Buying Space: Trends in U.S. SDA Acquisition

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Abstract Summary

This study tracks investments in the U.S. national security space domain awareness mission (SDA) from about fiscal year (FY) 1997 to the present as a means of identifying how priorities in the military space enterprise have evolved. This is particularly notable for the SDA mission which has historically been combined with other space missions and programs and acts as a secondary beneficiary to such. Space capabilities of the first space age, which is roughly defined from the development of the first satellites to the fall of the Soviet Union in 1991, were dominated by missions that supported the nuclear enterprise: command and control; intelligence, surveillance, and reconnaissance (ISR); and missile warning. Today, SDA is fundamental to modern satellite command and control, the tracking of debris, performing safe rendezvous and proximity operations (RPOs), and establishing and implementing potential rules or norms. As part of this study, the authors compiled a data set across more than twenty years of defense acquisition data to track Department of Defense (DoD) research, development, test & engineering (RDT&E) and procurement funding at the program element and line item level across SDA-related programs. While DoD funding for space programs may come from other titles of the budget (to include operation & maintenance (O&M) funding), acquisition data provides the most consistent and granular means of tracking investments in the development of individual programs. In addition to tracking investments by program element, the authors identified limitations within the dataset, including the exclusion of classified funding, as well as DoD's reporting of spending data. The space policy community is continually calling for more information and better awareness of actions and activities in space to increase sustainability of the domain and better identify and protect assets from space threats (both natural and human-made). This paper will examine the research and development, and procurement budgets from DoD for SDA over the years and align the data with stated policy priorities.

1. Introduction

Space situational awareness (SSA), later re-envisioned as space domain awareness (SDA), is the foundation of modern space operations. The distinction lies here: SSA is the knowledge and understanding of near-Earth objects and the space environment. SDA "encompasses the effective identification, characterization, and understanding of any factor associated with the space domain that could affect space operations and impact the security, safety, economy, or environment of our nation."[1] One way of thinking about the relationship between SSA and SDA is that SDA is the next evolution of more distinct and actionable space environmental data – or SSA 2.0. The term SDA pivots the mission from a relatively benign environment to a contested warfighting domain.

SDA has been evolving since the first satellite was launched in 1957, however characterizing, detecting, and tracking satellites in near-Earth orbits has never been quite as critical as it is today. In 2012, there were about 1,000 active satellites.[2] Only ten years later, as of May 1, 2022, there are 5,465 active satellites in orbit around the Earth.[3] The space domain has changed dramatically over the last five to ten years, becoming more crowded, contested, congested, and commercial. SDA is foundational for safe, sustainable, and secure operations in space. It also supports intelligence gathering of what actions satellites are taking in space such as how they are moving within orbital regimes, provides data on conjunction assessments, tracks objects as they leave the atmosphere and later re-enter, and supports attribution of potential attacks.

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[1] U.S. Space Systems Command, *SSC Hosts Space Domain Awareness Industry Day*, (El Segundo, CA: July 22, 2022), 1-2, https://www.ssc.spaceforce.mil/Portals/3/Documents/PRESS%20RELEASES/SSC%20Hosts%20Space%20Domain%20Awareness%20Industry%20Day.pdf?ver=l-M21OhTzxbOqAXcESon4w%3D%3D.

[2] Laura Grego, "Record Number of Satellites in Orbit", *Union of Concerned Scientists*, January 9, 2019, https://allthingsnuclear.org/lgrego/2018satellitedata/.

[3] "UCS Satellite Database," Union of Concerned Scientists, updated May 1, 2022, https://www.ucsusa.org/resources/satellite-database.

Civilian and military leaders have recognized the importance of SDA, however, with the incredible growth of low-Earth orbit (LEO), the problem of tracking and characterizing objects persists. SDA was a key point of General James Dickenson's, commander of U.S. Space Command, keynote at the Space and Missile Defense Conference in August 2022.Gen. Dickenson admitted that "the amount of debris is very concerning. We want to make sure we don't have a low Earth orbit that we can't operate safely in." Securing and understanding your environment is cornerstone to any successful military campaign, including in space. Dickenson went on to highlight that "if you read the national defense strategy, it talks about having a safe and stable and secure operating environment in the space domain." The SDA mission has been a real strategic and tactical challenge for the U.S. government since the 1950s, and it is only getting more difficult with increased activity and growing debris.

SDA in the 1950s and 1960s was accomplished through twelve global Baker-Nunn cameras, which became the world's first ground-based satellite-tracking stations. Located in Argentina, Australia, Curacao, India, Iran, Japan, Peru, South Africa, Spain, and at three sites in the United States, Harvard University's Dr. Fred L. Whipple, director of the Smithsonian Astrophysical Observatory, relied on teams of volunteer amateur astronomers to report observations.[4] Volunteers and amateur satellite observers were the backbone of SDA. The successful launch of Sputnik in 1957 accelerated many aspects of the United States' space program, including the first attempt at 24/7 space surveillance.[5]

Developing SDA capabilities has been an ongoing process since the launch of Sputnik in 1957 and has moved from a civil space responsibility to a military space mission. In fact, many of the sensor systems built in the 1960s and 1970s are still in use today with continued modernization.[6] Over time space SDA systems have become increasingly advanced and global. Ground and space-based systems are now necessary to successfully complete the SDA mission—the United States Space Force calls this collective architecture of SDA systems the Space Surveillance Network, or SSN. Often in public forums, space experts proclaim the fundamental necessity of good SDA data to enable security, sustainability, and cooperation in space.[7] Recently, F Schnell, senior materiel leader for SDA at U.S. Space Systems Command said to *SpaceNews*, "In a warfighting domain, in addition to knowing what an object in orbit is, we want to know its intent."[8] In order to explore these sorts of statements, this study evaluates if there is significant funding and attention to the SDA mission in the Air and Space Force's budgets.

2. Tracking Budgets

Funding for the SDA mission falls across different titles of DoD's budget including research, development, test & evaluation (RDT&E), procurement, and operation & maintenance (O&M). This study specifically tracks actual investments in Air Force (and later Space Force) SDA acquisition programs categorized under the RDT&E and procurement sections of the budget from FY 1997 to the present.[9] Analysis of RDT&E funding is conducted at the program element level while the analysis of procurement data was tracked largely at the topline level as an aggregate of SDA-related procurement spending.

DoD's reporting of SDA acquisition data poses a particular challenge to conducting a comprehensive, granular analysis of all SDA investments. RDT&E program elements may include funding for multiple projects, not all of which are directly or primarily related to SDA, and those program elements may be created, re-named, consolidated, or eliminated over time. Tracking SDA funding in the budget justification documents was further complicated by the

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[4] "Baker-Nunn Camera," Smithsonian Institution Archives, retrieved September 20, 2022, https://siarchives.si.edu/collections/siris_sic_8335. and Rick W. Sturdevant, "From Satellite Tracking to Space Situational Awareness: The USAF and Space Surveillance, 1957-2002," *Air Power History* , Vol. 55, No. 4 (WINTER 2008), p. 6-7.

