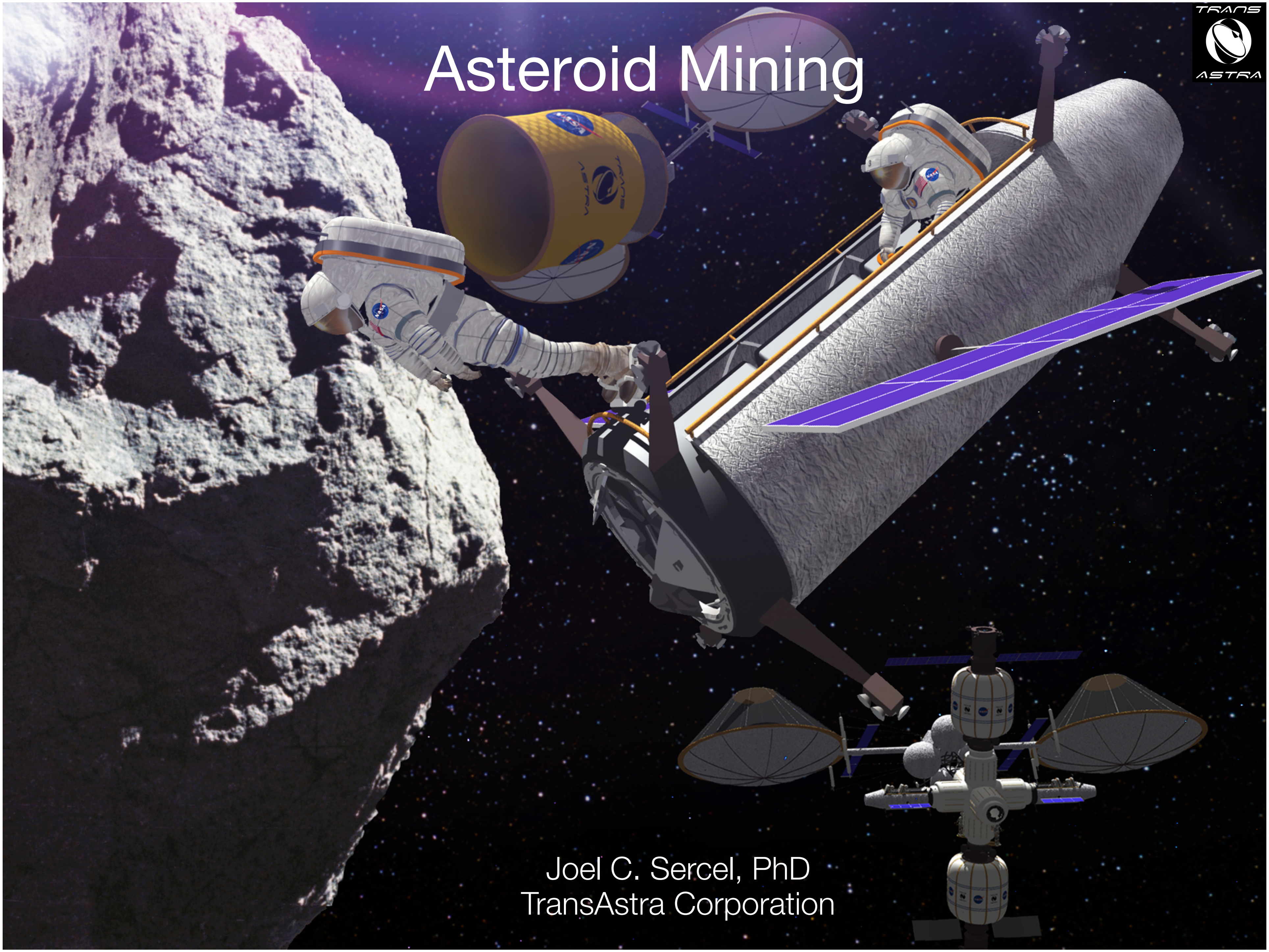
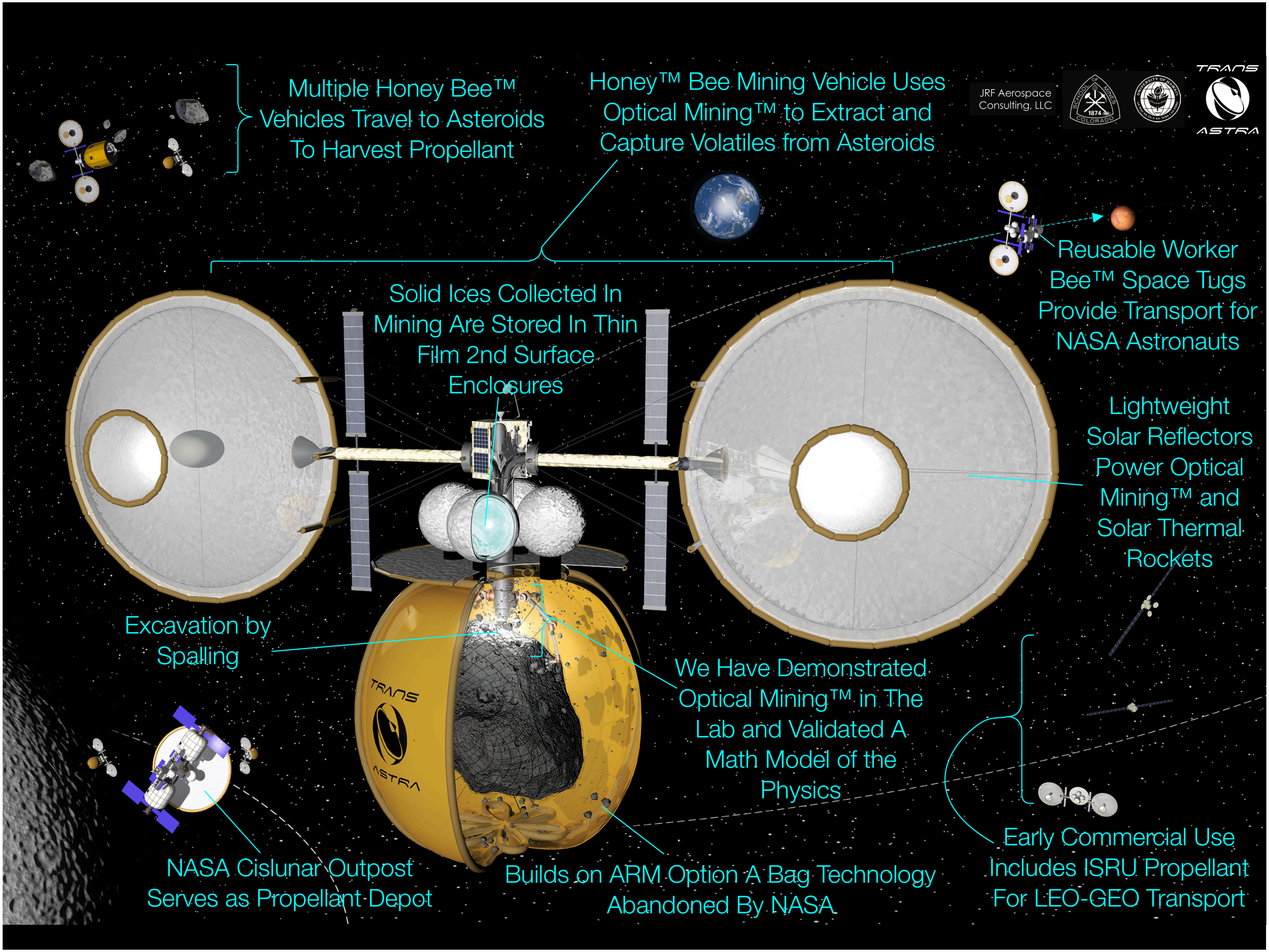
Asteroid Mining



Joel C. Sercel, PhD
TransAstra Corporation

Co-Investigators and Technical Collaborators

- Prof. Daniel Britt, University of Central Florida
- Mr. James French
- Dr. Robert Jedicke, University Of Hawaii Institute for Astronomy
- Prof. Chris Dreyer, The Colorado School of Mines
- Mr. Anthony Longman (Board Member)
- Dr. Stanley Love, NASA Astronaut


Multiple Honey Bee™ Vehicles Travel to Asteroids To Harvest Propellant
Honey™ Bee Mining Vehicle Uses Optical Mining™ to Extract and Capture Volatiles from Asteroids
JRF Aerospace Consulting, LLC
TRANS ASTRA
Reusable Worker Bee™ Space Tugs Provide Transport for NASA Astronauts
Solid Ices Collected In Mining Are Stored In Thin Film 2nd Surface Enclosures
Lightweight Solar Reflectors Power Optical Mining™ and Solar Thermal Rockets
Excavation by Spalling
We Have Demonstrated Optical Mining™ in The Lab and Validated A Math Model of the Physics
TRANS ASTRA
NASA Cislunar Outpost Serves as Propellant Depot
Builds on ARM Option A Bag Technology Abandoned By NASA
Early Commercial Use Includes ISRU Propellant For LEO-GEO Transport

Mission Applications of Asteroid Resources

- Lunar Orbital Outpost
  - Established in Lunar Distant Retrograde Orbit (LDRO) and operated for life of scenario
- Human Near Earth Object (NEO) Exploration
  - Focused on crewed missions to a variety of small (10 m class) targets (five 14 month missions)
- Lunar Surface Operations (LSO)
  - Establishment and operate a lunar surface base (two crewed and two cargo lander per year)
- Mars Exploration
  - Four crewed exploration mission to Deimos crewed Mars landing
  - Return missions could lead to establishment of Deimos or surface base, but not covered in the version of this scenario presented

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- LEO to GEO commercial satellite transportation
- Cislunar Tourism
- Other

It is About Public Private Partnership

	Total Cost $B	Savings $B	Comments
NASA Business As Usual, Supply From Earth	>400	0	Unaffordable: requires doubling the NASA Budget
Commercial Business Practices, Supply From Earth	~300	~90	Unaffordable: requires > 50% increase in NASA Budget
NASA Business As Usual, Asteroid Resources	~150	~250	Marginal, Requires ≈ 30% increase in NASA budget
Commercial Business Practices, Asteroid Resources	~95	~305	Affordable, Average NASA Human Exploration Budget ≈$6B Annually, Fits Within Congressional Guidelines for HEOMD.

Required: Major Shift to PPP for Deep Space Transportation Plus Massive ISRU

Sutter Survey:
Space Mission Roadmap to Prospecting Thousands of Asteroids

NASA NIAC Study

Joel C. Sercel, PhD and Robert Jedicke, PhD

Accepted Manuscript

Availability and delta-v requirements for delivering water extracted from near-Earth objects to cis-lunar space

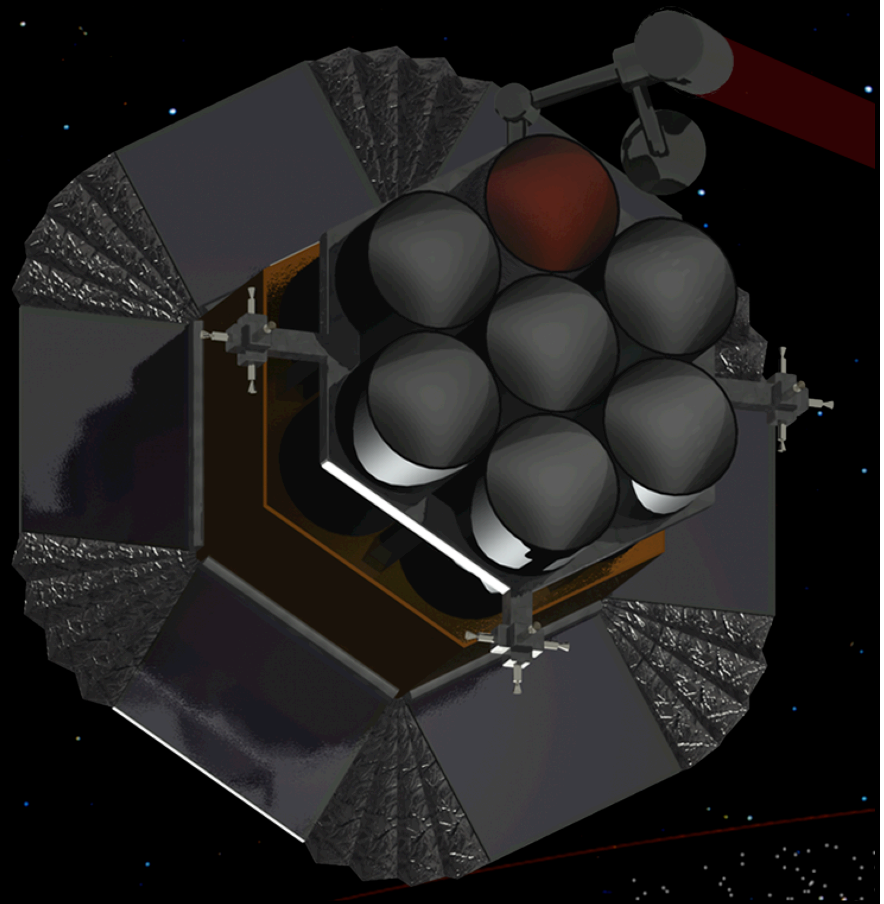
Robert Jedicke, Joel Sercel, Jeffrey Gillis-Davis, Karen J. Morenz, Leslie Gertsch

Key Findings

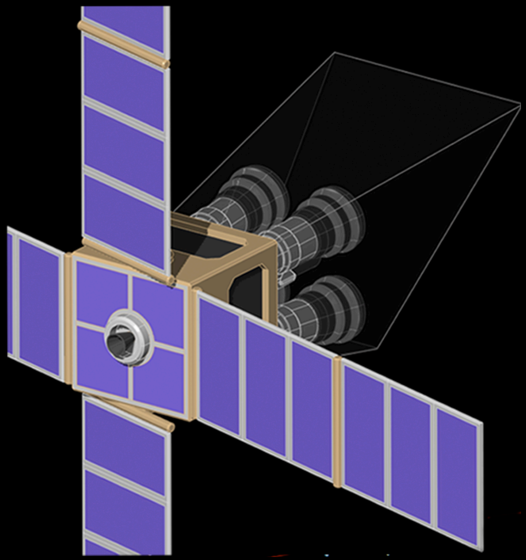
- ≈1,000 low ΔV targets (only a few found!)
- Population goes as cube of ΔV
- Water rich targets tend to be smaller

