

CONSORTIUM FOR SPACE MOBILITY AND ISAM CAPABILITIES

In-Space Servicing, Assembly, and Manufacturing (ISAM)

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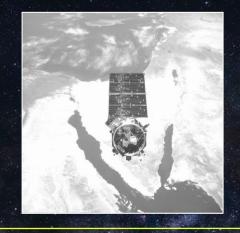
# What is ISAM?



In-Space

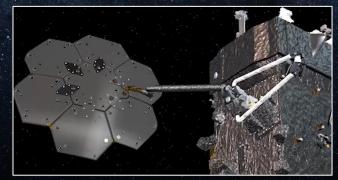


Servicing

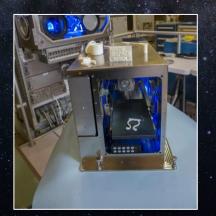


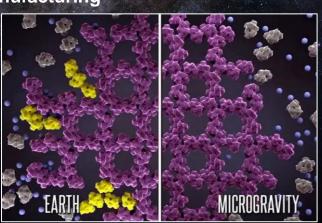
Assembly





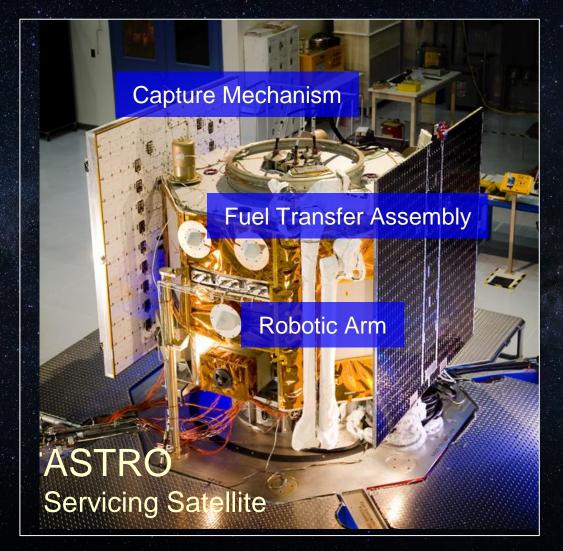
Manufacturing

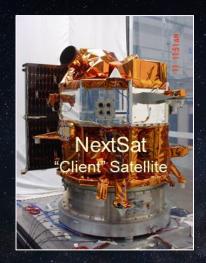




## My Background in ISAM

Started with DARPA's Orbital Express (launched 2007)

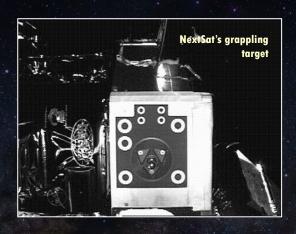


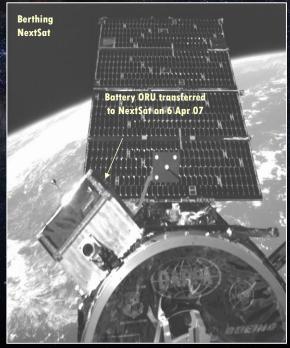












### OSAM National Initiative: Space Superhighway





### Earth-to-Orbit Logistics

Fosters a competitive commercial launch industry

EO Hub

Provides routine, low-cost access to space

Low Earth Orbit



Supports responsible disposal and debris mitigation

Geostationary Orbi

### **ISAM** National Strategy and Implementation Plan



### FOSTER AN ECOSYSTEM TO LEVERAGE ISAM CAPABILITIES

- Support and stimulate USG, academic, and commercial ISAM capability development
- Consistent with US Space Priorities Framework (Dec 2021)

#### **BENEFITS**

- Promote a sustainable space environment
- Improve scientific output of spacecraft and payloads
- Create robust, sustainable, and enduring in-space infrastructure
- Expand performance, availability, resilience, and lifetime of space systems

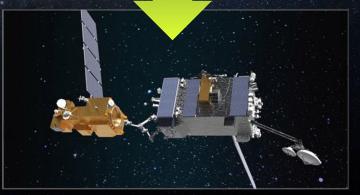
#### STRATEGIC GOALS

- 1. Advance ISAM research & development
- 2. Prioritize expanding scalable ISAM infrastructure
- 3. Accelerate the emerging ISAM commercial industry
- 4. Promote international collaboration and cooperation
- 5. Prioritize environmental sustainability
- 6. Inspire a diverse future space workforce









Develop technologies supporting emerging space industries including Satellite

**Servicing & Assembly** 

**Enabling in-space...** 



**Space Logistics** 

Roman Space Telescope

#### Close Inspection

Small inspectors diagnose anomalies, enabling corrective action and in-space repair operations. Small satellite inspectors launch "on need."

