IN-SPACE SERVICING, ASSEMBLY, AND MANUFACTURING NATIONAL STRATEGY

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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 http://www.whitehouse.gov/ostp/nstc.

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 http://www.whitehouse.gov/ostp.

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 the Office of Science and Technology Policy (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 strategy to guide U.S. Government (USG) direction for ISAM. OSTP formed an interagency working group, in collaboration with the National Space Council, for which this is the product. This ISAM National Strategy directly supports the United States Space Priorities Framework, with a focus on scientific and technological innovation, economic growth, commercial development, the rule of law, open markets, freedom of navigation, and fair trade.

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1. EXECUTIVE SUMMARY

The United States is a pre-eminent leader in space exploration, development, and operations, spanning a broad spectrum of applications from remote sensing to navigation to satellite communications. The benefits of U.S. leadership have had a positive impact on its citizens and provided economic and security benefits. As we move toward increased reliance on space-based services, the growing complexity and aspiration of global space missions are at an inflection point. Sustained leadership requires continual adoption of new capabilities.

The history of satellite servicing, refueling, assembly, and upgrade span from crewed servicing of telescopes, to in-space construction and maintenance of large structures, to autonomous robotic servicing missions. Recent commercial operations have extended the lifespan of satellites that are low on fuel. These novel and complex space activities are included within the In-space Servicing Assembly and Manufacturing (ISAM) set of capabilities, which support sustained economic activity and human presence in space. The United States will build on this foundation to accelerate a new, diverse, and market-focused ecosystem of autonomous persistent platforms and assets, to improve the way we use space for in-space and terrestrial operations.

This National Strategy outlines how the United States will support and stimulate the United States Government (USG), academic, and commercial ISAM capability development. It provides strategic goals to advance ISAM capability development discussed in the United States Space Priorities Framework. The next step following the strategy is to develop USG implementation action plans to fulfill the goals.

Six strategic goals build on existing investments and emerging capabilities, and chart a course for using a national approach to realize the opportunities enabled by ISAM. The six goals are: (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 future workforce as a potential outcome of ISAM innovation. These six goals aim to guide the United States as it continues to develop ISAM capabilities.

The goals address three challenges that need to be overcome in order to realize the benefits of ISAM capabilities: (1) improving coordination and collaboration both within the USG, as well as among the USG, academia, industry, and international partners; (2) sending a clear and consistent demand signal to private industry in order to stimulate investment, mitigate risk, and address investor confidence; and (3) establishing and adopting ISAM standards to help promote growth.

2. INTRODUCTION

DEFINITION

ISAM is a suite of capabilities, which are used on-orbit, on the surface of celestial bodies, and in transit between these regimes. ISAM capabilities enable specific activities, in the areas of s*ervicing*—the in-space inspection, life extension, repair, or alteration of a spacecraft after its initial launch, which includes but is not limited to: visually acquire, rendezvous and/or proximity operations, docking, berthing, relocation, refueling, upgrading, repositioning, undocking, unberthing, release and departure, reuse, orbit transport and transfer, and timely debris collection and removal; a*ssembly*—the construction of space systems in space using pre-manufactured components; and *manufacturing*—the transformation of raw or recycled materials into components, products, or infrastructure in space. These ISAM capabilities may use technologies that include *inter alia,* robotics; sensors and software for trusted autonomy; re-entry/deorbit systems; advanced in-space computing; verification and validation; standard interfaces; propulsion systems; systems engineering tools and techniques that support spacecraft serviceability; and low-cost reusable in-space mobility, logistics, and transportation systems, as appropriate. While commonality exists between the needs of on-orbit and surface-based activities, undertaking these activities in differing locations in space will require the development of tailored technologies, norms, standards, rules, and policies.

BENEFITS

ISAM capabilities can promote a sustainable space environment, improve the scientific output of in-space spacecraft and instruments, and create robust, sustainable, and enduring in-space infrastructure. Fostering an ecosystem that leverages ISAM capabilities can expand the performance, availability, resilience, and lifetime of space systems compared to the status quo. Space mobility, logistics, and reusability are enabled by ISAM capabilities. Cost-effective ISAM capabilities could bring economic benefits – remote sensing, climate science, human exploration – if available and effectively utilized through the coordination of relevant stakeholders.

3. CHALLENGES THIS STRATEGY ADDRESSES

The rapid growth of ISAM capabilities will continue to create unique opportunities and challenges for U.S. research and development, policy, legal, and regulatory initiatives over the next decades.

Stakeholders need better coordination. The first challenge is improving and facilitating coordination both within the USG, and between public and private institutions, to create a robust domestic ISAM ecosystem and provide worldwide leadership in this international environment. Some U.S. entities are already building and operating ISAM capabilities, and others are making major investments in the field. In response to this challenge, the USG will increase its coordination with these academic and commercial actors, to increase USG insights and acquisition of systems that incorporate academic and commercial capabilities. The United States will also maintain and expand coordination with key international partners. Likewise, collaboration will allow researchers and commercial companies to understand USG needs, and to develop capabilities to meet those needs.