Sutter is the Solution…

Sutter Extreme



Sutter



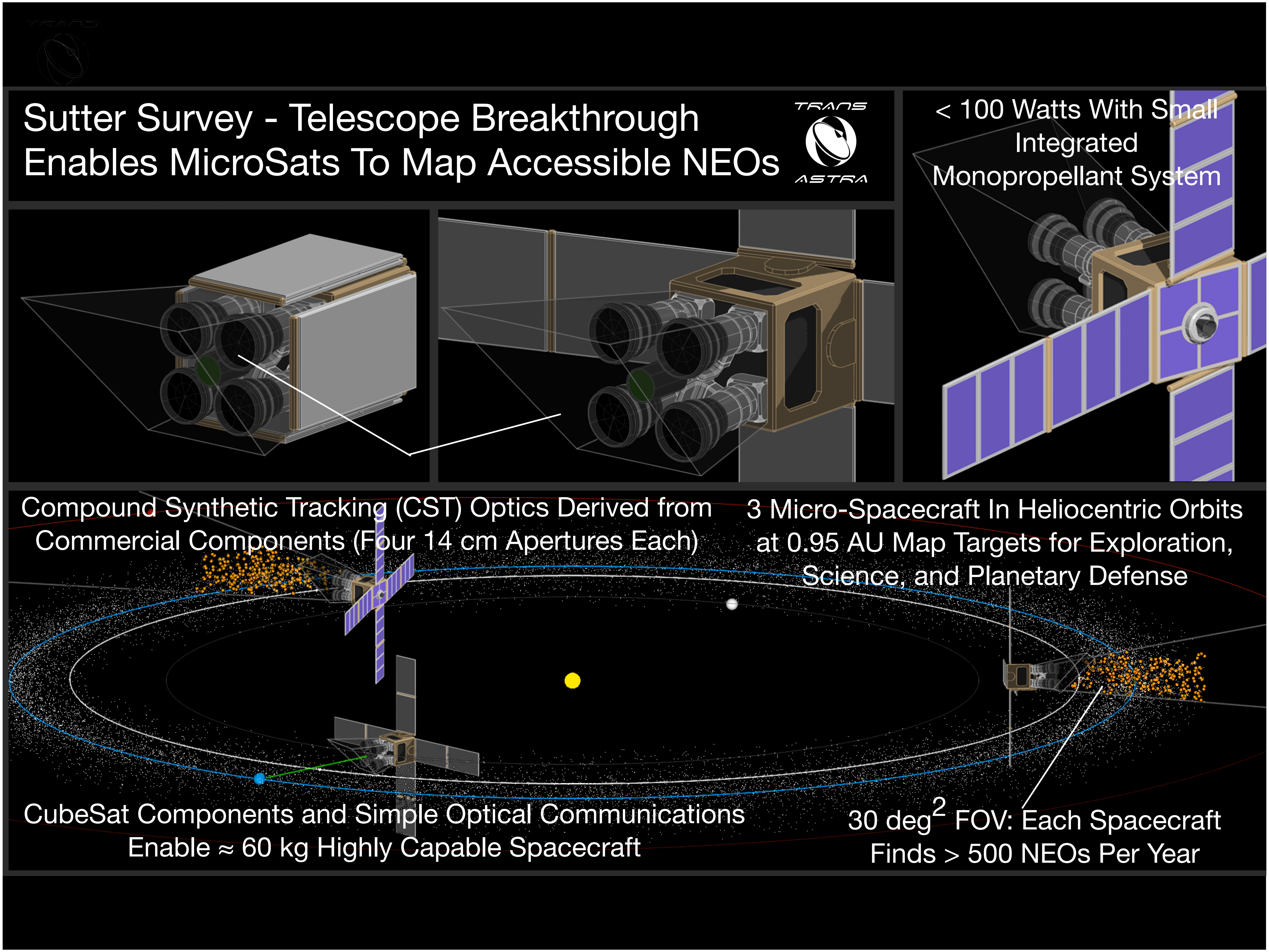
Sutter Demo

Sutter Demo

A CubeSat Scale Technology Demonstration Mission

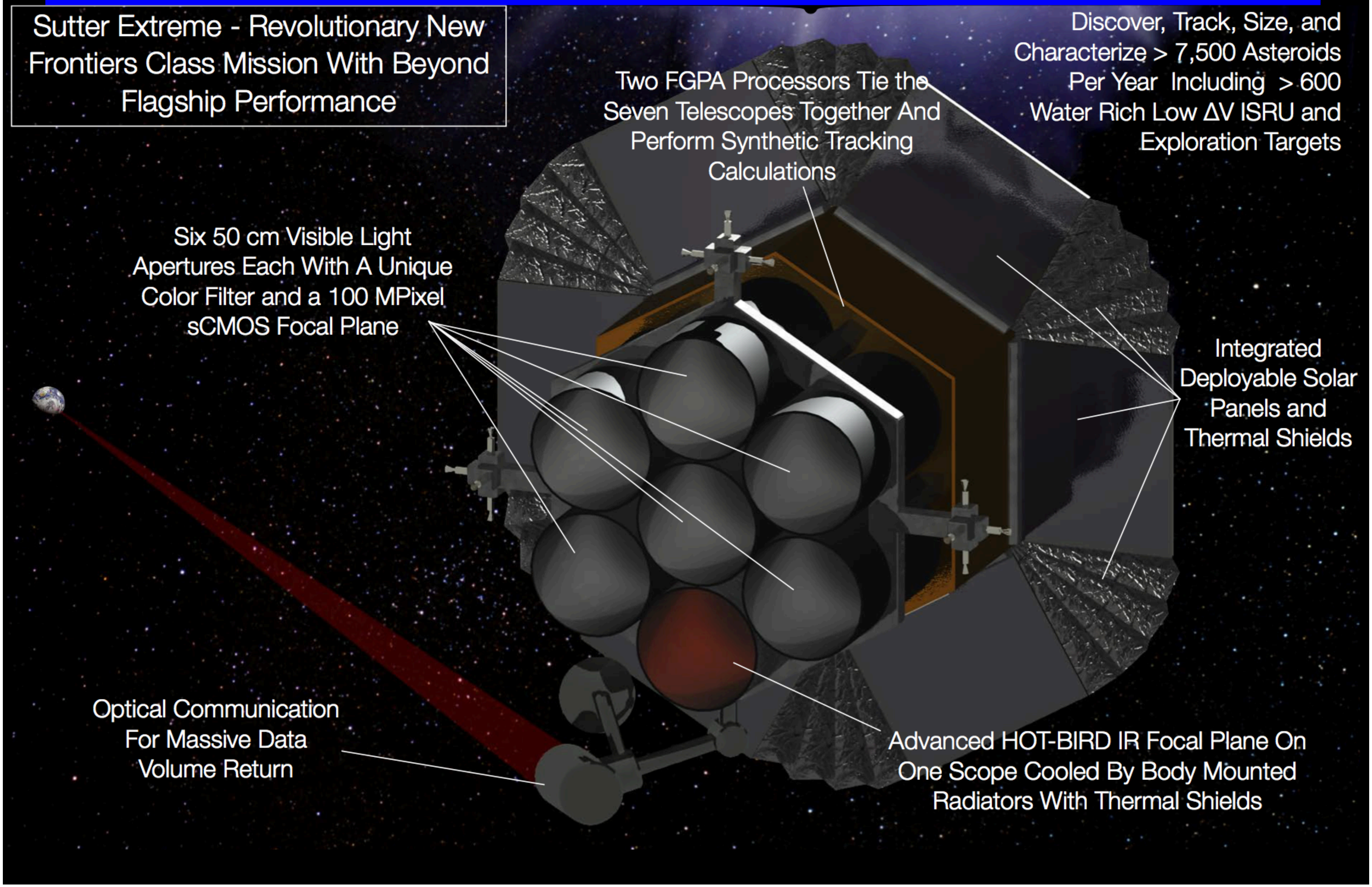
Competatively Selected by NASA for a $2.5M Flight Mission (Theia)

Issues With NASA Budget and Contract Negociation

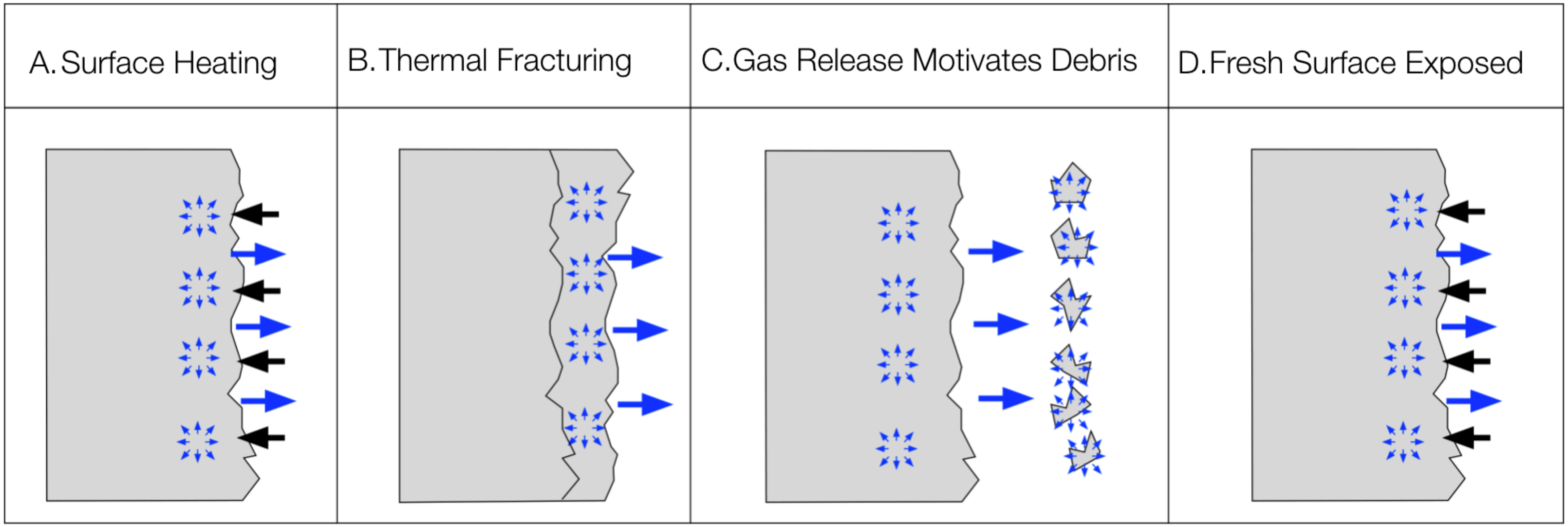

TRANS ASTRA
Sutter Survey - Telescope Breakthrough
Enables MicroSats To Map Accessible NEOs
< 100 Watts With Small
Integrated
Monopropellant System
Compound Synthetic Tracking (CST) Optics Derived from
Commercial Components (Four 14 cm Apertures Each)
3 Micro-Spacecraft In Heliocentric Orbits
at 0.95 AU Map Targets for Exploration,
Science, and Planetary Defense
CubeSat Components and Simple Optical Communications
Enable ≈ 60 kg Highly Capable Spacecraft
30 deg2 FOV: Each Spacecraft
Finds > 500 NEOs Per Year

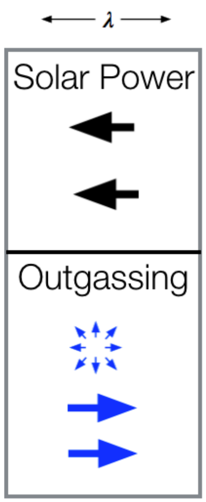
TRANS ASTRA

Sutter Extreme



Thermal Spalling: Key to Optical Mining™



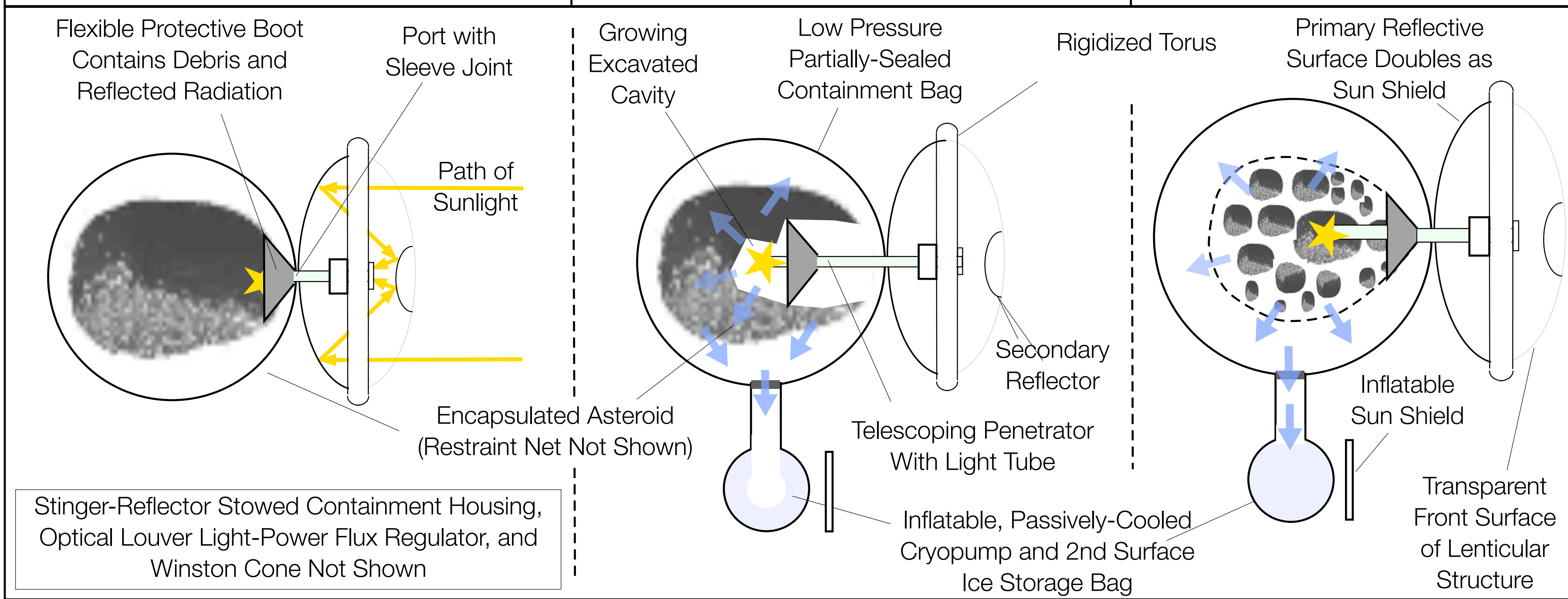


Progress continues at ≈1m/hr at surface blackbody peak temperature ≈1000K:

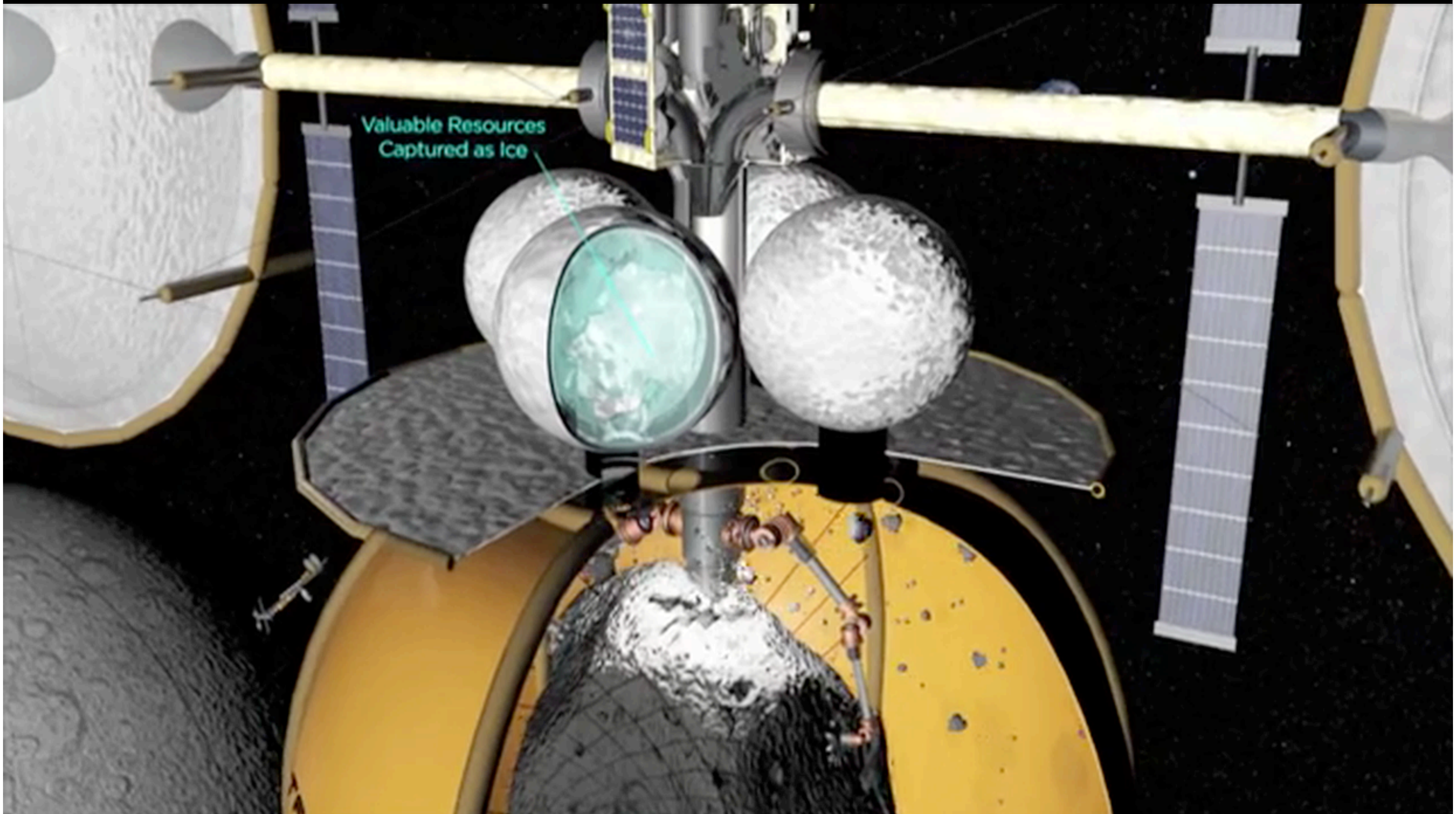
1. Cold surface temperature rises to near the blackbody temperature associated with the intensity of the applied radiation over a period of a few seconds establishing a mm scale hot layer.
2. A spall surface is created primarily by compressive thermal stress aided by thermal shear and gas pressure gradient.
3. mm scale spall particles fully outgas in seconds as surface outgassing drives them from the asteroid.
4. Process repeats in a continuous fashion exposing new surface to applied radiation.

