NASA

Office of Inspector General

NASA's Efforts to Demonstrate Robotic Servicing of On-Orbit Satellites

October 4, 2023

IG-24-002

Office of Inspector General

Results in Brief

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Why We Performed This Audit

NASA's On-Orbit Servicing, Assembly, and Manufacturing 1 (OSAM-1) project seeks to rendezvous with, refuel, and relocate Landsat 7, a U.S. satellite, to extend its life. As originally designed, the OSAM-1 space vehicle and its attached Space Infrastructure Dexterous Robot (SPIDER) payload would refuel Landsat 7 with at least 10 kilograms of hydrazine monopropellant, assemble a communications antenna, and demonstrate in-space manufacture of a 32-foot carbon fiber composite beam. If successful, OSAM-1 may give satellite operators new ways to manage their aging fleets. In addition, successfully completing this mission would demonstrate that servicing technologies are ready for incorporation into other NASA science and human exploration missions. NASA intends to transfer OSAM-1 technologies to commercial entities to help jumpstart a new domestic servicing industry that could be worth over $5 billion by 2030.

Over the years, NASA has launched multiple human-assisted repair missions for satellites in low Earth orbit (LEO). Over the past several years, NASA has shifted the focus of its satellite servicing efforts to remove the human element and develop technologies to enable robotic refuel, repair, and orbit modification services in LEO. In 2016, after years of pre-formulation activities and reconciling mission design differences with congressional advocates, NASA awarded the first contract in support of Robotic Servicing Demonstration Mission, called Restore-L, to demonstrate how in-orbit robotic servicing could restore a satellite to its original functioning capacity. In April 2020, with the addition of the SPIDER payload, NASA changed the mission's name to OSAM-1 to reflect the expanded scope of the world's first autonomous robotic in-orbit satellite servicing, assembly, and manufacturing mission.

As of October 2022, NASA managed seven significant contracts in support of OSAM-1 efforts. We selected two contracts for review—the spacecraft bus and SPIDER—both with Space Systems/Loral, LLC (now Maxar Technologies or Maxar). In December 2016, NASA awarded Maxar a $105 million firm-fixed-price (FFP) contract for the spacecraft bus. Maxar will provide the spacecraft bus to Goddard Space Flight Center (Goddard) and support integration, launch, and pre-launch testing. In January 2020, NASA modified the Statement of Work (SOW) for a previously awarded contract to Maxar to add requirements to design and build SPIDER.

In this report, we assessed NASA's management of the OSAM-1 project relative to established cost, schedule, and technological goals. We also assessed the feasibility of the OSAM-1 project servicing the Landsat 7 satellite, if NASA project management officials were effectively monitoring contractor performance, and the effect, if any, of congressionally directed funding for the project. Our assessment of the processes and practices included a review of NASA documents and interviews with NASA officials from the Space Technology Mission Directorate, OSAM-1 Project, and Goddard Procurement. We also interviewed U.S. Geological Survey, OSAM-1 Standing Review Board, and Maxar officials. Our primary criteria for assessing the practices and procedures were the Federal Acquisition Regulation, NASA Procedural Requirements, and the spacecraft bus and SPIDER contract terms and conditions. We performed this audit from September 2022 through August 2023.

What We Found

OSAM-1 cost growth and schedule delays are exacerbated by poor contractor performance and continued technical challenges. After rebaselining its cost and schedule in April 2022, the OSAM-1 project continues to experience cost growth and it now appears the Agency will exceed its current $2.05 billion price tag and the December 2026 launch date commitment to Congress. Development of the servicing payload—the system responsible for rendezvous and refueling Landsat 7—has continued to cost more and take longer than anticipated. Moreover, much of the project's cost growth and schedule delays can be traced to Maxar's poor performance on the spacecraft bus and SPIDER contracts with each deliverable approximately 2 years behind schedule. We found the structure of these FFP contracts does not provide NASA adequate flexibility to incentivize Maxar to improve its performance. Consequently, NASA is providing personnel and services to supplement Maxar's efforts to mitigate contractor performance issues and reduce further impacts to the project's cost and schedule. Additionally, because NASA continues to pay Landsat 7 operation costs through the on-orbit mission, extended launch delays for OSAM-1 will increase these costs as well.

Due to Maxar's poor performance, NASA is providing unplanned labor and services to supplement Maxar's efforts to develop OSAM-1's spacecraft bus. Specifically, between January 2022 and May 2023 NASA provided labor, such as assistance with flight software and systems engineering support, valued at approximately $2 million to help reduce impacts to the mission schedule. According to project officials, supplementing Maxar's efforts was necessary to reduce risk to the overall project schedule. At the same time, Agency project managers have not modified the spacecraft bus contract to decrease its value to account for the supplemental labor provided by NASA. Instead of making the changes to the contract's SOW with corresponding adjustments to the contract value, the project is tracking the supplemental government-provided labor using an informal document referred to by the project as a "puts and takes" list that describes the supplements to Maxar and their associated dollar values.

The spacecraft bus and SPIDER contracts are FFP with no incentive or award fee. Therefore, NASA lacks the flexibility to use monetary incentives to recognize and reward contractor performance that exceeds meeting basic contract requirements. For example, the government uses award fees to motivate positive contractor performance, and conversely, these fees are not paid when a contractor's overall cost, schedule, and technical performance is below satisfactory. In our discussions with senior leadership at Goddard, OSAM-1 Standing Review Board members, and procurement officials, each group agreed that the lack of an incentive or award fee on the contracts has limited NASA's ability to improve contractor performance. According to the Standing Review Board Chair at the time of the mission's Critical Design Review, the contract structure lacked the ability to incentivize the contractor's performance, particularly in cases such as this where the contractor is not profiting from the contract due to its FFP nature and cost and schedule overruns. In our discussions with Maxar officials, they acknowledged that they were no longer profiting from their work on OSAM-1.

WHAT WE RECOMMENDED

To increase transparency, accountability, and oversight of NASA contracts, we recommended that NASA leadership: (1) recoup the costs of the supplemental labor and services provided by NASA to Maxar to complete the work on the spacecraft bus contract; (2) ensure all work is contractually agreed upon and integrated into the contract SOW, and all changes are appropriately reflected in the SOW with adjustments to the contract value; and (3) issue guidance that contracting officials, as part of acquisition strategy planning, consider incorporating award or incentive fees into future fixed price development contracts.

We provided a draft of this report to NASA management who concurred or partially concurred with our recommendations and described planned actions to address them. We consider management's comments responsive; therefore, the recommendations are resolved and will be closed upon completion and verification of the proposed corrective actions.

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Acronyms

ABC	Agency Baseline Commitment
CONFERS	Consortium for Execution of Rendezvous and Servicing Operations
COSMIC	Consortium for Space Mobility and ISAM Capabilities
COVID-19	Coronavirus Disease of 2019
CPAR	Contractor Performance Assessment Report
FFP	firm-fixed-price
FY	fiscal year
GAO	Government Accountability Office
ISAM	In-Space Servicing, Assembly, and Manufacturing
KDP	Key Decision Point
LEO	low Earth orbit
LiDAR	Light Detection and Ranging
NPR	NASA Procedural Requirements
OIG	Office of Inspector General
OSAM-1	On-Orbit Servicing, Assembly, and Manufacturing-1
REU	Robot Electronics Unit
SPIDER	Space Infrastructure Dexterous Robot
STMD	Space Technology Mission Directorate
SOW	Statement of Work
USGS	U.S. Geological Survey
V&V	Verification & Validation

INTRODUCTION

Building on a history of upgrading and maintaining assets in space, NASA's On-Orbit Servicing, Assembly, and Manufacturing 1 (OSAM-1) technology demonstration project seeks to rendezvous with, refuel, and relocate a United States-owned satellite—Landsat 7—to extend its life.[1] The project intended to manufacture a lightweight, carbon fiber composite beam and assemble a communications antenna using a robotic arm. If successful, OSAM-1's capabilities may give satellite operators new ways to manage their fleets more efficiently and derive more value from their initial investment by enabling such in-space maintenance to extend the operational life of satellites, which also helps mitigate the growing problem of orbital debris. Successfully completing this mission would demonstrate that servicing technologies are ready for incorporation into other NASA science and human exploration missions. Moreover, NASA intends to transfer OSAM-1 technologies to commercial entities to help jumpstart a new domestic servicing industry that could be worth over $5 billion by 2030.[2]

Background

For decades, NASA has been developing systems to facilitate satellite servicing and by 2016 had completed 11 repair missions in low Earth orbit (LEO) of spacecraft like the Hubble Space Telescope.[3] Since completing these missions, NASA has shifted the focus of its satellite servicing to remove the human element and develop technologies to enable robotic refuel, repair, and orbit modification services in LEO. In 2016, after years of pre-formulation activities and reconciling mission design differences with congressional advocates, NASA awarded the first contract in support of robotic servicing demonstration mission, called Restore-L, to demonstrate how in-orbit robotic servicing could restore a satellite to its original functioning capacity—essentially refurbishment to enable a satellite to function for years beyond its designed operational life. The project was assigned to the Goddard Space Flight Center (Goddard).[4] In April 2020, with the addition of the Space Infrastructure Dexterous Robot (SPIDER) payload, NASA changed the mission's name to OSAM-1 to reflect the expanded scope of the world's first autonomous robotic in-orbit satellite servicing, assembly, and manufacturing mission.

