NATIONAL IN-SPACE SERVICING, ASSEMBLY, AND MANUFACTURING IMPLEMENTATION PLAN

Product of the

IN-SPACE SERVICING, ASSEMBLY, AND MANUFACTURING INTERAGENCY WORKING GROUP

of the

NATIONAL SCIENCE AND TECHNOLOGY COUNCIL

December 2022

About the Office of Science and Technology Policy

The Office of Science and Technology Policy (OSTP) was established by the National Science and Technology Policy, Organization, and Priorities Act of 1976 to provide the President and others within the Executive Office of the President with advice on the scientific, engineering, and technological aspects of the economy, national security, homeland security, health, foreign relations, the environment, and the technological recovery and use of resources, among other topics. OSTP leads interagency science and technology policy coordination efforts, assists the Office of Management and Budget with an annual review and analysis of Federal research and development in budgets, and serves as a source of scientific and technological analysis and judgment for the President with respect to major policies, plans, and programs of the Federal government. More information is available at https://www.whitehouse.gov/ostp.

About the National Science and Technology Council

The National Science and Technology Council (NSTC) is the principal means by which the Executive Branch coordinates science and technology policy across the diverse entities that make up the Federal research and development enterprise. A primary objective of the NSTC is to ensure science and technology policy decisions and programs are consistent with the President's stated goals. The NSTC prepares research and development strategies that are coordinated across Federal agencies aimed at accomplishing multiple national goals. The work of the NSTC is organized under committees that oversee subcommittees and working groups focused on different aspects of science and technology. More information is available at https://www.whitehouse.gov/ostp/nstc.

About the In-space Servicing, Assembly, and Manufacturing Interagency Working Group

The In-space Servicing, Assembly, and Manufacturing (ISAM) Interagency Working Group coordinates science and technology policy, strategy, and Federal research and development (R&D) pertaining to ISAM-related capabilities under the auspices of OSTP. This coordinated effort aims to ensure that U.S. leadership in servicing, assembly, manufacturing capabilities in space and their applications is maintained and expanded for future use.

About this Document

This document provides an interagency implementation plan to guide the activities of the U.S. government in addressing ISAM challenges. This ISAM Implementation Plan acts on the ISAM National Strategy. The Plan also supports the United States Space Priorities Framework, with a focus on scientific and technological innovation, economic growth, commercial development, open markets, freedom of navigation, and fair trade.

Copyright Information

NATIONAL SCIENCE & TECHNOLOGY COUNCIL

Chair
Arati Prabhakar
Director
White House Office of Science and Technology Policy

Executive Director (Acting)
Kei Koizumi
Principal Deputy Director for Policy
White House Office of Science and Technology Policy

IN-SPACE SERVICING, ASSEMBLY, AND MANUFACTURING

INTERAGENCY WORKING GROUP

Chair
Ezinne Uzo-Okoro, Assistant Director for Space Policy
White House Office of Science and Technology Policy

Members

Departments
Department of Commerce
Department of Education
Department of Defense
Department of State
Department of Transportation

Executive Office of The President
National Security Council
National Space Council
Office of Management and Budget

Agencies and Service Branches
Defense Advanced Research Projects Agency
Federal Aviation Administration
Federal Communications Commission
Intelligence Advanced Research Projects Activity
National Aeronautics and Space Administration
National Geospatial-Intelligence Agency
National Science Foundation
National Reconnaissance Office
Office of the Director for National Intelligence
United States Air Force
United States Naval Research Laboratory
United States Space Command
United States Space Force

TABLE OF CONTENTS

Executive Summary

The development of In-Space Servicing, Assembly, and Manufacturing (ISAM) capabilities represents the Biden-Harris Administration's commitment to scientific and technological innovation, economic growth, commercial development, a diverse U.S. skilled workforce, and international collaboration in space. These ISAM capabilities are on the brink of opening new possibilities for U.S. commercial industry and American workers to build, repair, and transport objects in space. With the new opportunities ISAM affords, global space operators will have access to technologies that can increase satellite lifetimes; move, tug, or deorbit satellites to avoid debris or to perform end-of-life maneuvers; inspect satellites for damage; maintain, refuel, and upgrade existing satellites; and build and operate larger, more complex systems in space that do not need to be designed to withstand the severe launch environment.

The ISAM Implementation Plan implements the strategic vision established in the April 2022 ISAM National Strategy. Both policy documents were developed by the National Science and Technology Council's Interagency Working Group on In-Space Servicing, Assembly, and Manufacturing. The Implementation Plan is organized around the six ISAM National Strategy goals:

1. Advancing ISAM research and development;
2. Prioritizing the expansion of scalable infrastructure;
3. Accelerating the emerging ISAM commercial industry;
4. Promoting international collaboration and cooperation to achieve ISAM goals;
5. Prioritizing environmental sustainability as we move forward with ISAM capabilities; and
6. Inspiring a diverse workforce as a potential outcome of ISAM innovation.

