



April 2023

SPACE SITUATIONAL AWARENESS

DOD Should Evaluate How It Can Use Commercial Data

Accessible Version

GAO Highlights

Highlights of [GAO-23-105565](#), a report to congressional committees

Why GAO Did This Study

As the number of threats and objects in space grows, SSA data about these objects are essential to managing commercial and military activities in space. A growing number of commercial companies are using ground-based sensors, such as radar and optical telescopes, to collect SSA data. These companies plan to sell the data, and licenses to use the data, to other companies and government agencies.

A House Armed Services Committee report included a provision for GAO to review planned procurement of commercial SSA data and provide an overview of the UDL. This report (1) describes the challenges DOD faces in identifying and characterizing objects in space, (2) assesses the extent to which DOD uses commercial SSA data, and (3) assesses the status of the UDL. To do this work, GAO reviewed and analyzed DOD and Space Force documents. GAO also interviewed DOD and Space Force officials and a non-generalizable sample of 10 out of about 50 SSA companies. We selected these companies based on what type of SSA products they provided and whether they had a contract with DOD.

What GAO Recommends

GAO is making two recommendations to the Space Force, including to (1) establish a process to regularly identify and evaluate commercial SSA capabilities for applicability to the Space Force's needs and (2) create a plan to determine how to use the UDL with its SSA systems. DOD concurred with the recommendations.

View [GAO-23-105565](#). For more information, contact Jon Ludwigson at (202) 512-4841 or LudwigsonJ@gao.gov, or Alissa H. Czyz at (202) 512-3058 or CzyzA@gao.gov.

April 2023

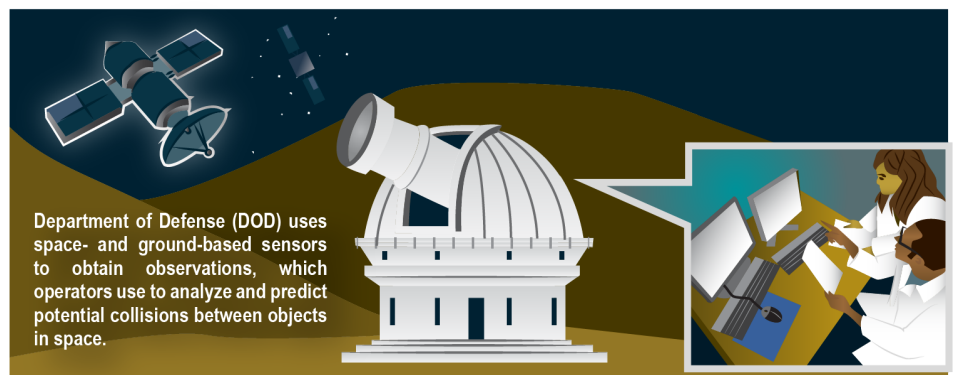
SPACE SITUATIONAL AWARENESS

DOD Should Evaluate How It Can Use Commercial Data

What GAO Found

Department of Defense (DOD) strategies emphasize that space is a contested environment with increasing threats to satellites. Thus, space situational awareness (SSA)—the foundational knowledge and characterization of objects in space and the environment—is critical. DOD conducts SSA as shown in the figure below.

Space Situational Awareness Steps



Source: GAO summary of Space Force data. | [GAO-23-105565](#)

The growth in the number of objects in space has created challenges for the Space Force. These include gaps in the geographical distribution of global sensors that collect data and limited sensor capability for objects in deep space. The Space Force is working to mitigate these challenges by adding other kinds of sensors for SSA and exploring ways to leverage commercial SSA data. Specifically, there is a growing commercial SSA sector that may provide benefits to DOD, including expanding geographic sensor coverage and providing unclassified, shareable SSA data.

Space Force has some efforts underway to use commercial SSA data. However, it has not comprehensively evaluated the range of data available to help meet SSA mission needs. DOD strategy emphasizes using commercial options when possible. However, the Space Force's evaluation and acquisition of licenses to access, use, and potentially share commercial SSA data have been limited to a few studies and training events. Establishing a process to regularly identify and evaluate commercial SSA data would better position the Space Force to meet its growing need to identify and characterize space objects.

The Space Force's Unified Data Library (UDL) is a cloud-based data repository designed to consolidate commercial and U.S. government SSA data, as well as data from other countries. In January 2021, the Space Force's Chief of Space Operations declared the UDL the single source for accessing and managing all data in support of Space Force operational systems. The Space Force has deployed an initial operational version of the UDL and plans to further develop it; however, staff who monitor objects in space are not using it in daily SSA operations because it is not integrated into their operational systems. A plan on how to use the UDL with SSA operational systems would facilitate the Space Force's ability to benefit from the amount of data in the UDL.

Contents

GAO Highlights		ii
	Why GAO Did This Study	ii
	What GAO Recommends	ii
	What GAO Found	ii
Letter		1
	Background	4
	DOD Faces SSA Challenges and Is Taking Steps to Address Them	9
	Space Force Has Not Fully Evaluated How Commercial SSA Data Could Meet Mission Needs	17
	Space Force Lacks a Plan on How to Use the Unified Data Library with SSA Systems	24
	Conclusions	31
	Recommendations for Executive Action	31
	Agency Comments and Our Evaluation	31
Appendix I: Objectives, Scope, and Methodology		34
Appendix II: Comments from the Department of Defense		38
Accessible Text for Appendix II: Comments from the Department of Defense		41
Appendix III: GAO Contact and Staff Acknowledgments		43
	GAO Contact	43
	Staff Acknowledgments	43
Tables		
	Table 2: Examples in the Fiscal Year 2023 Budget Estimates of Department of Defense Systems Supporting Space Situational Awareness Currently in Development	16
	Table 3: Types of Commercial Sensors that Provide Space Situational Awareness Data	18
	Table 4: Department of Defense Strategies Related to the Integration of Commercial Space Capabilities	20
Figures		
	Figure 1: Earth Orbits	4
	Accessible Data for Figure 1: Earth Orbits	4

Figure 2: Space Situational Awareness Functions	7
Accessible Text for Figure 2: Space Situational Awareness Functions	7
Table 1: Department of Defense Organizations with Space Situational Awareness Responsibilities (Space Force: Responsible for organizing, training, and equipping space forces, including acquiring capabilities to support Space Situational Awareness (SSA). ^a)	8
Figure 3. Objects in the Space Force Satellite Catalog, Calendar Years 2012-2022	10
Accessible Data for Figure 3. Objects in the Space Force Satellite Catalog, Calendar Years 2012-2022	11
Figure 4: Map of Ground-Based Space Situational Awareness Sensors	12
Accessible Data for Figure 4: Map of Ground-Based Space Situational Awareness Sensors	12
Figure 5: How Data Are Collected and Used via the Unified Data Library	27

Abbreviations

CAVENet	Correlation, Analysis, and the Verification of Ephemerides Network
C2	Command and Control
DARC	Deep Space Advanced Radar Capability
DOD	Department of Defense
DFARS	Defense Federal Acquisition Regulation Supplement
FY	Fiscal Year
GBOSS	Ground Based Optical Sensor System
GEO	geosynchronous Earth orbit
JCO	Joint Task Force-Space Defense Commercial Operations Cell
JTF-SD	Joint Task Force-Space Defense
LEO	low Earth orbit
MEO	medium Earth orbit
SACT	Sprint Advanced Concept Training
SPADOC	Space Defense Operations Center
SSA	Space Situational Awareness
UDL	Unified Data Library
USSPACECOM	U.S. Space Command

This is a work of the U.S. government and is not subject to copyright protection in the United States. The published product may be reproduced and distributed in its entirety without further permission from GAO. However, because this work may contain copyrighted images or other material, permission from the copyright holder may be necessary if you wish to reproduce this material separately.



April 24, 2023

Congressional Committees

As the number of threats and objects in the space environment grows, timely and accurate data about these objects are crucial to understanding and managing commercial and military activities in space. The Department of Defense (DOD) has stated that space is vital to our nation's security, prosperity, and scientific achievement.¹ DOD also emphasizes that space is a contested environment due to the increasing number of threats to satellites. For example, DOD has reported that countries such as China and Russia have developed and demonstrated capabilities designed to contest or deny U.S. access to, and operations in, space. Apart from potential threats from adversaries, space is also growing more congested, with substantial growth in the total number of satellites being launched.

Historically, the U.S. government and many satellite owners and operators relied almost exclusively on DOD to monitor objects in space and assess the potential for collisions that could cause damage to or loss of a satellite. DOD refers to tracking these objects as Space Situational Awareness (SSA)—the requisite foundational, current, and predictive knowledge and characterization of space objects and the environment upon which space operations depend.² The SSA mission is therefore essential to successful U.S. government and commercial space operations.

¹Department of Defense, *Defense Space Strategy Summary* (June 2020).

²This report focuses on Space Situational Awareness (SSA) as opposed to Space Domain Awareness and will use the term SSA throughout. The DOD Joint Publication 3-14, entitled *Space Operations*, defines SSA as “the requisite foundational, current, and predictive knowledge and characterization of space objects and the operational environment upon which space operations depend—including physical, virtual, information, and human dimensions—as well as all factors, activities, and events of all entities conducting, or preparing to conduct, space operations.” In 2019, the Deputy Commander of Air Force Space Command signed a memo defining the term Space Domain Awareness. This memo described space as a warfighting domain, necessitating the Air Force to shift its focus beyond simply knowing the location of objects in space to determining more information about these objects. Department of the Air Force, *Space Domain Awareness* (Oct. 4, 2019).

DOD has developed systems to provide SSA and relied upon these systems for decades. The current operational SSA systems include a network of ground- and space-based sensors and the Space Command and Control (C2) program. The Space C2 program is the Space Force's latest effort to modernize a system that gathers data from sensors, transmits these data to a repository, and processes the data to enable commanders to make timely decisions, take action, and counter threats.³ However, we reported in December 2021 that DOD has spent decades trying to modernize this system and it is still trying to do so.⁴

Recently, the number of commercial companies that collect and analyze SSA data has been growing, which presents opportunities for DOD.⁵ These private companies use sensors, such as radars and optical telescopes, to collect SSA data to sell to a variety of users including other companies and government agencies. An advantage that commercial SSA data provide over DOD data is that the commercial data are not classified, and therefore DOD potentially could purchase a license which would enable it to share data with other federal entities.⁶

The House Armed Services Committee's report 117-118 accompanying a bill for the National Defense Authorization Act for Fiscal Year 2022 contains a provision for GAO to review planned procurement of

³Congress established the Space Force in 2019 as a military department within the Air Force. See National Defense Authorization Act for Fiscal Year 2020, Pub. L. No. 116-92, §§ 951-961, (2019) (codified at 10 U.S.C. § 9081(a)).

⁴GAO, *Space Command and Control: Opportunities Exist to Enhance Annual Reporting*, [GAO-22-104685](#) (Washington, D.C.: Dec. 22, 2021).

⁵We previously reported on DOD and the Intelligence Community's use of commercial satellite imagery. See, GAO, *National Security Space: Actions Needed to Better Use Commercial Satellite Imagery and Analytics*, [GAO-22-106106](#) (Washington, D.C.: Sept. 7, 2022).