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1 Landsat 7, which cost $666 million through the first year of its operation, excluding launch vehicle costs, is the seventh satellite of the Landsat program. Launched in April 1999, Landsat 7's primary goal is to refresh the global archive of Earth satellite photos, providing up-to-date and cloud-free images.

2 MarketsandMarkets, *On-Orbit Satellite Servicing Market* (May 2023) available at, https://www.marketsandmarkets.com/Market-Reports/on-orbit-satellite-servicing-market-206789424.html (accessed, July 14, 2023).

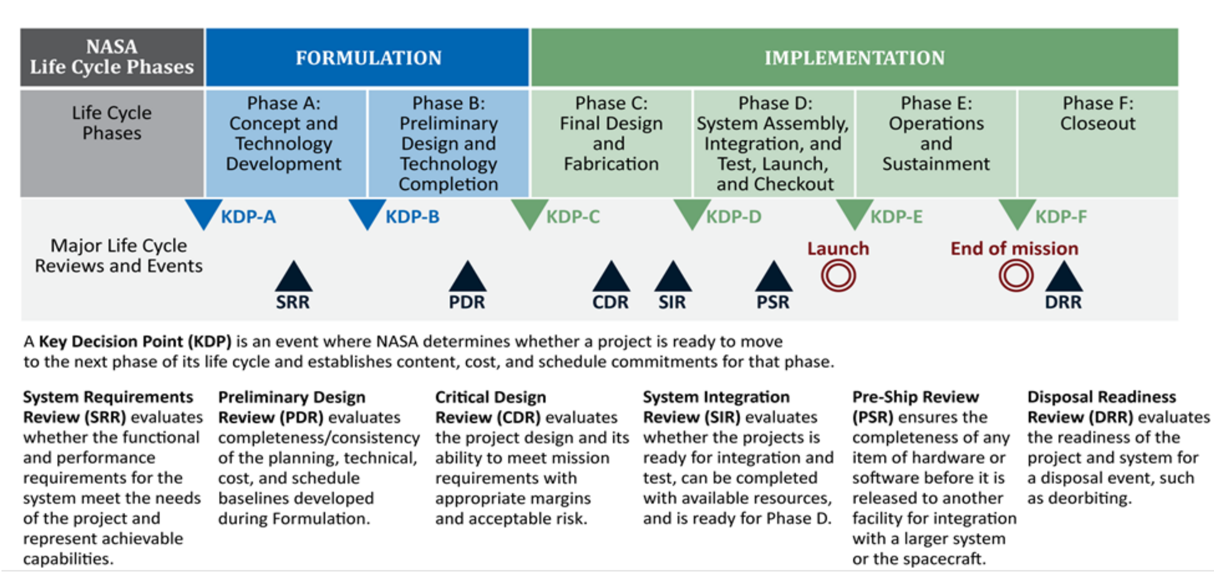
3 LEO is commonly used to position communication and remote sensing satellite systems at altitudes between 99 to 1,200 miles above the Earth's surface. The International Space Station and Hubble Space Telescope (Hubble) operate in LEO. Hubble is a large Earth-orbiting telescope launched into orbit by space shuttle Discovery on April 24, 1990. Hubble, which orbits about 332 miles above Earth, is the length of a large school bus and weighs as much as two adult elephants. Beginning in December 1993, NASA has undertaken five astronaut servicing missions to Hubble.

4 The purpose of pre-formulation concept studies is to produce a broad spectrum of ideas and alternatives for missions from which new projects can be selected. During this time, a study or proposal team analyzes a broad range of mission concepts that can fall within technical, cost, and schedule constraints and that contribute to program and Mission Directorate goals and objectives.

From Restore-L Formulation to OSAM-1 Development

As a space flight project, OSAM-1 is subject to the requirements of NASA Procedural Requirements (NPR) 7120.5F.[5] One of the fundamental concepts used by NASA for management of major systems is the project life cycle, which categorizes a program or project into distinct phases separated by Key Decision Points (KDPs). KDPs are the key points when the decision authority determines the readiness of a project to progress to the next phase of the life cycle. Phase boundaries are defined to provide natural points for "go" or "no-go" decisions. See Figure 1 for a description of NASA space flight project life-cycle phases, KDPs, and milestone reviews.

Figure 1: NASA Space Flight Project Life-Cycle Phases, Key Decision Points, and Milestone Reviews



Source: Office of Inspector General (OIG) presentation of NPR 7120.5F information.

In April 2017, Restore-L passed KDP-B of the Formulation Phase with an estimated cost for the project of $626 million to $753 million with a potential launch readiness date between June and December 2020.[6] Over the subsequent 2 years, Restore-L experienced cost increases and schedule delays, as well as an evolution of overall scope and capabilities. Specifically, the project had insufficient cost reserves to address risks and workforce shortages that led to delays in some of Restore-L's subsystems, to include the robotics system.[7] By June 2018, the project's preliminary cost estimate had grown to $1.04 billion. In March 2019, Space Technology Mission Directorate (STMD) officials directed the project to incorporate SPIDER—a payload developed under a NASA STMD tipping point procurement to advance

[5] NPR 7120.5F, *NASA Space Flight Program and Project Management Requirements* (August 3, 2021).

[6] At KDP-A, NASA evaluates the feasibility of the proposed mission concept(s) and its fulfillment of the program's needs and objectives to determine whether the maturity of the concept and associated planning are sufficient to begin Phase A. At KDP-B, NASA evaluates the credibility and responsiveness of the proposed mission or system architecture to the program requirements and constraints, including available resources to determine whether the maturity of the project's mission or system definition and associated plans are sufficient to begin Phase B.

[7] Cost reserves, now referred to as Unallocated Future Expenses in NPR 7120.5, is the portion of estimated cost required to meet a specified confidence level that has not been allocated to the specific project sub-elements.

technologies needed for an in-space robotic manufacturing and assembly capability—as part of the mission.[8]

In May 2020, the Agency Program Management Council evaluated the readiness of the project to proceed to Phase C of its life cycle development.[9] The review included a project overview, a Standing Review Board assessment, a project-led cost and schedule assessment, and recommendations from the Goddard Center Management Council and the Technology Demonstration Missions Program Office.[10] Based on the Program Management Council review, the project was approved to enter Phase C with an Agency Baseline Commitment (ABC) life-cycle cost of $1.78 billion and a launch readiness date of no later than September 2025.[11] However, Goddard and STMD leadership approved the project to proceed with 15 percent cost reserves at baseline, instead of the Goddard-recommended level of 25 percent, to allow for more technical content, such as SPIDER, within the existing project funding profile.[12] After more than 5 years of pre-formulation and Formulation activities, this was the first time NASA officially established an integrated set of OSAM-1 project requirements, cost, schedule, and technical content.

OSAM-1 with Arms Extended

Source: NASA.

OSAM-1 Mission and Capabilities

OSAM-1 intends to demonstrate first-of-its-kind robotic satellite servicing technology by grappling and refueling Landsat 7 to demonstrate the capability of extending the operational life of satellites on orbit. The Landsat missions are Earth-observing satellites that collect continuous image data of the Earth's

8 A technology is considered at a tipping point if an investment in a demonstration of its capabilities will result in a significant advancement of the technology's maturation, high likelihood of infusion into a commercial space application, and significant improvement in the ability to successfully bring the technology to market. These technologies also should bring substantial benefit to both the commercial and government sectors upon completion.

9 The Agency Program Management Council is the senior management group, chaired by the NASA Associate Administrator or designee, responsible for reviewing Formulation performance, recommending approval, and overseeing implementation of programs and projects according to Agency commitments, priorities, and policies.

10 The Standing Review Board is the entity responsible for conducting independent reviews of a program or project and providing objective, expert judgments to the convening authorities. Center Management Councils are the councils at each Center that perform oversight of programs and projects by evaluating all work executed at that Center. The Technology Demonstration Missions Program, part of STMD, focuses on crosscutting technologies with strong customer interest that meet the needs of NASA and industry by enabling new missions or enhancing existing ones.

