Asociación Interamericana de la Propiedad Intelectual
Inter-American Association of Intellectual Property
Associação Interamericana da Propriedade Intelectual

Global Power, Space Power

ASIPI - Panama City, Panama
December 4, 2024

My Background

- Global Space Executive, Space lawyer, Entrepreneur
- Former Executive Roles
  - Chief Strategy Officer, Rogue Space Systems
  - CEO & Director, Exolaunch US
  - Chief Space Liaison Officer, Space Hero
  - Director & Corporate Counsel, Bigelow Aerospace
  - Special Advisor, US Department of State, Office of Space & Advanced Technologies

- OSA Consulting
  - Provides strategic advising and management consulting to start up space and tech companies globally
  - Founder & CEO
  - www.osaconsultingdc.com

- The Space Court Foundation
  - Multinational nonprofit dedicated to the promotion of space law education and the rule of law offering global internship and research opportunities
  - Cofounder, Chairman, and Treasurer of the Space Court Foundation
  - www.spacecourtfoundation.org

Factories in Space

In-Space Economy Classification

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Human Spaceflight & Landers

Cargo Transportation & Landers

Surface Spacecraft & Mobility

Space Stations & Habitats

Surface Habitats & Structures

In-Space Manufacturing

Space Resources

Space Utilities

In-Space Transportation

Miscellaneous

Factories in Space

In-Space Economy

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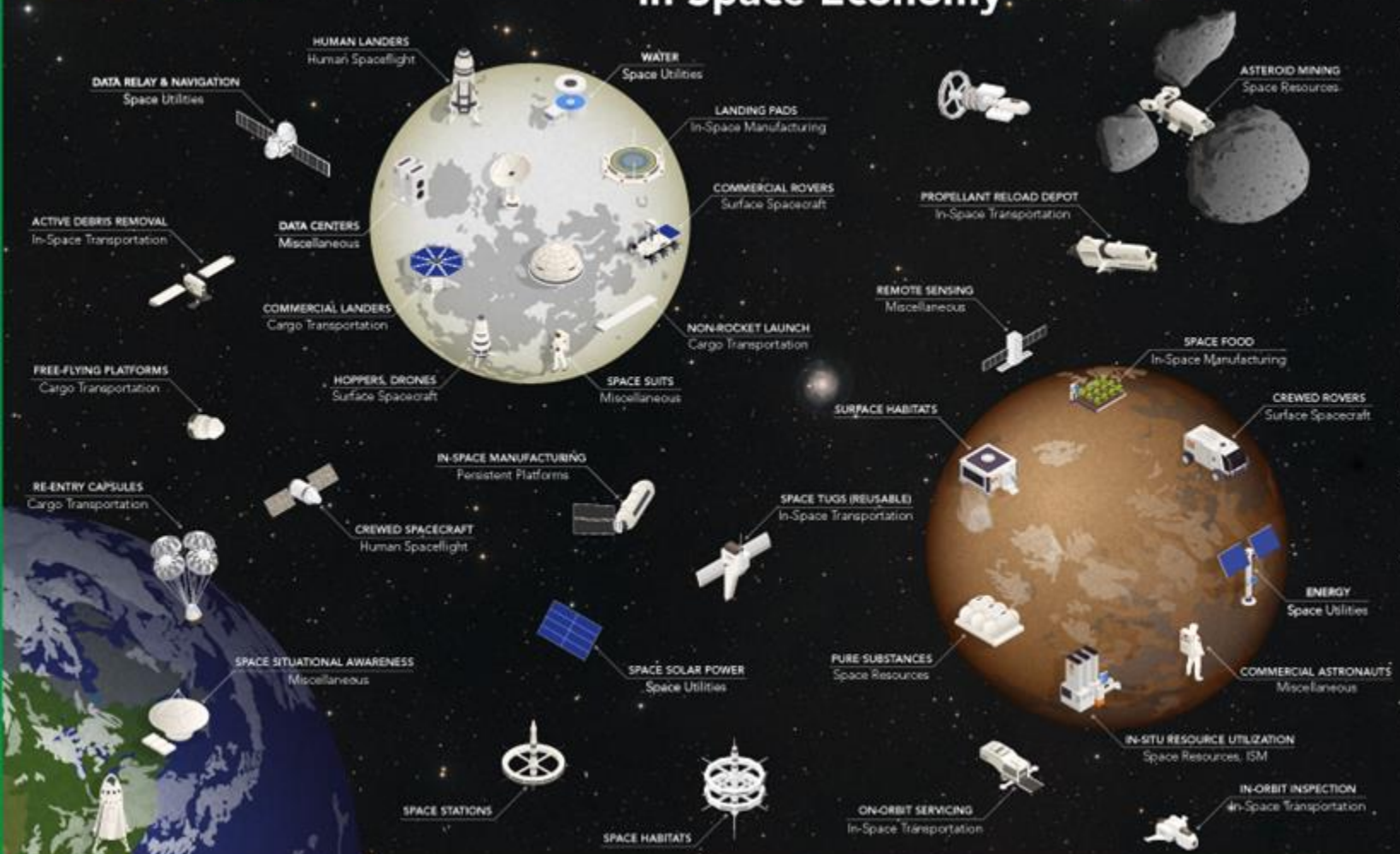


