United States Government Accountability Office

Report to Congressional Committees

September 2021

SATELLITE COMMUNICATIONS

DOD Should Explore Options to Meet User Needs for Narrowband Capabilities

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Highlights

Highlights of GAO-21-105283, a report to congressional committees

September 2021

SATELLITE COMMUNICATIONS

DOD Should Explore Options to Meet User Needs for Narrowband Capabilities

Why GAO Did This Study

DOD has invested $7.4 billion to develop, build, and begin delivering MUOS. However, longstanding gaps between the fielding of the satellite system and compatible user terminals have limited DOD's ability to fully use the system.

The Senate Armed Services Committee report to the bill for the National Defense Authorization Act for Fiscal Year 2020 contained a provision for GAO to review DOD's use of MUOS capabilities and any plans for a MUOS follow-on capability. In this report, GAO (1) provides information on the extent to which DOD is using MUOS advanced communications capabilities; (2) assesses DOD's challenges and steps taken in transitioning to these capabilities, and (3) assesses efforts DOD has underway to meet future narrowband satellite communications needs. This is a public version of a sensitive report that GAO issued in June 2021. Information that DOD deemed to be sensitive has been omitted.

GAO reviewed DOD planning documents, system assessments, and test reports. GAO also analyzed the services' terminal fielding and network transition plans. GAO interviewed oversight and acquisition officials across DOD.

What GAO Recommends

GAO recommends DOD (1) explore and implement an option for narrowband satellite communications capabilities to meet near-term needs, and (2) reexamine its future narrowband satellite needs. DOD concurred with our recommendations and provided comments, which we incorporated as appropriate.

View GAO-21-105283.For more information, contact Jon Ludwigson at (202) 512-4841 or ludwigsonj@gao.gov.

What GAO Found

The Department of Defense (DOD) is not using the full capabilities of its latest ultra high frequency (narrowband) military satellite communications system, the Mobile User Objective System (MUOS). MUOS provides secure communications less vulnerable to weather conditions or other potential impediments. The full constellation of MUOS satellites has been on orbit for over 4 years, but DOD has not been able to use the system's advanced capabilities—such as its 10-fold increase in communications capacity. A key reason is the military services' delayed delivery of compatible radio terminals to users (see figure). DOD is funding and developing plans to accelerate procurement and delivery of these terminals.

Army Soldiers Using a Mobile User Objective System-Compatible Portable Terminal

Source: Army Handheld, Manpack, and Small Form Fit program office. | GAO-21-105283

DOD faces other challenges to its narrowband communications capabilities.

- In the near term, users continue to rely on the communications system that preceded MUOS, which is oversubscribed and will remain so while DOD works to field terminals and transition to MUOS. DOD has not explored and adopted narrowband communication options, which, if implemented, could help to meet unmet near-term communication needs.
- In the longer term, the five MUOS satellites that are on orbit have limited design lives. DOD plans to buy and launch additional satellites to sustain the constellation's availability, but without the legacy capability of the older system.

DOD has not determined its future narrowband satellite communication needs after MUOS. DOD has not updated its narrowband requirements since 2010 and has no plans to do so, although the uses, technology, and threats to communications have changed. Reexamining its narrowband communications needs will enhance DOD's ability to field a timely replacement for MUOS and ensure warfighters have needed communications tools in the future.

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Abbreviations

AN/ARC	Army Navy Airborne Radio Communications
AN/PRC	Army Navy Portable Radio Communications
AOA	Analysis of Alternatives
CJCS	Chairman of the Joint Chiefs of Staff
DMR	Digital Modular Radio
DOD	Department of Defense
DOT&E	Director of Operational Test and Evaluation
FOC	full operational capability
GHz	gigahertz
HMS	Handheld, Manpack, and Small Form Fit
IOC	initial operational capability
JCIDS	Joint Capabilities Integration and Development System
JROC	Joint Requirements Oversight Council
JTRS	Joint Tactical Radio System
MDAP	Major Defense Acquisition Program
MHz	megahertz
MUOS	Mobile User Objective System
SATCOM	satellite communications
UHF	ultra high frequency
USASMDC	United States Army Space and Missile Defense Command

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September 2, 2021

Congressional Committees

The Department of Defense (DOD) has invested over $7.4 billion to develop and produce the Mobile User Objective System (MUOS). MUOS is DOD's latest ultra high frequency (narrowband) military satellite communications system and is designed to provide warfighters with voice and data communications worldwide in most weather and through thick foliage and urban terrain. The Navy designed the MUOS system, which consists of four satellites, one on-orbit spare satellite, and a ground control and network management system. The program is to provide advanced satellite communications to more users—with at least a 10-fold increase in communications capacity—than the system it is replacing, called the Ultra High Frequency (UHF) Follow-On system. MUOS development activities began in 2004, continued with the first satellite launch in 2012, and culminated with the launch of the fifth and final planned satellite in 2016.

Starting in 2007, and in subsequent reports, we found that DOD likely would not be able to use advanced MUOS capabilities as scheduled because it had not synchronized the deliveries of the MUOS satellites with updated user radio terminals capable of receiving and transmitting advanced MUOS voice and data signals, among other things.[1] We have reported on the long standing challenge DOD faces in synchronizing satellites and their associated ground systems, including user terminals.[2] DOD is taking steps to synchronize space system components to better utilize on-orbit capabilities and provide capabilities to the warfighter.

The Senate Armed Services Committee report to the bill for the National Defense Authorization Act for Fiscal Year 2020 contained a provision for GAO to review DOD's use of MUOS capabilities and any planning efforts for a MUOS follow-on capability.[3] In this report, we (1) provide information

[1]GAO, *Defense Acquisitions: Assessments of Selected Acquisition Programs,* GAO-07-406SP (Washington, D.C.: Mar. 30, 2007). For additional reports on this issue, please see the Related GAO Products page at the end of the report.

[2]GAO, *Defense Acquisitions: Challenges in Aligning Space System Components,* GAO-10-55 (Washington, D.C.: Oct. 29, 2009).

[3]S. Rep. No. 116-48, at 332 (2019), accompanying S. 1790, the National Defense Authorization Act for Fiscal Year 2020, Pub. L. No. 116-92 (2019).

on the extent to which DOD is using the advanced communications capabilities of MUOS; (2) assess what, if any, challenges DOD faces in transitioning to the advanced communications capabilities of MUOS and what DOD is doing to address them; and (3) assess the efforts DOD has underway for acquiring follow-on narrowband satellite communications capabilities.

This report is a public version of a sensitive report that we issued on June 3, 2021.[4] DOD deemed some of the information in our June 2021 report to be sensitive, which must be protected from public disclosure. Therefore, this report omits sensitive information about specific terminal fielding and network transition plans, the operational status of satellites, the status of narrowband SATCOM capabilities, and the challenges and potential impacts of delays in transitioning to advanced MUOS capabilities. Although the information provided in this report is more limited, the report addresses the same objectives as the sensitive report and uses the same methodology.

For each objective, we reviewed DOD oversight and Navy program office planning documents and system assessments from the start of the program in 2004 to the present. To provide information on the extent to which DOD is using the advanced communications capabilities of MUOS, we interviewed each of the U.S. military services on their current and future expected use of MUOS. We also received and reviewed documentation of the services' evaluation and training activities.

To assess any challenges DOD faces in transitioning to using MUOS and what DOD is doing to address them, we reviewed test reports and other DOD and Navy program documents for challenges identified. We also compared DOD's narrowband satellite communications decisions, plans, and other documents to DOD policies, such as the Chairman of the Joint Chiefs of Staff Instruction 6250.01F on DOD satellite communications.[5] We interviewed DOD officials responsible for managing DOD satellite communications as well as DOD satellite communications planners and users to further identify and assess challenges. We also conducted a satellite constellation assessment of MUOS satellites based on their expected service lives to assess plans for developing, acquiring, and

[4]GAO, *Satellite Communications: DOD Should Explore Options to Meet User Needs for Narrowband Capabilities*, GAO-21-349SU (Washington, D.C.: June 3, 2021).

[5]Chairman of the Joint Chiefs of Staff, *Instruction on Department of Defense Satellite Communications*, CJSCI 6250.01F (Feb. 26, 2019).

launching MUOS follow-on satellites to understand how long the MUOS constellation will be available.

To assess DOD's efforts for acquiring follow-on narrowband capabilities, we compared the extent to which DOD was conducting, or preparing to conduct, early acquisition activities to DOD Instruction on Analysis of Alternatives (AOA) and GAO identified leading practices in GAO's Cost Estimating and Assessment Guide.[6] We interviewed DOD officials in the Office of the Under Secretary of Defense for Acquisition and Sustainment, Navy program office, U.S. Space Command, and Space Force for any updates on acquisition planning and decisions. Appendix I contains additional details on our objectives, scope, and methodology.

We conducted this performance audit from April 2020 to June 2021 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives. We subsequently worked with DOD from June 2021 to September 2021 to prepare this public version of the sensitive report. This public version was also prepared in accordance with these standards.