11 The ABC establishes and documents an integrated set of project requirements, cost, schedule, and technical content that forms the basis for NASA's commitment to the Office of Management and Budget and Congress. Only one official baseline exists for a NASA program or project, and that is the ABC. The project also entered Phase C with a Management Agreement of $1.71 billion and a launch readiness date of no later than January 2025. The Management Agreement, an internal agreement between the project manager and the Agency, defines the parameters and authorities over which the project manager has control.

12 Goddard Procedural Requirements 7120.7B, *Funded Schedule Margin and Budget Margin for Flight Projects* (September 17, 2018).

surface as part of the U.S. Geological Survey (USGS) National Land Imaging Program.[13] Importantly, Landsat 7, which USGS had intended on decommissioning, was not originally designed to be refueled or serviced on orbit and therefore the project team is developing technologies to enable these capabilities. If all goes according to plan, the OSAM-1 space vehicle and its attached SPIDER payload will refuel Landsat 7 with at least 10 kilograms of hydrazine monopropellant and assemble a communications antenna.

OSAM-1 Spacecraft Bus Under Development

Source: Maxar Technologies

In addition to SPIDER, the OSAM-1 spacecraft consists of a spacecraft bus, a servicing payload with 16 subsystems including tools, vision systems, and 2 robotic arms.[14] Goddard manages the project and is responsible for designing, fabricating, assembling, and testing the servicing payload and its subsystems. NASA intends to demonstrate this satellite servicing technology for multiple potential uses, to include prolonging the life of current and future satellites and jumpstarting a new domestic on-orbit satellite servicing industry. Table 1 lists OSAM-1's planned servicing technologies.

Table 1: OSAM-1's Planned Satellite Servicing Technologies

OSAM-1 Servicing Technology	Description
Autonomous Real-Time Relative Navigation System	Sensors, algorithms, and a processor join forces, allowing OSAM-1 to rendezvous safely with its client
Servicing Avionics	In addition to ingesting and crunching sensor data, these elements control OSAM-1's rendezvous and robotic tasks
Dexterous Robotic Arms	Two nimble, maneuverable arms precisely execute servicing assignments
Advance Tool Drive and Tools	Sophisticated multifunction tools manufactured to execute each servicing task
Propellant Transfer System	Delivers measured amounts of fuel to the client at the right temperature, pressure, and rate

Source: NASA OIG presentation of Agency information.

Executive Initiatives, Interagency Collaboration, and Decadal Survey Support

In December 2022, the Office of Science and Technology Policy published the *National In-Space Servicing, Assembly, and Manufacturing (ISAM) Implementation Plan*.[15] Per this Plan, the development of ISAM capabilities represents the Administration's commitment to "scientific and technological innovation, economic growth, commercial development, a diverse U.S. skilled workforce, and

[13] Landsat 8 and 9, launched in 2013 and 2021 respectively, are currently operational.

[14] The basic structure of the spacecraft is called the "bus," which carries the engineering subsystems and scientific instruments.

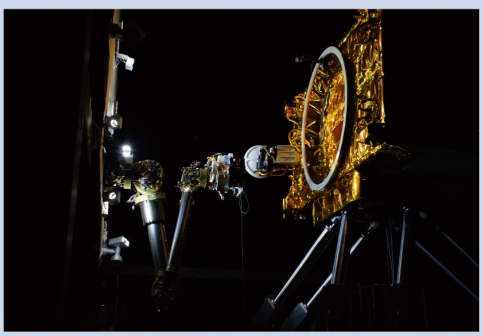
[15] The Office of Science and Technology Policy provides the President and the Executive Office of the President with advice on matters related to science and technology. The ISAM Implementation Plan is available at, https://www.whitehouse.gov/wp-content/uploads/2022/12/NATIONAL-ISAM-IMPLEMENTATION-PLAN.pdf (accessed, May 31, 2023).

international collaboration in space." These capabilities include "repairing and refueling spacecraft, building structures, and fabricating components in space as needs arise." The Plan identifies each participating Agency and Department and their specific roles in accomplishing the Plan's objectives. NASA, for example, is developing servicing, assembly, and manufacturing demonstrations while the Department of Defense is funding servicing satellites in geostationary orbit.[16]

More broadly, NASA funds (at approximately $2 million per year), leads, and facilitates the Consortium for Space Mobility and ISAM Capabilities (COSMIC), a nationwide coalition of industry, government, and academia that aims to invigorate domestic ISAM capabilities.[17] COSMIC's vision is to create a nationwide alliance that enables the U.S. space community to provide global leadership in ISAM, with a goal to accelerate the universal adoption of ISAM capabilities to develop future space architectures.

In addition, NASA participates in the Consortium for Execution of Rendezvous and Servicing Operations (CONFERS), established in 2017 by the Department of Defense through its research arm, the Defense Advanced Research Projects Agency. CONFERS provides a forum for the commercial, academic, and government sectors to develop ISAM standards and share best practices. The OSAM-1 project and ISAM technologies are of great interest to national security officials with a senior U.S. Space Force official recently commenting that the success of OSAM-1 would open the door for the refueling of U.S. Space Force satellites.[18]

OSAM-1's Robotic Servicing Arm



Source: NASA

The 2021 Astronomy and Astrophysics Decadal Survey developed by the National Academies of Science also supports satellite servicing initiatives. Specifically, it makes recommendations to "implement a comprehensive strategy and vision for a decade of transformative science at the frontiers of astronomy and astrophysics."[19] In particular, the Survey panel observes that several areas outside the usual mission development flow could have profound and far-reaching consequences if pursued, such as refueling and assembly of structures in space. Specifically, the Survey notes that servicing and refueling aging satellites could prove highly beneficial because of the need for fuel to reposition starshades—a spacecraft that would work in concert with a large telescope on Earth to block the light from a star so its light would not "blind" the telescope from seeing, for example, planets around the star. Further, assembly of structures in space might alleviate size limitation issues related to launching large telescopes (e.g., the complicated folding needed to fit the James Webb Space Telescope in its launch vehicle) and could enable assembly of even larger telescopes in space.[20]

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[16] Objects in geostationary orbit—about 22,000 miles above the Earth's surface—move along a path parallel to Earth's rotation and from a ground perspective appear in a fixed position in the sky.

[17] NASA provides funding for COSMIC logistics, operation, and management to execute day-to-day operations of the consortium. COSMIC's kickoff meeting is planned for fall 2023.

[18] Statements made by Major General Stephen Purdy in interview with SpaceNews, available at https://spacenews.com/military-to-tap-commercial-industry-for-space-mobility-services/ (accessed, March 6, 2023).

[19] The National Academies of Sciences, Engineering, and Medicine, *Pathways to Discovery in Astronomy and Astrophysics for the 2020s* (2021).

[20] The James Webb Space Telescope was launched from French Guiana in December 2021 aboard an Ariane 5 rocket.

OSAM-1 Budget

Since at least 2015, Congress has robustly supported NASA's robotic satellite servicing mission, appropriating more funding than NASA requested on several occasions. In particular, Senator Barbara Mikulski from Maryland—until her retirement in 2017—and other members of the Senate Appropriations committee provided consistent support for a robotic satellite servicing mission, stating that "it is fundamental to future NASA platforms and missions."[21] Congress appropriated $133 million for the Restore-L project in fiscal year (FY) 2016 followed by $130 million in FY 2017.[22] Subsequently, while NASA requested a total of $224.1 million for FYs 2018 through 2021, Congress appropriated $764.2 million to the project during that 4-year period—over half a billion dollars more than requested (see Table 2). For example, NASA requested no funding for the project in FY 2018 but rather proposed restructuring this mission to reduce its cost and better position it to support a nascent commercial satellite servicing industry. Nevertheless, Congress appropriated $130 million for the project that year.[23] In its FY 2019 and 2020 budget requests, NASA again sought to restructure and descope the project. In FY 2020 NASA proposed turning the project into a ground demonstration, but Congress rejected that suggestion.[24] It was not until the FY 2022 budget when NASA's request and Congress's appropriations were congruent.

Table 2: OSAM-1 Budget Requested and Received (in Millions) as of July 2023

	Fiscal Year								
	2016[a]	2017	2018	2019	2020	2021	2022	2023	Total
Requested	N/A	130.0	0.0	45.3	45.3	133.5	227.2	227.2	**$808.5**
Enacted	133.0	130.0	130.0	180.0	227.2	227.0	227.0	227.0	**$1,481.2**
Difference	133.0	0.0	130.0	134.7	181.9	93.5	-.2	-.2	**$672.7**

Source: NASA OIG presentation of Agency information.

[a] NASA did not identify a specific amount for Restore-L in its FY 2016 budget request.

