EXPLORESPACE TECH
TECHNOLOGY DRIVES EXPLORATION

EXPLORE: In-space Servicing, Assembly, and Manufacturing (ISAM) and Rendezvous, Proximity Operations and Capture (RPOC)
NASA Space Technology Mission Directorate

STMD welcomes feedback on this presentation. Please visit https://techport.nasa.gov/framework/feedback if you have any questions or comments regarding this presentation.

Develop technologies supporting emerging space industries including Satellite Servicing & Assembly

Seeker Test Flight, 2019

Gateway Deep Space Logistics

Roman Space Telescope

Rotating Space Station

Enabling in-space…

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 and client relocation.

Maintenance & Repair

US Spacecraft launch with standard interfaces enabling frequent upgrades. Commercial servicers 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.

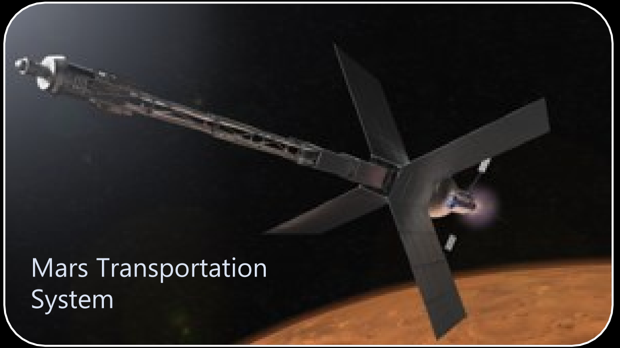
Installation and Upgrade

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 commercial-ization 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.

OSAM-1



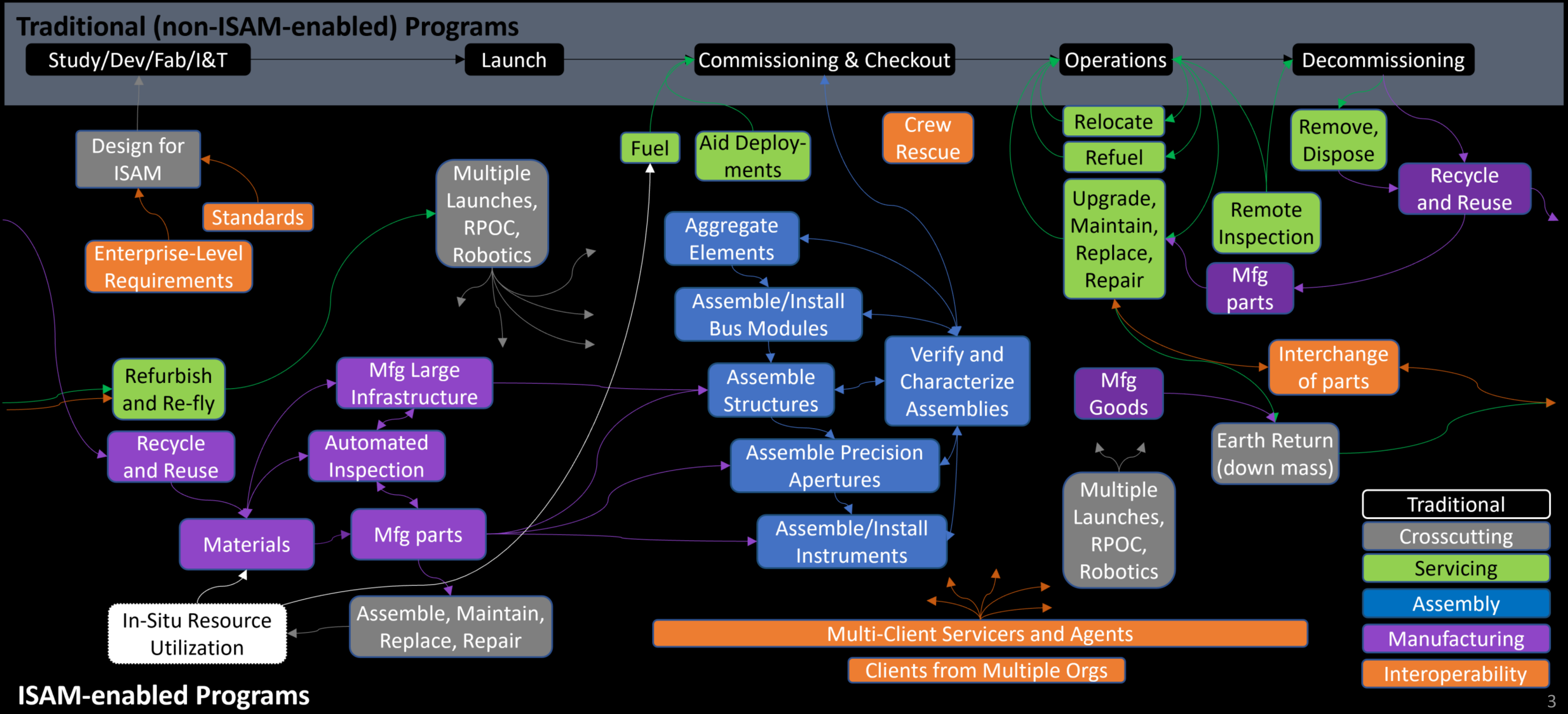
Mars Transportation System

Persistent Platform or “Instrument Hotel” (JPL)

Great Observatories

All activities depicted not currently funded or approved. Depicts “notional future” to guide technology vision.

What is In-Space Servicing Assembly & Manufacturing?



RPOC- & ISAM-Enabled or Enhanced Architectures

Civil Space
Human Exploration
Science
Commercial
National Security

NASA Exploration Platforms
- LEO
- Cislunar
- Robotic Lunar Surface
- Human Lunar Surface
- Mars Spacecraft
- Robotic Mars Surface
- Human Mars Surface

Notional NASA Science Platforms

Planetary
- Rover Upgrade
- Sample Return
- Small Body Missions
- Large Observatories

Earth
- Remote Observation Platforms (Hoteling)
- Refueling and Instrument Upgrade
- Distributed Observation Systems, Formation Flying (FF)

Astrophysics
- Large Observatories
- Very Large baselines interferometers (large structures and tethered FF)
- External Occulters (Starshades)
- External Optics FF (high energy imaging)

Heliophysics
- External Occulters (Solar) and External Optics
- Lunar Surface Instrumentation

Table of Contents

ISAM Introduction and Envisioned Future		Develop technologies supporting emerging space industries including Satellite Servicing & Assembly
		What is ISAM?
Priorities and Plan by Envisioned Future Architecture	NASA	Great Observatory Servicing and Assembly
		Human Exploration Vehicle Servicing and Assembly
	All	Space Fleet Refueling and Upgrade
		Platforms and Logistics
		Active Debris Remediation
Consolidated Priorities		Prioritized Activities
		Capability Gaps, State of the Art, Investments, and Goals
Acronyms		