[5] Sturdevant, "From Satellite Tracking to Space Situational Awareness," 8.

[6] U.S. Government Accountability Office, *Space Acquisitions: Development and Oversight Challenges in Delivering Improved Space Situational Awareness Capabilities*, (Washington, DC: May 2011), 7, https://www.gao.gov/assets/gao-11-545.pdf#page=12.

[7] Center for Strategic and International Studies, "Dancing Lights in Space: How to Manage the Risks of Satellite Close Approaches in Geostationary Orbit," filmed January 26, 2022, https://www.csis.org/events/dancing-lights-space-how-manage-risks-satellite-close-approaches-geostationary-orbit.

[8] Sandra Erwin, "Private industry aims to fill demand for space threat intelligence," SpaceNews, September 18, 2022, https://spacenews.com/private-industry-aims-to-fill-demand-for-space-threat-intelligence/.

[9] The time frame was selected based on the availability of consistent budget data. The actual data for a given fiscal year is reported in the budget request two years later. For example, actual data for an SDA program in FY 2019 would be collected from the budget justification documents in the FY 2021 budget request.

creation of a new spending category, or "major force program (MFP)," for national security space in FY 2018, which led to the re-numbering of all space-related program elements.[10] The creation of the Space Force in December 2019 similarly led to the creation of new program elements distinct to the new military service.

Another challenge in performing an open-source assessment of SDA-related budget data is that SDA is often a secondary or tertiary mission or a byproduct of other capabilities.[11] Command and control, missile warning, and other broad United States Air and Space Forces efforts often contribute data or context to the SDA mission beyond what is captured below. This trend is not new, in the late 1990s, many space control networks similarly fed data to the SSN, such as Pave Paws and PARCS (perimeter acquisition radar attack characterization system). Additionally, some SDA programs are classified, and spending data is unavailable as a result.[12] Some, like the Geosynchronous Space Situational Awareness Program (GSSAP) satellites are well known to perform a primary in-space SDA mission. However, these satellites are still within the classified DoD budget and therefore unable to be included in this analysis.

In order to present consistent analysis of SDA investments, the study team assessed funding for RDT&E program elements that almost exclusively funded SDA projects and tracked those investments over time and across the evolution of their program element numbers. Programs that evolved from projects under different program element numbers into their own distinct program element have been tracked as well.

Tracking investments in SDA-related procurement presented similar challenges. Distinct programs are not funded under individual line items and are instead compiled as sub-line items under several line items that include "Space Mods" or "Initial Spares/Repair Parts" among others. While sub-line items may be associated with specific program elements, they are not consistently reported over the duration of the time frame under analysis. Moreover, modifications to the tracking of line items and program elements in the transition from Air Force to Space Force reporting means the actual spending for sub-line items was not reported in FY 2019 and FY 2020. For this reason, SDA procurement spending is assessed as a topline. However, the vast majority of acquisition spending for SDA is in RDT&E rather than procurement.

An alternative assessment of SDA-related acquisition spending could track investments at the project level rather than the program element level for more granular analysis.[13] However, such analysis was outside the scope of this study given the effort and time required as well as the length of this publication. A project-level assessment would similarly run into the reporting issues outlined above. The study team may pursue such analysis as a follow-on project to this study.

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[10] In FY 2018, DoD created a new spending category, or "major force program (MFP)," for national security space known as MFP-12 which led to the re-numbering of all space-related program elements.
[11] U.S. Government Accountability Office, *Space Situational Awareness: Status of Efforts and Planned Budgets*, (Washington, DC: October 8, 2015) https://www.gao.gov/assets/gao-16-6r.pdf#page=27.
[12] Ibid.
[13] In 2011, the Government Accountability Office (GAO) conducted a review of acquisition for SSA capabilities and tracked actual spending for FY 2006 to FY 2009 at the project level. See GAO, *Space Acquisitions*, Appendix III, 41-43, https://www.gao.gov/assets/gao-11-545.pdf#page=46.

3. RDT&E Budget Trends in USAF SDA Programs, FY 1997 through Today

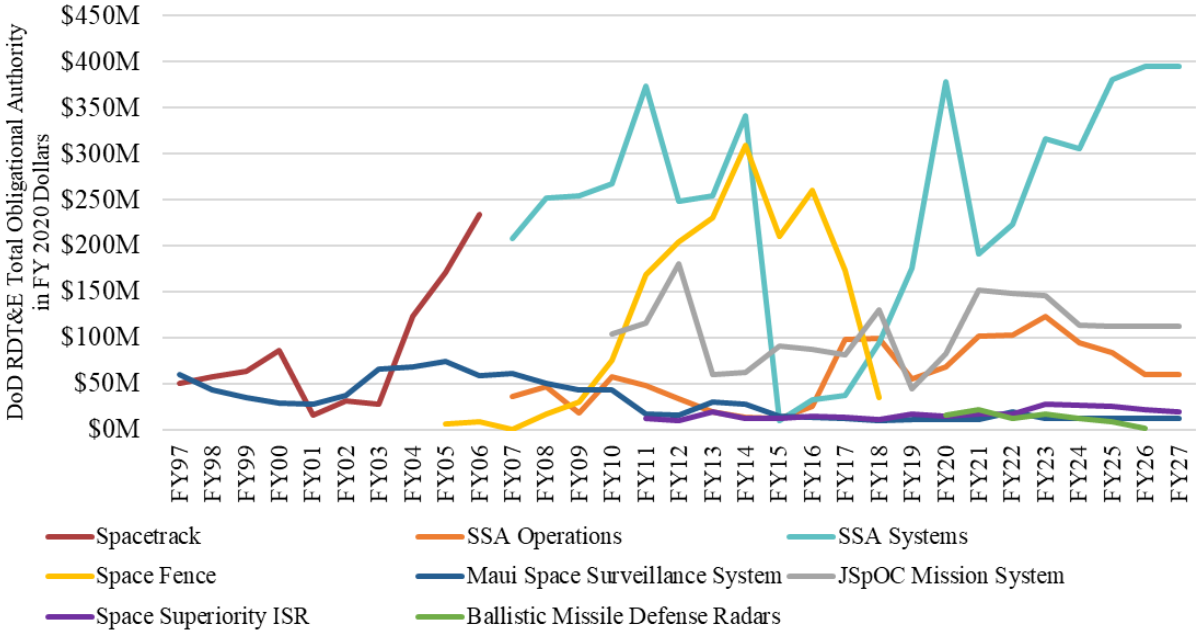

Fig. 1. RDT&E Funding by SDA Programs[14]

RDT&E funding for SDA programs has fluctuated considerably since FY 1997. Fig. 1. presents funding for SDA program elements from FY 1997 through the projections in the FY 2023 budget request. As the figure shows, SDA programs have varied significantly both in terms of RDT&E spending as well as program duration. The following section discusses the objectives and funding trends for each of these programs.