Background

DOD Uses Satellite Communications for Operations

DOD uses military satellite communications (SATCOM) to support air, land, sea, and space operations critical to U.S. national security, including, for example, beyond line-of-sight communications between commanders at a base and soldiers in the field carrying out operations.[7] DOD generally uses three types of SATCOM for different missions and capabilities:

- **Protected SATCOM.** Communications in this band use the upper portion of the Super High Frequency band and the lower portion of the Extremely High Frequency bands in the 20 gigahertz (GHz) to 60 GHz

[6]Department of Defense Instruction 5000.84, *Analysis of Alternatives* (Aug. 4, 2020). GAO, *Cost Estimating and Assessment Guide: Best Practices for Developing and Managing Program Costs*, GAO-20-195G (Washington, D.C.; Mar. 12, 2020).

[7] Beyond line-of-sight is a path between the transmitting and receiving antennas that is obstructed.

range to provide secure, assured communications, such as during a nuclear war.

- **Wideband SATCOM.** Communications in this band use the Super High Frequency band in the 3 GHz to 30 GHz range to support a global capacity for high-data-rate communications, such as for high-quality voice and imagery.
- **Narrowband SATCOM.** Communications in this band use the UHF band in the 300 MHz to 3 GHz range and provide secure communications less vulnerable than other types of SATCOM to weather conditions or other physical limitations, such as dense foliage and challenging terrain. Ultra-high frequencies are also used by television broadcasters, air traffic controllers, the Global Positioning System, and mobile network technology.

Currently, DOD relies on narrowband SATCOM capabilities provided via three types of DOD satellites—(1) the Navy's Fleet Satellite, (2) UHF Follow-On, and (3) MUOS. The MUOS satellite system consists of a four-satellite constellation (plus one spare satellite) in geosynchronous orbit.[8] Each of the five MUOS satellites has two sets of communication hardware on board: one dedicated to providing existing narrowband SATCOM and one dedicated to providing advanced MUOS capabilities. In this report, we refer to DOD's existing narrowband SATCOM capabilities provided through Fleet SATCOM, UHF Follow-On, and the existing narrowband SATCOM capability on the MUOS satellites as its "legacy UHF" SATCOM capabilities.

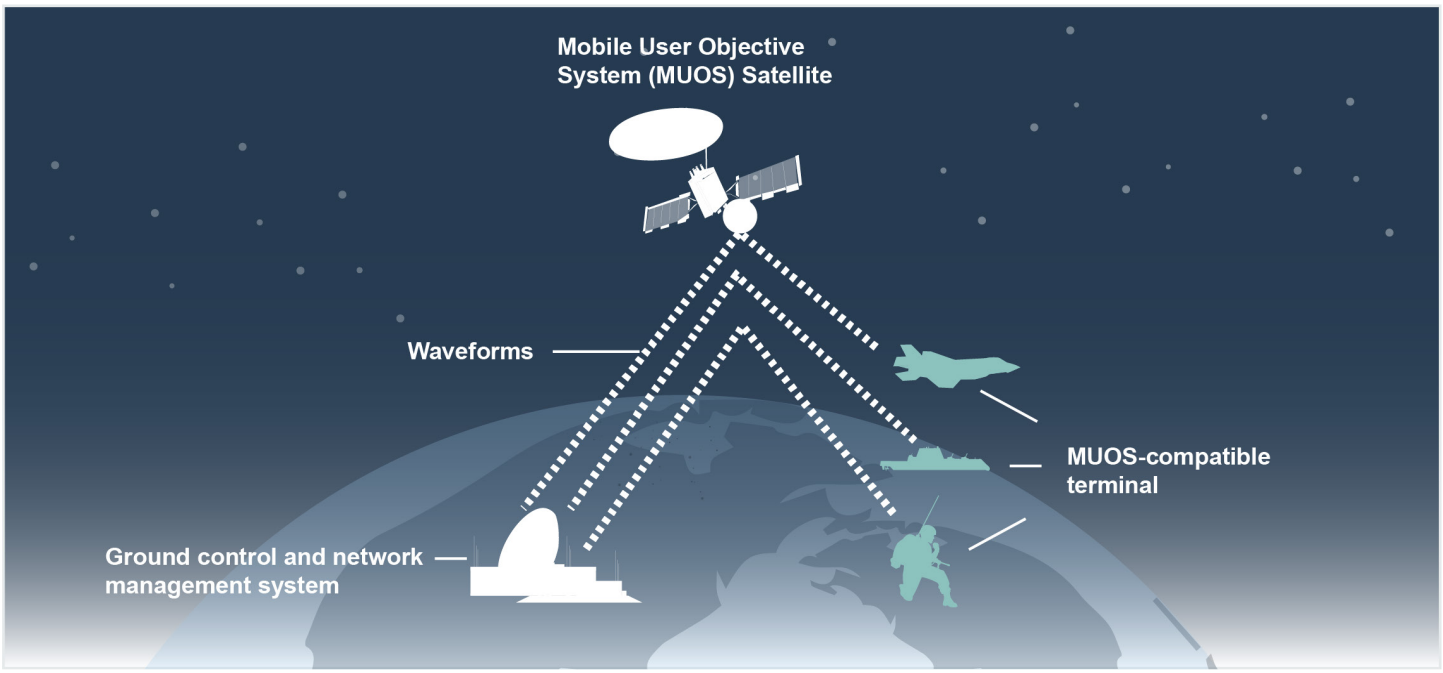
In order to communicate using narrowband SATCOM, in addition to DOD launching and maintaining capabilities of the satellites, warfighters also require compatible radio terminals that are small and portable enough for them to carry deep into military theaters of operation. Today, these legacy UHF terminals are in widespread use across DOD. Although DOD relies on its legacy UHF capability, it is working to transition to its newer, more advanced MUOS SATCOM capability.

In addition to the satellites, the MUOS system includes ground control and network management segments and a new communication waveform

[8]At an altitude of about 22,300 miles above the equator, a satellite in geosynchronous orbit has a revolution that is synchronized with the Earth's rotation giving it a seemingly stationary position above a fixed point.

used for transmission between terminals and the satellites.[9] MUOS users—whether individuals or those in aircraft, ships, or ground vehicles—also need MUOS-compatible terminals to access the advanced MUOS SATCOM capabilities of the system. Each of the segments involved in using the MUOS capability is shown in figure 1.

Figure 1: MUOS Satellite, Ground System, Waveform, and Compatible User Terminals



Source: GAO analysis of Navy and Johns Hopkins Applied Physics Lab Documents. | GAO-21-105283

The MUOS ground control and network management systems include stations and ground facilities to control the satellites' movements and positions in space and transmit signals between users. These systems also establish, monitor, and route the advanced capability communications between users and teleports for DOD's integrated

[9]As used in this report, a waveform is an electromagnetic signal with a certain shape designed to provide a desired function or application.

telecommunications network.[10] MUOS-compatible user terminals—whether they are carried by a soldier or installed into a ground vehicle, ship, or airplane (all are referred to as platforms)—are terminals that typically have multiple modes of communication, including the MUOS waveform. Figure 2 shows a MUOS-compatible portable terminal in use.

Figure 2: Army Soldiers Using a Mobile User Objective System-Compatible Portable Terminal

Source: Army Handheld, Manpack, and Small Form Fit program office. | GAO-21-105283

DOD planned for the advanced MUOS capability to offer significant improvements over the legacy systems, including the ability to increase communications capacity, reduce signal interference, and improve connectivity. The MUOS waveform—an electromagnetic signal designed to carry information—works by using technology found in cellular

[10]The Defense Information Systems Network is comprised of DOD-owned and leased subsystems and networks. It is DOD's worldwide enterprise-level infrastructure providing end-to-end information transfer in support of DOD operations. A teleport is a center providing interconnections between different forms of telecommunications, especially one that links satellites to ground-based communications.

telephone networks to provide narrowband SATCOM to more users. It also delivers a 10-fold increase in overall communications capacity over legacy UHF capabilities. It supports conventional voice, text, and data communications, including streaming and internet services. The MUOS waveform can connect users of the advanced capability to each other but not to legacy UHF users. However, in the future, MUOS is planned to allow some legacy UHF and MUOS users to communicate via a communications interface DOD is developing. This interface is intended to be a gateway to facilitate connectivity between users of legacy SATCOM with users of the advanced MUOS capability.

To date, the Navy has been primarily responsible for developing and delivering DOD's narrowband SATCOM capabilities, including MUOS. In May 2019, the Secretaries of the Air Force and the Navy outlined their intent to transfer these responsibilities from the Navy to the Department of the Air Force. In January 2021, DOD formally transferred the Milestone Decision Authority from the Navy to the Air Force.[11] According to officials, the Space Force will eventually be responsible for acquiring future narrowband capabilities. According to a Navy official, Navy program office personnel currently working on MUOS will continue to do so—whether in the Navy or the Space Force.

DOD Experienced Challenges Developing and Delivering MUOS Capabilities

The Navy and Army originally planned to field MUOS satellites and MUOS-compatible terminals at the same time, but technical challenges on both efforts brought them out of sync. Specifically, the Navy started MUOS development in 2004 and experienced challenges throughout, including in its operational testing. That same year, the Army started developing portable, software-defined radio terminals—some of which would be MUOS-compatible—and also ran into challenges in development.