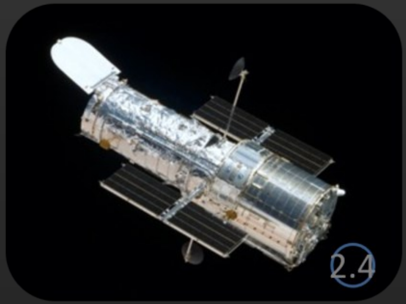
Notional Commercial Platforms
- Exploration / Tourism (e.g. Commercial LEO Destinations)
- Logistics / Depots (e.g. SpaceX Starship)
- Inspection (e.g. InsureSat)
- Remote Observation (e.g. ISS Bartolomeo)
- Communications (e.g. SPIDER)
- EOL Disposal (e.g. AstroScale)
- Servicing (e.g. MEV, MRV)
- Resource Mining and Prospecting (e.g. ULA)
- …

Notional National Security Space Platforms
- Space Domain Awareness
- Logistics
- Servicing
- Resiliency
- …

Notes:
1. For surface assembly applications, see "Excavation, Construction, and Outfitting" EFP, Hilburger et al
2. For in-space manufacturing details, see "Advanced Manufacturing" EFP, Vickers et al

Great Observatory Servicing & Assembly

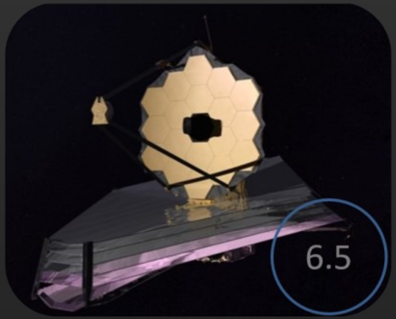
Hubble Space Telescope (1990, LEO)



Extensive servicing (Space Shuttle, crew + robotic)

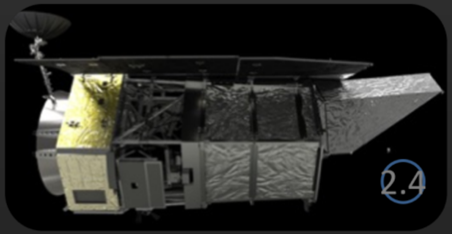
3+ decades of world class science

James Webb Space Telescope (2021, SE-L2)



No servicing or assembly planned

Roman Space Telescope (2025, SE-L2)



Refuelable (no servicer planned)

Increased science operations if refueled; potential to upgrade other systems

Sun-Earth L2 Servicer (mid 2030s, SE-L2)

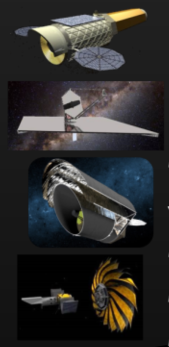
PROPOSED Astrophysics and Planetary Assembled Observatories

Robotic servicing and assembly of large SE-L2 telescopes and starshades;

"BIG" SCIENCE; Risk, cost, and mass distribution across multiple launches

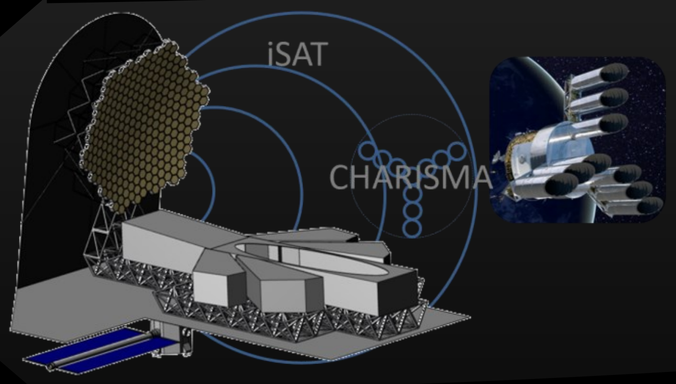
Astro2020 Great Observatory (2040s, SE-L2)

6m off-axis



Refuelable, modular, and upgradeable

Multi-decade, world-class science via planned instrument upgrade, refueling, and maintenance



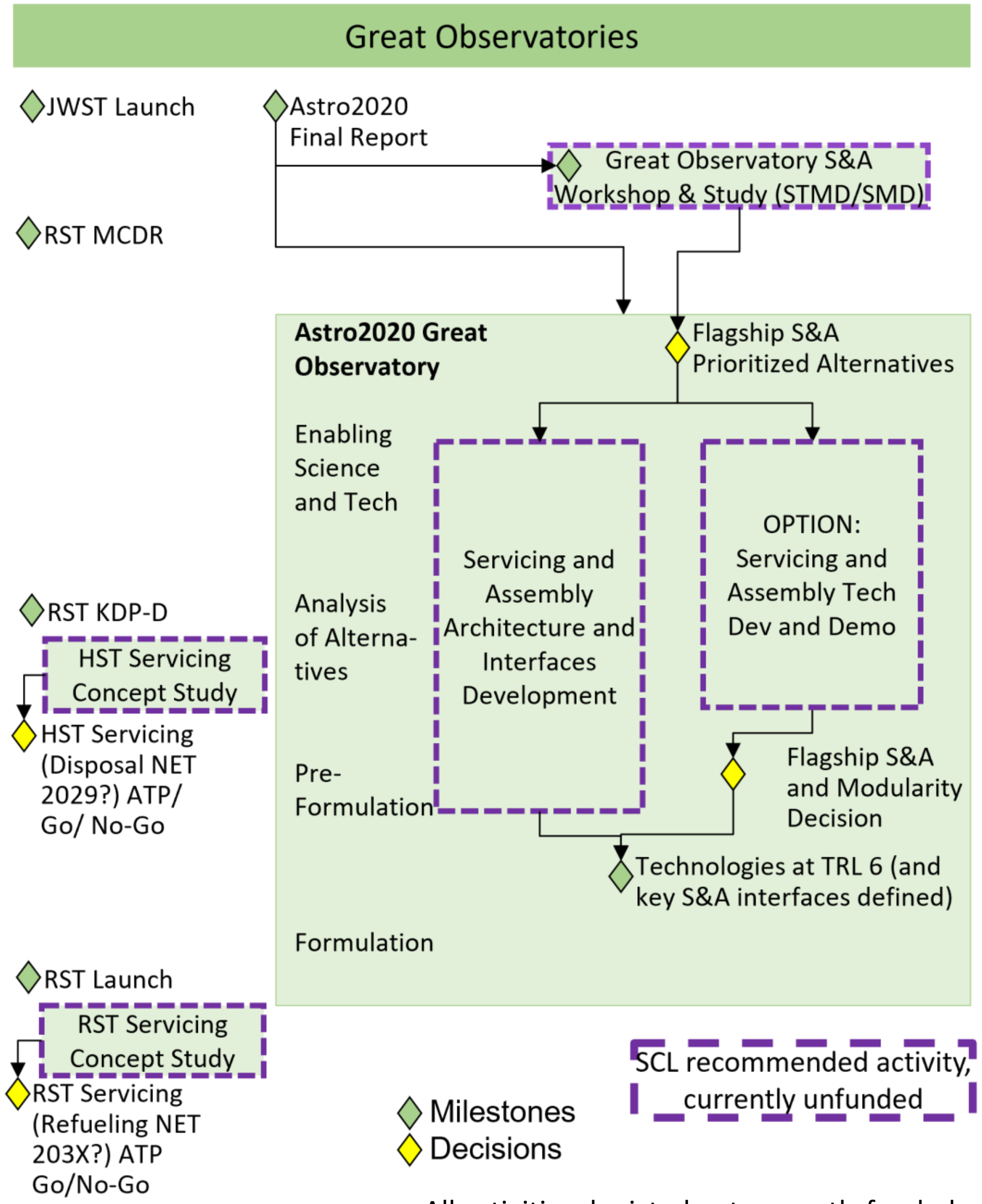
Assembled Great Observatories

Refuelable / Assembled Starshades

Primary mirror diameter (m)

All activities depicted not currently funded or approved. Depicts "notional future" to guide technology vision.

