing role of information competition and operations in the National Defense Strategy, National Military Strategy, and other policy documents. • Revise Services and Joint EMS operational concepts to include clear objectives for EMS operations, beyond gaining and maintaining superiority. Revise requirements to reflect operational concepts and training to reflect revised requirements. • Improve training ranges to support requirements for joint EMS operations.

Report	Topics Discussed	Summary of Recommendations to the Department of Defense (DOD) related to Electromagnetic Spectrum Operations (EMS)
Clark, Bryan, Whitney Morgan McNamara, and Timothy A. Walton. Center for Strategic and Budgetary Assessments. *Winning the Invisible War: Gaining an Enduring U.S. Advantage in the Electromagnetic Spectrum*. Washington, D.C.: 2019.	• Technology and equipment • Strategies • Doctrine • Training	• Implement new operational concepts that employ maneuver and complexity to fully exploit electronic warfare (EW) and EMS operations. As part of this, DOD will need to evolve its force design and command and control processes to fully exploit maneuver warfare. • Adopt more opportunity-based rather than requirements-based innovation. • Implement maneuver warfare in the EMS. This involves pursuing a goal of EMS superiority, rather than solving individual capability gaps. • Treat the EMS as an operational domain, even if not formally enacted into doctrine. • Emphasize virtual and constructive EW and EMS operations training instead of live events. • Recommendations for development of technical capabilities, including incorporating electronic support functionality in every EW and EMS operations system and electronic battle management program.
Davis, M. Thomas, David Barno, and Nora Bensahel. Center for New American Security. *The Enduring Need for Electronic Attack in Air Operations*. Washington, D.C.: 2014.	• Doctrine • Technology and equipment	• Commit to doctrine and investment programs that recognize the importance of both electronic attack (EA) and electronic protection (EP) in anti-access/aerial denial environments. • Integrate various air components across platform communities. • Explore developing EA systems that can give a comprehensive view of the battlespace with the authority to task assets from all services involved in the mission. • Create a “rapid acquisition system” to fast-track EA systems more quickly before they become outdated. • Prioritize development of the Next Generation Jammer and similar capabilities as they emerge.

Report	Topics Discussed	Summary of Recommendations to the Department of Defense (DOD) related to Electromagnetic Spectrum Operations (EMS)
Department of Defense. Defense Science Board. *Defense Applications of 5G Network Technology: Executive Summary*. 2019.[1]	• Spectrum management • 5G • Technology • Strategies	• Begin programs to develop hardened and secure 5G technologies and infrastructure and request funds to facilitate research and development of advanced secure spectrum sharing technologies and techniques. • The National Telecommunications and Information Administration and the Federal Communications Commission, with support from the DOD Chief Information Officer (CIO), should develop a National Spectrum Strategy. • CIO should develop a DOD spectrum strategy, roadmap, and action plan aligned with the National Strategy.
Department of Defense. Defense Science Board. *Task Force on Military Satellite Communication and Tactical Networking: Executive Summary*. 2017.[2]	• Technology and Equipment • Governance and organization	• Develop, produce, and increase several technologies that use the EMS, such as the Protected Tactical Waveform and Advanced Extremely High Frequency terminals for aircraft. • Services and Combatant Commands should develop and exercise with tactics, techniques, and procedures for operating in a degraded military satellite communications environment. • The Secretary of Defense should appoint a single, central authority for communications with responsibility for the overall DOD network and work with operational elements to create training and materiel capabilities.
Department of Defense. Chief Information Officer. *Information Paper: Expanded Office of the Secretary of Defense Level Responsibilities Necessary for the Full Range of Electromagnetic Spectrum (EMS) Activities within the Department of Defense*. 2020.	Governance and organization	• Recommends a course of action that would build on the status quo for CIO's EMS responsibilities by doing the following: • CIO will add activities and receive increased resources to achieve greater oversight and responsibility. • Adding staff and expertise to create and ensure effective EMS governance. • Leveraging existing responsibilities and expertise in other Office of the Secretary of Defense organizations. • Consolidating EMS and EW responsibilities to eliminate current duplication of efforts. • Increase in total resources supporting EMS responsibilities and functions.