Optical Mining™

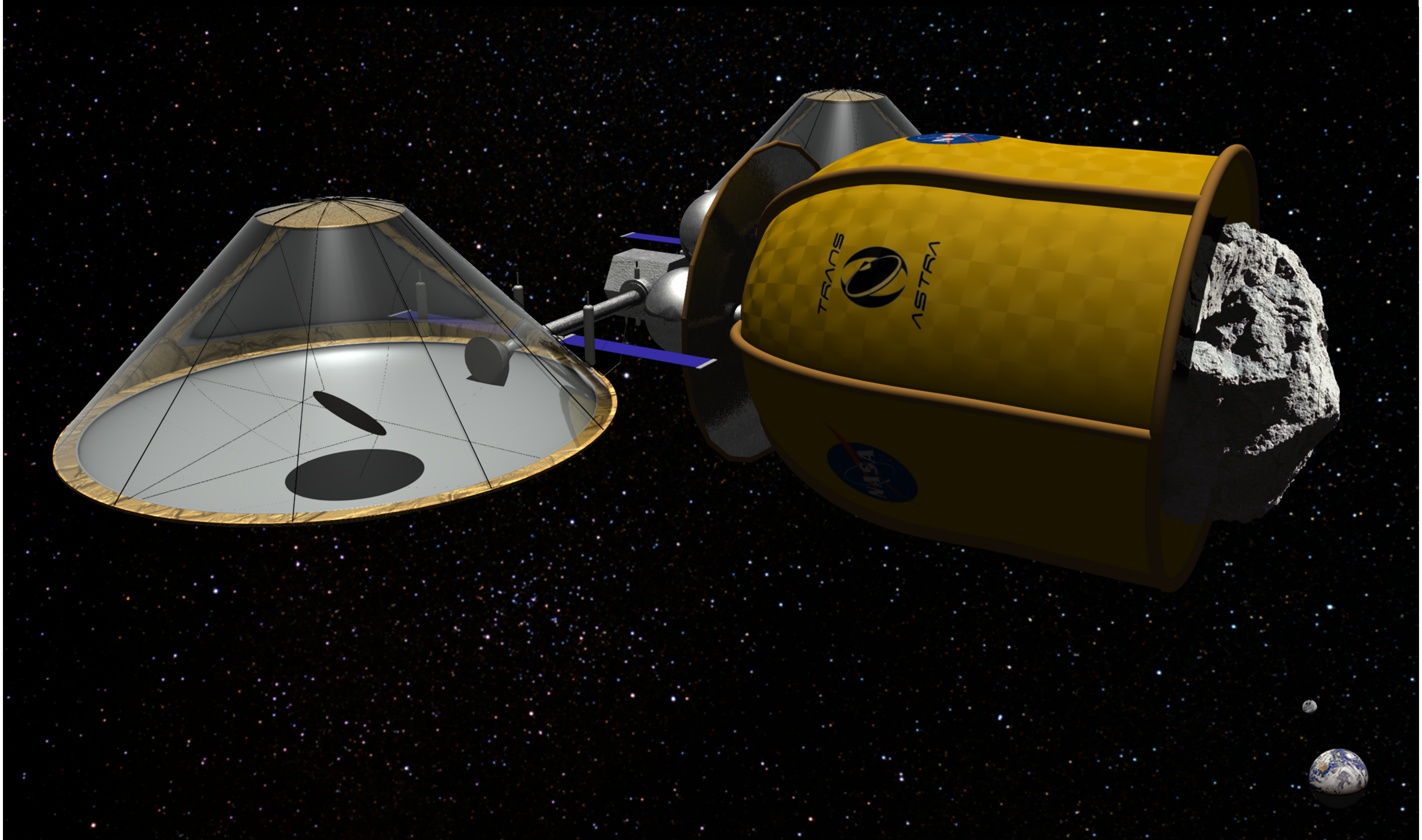
Fig. 1a: Optical Mining Starts With Asteroid Capture and Despin	Fig. 1b: Excavation by Spalling and Outgassing	Fig. 1c: Volatile Products Stored as Ice



Optical Mining™

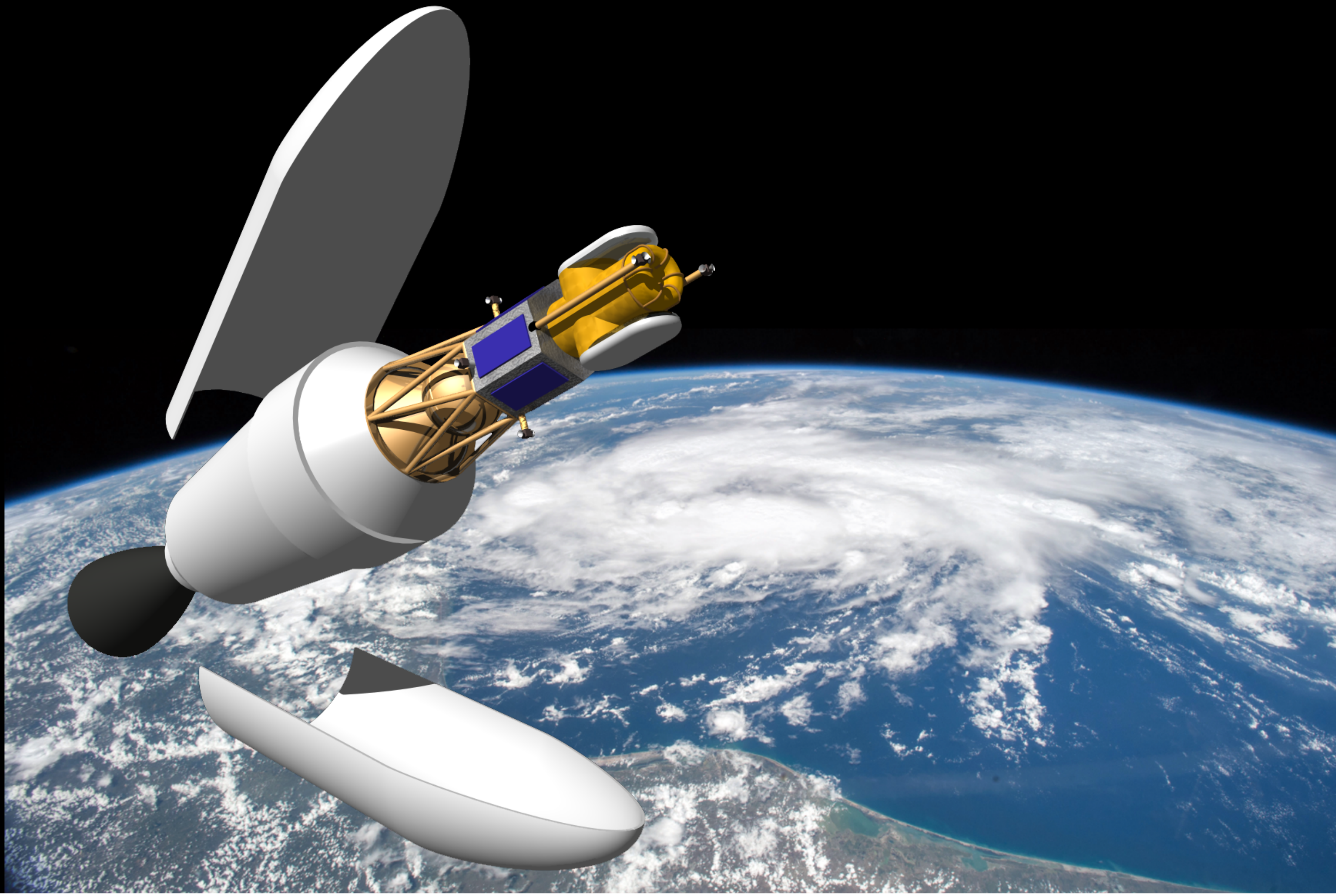


Honey Bee Robotic Asteroid Capture for ISRU Resource Return

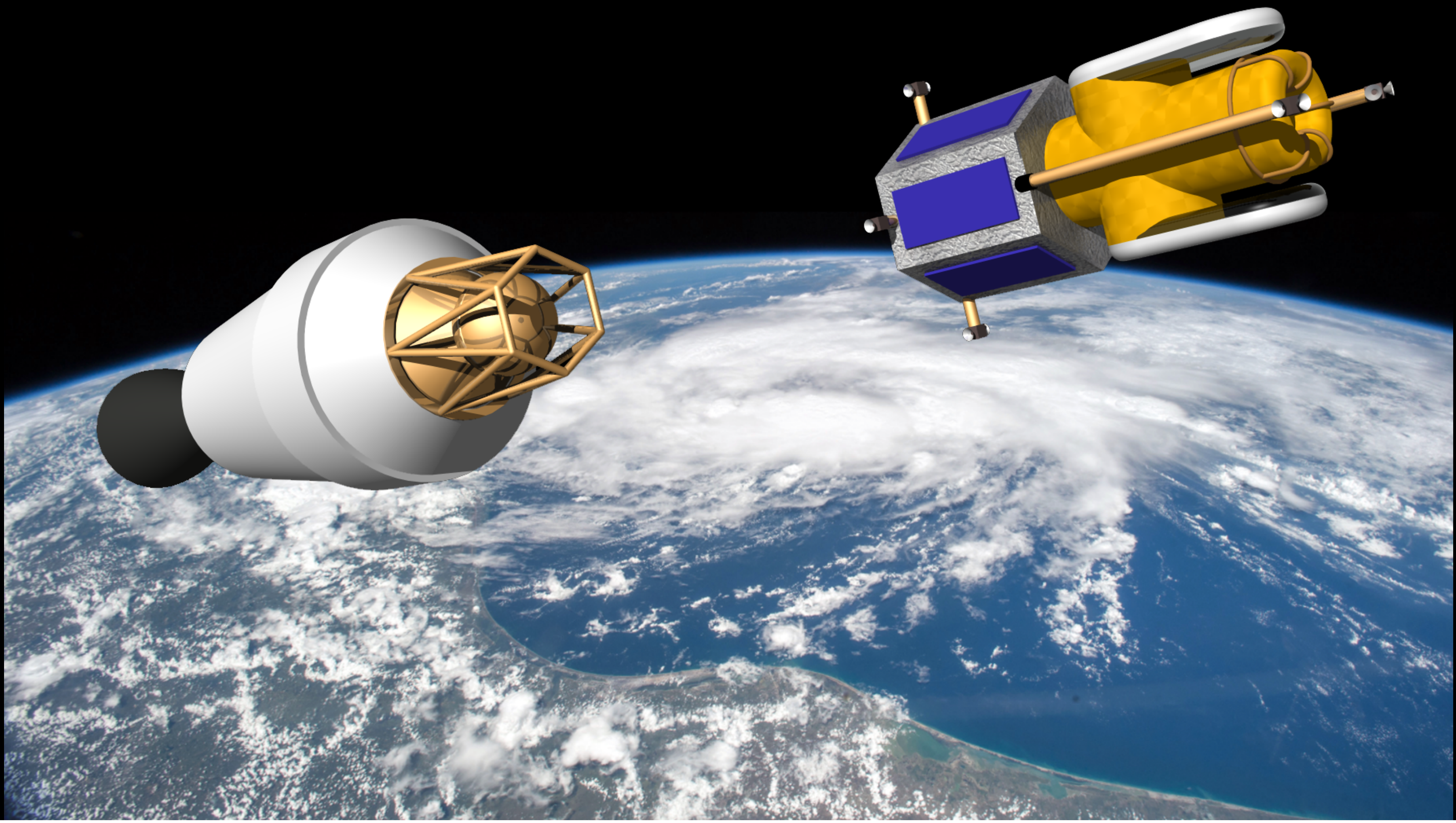


But First

Mini Bee Tech Demo Mission: Launch On A SmallSat Launcher (eg Launcher One)



