


NASA
In-space Servicing,
Assembly, and
Manufacturing (ISAM)

**Technology
Catalog
2021**



NASA In-space Servicing, Assembly, and Manufacturing (ISAM) Technology Catalog **Preview**

A photograph showing two astronauts in white space suits working on the exterior of a space station or satellite. The station is covered in various equipment and structures. The background is a clear blue sky.

NASA's Technology Transfer Program ensures that innovations developed for exploration and discovery are broadly available to the public, maximizing the benefit to the Nation. Whether you're looking to start a new company, enhance an existing product, or create a new product line, you can gain a competitive edge in the marketplace by putting NASA technology to work for you. Technology transfer promotes commercial activity, encourages economic growth, and stimulates innovation in business and commerce.

In-space Servicing, Assembly, and Manufacturing (ISAM) is an emerging set of capabilities that enables inspection, relocation, refueling, repair, replacement, upgrade, modular assembly, and construction of space assets. These technologies are needed to enable robotic science and human exploration missions that are sustainable, affordable, and resilient. The intended applications for ISAM technologies are assembly, exploration, sample return, and mission extension.

This is a preview of the catalog. An NDA is required to obtain the full version as it contains confidential and export controlled technical data. Goddard Space Flight Center controls the release of the catalog to domestic companies that have a reasonable opportunity to produce the technology.

Technology Transfer Initiative

By providing U.S. companies with early access and an equal playing field to ISAM technologies, NASA is helping to jump start multiple, new space-related industries including a satellite servicing market. A robust commercial marketplace will provide the U.S. government with cost-effective options for meeting future mission needs, while also bolstering the domestic economy.

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ISAM Technology Portfolio

Rise of the Immortal Spacecraft & Visionary Missions

Investments throughout this decade have made the once seemingly impossible, possible. The combined capability of Servicing, Assembly, and Manufacturing has created the possibility of an immortal spaceship that can be continually refueled, repaired, and upgraded. ISAM technologies allows us to manufacture new structures and components, repair and repurpose structures on-orbit, expand the scale of scientific instruments, and extend the service life of on-orbit assets.

Servicing

Servicing is the on-orbit and on-surface alteration of a client object after its initial launch using another spacecraft or surface agent.

Assembly

Assembly involves on-orbit and on-surface aggregation of components to create an asset that cannot be achieved with traditional deployment methods and available launch vehicles.

Manufacturing

Manufacturing involves on-orbit and on-surface transformation of raw materials into usable components and infrastructure.



Realizing the Promise of ISAM

Sustainable, Affordable, and Resilient Space and Surface Missions



The ISAM Technology Catalog provides domestic companies with insight and access to technology NASA has developed. By transferring technology *as it is developed* rather than only after it has been demonstrated in orbit, NASA expedites new capabilities into the commercial market and promotes U.S. global leadership in satellite servicing.

The catalog includes innovations that have been patented and are immediately available to license through the NASA Technology Transfer Portal. In addition, the catalog includes technologies that are in the preliminary design phase, as well as conceptual designs.

By documenting the existence and function of technology across this range of maturity, this catalog includes almost 200 items beyond the patented technologies listed in the Technology Transfer Portal.

How to use the Catalog

This catalog is intended for domestic companies to review and consider licensing opportunities for commercial use. NASA technology innovators prepared the following descriptions of ISAM technologies that have been developed in support of spaceflight missions, technology demonstration, or in pursuit of concept development. Organizations interested in commercializing ISAM technologies are invited to contact the points of contact listed in the catalog to discuss how they can be adapted for other spaceflight and surface applications.

Technology Descriptions

The ISAM technologies in this catalog have been described by function, technical maturity, and application. They represent design solutions for hardware and software algorithms, as well as the engineering insight to derive performance requirements and to adapt commercial hardware for space. Conceptual designs that represent the current pathfinding approach for ISAM capabilities that NASA is pursuing are also included in the catalog.

Functional Concepts

Spaceflight Adaptations

Algorithms

Hardware Designs

The icons shown are used to indicate the design maturity of each catalog entry.

While many catalog entries are immediately available for license, the majority of technologies are still in development, and patents will be pursued if there is commercial interest in licensing.