[14] Spending data is presented in constant FY 2020 dollars due to uncertainty surrounding the accuracy of inflation measures in the FY 2023 budget request. Given continued uncertainty over the future of current high inflation rates, projections over the FY 2023-FY 2027 period may change. All adjustments for inflation in this report are made using the GDP Chained Price Index published by OMB in Historical Table 10.1.

3.1 SPACETRACK

A no-longer active program element, SPACETRACK included several sub-projects which represent global sensors that collect electro-optical, passive radio frequencies, and radar. In FY 2004, SPACETRACK's sub-projects were split and transferred to Space Situation Awareness System and Space Situation Awareness Operations program elements (more on these below). However, from FY 1997 to FY 2006, SPACETRACK was the primary RDT&E program element for SDA. Over time, the SPACETRACK PE included the Advanced Electro Optical System (AEOS); the HAVE STARE radar in Norway; the Ground-based Electro-Optical Deep Space Surveillance (GEODSS) sustainment project in New Mexico, Deigo Garcia, and Hawaii; the Space Based Space Surveillance (SBSS) satellite constellation; Space Situational Awareness Initiatives; Sensor Service Life Extension Programs (Sensor SLEPs); and Orbital Deep Space Imager (ODSI).[15]

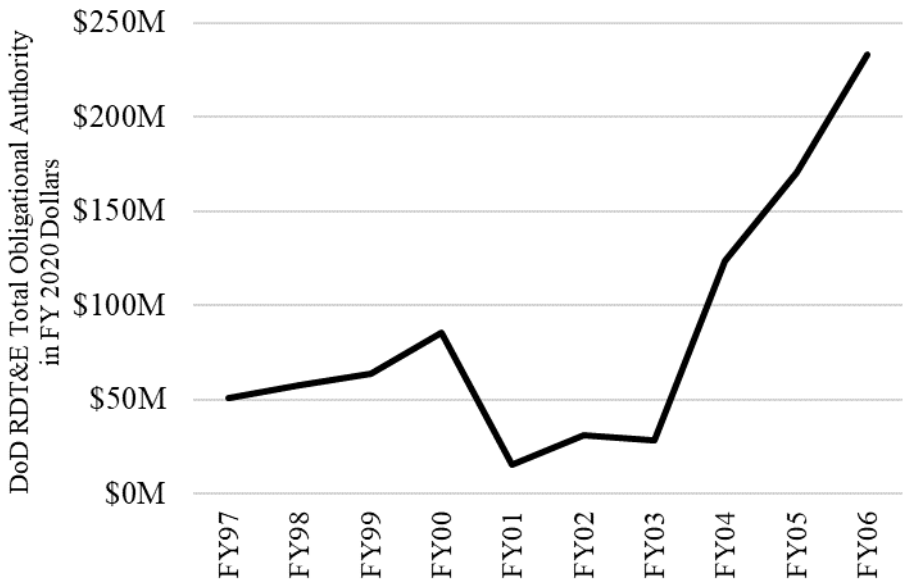

Fig. 2. Spacetrack RDT&E Funding

As Fig. 2. depicts, RDT&E funding for Spacetrack fell over 80 percent in real terms between FY 2000 and FY 2001. However, from FY 2001 to FY 2006, funding grew significantly to peak at approximately $233 million in FY 2006 before the projects under the program element were transferred to new program elements for SSA Systems and SSA Operations in FY 2007.

[15] U.S. Department of the Air Force, *Fiscal Year 2004/2005 Biennial Budget Estimates: Research, Development, Test and Evaluation – Descriptive Summaries*, Vol. I (Washington DC: February 2003), 1737, https://www.saffm.hq.af.mil/Portals/84/documents/FY04/AFD-070223-063.pdf?ver=2016-08-22-101828-843.; U.S. Department of the Air Force, *Fiscal Year 2000/2001 Biennial Budget Estimates: Research, Development, Test and Evaluation – Descriptive Summaries*, Vol. III (Washington DC: February 1999), 1622, https://www.saffm.hq.af.mil/Portals/84/documents/FY00/AFD-070223-225.pdf?ver=2016-08-10-143046-310.

3.2 Space Situation Awareness Systems

Once a part of Spacetrack, this catch-all program includes new sensors and information integration capabilities for the broader SSN. It has fielded various program upgrades and advances in SSA capability, including but not limited to: Space Based Space Surveillance (SBSS), Space Fence, Net-centric Sensors and Data Sources, and the C-Band Radar. Notably, in the FY 2022 budget it includes the Deep Space Advanced Radar Concept (DARC) which is a ground-based radar system that once developed will be able to detect, track, and maintain custody of satellites without gaps. It also includes the SBSS constellation follow-on program called SILENTBARKER. SILENTBARKER is a collaborative effort between the U.S. Space Force and the National Reconnaissance Office (NRO) to improve satellite threat intelligence and SDA. The NRO's budget is classified, so it is unclear how much additional funding is supporting this mission. The FY 2023 budget document states that the initial launch for SILENTBARKER is planned for that same fiscal year. It has a companion program called Space Situation Awareness Operations, described below.

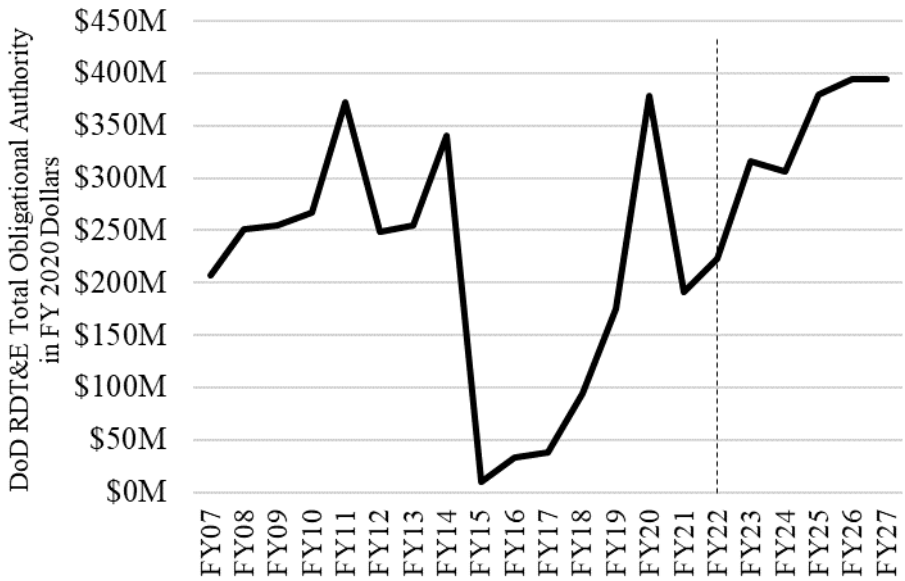

Fig. 3. SSA Systems RDT&E Funding

Funding for the SSA Systems program element has seen significant fluctuations since it was first created in the FY 2007 budget request as Fig. 3. shows. Program funding decreased by over 97 percent from FY 2014 to FY 2015 as the Space Fence project was shifted to a new program element. However, spending would grow from nearly $10 million in FY 2015 to over $378 million in FY 2020. Following a decline in FY 2021, funding is projected to grow into the future.