For FY 2023, OSAM-1 accounted for 18.9 percent of the total $1.2 billion STMD budget and 50.6 percent of the Directorate's Technology Demonstration Missions Program budget of $448.3 million. With the significant cost of the project in relation to the Directorate and Program budgets, STMD has consistently directed that OSAM-1 project managers plan to a flat funding profile. However, this type of funding profile is not ideal for space flight development projects. The most effective budget profile for large and

21 Press release of Senator Chris Van Hollen, July 26, 2017, available at, https://www.vanhollen.senate.gov/news/press-releases/van-hollen-fights-for-maryland-in-commerce-justice-science-appropriations-bill (accessed, July 14, 2023).

22 Senate Report No. 114-66, Departments of Commerce and Justice, and Science, and Related Agencies Appropriations Bill, 2016, accompanying the Consolidated Appropriations Act, 2016 (Pub. L. 114-113, December 18, 2015) also directed NASA to move the project from the Human Exploration and Operations Mission Directorate to the Space Technology Mission Directorate (STMD), stating that the demonstration mission will benefit multiple NASA mission directorates and, therefore, was more appropriately funded within STMD. In September 2021, NASA split the Human Exploration and Operations Mission Directorate into two organizations: the Exploration Systems Development Mission Directorate and the Space Operations Mission Directorate.

23 The Senate Appropriations Committee reiterated its support for Restore-L to "help establish a technology testbed for rendezvous, proximity operations, docking, inspection, refueling, and relocation of satellites."

24 Per NASA's FY 2020 budget request, "NASA believes $45.3 [million] is a realistic and more sustainable budget profile for advancing satellite servicing technologies to [Technology Readiness Level] 6 while maintaining a strong lunar focus on technology development investments and will continue to work with industry partners to enable demonstration on their commercial platforms."

complex space system development programs is steady funding in the early stages and increased funding during the middle stages of development. This is referred to as a bell curve funding profile, which can often decrease the risk of cost overruns and schedule delays due to critical tests and integration tasks being delayed until later in development under a flat funding profile.[25]

OSAM-1 Contracts

As of October 2022, NASA managed seven significant contracts in support of OSAM-1 efforts.[26] We selected two contracts for review—the spacecraft bus and SPIDER—both with Space Systems/Loral, LLC (now Maxar Technologies or Maxar) due to their significance for the OSAM-1 project and the dollar values of these efforts, accounting for 89 percent of the seven contracts' total value of $334.0 million. [27]

Maxar is a space technology and intelligence company based in Palo Alto, California. They partner with commercial businesses and more than 50 governments to monitor global change, deliver broadband communications, and advance space operations with capabilities in Space Infrastructure and Earth Intelligence. According to Maxar officials, approximately 95 percent of their work supported the private sector, but the amount of U.S. government work has been gradually increasing. Examples of Maxar's work for NASA includes a spacecraft bus for the Psyche mission and the Power and Propulsion Element for Gateway.[28]

Spacecraft Bus. In December 2016, NASA awarded Maxar a $105 million firm-fixed-price (FFP) contract for the spacecraft bus.[29] Maxar will provide the spacecraft bus to Goddard and then support integration, launch, and pre-launch testing through NASA's issuance of task orders. The contract's original period of performance extended through December 2021 but has since been extended through February 2027. The contract value is approximately $152.8 million and as of July 2023, $108.8 million (71 percent) has been obligated.

SPIDER. In January 2020, NASA modified the Statement of Work (SOW) for a previously awarded contract to Maxar to add requirements to design and build SPIDER.[30] Further, the contract requires that

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[25] The most efficient funding supports a ramp-up of budget, peaking before critical design review, then ramp-down to a lower level for integration and testing and launch vehicle integration. The Government Accountability Office's (GAO) *Cost Estimating and Assessment Guide, Best Practices for Developing and Managing Capital Program Costs* illustrates a typical space system life-cycle model and shows a bell-shaped funding curve for research, development, testing, and evaluation, because more resources are needed as development progresses and programmatic risks are identified and remediated.

[26] "Significant" was defined by OSAM-1 project management as all direct government contracts, not to include support services. At the time of our request, the contracts ranged in value from $1.8 million to $144.6 million.

[27] In 2017, Space Systems/Loral, along with three other companies, were acquired and became Maxar Technologies.

[28] Maxar's 1300-class satellite platform serves both commercial businesses and governments with 90 satellites on orbit. The platform is designed as a geostationary communications and remote sensing platform. The Psyche mission intends to journey to a unique metal asteroid orbiting the Sun between Mars and Jupiter. Maxar will build the spacecraft's solar-electric propulsion chassis with a payload that includes an imager, magnetometer, and a gamma-ray spectrometer. Gateway will be humanity's first space station in lunar orbit. A foundational component of the lunar outpost, the Power and Propulsion Element will provide Gateway with power to enable it to maintain its orbit around the Moon.

[29] Per Federal Acquisition Regulation, 16.202-1, "A firm-fixed-price contract provides for a price that is not subject to any adjustment on the basis of the contractor's cost experience in performing the contract. This contract type places upon the contractor maximum risk and full responsibility for all costs and resulting profit or loss."

[30] In 2016, NASA awarded the original FFP contract to Space Systems/Loral LLC for "On-Orbit Robotic Installation and Reconfiguration of Large Solid Radio Frequency Reflectors" with a value of $13.7 million and a potential 2-year period of performance. NASA later extended the contract for additional design, analysis, and testing. In this report, we refer to the original and modified contract as the SPIDER contract.

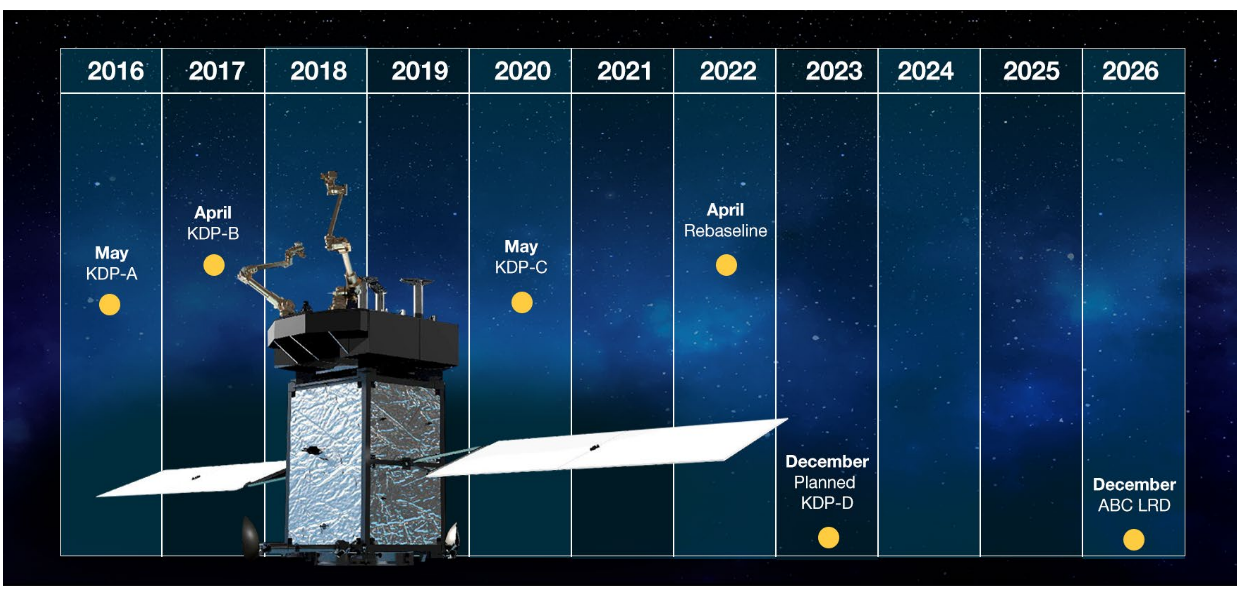
Maxar support integration of the payload to the spacecraft bus and associated testing. The current contract value, including the requirement to develop SPIDER, is approximately $163 million with an 8-year period of performance set to expire in August 2024. As of July 2023, $159.5 million (98 percent) had been obligated on the contract.

OSAM-1 Rebaselined Due to Cost Increases and Schedule Delays

With a KDP-C in June 2020, OSAM-1 was one of the first NASA projects to go through this milestone during the Coronavirus Disease of 2019 (COVID-19) shutdown, and Agency and project officials determined that COVID-19 impacts would not be incorporated into the project baseline at that time. Per the KDP-C decision memorandum, cost and schedule did not include impacts associated with the pandemic, stating that the project and Goddard will assess impacts in a “reasonable timeframe” and provide any budget and schedule updates to the Technology Demonstration Missions Program.[31]

After KDP-C, the project experienced schedule delays and cost increases due to the COVID-19 pandemic, as well as non-COVID impacts characterized by project officials as technical, programmatic, and scope changes. In particular, development of the servicing payload, which relies on contributions from Maxar, other contractors, and in-house development of subsystems by Goddard personnel, was slower and more costly than anticipated. In January 2022, the Associate Administrator for STMD issued a statutorily required notification to Congress because the Agency expected the OSAM-1 project to exceed its baseline development costs by more than 15 percent and its launch readiness date by more than 6 months. These cost and schedule overruns necessitated a project rebaseline and new ABC. In April 2022, the Agency rebaselined OSAM-1 from $1.78 billion to $2.05 billion (an increase of approximately $270 million) and pushed the launch date from September 2025 to December 2026 (15 months). See Figure 2 for significant OSAM-1 milestones and events.