Private sector needs a demand signal. The second challenge concerns the need for the private sector to receive consistent and reliable government demand signals that stimulate investment, mitigate risk, and create investor confidence. Robust commercial engagement, prudent planning, and stable funding are crucial to fully realize the potential impact of ISAM innovations. To respond to this challenge, when appropriate to the specific space domain endeavor, the USG will pursue its procurement of serviceable spacecraft and in-space commercial services to stimulate and sustain the ISAM sector.

Standards are nascent. The third challenge concerns support for the development of ISAM standards to enable efficient ISAM activities. The development and adoption of ISAM standards regarding spacecraft modularity, standard interfaces, materials and manufacturing processes, and operational safety will facilitate the emergence of a market for ISAM services. To respond to this challenge, the USG will support the development of ISAM standards, which are relevant to the unique challenges posed by the space environment. When possible, the USG will incorporate the consensus standards that exist in academia and the commercial industry, and reduce the differences in government and commercial mission requirements.

4. STRATEGIC GOALS

ADVANCE ISAM RESEARCH AND DEVELOPMENT

Use cases of ISAM capabilities are not fully characterized and proven due to the nascence of the field. Further academia-industry basic and applied research, development, demonstration, and testing are required. In order to maintain and expand U.S. leadership in this critical capability area, the United States will improve cutting-edge research and development, expand the ISAM-literate workforce, and coordinate among government, academic, and commercial sector actors.

Coordinate an R&D portfolio that fosters the development of high value ISAM capabilities. The United States will encourage R&D institutions, within academia, industry, and the USG to develop mission concepts and architectures that are enabled by ISAM capabilities. The United States will examine performance needs for future missions planned over the next decade, across all regimes from low Earth orbit to deep space, for civil, commercial, and national security space applications. The USG will align these R&D portfolios to support the identified mission needs, coordinate interagency partners, where appropriate, and reduce any unnecessary duplication of effort. Implementation of these USG R&D portfolios for ISAM capabilities will prioritize collaborations between industry and academia using cooperative R&D agreements, public-private partnerships, grants, and other mechanisms to drive innovation and investment.

Define a coherent ISAM ecosystem of available and needed capabilities. The United States will support the development of interface standards that would allow satellite servicers to connect to spacecraft for servicing. Other potential standards for support may be related to digital engineering and software interfaces. The United States will develop, prototype, and qualify

systems that incorporate these standards to enable missions with significantly increased efficiency and interoperability at the national level. The USG will advance technology readiness for architectures and missions; and support the development of cost models for ISAM-enabled systems to advance the maturation of ISAM-enabled technologies. The United States will seek to create defined paths for early stage in-space evaluation and demonstration of ISAM technologies and ensure availability for a broad range of researchers.

PRIORITIZE EXPANDING SCALABLE ISAM INFRASTRUCTURE

The USG in collaboration with academic and commercial ISAM stakeholders will, where needed, establish and build upon existing ground and space-based facilities and operations that enable ISAM capability development. The USG will outline ISAM capability development needs to enable future infrastructure for civil and national security interests, assess these needs against existing civil and commercial capabilities, and encourage policy, standards, and regulations to facilitate adoption within government efforts. The United States will use ISAM standards, best practices, technologies and capabilities to develop infrastructure.

Bolster ground-based infrastructure. The USG will identify and, where feasible, close gaps in current ground-based research facilities to support ISAM development and provide platform access to academic, industry, and international partners for technology development. The USG will, where appropriate and feasible, improve digital infrastructure to facilitate digital engineering and collaboration for ISAM activities. The United States will appropriately apply multiple tools to facilitate the scaling of industrial base ISAM capabilities for national need, contingency response, or national security.

Support development of space-based infrastructure. The United States will identify commercial ISAM capabilities to adopt for use in existing and future space and ground demonstration programs. Digital testbeds enable the transition from terrestrial infrastructure to space systems, and the USG will expand access for the academic and commercial space communities. An ISAM-enabled space infrastructure would simultaneously create a U.S. commercial advantage and open markets for national and international commercial interests. The United States recognizes the importance of establishing an ecosystem that promotes an affordable and sustainable transportation network and logistics capability.

ACCELERATE THE EMERGING ISAM COMMERCIAL INDUSTRY

The USG recognizes the commercial sector's capability, capacity, competency, and capitalization for rapid innovation. The sector seeks to expand and accelerate the development and delivery of ISAM capabilities and services in this growing market. The United States considers the development of a strong ISAM commercial base important to U.S. goals in space as described in the U.S. Space Priorities Framework.