⁶The government obtains technical data and license rights to use intellectual property assets in accordance with the Federal Acquisition Regulation and agency supplements to this regulation, such as the Defense Federal Acquisition Regulation Supplement (DFARS), and any specifically negotiated licenses in the contract. These rights control how the government can use, disclose, or reproduce contractor owned information. DFARS § 252.227.7013 (Rights in Technical Data – Noncommercial Items) and DFARS § 252.227-7014 (Rights in Noncommercial Computer Software and Noncommercial Software Documentation). For the purposes of this report, when we state that commercial data is purchased, what is being purchased is a license to use the commercial data, not the commercial data itself.

commercial SSA data.⁷ The provision also asked for an overview of the Unified Data Library (UDL), a DOD cloud-based, online data repository intended to improve the collection, sharing, and accessibility of SSA data. This report (1) describes the challenges DOD faces in identifying and characterizing objects in space, (2) assesses the extent to which DOD uses commercial SSA data, and (3) assesses the development status of the UDL and how DOD is using it.

To answer these objectives, we reviewed relevant documentation such as DOD's 2020 *Defense Space Strategy*, the 2022 U.S. Space Command's (USSPACECOM) *Commercial Integration Strategy Overview*, an Air Force report to congressional committees entitled *Commercial Space Domain Awareness Services* and the RAND Corporation *Commercial Space Capabilities and Market Overview 2022* report.⁸ Additionally, we interviewed officials from agencies with SSA responsibilities, including Space Force units and USSPACECOM. We also interviewed and collected information from a non-generalizable sample of 10 out of approximately 50 commercial companies. We selected these companies based on whether they had a contract with DOD regarding SSA and the type of SSA data they provided DOD.⁹ We also interviewed contractor representatives responsible for the UDL. Additional details on the report's methodology are in appendix I.

We conducted this performance audit from November 2021 to April 2023 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.

⁷H.R. Rep. No. 117-118, at 276 (2022).

⁸Department of the Air Force, *Commercial Space Domain Awareness Services* (Jan. 2021); RAND Corporation, *Commercial Space Capabilities and Market Overview* (2022).

⁹Results from non-generalizable samples cannot be used to make inferences about a population.

Background

Activity in the Space Environment

In space, there are three orbits in which most satellites operate. These include low Earth orbit (LEO), medium Earth orbit (MEO), and geosynchronous Earth orbit (GEO). Space beyond GEO is referred to as xGEO. These orbits are shown in figure 1 below.

Figure 1: Earth Orbits



Source: GAO Summary of Defense Intelligence Agency report and Air Force memorandum. | GAO-23-105565

Accessible Data for Figure 1: Earth Orbits

	distance range	1st number converted to miles (KMx0.6214=miles)	2nd number converted to miles (KMx0.6214=miles)	Labels on graphic	Source link
Low Earth Orbit	Up to 2,000 kilometers	1,243		Up to 1,243 miles	
Medium Earth Orbit	approximately 2,000 to 20,000 kilometers	1,243	12428	approximately 1,243 to 12,428 miles	
Geosynchronous Earth Orbit	approximately 36,000 kilometers	22370.4		approximately 22,370 miles	
xGEO	beyond GEO			Beyond GEO	FY23_ALL_STAFF-#210357

distance range	1st number converted to miles (KMx0.6214=miles)	2nd number converted to miles (KMx0.6214=miles)	Labels on graphic	Source link
Source: GAO summary of Defense Intelligence Agency report and Air Force Memorandum GAO-23-105565			see links in G13 and J10-14 for sources and report number	see links in G13 and J10-14 for sources and report number

Note: Diagram not to scale.

Over the past 5 years, commercial and military activities in space have grown considerably and continued growth is expected in the future. We reported in September 2022 that technological advancements allow for more affordable satellites and dramatic decreases in the cost to launch satellites, improving the potential to deploy large constellations of satellites that cover the entire globe.¹⁰ We also reported that some experts cited the potential for 58,000 additional active satellites to be launched by 2030. Today, activities in xGEO are focused on scientific missions and exploration of the moon and other celestial bodies, but activity in xGEO is also expected to increase.

In addition, the amount of debris and other inactive objects in space is substantial. According to a Defense Intelligence Agency report, the primary risk to spacecraft in orbit is from the 600,000 to 900,000 space objects between 5 millimeters and 10 centimeters in size, many of which are not tracked in DOD’s Satellite Catalog (referred to in this report as the catalog).¹¹ The catalog is a database of information about specific space objects, including the objects’ estimated size, location, and movements. Taken together, this information represents DOD’s capability to archive, integrate, disseminate, and exploit SSA data obtained from detection, tracking, and identification.

Lastly, in March 2022, we reported that threats to commercial and military use of space are emerging, including adversary development of ways to

¹⁰GAO, *Large Constellations of Satellites: Mitigating Environmental and Other Effects*, GAO-22-105166 (Washington, D.C.: Sept. 29, 2022).

¹¹Defense Intelligence Agency, *Challenges to Security in Space: Space Reliance in an Era of Competition and Expansion* (March 2022).

target U.S. space assets and communications.¹² There is more information on specific threats in space later in this report.

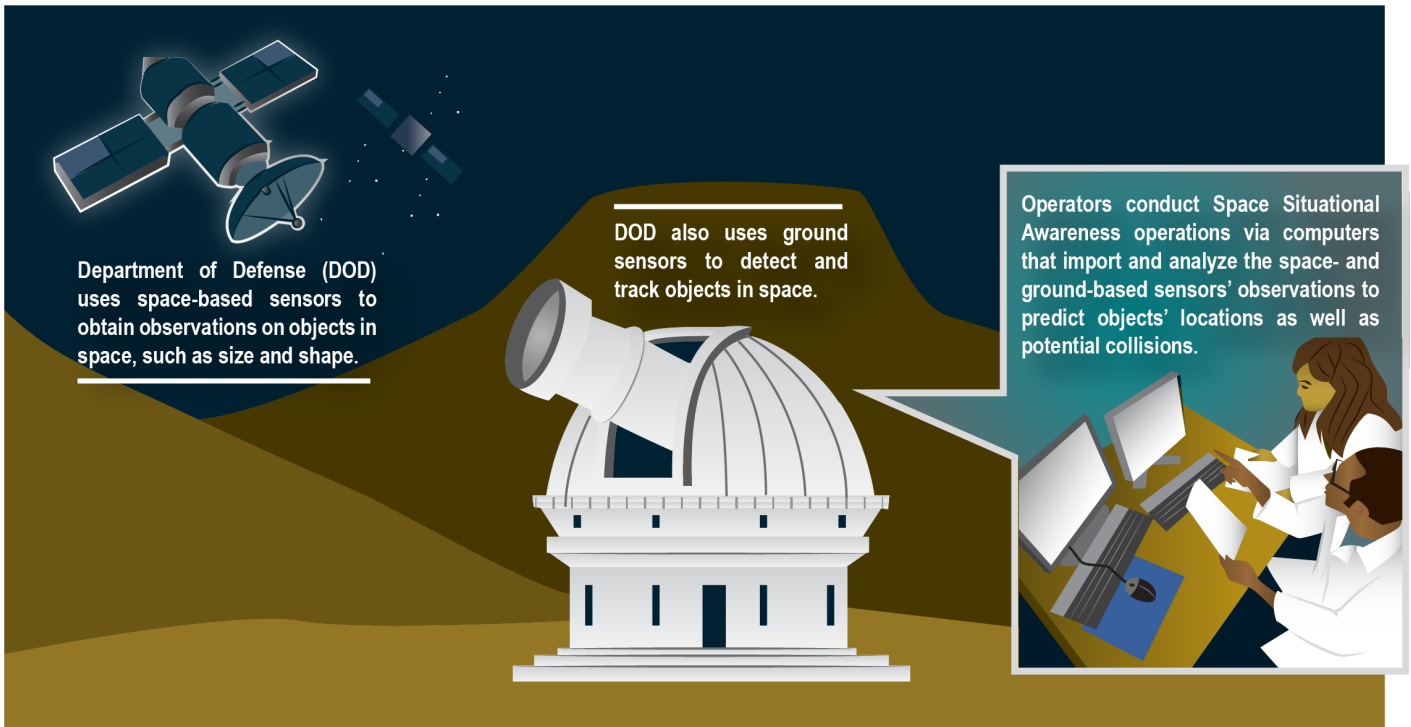
Overview of Space Situational Awareness

Since Russia's launch of the first space object in 1957, DOD has been conducting increasingly sophisticated SSA on active and inactive objects in space, from their launch to de-orbit. DOD uses its current SSA systems to conduct SSA. These systems include, among others, the Space Defense Operations Center (SPADOC) and the Space Fence radar.¹³ Fundamentally, conducting SSA involves detecting and identifying objects, tracking them to determine their location and trajectory, putting the objects into the catalog, and monitoring the objects for any changes in their behavior, as shown in figure 2 below.

¹²GAO, *Trends Affecting Government and Society*, [GAO-22-3SP](#) (Washington, D.C.: March 15, 2022).

¹³The Air Force developed SPADOC in the 1980s which was designed to process space situational awareness data and maintain orbital information of space objects. The Space Fence is a ground-based radar that detects objects in space.

Figure 2: Space Situational Awareness Functions



Source: GAO summary of Space Force data. | GAO-23-105565

Accessible Text for Figure 2: Space Situational Awareness Functions

- Department of Defense (DOD) uses space-based sensors to obtain observations and objects in space, such as size and shape.
- DOD also uses ground sensors to detect and track objects in space.
- Operators conduct Space Situational Awareness operations via computers that import and analyze the space- and ground-based sensors' observations to predict objects' locations as well as potential collisions.

Currently, DOD provides SSA data to satellite owners and operators worldwide, both government and commercial, through its catalog of space objects, which is available for anyone to access.¹⁴ DOD tracks the locations of objects and warns satellite operators when there is potential for a collision. Although DOD has been responsible for these tasks to date, this is changing. In 2018, the President issued Space Policy

¹⁴DOD provides unclassified SSA data to the public through the Space-Track.org website.

Directive-3, which directed that the SSA mission—for the purposes of conducting space traffic management—become the responsibility of the Department of Commerce.¹⁵ This will include tracking and collision notification for all parties other than national security agencies. Per Space Policy Directive-3, the transition of some of DOD’s responsibilities to Commerce is intended to allow DOD to focus on maintaining access to and freedom of action in space. While SSA for space traffic management is transitioning to Commerce, Space Policy Directive-3 explicitly states DOD will continue to maintain the authoritative catalog.

DOD Organizations with Space Situational Awareness Responsibilities

A number of DOD organizations have SSA responsibilities, as described in table 1.