#### **Free-Flyer Capture and Relocation**

Commercial servicers perform autonomous capture of active spacecraft and uncontrolled debris, relocating them to new operational, disposal or salvage orbits.

### **Delivery and Aggregation**

Commercial launch and high-efficiency in-space transportation systems deliver commodities and cargo to assets in multiple orbits, enabling frequent and lower-cost resupply.

#### Maintenance & Repair

US spacecraft launch with standard interfaces enabling commercial robotic servicers to conduct planned and on-demand manufacturing, repair and maintenance. Human exploration spacecraft refurbished and recertified in space.

#### Refueling and Fluid Transfer

Spacecraft launch with standard in-space fueling (and other) accommodations. Commercial servicers provide fueling on-demand in multiple orbits and planetary surfaces.

#### **Installation and Upgrade**

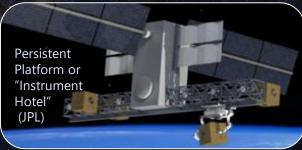
Great Observatories and platforms in multiple orbits enable hosting of operational and experimental instruments and payloads. Commercial servicers provide delivery, installation and hosting services.

#### **Manufacturing and Assembly**

Purpose-built in-space systems enable audacious new science, exploration, and commercialization of space: a 20-meter space telescope discovers signs of life on extrasolar planets; an outer planets human exploration mission departs aboard an in-space assembled craft; manufacturing products for use in space and on Earth provide a stimulus to the U.S. economy.









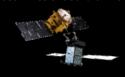


Not all activities depicted are currently funded or approved. Depicts "notional future" to guide technology vision.

### Space Access, Mobility and Logistics 2030

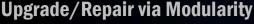
#### **Orbit Repositioning**

- Move assets at will
- Decommission at end-of-life



#### **Responsive Launch**

- Launch to any orbit from any location
- 24hr launch call-up
- Hot-swappable payloads
- **NEVER launch ballast again**



- **Enable high-performance processing**
- Upgrade electronics / sensors
- Upgrade with new capabilities
- Evolve capabilities along with missions and threats
- The "Immortal Spacecraft"



#### **XGEO SDA**

- Provide support for US interests
- Tailor orbits to time of year and lighting conditions
- Augment space traffic control along XGEO lanes and around Moon



- Inspection and characterization
- Multi-agent collaboration
- **Explore disaggregation beyond LEO**



### **XGEO Operations**

- Enable and protect commercial shipping lanes
- Support civil exploration of deep space
- Comm, PNT, processing nodes
- Maneuver dominated regime leverage multi-mode propulsion

### **Sustained Space Maneuver/**

**Maneuver Without Regret** 

- Unlock spacecraft from fuel constraints that currently exist
- Maneuver and reposition assets with impunity
- Protect and defend US government, civil and commercial interests
- Enable truly persistent assets and platforms throughout XGEO



#### **On-Orbit Assembly and Manufacturing**

- Assembly and construction of large structures
- Basis for space based logistics chain
- **Enable space commodity exchange**
- Tailor structures for environment not launch

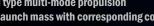


- Position orbital assets at time and place dictated by dynamic scenarios
- Create uncertainty through complexity



#### **Mid-flight Refueling**

- Use fuel required for the mission
- Decrease transit time/Increase revisit rate
- Fly novel flight paths for mission requirements
- Single fuel type multi-mode propulsion
- Decrease launch mass with corresponding cost reduction





#### **Novel Orbits**

- Learn how novel, low-energy orbits can be exploited
- Map the dynamic Earth-**Moon LaGrange Points**

VLEO - MEO

GEO – 2x GEO 3x GEO - L1/L2

# **Commercial ISAM Is Growing**







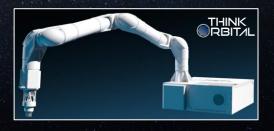












And many, many, many more...