The Navy began MUOS satellite and ground system development activities in 2004 and planned to achieve an initial operational capability

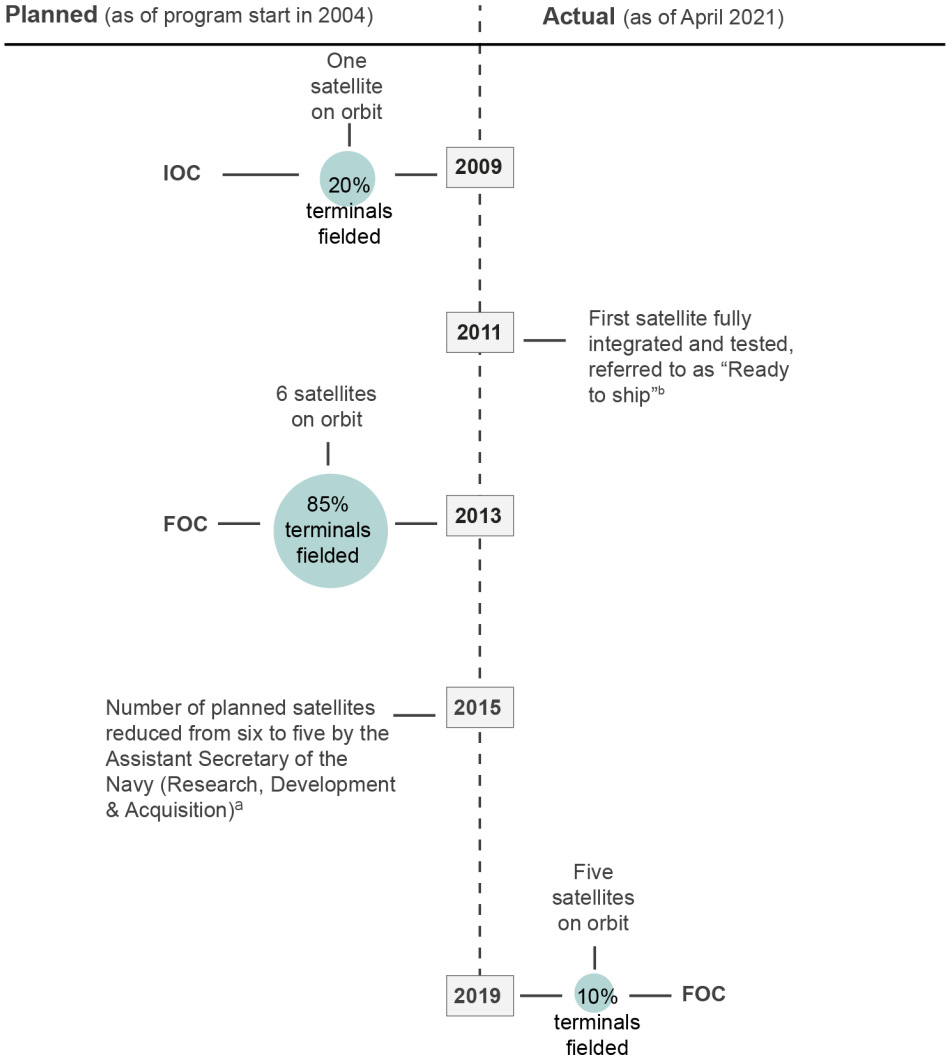
[11]The Milestone Decision Authority is the official designated with the overall responsibility and authority for acquisition decisions of a Major Defense Acquisition Program (MDAP). MDAPs are generally programs designated by the Secretary of Defense as such, or that are estimated to require eventual total expenditure for research, development, test, and evaluation of more than $525 million, or for procurement of more than $3.065 billion, in fiscal year 2020 constant dollars.

(IOC) in 2009 and full operational capability (FOC) by 2013.[12] At the beginning of the program, the Navy defined MUOS IOC as having the first satellite on orbit and operational. The Navy also emphasized that, to take advantage of MUOS capabilities, it was essential that DOD field 20 percent of its total planned MUOS-compatible user terminals and be ready to establish networks at the same time.[13] However, technical challenges in MUOS satellite and ground system development led to milestones that were significantly delayed or not achieved as originally intended, as shown in figure 3.

[12]The Navy defined MUOS full operational capability (FOC) as when all satellites were on orbit with the associated ground system in place and operational. Similarly, the Navy stipulated that FOC included fielding 85 percent of the planned MUOS-compatible terminals by that time.

[13]For this report, we refer to a network as a formally defined group of users in DOD who are connected to each other by using terminals, ground systems, and satellites to communicate.

Figure 3: Mobile User Objective System (MUOS) Original and Actual Capability Delivery Dates for Initial (IOC) and Full Operational Capability (FOC), Terminal Fielding, and Satellite Launch Dates



Source: GAO analysis of MUOS documents. | GAO-21-105283

[a]The MUOS program baseline originally planned to deliver six satellites. In 2015, the Assistant Secretary of the Navy (Research, Development & Acquisition) approved the reduction of satellite quantities to five.

[b]In 2010, the MUOS program office began reporting 'on-orbit capability,' which referred to one satellite with a satellite/network control ground station, with no expectation for fielding MUOS-compatible terminals. In 2012, on-orbit capability was changed to 'Ready to Ship,' which refers to one satellite fully integrated and tested, ready to be delivered to the launch site, along with an operational satellite/network control ground station.

DOD also faced challenges in developing the MUOS waveform. For example, although the Navy program office had completed waveform testing on generic hardware in a laboratory in 2012, operational testing was delayed due to reliability issues. The Navy has continued to update the MUOS waveform since 2012 and the most recent version—the operational version—has been available for installation into all current MUOS-compatible terminals since December 2017 and approved for operational use in 2020, according to DOD officials.

The MUOS program continued to experience development and testing challenges more recently. Specifically:

- Operational testing in 2015 determined that the MUOS satellites and ground system were not operationally effective, suitable, or secure, due in part to cybersecurity concerns in the ground system. Between 2015 and 2019, the program worked to address the deficiencies.
- Operational testing in 2019 found MUOS to be operationally effective and suitable, but the resulting test report provided recommendations to improve cybersecurity, which the Navy is implementing.

With the successful completion of operational testing in 2019, U.S. Space Command directed execution of MUOS full operational acceptance in April 2020—giving SATCOM users in DOD the ability to use MUOS to conduct operations.

The Army program focused on developing terminals—the Handheld, Manpack, and Small Form Fit Radios (HMS)—that also experienced significant schedule delays in their development.[14] For example, in March 2012, we reported that the terminal program had entered into production in June 2011 without demonstrating or assessing the maturity of all of its critical technologies.[15] According to program officials, its terminal designs were stable. However, the program was making software changes, and it identified reliability and heat-related issues in a 2011 test event. In fiscal year 2012, DOD test officials reported that the portable terminal was not

[14]The Army's HMS terminal program resulted from the cancelled Joint Tactical Radio System Ground Mobile Radios program, which DOD terminated in 2011. The Army planned for the HMS MUOS-compatible terminals to provide communications and networking capabilities for use by all of the military services. At the time these programs were started, the Army HMS program was the only program planned to deliver MUOS-compatible terminals for the services.

[15]GAO, *Defense Acquisitions: Assessments of Selected Weapon Programs*, GAO-12-400SP (Washington, D.C.: Mar. 29, 2012).

operationally effective or suitable based on the results of operational testing. DOD restructured the program in 2012. HMS is now acquiring multiple types of terminals, including the portable terminal—some of which will be MUOS-compatible—for the Army, Air Force, Navy, Marine Corps, and Special Operations Command communications needs. The services also plan to field terminals other than the Army's. For more information on the terminals the services plan to use with MUOS, see appendix II.

Delivery of MUOS Capabilities Lacked Synchronization

In 2007, we reported that a lack of coordination between the MUOS and HMS acquisition efforts contributed to synchronization challenges.[16] Ultimately, the issues the programs encountered in development led to the services delaying their acquisition and fielding of MUOS-compatible terminals for 10 years.

Other programs also faced the challenges of synchronizing the delivery of an end-to-end capability. In 2009, we reported that satellites, ground control systems, and user terminals in most of DOD's major space system acquisitions were not optimally aligned, leading to underutilized satellites and limited capability provided to the warfighter.[17] We also found that there was a lack of coordinated planning among organizations involved in the development of these space systems, which contributed to their lack of synchronization. As a result, we recommended in 2009 that the Secretary of Defense take a variety of actions to help ensure that DOD space systems provide more capability to the warfighter through better synchronization. Some of these actions included defining a basic level of expected synchronization for each program and formulating guidance on aligning space system segments. DOD concurred or partially concurred with these recommendations but has not taken actions to define synchronization or formulate guidance. In 2019, we reported on the challenges these programs—including MUOS—have had synchronizing delivery of capabilities to the warfighter.[18]

[16]GAO, *Defense Acquisitions: Assessments of Selected Weapon Programs*, GAO-07-406SP (Washington, D.C.: Mar. 30, 2007).

[17]GAO, *Defense Acquisitions: Challenges in Aligning Space System Components*, GAO-10-55 (Washington, D.C.: Oct. 29, 2009).