Table 1: Department of Defense Organizations with Space Situational Awareness Responsibilities (Space Force: Responsible for organizing, training, and equipping space forces, including acquiring capabilities to support Space Situational Awareness (SSA).^{a)}

Organization	Organization member
Delta 2 - Space Domain Awareness: Prepares, presents, and fights with assigned and attached forces executing combat-ready space domain awareness operations, including SSA, to maintain freedom of action for U.S., allied, and commercial partners. ^{b)}	18th Space Defense Squadron: Conducts daily SSA operations by tracking and monitoring objects in space, predicting potential collisions, and detecting satellite maneuvers, for all objects in space.
Delta 2 - Space Domain Awareness: Prepares, presents, and fights with assigned and attached forces executing combat-ready space domain awareness operations, including SSA, to maintain freedom of action for U.S., allied, and commercial partners. ^{b)}	19th Space Defense Squadron: Serves as a backup to the 18th Space Defense Squadron and is looking at the capabilities needed for SSA in xGEO.
U.S. Space Command (USSPACECOM): Conducts military operations in space, which includes planning and executing SSA operations. ^{c)} USSPACECOM has two subordinate commands.	Combined Force Space Component Command: Plans, integrates, conducts, and assesses the execution of global space operations to deliver space capabilities to combatant commanders, coalition partners, and the Joint Force. This includes responsibility for the management of sensors used to conduct SSA.
U.S. Space Command (USSPACECOM): Conducts military operations in space, which includes planning and executing SSA operations. ^{c)} USSPACECOM has two subordinate commands.	Joint Task Force-Space Defense (JTF-SD): Protects and defends important U.S. space assets, deterring adversary aggression, and defeating adversaries if needed. The JTF-SD executes its protect and defend mission in unity of effort with the Intelligence Community through the National Space Defense Center and its space domain awareness units. ^{d)}

Source: GAO assessment of Department of Defense information. | GAO-23-105565

¹⁵White House, *Space Policy Directive-3, National Space Traffic Management Policy* (June 18, 2018).

^aCongress established the Space Force in 2019 as a military department within the Air Force. See National Defense Authorization Act for Fiscal Year 2020, Pub. L. No. 116-92, §§ 951-961, (2019) (codified at 10 U.S.C. § 9081(a)). The Space Force and U.S. Space Command are parent organizations and each row under them contains other levels of organizations within each.

^bA Delta is a unit of organization in the Space Force.

^cPresidential Memorandum, 83 Fed. Reg. 65,483 (Dec. 18, 2018).

^dThe National Space Defense Center conducts 24/7/365 space domain awareness operations focused on protecting and defending the space domain. For DOD, protection comprises active and passive measures to ensure space systems provide the required quantity and quality of mission support in any operating environment or condition and defensive operations includes activities undertaken to neutralize or reduce the effectiveness of hostile action against U.S., allied, and partner space systems.

While several organizations conduct SSA operations, their roles have key distinctions. Specifically, the 18th and 19th Space Defense Squadrons conduct SSA for all actors in space, whether civil, commercial, academic, or military. In contrast, the Joint Task Force-Space Defense (JTF-SD) and its supporting components conduct SSA to protect and defend U.S. national security assets in space.

DOD Faces SSA Challenges and Is Taking Steps to Address Them

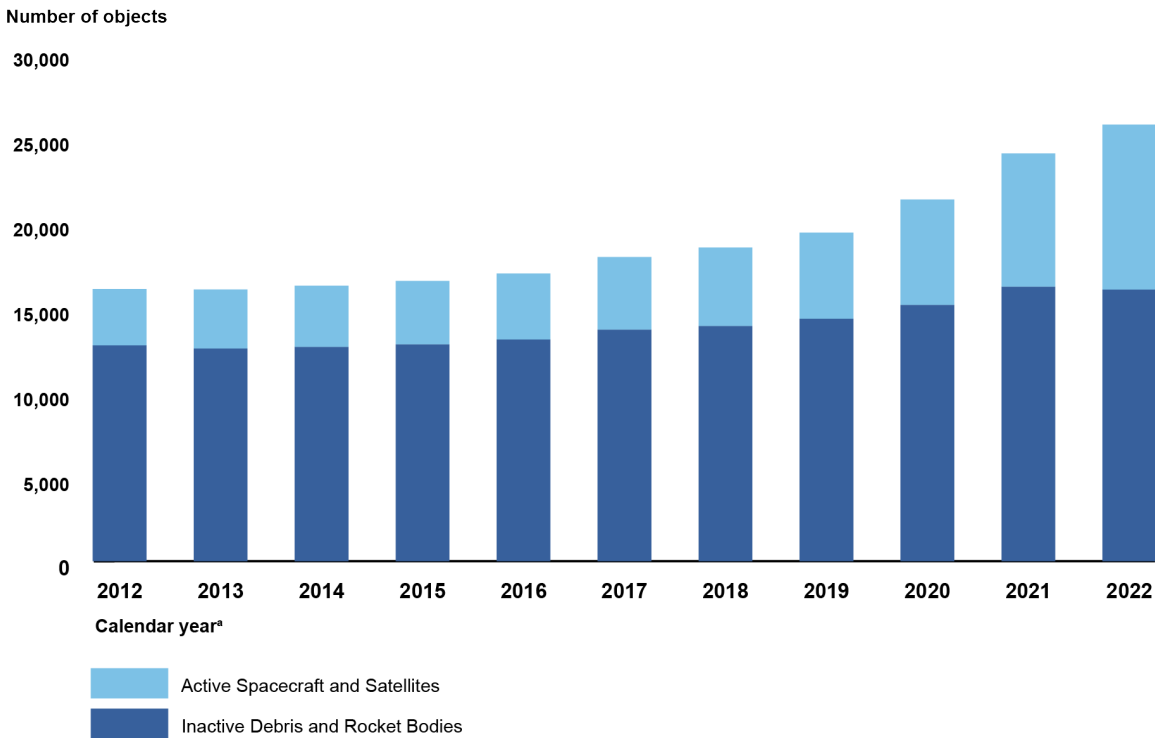
DOD Faces Challenges Obtaining SSA Data to Identify and Characterize Objects for SSA Mission

DOD faces a number of challenges obtaining data needed for the SSA mission, a mission that Space Force identifies as foundational to all space operations. Specifically, Space Force and USSPACECOM officials identified current and anticipated challenges obtaining SSA data in the evolving space domain, including the following:

Space is increasingly congested. The increasingly congested space domain places a strain on the personnel responsible for cataloging space objects. Space Force officials explained that large commercial constellations and events generating large amounts of debris are

manually intensive to catalog using the current systems.¹⁶ For example, a Space Force Delta 2 official told us that it took 3 months to catalog the nearly 1,500 items of debris resulting from the Russian test of an anti-satellite weapon in November 2021, which destroyed a Russian satellite. The number of objects cataloged by the Space Force has increased nearly every year over the last decade, as depicted in figure 3, and Space Force officials expect this trend to continue.

Figure 3. Objects in the Space Force Satellite Catalog, Calendar Years 2012-2022



Source: GAO analysis of Space Force data. | GAO-23-105565

¹⁶GAO has a body of work documenting DOD’s challenges replacing SPADOC, the current system. This includes our response to a provision in the National Defense Authorization Act for Fiscal Year 2020, Section 1613(a) of Public Law 116-92, for which we initiated a review of the Space Force’s Space Command and Control (C2) program. We expect to issue the report on this work in the spring of 2023. Pub. L. No. 116-92, § 1613(a).

Accessible Data for Figure 3. Objects in the Space Force Satellite Catalog, Calendar Years 2012-2022

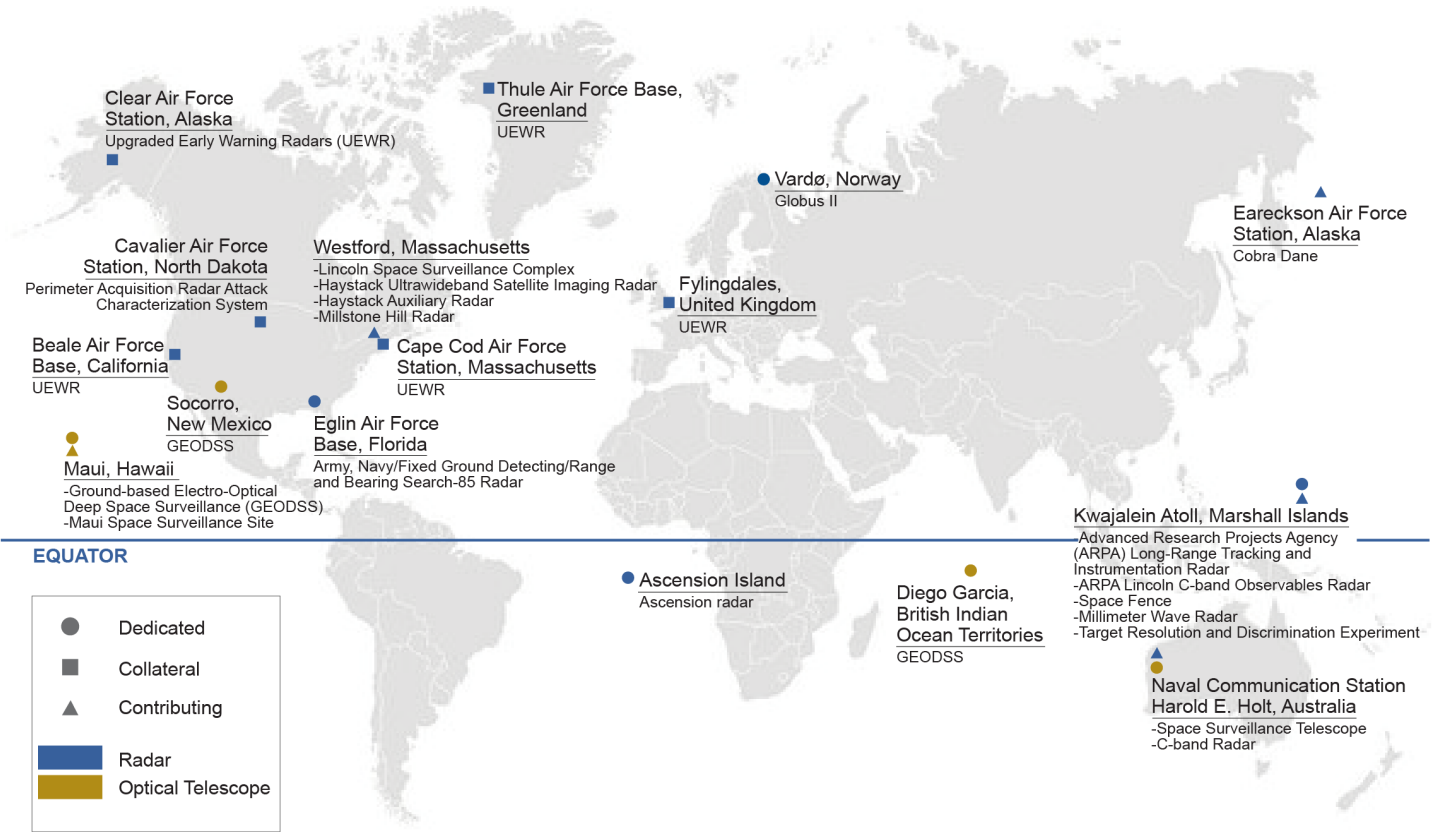
Calendar Year	Source:	Active Spacecraft and Satellites (number of objects)	Source:	Inactive Debris and Rocket Bodies (number of objects)	Source	T&V initial
2012	A2	3,323	C2	12,707	F2	OK. GM 11/30/22
2013	A3	3,478	C3	12,523	F3	OK. GM 11/30/22
2014	A4	3,618	C4	12,612	F4	OK. GM 11/30/22
2015	A5	3,742	C5	12,768	F5	OK. GM 11/30/22
2016	A6	3,884	C6	13,057	F6	OK. GM 11/30/22
2017	A7	4,289	C7	13,630	F7	OK. GM 11/30/22
2018	A8	4,621	C8	13,850	F8	OK. GM 11/30/22
2019	A9	5,069	C9	14,280	F9	OK. GM 11/30/22
2020	A10	6,216	C10	15,090	F10	OK. GM 11/30/22
2021	A11	7,860	C11	16,158	F11	OK. GM 11/30/22
2022	A12 and calendar year table note below. FY23_ALL_STAFF-#525819	<ul style="list-style-type: none"> • 9,725 • 9,868 	<ul style="list-style-type: none"> • C12 • R1 	<ul style="list-style-type: none"> • 15,679 • 15,857 	<ul style="list-style-type: none"> • F12 • R2 	OK. GM 11/30/22 See updated year end numbers for 2022. AC 4/3/23 OK. GM 4/3/23