[1]The full report is classified; our analysis is based on the unclassified summary.

[2]The full report is classified, our analysis is based on the unclassified summary.

Report	Topics Discussed	Summary of Recommendations to the Department of Defense (DOD) related to Electromagnetic Spectrum Operations (EMS)
Department of Defense. U.S. Air Force Air University, Curtis E. LeMay Center for Doctrine Development and Education. *Electromagnetic Defense Task Force 2018 Report.* Maxwell Air Force Base, AL: 2018.	• Strategies • Technology and equipment • Spectrum management • 5G • Staffing • Governance and organization	• Create a presidentially appointed position for an executive agent for EMS management. • Position the U.S. Space Force to assume management of all EMS activities. • Rapidly invest in 5G to ensure competition. • Develop national EMS standards for aircraft, ships, and vehicles. • Invest in next-generation research in quantum communications and other emerging EMS phenomena. •
GAO. *Airborne Electronic Attack: Achieving Mission Objectives Depends on Overcoming Acquisition Challenges*. GAO-12-175. Washington, D.C.: March 29, 2012.	• Technology and equipment	• Recommended certain program reviews to assess cost, schedule and performance. • Determine airborne EA capability gaps and how they can best be met using assets likely to be available. • Align service investments in science and technology with department-EW priorities. • Recommended reviewing certain capability programs to prevent unnecessary overlap. • All recommendations are closed as implemented
GAO. *Electronic Warfare: DOD Actions Needed to Strengthen Management and Oversight.* GAO-12-479. Washington, D.C.: July 9, 2012.	• Governance and organization • Strategies	• Recommended additional elements be included in annual reports to Congress on DOD's strategy for electronic warfare, including performance measures and resources necessary. • The Commander of U.S. Strategic Command should define the objectives of the Joint Electromagnetic Spectrum Control Center and issue an implementation plan. • Update key guidance regarding EW to clearly define oversight roles and responsibilities. • All recommendations are closed as implemented
GAO. *Future Warfare: Army Is Preparing for Cyber and Electronic Warfare Threats, but Needs to Fully Assess the Staffing, Equipping, and Training of New Organizations*. GAO-19-570. Washington, D.C.: August 15, 2019.	• Governance and organization • Doctrine • Staffing • Training	• The Army should assess the risks associated with staffing, equipping, and training the existing ICEWS unit prior to its incorporation into the Multi-Domain Task Force in fiscal year 2020. • The Army should assess the risks with staffing, equipping, and training new units that it plans to activate in an accelerated manner for the purpose of conducting multi-domain operations.
GAO. Defense Management: DOD Should Set Deadlines on Stalled Collaboration Efforts and Clarify Cross-Functional Team Funding Responsibilities. GAO-19-598. Washington, D.C.: August 20, 2019.	• Governance and organization	• DOD should make sure that the Chief Management Officer and the Electromagnetic Spectrum Operations Cross-Functional Team clarify roles and responsibilities for providing administrative support and funding for the team beyond fiscal year 2019.