Figure 2: Timeline of OSAM-1 Life Cycle as of July 2023



Source: NASA OIG presentation of Agency data.
Note: KDP is Key Decision Point. LRD is Launch Readiness Date. ABC is Agency Baseline Commitment.

[31] At KDP-C, NASA evaluates the completeness and consistency of the planning, technical, cost, and schedule baselines developed during Formulation and assesses compliance of the preliminary design with applicable requirements and to determine if the project is sufficiently mature to begin Phase C.

At the rebaseline in April 2022, project officials estimated the total COVID-19 cost impact to the project at $165.1 million and the rebaseline budget incorporated COVID-19 impacts through March 2022.[32] Table 3 provides examples of the COVID-19 impacts.

Table 3: Direct and Indirect COVID-19 Impacts to OSAM-1 Mission as of April 2022

COVID-19 Impacts	
Direct	**Indirect**
On-site work stoppage at NASA and contractor sites while still funding personnel	Limitations to official government travel for planned work
On-site work restrictions at NASA and contractor sites resulting in loss of efficiency	Inability to send Goddard technicians to contractor site causing significant rebaseline of where and who performed work with associated inefficiencies
Early interruptions and prolonged sporadic disturbance of supply chains	Delays in other projects, which influenced OSAM-1 priority for procurements, resources, and staffing
Work stoppages and delays at vendors	Increased difficulty and delays in collaboration due to the virtual environment

Source: NASA OIG presentation of Agency information.

Additionally, non-COVID issues increased project costs by $114.6 million. Examples of these non-COVID issues included (1) cost increases to the servicing payload, (2) space vehicle integration and testing alignment, (3) programmatic corrections to align budget and schedule, (4) SPIDER and spacecraft change proposals, (5) increases in contractor rates, (6) Goddard clean room upgrades, (7) launch vehicle cost growth, and (8) addressing lack of project cost reserves in FYs 2020 and 2021.

[32] Maxar submitted Requests for Equitable Adjustments for COVID-19 impacts during its development of the spacecraft bus and SPIDER that as of April 2023 totaled approximately $2 million. As of June 2023, the project Contracting Officer was evaluating these claims after previously rejecting earlier Maxar requests due to inadequate justification.

OSAM-1 Cost Growth and Schedule Delays Exacerbated by Poor Contractor Performance and Continued Technical Challenges

After rebaselining its cost and schedule in April 2022, the OSAM-1 project continues to experience cost growth and it now appears the Agency will exceed its current $2.05 billion cost and December 2026 launch date commitments to Congress. Development of the servicing payload—the system responsible for rendezvous and refueling Landsat 7—has continued to cost more and take longer than anticipated. Moreover, much of the project's cost growth and schedule delays can be traced to Maxar's poor performance on the spacecraft bus and SPIDER contracts with each deliverable approximately 2 years behind schedule. We found the structure of these FFP contracts does not provide NASA the flexibility to incentivize Maxar to try to improve its performance. Consequently, NASA is providing personnel and services to supplement Maxar's efforts to mitigate contractor performance issues and reduce further impacts to the overall project cost and schedule. Additionally, because NASA continues to pay Landsat 7 operation costs through the on-orbit mission, OSAM-1's estimated launch delays will increase these costs as well.

OSAM-1 Continues to Experience Cost Increases and Schedule Delays

Since the April 2022 rebaseline, the OSAM-1 project continues to struggle to meet its cost and schedule commitments. The servicing payload, managed by Goddard with contributions from Maxar, Honeybee Robotics, and other contractors, continues to struggle with its technology development.[33] However, a major contributor to more recent project overruns is Maxar's poor performance on both the spacecraft bus and SPIDER contracts. The original spacecraft bus contract, awarded to Maxar in December 2016, required spacecraft delivery in November 2018 in order to meet a planned June 2020 launch for Restore-L. When SPIDER was added to the mission in January 2020, the expected delivery date for the spacecraft bus was extended to February 2021.[34] However, NASA now estimates the spacecraft bus will not be delivered until August 2023—30 months later than planned.[35]

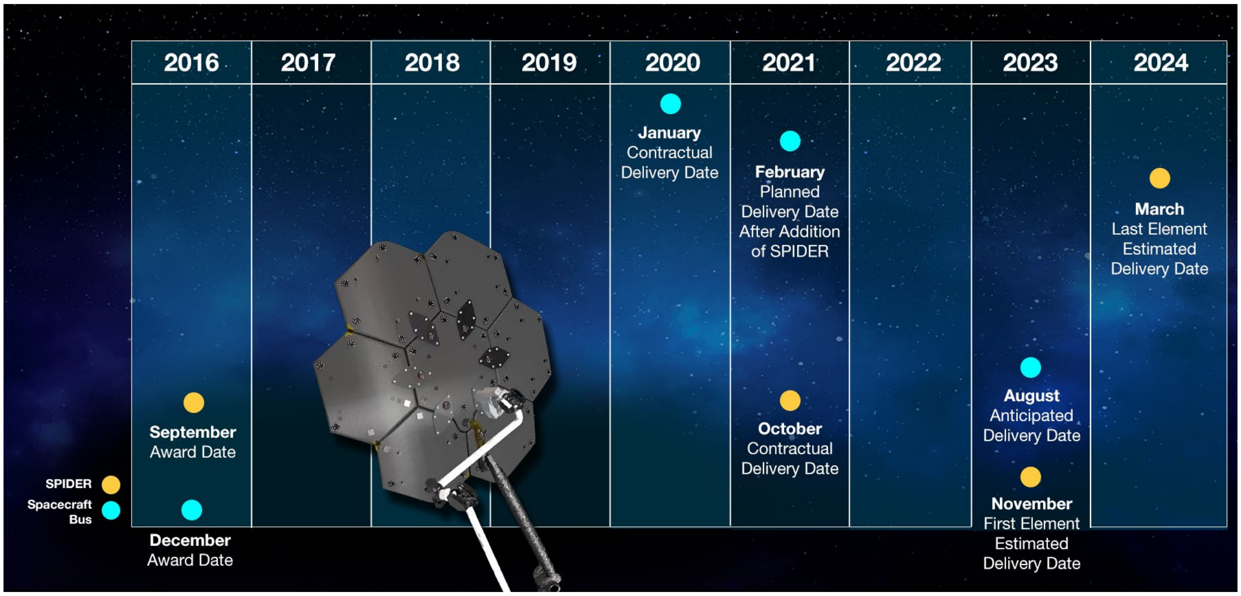
[33] Honeybee Robotics is the subcontractor responsible for developing the motors that are part of the robot arm systems for the servicing payload and SPIDER.

[34] Although the project planned to receive the spacecraft bus in February 2021, the contractual spacecraft bus delivery date was never revised from January 2020.

[35] After our draft report was released to NASA management for comment, Maxar shipped the spacecraft bus and delivered it to Goddard on September 20, 2023.

Maxar is also 25 months late in SPIDER contract deliveries. When SPIDER was added to the project in January 2020, Maxar's contractual delivery date to Goddard was October 2021. As of July 2023, Maxar is planning to deliver SPIDER by element, with the first major piece—a modular reflector element—in November 2023.[36] The remaining five elements of SPIDER are scheduled for delivery between November 2023 and March 2024. Figure 3 provides a comparison of the contractual and anticipated delivery dates for the spacecraft bus and SPIDER.

Figure 3: Contractual Versus Anticipated Delivery Dates for Spacecraft Bus and SPIDER (as of July 2023)



Source: NASA OIG presentation of Agency data.

Servicing Payload Development Continues to Face Technical Challenges

Goddard is experiencing technical challenges with the development of subsystems of the servicing payload, which will rendezvous, grapple, and refuel Landsat 7. These challenges are resulting in project cost increases and schedule delays. At the project's Baseline Performance Review in April 2023, project officials reported cost growth due to poor schedule performance and higher labor costs across the servicing payload, citing supply chain issues and over-subscribed vendors as factors in hardware delivery delays. Specifically, Goddard continues to struggle with developing the robot electronics units (REU) and the Light Detection and Ranging (LiDAR).[37] In July 2023, project officials reported that challenges

[36] Examples of SPIDER elements include the modular antenna, pallet, robot arm subsystem, and solar array.