Note: The objects in this figure include all objects entered into the Space Force Satellite Catalog (catalog). It does not include objects which do not meet the quality or consistency standards required to be in the catalog, which is around 21,000 additional objects, as of October 2022. The catalog includes objects 10 centimeters or larger.

^aThe number of objects in the catalog may fluctuate throughout the year.

Ground-based sensor coverage varies by location, limiting SSA data collection. The ground-based, government-owned network of sensors used to collect SSA data is not evenly distributed throughout the world, which leads to gaps in the SSA data collected in some areas. Specifically, Space Force officials identified challenges collecting SSA data on objects over parts of the Southern Hemisphere because fewer sensors are there to collect the data. According to Space Force documentation, as of April 2022, all of Space Force’s sensors capable of collecting data for objects in LEO are in the Northern Hemisphere. However, some objects tracked in the catalog have orbits that can shift in such a way that the point at which they are closest to Earth is in either the Northern or Southern Hemisphere. When the objects’ orbit shifts and the objects are closest to the Earth while in the Southern Hemisphere, Space Force loses track of the objects for months at a time. See figure 4 for a depiction of the geographic distribution of the sensor network.

Figure 4: Map of Ground-Based Space Situational Awareness Sensors



Source: GAO analysis of Department of Defense information. | GAO-23-105565

Accessible Data for Figure 4: Map of Ground-Based Space Situational Awareness Sensors

Sensor name	Location	Dedicated/Collateral/Contributing	T&V
Upgraded Early Warning Radars (UEWR)	Clear Space Force Station, Alaska	Collateral	AC 11/30/22
Perimeter Acquisition Radar Attack Characterization System (PARCS)	Cavalier Air Force Station, North Dakota	Collateral	AC 11/30/22
UEWR	Beale Air Force Base, California	Collateral	AC 11/30/22
Ground-based Electro-Optical Deep Space Surveillance (GEODSS)	Maui, Hawaii	Dedicated (Optical telescope)	AC 11/30/22
Maui Space Surveillance Site (MSSS)	Maui, Hawaii	Contributing	AC 11/30/22
GEODSS	Socorro, New Mexico	Dedicated (optical telescope)	AC 11/30/22
AN/FPS-85	Eglin Air Force Base, Florida	Dedicated	AC 11/30/22

Letter

Sensor name	Location	Dedicated/Collateral/Contributing	T&V
Space-Based Surveillance System (SBSS), Geosynchronous Space Situational Awareness Program (GSSAP), Operationally Responsive Space (ORS-5), Advanced Technology Risk Reduction (ATRR)	On orbit	Dedicated	AC 11/30/22
Lincoln Space Surveillance Complex (LSSC): Haystack Ultrawideband Satellite Imaging Radar (HUSIR), Haystack Auxiliary Radar (HAX), Millstone Hill Radar	Westford, Massachusetts	Contributing	AC 11/30/22
UEWR	Cape Cod Space Force Station, Massachusetts	Collateral	AC 11/30/22
UEWR	Thule Air Base, Greenland	Collateral	AC 11/30/22
Globus II	Vardø, Norway	Dedicated	AC 11/30/22
UEWR	Fylingdales, United Kingdom	Collateral	AC 11/30/22
Cobra Dane	Eareckson Air Station, Shemya, Alaska	Contributing	AC 11/30/22
ARPA Long-Range Tracking and Instrumentation Radar (ALTAIR)	Kwajalein Atoll, Marshall Islands	Contributing	AC 11/30/22
ARPA Lincoln C-band Observables Radar (ALCOR)	Kwajalein Atoll, Marshall Islands	Contributing	AC 11/30/22
Space Fence	Kwajalein Atoll, Marshall Islands	Dedicated	AC 11/30/22
GEODSS	Diego Garcia, British Indian Ocean Territory	Dedicated (optical telescope)	AC 11/30/22
Ascension radar	Ascension Island Auxiliary Airfield	Dedicated	AC 11/30/22
C-band Radar	Edinburgh, Australia	Contributing	AC 11/30/22

Note: There are three types of sensors: dedicated, collateral, and contributing. Dedicated sensors support SSA as their primary mission; collateral sensors support missions other than SSA as their primary mission, such as sensors used for missile defense and missile warning; and contributing sensors support SSA when requested. This graphic shows all SSA unclassified sensors.

Space Force has limited sensor capability for xGEO objects. While the Space Force has both the previously discussed ground-based SSA sensors and some space-based SSA sensors designed to collect SSA data about objects in LEO, MEO, or GEO, Space Force officials explained that the sensors were not designed to collect data beyond GEO. The Space Force Capstone Publication recognizes that while space activities have generally been confined to these orbits, new technologies have the potential to expand space activities beyond GEO.¹⁷ According to the

¹⁷United States Space Force, *Space Capstone Publication, Spacepower* (June 2020).

Defense Intelligence Agency, activity in xGEO poses a unique challenge to the Space Force, as spacecraft in xGEO are difficult to track and characterize, and could threaten U.S. or allied satellites. For example, that report stated that adversaries could place operational or reserve satellites in deep space so they are much harder to monitor, and then move them to lower orbits for later use.¹⁸

Finally, DOD's ability to maintain SSA is increasingly important as adversaries develop and test capabilities designed to interfere with other satellites, including critical DOD satellites. Over the last several years there have been some high-profile examples of adversary space capabilities. For example, as reported by the Defense Intelligence Agency, China has demonstrated the ability to use a satellite to move a second satellite to a new location. The report also describes one of Russia's satellites following a U.S. national security satellite. According to USSPACECOM leadership, the ability to identify and track potential threats—which includes maintaining SSA—is key to ensuring the safety of U.S. space systems. The Space Force has several efforts underway to improve its ability to conduct SSA on the growing number of objects and threats in space, as described below.

Space Force and USSPACECOM Are Taking Steps to Mitigate SSA Challenges

The Space Force and USSPACECOM have efforts planned and underway to mitigate SSA challenges and improve access to data needed for the SSA mission. These efforts include the following:

Incorporating additional sensors with primary missions other than SSA. USSPACECOM leadership stated that the command is actively expanding its integration of nontraditional sensors to increase the data available. This effort includes collecting data from the Army-Navy Transportable Radar Surveillance-2, Sea-Based X-Band Radar, and Aegis radar platforms to provide improved awareness of the space

¹⁸Defense Intelligence Agency, *Challenges to Security in Space: Space Reliance in an Era of Competition and Expansion* (March 2022).

domain.¹⁹ This integration is being done in partnership with the Missile Defense Agency and other combatant commands.

Developing new tactics, techniques, and procedures. Space Force officials told us that they are making incremental progress toward developing new SSA tactics, techniques, and procedures to more quickly on-ramp capabilities to operations.²⁰ This includes Pivot SDA, a Space Force effort intended to more quickly enable operator use of capabilities. The completion of the new procedures depends on a variety of factors, including the modernization or replacement of antiquated hardware and software and a limited number of operators.

Reassessing SSA needs and updating requirements document. USSPACECOM indicated it is identifying its current SSA needs and updating its requirements for future acquisitions through a new Space Domain Awareness Initial Capabilities Document. Space Force officials stated that absent updated guidance from USSPACECOM they continue to acquire systems based on old requirements dating from 2012 and 2015. According to a DOD official, DOD just approved an updated Initial Capabilities Document in early April 2023.²¹

Acquiring new SSA systems. The Space Force is also acquiring and fielding new systems that will enhance the SSA mission.²² The Chief of Space Operations—the senior uniformed Space Force officer—performs duties under the authority, direction, and control of the Secretary of the Air Force, such as transmitting plans and recommendations to the

¹⁹General James Dickinson, *Fiscal Year 2023 Priorities and Posture of United States Space Command* (Mar. 1, 2022).

²⁰Tactics are the employment and ordered arrangement of forces in relation to each other. Techniques are nonprescriptive ways or methods used to perform missions, functions, or tasks. Procedures are standard, detailed steps that prescribe how to perform specific tasks.

²¹We further discussed USSPACECOM's update of this document in our work reviewing the National Space Defense Center. GAO, *Space Operations: National Space Defense Center Faces Enduring Challenges*, GAO-23-105371C.

²²In this report, we use the term SSA systems to refer to various types of systems, such as satellites, sensors, C2 systems, and ground systems, which the Space Force uses to conduct SSA operations. For example, GAO previously reported on one of these systems, the Deep Space Advanced Radar Capability (DARC) as part of its annual weapon system assessment, see GAO, *Weapon Systems Annual Assessment: Challenges to Fielding Capabilities Faster Persist*, [GAO-22-105230](#) (Washington, D.C.: June 8, 2022).

Secretary as well as implementing plans.²³ The Space Force is acquiring these systems to expand its ability to detect and track space objects, and provide enhanced indications and warning of potential threats, among other purposes. According to Space Force officials, these systems are being developed to address requirements identified in 2012 and 2015. See table 2 for details on three of these systems.

Table 2: Examples in the Fiscal Year 2023 Budget Estimates of Department of Defense Systems Supporting Space Situational Awareness Currently in Development

System name	Actual and planned funding reported in fiscal year (FY) 2023 budget request for 2021-2027 (millions of FY23 dollars)	Purpose	Development timeline
Silent Barker	994	Space-based satellite system that will provide Space Domain Awareness for timely space event detection and custody. It will conduct large volume searches for objects in GEO.	Research and development started in fiscal year 2021. Initial launch scheduled for fiscal year 2023. Planned launch and Full Operational Capability is scheduled for fiscal year 2026.
Deep Space Advanced Radar Capability (DARC)	1,417	Ground-based radar system to detect, track, and maintain custody of deep space objects 24/7. The system will have three geographically separated radar sites to track objects in GEO.	Research and development started in fiscal year 2021. Successful technology demonstration in August 2021. Site builds are scheduled as follows: Site 1 FY 2021-2025 Site 2 FY 2024-2026 Site 3 FY 2025-2027
Ground Based Optical Sensor System (GBOSS)	212	System-wide upgrade of the three Ground Based Electro-Optical Deep Space Surveillance sites and construction of a new site in Europe. The system provides global search, tracking of launches not registered with the U.S. government, precise tagging of clustered objects, and detection of closely spaced dim objects. It is intended to fill gaps for SSA requirements.	Research and development started in fiscal year 2021. Initial Operational Capability is scheduled for fiscal year 2024. Full Operational Capability is scheduled for fiscal year 2027.