Gaps, Priorities, Investments, and Plans for Great Observatory S&A



Priority Gap: Astro2020 Great Observatory Servicing & Assembly (S&A)

Architecture: telescope and spacecraft modularity; Sun-Earth L2 (SE-L2) logistics, servicing, and assembly concept of operations (conops) and agents; use of deployment and assembly techniques;

Closure Plan: Great Observatory Servicing and Assembly Workshop and Study

- Multi-org activity to mature architectural options and ConOps, and identify and prioritize technology gaps for a serviceable and/or assembled Astro2020 flagship

Other Priority Gaps

- Instrument installation and upgrade – telescope and instrument design features to accommodate in-space servicing
- Sun-Earth L2 Robotics – especially mobile systems for manipulation of very large and sensitive instruments
- Standards – define ISAM cooperative interfaces, aids, and interoperability
- Lifecycle Cost Benefit Analysis (Value Proposition) – utility gained vs. cost incurred by mission phase to incorporate cooperative ISAM features, extend mission life, assemble in space
- Optical telescope modular assembly, metrology, and V&V

Selected Relevant Investments

- Servicing and Assembly robotics – OSAM-1, SPIDER, OSAM-2, Canadarm3 (CSA)
- Assembly interfaces – SPIDER RF reflector assembly (STMD/Maxar), Precision Assembled Space Structure (PASS, STMD)
- Deep Space Delivery Logistics – Gateway Logistics Services

All activities depicted not currently funded or approved. Depicts “notional future” to guide technology vision.

Human Exploration Vehicle Servicing and Assembly

Skylab (1973, LEO)

Crew and Logistics Delivery (Apollo docking), EVA Repair

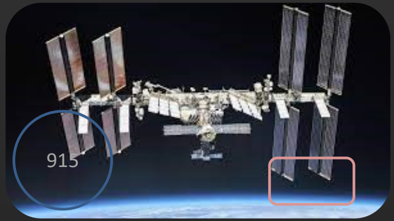
3 crewed periods totaling 172 days over 9 months

Space Shuttle Orbiter (1981-2011, LEO)

Crew and Cargo Del., Spacecraft Reloc., Earth Return, Servicing, and Assembly

133 total missions; serviced dozens of spacecraft (including HST), assembled ISS

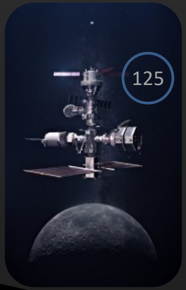
International Space Station (2000, LEO)



Assembly, bi-prop refueling, module replace-ment, payload hosting and deployment, tele-operated robotics, EVA repair

Humans and robots living and working in LEO for 20 years and counting

Gateway (2024, Cislunar)



Assembly of Elements (docking), Crew and Cargo Delivery, Chem/ Xenon Refueling, Robotics

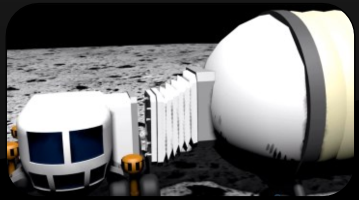
Sustainable lunar and solar system exploration via cislunar operations

Commercial LEO Destinations Program (202X, LEO)

Private, crewed, orbiting platforms supporting human research, technology demonstrations, biological and physical science, and the National Lab

Lunar Landing and Surface Systems (202X)

In-space and surface docking for Fueling and Crew Transfer

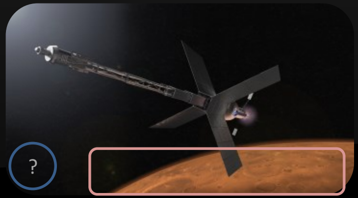


Sustained return to the lunar surface

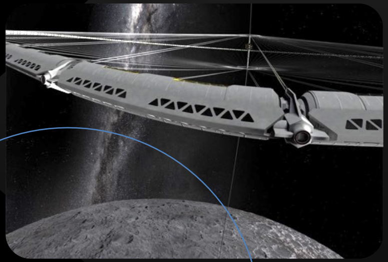
Mars Exploration (20XX)

Mars Transportation System cislunar assembly, (re)fueling, refurb, recert; Maintenance *en route* to and on surface of Mars; Mars Ascent Vehicle surface fueling

First humans on Mars



Where to Next?



Very large-scale space manufacturing assembly, and servicing

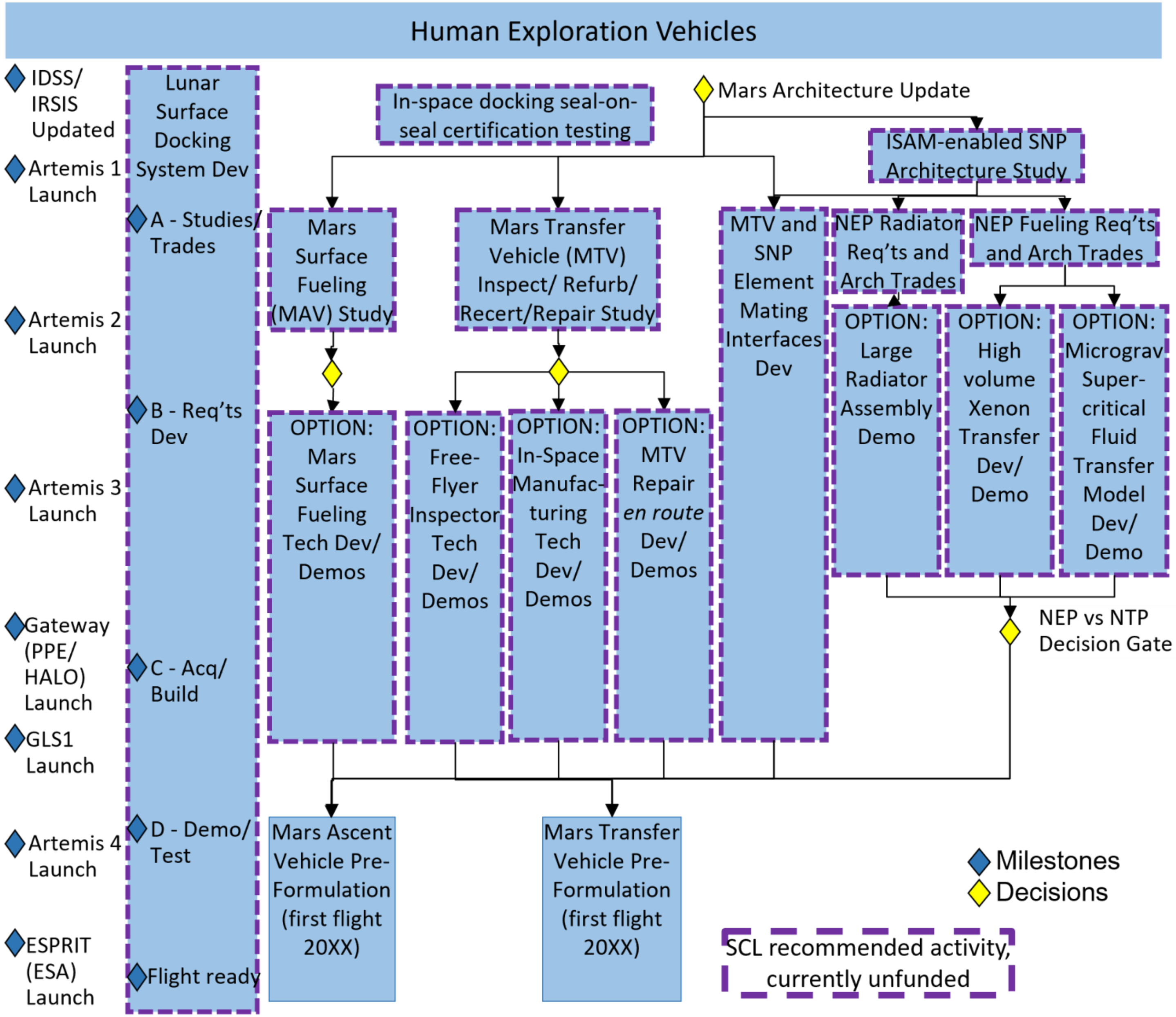
Space Factories? Human exploration beyond Mars?