Provide a sustained demand signal for ISAM capabilities. The USG will define and describe its requirements for ISAM-relevant missions, and prepare for the procurement of ISAM capabilities that meet these requirements. The USG supports the ownership and operation of space launch,

in-space logistics, spacecraft servicing, assembly, and manufacturing systems and services provided by the U.S. commercial space industry. The USG will assess emergent commercial ISAM capabilities for their applicability in supporting USG space missions. The USG will prioritize procurement and operation of ISAM servicing and lifetime extension capabilities from commercial providers over the development of USG capabilities, consistent with U.S. law and national policy.

Increase collaboration between government stakeholders and with industry. The USG will convene a nationwide alliance of ISAM capability 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. The purpose is to enable closer alignment and coordination of government needs with commercial capabilities, actively engage the private sector in standards development, and facilitate a predictable private investment climate. Where appropriate, the USG will increase opportunities for small, medium-sized, new entrant, and non-traditional businesses to support or provide ISAM capabilities. USG support could include acquisition of ISAM capabilities when appropriate, R&D awards, and access to government facilities and expertise.

PROMOTE INTERNATIONAL COLLABORATION AND COOPERATION

The USG will encourage international collaboration for responsible and interoperable ISAM capabilities among the global community of space-faring organizations, particularly among its allies and partners. The USG, in collaboration with the private sector, when appropriate, will work with the international community to identify areas of potential collaboration and cooperation on ISAM capabilities and operations to advance adoption of standards. The USG will maintain awareness of international ISAM developments and plans while forging and enabling agreements and arrangements that support United States priorities and goals. The USG will continue to consider global impacts and engage in cooperative relationships bolstered by positive domestic and international sentiment and support. When appropriate, ISAM technology will be leveraged to ensure the United States remains a global leader in space.

The United States supports advancing the development of voluntary international standards, best practices, guidelines, and norms for ISAM activities. Potential cooperative ISAM activities include rendezvous and proximity operations, docking, robotic capture and manipulation, in-space construction, and inspection. Efforts to develop and use ISAM will be cognizant of and consistent with relevant domestic and international frameworks and obligations. As ISAM and related space activities evolve, the United States will update its domestic regulatory regime as necessary to improve clarity and certainty for the authorization and continuing supervision of non-governmental ISAM activities. If unnecessary barriers to ISAM development exist, the United States will evaluate existing regulations.

PRIORITIZE ENVIRONMENTAL SUSTAINABILITY

Enabling, performing, and regulating ISAM capabilities creates a foundation for safe and responsible operations in space. The USG will continue to develop and implement best practices to support space safety and sustainability, promote the long-term use of outer space, and continue

to demonstrate responsible behavior and the stewardship of space. The United States will develop and promote standards and best practices widely - domestically and internationally - to spur a sustainable space economy and environment.

The USG will collaborate with commercial partners to support cost-effective space debris removal. The USG commits to mitigating long-lived debris through its investment and employment of ISAM and other capabilities. The USG will incentivize emerging ISAM logistics providers to remove space debris utilizing mission concepts such as fee-for-service, credits, bounties, or prizes.

Through ISAM projects, the United States will realize new climate science approaches to help global environmental sustainability, such as the monitoring of Earth's climate and the development of space products and services

INSPIRE THE FUTURE SPACE WORKFORCE

The development of new ISAM capabilities provides an opportunity for the Nation to continue to grow its science and technology workforce. By prioritizing ISAM capabilities, the United States will use the need for technology innovation as an area for recruitment of technical talent from all across the United States and abroad. This will equitably support the ability of a diverse and technically-skilled workforce to thrive and succeed in creating technologies to support space endeavors and exploration.

The USG will collaborate with academic institutions developing ISAM-enabled research and technological innovations. The United States will support curriculum development to teach the multi-disciplinary nature of ISAM. The USG will advocate for apprenticeships and work-integrated learning to foster industry-academia collaborations. The USG will employ the full suite of long-term grants, incentives, internships, and collaborative research, development, test, and evaluation options. These ISAM efforts will inspire K-12 students to be a part of the future of space, motivate multi-disciplinary study across a number of science and engineering disciplines, and train the next generation of technical, policy, and legal experts.

5. CONCLUSION

The maturation of ISAM capabilities offer the opportunity to improve the performance, affordability, endurability, resiliency, and flexibility of space systems. The six national strategic goals outlined in this strategy – the advancement of R&D capabilities; prioritizing scalable infrastructure; accelerating commercial innovation; promoting international cooperation and collaboration; fostering environmental sustainability; and inspiring the future space workforce – will produce greater space capabilities through appropriate policies, procedures, and operational infrastructure. ISAM capabilities can create the foundation for sustainable operations and serve as a strategic enabler to spur U.S. scientific and technological innovation, ensure the freedom to operate, and preserve the use of space for future generations.