Achieving the strategic goals requires U.S. leadership and successful engagement and coordination with industry, non-profit organizations, academia, and the international community. Each of the National ISAM strategic goals is broken down into objectives to organize 28 discrete ISAM implementation activities that Federal departments and agencies will undertake to advance the ISAM National Strategy.

Advancing ISAM R&D is the foundation of this Implementation Plan by calling for agencies to define future missions and architectures to use ISAM capabilities. It also calls for studies of ISAM capability needs and gaps to further advance ISAM technologies. The U.S. government has a clear role in helping the spacecraft and mission designers and operators develop standards to facilitate ISAM use not only through engagements with commercial partners, but through incorporating those well-developed standards into government spacecraft. Regarding test infrastructure, the Plan highlights activities to assess the gaps in the current capabilities as well as directs agencies to develop an approach for in-space propellant infrastructure.

Through a number of activities outlined in this Plan, the U.S. government aims to drive positive change for the U.S. space sector by promoting and enabling the adoption of ISAM capabilities. A number of activities call for promoting opportunities for international cooperation with partners and prioritizing environmental responsibility results in activities that motivate space operators to conduct ISAM in a safe and responsible manner. There are a set of activities put forth to inspire, prepare, and employ a diverse, future space workforce through increased educational opportunities, access to secondary and post-secondary programs, and promoting interdisciplinarity to enable ISAM capabilities. The Plan outlines activities for the United States to lead in a future of space exploration in which U.S. commercial industry and American workers are manufacturing, assembling, and repairing space systems in orbit, around the Moon, and in deep space.

Introduction

As defined in the ISAM National Strategy, ISAM is not a specific capability, but rather "a suite of capabilities used on-orbit, on the surface of celestial bodies and in transit between these regimes" to include repairing and refueling spacecraft, building structures, and fabricating components in space as needs arise. ISAM capabilities will create new approaches for space activities. These new capabilities could equip the United States to produce the next generation of space-based telescopes, manufacture lunar and Martian surface structures, and enable astronauts on deep space missions to repair their spacecraft or rescue themselves without direct Earth resupply. The 2022 ISAM National Strategy identifies six strategic goals to advance ISAM and promote U.S. leadership. This Implementation Plan builds on the ISAM National Strategy and offers tangible, actionable steps the Federal Government can take to continue leading the world in realizing the promise ISAM offers.

To date, the United States and our international partners have conducted a number of ISAM missions. The construction and operation of the International Space Station was a crewed in-space assembly mission that was the first of its kind. Similarly, the five Hubble servicing missions repaired and upgraded instruments in the telescope. The Hubble Space Telescope continues to provide remarkable images and data for scientists, well beyond its expected lifetime. While these missions were labor intensive, future ISAM missions will be autonomous, enabled through advancements in robotics and automation—coupled with lower costs to access space.

The United States continues to develop ISAM technologies and capabilities, pushing the state of the art. For example, the National Aeronautics and Space Administration (NASA) is investing in servicing, assembly and manufacturing demonstrations, and the Department of Defense (DOD) is funding servicing satellites in geostationary orbit. The DOD through the Defense Advanced Research Projects Agency (DARPA) established the Consortium for Execution of Rendezvous & Servicing Operations (CONFERS) in 2017, providing a forum for the commercial, academic, and government sectors to develop ISAM standards and best practices. Since then, CONFERS has grown from an initial six founding members, all but one from the United States, to 62 members from 10 countries and will soon be converted to an entirely member-supported organization. This is a testament to the space sector's commitment to creating a permanent, self-sustaining organization where industry can collaborate and engage with the U.S. government about ISAM. While a number of ISAM activities have been funded in the past, the Federal government will continue to coordinate and collaborate on research, development, and policies related to ISAM through the Implementation Plan.

In May 2022, OSTP issued a Request for Comment to solicit feedback from commercial, academic, and non-profit entities on the next steps the Federal government should pursue to realize the ISAM National Strategy. The resulting set of ISAM activities coordinates U.S. government ISAM collaborative efforts to advance the National Strategy and vision. Any commitment of Federal resources to support this Implementation Plan will be determined through the budget process.