[18]GAO, *Weapon Systems Annual Assessment: Limited Use of Knowledge-Based Practices Continues to Undercut DOD's Investments*, GAO-19-336SP (Washington, D.C.: May 7, 2019).

MUOS Satellites Enabled Continued Use of Legacy UHF SATCOM, but DOD Has Not Taken Full Advantage of MUOS Capabilities

DOD launched the first MUOS satellite into orbit over 9 years ago; however, DOD has not taken full advantage of MUOS capabilities due to delays in fielding MUOS-compatible terminals. DOD has recently begun using the terminals in several military operations or exercises.[19] Additionally, most of the services have begun using their terminals in testing, training, and evaluations over the past few years.

Delayed Terminal Fielding Has Resulted in DOD Underutilizing MUOS

DOD uses the legacy UHF SATCOM capabilities on the MUOS satellites. MUOS satellites included legacy UHF communications hardware, which has enabled the continued use of legacy UHF SATCOM. This legacy SATCOM accounts for less than 10 percent of the MUOS satellites' total capacity. Due in part to delays in acquiring and fielding MUOS-compatible terminals, DOD has not used the bulk of the satellites' remaining capacity, comprising nearly all of the advanced capabilities MUOS was intended to deliver. These advanced capabilities include a 10-fold increase in communications capacity for supporting more users and efficient use of the electromagnetic spectrum, improved signal interference mitigation, and connectivity to defense information networks.

Before 2020, the services had acquired a few terminals to use in testing. However, since then, the services accelerated their efforts to acquire terminals. As of fiscal year 2021, the services have fielded about 18 percent, of their planned MUOS-compatible terminals. Among the services, plans for fielding MUOS-compatible terminals vary significantly, with some services planning to complete terminal fielding sooner than others, depending on the platform, which includes ships, aviation, or are hand-held.

Military Services Have Begun Using MUOS in Testing, Training, and Evaluations

DOD has recently begun using advanced MUOS capabilities in a small number of military operations.[20] Most services have used MUOS in test activities, such as in operational test events, though the Marine Corps is further along than the other services. For example:

[19]DOD launched the first MUOS satellite in 2012 to sustain legacy UHF capabilities, despite the fact that its advanced capabilities would be underutilized.

[20]According to Navy program officials, MUOS advanced capabilities were used in a military operation in 2019 and again in 2020.

- **Marine Corps.** In 2017, the Marine Corps began using existing terminals that it adapted to be MUOS-compatible to conduct training and field user evaluations and develop procedures for using MUOS in military operations, according to Marine Corps officials. For example, in 2017, the Marine Corps conducted an evaluation at Camp Pendleton, CA, to test the functionality of MUOS in an operational-like environment.[21] During the evaluation, Marines successfully used MUOS to conduct voice and data communications. In addition, in exercises and tests to date, Marine Corps officials told us that MUOS capabilities are exceeding their expectations, such as enabling communications at higher latitudes than the MUOS requirement.
- **Army.** The Army has conducted operational testing with MUOS. In addition, according to officials, the Army conducted an Initial Operational Test of the Leader Radio/Manpack Radio in January 2021 at Fort Bragg, NC. The 82nd Airborne Division used MUOS-compatible portable radios during exercises to test Army operating procedures. Additionally, the Army is currently fielding MUOS-compatible terminals to two different Infantry Brigade Combat Teams located in Hawaii and Italy.
- **Air Force.** As of July 2020, the Air Force stated it had fielded approximately 10 percent of its planned ground terminals and conducted training with a subset of them. According to Air Force officials, the Air Force plans to field MUOS-compatible terminals on both ground and aircraft platforms. However, officials said the Air Force has not tested, trained its personnel, or evaluated MUOS-compatible radios for its aircraft. According to these officials, such testing will begin once the Air Force installs MUOS-compatible radios onto aircraft, updates aircraft operational flight programs, and confirms that the interfaces between the radios and aircraft are functional. To move operations to the MUOS-compatible radios, according to Air Force officials, the Air Force will then train personnel to obtain the required operational certifications.
- **Navy.** For its platforms, the Navy is conducting integration testing, according to Navy officials. Specifically, for ships, the Navy is in the process of conducting integration testing for planned terminals. Depending on the ship, these officials said that more than one MUOS-compatible terminal may be installed onto the platform. Similarly, for Navy aircraft, platform integration labs are testing terminals planned for installation.

[21]An operational-like environment characterizes the typical scenario MUOS will observe once fielded.

- **Coast Guard.** As of 2021, the Coast Guard had transitioned several terminals across its platforms but stated it did not have a written communications plan that included MUOS. According to Coast Guard officials, they do plan to conduct system operation verification tests and other on-site user training prior to using MUOS in operations.
- **Space Force.** According to Space Force officials, the Space Force currently does not conduct operations that would use MUOS, and any future plans to do so are dependent on direction from leadership. As such, Space Force officials said it has no MUOS training or equipping responsibilities.

DOD Has Taken Steps to Address Key MUOS Challenges but Is Not Pursuing Options to Fully Address Near-Term Needs

The key challenges DOD faces in transitioning from using legacy UHF SATCOM to advanced MUOS capabilities are fielding terminals in sufficient quantities and establishing MUOS communications networks. To address these challenges, DOD has a plan to prioritize fielding MUOS-compatible terminals and accelerate network transitions. In addition, DOD faces a challenge in maintaining its current MUOS capabilities as the satellites age on orbit. This challenge, coupled with DOD's reliance on legacy UHF capabilities, means that available narrowband SATCOM remains oversubscribed in the near-term.

DOD Is Taking Steps to Address Key Terminal Fielding and Network Transition Challenges

Terminal Fielding

Oversight and acquisition offices across DOD cited the fielding of MUOS-compatible terminals as a key challenge to MUOS utilization. Terminal program managers cited three factors impeding terminal fielding: (1) lack of terminal funding, (2) fragmented management of terminal acquisitions, and (3) terminal integration challenges.

- **Lack of terminal funding.** The military services delayed providing funding for MUOS-compatible terminals in the past. According to DOD officials we spoke to, before 2019, the services were reluctant to fund the acquisition and fielding of terminals because the MUOS capability had not yet been validated through operational testing and MUOS had not achieved operational acceptance, both of which have since been accomplished. To address terminal funding, in 2019, the Deputy Secretary of Defense requested the services to provide for additional funding to accelerate the fielding of MUOS-compatible terminals in their budget documents.

- **Fragmented management of terminal acquisitions.** According to officials, DOD's fragmented management of acquiring MUOS-compatible terminals also contributed to delays in terminal fielding.[22] Each of the military services—except the Space Force—has separate program offices to acquire MUOS-compatible terminals for users within that service. For example, the Army Program Executive Officer for Command, Control, and Communications – Tactical, manages the acquisition and fielding of the Army's portable ground terminals, whereas the Army's Program Executive Officer for Aviation manages the acquisition of the Army's airborne terminals. Furthermore, the Navy's Air Combat Electronics program office manages the acquisition of a terminal designed for fielding on air and maritime platforms, while the Navy's Naval Information Warfare Systems Command acquires a different terminal for maritime and other platforms. According to DOD officials, because of a lack of coordination and effective oversight over the many acquisition organizations involved, DOD struggled to align the fielding of MUOS-compatible terminals with other MUOS system segments. As mentioned above, the fragmented structure of space system acquisitions is not a new challenge and it is not unique to MUOS.

  To address the fragmented management, the office of the Joint Chiefs of Staff formed a Narrowband Network Transition Plan Working Group to develop a transition plan with the goal of providing MUOS SATCOM capability as soon as possible.[23] The working group held a kick-off meeting in February 2020 to discuss metrics to measure progress, identify roles and responsibilities, and create deadlines. DOD finalized its transition plan in October 2020, and it is now working to implement it.

- **Challenges of integrating terminals onto weapon platforms.** DOD officials told us that the complexity of terminal integration varies significantly depending on the designated weapon platform and is another key challenge to transitioning to using MUOS. For example, ground portable terminals—terminals carried by soldiers—require little

[22]According to U.S. Army Space and Missile Defense Command officials, the restructuring of the original terminal acquisition program—Joint Tactical Radio System (JTRS)—contributed to fragmented terminal acquisitions. The JTRS program faced delays in development and production and experienced significant cost, schedule, and performance problems. In 2012, DOD restructured the program, splitting it into several subprograms with separate acquisition strategies.

[23]The Narrowband Network Transition Plan Working Group includes representation from the Combatant Commands, the DOD Chief Information Officer, the Office of Cost Assessment and Program Evaluation, U.S. Army Space and Missile Defense Command, the military services, and the Under Secretary of Defense for Acquisition and Sustainment.

to no integration activities because they are stand-alone devices. However, according to DOD officials, installing MUOS-compatible terminals onto aircraft or other platforms requires additional activities, such as airworthiness testing for aircraft, to ensure that the terminal does not interfere with preexisting systems. Activities focused on integrating MUOS into existing platforms and systems can take time to complete and as a result, officials from each service expect to field portable terminals before they can integrate terminals onto ships and aircraft.