[37] The REU subsystem provides the electrical design, integration, test, and delivery of the electronics that drive OSAM-1's two robotic arms. LiDAR is used to determine distances between objects by targeting an object with a laser and measuring the time for the reflected light to return to the receiver.

with servicing payload development were primarily due to REU schedule delays with development hampered by gaps in staffing.

Technical challenges and failure of components have also hampered Goddard's LiDAR development efforts resulting in project officials considering commercial solutions. Additionally, Honeybee Robotics has repeatedly delayed delivery of servicing payload robot motors. In one instance, the motors were damaged and required rework due to a design error. The project has also experienced delays to the servicing payload build due to actuator and electronics unit delivery delays. Project officials said that the actuator delays are primarily due to Maxar not having enough sufficiently skilled staff to build and test actuators.

Maxar Is Failing to Perform Adequately, Resulting in Increased Costs and Schedule Delays

According to Maxar and OSAM-1 project officials, Maxar significantly underestimated the scope and complexity of the work involved in tailoring a commercial spacecraft bus to meet NASA standards and OSAM-1 mission requirements. In addition, Maxar has not performed the required testing or Verification & Validation (V&V) activities, required ahead of spacecraft bus delivery, according to the project's schedule. Project officials reported that the spacecraft bus schedule delays are due to Maxar's poor prioritization and staffing of the required work, to include underestimating the scope of the design and analysis effort to meet mission requirements, Integration & Testing, Flight Software development, and V&V effort.[38] Maxar has also experienced quality issues requiring rework as well as technical issues with flight software. At the project's latest Baseline Performance Review in April 2023, OSAM-1 project officials reported that taken together these issues have delayed delivery of the spacecraft by an additional 8 months in just the last year.[39]

For SPIDER, the most recent contractor performance issues have been related to Maxar's management of subcontractor deliverables, underestimating the scope of the integration and testing effort, technical mistakes requiring rework, changes to the avionics design, and losses of key subcontractor personnel. For example, Maxar was not meeting schedule and delivery needs or technical requirements for Makersat—the manufacturing subsystem of SPIDER that intended to produce the lightweight composite beam.[40] Taken together, these issues have resulted in major slips in project milestones and deliveries.

In our discussions with Maxar officials, they said there was a difference in requirements expectations between Maxar and NASA, attributing their lack of understanding of government requirements to the company's minimal experience working with NASA on development contracts. However, each contract has a detailed SOW that describes the contractor's responsibilities and corresponding requirements. For example, per the spacecraft bus SOW, the contractor is required to conduct a spacecraft bus

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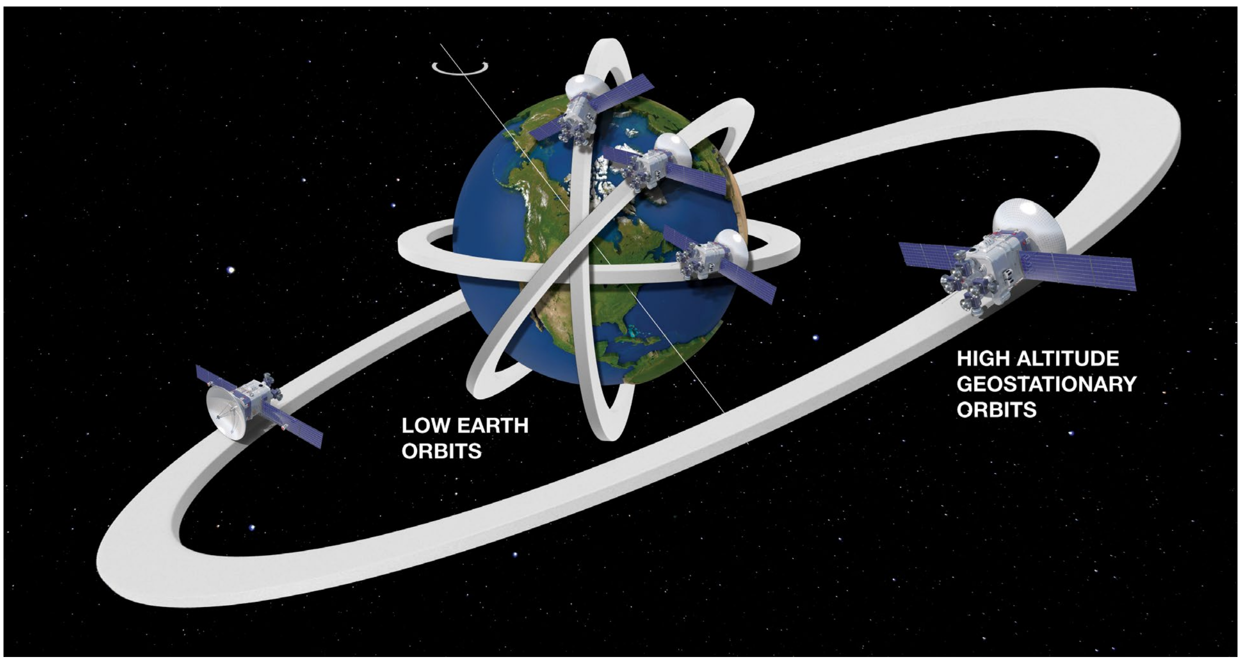
[38] Integration transforms lower-level products into higher-level products. Verification demonstrates that an end product conforms to its requirements or specifications. Validation confirms that a verified end product fulfills its intended use when placed in its intended environment.

[39] The Baseline Performance Review is NASA's senior performance management review. This review integrates Agency-wide communication of performance metrics, analysis, and independent assessment for mission and mission support programs, projects, and activities. The review is co-chaired by the NASA Associate Administrator and the Associate Deputy Administrator.

[40] Makersat was the subsystem intended to demonstrate in-space manufacturing by producing a 32-foot (minimum) lightweight composite beam to verify its capability to form large spacecraft structures for future missions.

requirements review to ensure that the bus requirements are understood and that the contractor's approach will meet these requirements. In addition, the contract outlines the applicable policy documents, including NASA Procedural Requirements, that the contractor must follow in performing the contract. Maxar personnel said they believed they would be able to deliver their standard spacecraft bus—designed to operate about 22,000 miles above the Earth as a geostationary communications and remote sensing platform—with only minor changes to operate and rendezvous with Landsat 7 in LEO about 440 miles above the Earth. Maxar officials admitted they underestimated the complexity of adapting their spacecraft bus from operating in geostationary orbit to LEO (see Figure 4), and they were overly optimistic about NASA's willingness to accept their normal commercial practices as meeting the OSAM-1 contract requirements. Maxar also admitted to having deficiencies with V&V, limited flight software expertise, and overall staffing issues.

Figure 4: Difference Between Geostationary and Low Earth Orbit Satellites



Source: NASA OIG presentation of Agency data.

Contract Structure Does Not Allow for Monetary Incentives to Improve Contractor Performance

The spacecraft bus and SPIDER contracts are FFP with no incentive or award fee. Therefore, NASA lacks the flexibility to use monetary incentives to recognize and reward contractor performance that exceeds meeting basic contract requirements. For example, award fees are used to motivate exceptional performance, and conversely, fees are not paid when a contractor's overall cost, schedule, and technical performance is below satisfactory. In our discussions with senior leadership at Goddard, OSAM-1 Standing Review Board, and procurement officials, each group agreed that the lack of an incentive or award fee on the contracts has limited NASA's ability to improve contractor performance. According to the Standing Review Board Chair at the time of the mission Critical Design Review, the contract structure lacked the ability to incentivize the contractor's performance, particularly in cases such as this where the contractor is not profiting from the contract. In our discussions with Maxar officials, they acknowledged that they were no longer profiting from their work on OSAM-1. Moreover, project officials stated that OSAM-1 does not appear to be a high priority for Maxar in terms of the quality of its staffing. However, they also said that the contract would have cost the Agency more if it were a cost-type contract that NASA typically uses in development projects.

Absent incentive or award fees, the primary mechanism the Agency has to incentivize Maxar's performance is the Contractor Performance Assessment Report (CPAR).[41] NASA's annual assessments of Maxar's performance on the spacecraft bus and SPIDER contracts from 2016 to 2020 stated that schedule performance on both was either "satisfactory" or "very good."[42] It was not until the 2021 and 2022 CPARs that evaluations categorized spacecraft bus schedule performance as "unsatisfactory," citing significant schedule slips in meeting primary flight hardware milestones and delivery dates. Similarly, assessments of the SPIDER's schedule performance from 2016 through 2021 was either "satisfactory" or "very good." Most recently, the 2022 assessment rated schedule performance as "marginal," citing technical issues with antenna system development, poor performance of a key subcontractor providing robotic arm system motors, and delays in verification deliverables. In our reading of the performance standards, significant delays should have resulted in "unsatisfactory" performance ratings over multiple years.