Implementation Activities

1. Advance ISAM Research and Development

The ISAM National Strategy established the strategic goal of advancing ISAM R&D to realize the possibilities that ISAM could enable for new missions and architectures. The intent is to identify cutting-edge, high-quality ISAM R&D areas that require government, academic, and commercial collaboration and coordination to make an impact. Through improved coordination, R&D outcomes and impacts will be achieved more efficiently. Here are a set of tangible activities to realize this strategic goal:

1.1 Define the future missions and architectures that will use ISAM capabilities

- 1.1.1 Estimate the value of using ISAM capabilities in future architectures and programs. Identify high-priority future U.S. government missions and architectures that could be enabled or enhanced by ISAM R&D and associated needs. (Lead: DOD and NASA)
- 1.1.2 Develop an ISAM test or demonstration capability for specific ISAM technologies, consistent with national and international Orbital Debris guidelines. Develop plans to make this capability available to academia, and commercial entities. (Lead: DOD and NASA)

1.2 Study ISAM capability needs, technology gaps, and develop a plan to advance ISAM technologies.

- 1.2.1 Maintain a repository of available ISAM capabilities, gaps, ongoing activities, and existing facilities, and communicate this information to mission developers and regulatory agencies, as appropriate. (Lead: DOD and NASA)
- 1.2.2 Prioritize basic and applied ISAM-related research, ranging from technologies, capabilities, and services – including experimental, demonstration, and prototype missions, where appropriate. (Lead: DOD and NASA)
- 1.2.3 Advance unclassified research at IARPA to improve energy storage in space, specifically, efforts focused on developing power sources for high-power, high-energy, or pulse power after extended storage. (Lead: ODNI)
- 1.2.4 Improve unclassified research at IARPA related to autonomous operations, onboard decision-making, and other AI that could contribute to ISAM. Improve the hardware-software-algorithm-architecture ecosystem for specific AI applications, and develop new science, materials, and processing that will improve the performance of the microelectronics used to run AI/ML applications. (Lead: ODNI)

2. Prioritize Expanding Scalable ISAM Infrastructure

Across all R&D fields, physical and digital infrastructure are foundational to advancement. Standards play an important role and can be viewed as structurally necessary to enable an innovation system that allows for interoperability and technical certainty. One of the challenges outlined in the ISAM National Strategy was that standards in this field are nascent and that by facilitating standards development in the areas of modularity, interfaces, and material processes and operational processes, a more robust commercial market for ISAM services can emerge. The next set of activities describes specific steps the government can take to support the development of standards as well as the physical and digital infrastructure to advance ISAM.

2.1. Develop Standards to Facilitate ISAM Capability Use

2.1.1. Engage with the private sector, industry partners, domestic and international bodies, and academia in universal standards development for ISAM technologies. (Lead: DOC; Support: DOD, DOS, NASA)

2.1.2. Incorporate defined standards and cooperative features in government spacecraft when possible and advantageous. (Lead: NASA; Support: DOC, DOD)

2.1.3. Support the flight qualification of standard interface hardware, to facilitate commercial interface component availability for future spacecraft. (Lead: DOD; Support: DOC, NASA)

2.2. Support Development of Space and Ground Infrastructure

2.2.1. Identify and assess gaps within existing U.S. government space infrastructure and ground test facilities infrastructure and develop a plan to close those gaps. Support and leverage commercial in-space infrastructure to support in-space demonstration of new technologies and capabilities. Improve digital infrastructure for and foster development of modeling and simulation tools. (Lead: DOD and NASA)

2.2.2. Develop an approach to purchase commercial in-space propellant services and infrastructure to assist U.S. government ISAM operations. This should include coordinating with industry to define a range of fuel and refueling interface standards for use by U.S. government spacecraft. (Lead: DOD; Support: DOC, DOT, NASA)

3. Accelerate the Emerging ISAM Commercial Industry

One of the biggest challenges and risks to ISAM technology development is the lack of a consistent demand signal to the private sector on government ISAM needs. As with many nascent industries, ISAM commercial partners seek to develop new ISAM technologies and capabilities through engagement with the U.S. government. Through these contracts, the ISAM commercial community can lower the risk of their technologies and eventually transition services to other customers. The following activities help boost the ISAM commercial industry:

3.1 Encourage ISAM Capabilities in Government Space Activities

3.1.1. Adopt commercially-developed modular infrastructure, as appropriate, to reduce the barrier of entry for ISAM innovation and improve the efficiency of U.S. government space operations. (Lead: DOD and NASA; Support: DOC)

3.2. Enable Commercial In-Space Services and Infrastructure to Thrive

3.2.1. Convene a national consortium to improve communication between government, industry, and academia. Assemble stakeholders including Federal agencies, universities, non-profit research institutions, industry groups, existing ISAM organizations, non-traditional providers, and commercial companies – particularly, the space start-up community – to assess ISAM opportunities and needs. Incentivize industry collaboration and encourage adoption of open standards as appropriate. (Lead: NASA; Support: DOC, DOD, ED)