The algorithms offered here will be provided as Algorithm Description Documents (ADD). Please refer to NASA's Software Catalog for code at <https://software.nasa.gov>.

Conceptual design

solutions (ideas) to inspire new or current development efforts.



Identifying the driving performance requirements to accomplish

ISAM functions in a space

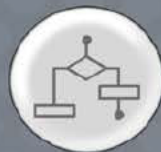
environment is often a key factor in custom

vs commercial decisions. Industry can benefit from decades of innovative expertise applied to deriving those

parameters, critically evaluating spaceflight worthiness of commercial hardware, and adapting & qualifying hardware for space.



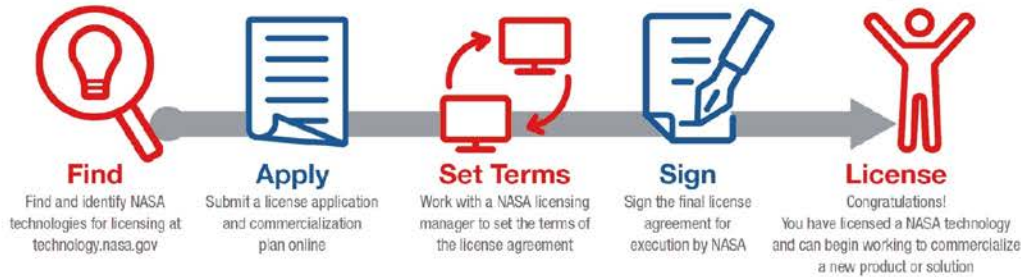
Algorithms and software development conventions.



Proven designs for ISAM functions.



How to License NASA Technology



NASA develops all sorts of technology to solve the tough challenges of exploring space, advancing the understanding of our home planet, and improving air transportation. Often, those same inventions have other untapped applications. Through patent licensing, those technologies can be transformed into commercial products and solutions that can give your business a competitive edge.

Center
Partnership
Offices

Servicing @ GSFC

<https://technology-gsfc.ndc.nasa.gov/>

Assembly @ LaRC

<https://technology.nasa.gov/larc/>

Manufacturing @ MSFC

https://technology-msfc.ndc.nasa.gov

ISAM Technology Points of Contact

Technology innovators at various NASA field centers have contributed to the ISAM technologies listed in this catalog. They have initiated New Technology Reports (NTR) or patents to document functionality and performance, and they can discuss the design rationale and performance with companies considering applying for a license. Organizations interested in commercializing ISAM technologies should contact:

Servicing @ GSFC

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Assembly @ LaRC

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Manufacturing @ MSFC

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ISAM Technology Transfer Workshops



Significant investments are being made by industry and government agencies in the development of ISAM capabilities. The shared vision to establish the infrastructure for ISAM services will only be possible through an affordable commercial marketplace for ISAM products.

NASA is leading the way to promote commercial interest in ISAM technologies by hosting an annual Technology Transfer Workshop. Our technology innovators present their latest developments, and our project managers discuss the current status of ISAM missions. Invited speakers from

NASA program offices and other government agencies present the broader market need for ISAM capability, and participants are given a tour of NASA's state of the art facilities used to demonstrate new hardware and software.

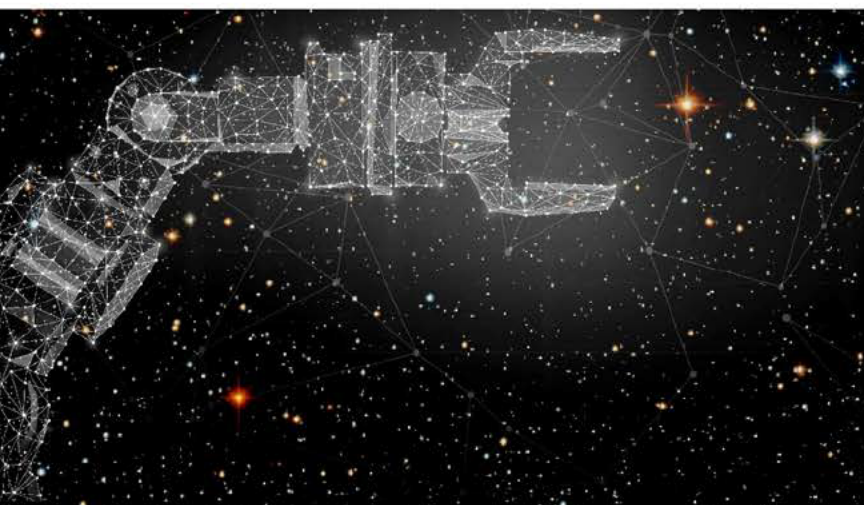
Join us to learn about what ISAM can do for you!