Report	Topics Discussed	Summary of Recommendations to the Department of Defense (DOD) related to Electromagnetic Spectrum Operations (EMS)
Gunzinger, Mark A. Center for Strategic and Budgetary Assessments. Sustaining *America's Strategic Advantage in Long-Range Strike*. Washington, D.C.: 2010.	• Technology and equipment	• Recommends new EA systems and timing of investments, including penetrating bombers and manned or unmanned airborne EA platforms to support long-range strike operations.
Institute for Defense Analysis. *Independent Assessment of EMS Enterprise Organizational Alternatives*. Alexandria, VA: 2019.	• Governance and organization	• Recommends the department establish a comprehensive new EMS organizational structure with a civilian organization to serve as capabilities integrator and a military organization to serve as an "operational effects provider" and integrator. • Recommends that the department broaden U.S. Cyber Command's responsibilities to serve as the operational effects provider. • The department should establish an Assistant Secretary of Defense (ASD) as the civilian element, who will broaden the responsibilities of the existing CIO. • The new ASD should be supported by a new defense agency or field activity to provide technical support. • To transition to this new EMS organizational structure, the study recommends establishing an EMS Task Force led by a senior civilian and senior military (3 star level) on a full-time or near full-time basis for 1-2 years. The Task Force will develop a transition plan to the new EMS structure, identify immediate materiel and non-materiel actions to address EMS shortfalls, and lay the groundwork for long-term actions. • The EW Executive Committee should be renamed the EMS Executive Committee with the new ASD taking over as civilian co-chair and the Vice Chairman of the Joint Chiefs of Staff continuing to serve as the military co-chair, to provide advice to the new hybrid EMS organizational structure.
Porche, Isaac R. III, et al. RAND Corporation. *Redefining Information Warfare Boundaries for an Army in a Wireless World*. Santa Monica, CA: 2013.	• Doctrine • Governance and organization	• Develop new doctrine that divides current information operations doctrine into information technical operations (including EW) and inform and influence operations. Information technical operations would fall under cyber-electronic operations or cyber-electromagnetic operations.

Source: GAO analysis of the identified reports. | GAO-21-64

Note: This table includes only explicitly stated recommendations. Also, we included only recommendations related to the electromagnetic spectrum or electromagnetic warfare. We did not assess to what extent the Department of Defense has addressed these recommendations.

Appendix III: Comments from the Department of Defense

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THE JOINT STAFF
WASHINGTON, DC

DJSM 0182-20
23 November 2020

Reply Zip Code:
20318-0300

MEMORANDUM FOR Dr. Joseph Kirschbaum
Director, Defense Capabilities and Management
U.S. Government Accountability Office

SUBJECT: (U) Electromagnetic Spectrum Operations: DOD Needs to Address Governance and Oversight Issues to Help Ensure Superiority

1. (U) Attached is the Department of Defense (DoD) response to the Government Accountability Office (GAO) draft report GAO-21-64, "ELECTROMAGNETIC SPECTRUM OPERATIONS: DoD Needs to Address Governance and Oversight Issues to Help Ensure Superiority" October 6, 2020 (GAO Code 104126).

2. (U) The Joint Staff point of contact is CAPT Terrence Shashaty; Terrence.M.Shashaty@mail.mil; 703-571-1899.

Sincerely,

ANDREW P. POPPAS, LTG, USA
Director, Joint Staff

Attachment:
As stated

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GAO DRAFT REPORT DATED OCTOBER 6, 2020
GAO-21-64 (GAO CODE 104126)

"ELECTROMAGNETIC SPECTRUM OPERATIONS: DOD NEEDS TO ADDRESS GOVERNANCE AND OVERSIGHT ISSUES TO HELP ENSURE SUPERIORITY"

DEPARTMENT OF DEFENSE COMMENTS TO THE GAO RECOMMENDATION

RECOMMENDATION 1: The Government Accountability Office (GAO) recommends that the Secretary of Defense (SecDef) should ensure that the Vice Chairman of the Joint Chiefs of Staff (VCJCS), as Senior Designated Official (SDO) of the Electromagnetic Spectrum Operations (EMSO) Cross-functional Team (CFT), identifies the procedures and processes necessary to provide for integrated defense-wide strategy, planning, and budgeting with respect to joint electromagnetic spectrum operations, as required by the Fiscal Year (FY) 2019 National Defense Authorization Act (NDAA).

DoD RESPONSE: CONCUR. The VCJCS, as SDO and lead of the EMSO CFT, has taken steps to complete all of the items required by the FY19 NDAA. The EMSO CFT, in coordination with the Department of Defense (DoD) Chief Information Officer, is developing an implementation plan for the September 2020 EMS Superiority Strategy, which identifies the need to integrate strategy, planning, and budgeting.