Source: GAO assessment of DOD information. | GAO-23-105565

²³The Chief of Space Operations was established as the Head of the Space Force, and is responsible for organizing, training and equipping the Space Force. See National Defense Authorization Act for Fiscal Year 2020, Pub. L. No. 116-92, §§ 951, 953 (2019) (codified at 10 U.S.C. § 9081(a)-(d) and § 9082(d)(1)-(5)).

Space Force Has Not Fully Evaluated How Commercial SSA Data Could Meet Mission Needs

Commercial companies collect a variety of SSA data and the Space Force and USSPACECOM are looking at ways to use these data. To date, the Space Force and USSPACECOM have worked to draft strategies or plans to integrate commercial SSA data, but two of these efforts have been put on hold. While DOD strategies direct the use of commercial capabilities when possible, the Space Force has not fully evaluated how the commercial data could help meet SSA mission needs.

Commercial Companies Provide a Variety of SSA Capabilities

SSA companies vary in terms of their size and age and they provide a wide range of SSA capabilities, including SSA data. According to a 2022 RAND Corporation report, commercial SSA is an emerging market with several companies that have developed or are developing capabilities to provide SSA observational data and analysis to the national security enterprise and other commercial customers.²⁴ For example, one company we talked to is a small business that has been providing SSA to other companies for 9 years. Another company we talked to is a mid-sized company that has existing contracts with DOD for SSA and other services.

Commercial SSA companies use sensors such as telescopes and radars to collect data on objects in space. The type of sensor used determines the type of data it can collect. For example, ground-based optical telescopes can be used to observe objects in all orbits; however, they are not ideal to track objects in LEO, which are moving quickly and orbit Earth every 90 minutes. See table 3 for information on the types of commercial sensors, data collected, and their advantages and disadvantages, according to various companies, DOD, and other sources.

²⁴RAND Corporation, *Commercial Space Capabilities and Market Overview* (2022).

Table 3: Types of Commercial Sensors that Provide Space Situational Awareness Data

Sensor type	Orbit	Data collected	Advantages	Disadvantages
Ground-based radars	Low Earth orbit (LEO), medium Earth orbit (MEO)	Orbit determination; maneuver detection	Excel at capturing objects moving through LEO; Control how, when, and where the radar scans; Detect inactive objects; Some track objects as small as 1-2 centimeters in diameter	Few radars can detect objects in geosynchronous Earth orbit (GEO); unable to differentiate between multiple objects when they are close together
Passive radio frequency antennas	All orbits	Orbit determination; maneuver and trajectory detection; spacecraft identification	Detect maneuvers and anomalies day or night and in all-weather conditions; Characterize behavior; able to differentiate between objects when they are close together	Objects must emit an active radio frequency signal to be tracked
Ground-based telescopes	All orbits	Orbit determination; maneuver detection	Detect objects in GEO; detect inactive objects	Unavailable for use when it is cloudy, during daylight, or the object is too closely aligned with the sun; unable to differentiate between multiple objects when they are close together

Source: GAO summary of company, Department of Defense, and other information. | GAO-23-105565

Although the SSA companies we talked to are using similar sensing technologies as DOD, they do offer some advantages to DOD. Some companies have deployed sensors across the globe, and in some cases, in locations that DOD would not be able to do so because of political or security concerns. For example, one of the companies we interviewed has access to over 300 sensors on five continents, with many assets located in the Southern Hemisphere where DOD has limited sensor coverage. In addition, most of DOD’s ground-based radars can only track objects larger than 10 centimeters in diameter in LEO and objects about 1 meter in diameter in GEO.²⁵ However, according to one company, its commercial sensors can track objects as small as 2 centimeters in diameter, about the size of a marble. Finally, according to a Space Force official, certain classified policies restrict DOD from using some of its sensors’ full capabilities and all of the data the sensors collect. DOD explained that commercial SSA capabilities and data are not subject to those policy restrictions. The official noted that, as a result, DOD relies on commercial SSA data to fully explore the potential benefits the DOD sensors could provide in understanding the dynamic space environment.

²⁵Apart from the other DOD sensors, the Space Fence is a ground-based radar that tracks objects as small as 1-2 centimeters in LEO.

A few companies use passive radio frequency antennas to help users distinguish between two satellites when they pass close together. This is helpful because, with less sensitive sensors, it is difficult to distinguish between two satellites and they can appear to be one object when they are close together. Some of these companies provide additional services such as SSA data analysis and signal monitoring. While the industry is growing, it also faces a number of challenges. According to a RAND Corporation report, while there is potential for growth, there is also significant uncertainty relative to the future size and stability of the SSA market.²⁶ Part of this uncertainty stems from the fact that the U.S. government provides much of its SSA data to the public for free, and SSA providers must add additional value beyond that which is provided by the government.

Further, the report stated that because commercial companies believe the government will be the “anchor” customer, uncertainty in the government’s planned and future SSA funding and support could cause stagnation in the fielding of additional commercial capabilities or even drive companies or services out of the market. Echoing these uncertainties, several companies we talked to voiced concerns over the Space Force’s lack of budgeting and planning for acquiring commercial SSA data. The report noted that commercial SSA capabilities are technically mature and though the companies are not offering new capabilities, the number of potential options has increased. This creates opportunities that the Space Force could leverage, such as delivering capabilities faster, accessing new sources of innovation, and cost savings from competition.

DOD Emphasizes Using Commercial Space Capabilities When Possible

DOD documents prioritize the use of commercial space capabilities when possible. See table 4 for a summary of DOD strategies establishing the department’s intent to use commercial capabilities.

²⁶RAND Corporation, *Commercial Space Capabilities and Market Overview* (2022).

Table 4: Department of Defense Strategies Related to the Integration of Commercial Space Capabilities

Document title and owner	Summary of guidance
2020 <i>Defense Space Strategy</i> , DOD	The 2020 <i>Defense Space Strategy</i> identifies commercial innovation as a cornerstone enabler of the strategy's lines of effort to outpace potential adversary threats. The strategy references commercial companies as an integral partner in achieving collective space security.
2022 <i>National Defense Strategy</i> , DOD	The 2022 <i>National Defense Strategy</i> places increased emphasis on commercial integration to leverage technological advancements and enable emerging capabilities. Further, the document directs DOD to repurpose decision systems using innovations in both the commercial and military sectors to make smarter technology investments; leverage experimentation to solve problems; generate more flexible military capability requirements; and rapid experimentation, acquisition, and fielding.
2022 <i>Commercial Integration Strategy Overview</i> , USSPACECOM	The <i>Commercial Integration Strategy Overview</i> sets forth the framework for how USSPACECOM will collaborate, integrate, and partner with the U.S. commercial industry. The strategy sets priorities and synchronizes commercial integration efforts so that USSPACECOM can mitigate capability gaps, improve space architecture resiliency, and gain and maintain a technological and operational advantage over adversaries.

Source: GAO assessment of DOD information. | GAO-23-105565

The Space Force had intended to draft a plan to integrate commercial SSA capabilities in particular, but according to Space Force officials, this effort has been replaced by USSPACECOM's Commercial Integration Strategy Overview. However, this USSPACECOM strategy, while it has a section on SSA, primarily covers how USSPACECOM will use commercial satellite imagery, not commercial SSA data.²⁷ The Air Force and Space Force are drafting a commercial integration strategy.

In addition to the strategies above, DOD also updated its Space Policy Directive 3100.10 in 2022 to assign responsibility for DOD space-related activities in accordance with national and DOD policies.²⁸ This Directive states that "consistent with national security requirements, commercial systems, services, and technologies will be used to the maximum practical extent, and commercial capabilities will be modified to meet those requirements when doing so is more cost-effective and timely for the U.S. government."

²⁷According to a Space Force official, USSPACECOM is drafting an implementation plan for this strategy.

²⁸DOD Directive 3100.10, *Space Policy* (Aug. 30, 2022).

DOD Acquisition and Evaluation of Commercial SSA Data Has Been Limited

DOD acquires a small amount of commercial SSA data primarily to meet its protect and defend mission through the JTF-SD Commercial Operations Cell (JCO).²⁹ This USSPACECOM initiative is focused on purchasing commercial SSA data in support of the command's mission to protect and defend U.S. space assets. According to Space Force officials, as of May 2022, the JCO was buying commercial data for a few hundred objects of interest to the JTF-SD. The JCO purchases this data through its Space Domain Awareness marketplace.³⁰

According to company representatives whom we interviewed, Space Force funding for purchases of SSA data for the JCO have been provided on an ad-hoc or monthly basis. However, the Space Force requested funding to buy commercial data in its budget request for the first time in fiscal years 2022 and 2023. According to a memorandum of understanding between Space Force and USSPACECOM, Space Force is planning to provide approximately \$20 million to the JCO for commercial SSA data purchases in fiscal year 2023 and a total of approximately \$110 million for fiscal years 2023 through 2027. According to a Space Force official, this funding covers a limited subset of SSA missions—namely, SSA for the protect and defend mission. Space Force officials confirmed that currently all of its commercial SSA purchases occur through the JCO.

The JCO also evaluates some companies' commercial SSA data. Specifically, the JCO hosts events every 4 months, known as Sprint Advanced Concept Trainings (SACT). According to officials, these events are a way to experiment with and evaluate some commercial companies' SSA data against the full range of SSA missions. According to Space Force officials, early SACTs proved the usefulness of commercial SSA data to JTF-SD's protect and defend mission. The events are now being

²⁹The government acquires licenses to use commercial SSA data in accordance with the Federal Acquisition Regulation, DFARS, and any specifically negotiated licenses, as mentioned above. Throughout this section, when we state that commercial data is acquired or purchased, what is being purchased is a license to use the commercial data, not the commercial data itself. See generally DFARS § 252.227.7013 (Rights in Technical Data – Noncommercial Items) and DFARS § 252.227-7014 (Rights in Noncommercial Computer Software and Noncommercial Software Documentation).

³⁰This is an online market that facilitates the purchase of SSA data stored in the UDL. Both the marketplace and the UDL are discussed later in the report.

used to examine the utility of commercial capabilities for other aspects of the SSA mission, including spaceflight safety.