Information about current ISAM projects and the ISAM Technology Transfer Workshop are posted on our website.

<https://www.nasa.gov/nexis/isam/>



**Promoting Domestic Expertise
in ISAM Technologies
that will Prepare the Nation
to Accomplish NASA's Vision**



Robotic Servicing for Space Applications

In the coming decade, robotic servicing is expected to bring about the dawn of a new era of extended and upgraded spacecraft utility, saving billions of dollars in satellite manufacturing costs. Spacecraft life spans are limited by consumables, the exceedingly harsh natural space environment, and sometimes imperfect human design. It is now possible to refuel, repair and upgrade on-orbit assets to extend their life, relocate their vantage point, and improve performance with enhanced subsystems and sensors.

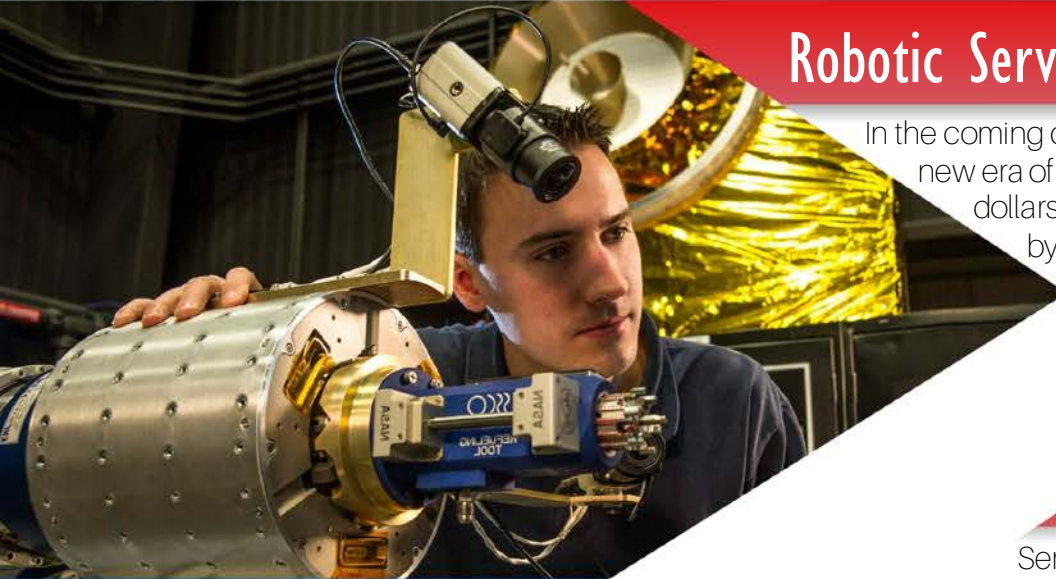
and Terrestrial Missions

Servicing can enable unprecedented science and human exploration of our solar system and beyond. Robots will serve as helpful companions alongside astronauts in terrestrial conditions, constructing habitats, moving resources, and extending human presence farther than ever before. Servicing can extend mankind's reach on large scale, in-space construction of large telescopes unconstrained by fairing size, and persistent platforms designed for modular instrument replacement, and regularly renewed resources.

ISAM Technologies for On-Orbit Servicing

Servicing covers a wide range of activities spanning fixing, improving, and reviving satellites and refers to any work to refuel, repair, replace or augment an existing asset in space. Servicing allows for satellite life-extension and upgradability as technology evolves on Earth. The most mature and robust of the ISAM capabilities, servicing is the conduit through which NASA will end the era of one-and-done spacecraft.