Future

Pressurized Volume (m^3)
Radiator Area

All activities depicted not currently funded or approved. Depicts “notional future” to guide technology vision.

Gaps, Priorities, Investments, and Plans for Human Exploration



All activities depicted not currently funded or approved. Depicts "notional future" to guide technology vision.

Priority Gap: Space Nuclear Propulsion Servicing and Assembly Architectures – Large in-space transportation systems require unprecedented scale of fueling operations and heat rejection systems likely to benefit from in-space assembly techniques

Closure Plan: SNP Technology Maturation Planning – Ongoing activities including assembly, autonomy, and fluid transfer subject matter experts to develop NEP fueling and radiator assembly concepts and identify critical technology development activities

Other Priority Gaps – pending Mars architecture updates

- Lunar and Mars surface pressurized crew transfer interfaces – includes suitport and surface docking and tunnels
- In-space docking system seal-on-seal certification – supports active-to-active docking system mating (androgyny)
- Mars surface storable fueling systems – supports Mars Ascent Vehicle (propellant landed separately from vehicle)
- Free-flyer inspection, and robotic repair, maintenance, refurbishment and recertification requirements and architecture – support Mars Transportation Vehicle *en route* to Mars and between trips

Relevant Current Investments

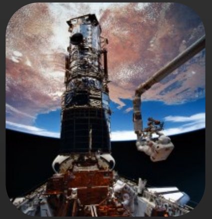
- In-space Manufacturing – investment (funding source)
- In-Space Assembly – PASS, ARMADAS (STMD)
- In-Space Robotics – OSAM-1, OSAM-2 (STMD), Canadarm3 (CSA)
- In-Space Fluid Transfer (non-cryo) – Gateway (SOMD), OSAM-1 (STMD), ESPRIT (ESA)

Space Fleet Servicing and Upgrade

JP-8 (1990)

USG specifies JP-8 as the common fuel for US military aircraft

Hubble Servicing Missions (1993-2009, LEO)



Five servicing missions installed corrective optics, new instruments, and modular bus H/W

USB (1996)

First USB standard released with specs for cables, connectors, and protocols for computers

Orbital Express (2007, LEO)

Demo of fully autonomous coop-erative rendezvous and docking, re-fueling, and compo-nent replacement

ISS & RRM (2011-21, LEO)

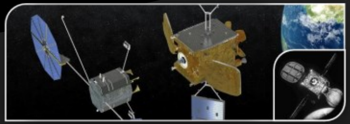
Dozens of robotic and EVA ORU installations; Coop. Bi-prop refueling (Russian), Robotic fluid transfer demos including cryo and storable fluids (high pressure Xe demo pending) to legacy and cooperative interfaces

PROPOSED Responsive and Resilient Space Fleet

Cooperative servicing features and modular designs; Commercial services for routine planned, and on demand robotic servicing

Modular designs, and In-space logistics enable on-demand, responsive spacecraft for planned and unplanned operations.

MEV (2020-21, GEO)

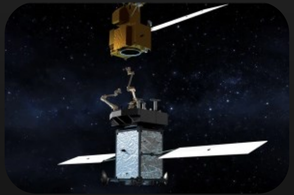


1st commercial satellite servicing via life extension

RSGS/MRV (2024, GEO)

Public-private partnership develops a robotic servicer including module delivery and installation

OSAM-1 (2026, LEO)



Refuels a legacy satellite and demonstrates assembly and manufacturing ops

Refuelable Spacecraft

All spacecraft launched with interfaces enabling autonomous robotic refueling of standard fuels

Upgradeable Spacecraft

All spacecraft launched with "USB for Space" interfaces to enable upgrade

Paradigm Change

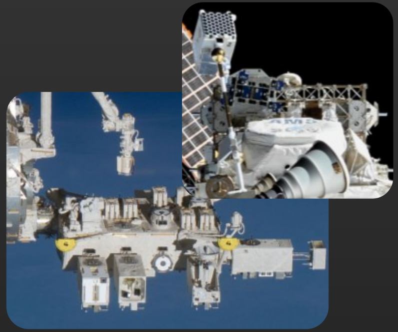
Routine refueling and on-orbit upgrade

In-space logistics support Space Fleet

All activities depicted not currently funded or approved. Depicts "notional future" to guide technology vision.

Platforms and Logistics

ISS Hosted Payloads (2000, LEO)



Internal and external payload delivery, installation, and hosting

Dozens of internal and external payloads delivered and hosted

Commercial ISS Platforms

Commercial payload hosting services in 51.6deg inclined LEO

Commercial LEO Destinations

Commercial payload hosting and crew destinations

Gateway (202X, Cislunar)

Internal and external payload delivery, installation, and hosting

Cislunar hub for lunar and solar system exploration

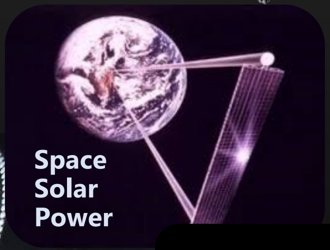
PROPOSED creation of long duration evolvable platforms

Robotic Servicing, Assembly and Manufacturing of advanced space infrastructure; Interoperable, cooperative, modular interfaces on all USG spacecraft