3.3 Space Situation Awareness Operations

This collective program includes "new network sensors and improved information integration capabilities across the space surveillance network (SSN)." It has fielded various program upgrades and advances in SSA capability, including but not limited to: SBSS, Space Fence, Net-centric Sensors and Data Sources, and the C-Band Radar. Notably, in the FY 2022 budget it includes the Deep Space Advanced Radar Concept (DARC) which is a ground-based radar system that once developed will be able to detect, track, and maintain custody of satellites without gaps. It also includes the SBSS constellation follow-on program called SILENTBARKER. SILENTBARKER is a collaborative effort between the U.S. Space Force and the National Reconnaissance Office (NRO) to improve satellite threat intelligence and SDA. The NRO's budget is classified, so it is unclear how much additional funding is supporting this mission. The FY 2023 budget document states that the initial launch for SILENTBARKER is planned for that same fiscal year. It has a companion program called Space Situation Awareness Operations, described below.

It also includes the Ground-Based Optical Sensor System (GBOSS), which is a series of upgrades to the GEODSS) system. GEODSS critically tracks objects from about 10,000 to 45,000km from Earth, which includes medium Earth orbit (MEO), geosynchronous Earth orbit (GEO), and GEO's graveyard orbit.[16] There are three GEODSS systems at Diego Garcia, White Sands Missile Range, New Mexico, and on top Haleakalā in Maui, Hawaii. These upgrades include "image processing and optical subsystems that will enhance the sensitivity and search rate, and fields new multi-spectral advanced technology sensors supporting extended operations, high-fidelity characterization, enhanced indications and warnings (I&W), and attribution."[17]

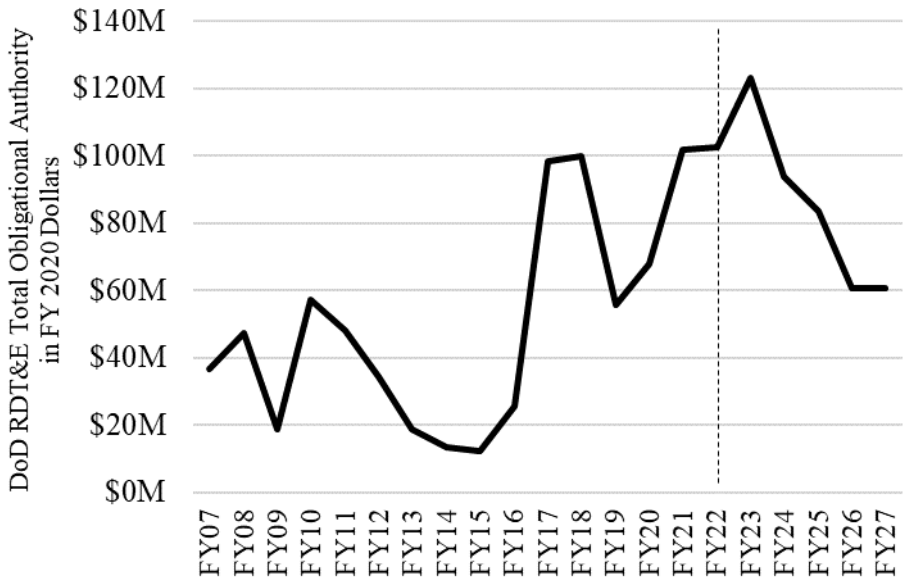

Fig. 4. SSA Operations RDT&E Funding

Since created as a separate program element from Spacetrack in FY 2007, funding for SSA Operations has varied considerably, reaching a low point in FY 2015 before peaking in FY 2022. Spending for the program element is projected to increase, then fall into the future, as shown in Fig. 4.

[16] "Ground-Based Electro-Optical Deep Space Surveillance," Air Force Space Command Archive, published March 22, 2017, https://www.afspc.af.mil/About-Us/Fact-Sheets/Article/249016/ground-based-electro-optical-deep-space-surveillance/.

[17] U.S. Department of the Air Force, *Fiscal Year (FY) 2023 Budget Estimates: Research, Development, Test & Evaluation, Space Force*, Vol. I (Washington, DC: April 2022), 237, https://www.saffm.hq.af.mil/Portals/84/documents/FY23/RDTE_/FY23%20Space%20Force%20Research%20Development%20Test%20and%20Evaluation.pdf?ver=I2npdFjyjdbiZU_fpVnOAw%3d%3d.

3.4 Space Fence

Space Fence is a ground-based sensor and entered initial operating capability in March 2020. It was a long-awaited program to add capacity to the SDA mission and greatly expands the detection and tracking of space objects. Its coverage includes LEO, MEO, and GEO; and it was expected to grow the catalog of objects from around 20,000 to over 100,000 since its detection includes much smaller objects than prior SDA sensors. Space Fence is capable of detecting "closely spaced objects, breakups, maneuvers and launches."[18] Detecting and tracking closely spaced satellites, breakups, and maneuvers are critical to ensuring the security of U.S. space assets and for increasing transparency and building norms within the space domain. Exquisite SDA lifts the "fog of war" and allows for operators and combatant commanders to have a clear understanding of satellites in the domain and counterspace weapons that may be used against them.