### **COSMIC:** A Nationwide Alliance for ISAM



### **VISION**

Create a nationwide alliance that enables the U.S. space community to provide global leadership in ISAM.

### **MISSION STATEMENT**

Making ISAM a routine part of space architectures and mission lifecycles.



### CAPABILITY DEVELOPMENT

Develop, mature, and demonstrate ISAM technologies that enable and enhance mission utility.



# ECOSYSTEM ECONOMICS

Promote U.S. leadership in ISAM technologies and capabilities that change the business model away from single-use space assets.



### MISSION APPLICATIONS

Encourage and guide missions to use ISAM capabilities as part of commercial and government program lifecycles.

COSMIC information approved for unlimited public release

# **COSMIC** Organization











**Steering Committee** 

(USG + Industry + Academia)

**Consortium Management Entity** 

Execute day-to-day operations according to strategic guidance from the Steering Committee

**Industry Caucus** 

**Academia Caucus** 

**Government Caucus** 

Research & Technology

Demonstration Infrastructure

Missions & Ecosystems

Policy & Regulation

Workforce Development

### **COSMIC 2024 Products**



### **Steering Committee (SC)**

State of COSMIC Assessment

### **Consortium Management Entity (CME)**

**COSMIC Lexicon** 

Mapping of Products to COSMIC Objectives

Mapping of Products to National ISAM Implementation Plan

**Government Caucus** 

**Industry Caucus** 

Academia Caucus

### Research & Technology (RT)

ISAM Technology Taxonomy

ISAM Technology Inventory

Data Collection for ISAM Critical Capabilities Roadmap

### Demonstration Infrastructure (DI)

ISAM Testbed Taxonomy (Digital, Ground, Flight)

**ISAM Testbed Inventory** 

State of US ISAM Testbeds Report

### Missions & Ecosystems (ME)

ISAM Capability Taxonomy

ISAM Use Cases & Value Proposition

ISAM Funding Opportunities Repository

Data Collection for ISAM Critical Capabilities Roadmap

### Policy & Regulation (PR)

ISAM Policy and Regulation Repository

ISAM Policy Education Seminar Series

### Workforce Development (WD)

ISAM Education Advocate Inventory

**ISAM Hard Problems List** 

ISAM STEM Resources and Outreach Opportunities

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# COSMIC Supports the National ISAM Implementation Plan



1. Advance ISAM Research & Development

1.1.1 Evaluate ISAM cost / benefit

ME1 ME2

1.1.2 Launch an in-space ISAM test capability

1.2.1 Maintain ISAM State of Play

RT1

RT2



ME2

1.2.2 Prioritize ISAM research

RT3

ME4

1.2.3 Research power technologies

1.2.4 Research autonomy technologies

2. Prioritize Expanding Scalable ISAM Infrastructure

2.1.1 Coordinate on standards development

2.1.2 Incorporate standards in government SVs

2.1.3 Flight qualify standard hardware

2.2.1 Close gaps in US testing capability

DI1

DI2

DI3

2.2.2 Create propellant purchasing strategy

3. Accelerate the Emerging ISAM Commercial Industry

3.1.1 Adopt commercial modular infrastructure

3.2.1 Convene a nationwide ISAM consortium

3.2.2 Improve access to USG test facilities

DI2

3.3.1 "Buy services" vs. "buy hardware"

ME3

3.3.2 Create procurement documentation for ISAM

ME3

4. Promote International Collaboration & Cooperation

4.1 Encourage international cooperation on norms

4.2 Assess ISAM national security risks

4.3 Inform ISAM regulations



4.4 Promote US regulatory intent



PR2

4.5 Promote international cooperation

4.6 Promote international research and joint testing

DI:

. Prioritize Environmental Sustainability

5.1 Develop ISAM procurement options

5.2 Revise US policy for RPO

PR2

5.3 Evaluate EOL disposal policies

PR2

6. Inspire the Future Space Workforce

6.1 Engage K-12 students in ISAM

WD3

6.2 Increase access to education programs



WD3

6.3 Expand multi-disciplinary education opportunities



WD3

LEGEND:



- Indirectly informs

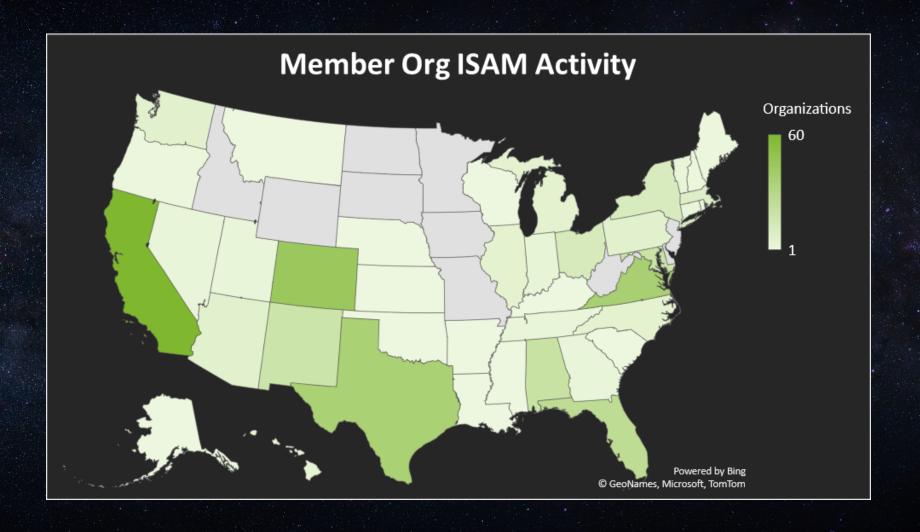


Directly supports

### **COSMIC Membership**



- 180 member organizations
- 791 authorized participants
  - 51% industry
  - 39% government
  - 10% academia
- No cost to join
  - US persons working for US organizations with a vested interest in US leadership in ISAM







# NOW ACCEPTING MEMBERSHIP APPLICATIONS



**MEMBER ORGANIZATIONS** 

**AUTHORIZED PARTICIPANTS** 

**COLLABORATION SITE** 

Join today!! cosmicspace.org/membership

### **ISAM** Research & Technology

- In-space manufacturing for Earth
  - Semiconductors
  - Optical fibers
  - Pharmaceuticals
  - Tissues
- In-space assembly and manufacturing for Space
  - Robotic assembly of large structures
  - Robotic assembly of spacecraft and spacecraft components
- In-space servicing
  - Inspection
  - Life Extension
  - Refueling (robotic spacecraft, crewed missions to the Moon or Mars)
  - Upgrade / Repair



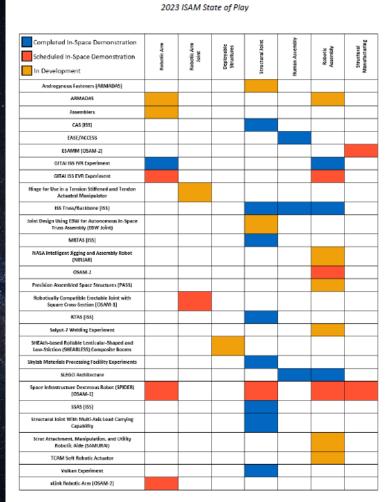


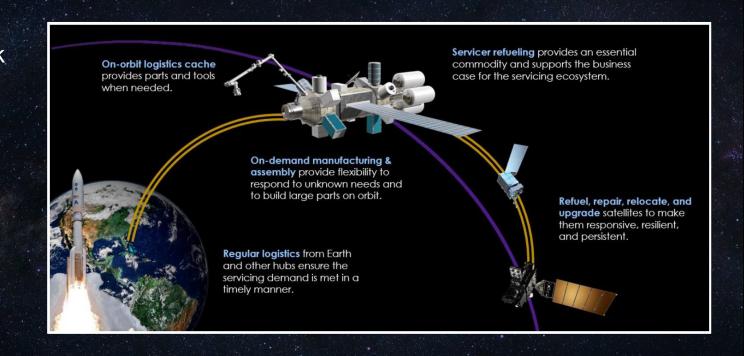
Figure 9: The technologies which contribute to the capability of structural manufacturing and assembly are wide ranging, due to the complexity of the process. The current advancement in this capability area focuses on robotic structural manufacturing and assembly.

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### Making ISAM a Routine Part of Space



- "ISAM includes capabilities where the future looks different through the windshield than it does through the rearview mirror" – Ron Birk
- Information sharing for collaboration
- Use cases and value propositions
- Gaps technology, operations, acquisition, policy, legal, funding
- Standardization / interoperability





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