3.2.2. Facilitate commercial and academic access to U.S. government ground-based facilities that enable ISAM technology development and testing, as appropriate. (Lead: DOD and NASA)

3.2 Balance Government and Industry Roles and Responsibilities

3.3.1. Delineate the ISAM capabilities that the U.S. government intends to procure as services versus government-owned and operated. (Lead: DOD and NASA; Support: DOC)

3.3.2. Include contract options and clauses in spacecraft procurements to facilitate applicable ISAM operations post-launch where appropriate. Improve contract and solicitation flexibility to support beyond set programs (e.g., standalone facilities, broad research) and to improve the contract vehicles for licensing, which is a recurring barrier. (Lead: DOD and NASA; Support: DOC)

4. Promote International Collaboration and Cooperation

Activities in space frequently involve international collaboration and cooperation. As such, cooperation with allies and partners on developing and implementing new guidelines, best practices, and other arrangements to help ensure space continues to be a domain where all nations and communities can benefit is important. Given the infancy of the ISAM sector, it is important to work with the international community to ensure ISAM capabilities support safe and sustainable operations in space. The following set of steps will help realize this goal:

4.1. Encourage international cooperation on the development and effective implementation of guidelines, best practices, and norms of responsible behavior, as part of a framework for responsible ISAM activities. (Lead DOS; Support: DOC, DOD, DOT, NASA)

4.2. Evaluate current and nascent ISAM technologies and services (including U.S. commercial non-Earth imaging) to assess the national security and foreign policy risks associated with their export or foreign access to them. Update U.S. national regulations based on that assessment. (Lead: DOS; Support: DOC, DOD, NASA)

4.3. Maintain continued awareness of ISAM innovations and capabilities, and communicate this information to regulators to enable predictive and agile regulations that protect U.S. national security and foreign policy equities while removing unnecessary obstacles to international participation. (Lead: DOS; Support: DOC, DOD, NASA)

4.4. Promote U.S. regulatory intent bilaterally and multilaterally to facilitate interoperability and harmonization of ISAM operations. (Lead: DOS)

4.5. Promote opportunities for international cooperation with partners on ISAM capabilities and activities, as appropriate and consistent with U.S. law, regulation, policy, and international commitments. (Lead: DOS; Support: DOC, DOD, NASA)

4.6. Explore possible arrangements for appropriate access by allies to U.S. government test facilities on the ground and in space, as appropriate and leverage academia to help bring talent and research together to hasten development and iteration cycles. (Lead: DOS; Support: DOD, NASA, NSF)

5. Prioritize Environmental Sustainability

ISAM capabilities can promote a more sustainable space environment. From extending the life of satellites to managing policies to conduct rendezvous and proximity operations, it is important for the ISAM community to promote the responsible and sustainable use of space through ISAM technologies. The activities will

consider the implications of new ISAM technologies to astronomical observations. The following steps will support this effort:

5.1. Develop options to procure services to repair, upgrade, and extend the lifetimes of U.S. government space assets, thereby reducing the need to launch more spacecraft which may contribute to the creation of harmful debris. (Lead: DOD; Support: NASA)

5.2. Revise policy for on-orbit imaging devices used for rendezvous proximity operations to support long-term sustained operations and services for a variety of customers at diverse orbital locations. (Lead: DOC and DOS)

5.3. Explore the policy ramifications of requiring spacecraft, components, and transportation vehicles to achieve safe disposal upon mission completion to mitigate space debris. Consider both traditional self-disposal (minimum fuel onboard and/or grappling or docking mechanisms) and ISAM-based approaches (refueling and end-of-mission disposal services). (Lead: DOT and FCC)

6. Inspire the Future Space Workforce

Progress in any scientific domain requires a driven, qualified, and inspired workforce. To achieve the goals outlined in the ISAM National Strategy, the future space workforce must be diverse and be ready to tackle some of the most challenging space problems. Education and workforce training programs must prepare and inspire the next generation of space scientists, engineers, and technologists to advance ISAM capabilities. These activities provide detailed steps on how to achieve this goal:

6.1. Increase educational opportunities that engage K-12 students to learn about ISAM capabilities and encourage students to discover the educational and career possibilities in ISAM. (Lead: NASA; Support: ED)

6.2. Broaden access to secondary and postsecondary education programs to capture talent from diverse technical backgrounds and build a capable workforce to support ISAM. (Lead: ED and NSF; Support: DOC, DOD, NASA)

6.3. Expand opportunities at the high school, undergraduate, graduate, and post-doctoral level to attract students from multiple disciplines – engineering, science, technology, policy, law, etc. – to tackle ISAM challenges through learning activities, awards and grants, internships, research opportunities, and other incentives to inspire a diverse workforce. (Lead: ED and NSF; Support: DOC, DOD, NASA)