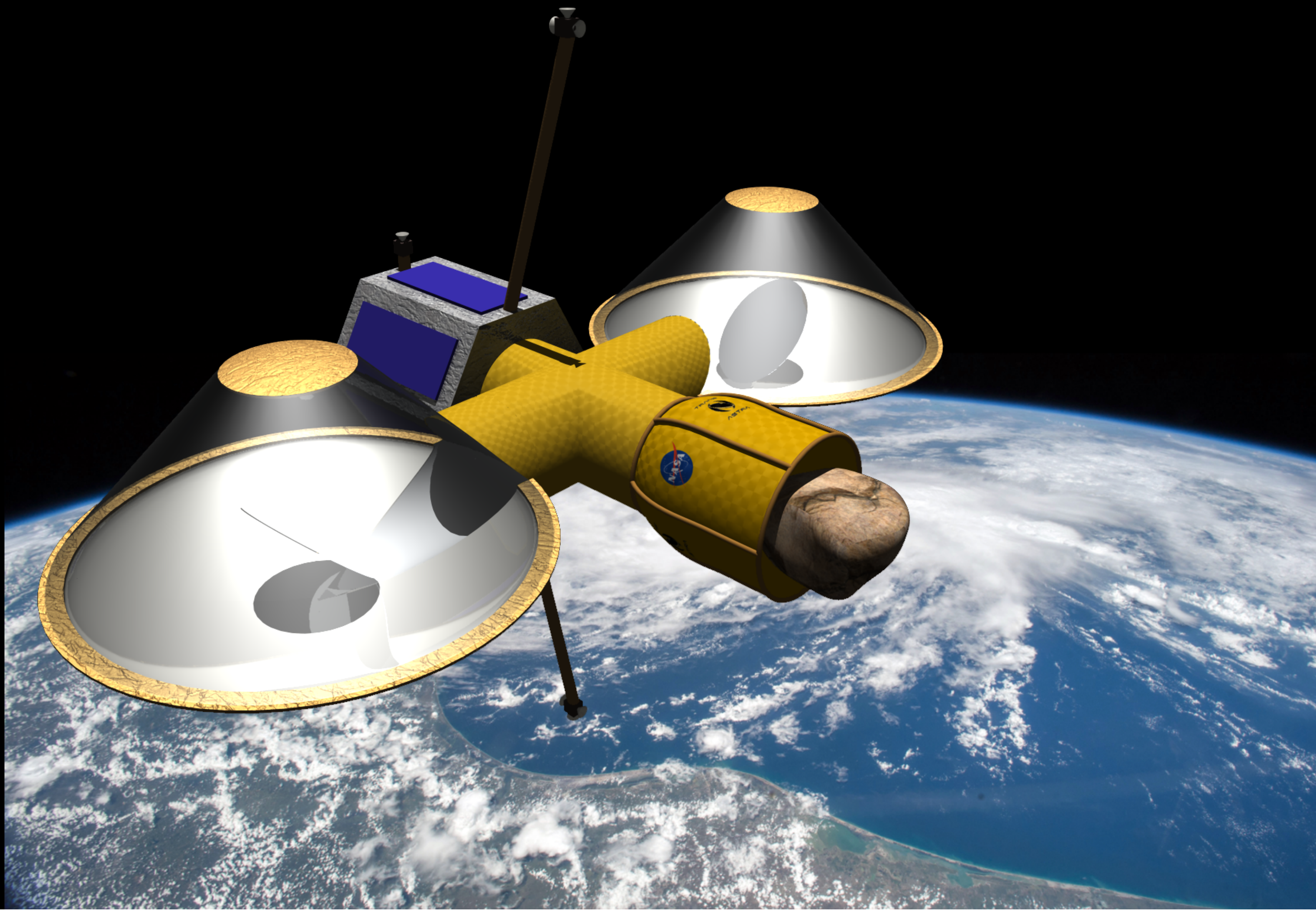
Mini Bee Separation



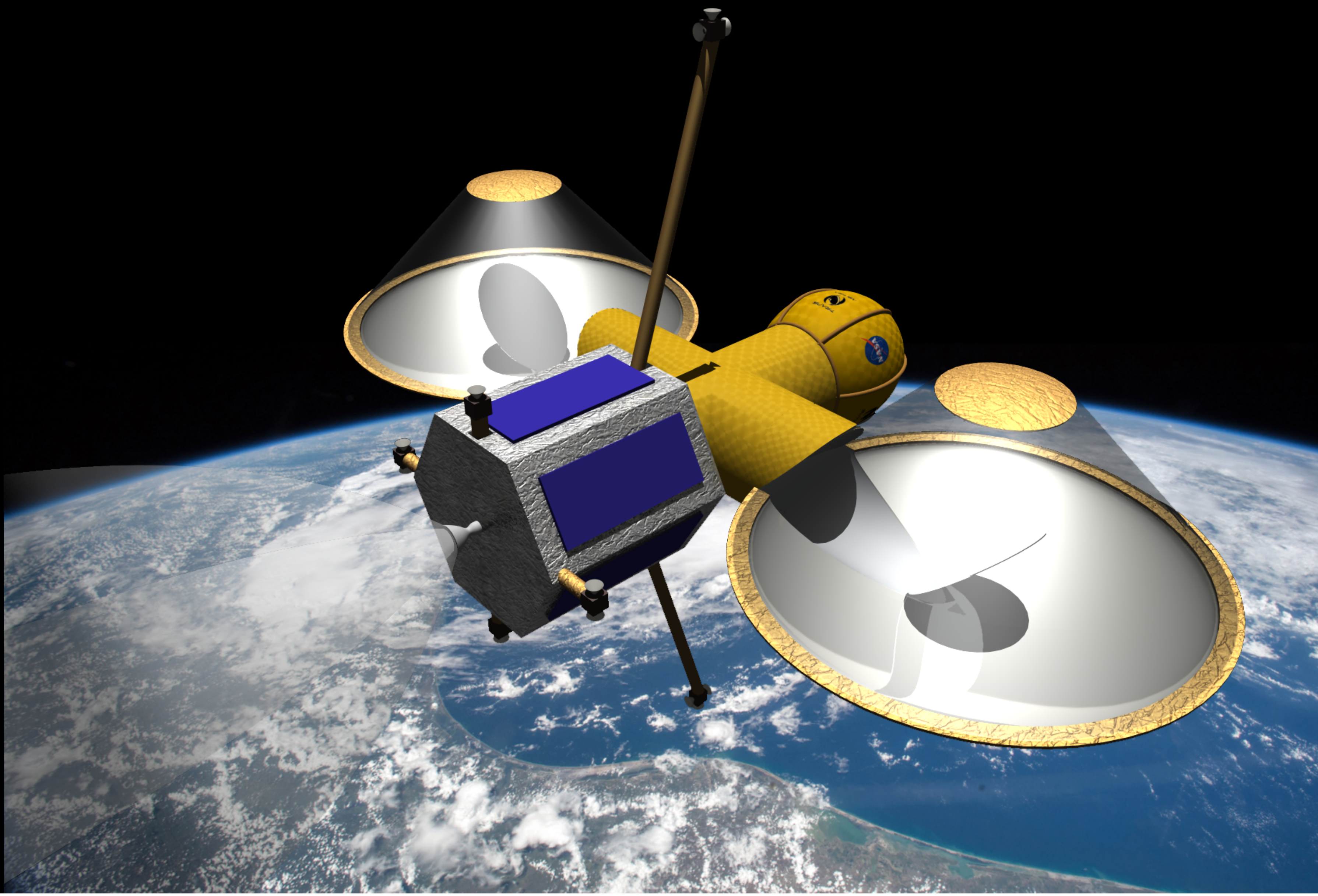
Synthetic Asteroid and Structures Deployment

TRANS ASTRA

Synthetic Asteroid Capture and Optical Mining Demonstraton

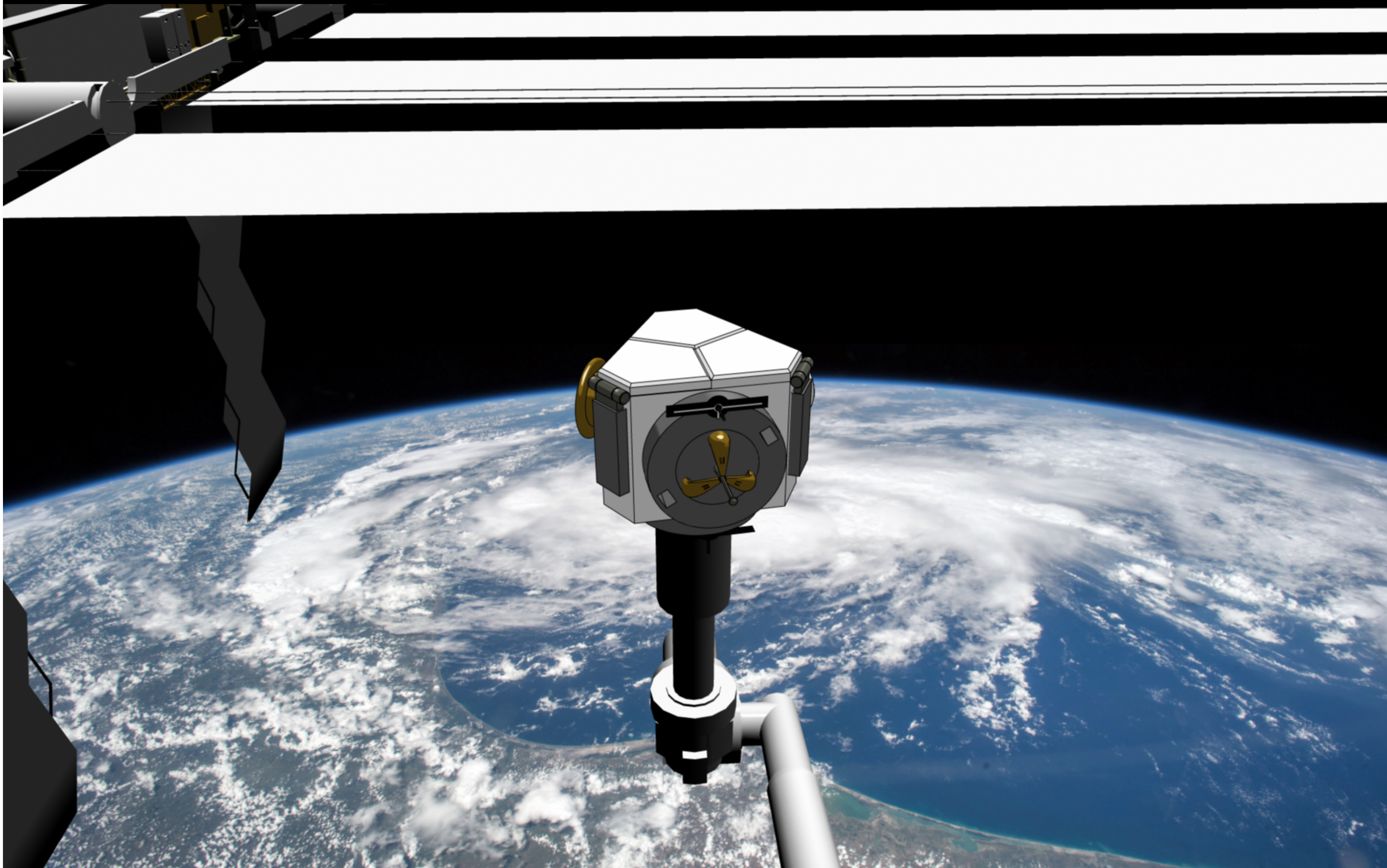


Demonstration of Solar Thermal Rocket Maneuvering With Mined Propellant

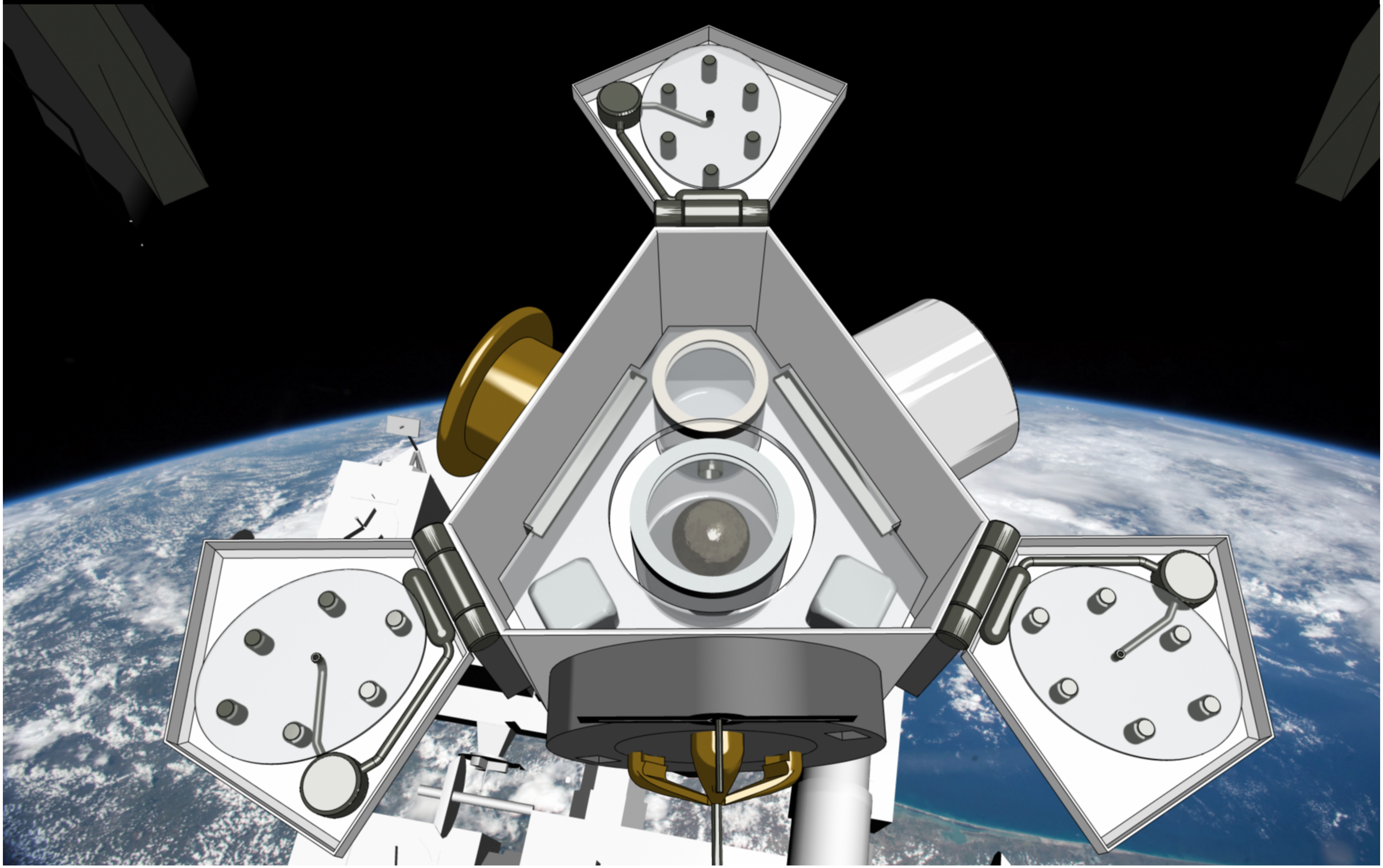


Before That

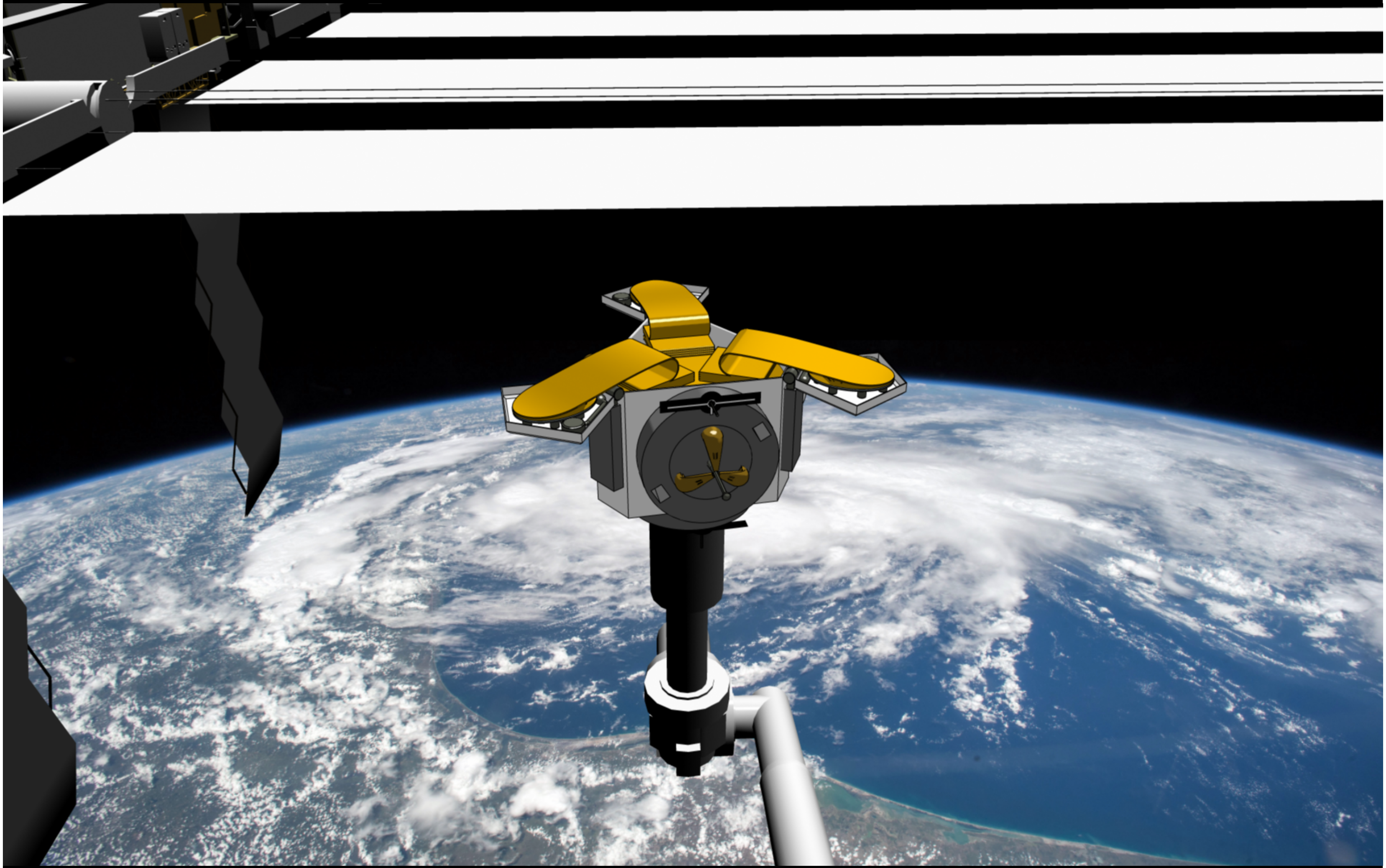
Optical Mining Experiment Module (OMEM)