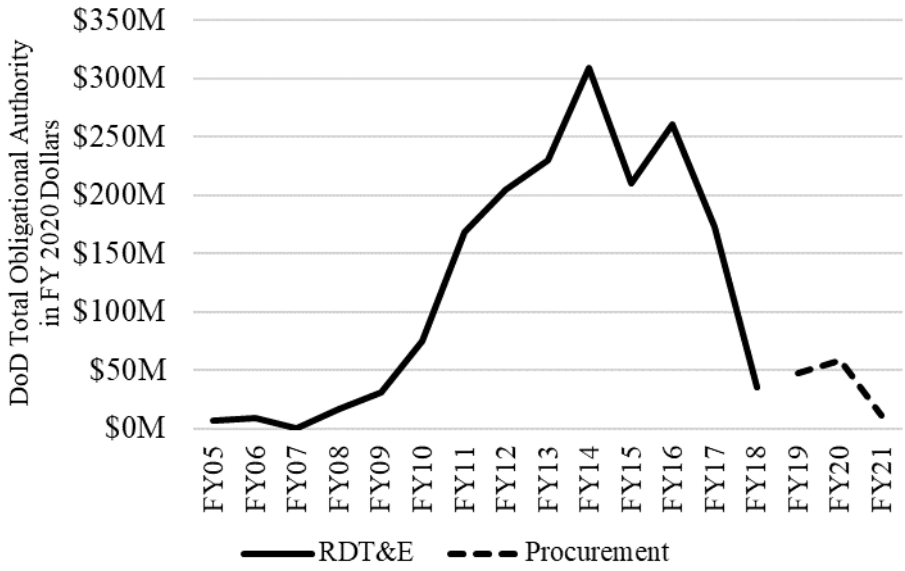

Fig. 5. Space Fence Funding

The Space Fence program initially received funding under the Spacetrack program element before transitioning under the SSA Systems program in FY 2007. It was categorized under that program element until FY 2015 when it became its own distinct program. As Fig. 5. shows, funding for Space Fence grew over $302 million (measured in FY 2020 dollars) between FY 2006 and its peak in FY 2014. Funding largely declined as the program transitioned into the procurement phase. Unlike other SDA programs, Space Fence received procurement funding under its own distinct line item (shown in Fig. 5.) from FY 2019 to FY 2021 when the program ended.

[18] "Space Fence," Lockheed Martin, https://www.lockheedmartin.com/en-us/products/space-fence.html.

3.5 Space Superiority ISR

Funding in this element supports ISR and electronic support for SDA missions. Prior to FY 2022 this program element was titled Space Superiority Intelligence—the program was re-named with the first Space Force RDT&E budget request in May 2021. Critically, Space Superiority ISR funds developmental intelligence collection capabilities, including "ISR Planning and direction, Collection, Processing and exploitation, Analysis and production, Dissemination and integration." All these mission areas feed into greater battlespace awareness and support decision-making capabilities for combatant commanders. It also supports various analysis centers, labs, and systems designed to conduct current and future threat studies.

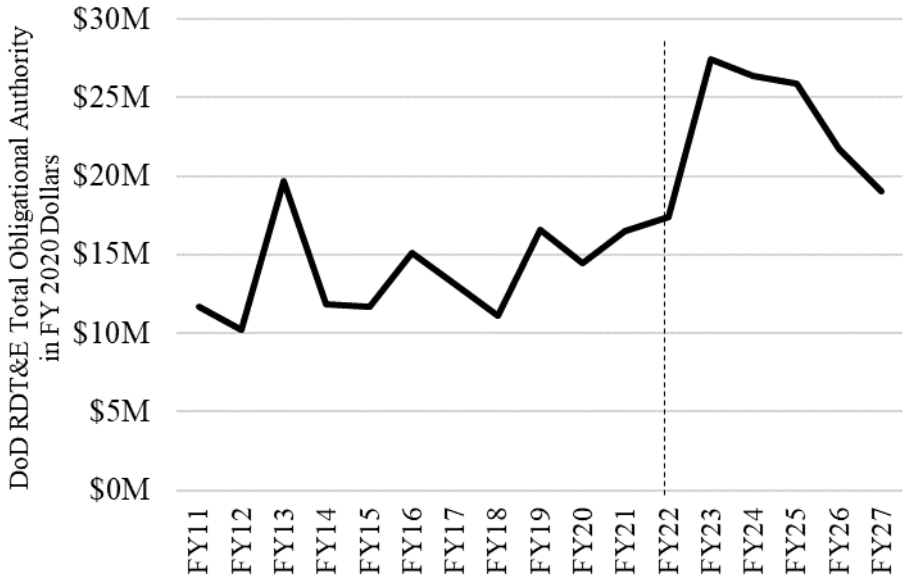

Fig. 6. Space Superiority ISR RDT&E Funding

Since RDT&E funding for Space Superiority ISR began in FY 2011, it has consistently remained above $10 million as measured in FY 2020 dollars, peaking in FY 2013. Funding is projected to increase in the FY 2023 request and fall thereafter.

3.6 Maui Space Surveillance System

The Maui Space Surveillance System (MSSS) is a series of ground-based optical space situational awareness systems and one of the foundational elements of the overall Space Surveillance Network (SSN). Located atop an inactive volcano, Haleakalā, the site sits above most mid- to low- clouds at about 10,000 feet above sea level. The altitude, lack of clouds, and lack of ambient light makes the MSSS site a premier location for detecting and tracking satellites.

MSSS continually undergoes upgrades and maintenance for its many systems, such as the Air Force Maui Optical Station (AMOS). Initially, AMOS was included in the broader SPACETRACK Air Force program, but both AMOS and MSSS were separated out in FY 2000 and given to the Air Force Research Laboratory (AFRL) to manage.[19] AMOS consists of "small, medium, and large-aperture tracking optics, including the DoD's largest optical telescope designed for tracking and imaging satellites, with visible and infrared sensors to collect data on near-Earth and deep-space objects."[20]

The Advanced ElectroOptical System (AEOS) is also a legacy part of the MSS, with initial plans originating in the 1990 and becoming operational in the late 1990s.[21] AEOS is a ground-based 3.67 meter telescope with adaptive optics designed for satellite detection and tracking.[22] While AEOS is primarily used by the U.S. military, the U.S. scientific and academic communities are able to gain access as well. AEOS, AMOS, and other aspects of the MSSS have been in continual development and upgrade for several decades. Like AMOS, AEOS funding was also included in SPACETRACK in the late 1990s and early 2000s.