Each SACT event has its own unique learning objectives set by the JCO and as a result, the companies participating in different SACTs are evaluated against different objectives. The SACTs also vary regarding which specific company's capabilities are being demonstrated as part of the event. According to the May 2022 SACT report, about 70 SSA companies participated in the event, a number that had been increasing since the SACTs started in 2019, but that number started to level off in November 2021, according to officials. JCO officials noted that a company's participation in a SACT, including successful demonstration of a potentially useful capability, does not guarantee that JCO will purchase that capability.

Although the commercial data purchased by the JCO is currently of limited use to the 18th and 19th Space Defense Squadrons for conducting their SSA mission, the Space Force is testing new capabilities in a few ways. For example, 18th Space Defense Squadron operators told us that they have browsed through the UDL to see what type of commercial SSA data it contains and they have observed some of the JCO's SACT events, as mentioned above. Also, the 19th Space Defense Squadron is evaluating commercial and academic capabilities to improve SSA in xGEO.

DOD has also sponsored some limited assessments of commercial SSA data, but they were done a few years ago and were limited to two companies. The Air Force Research Laboratory and the Defense Innovation Unit sponsored one study in 2019 and another in 2020.³¹ The first study looked at one company and found that its commercial data could be used operationally by the military and that the company's SSA capabilities could fill an unmet operational need. The second study looked at a different company's data and demonstrated that company's LEO tracking capabilities. According to officials from the first company, after the study was completed, they understood that a government entity would buy commercial SSA data, but that purchase never occurred.

³¹ExoAnalytic Solutions, *Commercially Augmented Mission Operations Final Report* (April 2019); Leo Labs, Inc., *Final Report for Defense Innovation Unit W15QKN1990001 Commercially Augmented Mission Operations*.

In addition, the Massachusetts Institute of Technology Lincoln Laboratory conducted a study in 2022 assessing the ability of commercial SSA to help address DOD SSA needs for monitoring and keeping track of all space objects and responding quickly to threats.³² The study found that commercial SSA data available today do not provide significant utility for the U.S. government. Specifically, the study identified significant obstacles to DOD's use of commercial SSA, including limited data rights, understandable and agreed-upon formats, and consistent data availability. It also identified actions the government could take to address the challenges. However, Space Force officials stated that the study's scope was limited because the Massachusetts Institute of Technology Lincoln Laboratory could use only the commercial data that the JCO had purchased. Space Force officials confirmed that there are other commercial data products that were not available to the Massachusetts Institute of Technology Lincoln Laboratory to be assessed in the study.

All of these studies considered only the commercial capabilities available at the time of the study, so they do not take into account any new capabilities the companies have developed since the completion of these studies. For example, one company in the Massachusetts Institute of Technology Lincoln Laboratory study planned to expand its GEO tracking capabilities to LEO as of September 2022. Additionally, novel capabilities in development may become more important as DOD expands its areas of surveillance beyond traditional orbits and into xGEO.

In addition to the DOD strategies and directive mentioned above, the *DOD Guidebook for Acquiring Commercial Items* states that in reviewing contractor proposals, "the contracting official should continuously evaluate and understand the acquisition need, as there may be available alternatives in the marketplace that could expand competition."³³ The evaluations of commercial SSA capabilities done so far by JCO and

³²The Massachusetts Institute of Technology Lincoln Laboratory is a Federally Funded Research and Development Center. As such, it provides DOD with research and development functions, among other things. DOD Instruction 5000.77, DOD Federally Funded Research and Development Center Program (effective January 31, 2018; change 2 effective November 6, 2019). Massachusetts Institute of Technology Lincoln Laboratory conducted this study, which was jointly sponsored by the JCO, the Space Force Space Systems Command Space C2 program office, and the Office of Space Commerce under the National Oceanic and Atmospheric Administration. This study assessed 18 companies' SSA data. Massachusetts Institute of Technology Lincoln Laboratory, *Space Domain Awareness: Commercial Data Contribution* (Aug. 2, 2022).

³³DOD, *Department of Defense Guidebook for Acquiring Commercial Items: Part B: Pricing Commercial Items* (Jan. 2018).

Space Force have been limited in purpose and scope and are not comprehensive. Specifically, the SACT events evaluate different companies' capabilities against different learning objectives in each event. In addition, some Space Force officials told us that they are hesitant to rely on commercial data because they cannot guarantee that it will be consistently available (if, for example, a company goes out of business) and they do not have control over what data the companies provide. Furthermore, the ability to use and share the data may be limited depending on the type of data rights and licenses the Space Force buys. As a result, Space Force officials were unsure of the extent to which commercial capabilities could support various Space Force SSA needs.

The Space Force does not have a current and complete understanding of commercial SSA capabilities because the Space Force has not established a comprehensive process to regularly identify and evaluate those capabilities, including the extent to which commercial SSA data could meet its SSA needs. Considering the limitations of the DOD studies in this area, lack of a comprehensive process for evaluation by the Space Force, and the previously discussed rapid growth of commercial capabilities, more complete and regular evaluations of commercial SSA data would help make the Space Force aware of the full range of SSA data available on the commercial market. Further, these evaluations would better position the Space Force to understand how it could use these capabilities to meet the growing need to identify and characterize space objects. Without a process to regularly identify and evaluate commercial SSA capabilities, the Space Force may be missing opportunities to use commercial data to help better address its SSA needs.

Space Force Lacks a Plan on How to Use the Unified Data Library with SSA Systems

The Space Force's UDL is a cloud-based data repository that is designed to consolidate commercial and U.S. government SSA data, as well as data from academic sources and other countries, into one place. The Space Force has deployed an initial operational version of the UDL and plans to further develop it through 2024. Although the UDL is operational, the 18th and 19th Space Defense Squadron operators are not using it in daily SSA operations. Furthermore, the Space Force lacks a plan to address challenges it faces using the UDL with SSA operational mission systems.

Space Force Has Fielded the UDL and Continues to Develop New Capabilities

The Space Force began development of the UDL as a research and development effort in 2018 for \$150,000. In 2019, the Space Force awarded a contract to continue the UDL development and fielded an initial operational system in 2022.³⁴ In April 2022, the UDL received a 3-year Authority to Operate by the Air Force, accrediting the system to be used operationally at the unclassified, secret, and top-secret levels. According to a contractor representative, although agencies outside of DOD and the Space Force are using the UDL to store other types of data, it is primarily a cloud-based repository of SSA data, with 85 percent of the data being SSA-related as of November 2022. In addition, the UDL can connect directly to sensors and store sensor data automatically. In April 2022, data from the Space Fence radar were directly uploaded and made available to the classified UDL, establishing the UDL's first direct DOD sensor connection. This demonstrates the UDL's ability to connect to a sensor in the DOD Space Surveillance Network, which includes all of DOD's SSA sensors.³⁵ Since April, the UDL has connected to an additional sensor at the classified level and several other sensors at the unclassified level.

As of November 2022, the UDL had over 4,500 users, including SSA companies, academic institutions, DOD users, and users from over 20 allied nations. SSA companies upload their SSA data to the UDL. As owners of this data, they determine who has access to it via a system of "data card" permissions—a tool the UDL uses in the software application to manage users' access.³⁶ DOD users with an account can purchase

³⁴Development continues on the UDL, with total contract value exceeding \$280 million as of February 2023.

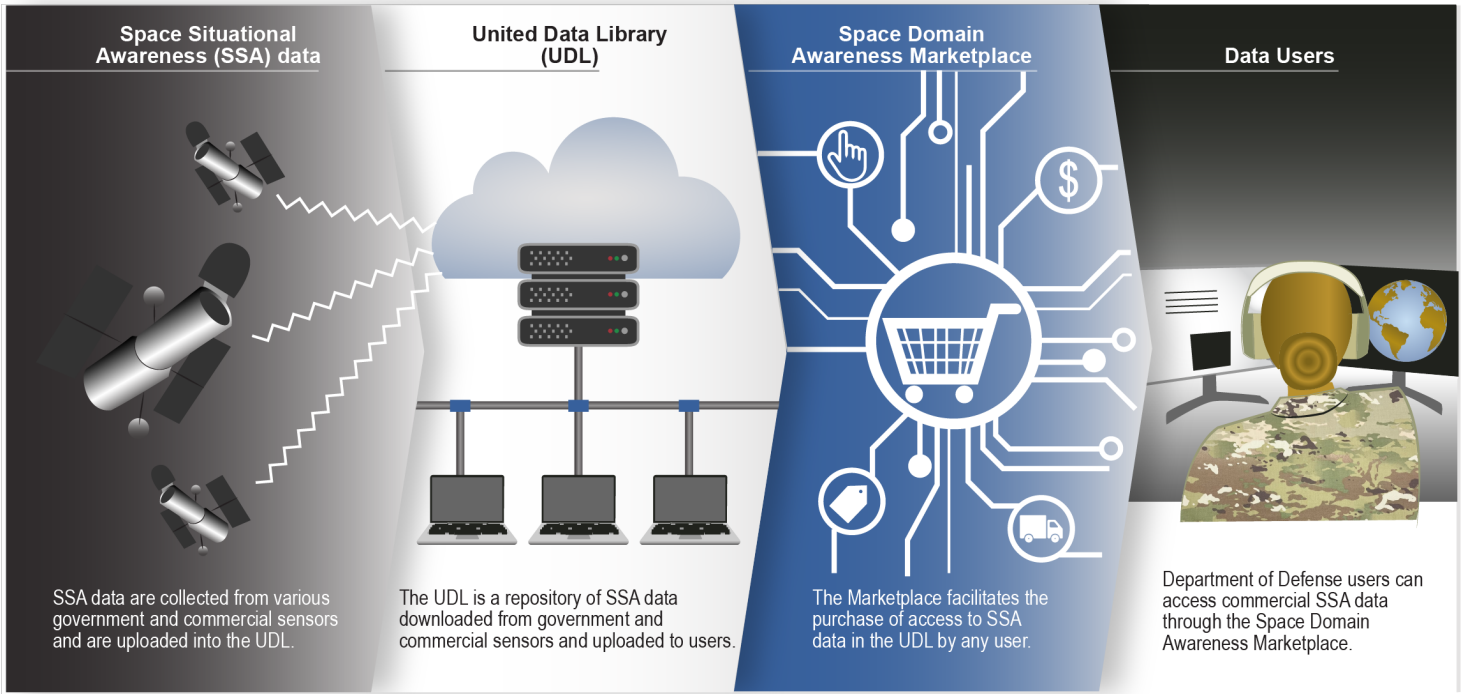
³⁵The Space Surveillance Network is a collection of radars and ground- and space-based optical telescopes that tracks more than 27,000 satellites and pieces of orbital debris for the catalog.

³⁶Access to the data cards is provided after the user requests access, with some commercial providers charging for access to their data.

access to commercial SSA data stored in the UDL through the JCO's online Space Domain Awareness marketplace, as shown in figure 5.³⁷

³⁷DOD users gain access to the UDL by agreeing to the terms of the End User License, and have the option of purchasing licenses to any commercial SSA data in the UDL. However, as we state above, JCO officials indicated that as of May 2022, the JCO was buying commercial data licenses for a few hundred objects of interest to the JTF-SD.