Journeying Longer
and Seeing
Farther



Servicing Spectrum

ISAM capabilities include these functions that will enable bold new space missions, operations, and infrastructure:

- Remote Survey & Rendezvous
- Capture and Relocate Space Assets
- Refuel and Replenish
- Replace Spacecraft Bus Modules
- Replace Instrument Modules
- Repair & Augment



Servicing Technologies

Relative Navigation System

Rendezvous and Proximity Operations (RPO) Algorithms

RPO Sensor Suite

Reconfigurable Avionics & Software

Robot System & Servicing Arm

Tools and Mating Systems

Tool Drive

Vision Systems for Tool Worksites

Tool Avionics

Motors

Robotic Tools

Robotic Modular Tool Adapters

Tool Stowage

Astronaut Tools

Other Tools

Fluid Transfer System

Cooperative Servicing Aids

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114

Enabling Bold
Space Missions

Break out of the Launch Vehicle Fairing

The ability to launch individual components of a large structure and robotically assemble them in space makes various seemingly impossible concepts possible. This capability allows for assembly of habitats in places further away than low-Earth orbit, and opens up the door for constructing large telescopes and other platforms that would otherwise be impossible to deploy from the confines of the launch vehicle fairing.

Design with Room to Grow

In-space assembly provides the compelling opportunity to expand orbiting structures and enhance science measurements. Truss structures can be assembled so that a persistent orbiting platform can serve as host for short-term technology demonstrations, or long-term instrument hoteling. The persistent platform can evolve to incorporate upgrades of support subsystems and new technologies, and is tailored to the operational environment, not the launch environment.

ISAM Technologies for On-Orbit Assembly

Assembly is the practice of gathering two or more parts together in space into a single, functional aggregate structure. A suite of assembly capabilities allows us to launch individual parts to space separately and bring them together, thereby overcoming the constraints of rocket fairing volume limitations.



Expand and Evolve
with In-Space
Assembly

Building a Sustainable Future

Long-duration Exploration missions require a paradigm shift in the design and manufacturing of space architectures. The ability to perform In-Space Manufacturing (ISM) provides a solution towards sustainable, flexible missions, both in-transit and on-surface, through on-demand fabrication, repair, and recycling capabilities for critical systems, habitats, and mission logistics and maintenance. ISM capability is of particular interest for its potential to contribute to in situ resource utilization (ISRU).



for Humanity in Space

Manufacturing is the fabrication of components in space as the need arises. This capability allows for greater adaptability in dealing with unforeseen challenges and has the potential to eliminate the need to launch as many components (including contingency components) up front. It also allows for the production of unprecedented monolithic structures, such as jointless truss beams. On-orbit coating applications and nano-manufacturing allows for surface coatings to be applied or renewed to recover optical and thermal properties.

**ISM - Make It -
Don't Take
It**

ISAM Technologies for In-Space Manufacturing (ISM)

The suite of in-space manufacturing technologies listed in the catalog are still in development, and represent the current pathfinding approach that NASA is pursuing. Organizations interested in developing ISM technologies are invited to contact the POCs listed in the catalog.

Resilient Systems with Adaptive Capacity

The basic formula for sustainable space exploration combines all three ISAM capabilities: consumable replenishment and component repair (servicing), construction of large and precise structures (assembly), and creation of components from feedstock or in-situ resources (manufacturing) to break the dependence on earth supply chain logistics. Development of flight-proven ISAM capabilities is continuously evolving, and today the pace of development is accelerating.

for Sustainable Space Exploration

ISAM technologies facilitate the replenishment of supplies that run out from spacecraft fuel, to coolant, to oxygen. They can help in ensuring the longevity and operability of spacecraft and life support systems with unplanned repair and planned maintenance. In-space manufacturing contributes to the ability to adapt to the unforeseen and utilize in-situ resources. Together, servicing, assembly, and manufacturing promise flexible, resilient, and cost-effective space operations for sustainable exploration.



Design to Manage the Unforeseen

ISAM Technologies for Adaptive Capacity

Adaptive Capacity is designing to remedy unforeseen disruptions, such as:

- Repair faulty or damaged equipment
- Relocate to more advantageous location/orbit, avoid hazards
- Remove and replace new or upgraded instruments (e.g. Moore's Law)
- Construct and/or reconfigure based on evolving scenarios
- Evolve topography based on new opportunities
- Produce elements and components not needed at launch
- Fabricate gossamer structures unable to handle launch loads
- Manufacture the toolset needed for temporal challenge