Delays Jeopardize Cost and Schedule Commitments and Mission Success

Maxar's delays in spacecraft bus and SPIDER deliveries have significantly impacted the project's ability to meet its cost and schedule commitments. At the OSAM-1 rebaseline in April 2022, NASA established a new cost and schedule commitment with a schedule margin of 17 months and $199.8 million of cost reserves.[43] Both are being depleted faster than planned and as of May 2023, 11 months of schedule margin and $130.0 million in cost reserves remain. As of July 2023, the estimated cost at completion was $2.1 to $2.17 billion, with a projected launch date between March and June of 2027, which exceeds the Agency's cost and schedule commitments to Congress of $2.05 billion and a December 2026 Launch Readiness Date. Further, upcoming Phase D activities such as System Assembly, Integration, and Test; Launch; and Checkout historically have posed significant challenges and impacted schedules for other NASA space flight projects, and OSAM-1 faces similar risks.

Due to cost increases and schedule delays, project officials proposed descopes—i.e., removing scientific or operational requirements from the development or mission of the project to reduce cost—that affect the ability to meet level 1 mission requirements.[44] Specifically, because Maxar was not meeting schedule and delivery timetables or technical requirements for Makersat, in April 2023 the project proposed removing the entire Makersat subsystem—the standalone payload responsible for

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[41] A Contractor Performance Assessment Report (CPAR), completed by Agency program and contracting officials, assesses a contractor's performance, both positive and negative, on a contract for a specific period of the time. The rating scale used is "exceptional," "very good," "satisfactory," "marginal," and "unsatisfactory." The CPAR System is NASA's official source for past performance information and is used to view contractor performance evaluations when awarding contracts.

[42] CPARs for FFP contracts do not include a rating for "cost performance."

[43] Schedule margin is a separately planned quantity of time (working days) above the planned work duration estimate used specifically to address or absorb the impacts due to risks and uncertainties.

[44] Level 1 requirements are those scientific determinations and results required for successful completion of the mission's objectives. Level 1 requirements do not specify implementation details for the mission.

manufacturing—from the SPIDER payload. STMD concurred with this recommendation and, as a result, the project will not include a manufacturing demonstration on the mission. As of July 2023, the project had spent an estimated $12 million on this element.[45] Project officials indicated that they plan to negotiate a new total contract price for the descoped effort.

Maxar has also repeatedly failed to align flight software completion with the spacecraft delivery date. Therefore, the project has removed completion of flight software V&V and other testing from the criteria required before Maxar ships the spacecraft bus to Goddard. Instead, Maxar will continue some testing in parallel with critical software V&V and testing being completed while the spacecraft is at Goddard. This decision may increase the project's ability to meet schedule goals, but it introduces a potential risk of losing Maxar personnel resources. Specifically, project officials are concerned that Maxar will not view OSAM-1 as a high priority and will shift key staff resources to other projects after spacecraft bus delivery.

NASA Is Providing Labor to Supplement Maxar's Inability to Complete Contracted Responsibilities

Due to Maxar's poor performance, NASA is providing unplanned labor and services to supplement Maxar's efforts to develop OSAM-1's spacecraft bus. Specifically, between January 2022 and May 2023, NASA provided labor valued at approximately $2 million to help reduce impacts to the mission schedule such as flight software and systems engineering support. According to project officials, supplementing Maxar's efforts was necessary to reduce risk to the overall project schedule. At the same time, Agency project managers have not modified the spacecraft bus contract to decrease its value to account for the supplemental labor provided by NASA. Therefore, we question the approximately $2 million of increased costs NASA has incurred by providing government resources to help fulfill Maxar's contractual obligations.

Instead of making the appropriate changes to the contract's SOW with corresponding adjustments to the contract value, the project is tracking the supplemental government-provided labor using an informal document referred to by the project as a "puts and takes" list that describes the supplements to Maxar and their associated dollar values. The project's current Contracting Officer only became aware of the team's use of supplemental staff and the existence of a "puts and takes" list during conversations with our audit team in February 2023. The Contracting Officer indicated that had she been aware of the project's actions, she may have requested a modification of the spacecraft bus contract to account for these NASA-funded efforts.

Delays May Increase Landsat 7 Operations Costs and Risk of Failure

OSAM-1 has only been approved to service Landsat 7, which was launched in 1999 and has long outlived its planned mission duration of 5 years. Since FY 2022, the USGS has required NASA to fund Landsat 7's continued operations as they would have otherwise decommissioned the satellite. The OSAM-1 project baselined $27 million as reimbursement to USGS for keeping Landsat 7 operational through the project's Management Agreement launch date of February 2026 (although the Agency has not provided additional funding to meet the ABC launch date of December 2026). Since NASA is responsible for

[45] One of the primary objectives of the mission, in agreement with the Level 1 requirements, is to demonstrate on-orbit manufacturing.

funding Landsat 7 operations through successful completion of the satellite servicing mission, any OSAM-1 project launch delays beyond the February 2026 launch date would require the Agency to provide additional funds to USGS at a rate of approximately $482,000 per month. With the projected Launch Readiness Date now no earlier than March 2027, NASA will likely incur at least $6.3 million in additional costs to continue Landsat 7 operations.

Because of Landsat 7's age, in 2020 OSAM-1 project officials conducted an assessment to identify alternative satellites and mitigate the risk should Landsat 7 fail and be unavailable prior to OSAM-1's launch. The project identified three alternative satellites owned and operated by NASA's Science Mission Directorate that would meet all OSAM-1 Level 1 requirements. However, Science Mission Directorate officials declined to provide the satellites as alternatives to Landsat 7, citing significant cost or schedule impacts to their satellites. In discussions with OSAM-1 project officials, they acknowledged the mission risk posed to the operational satellites by participating in a technology demonstration. Moreover, as of March 2023 USGS reported that all data indicates Landsat 7 is a healthy 23-year-old spacecraft with no concerning trends.

CONCLUSION

NASA's OSAM-1 project is a technology demonstration mission that seeks to prove the feasibility of robotic satellite servicing capabilities for satellites in LEO, as well as demonstrating the ability to autonomously build structures in space. Beginning as the Restore-L mission, which NASA had been working on since 2015, the project was renamed OSAM-1 with the addition of the SPIDER payload in 2020 and began its Implementation Phase the same year. In 2022, the Agency rebaselined the project from $1.78 billion to $2.05 billion and delayed its launch date from September 2025 to December 2026, citing COVID-19 impacts and technical, programmatic, and scope changes. After rebaselining, the project continues to experience cost and schedule overruns.

Although Goddard continues to struggle with development of several key components of the servicing payload, we found that project cost increases and schedule delays were primarily due to the poor performance of Maxar, OSAM-1's prime contractor, and its inability to provide the spacecraft bus and SPIDER in accordance with contract requirements. NASA and Maxar officials acknowledged that Maxar underestimated the scope and complexity of the work, lacked full understanding of NASA technical requirements, and were deficient in necessary expertise.

RECOMMENDATIONS, MANAGEMENT'S RESPONSE, AND OUR EVALUATION

To increase transparency, accountability, and oversight of NASA contracts, we recommended that the Associate Administrator of STMD, in coordination with the OSAM-1 Contracting Officer:

1. Recoup the costs of the labor and services (supplemental work) provided by NASA to Maxar to complete the work on the spacecraft bus contract.
2. Ensure all work is contractually agreed upon and integrated into the contract SOW, and all changes are appropriately reflected in the SOW with adjustments to the contract value.

In addition, we recommended NASA's Assistant Administrator for Procurement:

3. Issue guidance that contracting officials, as part of acquisition strategy planning, consider incorporating award or incentive fees into future fixed price development contracts.

We provided a draft of this report to NASA management who concurred or partially concurred with our recommendations and described planned actions to address them. We consider management's comments responsive; therefore, the recommendations are resolved and will be closed upon completion and verification of the proposed corrective actions.

Management's comments are reproduced in Appendix C. Technical comments provided by management and revisions to address them have been incorporated as appropriate.

Major contributors to this report include Raymond Tolomeo, Science and Aeronautics Research Audits Director; Sarah Beckwith, Assistant Director; Derek Gainsboro; Greg Lokey; Theresa Becker; and Amanda Perry.

If you have questions about this report or wish to comment on the quality or usefulness of this report, contact Laurence Hawkins, Audit Operations and Quality Assurance Director, at 202-358-1543 or laurence.b.hawkins@nasa.gov.

Paul K. Martin
Inspector General

APPENDIX A: SCOPE AND METHODOLOGY

We performed this audit from September 2022 through August 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.