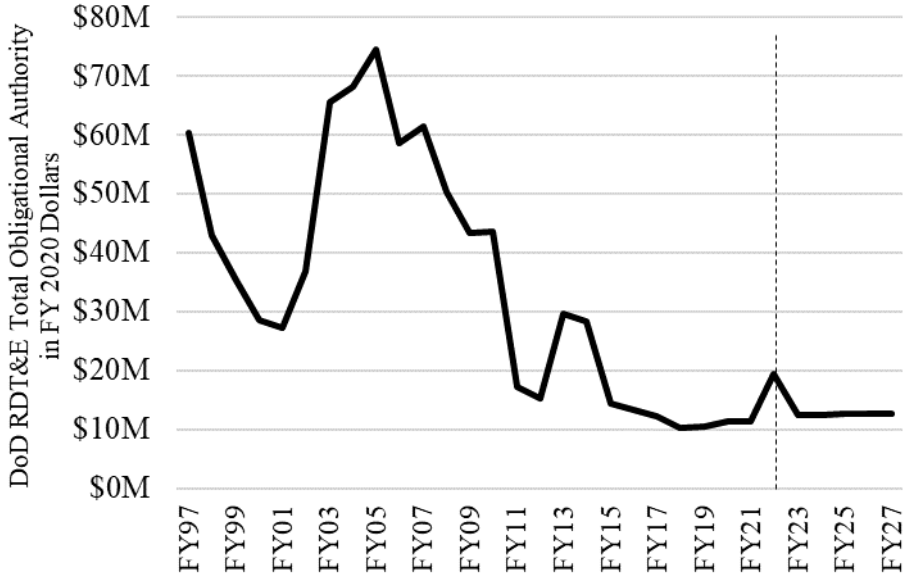

Fig. 7. Maui Space Surveillance System RDT&E Funding

RDT&E funding for the Maui Space Surveillance System was designated a distinct program element in FY 2001. As Fig. 7., shows, funding increased over 170 percent between FY 2001 and its peak in FY 2005. Since then, funding has generally decreased and remained between $10 and $20 million since FY 2015.

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[19] Department of the Air Force, *Fiscal Year 2000/2001 Biennial Budget Estimates: Research, Development, Test and Evaluation – Descriptive Summaries*, 1624.

[20] "Maui Space Surveillance Complex, Hawaii," Space Base Delta 1, accessed September 21, 2022, https://www.spacebasedelta1.spaceforce.mil/Maui-Hawaii/.

[21] Department of the Air Force, *Fiscal Year 2000/2001 Biennial Budget Estimates: Research, Development, Test and Evaluation – Descriptive Summaries*, 1624.; "Advanced Electro-Optical System (AEOS) (U)," GlobalSecurity, accessed September 21, 2022, https://www.globalsecurity.org/space/library/report/1999/nssrm/initiatives/aeos.htm.

[22] Department of the Air Force, *Fiscal Year 2000/2001 Biennial Budget Estimates: Research, Development, Test and Evaluation – Descriptive Summaries*, 1624.

3.7 JSpOC Mission System

The Joint Space Operations Center (JSpOC) Mission System (JMS) is an acquisition program currently managed by the Space and Missile Systems Center (SMC) with the intended goal to " provide a collaborative environment that will enhance and modernize space situational awareness (SSA) capabilities; create decision-relevant views of the space environment; rapidly detect, track and characterize objects of interest; identify / exploit traditional and non-traditional sources; perform space threat analysis; and enable efficient distribution of data across the Space Surveillance Network (SSN)." In short, it was to become the new backbone of the Space Surveillance Network and replace the dated Space Defense Operations Center (SPADOC). Other aspects of its mission include supporting command and control, to include the nuclear enterprise.

However, the JMS has suffered several setbacks and failures along the way of the program's life—first funding began in FY 2010. After a lengthy review in 2018 by the Air Force Operational Test and Evaluation Center on JMS Increment 2, Service Pack (SP)-9, it was determined that "SP-9 is not operationally effective or suitable for its Space Situational Awareness (SSA) mission."[23] According to the report, the fault lies with the JMS program officers which may have prevented the many cumulative errors that led to SP-9 being inoperable. This has led to the U.S. Air Force continuing to rely on the dated SPADOC. To add perspective, a February 2016 defense budget justification book states that SPADOC "has 75% of its components beyond end of life or end of service, and the majority of its software no longer vendor-supported."[24] The latest fix to SPADOC to keep it functioning appears to be a series of small upgrades and patches.[25] In the FY 2023 budget, this program element was transferred to a new program element titled Space Command & Control - Software Pilot Program.[26]

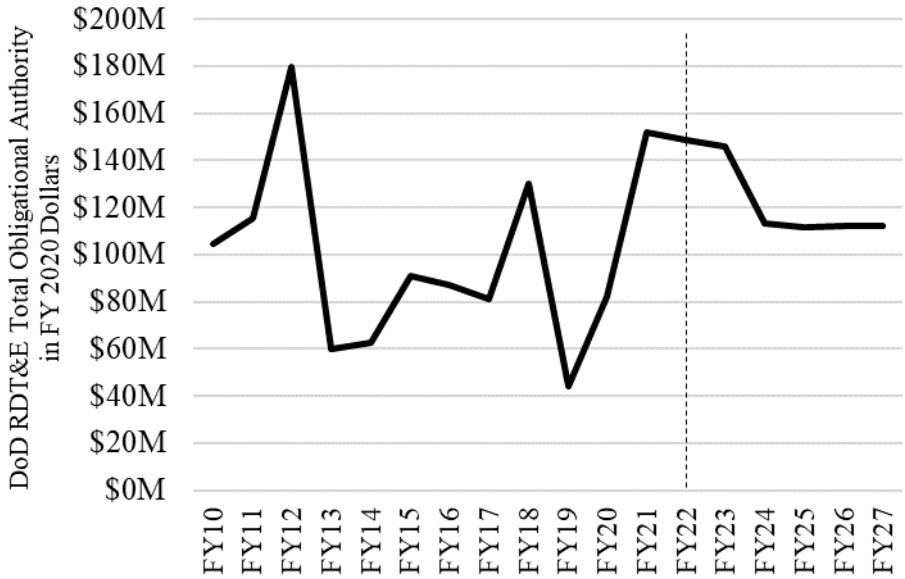

Fig. 8. JSpOC RDT&E Funding

JSpOC is another program which has seen RDT&E funding fluctuate significantly, growing 72 percent in real terms between FY 2010 and FY 2012 before falling 67 percent over the next year. Funding shifted several times over the next several years including nearly a 250 percent increase from FY 2019 to FY 2021.

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[23] U.S. Director of Operational Test and Evaluation, *Joint Space Operations Center (JSpOC) Mission System (JMS)*, (Washington DC: 2018), https://www.dote.osd.mil/Portals/97/pub/reports/FY2018/af/2018jms.pdf?ver=2019-08-21-155844-180#:~:text=The%20JMS%20Program%20Office%2C%20developers,and%20all%20stages%20of%20testing.

[24] U.S. Department of the Air Force, *Fiscal Year (FY) 2017 President's Budget Submission,* Vol. III, Part 2, (Washington, DC: February 2016), 483, https://www.saffm.hq.af.mil/Portals/84/documents/FY17/AFD-160208-053.pdf?ver=2016-08-24-102138-420#page=535.

[25] "What about JMS? Air Force Reanimates 'Old Clunker' Space Tracking System," BreakingDefense, published April 8, 2019, https://breakingdefense.com/2019/04/what-about-jms-air-force-reanimates-old-clunker-space-tracking-system/.

[26] U.S. Department of the Air Force, *Fiscal Year (FY) 2023 Budget Estimates: Research, Development, Test & Evaluation, Space Force,* 669.