In-Space Economy Classification:

1) Human Spaceflight
   - Crewed Spaceships & Shuttles
   - Crewed Landers
2) Cargo Transportation & Landers
   - Robotic Landers (Moon, Mars)
   - Re-Entry Vehicles & Capsules
   - Cargo Resupply Services
   - Reusable Satellites
3) Surface Spacecraft
   - Surface Mobility
   - Robotic Rovers
   - Drones, Hoppers
4) Space Stations & Habitats
   - Persistent Platforms
   - Robotic Space Stations
5) Surface Habitats & Structures
   - Surface Facilities, Infrastructure
6) In-Space Manufacturing (ISM)
   - In-Space Production
   - Space Food, Space Agriculture
   - Microgravity Manufacturing
   - In-Space Assembly & Construction
   - Geoengineering
7) Space Resources
   - ISRU (In-Situ Resource Utilization)
   - Pure Substances (Ice, O2, Metals)
   - Space, Lunar & Asteroid Mining
   - Prospecting, Processing, Recycling
8) Space Utilities
   - Energy, Power Beaming
   - In-Space Internet, Data Relay
   - Navigation
   - Water, Propellant
9) In-Space Transportation
   - Space Tugs, Space Trucks
   - Orbital Transfer Vehicles (OTV)
   - On-Orbit Servicing
   - Propellant Reloading Depot
   - Active Debris Removal (ADR)
   - In-Orbit Inspection
   - In-Space Mobility, Space Logistics
   - Satellite Life Extension
   - Last Mile Delivery
10) Miscellaneous
   - Microgravity Payload Services
   - In-Orbit Computing, Storage
   - Space-Flown Items
   - Space Suits & Garments
   - Commercial Astronauts
   - Space Entertainment, Advertising
   - Space Traffic Management
   - Space Tourism Support, etc.

In-Space Manufacturing

Factories in Space

1: Launch / Re-supply

Equipment launched from Earth.
Raw materials & consumables from:
1) Earth
2) recycling
3) Moon
4) asteroids

ASTEROID MINING
AstroForge, Karman+

SPACE RESOURCES TRANSPORTATION
Momentus, TransAstra, Orbit Fab, Lunasa, Impulse, Atomos, Astroscale, Coactum, ClearSpace, D-Orbit, Exotrail

SPACE DEBRIS RECYCLING
Redwire, CisLunar Industries, Orbit Recycling

RE-SUPPLY VECHICLES (2-WAY)
Dragon, Starship, Starliner, Dream Chaser, Sojuz, RFA

RE-SUPPLY VECHICLES (1-WAY)
Cygnus, Progress, HTV, Tianzhou

2: On-Orbit Manufacturing

Using microgravity to make new products and materials, on or nearby multi-use or dedicated:
1) space stations (robotic or crewed)
2) free-flying spacecraft

SPACE STATIONS
ISS, Gateway, Tiangong

COMMERCIAL SPACE STATIONS
Axiom, Nanoracks, Orbital Reef, Starlab, Gravitics, VAST

DEDICATED FREE-FLYERS
SpaceX, Space Tango, Space Forge, Varda, Space Rider, Sierra Space, The Exploration Company

MICROGRAVITY ACCESS SERVICES
Nanoracks, Ice Cubes, Bartolomeo, Space Tango, Yuri, Space Cargo

IN-SPACE ASSEMBLY & CONSTRUCTION
Redwire, Arkisys, Above Space, Astroport, ThinkOrbital, Space Applications, Rovial, ICON, ArcSpace, Orbital Matter, GITAI

3: Use in Orbit / Re-Entry

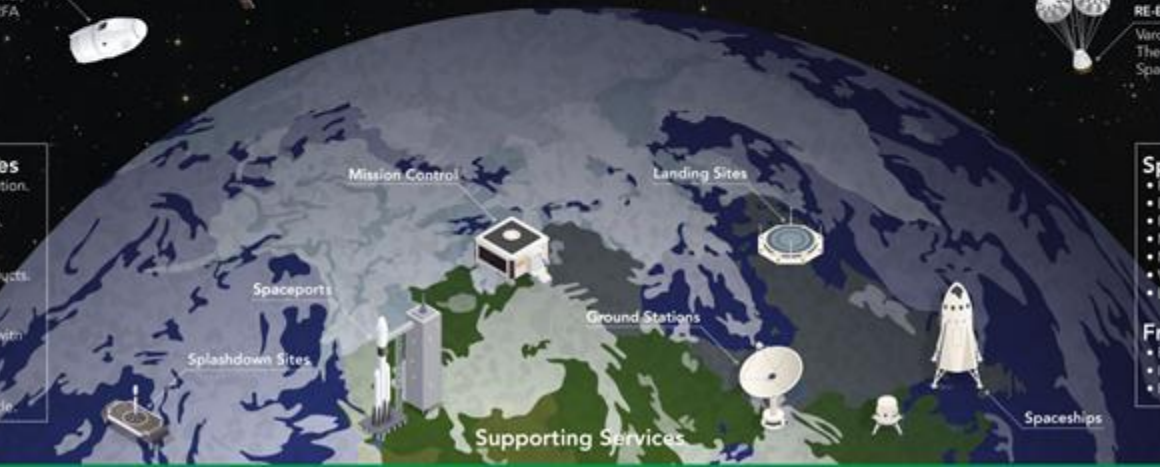
1) Large-scale space structures, space solar power stations, space food etc will remain for use in space.
2) Re-entry capable vehicles to bring samples and products to Earth, which will likely be the largest market for many materials.