Figure 5: How Data Are Collected and Used via the Unified Data Library



Source: GAO assessment of Space Force information. | GAO-23-105565

As of November 2022, the UDL contained commercial and DOD data on over 25,000 objects in space, updated in real-time. According to a contractor representative, much of these DOD data are available at the unclassified level to all UDL users for free, through the 18th Space Defense Squadron’s data card. If a user does not have a UDL account, all of the same unclassified DOD data are also available on the Space-track.org website, which is also free to access and use.³⁸

According to Space Force officials, however, the UDL does not meet all of the DOD users’ SSA needs. The Space Force is continuing to develop and plans to deliver additional UDL capabilities. Specifically, the Space Force is looking into the tactical UDL capability that is portable and can be used in any operational environment. In addition, the Space Force is planning to field the Allied Exchange Environment on the UDL—a capability to share data with international partners at the secret level—as

³⁸Space-Track.org is the website DOD uses to provide SSA data to satellite owners and operators worldwide.

well as a special access program level UDL environment. To that end, the Space Force has budgeted for about \$20 million each year, for fiscal years 2023 through 2027, to fund expanding infrastructure across multiple security environments, purchase commercial SSA data, and address increasing cloud hosting costs, among other things.³⁹

SSA Systems Are Not Using the UDL in Operations and Space Force Does Not Have a Plan to Address Existing Challenges and Determine How to Use the UDL

Although the UDL is used as a repository for commercial and DOD SSA data, DOD's SSA C2 systems—SPADOC and the Correlation, Analysis, and the Verification of Ephemerides Network (CAVENet)—are largely not taking data from the UDL. The 18th and 19th Space Defense Squadrons rely on these SSA C2 systems to perform their mission functions, such as assessing potential collisions and maintaining custody of space objects. These systems use DOD's SSA data in the catalog to carry out these functions, but not commercial SSA data from the UDL.

Operators from the 18th and 19th Space Defense Squadrons cited three key challenges to integrating the UDL into operations. The first challenge is that DOD's SSA C2 systems cannot automatically integrate the commercial SSA data through the UDL. According to a UDL contractor representative, the user has the ability to set up a machine-to-machine interface between the UDL and the user's system, so that automatic, real-time data access is available versus the user searching manually for data in the UDL. In addition, UDL contractor representatives told us that a user can set up alerts to notify them when new data are available.

According to Space Force officials, any commercial SSA data in the UDL that the 18th and 19th Space Defense Squadrons might use are stored in a separate system from the DOD SSA data. DOD's C2 systems are not configured to automatically incorporate for operational use commercial data from the UDL. Specifically, 19th Space Defense Squadron operators told us that they must manually search for data in the UDL and they are not automatically notified when new data are available. Even once they have identified useful data, the operator must then send the data from the UDL through two data formatters and a system interface before incorporating it into the SSA systems. This transfer process takes several

³⁹This budgeted funding is in addition to the funding request mentioned above for the Space Force to buy commercial SSA data.

minutes and is labor-intensive, providing significant disincentives for using the UDL. According to DOD officials, this is because the legacy systems were never designed for data sharing or connecting to a network, but to operate as standalone systems.

According to Space Force officials, the Space Force is currently testing ways to put commercial data into a common internal format for the UDL so that it can better integrate with existing C2 systems. This effort requires the ability to calibrate and monitor the quality of data from non-DOD sources to ensure they are safe and accurate for use in Space Force missions. Such a capability would mark a “paradigm shift,” according to the officials. Also, the Space Force recently began a trial period for the first full path using data from the UDL for integration with the 18th and 19th Space Defense Squadrons. Specifically, this trial is incorporating data from four Air Force Research Laboratory sensors through the UDL that are not otherwise able to connect with these C2 systems and are not part of the Space Surveillance Network. According to Space Force officials, the UDL connection to these non-traditional sensors, which are owned by the government, is intended to pave the way for eventual machine-to-machine commercial data integration into DOD’s SSA systems. The Space Force is using the data coming from these sensors to conduct SSA during the trial period, which began in January 2023 and was ongoing as of February 2023. While this is a good first step, the Space Force still needs to consider what further steps to take to determine how to use the UDL in SSA operations.

Second, some DOD officials told us that there is no single defined data standard being used, but that there should be. In response to this challenge, a contractor representative told us that no organization should push for a common standard across the world but accept the various standards from all sources. According to Space Force officials, the contract to develop the UDL intentionally did not include a reference to a specific data standard because the UDL’s goal is to consolidate data from various DOD data sources, which use both old and new data formats with the ability to translate back and forth using clearly documented standards published in the UDL. The intent and design of the UDL is to accommodate both old and new data standards. The application and user interfaces are designed to support both old and new programs. However, according to officials, the reason the UDL has not yet been integrated is that current SSA C2 systems are limited in the amount of data they can process.

A third challenge cited by the 18th Space Defense Squadron operators relates to the timeliness of the data in the UDL, which can vary depending on how the UDL is being used. Some officials stated that the commercial SSA data are not uploaded to the UDL in a timely enough manner to be useful in operations. In addition, the Space Force told us that some delays are exterior to the UDL, including slow transport of the data via outdated communication links and delays with processing incoming data at the SSA sensor sites. However, the UDL and the data contained therein are always available and include “near real-time” distribution, measured in milliseconds. There are some instances in which it takes companies longer to either format their raw data or upload their data to the UDL. For example, data may take longer to upload depending on whether the data providers are uploading basic orbital data versus large imagery files. According to the contractor, while there may be latency in some UDL use cases, they are working to reduce it. For example, one way to reduce latency is for users to set up their accounts to automate their use of data in the UDL.

In a memorandum from January 2021, the Chief of Space Operations declared the UDL the single source for accessing and managing all data in support of Space Force operational systems.⁴⁰ Further, the memo states that the UDL will provide a central location to find and access data, enabling analytics through consolidation and enhanced security. While the Space Force uses the UDL in specific situations, it has only recently begun a trial period to test a first path for how to use it with SSA C2 systems. The Space Force has not planned for how to use the UDL as the single source for accessing and managing all data with DOD’s SSA C2 systems in daily SSA operations. Officials told us that to use the UDL in this way, the Space Force needs to figure out how best to integrate the UDL with current or planned SSA C2 systems. According to officials, once the Space Force can use some commercial data from the UDL, it will have to start with a small amount due to the current C2 systems limited data processing capabilities. A plan on how to use the UDL with SSA operational systems would facilitate the Space Force’s ability to benefit from the data in the UDL. In addition, a plan for the use of the UDL would enable DOD users to become more familiar with the data in the UDL, and better leverage the UDL to support SSA operations.

⁴⁰Department of the Air Force memorandum: Unified Data Library Mission Integration Policy (Jan. 8, 2021).

Conclusions

The rapid rise in the importance and challenges of operating in space necessitates enhancements to SSA capabilities, including consideration of commercially available data and tools. Key challenges remain unaddressed with regard to regularly evaluating commercial capabilities and using the UDL for space operations. In particular, while there has been periodic evaluation and use of some commercial capabilities, these efforts have been limited. Establishing a process to regularly identify and evaluate commercial SSA capabilities, including the extent to which commercial SSA data could meet Space Force SSA needs, could enhance DOD's ability to conduct this important national security mission. Such a process would also better ensure DOD meets the requirement to make use of commercial capabilities when doing so meets its mission needs. Similarly, while the creation of the UDL and the standup of its initial operational capability provides a single location for key data to be stored, the efforts to date do not yet meet the DOD requirement that the UDL be used to support all operational space activities. Creating a plan to integrate the UDL into Space Force operational systems, such as SSA and Space C2 missions, would better ensure operators had access to the full suite of DOD and commercial data to execute these critical national security missions.

Recommendations for Executive Action

We are making the following two recommendations to the Air Force:

The Secretary of the Air Force should ensure that the Space Force establishes a process to regularly identify and evaluate commercial SSA capabilities, including the extent to which commercial SSA data could meet Space Force SSA needs. (Recommendation 1)

The Secretary of the Air Force should ensure that the Space Force creates a plan for programs to determine how to use the UDL to access and manage all data for Space Force SSA systems. (Recommendation 2)

Agency Comments and Our Evaluation

We provided a draft of this report to DOD for review and comment. DOD provided written comments in which it concurred with our

recommendations. DOD also provided technical comments which we incorporated as appropriate. DOD's written comments are reprinted in their entirety in appendix II.

DOD concurred with our recommendation that the Space Force establish a process to regularly identify and evaluate commercial SSA capabilities, including the extent to which commercial SSA data could meet Space Force needs. In its written response, the department stated that the Air Force and the Space Force are currently collaborating on a Space Force Commercial Space Strategy, which will consider and address this recommendation. DOD expects this strategy to be complete by June 2023.

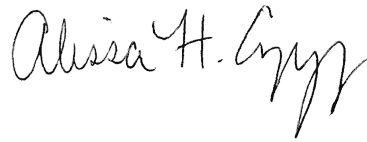
DOD concurred with our recommendation that the Space Force create a plan for programs to determine how to use the Unified Data Library to access and manage all data for Space Force SSA systems. Similar to our first recommendation, the department stated in its written response that the Air Force and the Space Force are currently collaborating on a Space Force Commercial Space Strategy, which will consider and address this recommendation.

We are sending copies of this report to the appropriate congressional committees, the Secretary of Defense, and the Secretary of the Air Force. 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 Jon Ludwigson at (202) 512-4841 or LudwigsonJ@gao.gov, or Alissa Czyz at (202) 512-3058 or CzyzA@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 members who made key contributions to this report are listed in appendix III.



Jon Ludwigson
Director, Contracting and National Security Acquisitions



Alissa H. Czyz
Director, Defense Capabilities and Management

List of Committees

The Honorable Jack Reed
Chairman
The Honorable Roger Wicker
Ranking Member
Committee on Armed Services
United States Senate

The Honorable Jon Tester
Chair
The Honorable Susan Collins
Ranking Member
Subcommittee on Defense
Committee on Appropriations
United States Senate

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

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

Appendix I: Objectives, Scope, and Methodology

The House Armed Services Committee’s report accompanying a bill for the National Defense Authorization Act for Fiscal Year 2022 contains a provision for GAO to review how the Department of Defense (DOD) conducts its Space Situational Awareness (SSA) mission and its plans for incorporating commercial SSA.¹ This report (1) describes the challenges DOD faces in identifying and characterizing objects in space, (2) assesses the extent to which DOD uses commercial SSA data, and (3) assesses the development status of the Unified Data Library (UDL) and how DOD is using it.

To describe the challenges DOD faces in identifying and characterizing objects in space, we reviewed relevant documents, both publicly available and obtained from DOD. Examples of publicly available documents include the Defense Intelligence Agency *Challenges to Security in Space* 2022 report, the RAND Corporation *Commercial Space Capabilities and Market Overview* 2022 report, and the July 2022 National Science and Technology Council’s *National Orbital Debris Implementation Plan*.