To address this challenge, DOD's transition plan made several recommendations, including that the Air Force document the budget needed for terminal integration activities. However, the plan does not specifically address risks such as the time needed to integrate the systems and conduct testing, which can make integration a challenge.

According to the services' plans, all of the services plan to field at least 50 percent of the total number of terminals they plan to acquire by the mid-2020s. Table 1 illustrates the services' plans to field MUOS compatible terminals.

Table 1: Fielding Plans for Mobile User Objective System-Compatible Terminals, as of 2020

Military service	Percent of total terminals planned to be fielded by mid-2020s
Air Force	94
Army	56
Navy	80
Marine Corps	91
Coast Guard	97
Total	**71**

Source: GAO analysis of Department of Defense data. | GAO-21-105283

Note: The Space Force does not have plans to acquire Mobile User Objective System-compatible terminals and therefore is not included here.

According to Army terminal fielding plans, the time frame for fielding terminals is dependent on the outcome of its operational testing, which occurred in January 2021. Army officials said they plan to make a full rate production decision based on that testing in July 2021.

Network Transition

Officials across DOD cited the transition of legacy UHF SATCOM user networks to MUOS networks as another key challenge to using advanced MUOS capabilities. Current DOD plans indicate that some DOD users will have transitioned to using advanced MUOS capabilities by the mid-2020s. Based on our assessment of DOD's plan, the primary factors that have hindered DOD's network transitions are delayed and incomplete planning for transitioning to MUOS networks.

- **Delayed transition planning.** DOD has been primarily focused on fielding MUOS terminals over planning for network transitions the past several years. Though DOD acknowledged the need to plan for this in 2014, it did not begin to develop a network transition plan until 2020. DOD drafted and finalized its network transition plan in October 2020, which it is now working to implement. DOD officials told us that its narrowband network transition plan is a living document and will be updated to include more specific network transition plans in the future. Table 2 illustrates the services' current plans to transition networks by the mid-2020s.

Table 2: Military Service Narrowband Satellite Communication Network Transition Plans, as of 2020

Military Service	Percent of networks planned to transition by mid-2020s
Air Force	47
Army	92
Navy	81
Marine Corps	74
Coast Guard	25
Total	**78**

Source: GAO analysis of Department of Defense data. | GAO-21-105283

Note: The Space Force does not have networks to transition and therefore is not included here.

- I**ncomplete service- and theater-level transition plans.** Though the services each have transition plans in place, they lack key information. For example, the Navy's network transition plan does not provide associated terminal types and quantities for all ships and aircraft by network. Additionally, network transition plans for special, joint, and other users have not yet been developed. For example, joint network transition plans—that is, networks made up of users from multiple services or containing other users—are complex and require

additional coordination. According to the overarching transition plan, these other networks, which account for about 30 percent of the total number of networks DOD plans to transition, will be included in theater-level plans. Additionally, the overarching transition plan states that the theater-level plans, currently under development and planned to be updated on an annual basis, are to provide a detailed view of legacy networks by theater and track all items necessary to complete transition.

Additional Forthcoming MUOS Satellites Will Support Advanced MUOS but Not Legacy UHF Capabilities

In 2020, the Deputy Secretary of Defense directed the Navy to acquire additional satellites to extend the service life of the current MUOS system, MUOS 6 and 7, to be launched in the mid- to late-2020s. According to officials, DOD is planning for these satellites to have the same advanced MUOS capabilities as the original MUOS satellites, but they will not include the legacy UHF capabilities because of an assumption that the services would be able to accelerate the fielding of MUOS-compatible terminals and transition most networks by the mid-2020s.

However, according to Navy officials, the mid-2020s launch date for MUOS 6 was based on an expedited time frame that is no longer feasible. Specifically, because development and production of the original MUOS satellites occurred over 5 years ago, officials told us that acquiring the additional satellites will most likely involve first-time design, integration, and testing activities typically used for new satellite programs, which add time to development schedules. Additionally, officials told us that funding delays contributed to starting development efforts one year later than planned. As a result, MUOS program office officials expect that MUOS 6 and 7 development efforts will likely not start until the early 2020s, with the first satellite launch not occurring before the late 2020s.

DOD Is Seeking Few Options for Providing Additional Narrowband Capabilities in the Near Term

Delays in MUOS development and fielding compatible terminals have led to continued reliance on legacy UHF capabilities, the demand for which has exceeded supply. For example, a 2019 Navy analysis found that users across DOD consistently used 100 percent of the available UHF SATCOM channels. The true extent of the oversubscription is unclear. According to U.S. Space Command officials, some users decide not to request legacy UHF services, anticipating that the requests will be denied.

In its 2019 analysis, USASMDC recommended consideration of several options, including: (1) launching additional legacy UHF satellites, (2) retaining legacy UHF communications hardware on future MUOS satellites, and (3) retaining legacy UHF communications hardware on

future satellites. According to Office of the Under Secretary of Defense for Acquisition and Sustainment officials, the Office of the Secretary of Defense decided not to implement these options.

DOD is pursuing two potential solutions to enable legacy UHF terminal users that do not transition to MUOS to communicate using the advanced MUOS satellite communications hardware. First, DOD is developing a gateway that will enable communications between legacy UHF and MUOS signals using software to translate the signals through the ground stations.[24] Under development by the Defense Information Systems Agency, the gateway will provide connectivity between legacy UHF and MUOS users. DOD plans to install a gateway at several of the Defense Information Systems Agency teleports, which link satellites to ground-based communications. According to the Defense Information Systems Agency, it plans to deploy a functional gateway to interoperate with coalition partners in the early 2020s. Second, the Office of the Under Secretary of Defense for Research and Engineering is overseeing a technology demonstration for a capability that may allow legacy UHF users to communicate with one another over the advanced MUOS communication hardware on the satellites.

These two solutions are intended for use by those users who do not currently have plans to transition to MUOS and have compatible equipment—such as DOD special users and U.S. allies—and are not intended for most DOD users. Consequently, these solutions will not fully address the near-term oversubscription of narrowband SATCOM capabilities. The 2019 Chairman of the Joint Chiefs of Staff Instruction on DOD SATCOM cites key operational goals including that SATCOM systems be sized, deployed, and agile enough to meet current and future DOD SATCOM user requirements. This goal will be difficult to meet if DOD does not pursue additional options for providing near-term narrowband SATCOM capability.[25]

[24] In regards to DOD SATCOM, a satellite gateway consists of antennas and networking equipment that transmit and receive satellite data. The Defense Information Systems Agency is developing a MUOS to Legacy Gateway Component and a MUOS Voice Gateway to facilitate interoperability between MUOS and UHF users through newly developed ground based infrastructure.

[25]Chairman of the Joint Chiefs of Staff Instruction 6250.01F, *Department of Defense Satellite Communications* (Feb. 26, 2019).

DOD Has Not Taken Steps to Plan for Its Future Narrowband Needs after MUOS

Over the past 7 years, DOD reports have recommended that the Navy identify and assess potential solutions for meeting users' future narrowband SATCOM needs. However, DOD reports also found that DOD's narrowband SATCOM requirements do not reflect current and future user needs, and the department does not have plans in place to update them.

DOD Reports over the Past 7 Years Have Recommended That the Navy Conduct an Analysis of Alternatives

DOD has acknowledged the need to conduct a narrowband SATCOM analysis of alternatives (AOA)—a study to identify and assess potential solutions for meeting user need—to focus on SATCOM after MUOS, but it has yet to do so. Starting in 2014, DOD studies recommended the Navy conduct an AOA for narrowband SATCOM capabilities based on the evolving communications needs of the warfighter. Organizations conducting these studies include the following:[26]

- **DOD's Executive Agent for Space.** In September 2014, the Executive Agent for Space reported on the future of DOD narrowband SATCOM to determine the way ahead beyond the expected MUOS service life span.[27] The report recommended that DOD conduct an AOA to begin in fiscal year 2016 to maximize the number of future narrowband end-to-end options available.
- **Defense Information Systems Agency.** This agency completed a study of all wideband, narrowband, protected, and commercial SATCOM support for DOD users in 2014.[28] It recommended that DOD complete an AOA in 2016 or 2017 to support user requirements covering the 2018-2030 time frame.[29]
- **Johns Hopkins University's Applied Physics Laboratory.** This 2014 report, prepared for DOD's Chief Information Officer, provided a

[26]This report omits additional, sensitive details on these study findings.

[27]DOD Executive Agent for Space, *Narrowband Satellite Communication Study* (Sept. 22, 2014). In October 2015, the Deputy Secretary of Defense re-designated the Executive Agent for Space as the Principal DOD Space Advisor. The National Defense Authorization Act for Fiscal Year 2018 required termination of the Principal DOD Space Advisor.

[28]Defense Information Systems Agency, *DOD Satellite Communications Mix of Media Study* (Sept. 25, 2014).

[29]This report's stated purpose was to examine the planned mix of wideband, narrowband, protected, and commercial SATCOM user requirements together.

long-term planning approach to meet future narrowband SATCOM needs.[30] It recommended starting an AOA in fiscal year 2015 to decide whether to replace, extend the service life of, or replenish the narrowband capability MUOS provides. It further provided a framework and beginning analysis for DOD to consider using to inform an AOA.