In this report, we assessed NASA's management of the OSAM-1 project relative to established cost, schedule, and technological goals. We also assessed the feasibility of the OSAM-1 project servicing the Landsat 7 satellite, if NASA project management officials were effectively monitoring and enforcing contractor performance, and the effect, if any, of congressionally directed funding for the project.

Our assessment of the processes and practices included a review of NASA documents and interviews with NASA officials from the Space Technology Mission Directorate, OSAM-1 Project, and Goddard Procurement. We also interviewed U.S. Geological Survey, OSAM-1 Standing Review Board, and Maxar officials. Our primary criteria for assessing the aforementioned practices and procedures were the Federal Acquisition Regulation, NASA Procedural Requirements, and the spacecraft bus and SPIDER contract terms and conditions.

Assessment of Data Reliability

We only utilized computer-processed data in the identification of our sample. We did not validate the reliability of any computer processed data, as no computer-processed data was used to support the findings of this report. All findings identified were internal control process weaknesses, and any inaccuracies in computer-processed data would not substantively change the findings of this report.

Review of Internal Controls

We assessed internal controls and compliance with laws and regulations as they relate to OSAM-1 project management, contract administration, and contract terms and conditions. We focused specifically on whether NASA officials effectively managed the project relative to cost, schedule, technology, and whether procurement officials administered procurement actions in compliance with federal acquisition regulations. We identified control weaknesses with NASA's project management and procurement practices that are addressed in the findings. Our recommendations, if implemented, will ensure compliance with cited federal statutes and correct the control weaknesses identified in this report.

Prior Coverage

During the last 5 years, the NASA Office of Inspector General and Government Accountability Office have issued four reports of significant relevance to the subject of this report. Reports can be accessed at https://oig.nasa.gov/audits/auditReports.html and https://www.gao.gov, respectively.

NASA Office of Inspector General

Review of NASA's Space Technology Mission Directorate Portfolio (IG-23-005, December 19, 2022)

Government Accountability Office

NASA: Assessments of Major Projects (GAO-23-106021, May 31, 2023)

NASA: Assessments of Major Projects (GAO-22-105212, June 23, 2022)

NASA: Assessments of Major Projects (GAO-21-306, May 20, 2021)

Appendix B: Schedule of Questioned Costs with Dollar-Related Findings

Table 4 summarizes the questioned costs identified during our audit and discussed in this report. Questioned costs related to NASA providing labor, services, and other contributions to supplement Maxar's efforts under the fixed-price spacecraft bus contract, as detailed in the report.

Table 4: Schedule of Questioned Costs

Issue	Recommendation Number	Questioned Costs[a]
Labor, services, and other contributions provided by NASA to Maxar to supplement Maxar's efforts under the fixed-price spacecraft bus contract	1	$2,000,000
Total		**$2,000,000**

Source: NASA OIG analysis.

[a] Questioned Costs are expenditures that are questioned by the OIG because of alleged violation of law, regulation, or contractual requirement governing the expenditure of funds; costs that are not supported by adequate documentation at the time of our audit; or are unallowable, unnecessary, or unreasonable.

Appendix C: Management's Comments

National Aeronautics and Space Administration

Mary W. Jackson NASA Headquarters
Washington, DC 20546-0001

Reply to Attn of: Space Technology Mission Directorate

TO: Acting Assistant Inspector General for Audits

FROM: Acting Associate Administrator for Science Technology Mission Directorate and Assistant Administrator for Procurement

SUBJECT: Agency Response to OIG Draft Report, "NASA's Efforts to Demonstrate Robotic Servicing of On-Orbit Satellites" (A-22-15-00-SARD)

The National Aeronautics and Space Administration (NASA) appreciates the opportunity to review and comment on the Office of Inspector General (OIG) draft report entitled, "NASA's Efforts to Demonstrate Robotic Servicing of On-Orbit Satellites" (A-22-15-00-SARD), dated August 30, 2023.

In the report, the OIG found that NASA's On-Orbit Servicing, Assembly, and Manufacturing 1 (OSAM-1) cost growth and schedule delays are exacerbated by poor contractor performance and continued technical challenges. The OIG also determined that it now appears the Agency will exceed its current $2.05 billion price tag and the December 2026 launch date commitment to Congress. The OIG makes two recommendations to the Associate Administrator of Science Technology Mission Directorate (STMD) and one to NASA's Assistant Administrator for Procurement intended to increase transparency, accountability, and oversight of NASA contracts.

Specifically, the OIG recommends the following:

Recommendation 1: Recoup the costs of the labor and services (supplemental work) provided by NASA to Maxar to complete the work on the spacecraft bus contract.

> **Management's Response:** NASA partially concurs. NASA will attempt to recoup costs through discussions with Maxar on potential equitable adjustments. Per our experience, it may take some time to negotiate the final result.
>
> **Estimated Completion Date:** December 30, 2024.

Recommendation 2: Ensure all work is contractually agreed upon and integrated into the contract SOW, and all changes are appropriately reflected in the SOW with adjustments to the contract value.

Management's Response: NASA partially concurs. The spacecraft contract consists of a "core" portion and an indefinite-delivery, indefinite-quantity (IDIQ) portion. The core portion of the spacecraft contract is substantially completed as the spacecraft has been shipped to Goddard Space Flight Center, and the remaining work/acceptance testing will occur over the next few months. NASA does not anticipate that an agreement can be reached with the Contractor regarding the modified/updated Statement of Work (SOW) or adjusted contract value prior to completion of the core portion of the work. As a result, NASA is unable to ensure that all work will be contractually agreed upon and integrated into the contract SOW. The IDIQ portion of the contract will go into effect in fiscal year (FY) 2024. For the IDIQ portion of work, each task will have its own SOW. STMD will review the SOW for the first task and subsequent SOWs for tasks going into effect in FY 2024. NASA will endeavor to have the work under the task orders contractually agreed upon with all changes reflected in their respective SOWs with adjustments to each task order value, as appropriate.

Estimated Completion Date: September 30, 2024.

In addition, the OIG recommends that NASA's Assistant Administrator for Procurement:

Recommendation 3: Issue guidance that contracting officials, as part of acquisition strategy planning, consider incorporating award or incentive fees into future fixed price development contracts.

Management's Response: NASA concurs. NASA will emphasize the Federal Acquisition Regulation (FAR) and NASA FAR Supplement (NFS) guidance that Contracting Officers (COs) are required to consider when incorporating award or incentive fees into future fixed-price development contracts.

The Office of Procurement (OP) will revise the Procurement Strategy Meeting template to address the considerations that COs must evaluate when incorporating incentives into future fixed-price development contracts. In addition, OP will conduct enterprise-wide training to reinforce CO's knowledge and understanding of the FAR and NFS requirements in an OP quarterly procurement webinar. These webinars will be accessible both in real-time and as a recorded session.

Estimated Completion Date: September 30, 2024.

We have reviewed the draft report for information that should not be publicly released. As a result of this review, we have not identified any information that should not be publicly released.

Once again, thank you for the opportunity to review and comment on the subject draft report. If you have any questions or require additional information regarding this response, please contact Ashley Edwards at (202) 358-1756.

Prasun Desai Digitally signed by Prasun Desai Date: 2023.09.29 09:12:40 -04'00'

Prasun Desai
Acting Associate Administrator for the
Space Technology Mission Directorate

Karla Jackson Digitally signed by Karla Jackson Date: 2023.09.29 11:21:18 -04'00'

Karla Smith Jackson
Assistant Administrator for
Procurement

APPENDIX D: REPORT DISTRIBUTION

National Aeronautics and Space Administration

Administrator
Deputy Administrator
Associate Administrator
Deputy Associate Administrator
Chief of Staff
Chief Program Management Officer
Associate Administrator for Space Technology Mission Directorate
Technology Demonstration Missions Program Director
OSAM-1 Project Manager
Goddard Space Flight Center Director

Non-NASA Organizations and Individuals

Office of Management and Budget
Deputy Associate Director, Climate, Energy, Environment and Science Division

Government Accountability Office
Director, Contracting and National Security Acquisitions

Honeybee Robotics

Maxar Technologies

Congressional Committees and Subcommittees, Chairman and Ranking Member

Senate Committee on Appropriations
Subcommittee on Commerce, Justice, Science, and Related Agencies

Senate Committee on Commerce, Science, and Transportation
Subcommittee on Space and Science

Senate Committee on Homeland Security and Governmental Affairs

House Committee on Appropriations
Subcommittee on Commerce, Justice, Science, and Related Agencies

House Committee on Oversight and Accountability
Subcommittee on Government Operations and the Federal Workforce

House Committee on Science, Space, and Technology
Subcommittee on Investigations and Oversight
Subcommittee on Space and Aeronautics

(Assignment No. A-22-15-00-SARD)