RECOMMENDATION 2: The GAO recommends that SecDef should ensure that the VCJCS as SDO of the CFT proposes EMS governance, management, organizational, and operational reforms to SecDef.

DoD RESPONSE: CONCUR. The department agrees that the SecDef has designated VCJCS to serve as the current SDO, and has given him the responsibility to propose EMSO governance, management, organization, and operational reforms to the SecDef, after review and comment by the Electronic Warfare Executive Committee, per the FY 2019 NDAA. VCJCS, with his multiple roles and responsibilities in various boards, committees, and advisory groups, is in the best position to integrate the many ongoing efforts in the department and provide those recommendations to the SecDef.

RECOMMENDATION 3: The GAO recommends that SecDef should assign clear responsibility with authority and resources necessary to compel action to a senior official for long-term implementation of the 2020 strategy, in time to oversee the execution of the 2020 strategy implementation plan.

DoD RESPONSE: PARTIALLY CONCUR. DoD agrees that successful implementation of the 2020 EMS Superiority Strategy requires clear authorities and proper resourcing. DoD is developing organizational reform recommendations, which will provide SecDef options for EMS organization and governance. Until SecDef reviews options, DoD is unable to concur or non-concur with the recommendation that a single, senior official implements all of the items in the 2020 EMS Superiority Strategy.

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RECOMMENDATION 4: The GAO recommends that the SecDef should ensure that SDO for long-term strategy implementation issues an actionable implementation plan within 180 days following issuance of the 2020 strategy.

DoD RESPONSE: PARTIALLY CONCUR. DoD agrees with the recommendation to issue an actionable implementation plan within 180 days of the September 2020 release of the 2020 EMS Superiority Strategy. DoD believes that the SecDef designated SDO, currently VCJCS, is responsible for overseeing the implementation plan. Until SecDef reviews options as described in Recommendation #3, SDO, in coordination with DoD CIO, has convened an implementation plan development team that will develop and promulgate an actionable implementation plan within 180 days of the September 2020 release of the EMS Superiority Strategy.

RECOMMENDATION 5: The GAO recommends that SecDef should ensure that the SDO for long-term strategy implementation creates oversight processes that would facilitate DoD's implementation of the 2020 strategy.

DoD RESPONSE: PARTIALLY CONCUR. DoD agrees that long-term strategy implementation requires oversight processes to facilitate DoD's implementation of the 2020 EMS Superiority Strategy. Until SecDef reviews options as described in Recommendation #3, VCJCS, in coordination with DoD CIO, has convened an implementation plan team that will create oversight processes that facilitate the implementation of the EMS Superiority Strategy.

Appendix IV: GAO Contacts and Staff Acknowledgments

GAO Contact

Joseph W. Kirschbaum, (202) 512-9971 or KirschbaumJ@gao.gov

Staff Acknowledgments

In addition to the individual named above, Tommy Baril (Assistant Director), Jennifer Spence (Analyst-in-Charge), Haley Dunn, Matthew Jacobs, and Gabrielle Matuzsan made key contributions to this report. Other contributors include Tracy Barnes, David Jones, Jamilah Moon, Richard Powelson, Terry Richardson, Pamela Snedden, and Hai Tran.

Related GAO Products

National Security: Actions Needed to Address 5G Telecommunications Risks. GAO-21-121C. Washington, D.C.: November 5, 2020.

National Security: Additional Actions Needed to Ensure Effectiveness of 5G Strategy. GAO-21-155R. Washington, D.C.: October 7, 2020.

5G Deployment: FCC Needs Comprehensive Strategic Planning to Guide Its Efforts. GAO-20-468. Washington, D.C.: June 12, 2020.

Science and Tech Spotlight: 5G Wireless. GAO-20-412SP. March 25, 2020.

Defense Management: More Progress Needed for DOD to Meet Outstanding Statutory Requirements to Improve Collaboration. GAO-20-312. Washington, D.C.: January 30, 2020.

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