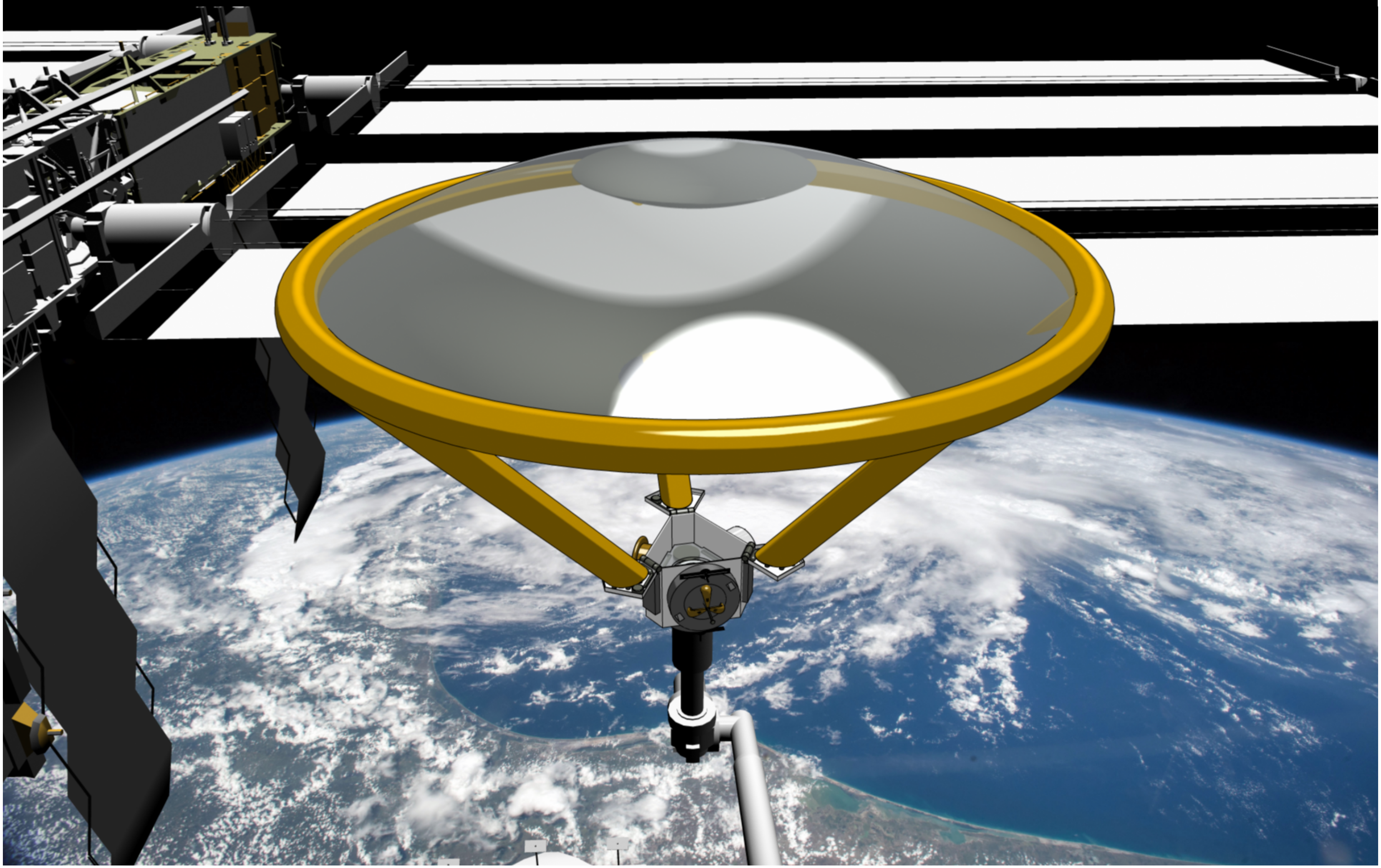
OMEM Interior Cutaway



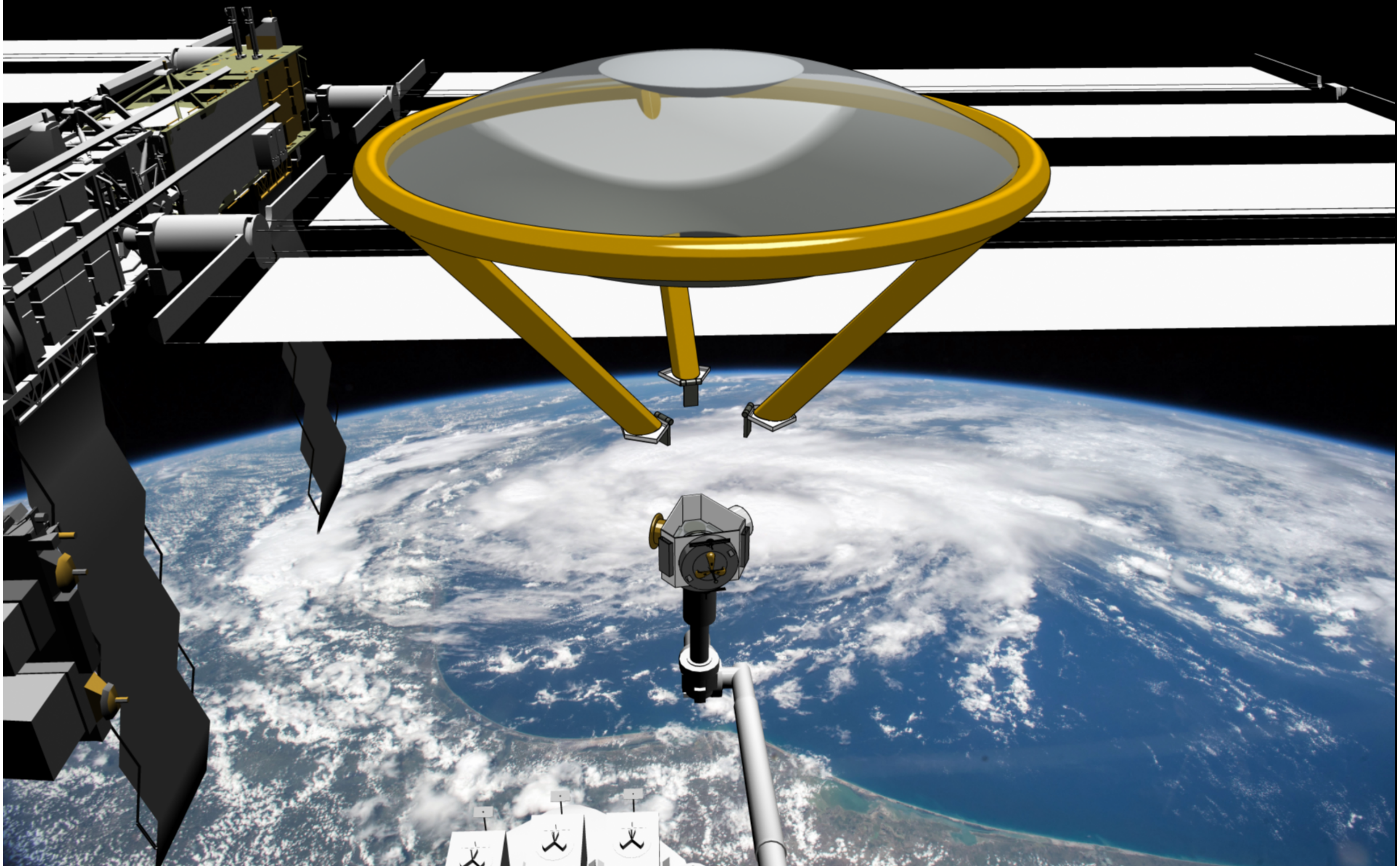
OMEM Inflatable Deployment



OMEM Optical Mining Demonstration

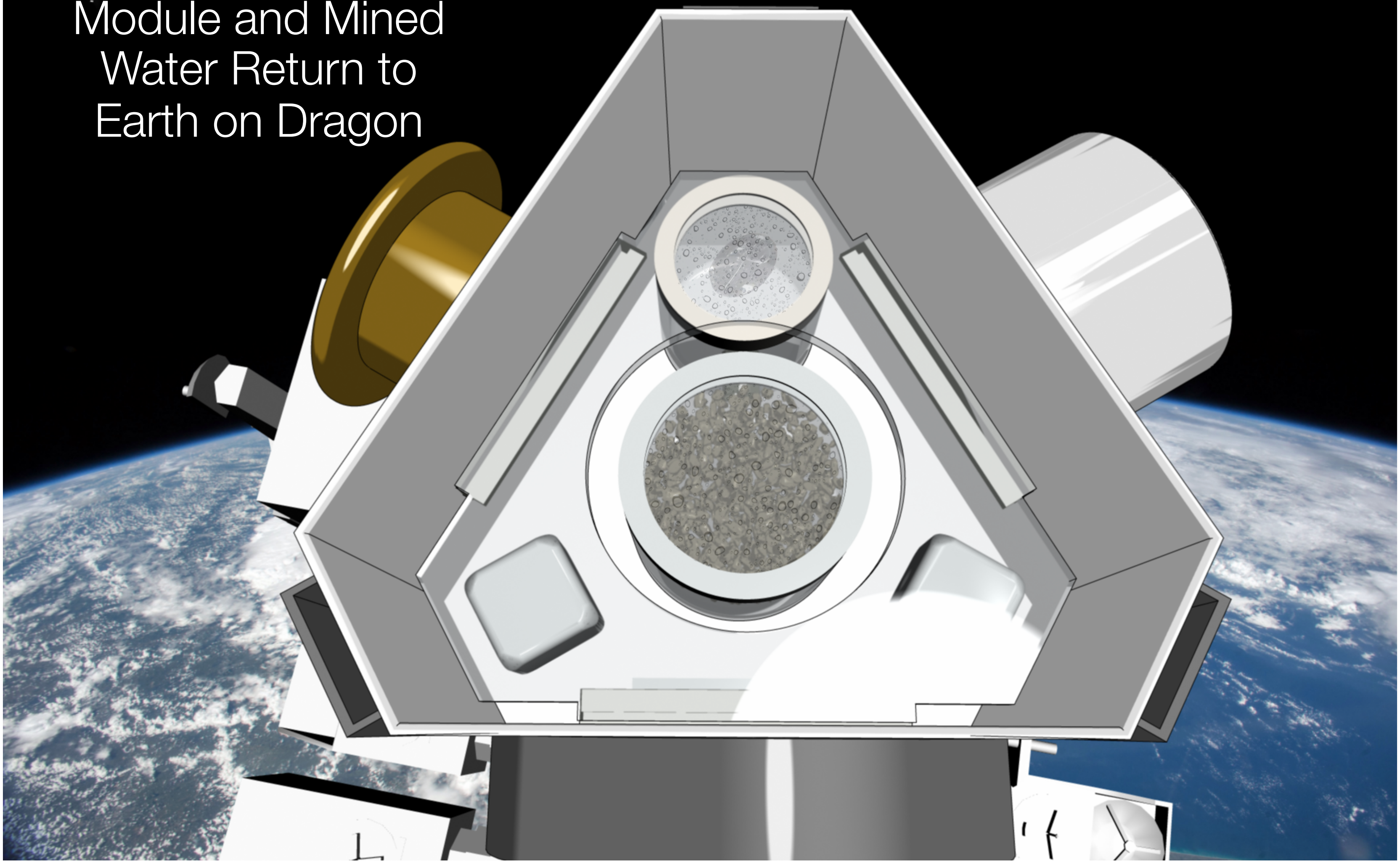


Inflatable Structure Separation and Deployment



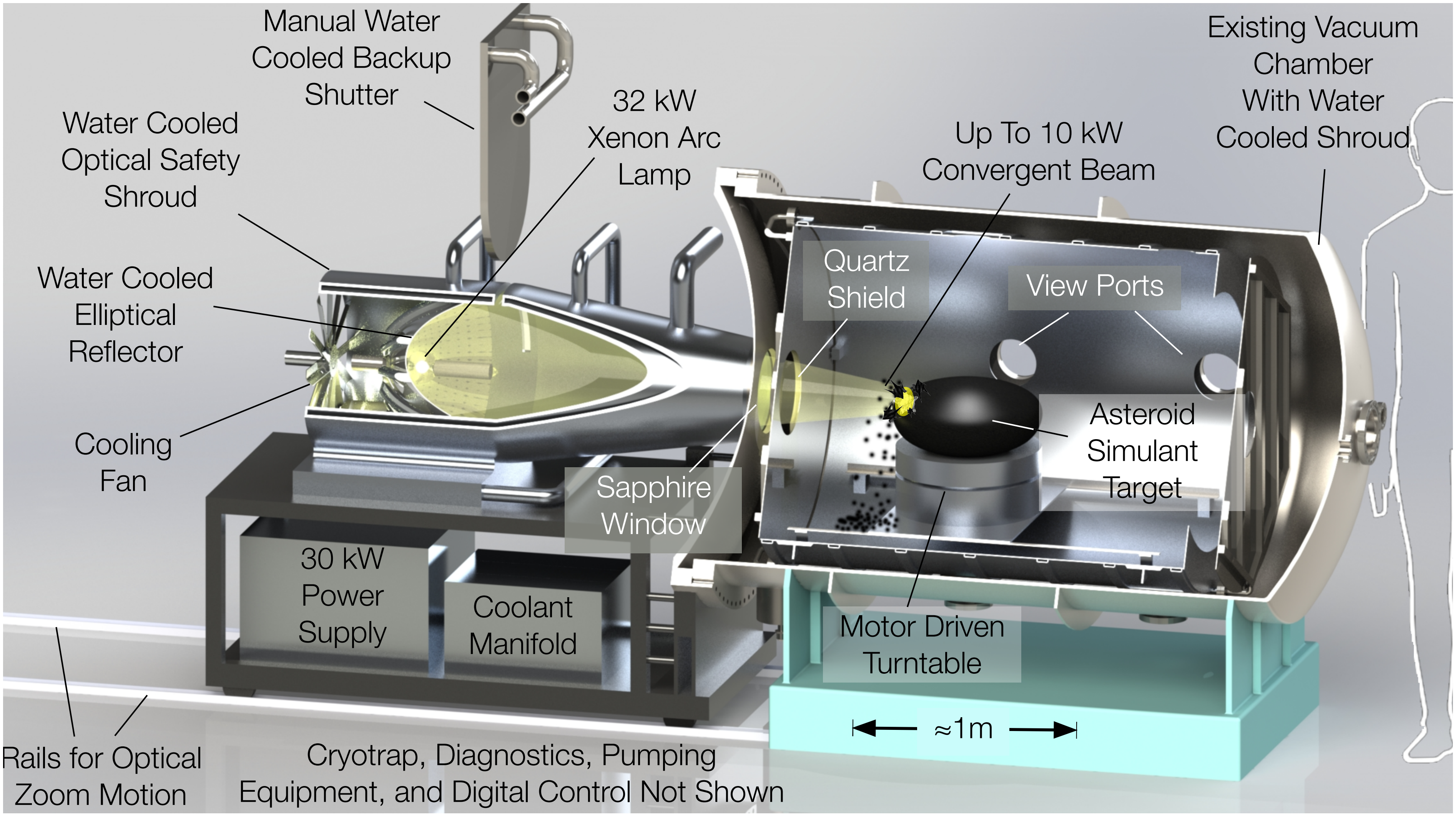
First Space Asteroid Mining!