- **MUOS Program Office.** In 2016, a MUOS program office study noted the need for an AOA to ensure narrowband requirements are met beyond MUOS's expected life span.

DOD issued an implementation memo and tasks were assigned to specific DOD offices to address the recommendation to complete an AOA. DOD assigned the task to conduct a narrowband AOA in fiscal year 2017 to the Navy. However, according to officials, this task was not completed due to competing priorities such as completing a wideband SATCOM AOA.

Navy officials told us they had delayed conducting an AOA in part because DOD lacked operational data from MUOS users that could help inform the analysis. Officials from the Office of the Under Secretary of Defense for Acquisition and Sustainment told us that the Space Force may receive funding for an AOA in fiscal year 2022. According to Space Force officials, they could start a narrowband AOA that year.

DOD Has Not Taken Key Steps to Prepare for Completion of a Timely Analysis of Alternatives to Support a Follow-On Program to MUOS

An AOA is a required element of the DOD weapons development and acquisition process.[31] It analyzes cost, schedule, and performance of status quo and proposed solutions that could meet mission needs. According to leading practices we identified, a reliable AOA enables the government to identify the best viable alternative that meets a mission need.[32] According to a 2014 study prepared for DOD's Chief Information Officer, postponement of an AOA could have two effects for narrowband SATCOM: (1) it severely limits feasible alternatives that could be implemented before the MUOS satellites begin to fail, and (2) it fails to

[30]Johns Hopkins University Applied Physics Laboratory, MITRE Corporation, Booz Allen Hamilton, Systems Technology Forum, *Future Narrowband Study Report* (Jan. 15, 2014).

[31]Department of Defense Instruction 5000.84*, Analysis of Alternatives* (Aug. 4, 2020).

[32]GAO, *Cost Estimating and Assessment Guide: Best Practices for Developing and Managing Program Costs,* GAO-20-195G (Washington, D.C.: March 2020).

evolve narrowband SATCOM capabilities in pace with advances in technology.[33]

DOD's policy for completing an AOA states that the DOD component will first complete (1) documents justifying the requirements, and (2) any preparatory actions necessary to begin an AOA.[34] The Joint Chiefs of Staff has issued the Joint Capabilities Integration and Development System for addressing when warfighter needs are no longer met by current solutions.[35] This process is in line with leading practices in our guide for conducting a reliable AOA. These practices describe the first two steps as (1) the customer defines mission need, and (2) the customer defines the functional requirements the selected alternative must have based on that need.[36]

The process leads to an AOA, as shown in figure 4.

[33]Johns Hopkins University Applied Physics Lab, MITRE Corporation, Booz Allen Hamilton, Systems Technology Forum, *Future Narrowband Study Report* (January 15, 2014).

[34]DOD Instruction 5000.84, *Analysis of Alternatives* (Aug. 4, 2020).This instruction states that the DOD Component will inform the Office of CAPE of impending Major Defense Acquisition Programs by 60 business days before the Materiel Development Decision. The notification is to include a copy of the latest requirements document for the program approved by the requirements validation authority and a copy of the analysis justifying that requirement document, such as a capabilities based assessment.

[35]Chairman of Joint Chiefs of Staff Instruction 5123.01H, *Charter of the Joint Requirements Oversight Council (JROC) and Implementation of the Joint Capabilities Integration and Development System (JCIDS*) (Aug. 31, 2018). The Joint Chiefs of Staff functions as military advisers. Specifically, the Chairman of the Joint Chiefs of Staff (CJCS) is the principal military adviser to the President, the National Security Council, the Homeland Security Council, and the Secretary of Defense. 10 U.S.C. § 151. The Joint Requirements Oversight Council (JROC) is responsible for assisting the CJCS in assessing joint military capabilities, and identifying, approving, and prioritizing gaps in such capabilities to meet applicable requirements in the national defense strategy.10 U.S.C. § 181. As such, JROC is responsible for assisting the CJCS in establishing and approving capability requirements documents that fulfil a gap in joint military capabilities, which would inform an AOA.

[36]GAO-20-195G.

Figure 4. Elements of the Joint Capabilities Integration and Development System Process

Source: GAO's analysis of Manual for the Operation of the Joint Capabilities Integration and Development System, 2018. | GAO-21-105283

As we previously reported, an AOA can take a few years to complete.[37] However, DOD recently changed its AOA process generally to require completion of the AOA within 9 months.[38] Advance preparation, as discussed in DOD's instruction, is important to develop key information before starting a narrowband SATCOM AOA in order to ensure its timely completion. [39]

To determine whether DOD would have time to complete this process and launch another satellite when needed, we conducted an assessment of the constellation's availability with MUOS 6 and 7. We found that DOD

[37]GAO-09-665.

[38]Department of Defense Instruction 5000.84 provides for completion of the AOA within 9 months after approval of the AOA study plan, unless waived by the Secretary of Defense or designee, under certain circumstances.

[39]DOD Instruction 5000.84 discusses advanced preparation. For example, the instruction states DOD Components should identify and begin the process of obtaining long lead items needed to conduct the AOA so the analysis can begin in a timely manner. Examples of long lead items include: security clearances (including clearances for any special access program(s) necessary for performance of the AOA); technical and threat data to support combat simulations and modeling; scenarios; methods of employment; and tactics, techniques, and procedures.

would need to launch the follow-on solution in 2034. Therefore, a timely AOA, if completed in 2023, would give DOD about 11 years to plan and initiate an acquisition program and deploy a solution to provide continuity to the narrowband SATCOM mission.[40] For context, the MUOS program also took about 11 years from the time it completed its AOA to launch its first satellite. Delays to identifying updated requirements would result in DOD having limited choices to make decisions about how to meet future needs, such as acquiring additional MUOS satellites beyond MUOS 6 and 7.

According to DOD reports, DOD's narrowband SATCOM requirements are outdated. DOD last updated its narrowband SATCOM requirements in 2010. Since that time, user needs have evolved as a result of (1) space becoming a contested operational environment for future satellite-based communications systems, (2) increased communication needs of users, and (3) advances in communication and related technologies:

- **Space as a contested operational environment.** According to DOD, as U.S. adversaries' capabilities to contest the space environment have increased, space systems have become vulnerable to a variety of threats, such as attacks on satellites and signal jamming. In January 2020, as the Space Force outlined its vision for SATCOM, it noted that in the 21st century, space is a contested domain.[41] DOD's June 2020 Defense Space Strategy Summary likewise notes that space is a distinct warfighting domain and that the current U.S. defense space enterprise was not built to keep pace with U.S. adversaries' improved capability to contest the space environment.[42] The summary underscored the importance of addressing resilience against attacks.
- **Increased warfighter communication needs.** DOD's narrowband SATCOM needs have evolved. For example, a 2014 U.S. Strategic Command study and DOD officials we spoke to noted three changes

[40]This assumes the required probability of availability of four MUOS satellites is still valid at that time. Most satellites last longer than their expected design life and as a result, the actual need date for a post-MUOS solution is uncertain. Specifically, the Aerospace Corporation's 2019 Satellite Lifetime Study reported that a majority of satellites exceed their design life, including U.S. military satellites.

[41]United States Space Force, *Vision for Satellite Communications (SATCOM)* (Jan. 23, 2020).

[42]Department of Defense, *Defense Space Strategy Summary* (June 2020).

when compared to 2001 MUOS requirements: (1) communication data rates are much higher, (2) regional congestion is much higher, and (3) use of images and other large data files has increased. [43]

- **Technology advancements.** When the MUOS program started development, Third Generation cellular technology—the foundation for delivering MUOS capabilities—was state-of-the-art. Now, it is facing obsolescence as DOD and the world at large are moving to Fifth Generation cellular technology. DOD's 2020 Command, Control, and Communications Modernization Strategy notes that new technologies such as Fifth Generation mobile networks, cloud computing, and artificial intelligence will accelerate the pace of change and reshape how future military forces operate.[44] Moreover, dramatic increases in warfighter demands for real time data drive the need to innovate and modernize technology solutions for communications. The modernization strategy found that DOD must continuously modernize to keep pace with current and future threats in its technological solutions to address capability needs.

DOD recognized the need to update its SATCOM requirements in September 2014 in its Narrowband Satellite Communication Study.[45] This study recommended that DOD update its narrowband SATCOM requirements and estimate its future needs in fiscal year 2015, prior to starting an AOA. Furthermore, several officials we interviewed—including those from the DOD's Chief Information Officer, the Joint Chiefs of Staff, U.S. Space Command, and USASMDC—confirmed that a gap exists in meeting DOD's current narrowband SATCOM needs. According to officials from DOD's Chief Information Officer, DOD had not prioritized updating its narrowband requirements, in part, because it was focused on

[43]According to Navy program officials, UHF narrowband SATCOM was never intended to be used as a high bandwidth system, instead offering canopy penetration and clear and effective communications in urban environments and mountainous terrain.

[44]Department of Defense, *Command, Control, and Communications Modernization Strategy* (September 2020).