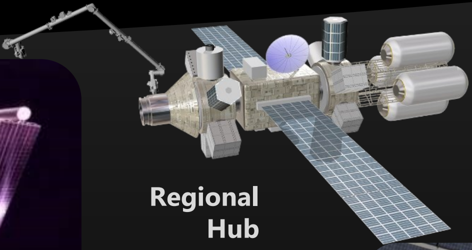
"Space Superhighway", logistics, vehicles and platforms in multiple orbit regimes host science, weather, and in-space test payloads, and provide transportation and fueling, enabling increased flexibility, reduced cost and risk, enabling ambitious space endeavors and economic growth

Space Tugs

Fuel Depots

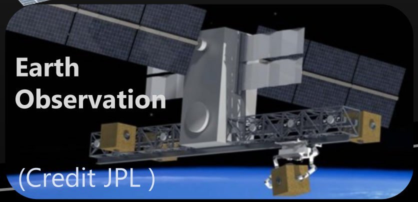


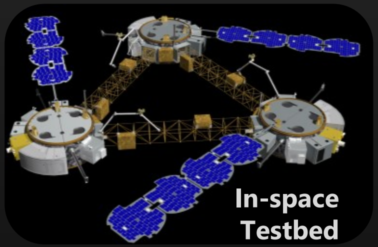
DARPA NOM4D

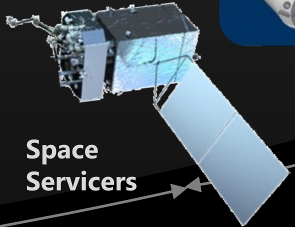


Regional Hub

DIU Orbital Outpost







Space Servicers

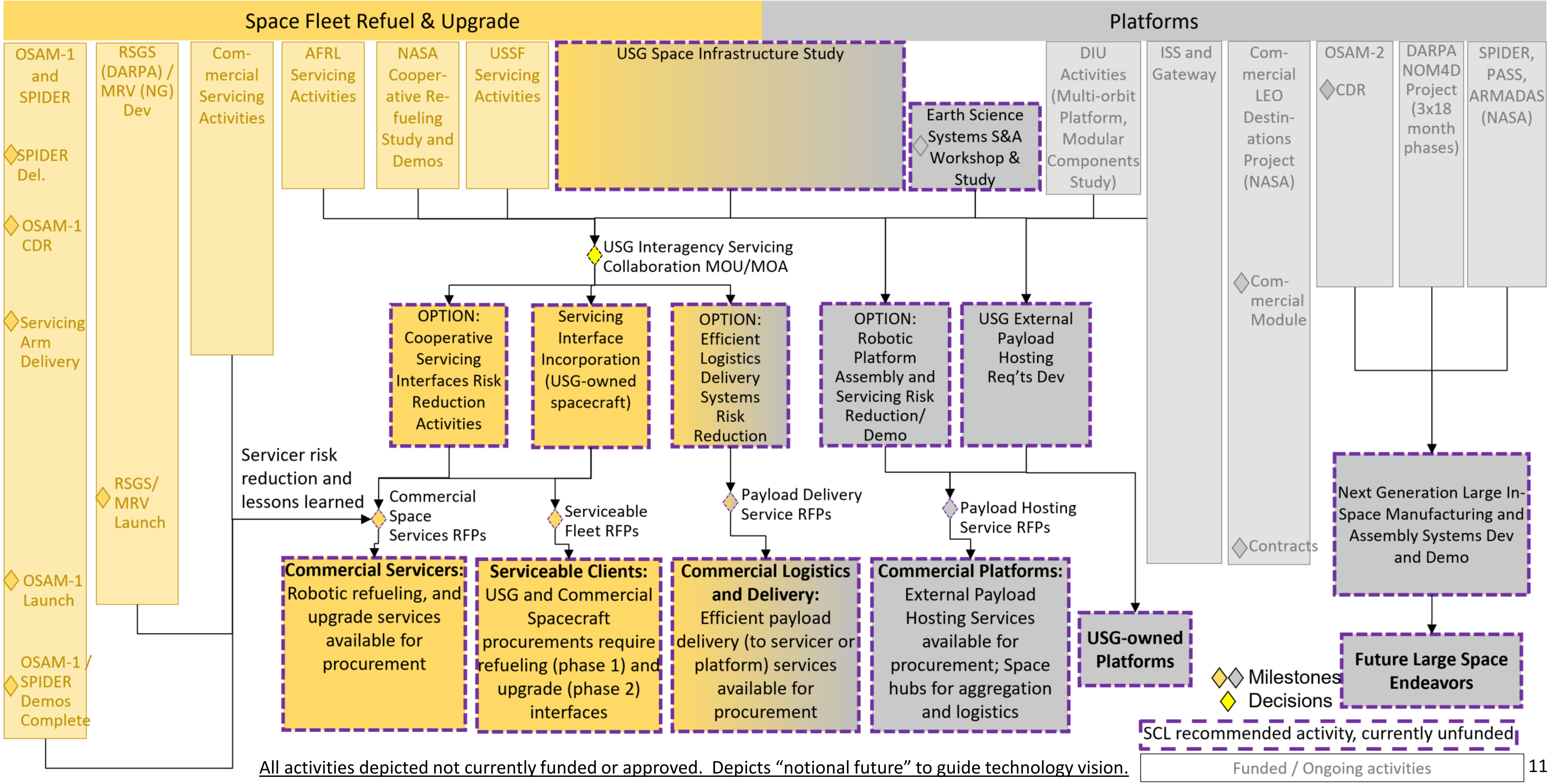
Future Large Space Endeavors

Persistent Observation and Testing Platforms

In-Space Logistics

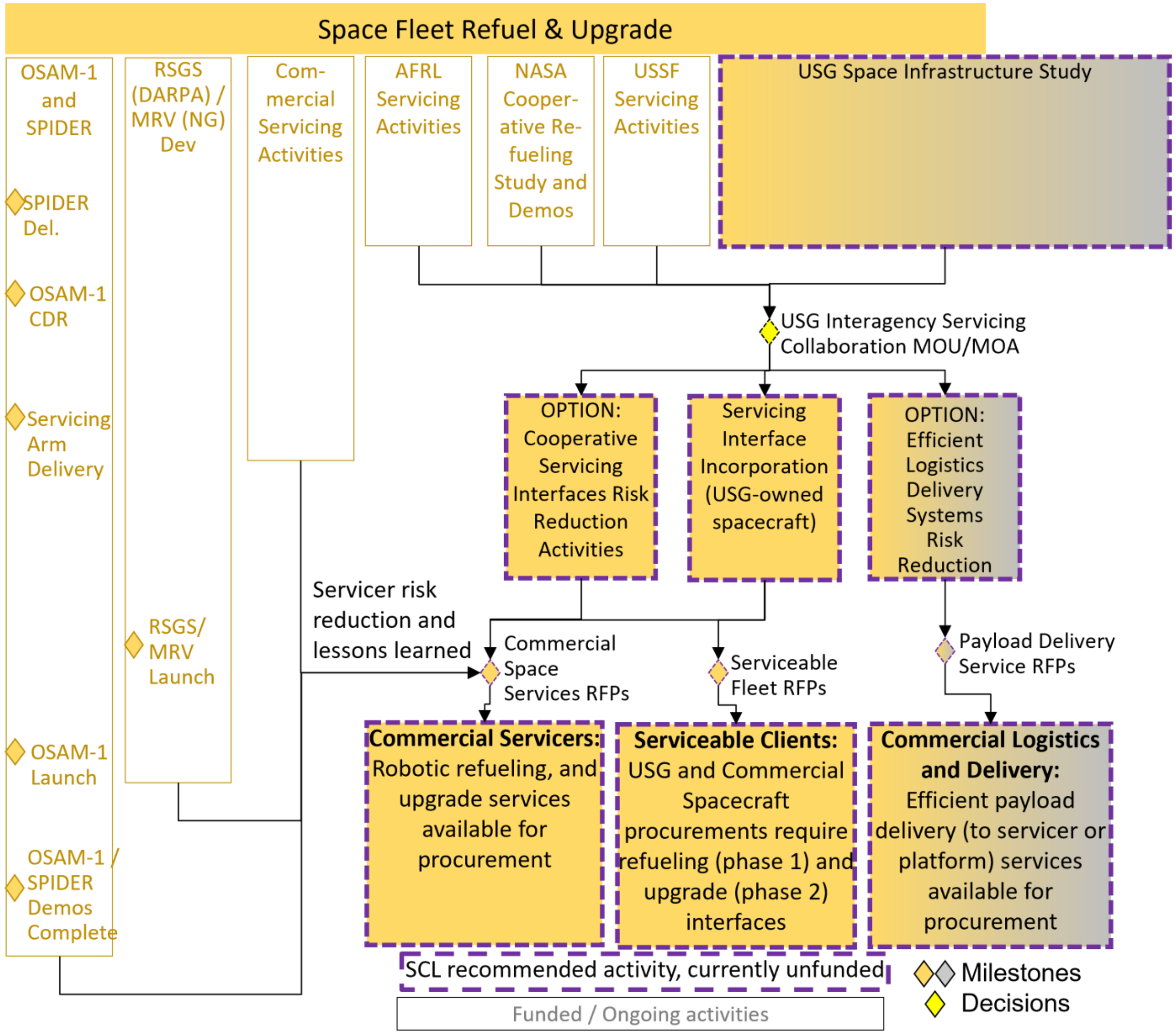
All activities depicted not currently funded or approved. Depicts "notional future" to guide technology vision.

Cross-Cutting Space Infrastructure and Logistics



All activities depicted not currently funded or approved. Depicts "notional future" to guide technology vision.

Gaps, Priorities, Investments, and Plans for Space Fleet Refueling and Upgrade



Priority Gap: Refuelable and upgradable space fleet and servicers - interoperable ecosystem of serviceable client spacecraft, servicers, and delivery vehicles

Closure Plan: Space Infrastructure Study & Workshops

- Coordination USG space infrastructure plans