Module and Mined
Water Return to
Earth on Dragon



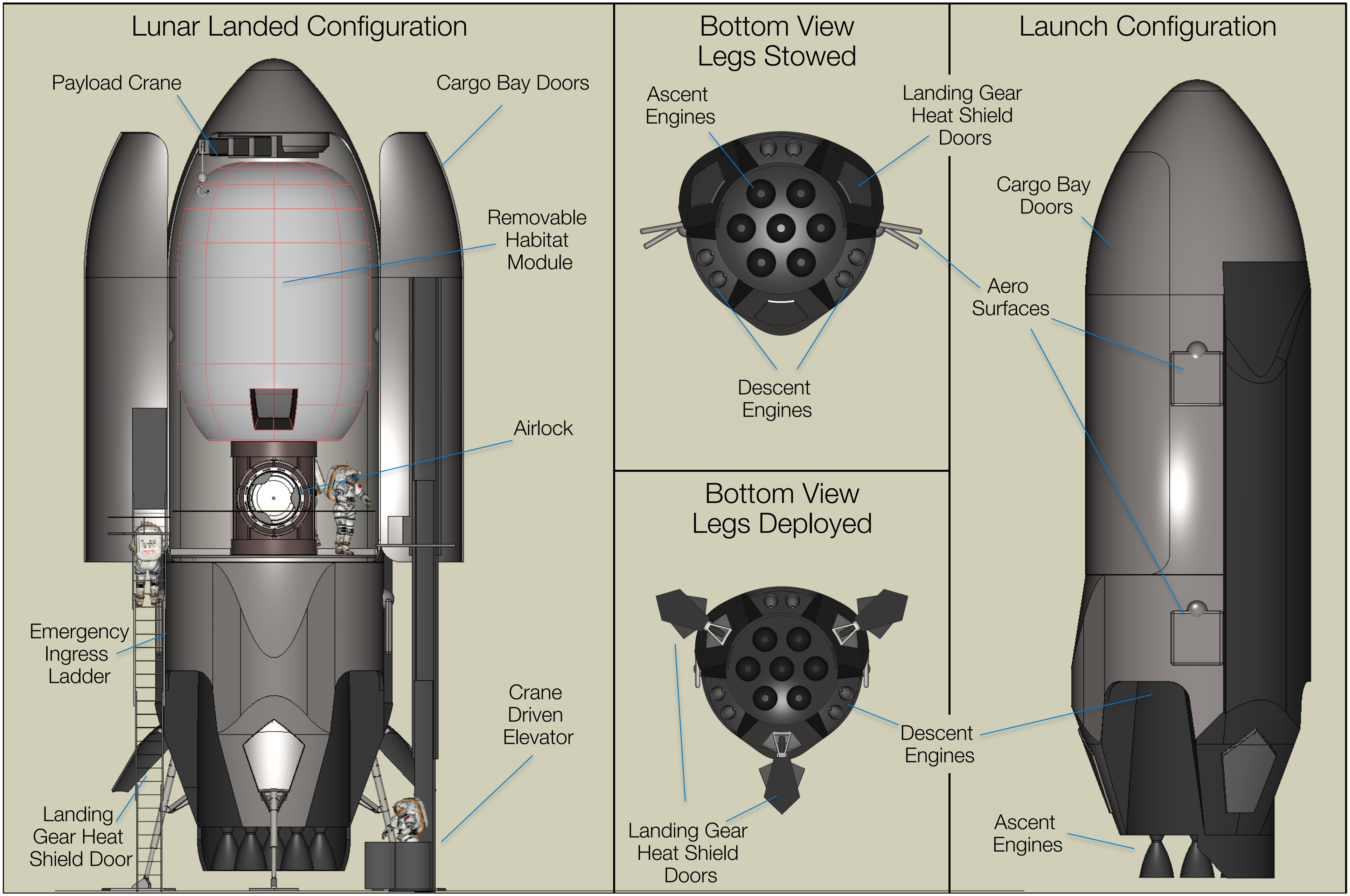
But First

The Next Step…
The Optical Mining™ Test Bed (OMTB)

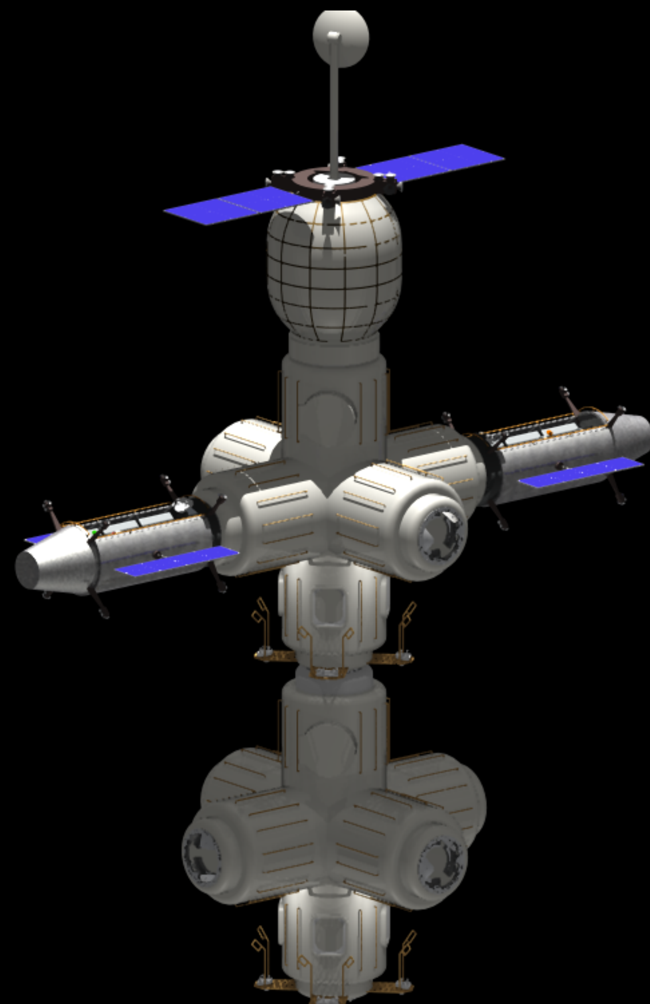


Builds on Complete Theory and Dozens of Demonstrations

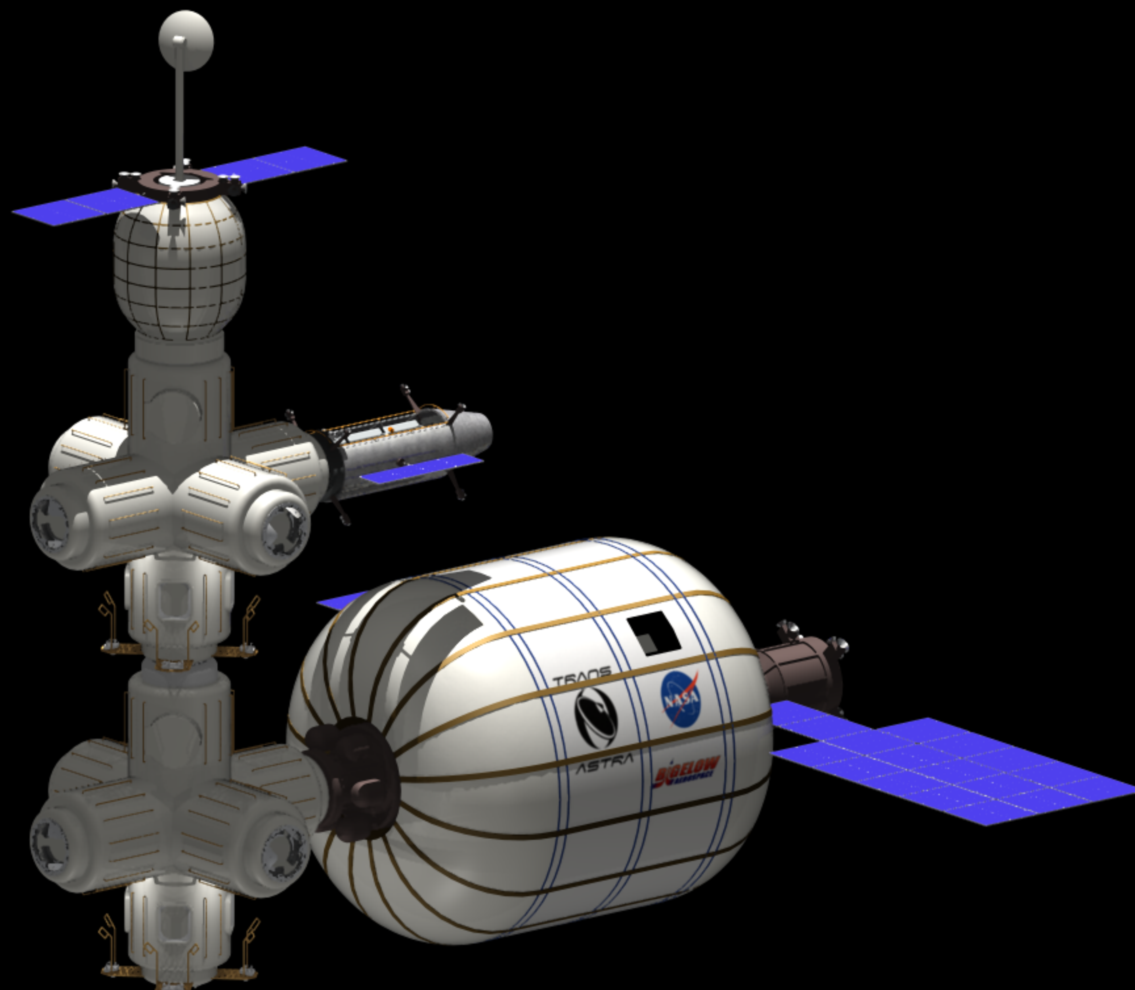
Reusable Spaceship Upper Stage



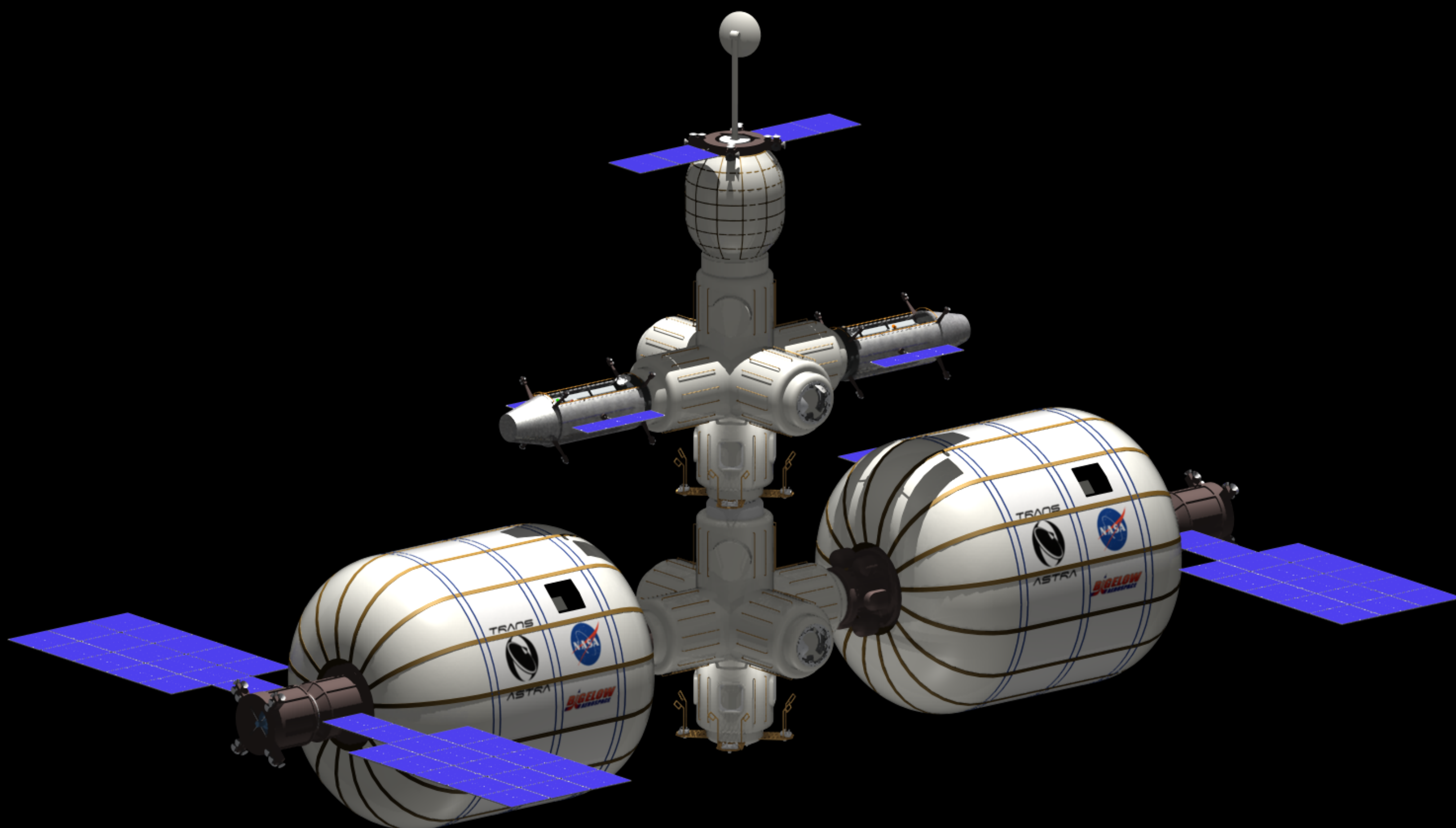
Lunar Orbital Outpost Build Sequence (1)



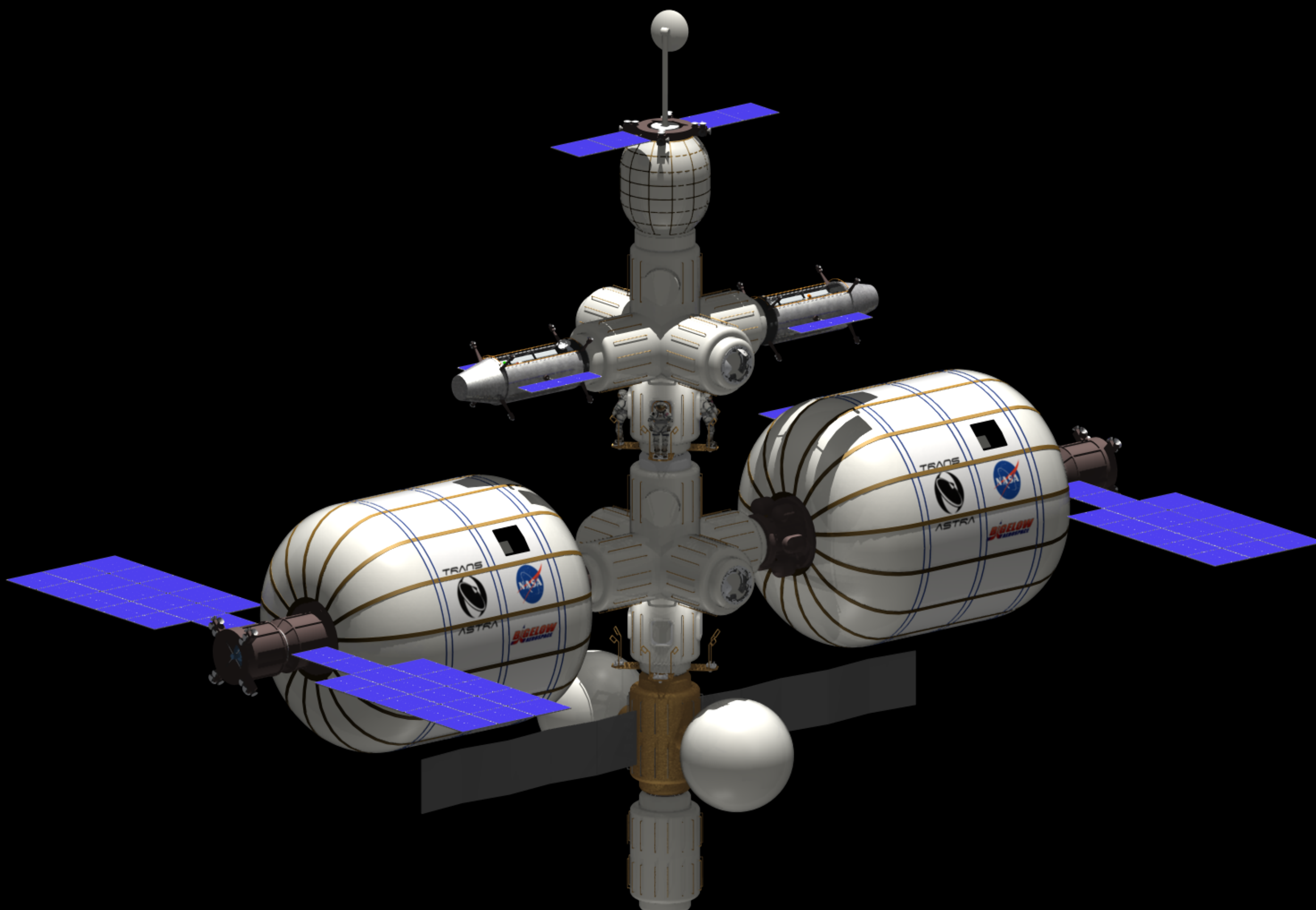
Lunar Orbital Outpost Build Sequence (2)