[45]DOD Executive Agent for Space, *Narrowband Satellite Communication Study* (Sept. 22, 2014). This report, as well as the others we mention, resulted in DOD issuing narrowband SATCOM study implementation guidance in January 2015 with tasks assigned to different DOD offices. The task of updating narrowband requirements was assigned to the Joint Chiefs of Staff Directorate J-8 Force Structure, Resources, and Assessment Directorate—which provides support to the Chairman of the Joint Chiefs of Staff—as the office of primary responsibility, and other offices of collateral responsibility.

fielding MUOS-compatible terminals and delivering an end-to-end MUOS capability.

DOD has taken some steps to improve its understanding of its SATCOM needs, but does not have specific plans to update its narrowband needs. For example, officials in the office of the Joint Chiefs of Staff told us that U.S. Strategic Command initiated a partial update to the 2010 Joint Space Communications Layer Initial Capabilities Document—which had identified DOD's SATCOM capability needs—in 2018.[46] Those officials told us, however, that the update focused on needs other than those for narrowband SATCOM. According to these officials, responsibility for the full update transferred to U.S. Space Command. Officials from U.S. Space Command said they did not have an estimate for when the full update would be complete. Without updated future narrowband requirements, DOD will not be in a position to conduct an effective and timely AOA—currently estimated to begin as early as fiscal year 2022—for determining the best way forward to meet warfighters' narrowband communication needs critical for mission success.

Conclusions

Although DOD has taken steps to encourage the services to field a MUOS capability sooner, these steps will not fully address the near-term oversubscription of narrowband SATCOM capabilities. Consequently, user needs will remain unmet unless DOD explores additional options and takes steps to provide additional near-term narrowband capabilities during the transition to using advanced MUOS capabilities.

Furthermore, DOD faces a challenge to begin deciding what comes after the current MUOS capability to ensure warfighter narrowband SATCOM needs will continue to be met before 2034, when the current MUOS system is estimated to degrade. Updating its 11-year-old narrowband SATCOM requirements would enable DOD to reflect any changes in narrowband SATCOM usage, development of advanced technologies, and the militarization of the space environment. Because these types of requirements assessments can take several years to accomplish, any

[46]An initial capabilities document is a record of the need for a military materials and equipment solution to a specific capability gap. DOD commonly uses the initial capabilities document as a requirements basis for conducting an analysis of alternatives. The Joint Requirements Oversight Council (JROC) is responsible for assisting the CJCS in assessing joint military capabilities, and identifying, approving, and prioritizing gaps in such capabilities to meet applicable requirements in the national defense strategy. As such, this office is responsible for establishing and approving capability requirements documents, which would inform an AOA. The Vice Chairman of the of the Joint Chiefs of Staff serves as the chair of the JROC.

further delays could lead to DOD having fewer feasible options available for delivering future capabilities, and could lead to resorting to solutions that fall short of meeting user needs and potentially impacting the operational effectiveness of the warfighter.

Recommendations for Executive Action

We are making two recommendations to the Department of Defense.

The Secretary of Defense should ensure the Office of the Under Secretary of Defense for Acquisition and Sustainment explores and implements an additional option for providing narrowband satellite communication capabilities in the near-term. (Recommendation 1)

The Secretary of Defense should ensure appropriate offices and components (such as the Joint Chiefs of Staff and U.S. Space Command) update DOD's future narrowband satellite communication requirements for the Space Force to prepare for an analysis of alternatives to begin as early as fiscal year 2022. (Recommendation 2)

Agency Comments and Our Evaluation

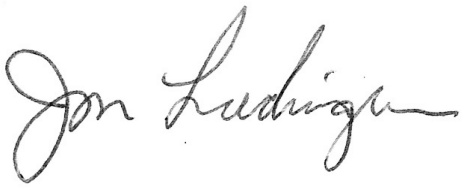
We provided a draft of this report to DOD for review and comment. DOD provided us with written comments, which are reprinted in part, in appendix III. We did not reprint the comments in full due to their sensitivity. DOD also provided technical comments, which we incorporated as appropriate.

DOD concurred with our recommendations and provided two additional comments. In its first additional comment, DOD stated that it has explored options for additional legacy narrowband SATCOM capability but chose not to invest in replenishing legacy payloads as a method for increasing on-orbit capability. However, DOD reiterated its agreement with our recommendation that more options need to be explored. In its second additional comment, DOD provided information on the space environment in which MUOS was designed to operate. As a result, we made changes to the report to clarify how the space environment has evolved since MUOS was initially designed.

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

If you or your staff have any questions about this report, please contact me at (202) 512-4841 or by email at ludwigsonj@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.



Jon Ludwigson
Director, Contracting and National Security Acquisitions

List of Committees

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

The Honorable Jon Tester
Chairman
The Honorable Richard Shelby
Ranking Member
Subcommittee on Defense
Committee on Appropriations
United States Senate

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

The Honorable Betty McCollum
Chair
The Honorable Ken Calvert
Ranking Member
Subcommittee on Defense
Committee on Appropriations
House of Representatives

Appendix I: Objectives, Scope, and Methodology

The Senate Armed Services Committee's report to the bill for the National Defense Authorization Act for Fiscal Year 2020 contained a provision for us to review the Department of Defense's (DOD) use of Mobile User Objective System (MUOS) capabilities and any planning efforts underway for a MUOS follow-on capability.[1]

In this report, we (1) provide information on the extent to which DOD is using the advanced communications capabilities of MUOS; (2) assess the challenges DOD faces in transitioning to the advanced communications capabilities of MUOS and what DOD is doing to address them, and (3) assess the efforts DOD has underway for acquiring follow-on narrowband satellite communications capabilities.

This report is a public version of a sensitive report that we issued on June 3, 2021.[2] DOD deemed some of the information in our June 2021 report to be sensitive, which must be protected from public disclosure. Therefore, this report omits sensitive information about specific terminal fielding and network transition plans, the operational status of satellites, the status of narrowband SATCOM capabilities, and the challenges and potential impacts of delays in transitioning to advanced MUOS capabilities. Although the information provided in this report is more limited, the report addresses the same objectives as the sensitive report and uses the same methodology.

To provide information on the extent to which DOD is using the advanced communications capabilities of MUOS, we reviewed key DOD and Navy documentation on its use of MUOS to date, such as MUOS test reports and user evaluations, Navy and DOD satellite communications (SATCOM) oversight briefings, and internal as well as independent assessments of MUOS. For example, we reviewed MUOS test reports and then interviewed an official from the office of the Director, Operational Test and Evaluation on the specifics of the MUOS operational test results therein. In addition, we reviewed the Marine Corps field user evaluation report from 2018.

To report on the extent to which the services fielded terminals, we reviewed past MUOS program acquisition, planning, and requirements

[1]S. Rep. No. 116-48, at 332 (2019), accompanying S. 1790, National Defense Authorization Act for Fiscal Year 2020, Pub. L. No. 116-92 (2019).

[2]GAO, *Satellite Communications: DOD Should Explore Options to Meet User Needs for Narrowband Capabilities*, GAO-21-349SU (Washington, D.C.: June 3, 2021).

documents and the military services' actual terminals procured. In addition, we reviewed past DOD and GAO reports on the MUOS and Handheld, Manpack, and Small Form Fit development programs. We talked to other entities in DOD, such as the Space Force's Commercial Satellite Communications Office regarding DOD's use of commercial SATCOM. We also interviewed knowledgeable officials in each of the U.S. military services on the details of their current use of ultra-high frequency (UHF) and MUOS capabilities in testing, training, and evaluations.

To assess any challenges DOD faces to transition to MUOS and what DOD is doing to address them, we reviewed MUOS test reports from 2010 to 2019 and other DOD and program documents, such as the MUOS Selected Acquisition Reports and the Navy's 2018, 2020, and 2021 Reliability Engineering Assessments (previously called Functional Availability Reports) of its narrowband satellites. We noted challenges identified in these documents, which we then categorized and analyzed.

We interviewed DOD oversight and other DOD officials responsible for managing DOD SATCOM as well as DOD SATCOM planners and users to further identify challenges. For example, we interviewed officials in the following organizations: Defense Information Systems Agency, Cost Assessment and Program Evaluation, DOD Chief Information Officer, and Office of the Under Secretary of Defense for Acquisition and Sustainment. We met with officials of the Office of the Under Secretary of Defense for Research and Engineering regarding DOD's plans to adapt advanced MUOS capabilities for legacy UHF communications. We also met with contractors who developed the MUOS satellite components and terminals, including Lockheed Martin, Boeing, Collins Aerospace, and L3Harris Technologies. We also interviewed other key stakeholders for DOD SATCOM such as the Army's Space and Missile Defense Command and the Navy MUOS program office.