3.8 Ballistic Missile Defense Radars

This program element contains two primary missions: missile defense and warning, and SDA. The COBRA DANE is a "single faced ground-based, L-band phased-array" 40+ year old radar located in Alaska.[27] COBRA DANE supports the SSN "for cataloging hazardous and difficult-to-track satellites and space debris objects that clutter the near-earth orbital regime that cannot be detected by most other SSN tracking assets."[28] These two primary missions alternate in priority. If the radar detects an incoming missile, it will transition automatically into 'missile defense mode' but at all other times, the radar primarily supports the SSN.

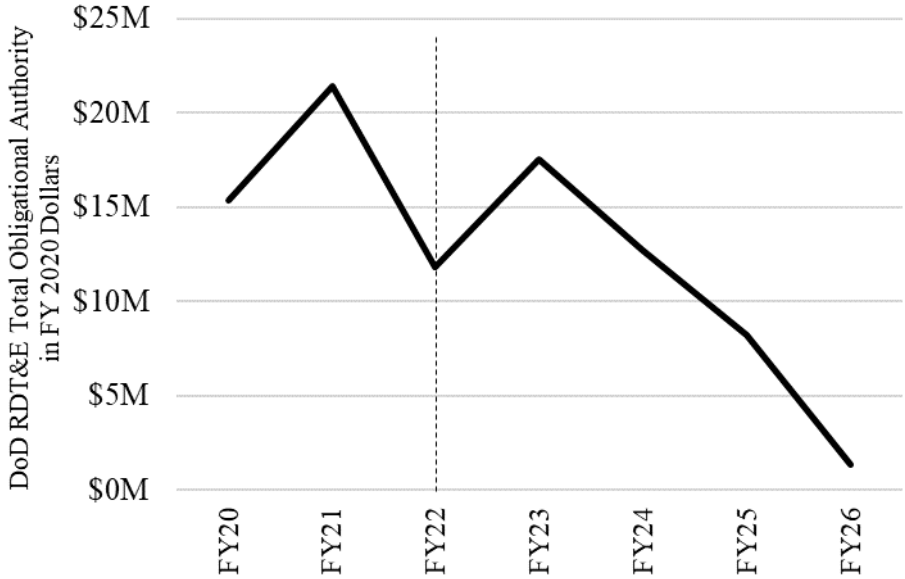

Fig. 9. Ballistic Missile Defense Radars RDT&E Funding

Funding for Ballistic Missile Defense Radars as a separate program element began in FY 2020 but marked a "continuation of effort for a joint Air Force and Missile Defense Agency program."[29] Funding is expected to draw down by FY 2026 as shown in Fig. 9., although there is also procurement funding associated with this program element.

[27] "COBRA DANE Radar," United States Space Force, accessed September 21, 2022, https://www.spaceforce.mil/About-Us/Fact-Sheets/Article/2197716/cobra-dane-radar/.

[28] U.S. Department of the Air Force, *Fiscal Year (FY) 2022 Budget Estimates: Research, Development, Test & Evaluation, Space Force*, Vol. I (Washington, DC: May 2021), 411, https://www.saffm.hq.af.mil/Portals/84/documents/FY22/RDTE_/FY22%20DAF%20J-Book%20-%203620%20-%20SF%20RDT%20and%20E.pdf?ver=IjGtfzXsB_JjzQshbt68Fw%3d%3d.

[29] U.S. Department of the Air Force, *Fiscal Year (FY) 2020 President's Budget Submission: Research, Development, Test & Evaluation, Air Force*, Vol. III Part 2, (Washington DC: March 2019), 924, https://www.saffm.hq.af.mil/Portals/84/documents/FY20/RDTE/FY20_PB_RDTE_Vol-IIIb.pdf?ver=2019-03-18-153459-043.

4. SDA Procurement Spending, FY 1997 through Today

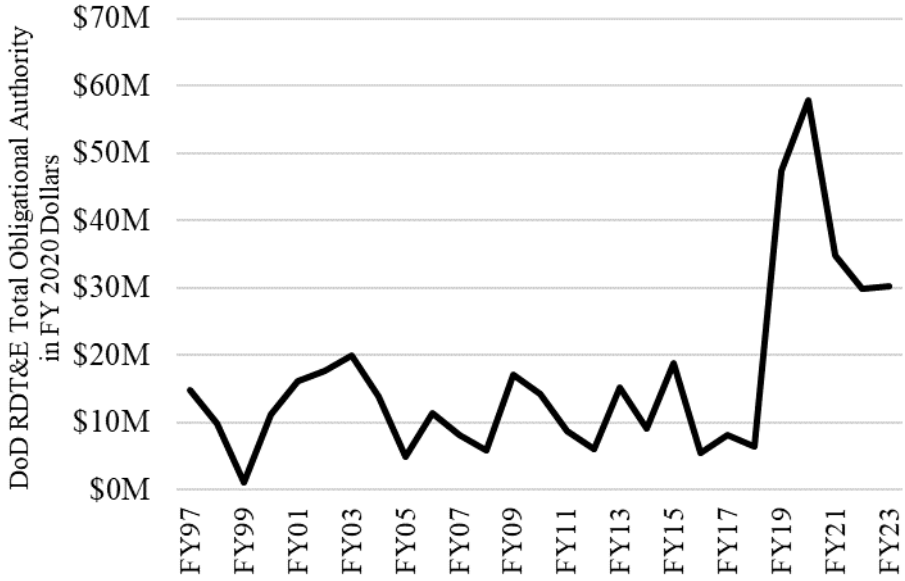

Fig. 10. Topline SDA Procurement Funding[30]

As previously mentioned, DoD spends significantly less procurement funding on SDA programs compared to the RDT&E investments outlined above. Fig. 10. shows the aggregate total of procurement funding for SDA-related sub-line items. Total procurement spending fluctuated significantly between FY 1997 and FY 2023, growing by nearly $19 million from FY 1999 to FY 2003 before falling over $15 million to a relative low point in FY 2005. SA-related procurement funding spiked in FY 2019 due to the start of procurement for the Space Fence program. Total funding fell again falling competition of the project in FY 2021.