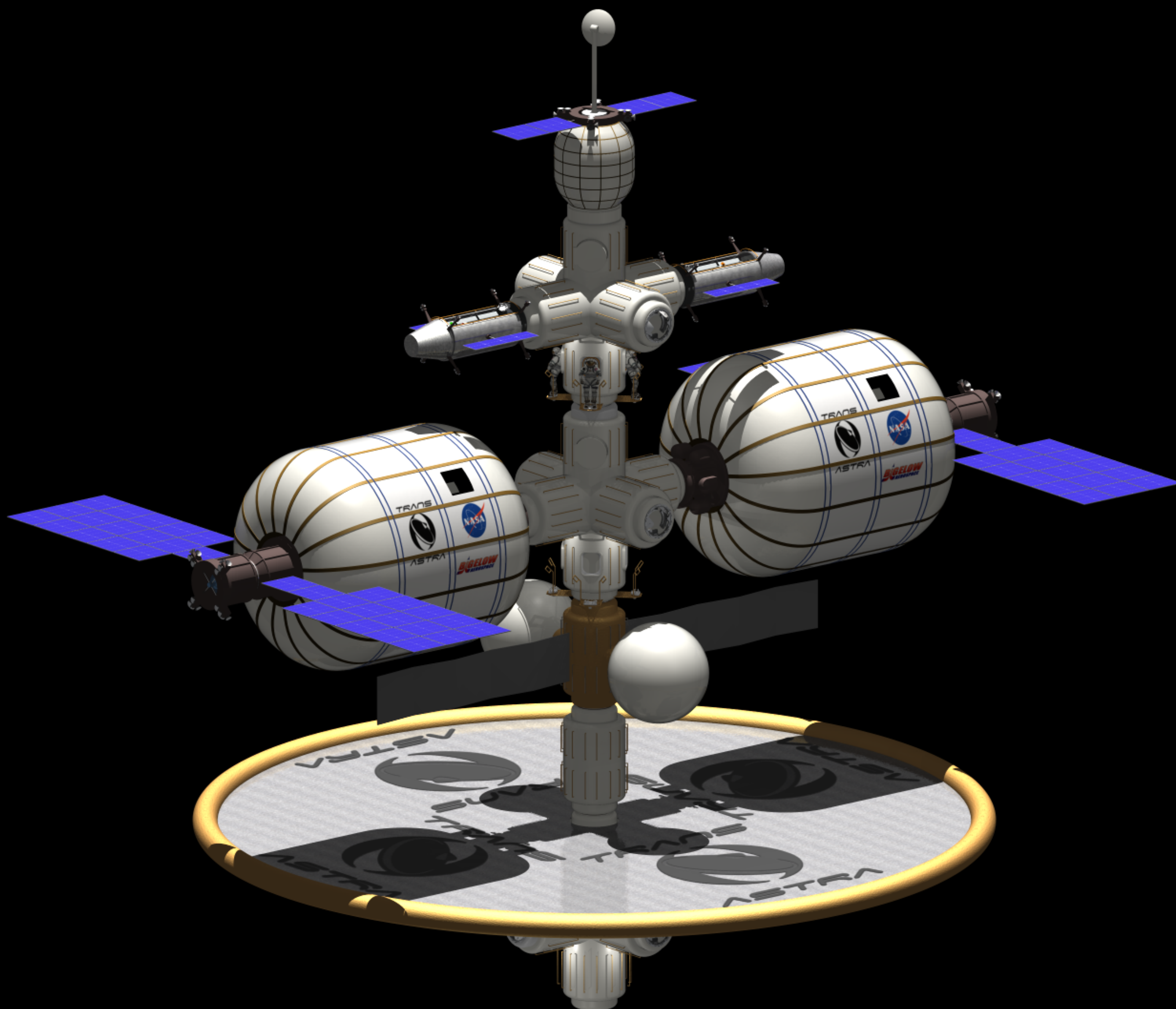
Lunar Orbital Outpost Build Sequence (3)



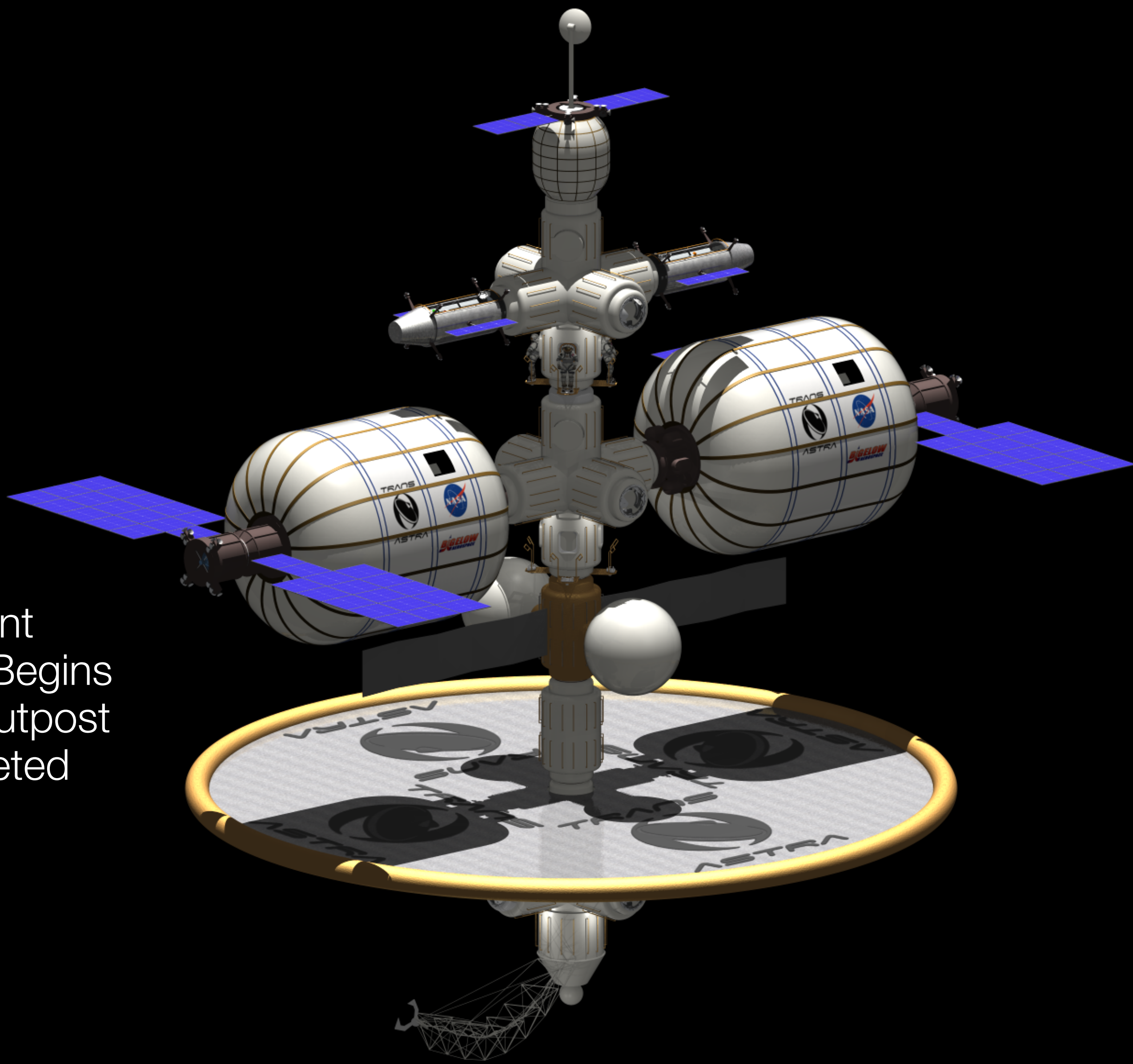
Lunar Orbital Outpost Build Sequence (4)



Lunar Orbital Outpost Build Sequence (5)

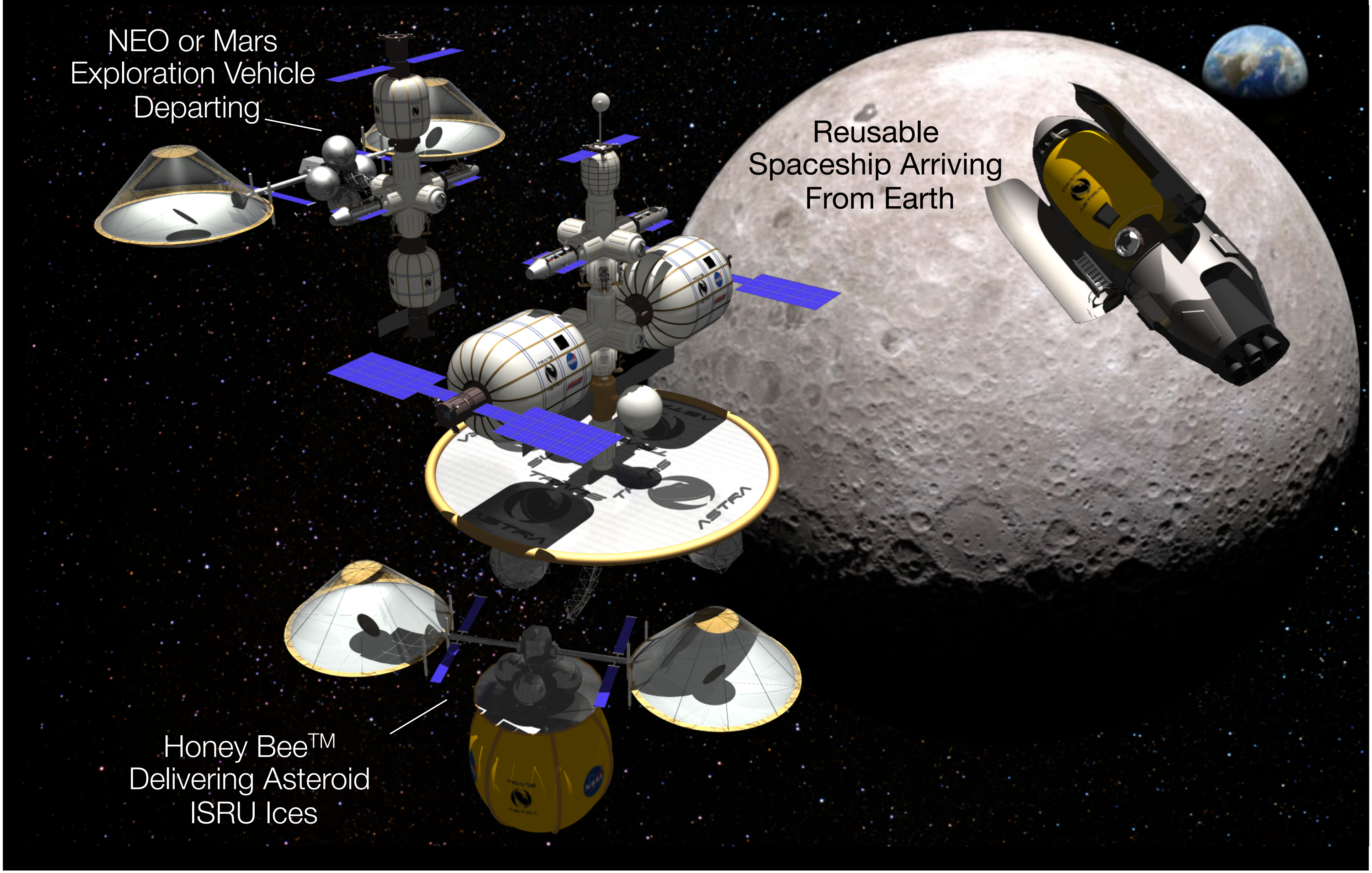


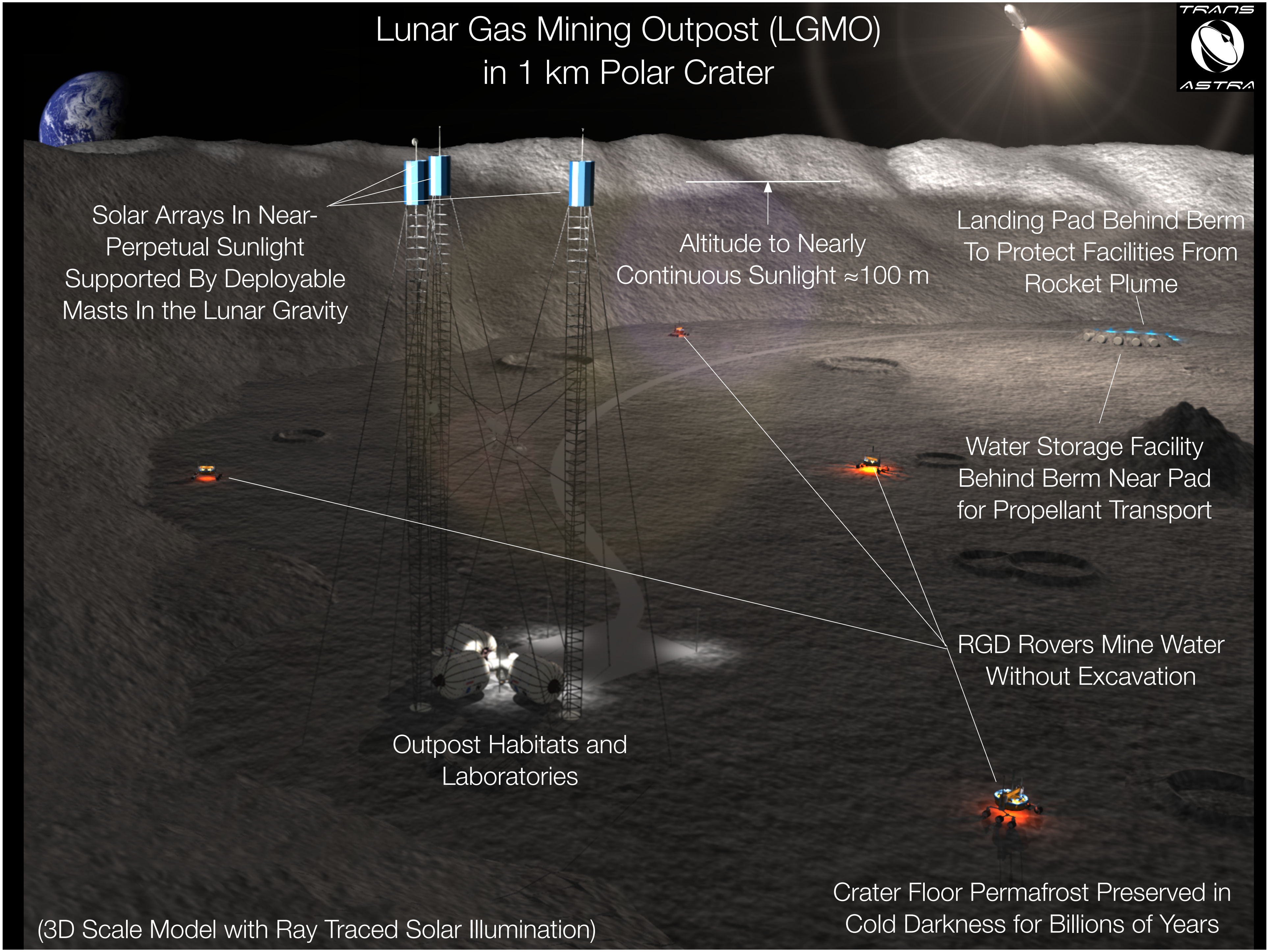
Lunar Orbital Outpost Build Sequence (6)