We analyzed the acquisition, terminal fielding, and network transition plans from the Army, Navy, Marine Corps, Air Force, and Coast Guard to understand the current operating environment. We also analyzed the services' terminal fielding and network transition plans through 2030 to examine the extent to which the transition to MUOS aligned with a decrease in DOD's UHF capability. We conducted an assessment of the MUOS satellites based on their expected service lives and performance and how this assessment could inform DOD's plans for developing, acquiring, and launching MUOS 6 and 7 and any follow-on satellites. We

reviewed DOD policies and instructions on DOD SATCOM and weapon system acquisitions and compared them to DOD's plans.[3]

To assess DOD's plans to acquire follow-on narrowband capabilities beyond MUOS, we analyzed the extent to which DOD was conducting, or preparing to conduct, early acquisition activities against Analysis of Alternatives (AOA) leading practices in GAO's Cost Estimate and Assessment Guide.[4] We also compared DOD's decisions, plans, and other documents to DOD policies, such as the DOD Instruction 5000.84 on conducting an AOA.[5] We interviewed senior DOD officials in the Office of the Under Secretary of Defense for Acquisition and Sustainment; Navy MUOS program office officials; and Air Force, Space Command, and Space Force officials for any updates on acquisition planning and decisions. We reviewed prior DOD recommendations and reports to learn how the follow-on narrowband need was identified and developed. We assessed the MUOS satellite constellation's availability to determine when follow-on satellites are needed to launch and maintain DOD's required availability threshold. We reviewed policies and procedures in documents as well as process flow charts to understand how decisions are made and which data inform the decision-making process for future narrowband communications solutions.

We conducted this performance audit from April 2020 to June 2021 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives. We subsequently worked with DOD from June 2021 to September 2021 to prepare this public version of a sensitive report. This public version was also prepared in accordance with these standards.

[3]Chairman of the Joint Chiefs of Staff Instruction 6250.01F, *Department of Defense Satellite Communications* (Feb. 26, 2019); DOD Instruction 5000.85, *Major Capability Acquisition* (August 6, 2020); DOD Instruction 8420.02*, DOD Satellite Communications* (November 25, 2020).

[4]GAO, *Cost Estimating and Assessment Guide: Best Practices for Developing and Managing Program Costs*, GAO-20-195G (Washington, D.C.; Mar. 12, 2020).

[5]Department of Defense Instruction 5000.84, *Analysis of Alternatives* (Aug. 4, 2020).

Appendix II: U.S. Military Services' Planned Mobile User Objective System-Compatible Terminals

To use the Mobile User Objective System (MUOS), the Department of Defense (DOD) must field MUOS-compatible terminals. According to DOD's 2020 Narrowband Network Transition Report, the services plan to field five types of MUOS-compatible terminals. Table 3 identifies each terminal's vendor and the services planning to field them. Table 3 also categorizes the type of radio, such as Army Navy Portable Radio Communications (AN/PRC) terminals, which serve as portable radios; the Army Navy Airborne Radio Communications (AN/ARC) terminal, which serves as an airborne radio; and the Digital Modular Radio (DMR), which serves as a maritime terminal.

Table 3: Mobile User Objective System-Compatible Terminals and Planned Users

Terminal	Vendor	Type	Air Force	Army	Navy	Coast Guard	Marine Corps
AN/PRC 117-G	L3Harris Technologies	portable	X	—	X	X	X
AN/PRC 158	L3Harris Technologies	portable	—	X	—	X	X
AN/PRC 162	Collins Aerospace	portable	—	X	—	—	—
AN/ARC-210	Collins Aerospace	airborne	X	—	X	X	X
DMR	General Dynamics Mission Systems	maritime	—	—	X	X	—

Legend: AN/PRC = Army Navy Portable Radio Communications; AN/ARC = Army Navy Airborne Radio Communications; DMR = Digital Modular Radio; and "—" = not applicable.

Source: GAO analysis of Department of Defense data. | GAO-21-105283

Note: The Space Force does not have plans to acquire Mobile User Objective System-compatible terminals and therefore is not included here.

Appendix III: Comments from the Department of Defense

OFFICE OF THE ASSISTANT SECRETARY OF DEFENSE
3600 DEFENSE PENTAGON
WASHINGTON, DC 20301-3600

ACQUISITION

Mr. Jon Ludwigson
Director, Contracting and National Security Acquisitions
U.S. Government Accountability Office (GAO)
441 G Street, NW
Washington DC 20548

17-May-2021

Dear Mr. Ludwigson:

(U) Enclosed is the Department of Defense (DoD) response to the GAO Draft Report GAO-21-349SU, "SATELLITE COMMUNICATIONS: DOD Should Explore Options to Meet User Needs for Narrowband Capabilities," dated April 2021 (GAO Code 104255).

(U) The Department appreciates the effort of the GAO and the opportunity to comment on the draft report.

Sincerely,
WEATHERINGTON.DYKE.DAVID.1087976218
Digitally signed by WEATHERINGTON.DYKE.DAVID.1087976218
Date: 2021.05.17 12:26:52 -04'00'
Dyke D. Weatherington
Performing the Duties of Assistant Secretary of Defense for Acquisition

Enclosure:
As stated

GAO DRAFT REPORT DATED APRIL 2021
GAO-21-349SU (GAO CODE 104255)

SATELLITE COMMUNICATIONS: DOD SHOULD EXPLORE OPTIONS TO MEET USER NEEDS FOR NARROWBAND CAPABILITIES

DEPARTMENT OF DEFENSE COMMENTS TO THE GAO RECOMMENDATION

RECOMMENDATION 1: The GAO recommends the Secretary of Defense should ensure the Office of the Under Secretary of Defense for Acquisition and Sustainment explores and implements an additional option for providing narrowband satellite communications capabilities in the near-term.

DoD RESPONSE: The DoD concurs with the GAO recommendation to explore and implement an option for providing narrowband satellite communications (SATCOM) in the near-term. The DoD however, believes the best approach to mitigating risks in the near-term for narrowband SATCOM capabilities is to continue to look for opportunities to accelerate our plans to field Mobile Users Objective System (MUOS) terminals and transition from legacy narrowband satellite networks.

RECOMMENDATION 2: The GAO recommends the Secretary of Defense should ensure appropriate offices and components (such as the Joint Chiefs of Staff and U.S. Space Command) updates DOD's future narrowband satellite communications requirements for the Space Force to prepare for an analysis of alternatives to begin as early as fiscal year 2022.

DoD RESPONSE: The DoD concurs with the recommendation for appropriate offices and components to update or validate narrowband SATCOM requirements to support an analysis of alternatives. The Space Force has budgeted $12M to initiate the Low-Band Beyond Line of Sight Analysis of Alternatives (AoA) in fiscal year 2022, and valid user requirements are critical to its successful implementation. During AoA execution, it is standard practice for the Joint Staff to task Combatant Commands, Services, and other stakeholders to update capacity and coverage requirements, as well as other needs, such as increased resiliency. The ability to update requirements quickly was demonstrated during the previously completed Wideband Communications Services AoA.

OTHER DoD COMMENTS:

The DoD is concerned with how GAO characterized DoD's efforts for options for mitigating potential narrowband SATCOM shortfalls. DoD has explored options for additional legacy narrowband SATCOM capability, however the Department chose to not invest in replenishing legacy payloads as a method for additional on-orbit capability. More options do need exploring, as expressed in the response to Recommendation 1.

The GAO report notes MUOS has become increasingly vulnerable to a variety of threats. The report indicates that MUOS was designed for a "benign" environment, but the report does not recognize that MUOS does have additional protections. The DoD use of the term "benign environment" in relation to the space environment does not mean fully benign. As noted, MUOS provides more reliable communications than the legacy UHF capability. It is used in relation to the current, not explicitly contested environment, where some natural, inadvertent, or persistent low-level interference consistently occurs. Space is now a contested environment and MUOS will serve as a gap filler as the new replacement system requirements are validated.

Appendix IV: GAO Contact and Staff Acknowledgments

GAO Contact

Jon Ludwigson, (202) 512-4841 or ludwigsonj@gao.gov

Staff Acknowledgments

In addition to the contact named above, Rich Horiuchi (Assistant Director), Erin Cohen, Desiree Cunningham, Pete Anderson, Margaret Fisher, Jenny Shinn, Lucas Smith, Jay Tallon, and Robin Wilson made key contributions to this report. Assistance was also provided by Marie Ahearn, Lorraine Ettaro, Brent Helt, Josh Leiling, Jennifer Leotta, Chi Mai, and Alyssa Weir.

Related GAO Products

Defense Acquisitions Annual Assessment: Drive to Deliver Capabilities Faster Increases Importance of Program Knowledge and Consistent Data for Oversight. GAO-20-439. Washington, D.C.: June 3, 2020.

Cost Estimating and Assessment Guide: Best Practices for Developing and Managing Program Costs. GAO-20-195G. Washington, D.C.: March 2020.

Space Acquisitions: DOD Faces Significant Challenges as it Seeks to Address Threats and Accelerate Space Programs. GAO-19-482T. Washington, D.C.: April 3, 2019.

DOD Space Acquisitions: Including Users Early and Often in Software Development Could Benefit Programs. GAO-19-136. Washington, D.C.: March 18, 2019.

Defense Acquisitions: Assessments of Selected Weapon Programs. GAO-15-342SP. Washington, D.C.: March 12, 2015.

Space Acquisitions: DOD Is Overcoming Long-Standing Problems, but Faces Challenges to Ensuring Its Investments Are Optimized. GAO-13-508T. Washington, D.C.: April 24, 2013.

Defense Acquisitions: Challenges in Aligning Space System Components. GAO-10-55. Washington, D.C.: October 29, 2009.