- Collaborate with industry on standardization of propellant commodities, common interfaces for capture, refueling, and upgrade of components
- Goal is infrastructure of commercial services providing refueling, component upgrade, on-demand, in multiple orbit locations

Other Priority Gaps

- Incorporation of common interfaces for RPO, capture, refueling, and upgrades across the fleet
- Key fluid transfer challenges: liquid-free venting of PMD tanks in microgravity; flight pneumatic compressor for GHe/GN2 transfer and refill; propellant accounting (high accuracy and multi-phase fluid flow metering)
- In-space demonstration of suite of high priority gaps needed for future systems

Selected Relevant Current Investments

- RPOC – ISS VV (commercial), GLS, Gateway, Orion (ESDMD), OSAM-1 (STMD), Others
- Servicing – OSAM-1 (STMD), RSGS (DARPA), Others
- Refueling – OSAM-1, Gateway (ESDMD), USSF, Others

All activities depicted not currently funded or approved. Depicts "notional future" to guide technology vision.

Gaps, Priorities, Investments, and Plans for Platforms and Logistics

Priority Gap: In-Space Logistics Infrastructure – Commercial logistics, delivery, and payload hosting platforms

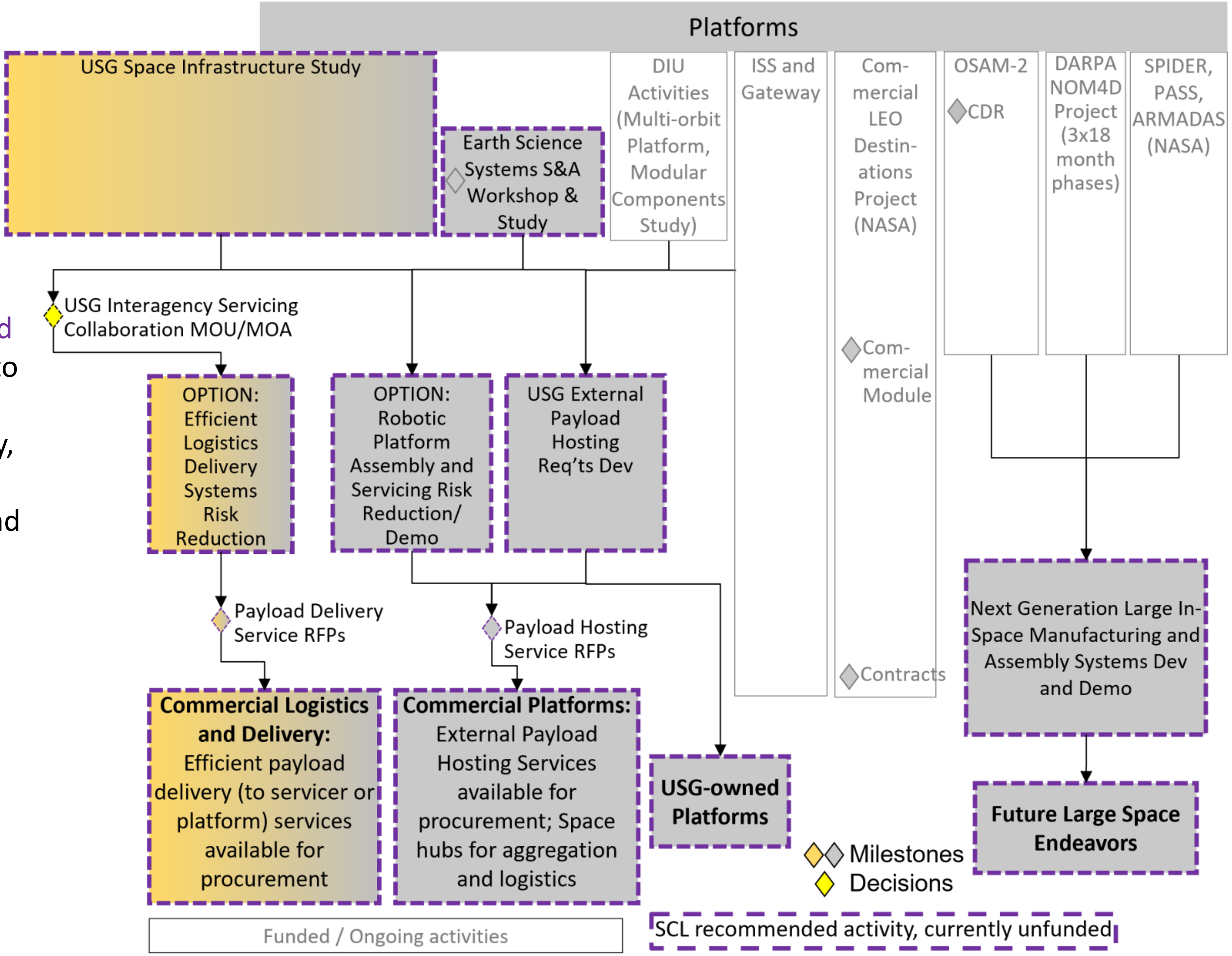
Closure Plan: Space Infrastructure and Logistics Study - Study to define future architectures to leverage future envisioned capabilities leading to selected end states