We also interviewed DOD, U.S. Space Command (USSPACECOM), and Space Force officials involved in supporting the SSA mission and acquiring solutions for the warfighter to conduct DOD SSA. We interviewed DOD officials from the Office of the Secretary of Defense, including the offices for Acquisition and Sustainment; Intelligence and Security; Policy; and the Director, Operational Test and Evaluation—the main offices responsible for acquisition policy, development, and testing. We also interviewed officials from USSPACECOM; officials from U.S. Space Force Space Systems Command; the Space Situational Awareness Program Element Monitor; selected SSA system operators; and officials from the UDL program about their SSA-related responsibilities. We also interviewed operators in the 18th and 19th Space Defense Squadrons about the challenges they face in the daily tracking of objects in space. We reviewed classified documents to understand the context of the challenges DOD faces in identifying, tracking, and characterizing objects in space. While we reviewed this

¹H.R. Rep. No. 117-118, at 276 (2022).

information, we only included information from unclassified documentation in this report.

To assess the extent to which DOD uses commercial SSA data, we selected a non-generalizable sample of 10 commercial SSA companies to interview, out of approximately 50 commercial SSA companies that have had some level of engagement with DOD. To select these 10 companies, we took several steps. DOD first provided us with a list of companies on the Space Domain Awareness marketplace. We also obtained from DOD a list of companies that it has current contracts with to buy SSA data. We added two companies to our list involved in research and development efforts with DOD, to gain their perspective on trying to earn a contract award. We identified these companies by attending a Space Systems Command Space Domain Awareness Industry Day in July 2022. We selected them as, although they were engaged with DOD, they did not have current contracts. From the list of 50 companies, we selected 10 to interview based on what type of SSA products they provided and whether they had a contract with DOD. The 10 companies we selected are

- AstronetX PBC,
- Bluestaq LLC,
- COMSPOC Corp.,
- ExoAnalytic Solutions Inc.,
- Kratos Defense and Security Solutions, Inc.,
- L3Harris Technologies Inc.,
- LeoLabs Inc.,
- Safran Data Systems, Inc., United States,
- Slingshot Aerospace, and
- Zimagine Innovations, LLC.²

We interviewed these companies on their experiences working with DOD, Space Force, and USSPACECOM.

We collected and reviewed three assessments of these companies' SSA capabilities compared with DOD's two of which were sponsored by the Air Force Research Laboratory and the Defense Innovation Unit in 2019 and

²We interviewed the Numerica Corporation, which was acquired by Slingshot Aerospace during our audit.

2020 and one of which was done by the Massachusetts Institute of Technology Lincoln Laboratory in 2022. For example, we reviewed ExoAnalytic Solutions, Inc. *Commercially Augmented Mission Operations* Final Report from 2019. We also interviewed Space Force and USSPACECOM units experimenting with using commercial SSA data to conduct the Space Force's SSA mission. These included the Joint Task Force-Space Defense Commercial Operations Cell—the primary office experimenting with using commercial SSA data, and the Commercial Integration Cell—the organization supporting the Combined Space Operations Center at Vandenberg Space Force Base. We reviewed DOD documentation, such as the Air Force report to congressional committees entitled, *Commercial Space Domain Awareness Services*.³ We also examined DOD and U.S. Space Force policies and strategy documents including the *2020 Defense Space Strategy*, *2020 National Space Policy*, the Space Doctrine Note, and the Space Operations Joint Publication 3-14. We also identified relevant space policies and strategies through other, similar past and ongoing GAO audits, such as our report entitled *National Security Space: Actions Needed to Better Use Commercial Satellite Imagery and Analytics*.⁴

To assess the development status of the UDL and how DOD is using it, we interviewed the Space Force officials and contractor representatives responsible for its development and operations regarding the past development activities and the current use of the UDL. We also asked DOD entities and the companies we interviewed for their perspectives on the UDL and the extent to which they have used it for their own purposes, whether to sell or buy commercial SSA data. We also reviewed relevant documents, such as the UDL contracts, Space Force memoranda regarding use of the UDL, and Space Force briefings on the UDL. We reviewed these documents for information on the status and scope of the UDL development. We also attended several UDL demonstrations that showed us how the UDL was designed, how it was intended to be used, and which companies have data on the UDL.

We conducted this performance audit from November 2021 to April 2023 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain

³Department of the Air Force, *Commercial Space Domain Awareness Services* (Jan. 2021).

⁴GAO, *National Security Space: Actions Needed to Better Use Commercial Satellite Imagery and Analytics*, [GAO-22-106106](#) (Washington, D.C.: Sept. 7, 2022).

**Appendix I: Objectives, Scope, and
Methodology**

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.

Appendix II: Comments from the Department of Defense

**Appendix II: Comments from the Department
of Defense**


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

Dear Mr. Ludwigson,

This is the Department of Defense (DoD) response to the GAO Draft Report, GAO-23-105565, "SPACE SITUATIONAL AWARENESS: DOD Should Evaluate How it Can Use Commercial Data" dated March 6, 2023 (GAO Code 105565).

Attached is DoD's response to the subject report. My point of contact is Lt Col Daniel Kimmich who can be reached at daniel.kimmich.1@spaceforce.mil and phone (719) 377-0487.

Sincerely,



D. JASON COTHERN
Brigadier General, USSF
Deputy Commander

Attachment:
Department of Defense Comments to the GAO Recommendations

GAO DRAFT REPORT DATED March 6, 2023
GAO-23-105565 (GAO CODE 105565)

“SPACE SITUATIONAL AWARENESS: DOD SHOULD EVALUATE HOW IT
CAN USE COMMERCIAL DATA”

DEPARTMENT OF DEFENSE COMMENTS
TO THE GAO RECOMMENDATION

RECOMMENDATION 1: The secretary of the Air Force should ensure that the Space Force establishes a process to regularly identify and evaluate commercial SSA capabilities, including the extent to which commercial SSA data could meet Space Force needs.

DoD RESPONSE: Concur. The DAF and USSF are currently collaborating on a USSF Commercial Space Strategy in which this GAO recommendation will be considered and addressed. ECD: 30 June 2023

RECOMMENDATION 2: The Secretary of the Air Force should ensure that the Space Force creates a plan for programs to determine how to use the UDL to access and manage all data for Space Force SSA systems.

DoD RESPONSE: Concur. The DAF and USSF are currently collaborating on a USSF Commercial Space Strategy in which this GAO recommendation will be considered and addressed. ECD: 30 June 2023

Accessible Text for Appendix II: Comments from the Department of Defense

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

Dear Mr. Ludwigson,

This is the Department of Defense (DoD) response to the GAO Draft Report, GAO-23-105565, "SPACE SITUATIONAL AWARENESS: DOD Should Evaluate How it Can Use Commercial Data" dated March 6, 2023 (GAO Code 105565).

Attached is DoD's response to the subject report. My point of contact is Lt Col Daniel Kimmich who can be reached at daniel.kimmich.l@spaceforce.mil and phone (719) 377-0487.

Sincerely,

D. JASON COTHERN
Brigadier General, USSF
Deputy Commander

Attachment:

Department of Defense Comments to the GAO Recommendations

GAO DRAFT REPORT DATED March 6, 2023
GAO-23-105565 (GAO CODE 105565)

"SPACE SITUATIONAL AWARENESS: DOD SHOULD EVALUATE HOW IT CAN
USE COMMERCIAL DATA"

DEPARTMENT OF DEFENSE COMMENTS TO THE GAO RECOMMENDATION

RECOMMENDATION 1: The secretary of the Air Force should ensure that the Space Force establishes a process to regularly identify and evaluate commercial SSA

capabilities, including the extent to which commercial SSA data could meet Space Force needs.

DoD RESPONSE: Concur. The DAF and USSF are currently collaborating on a USSF Commercial Space Strategy in which this GAO recommendation will be considered and addressed. ECD: 30 June 2023

RECOMMENDATION 2: The Secretary of the Air Force should ensure that the Space Force creates a plan for programs to determine how to use the UDL to access and manage all data for Space Force SSA systems.

DoD RESPONSE: Concur. The DAF and USSF are currently collaborating on a USSF Commercial Space Strategy in which this GAO recommendation will be considered and addressed. ECD: 30 June 2023

Appendix III: GAO Contact and Staff Acknowledgments

GAO Contact

Jon Ludwigson, (202) 512-4841 or LudwigsonJ@gao.gov, Alissa Czyz,
(202) 512-3058 or CzyzA@gao.gov

Staff Acknowledgments

In addition to the contacts named above, Rich Horiuchi, Laura Hook, Nick Cornelisse, and Jay Tallon (Assistant Directors), Desirée E. Cunningham (Analyst-in-Charge), Adrienne Cline, Laura Greifner, Tonya Humiston, Jean Lee, Albirio Madrid, and Gabrielle Matuzsan made key contributions to this report. Assistance was also provided by Ethan Kennedy, Jennifer Leotta, Chi L. Mai, Christine Pecora, Trish Powell, Jenny Shinn, and Alyssa Weir.

GAO's Mission

The Government Accountability Office, the audit, evaluation, and investigative arm of Congress, exists to support Congress in meeting its constitutional responsibilities and to help improve the performance and accountability of the federal government for the American people. GAO examines the use of public funds; evaluates federal programs and policies; and provides analyses, recommendations, and other assistance to help Congress make informed oversight, policy, and funding decisions. GAO's commitment to good government is reflected in its core values of accountability, integrity, and reliability.

Obtaining Copies of GAO Reports and Testimony

The fastest and easiest way to obtain copies of GAO documents at no cost is through our website. Each weekday afternoon, GAO posts on its [website](#) newly released reports, testimony, and correspondence. You can also [subscribe](#) to GAO's email updates to receive notification of newly posted products.

Order by Phone

The price of each GAO publication reflects GAO's actual cost of production and distribution and depends on the number of pages in the publication and whether the publication is printed in color or black and white. Pricing and ordering information is posted on GAO's website, <https://www.gao.gov/ordering.htm>.

Place orders by calling (202) 512-6000, toll free (866) 801-7077, or TDD (202) 512-2537.

Orders may be paid for using American Express, Discover Card, MasterCard, Visa, check, or money order. Call for additional information.

Connect with GAO

Connect with GAO on [Facebook](#), [Flickr](#), [Twitter](#), and [YouTube](#).
Subscribe to our [RSS Feeds](#) or [Email Updates](#). Listen to our [Podcasts](#).
Visit GAO on the web at <https://www.gao.gov>.

To Report Fraud, Waste, and Abuse in Federal Programs

Contact FraudNet:

Website: <https://www.gao.gov/about/what-gao-does/fraudnet>

Automated answering system: (800) 424-5454 or (202) 512-7700

Congressional Relations

A. Nicole Clowers, Managing Director, ClowersA@gao.gov, (202) 512-4400, U.S. Government Accountability Office, 441 G Street NW, Room 7125, Washington, DC 20548

Public Affairs

Chuck Young, Managing Director, youngc1@gao.gov, (202) 512-4800
U.S. Government Accountability Office, 441 G Street NW, Room 7149
Washington, DC 20548

Strategic Planning and External Liaison

Stephen J. Sanford, Managing Director, spel@gao.gov, (202) 512-4707
U.S. Government Accountability Office, 441 G Street NW, Room 7814,
Washington, DC 20548



Please Print on Recycled Paper.