LARGE SPACE STRUCTURES

IN-SPACE MANUFACTURING
Redwire, FOMS, Flawless Photonics, Nanoracks, Apsidal, BioOrbit, Varda, LambdaVision, Maana Electric

SPACE FOOD
Nanoracks, Starlab Oasis, Sierra Space, InterstellarLab

RE-ENTRY SPACECRAFT & CAPSULES
Varda, Space Forge, In Orbit, Outpost, The Exploration Company, A-SpaX, ATMOS Space Cargo, ElevationSpace, Inversion



Path 1: Space Stations ISM Services

1) Launch orbital factory to the ISS or commercial station. As preparation or equipment together with supplies.
1a) Resupply raw materials & consumables (optional).
2) Use the automated space factory and help from (commercial) astronauts to manufacture the goods.
3) Use (the same) re-entry vehicles to return the products.

Path 2: Dedicated Free-Flyers

1) Launch (reusable) spacecraft (e.g. Cargo Dragon) with raw materials, consumables and fully automated manufacturing apparatus included.
2) Use the free-flying spacecraft as factory in space.
3) Enter atmosphere and retrieve the (reusable) vehicle.

*The lists of example companies are not exhaustive

Space Station > Free-Flyer

- Recurring Dragon, Starliner, Starship etc flights.
- Extra 1-2 months is a small difference for near-future.
- Product quantinities likely small for the short term.
- Multi-use and more consumables due to resupply.
- More power, faster communications, mission control.
- Vehicle retrival (tracking, legal, transport) handled.
- Lower costs all around to help with ISM economics.

Free-Flyer > Space Station

- Reusable satellites or dedicated vehicles are flexible.
- Independence when aiming for vertical integration.
- Full use of payload capacity and 100% automation.

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Factories in Space

Flywheel Effect / Kickstarter

After finding the "killer app" or "space gold" for in-space economy and bypassing the chicken-and-egg dilemma

SHORT-TERM

1. Launching parts and raw materials from Earth.
2. In case of in-space manufacturing, using the ISS or freeflyers to make products.
3. Serving existing terrestrial markets.

- Likely activity: Microgravity manufacturing or space solar power.
- Assumption: New revenue and profit sources in space
- Stimulates: cheaper launch, recycling, space resources.
- Customer for: freeflyers, space stations, in-space mobility, in-space services

MATERIALS: from Earth

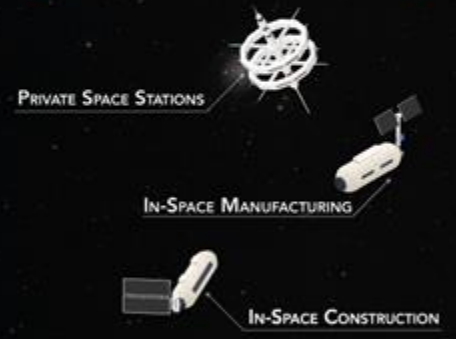
MARKET: on Earth

MEDIUM-TERM

1. Recurring profitable activities in space have been economically proven.
2. Creating a potential market and becoming the first customer for many other in-space economy services if the price is lower.
3. First commercial steps towards using space resources and space utilities.
4. In case of in-space manufacturing, activities are moved to larger (dedicated) space stations or persistent platforms where the equipment stays in orbit.
5. Stimulates faster/cheaper services and economies of scale starts to lower costs.

MATERIALS: some from space

MARKET: some in space



MATERIALS: most from Earth, some from space

MARKET: most on Earth, some in space

LONG-TERM

1. Drive towards lower costs creates competition and market for better solutions.
2. Whole ecosystems and supply chains are now in space.
3. Lower costs bring out the elasticity in markets making further commercial activities feasible.
4. The new technologies also improve space exploration and space settlement, while enabling even more industries to be moved off-Earth.

MATERIALS: Moon asteroids

MARKET: Moon

MATERIALS: recycled

MARKET: space

MATERIALS: some from Earth, most from space

MARKET: half on Earth, half in space

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