Other Gaps

- Efficient servicing and assembly payload delivery and logistics – in-space systems to deliver commodities to servicers and platforms
- Modular elements and interfaces for initial assembly, in-situ exchange, expansion/adaption/evolution (extend power, heat control, communication, payload rotations, etc.) with associated design guides
- Systems for “next generation” in-space manufacturing and assembly of very large space platforms

Relevant Investments

- Automated Assembly Architectures – Automated Reconfigurable Mission Adaptive Digital Assembly Systems (ARMADAS) (STMD), PASS (STMD)
- Human/Autonomy Trust – ISS, CLD, Orion, Gateway (ESDMD/SOMD)

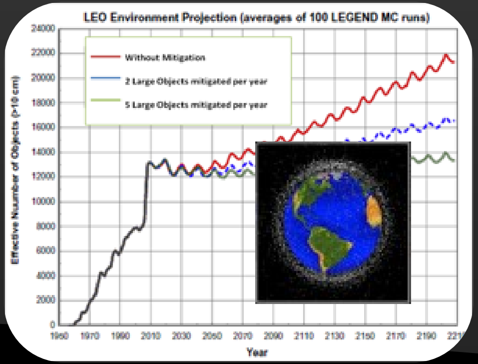


All activities depicted not currently funded or approved. Depicts “notional future” to guide technology vision.

Active Debris Remediation

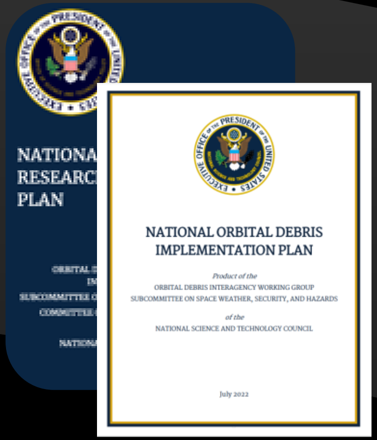
1984 – STS-51-A mission retrieves and de-orbits the defunct Westar 6 satellite after failed deployment

2010 - Pivotal work by NASA ODPO and others recommends mitigation and remediation action



2018 - European RemoveDEBRIS mission tests a variety of remediation technologies

National Orbit Debris R&D Plan (2021) and Implementation plan (2022)



ELSA-d (LEO, 2021)

PROPOSED Ability to move, remove, and reuse debris

Large and small debris is manipulated to avoid collisions just-in-time; Bulk debris removal services are commercially available; Defunct satellites are sold to private companies for refurbishment or scrap

The ability to avoid debris-on-debris collisions, rapidly clean up orbits after debris generating events, and de-orbit dangerous debris reverses Kessler Syndrome and reduces costs to space operators

ESA ClearSpace-1 Launch (2025) Credit Clear Space

JAXA Commercial Removal of Debris Demonstration (CRD2)

Phase II: Debris deorbit (by 2026)

Phase I: Debris Inspection (by 2023)

NASA OTPS ADR Cost Benefit Study (2022)

X Prize ADR Challenge Study (2022)

SpaceWERX (USSF) Orbital Prime STTR Awards (2022)

NASA STMD Ignite SBIR Solicitation ADR Topic Released (2022)

International ADR missions

<u>All activities depicted not currently funded or approved. Depicts "notional future" to guide technology vision.</u>

Gaps, Priorities, Investments, and Plans for Active Debris Remediation

Priority Gap: Active Debris Remediation Approach – Identify prioritized ADR approaches that reduce operational risks and minimize cost in order to focus near term technology investment

Closure Plan:

- **Step 1 – NASA OTPS Cost Benefit Analysis Study** – in progress, to be completed November 2022

Other Priority Gaps – pending CBA final report

- **Capture of large space debris** – capture of various types of uncontrolled large space debris, including spent upper stages and derelict spacecraft. RPO and capture systems to perform pose estimation and capture of uncontrolled, non-prepared objects at order of magnitude higher relative attitude rates as compared to existing state of the art.
- **Capture and remediation of small space debris** – Capture and remediation of small space debris (<10cm)
- **Non-traditional ADR mission concepts and capabilities** – just in time collision avoidance (JCA), responsive post-fragmentation cleanup, and other concepts could be more scalable than traditional approaches that physically capture debris. Additional study is required to determine feasibility and scalability.

Relevant Gaps captured in other EFPs

- ESPA-Class High-ΔV SEP (Propulsion Gap)
- Laser ranging for unprepared spacecraft and debris
- Small Spacecraft Propellentless Deorbit Devices (EDL Gap)
- In-space recycling and re-use (Advanced Manufacturing Gap)

Selected Relevant Current Investments

- **SBIR Ignite** – 2023 solicitation is progress
- **Small Satellite Propulsion Systems** – Several ongoing investments
- **Studies and Analyses** – Cost benefit, risk assessments, tech evaluations
- **OSAM-1** – Rendezvous, proximity operations, and capture of a (controlled) non-prepared (legacy) spacecraft, including sensors, computer vision, robotics and tools

A more simplified view – Where should USG ISAM stakeholders focus?

ISAM Clients
(The Customer)

Priority: Support USG customer

- Focus on USG ***enterprise-level*** cost and risk
- Educate USG spacecraft buyer
  - Quantify alternatives/benefits (studies and trades)
  - Include ISAM capabilities in early mission architecture trade space
- Help USG spacecraft buyers and operators:
  - Specify and procure serviceable and assembled spacecraft
  - Procure in-orbit services

ISAM Agents
(Servicers, Inspectors, Robotics, Tools, Manufacturers, EVA)

Priority: Enable commercial providers

- Purchase services and fund infrastructure / destinations
- Break down regulatory hurdles
- Assist the providers: publish and share guidelines, best practices, lessons learned, support standards development efforts
- Fund high risk, high return enabling technology development and demos

(Cargo launch, transport, "last mile" delivery)

ISAM Logistics

RPOC and Sat S&A Gaps by Roadmap Team (1/2)