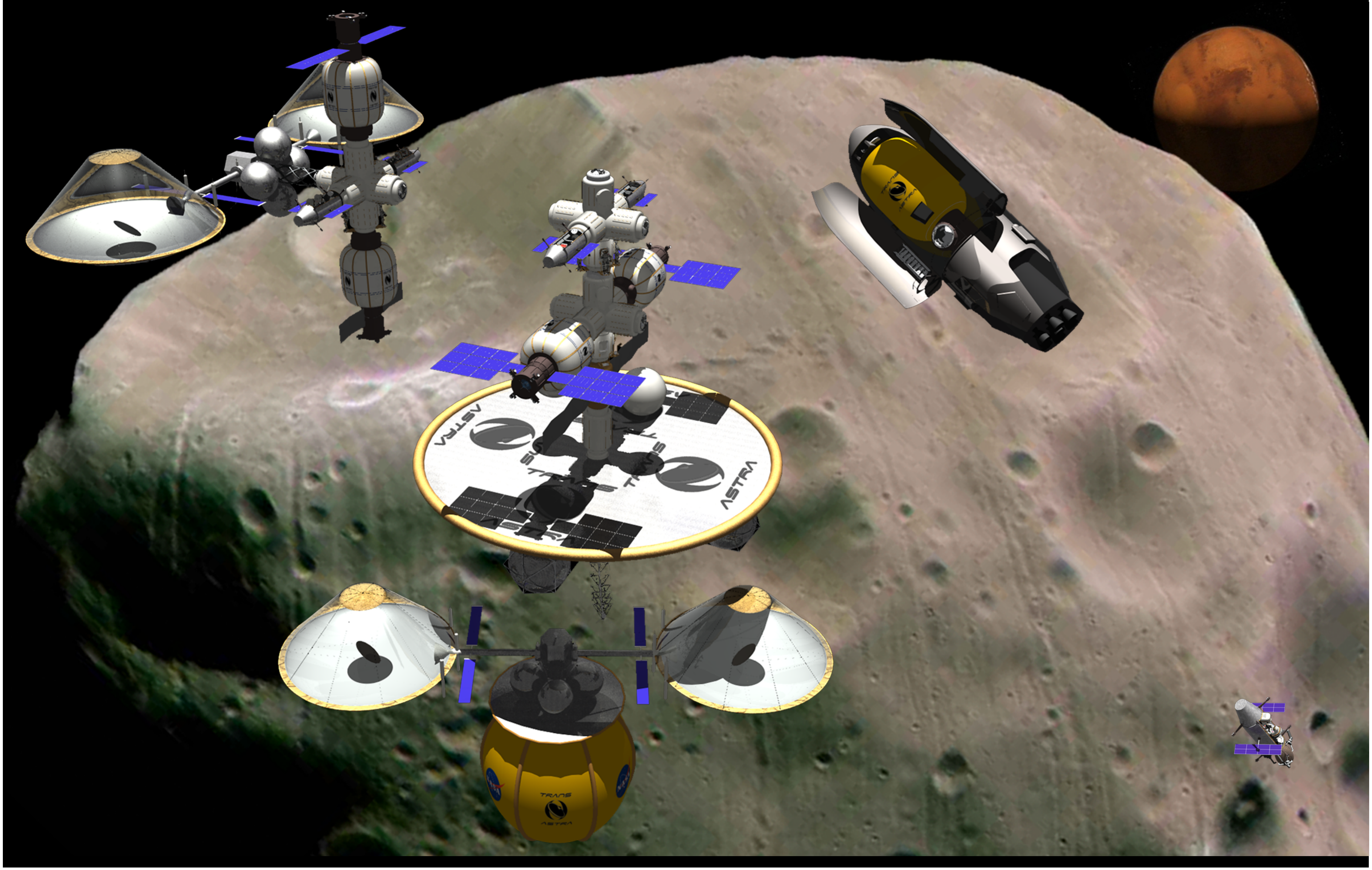
Propellant
Processing Begins
When the Outpost
is Completed

Operational Lunar Orbital Outpost

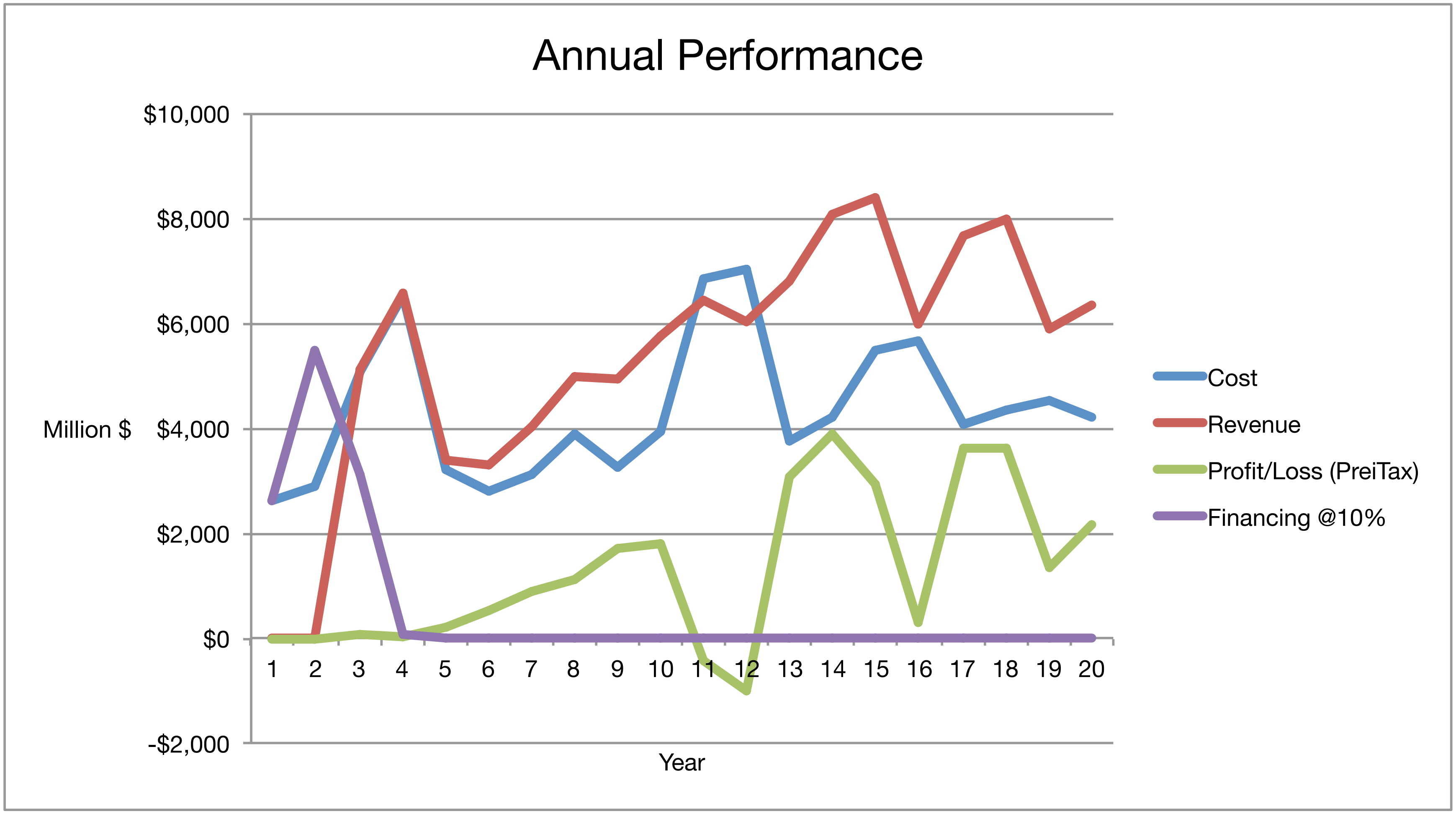



Lunar Gas Mining Outpost (LGMO)
in 1 km Polar Crater
TRANS ASTRA
Solar Arrays In Near-Perpetual Sunlight Supported By Deployable Masts In the Lunar Gravity
Altitude to Nearly Continuous Sunlight ≈100 m
Landing Pad Behind Berm To Protect Facilities From Rocket Plume
Water Storage Facility Behind Berm Near Pad for Propellant Transport
RGD Rovers Mine Water Without Excavation
Outpost Habitats and Laboratories
Crater Floor Permafrost Preserved in Cold Darkness for Billions of Years
(3D Scale Model with Ray Traced Solar Illumination)

Mars Exploration Systems at Deimos



TransAstra Minimum Business Case: Summary of Costs and Revenues



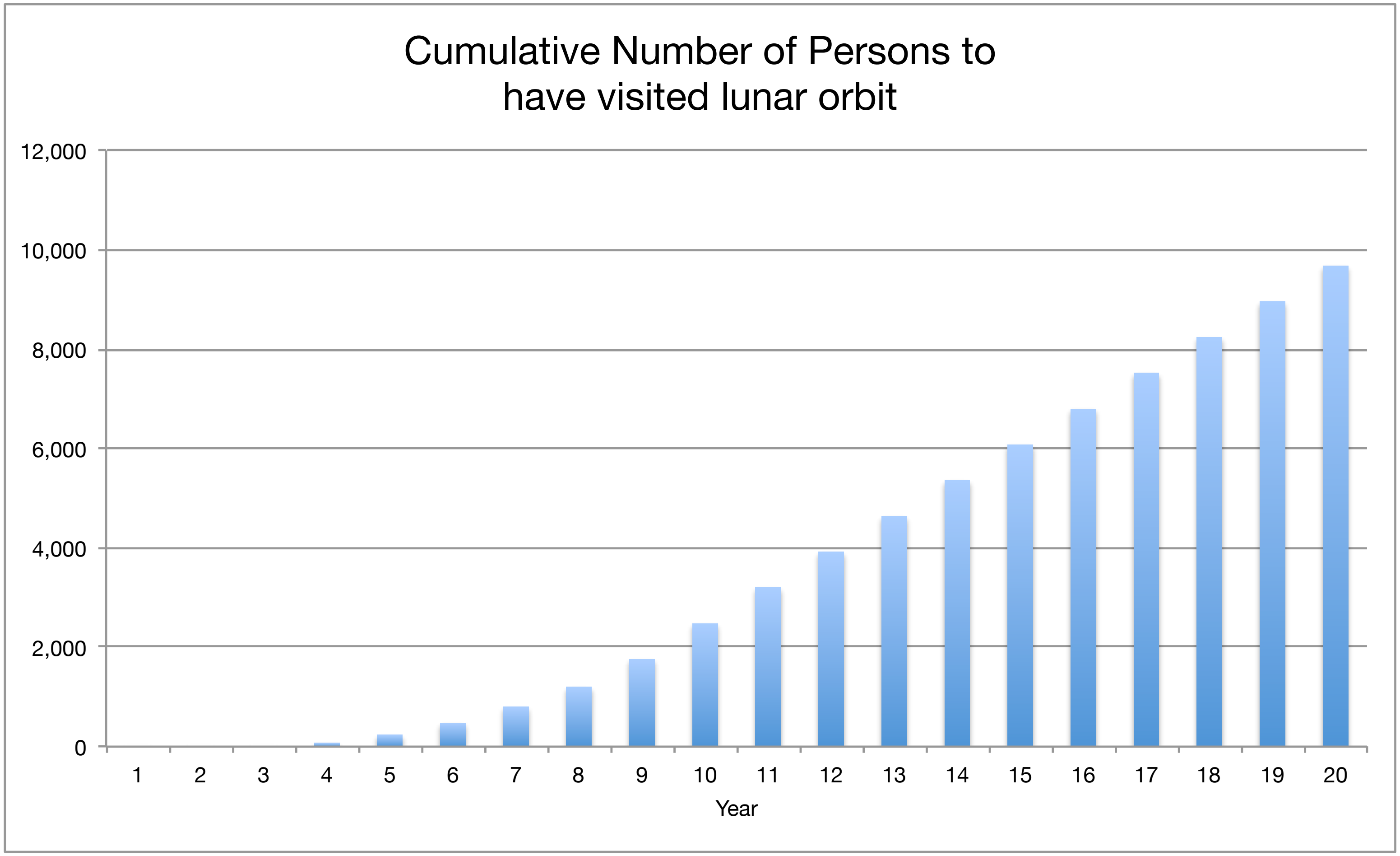
Business Case: Transportation Service Price Analysis

- Propellant cost based on:
  - Honey Bee™ Unit Cost: 174 M$ (DDT&E TFU=$1.7B)
  - Honey Bee™ lifetime: 10 years
  - Honey Bee™ lifetime number of trips: 7
  - Replacement Asteroid Capture System (each): 20 M$
    - 6 will be required over the lifetime.
  - Replacement Inflatable Systems (each): 10 M$
    - 2 will be required over the lifetime
  - Initial Launch Cost: 63 M$ (Falcon 9)
  - Mass returned per trip: 100,000 kg on average
  - Average Propellant production from Mass returned: 60,000 kg
  - Total Lifetime Propellant production: 420 MT
  - Honey Bee™ lifetime costs: 174 + 120 +20 +63 = 377 M$
  - 377/420 = 748 $/kg Propellant Cost
  - Price is 748 $/kg + 20% or 897 $/kg

Cost to LEO would be $3,000/kg, Cost to LDRO would be $12,000/kg

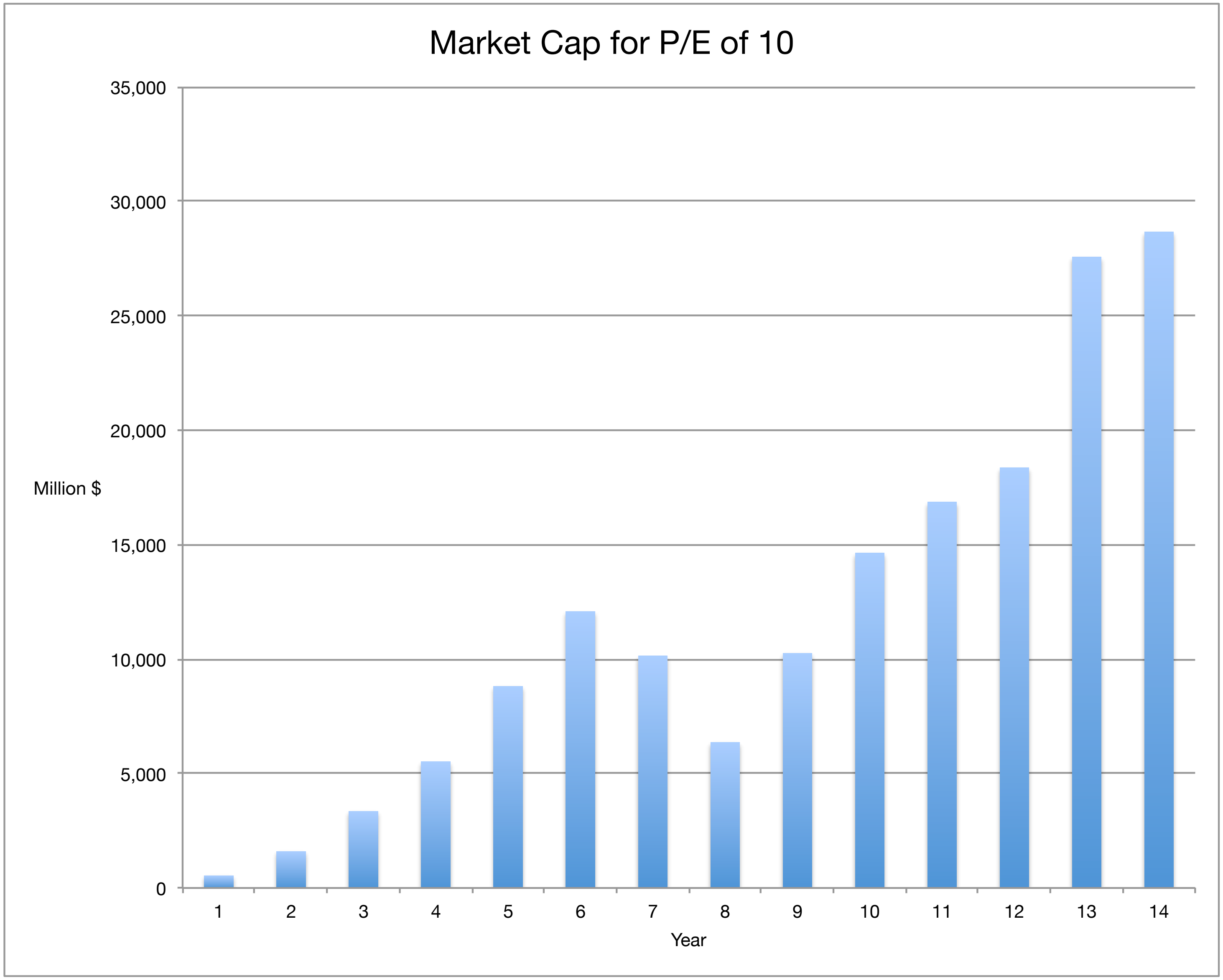
Space Tourism Market: Very High Net Worth People

Lunar Tourism Market Projection



Post Apollo

TransAstra Projected Market Cap Based on Five Year Forward PE 10:1



Connect

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