5. Conclusion

In conclusion, a complete history tracking SDA funding across years within the Air Force and Space Force is challenging, if not impossible. The programs that were created often 'double dipped' with space control systems that would feed telemetry data to the SSN. DoD is still unable to delineate the SDA mission in the budget for this reason. This causes several methodology challenges and limitations to accurately evaluating DoD mission priorities and whether the SDA mission is a primary one, or a secondary or tertiary mission. Ongoing programs that are examples of this include:

- The **Space Control Technology** program supports several missions: command and control, offensive and defensive counterspace, and battle management. For the SDA mission in particular, Space Control Technology supports "monitoring, detecting, identifying, tracking, assessing, verifying, categorizing, and characterizing objects and events in space and includes terrestrial based space capabilities." [31] This is crucial to presenting operators and analysts with a clear understanding of the space environment and how national and international satellites are operating within. The Space Control Technology program was initiated in 1999 and is one of the longest ongoing SDA programs and is likely to maintain or increase funding levels in the years to come.
- **NCMC - TW/AA** is the North American Aerospace Defense Command (NORAD) Cheyenne Mountain Complex (NCMC) - Integrated Tactical Warning Attack Assessment (ITW/AA) system, which is a suite of missile warning capabilities that provide "timely, unambiguous, and continuous warning and attack

[30] Estimated totals for FY 2019 and FY 2020 may be slightly low due to a lack of reporting. Modifications to the tracking of line items and program elements in the transition from Air Force to Space Force reporting meant that the actual spending for sub-line items was not reported in FY 2019 and FY 2020.

[31] U.S. Department of the Air Force, *Fiscal Year (FY) 2022 Budget Estimates: Research, Development, Test & Evaluation, Space Force,* 103.

assessment of air, missile and space threats to North America, and geographical theaters."[32] While this program does not directly focus on the SSN, the data from these sensors is processed in and may contribute to the overall SDA mission.

- **Space Security and Defense Program**: historically a USAF (now the USSF) and NRO collaborative project, both with separate budget elements feeding into a broader effort to evaluate, analyze, and develop systems to make space systems, plans, and operations more resilient and secure. While SDA certainly plays a role here, it is unclear how much, if any, of this funding feeds directly into the SSN.[33]
- The **Space Systems Prototype Transitions** (SSPT) program element contains several non-SDA-related programs. However, it also includes the QZSS-HP. The QZSS (or Quasi-Zenith Satellite System) is a positioning, navigation, and timing (PNT) satellite designed and fielded by the Japan Aerospace Exploration Agency (JAXA). HP stands for 'hosted payload' and is a U.S.-designed capability placed on one of the Japanese QZSS satellites that "enhances Geostationary Earth Orbit (GEO) Space Domain Awareness (SDA) capabilities over the Eurasian theater and facilitates resilient capabilities in the Space Surveillance Network (SSN)."[34] Unfortunately, there is not publicly-available data on specific funding for individual programs captured within the overall budget element, so it is unclear how much the hosted payload cost in the RDT&E and procurement processes.
- In FY 2023, JSpOC Mission System's SSA/Battle Management C2 efforts were transferred to **Space Command and Control (Space C2) software program** for greater transparency. This program element supports a new space C2 and SDA mission capability. The C2 software is intended to be a collaborative environment that will create decision-relevancy out of SSN data, including "identify / exploit traditional and non-traditional sources; perform space threat analysis."[35] While this system does not perform the identify or track mission, it will support the broader SDA mission by visualizing and operationalizing the SSN data for decision-makers.

All of these programs play a SDA role and collect data that supports the SDA mission; however, they are primarily dedicated to other missions. In contrast, the Ballistic Missile Defense Radars program element where COBRA DANE is housed may be an example of the opposite phenomenon. COBRA DANE is a stated missile detection system that has two 'primary' missions of missile detect and track and SDA – after reviewing the annual budget justification books, it is more likely that while the system was designed for the missile detect and track mission, it compiles more SDA data than the missile data due to the low-volume of missile launches in that region. The most recent DoD space policy that was released in August 2022 states that the U.S. military will provide mission assurance and

> *"Improve intelligence, space domain awareness (SDA), and command and control capabilities, in partnership with the Director of National Intelligence (DNI), to detect, track, characterize, warn, attribute, and respond to space-related behaviors and activities that threaten the interests of the United States and its allies and partners, by: (1) Developing improved tools for military space intelligence, expanding SDA capabilities, and enhancing means for detection and attribution of activities in space to support warning and potential response options. (2) Enhancing the ability to detect, track, and characterize current and future threats to U.S. space missions to enable effective deterrence and defense…"*

There are few dedicated dollars for the SDA mission because it is often treated as secondary—Space Fence is the clear exception. Space Fence is one of the only SDA programs that can be easily tracked throughout its lifecycle, as it started as a project within SPACETRACK, then moved to Space Situation Awareness Systems in 2007, and finally was elevated to its own program element in 2015. But there is no indication on what is next for the SDA mission. Space programs often take decades to fully fund and implement, so whether the need is more space-based systems or cislunar SDA, there is little indication of the strategy for carrying out this mission in the future.

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[32] U.S. Department of the Air Force, *Fiscal Year (FY) 2023 Budget Estimates: Research, Development, Test & Evaluation, Space Force*, 583.

[33] U.S. Department of the Air Force, *Fiscal Year (FY) 2014 President's Budget Submission: Research, Development, Test & Evaluation, Air Force*, Vol. II, (Washington DC: April 2013), 127, https://www.saffm.hq.af.mil/Portals/84/documents/FY14/AFD-130408-066.pdf?ver=2016-08-24-092814-877#page=193.; U.S. Department of the Air Force, *Fiscal Year (FY) 2022 Budget Estimates: Research, Development, Test & Evaluation, Space Force*, Vol. I (Washington, DC: May 2021), 111.

[34] U.S. Department of the Air Force, *Fiscal Year (FY) 2023 Budget Estimates: Research, Development, Test & Evaluation, Space Force*, 130.

[35] Ibid., 670.

Articulating how SDA is different from other missions and delineating funding for the SDA mission may help Space Force showcase the value to appropriators. Furthermore, the SDA mission is a potential opportunity for Space Force to source data from commercial providers. Several highly-capable commercial SSA data providers have developed independent ground stations around the world. Adding more data increases the fidelity of accurate predictions, assessments, and attribution. Instead of building the next Space Fence—an expensive and exquisite program—the Space Force may leverage commercial industry.

SDA is fundamental, reinforced by its focus in this policy and the intergovernmental cooperation with the DoD and intelligence community on this mission. However, as Space Fence and other upgrades have showcased, SDA is becoming a primary mission instead of a secondary or byproduct mission. With the establishment of the Space Force in December 2019, there is opportunity to provide clarity to the SDA mission both through dedicated programs and officers. Specifically, clarifying SDA as a primary mission with dedicated RDT&E funding.

This study was challenged by the lack of clarity in SDA RDT&E and procurement data. Follow on work could include delineating by project and matching project-level funding with the associated sub-line item funding in procurement budgets. There would still be limitations with this approach, such as missing or classified data, however it would provide a more granular track of SDA funding. Another step could be to track SDA funding based on whether it is a program's primary or secondary (or tertiary) mission. This framework would better support research into the primacy of the SDA mission across the Space Force. Finally, a review of O&M investments would lend better insight into which legacy systems are continually operated, updated, and maintained.