Team	Gap Title	Currently Investing
In-orbit and Surface Docking and Berthing Systems	In-space Docking and Berthing Systems	
	Pressurized In-Space IDSS System Technologies	✓
	Unpressurized In-Space Docking and Berthing	✓
	Pressurized In-Space Next Generation Docking for Crew and Cargo	✗
	Surface Mating Systems	
	Pressurized Surface Mating between Vehicles and Elements for Crew and Cargo	✓
	Unpressurized Surface Mating and Berthing Systems	✗
	Mating port for transfer of crew and cargo (Suit port)	✓
	Dust Tolerant Sealing Surfaces and Mechanisms	✓
Instrument Servicing and Installation	Future Great Observatory Servicing and Assembly architecture and agents	✗
	Upgrade or install instruments on large space observatories	✗
	Precision instrument latches	✗
	Modular thermal design for on-orbit Instrument Installation	✗
	Address contamination concerns associated with on-orbit instrument servicing & installation	✗
	Thermal safekeeping approach for unpowered on-orbit or on-surface installation	✗
Storable and EP Propellant Refueling	Storable Propellant Mass Accounting	✓
	Pressurant accommodation and ullage venting for in-space fluid transfer	
	Venting of PMD Tanks in Microgravity	✗
	Efficient Pneumatic Compressor/Pump for In-Space Gas Transfer	✓
	In-Space Xenon Transfer Technologies	✗
	Filling of PMD Tanks in Microgravity	✗
Design for ISAM	Modular design for on-orbit installation	✓
	ISAM cooperative interfaces, aids, and standards	✓
	ISAM Value Proposition and Acquisition Strategy	✓

RPOC and Sat S&A Gaps by Roadmap Team (2/2)

Team	Gap Title	Currently Investing
In Space Manufacturing	In-space structural joining and welding	✓
	In-space salvage and recycling	✓
On-Orbit and On-Surface Validation and Verification	Integrated modeling and digital twin for space-based V&V	✗
	V&V of in-space assembled modular structures using metrology	✗
	V&V of a precision assembled telescope using metrology	✗
ISAM Robotics Systems and Hardware	Affordable servicing and assembly robotics (supply chain)	✓
	Deploy, install, manipulate soft goods (umbilicals and shades)	✗
	Proximity and vision sensors for increased robotic autonomy	✓
	Contact sensors for robotic manipulation	✓
	Robotic manipulation system architectures enabling large and dispersed workspaces	✓
Small Sat and ISAM Delivery Logistics RPOD	Consolidated advanced sensors for relative navigation	✓
	Small satellite RPOC with close free-flying inspection of a high-value asset	✓
	Affordable on-demand unpressurized cargo module delivery to in-space assets	✓
	Small satellite docking systems	✓
	SmallSat RPO Propulsion Capability	✓
ISAM Materials	Dimensionally Stable High Stiffness Structural Materials for In-Space Assembled Telescopes	✓
Assembly of Structures	Assembly of modular structures	
	Assembly of efficient, modular, stable structures	✓
	Assembly of Nuclear Propulsion Vehicle backbone structure with utility connections	✗
	Robotically Assemble In-Space Platform	✓
Active Debris Remediation	Capture of large space debris	✗
	Capture and remediation of small space debris	✗
	Non-traditional ADR mission concepts and capabilities	✗

Acronyms

- ADR = Active Debris Removal
- AFRL = Air Force Research Laboratory
- ARMADAS = Automated Reconfigurable Mission Adaptive Digital Assembly Systems
- APD = Astrophysics Division
- ATP = Authority to Proceed
- cc = cubic centimeter
- CDR = Critical Design Review
- CHARISMA = Caroline Herschel high-Angular Resolution In-Space assembled Multi-Aperture
- CIF = Center Innovation Fund
- ConOps = Concept of Operations
- COTS = Commercial Off The Shelf
- CPOD = Cubesat Proximity Operations Demo
- CSA = Canadian Space Agency
- DARPA = Defense Advanced Research Projects Agency
- DIU = Defense Innovation Unit
- DSNE = Design Specification for Natural Environments
- ECI = Early Career initiative
- EFP = Envisioned Future Priorities
- ESA = European Space Agency
- ESDMD = Exploration Systems Development Mission Directorate
- ESPRIT = European System Providing Refueling, Infrastructure and Telecommunications
- EVA = Extra Vehicular Activity
- ExPA = Express Pallet Adapter
- FF = Formation Flying
- FTS = Force-Torque Sensor
- GCD = Game Changing Development
- GEO = Geosynchronous Orbit
- GHe = Gaseous Helium
- GLS = Gateway Logistics Services
- GN2 = Gaseous Nitrogen
- GO = Great Observatory
- GW = Gateway
- HABEX = Habitable Exoplanet Observatory
- HALO = Habitation and Logistics Outpost
- HEV = Human Exploration Vehicle
- HST = Hubble Space Telescope
- H/W = Hardware
- I&T = Integration & Test
- IDA = International Docking Adaptor
- IDSS = International Docking System Standard
- IRSIS = International Rendezvous System Interoperability Standards
- ISAM = In-Space Servicing, Assembly, and Manufacturing
- iSAT = in-Space Assembled Telescope
- ISM = In-Space Manufacturing
- ISS = International Space Station
- JP-8 = Jet Propellant-8
- JWST = James Webb Space Telescope
- KDP = Key Decision Point
- LEO = Low Earth Orbit
- LST = Large Space Telescope
- LUVOIR = Large UV/Optical/IR Surveyor
- MAV = Mars Ascent Vehicle
- MCDR = Mission Critical Design Review
- MEV = Mission Extension Vehicle
- Mfg = Manufacturing
- MOA = Memorandum of Agreement
- MOU = Memorandum of Understanding
- MRV = Mission Robotic Vehicle
- MSS = Mobile Servicing System
- MTV = Mars Transfer Vehicle
- MUSES = Multi-User System for Earth Sensing
- NDS = NASA Docking System
- NEP = Nuclear Electric Propulsion
- NET = No Earlier Than
- NG = Northrop Grumman
- NICER = Neutron Star Interior Composition Explorer
- NOM4D = Novel Orbital and Moon Manufacturing, Materials and Mass-efficient Design (pronounced “NOMAD”)
- NTO = Nitrogen Tetraoxide
- NTP = Nuclear Thermal Propulsion
- ORU = On-orbit Replaceable Unit
- OSAM = On-Orbit Servicing, Assembly, and Manufacturing
- PASS = Precision Assembled Space Structure
- PM = Primary Mirror
- POD = Payload Orbital Delivery
- PPE = Power & Propulsion Element
- ProxOps = Proximity Operations
- RF = Radio Frequency
- RFP = Request for Proposals
- RPOC = Rendezvous, Proximity Operations, and Capture
- RSGS = Robotic Servicing of Geostationary Spacecraft
- RST = Roman Space Telescope
- S&A = Servicing & Assembly
- SCL = System Capability Lead
- SE-L2 = Sun-Earth L2 (Lagrange Point)
- SF = Space Fleet
- SIL = Servicing Infrastructure & Logistics
- SLSTD = System Level Segmented Telescope Design
- SMD = Science Mission Directorate
- SNP = Space Nuclear Propulsion
- SOMD = Space Operations Mission Directorate
- SPIDER = Space Infrastructure Dexterous Robot
- STMD = Space Technology Mission Directorate
- TBD = To Be Determined
- TRL = Technology Readiness Level
- TDM = Technology Demonstration Missions
- ULA = United Launch Alliance
- ULTRA = Ultra Stable Telescope Research & Analysis
- USB = Universal Series Bus
- USG = United States Government
- USSF = United States Space Force
- V&V = Validation & Verification
- VV = Visiting Vehicle (at ISS)
- WFE = Wavefront Error