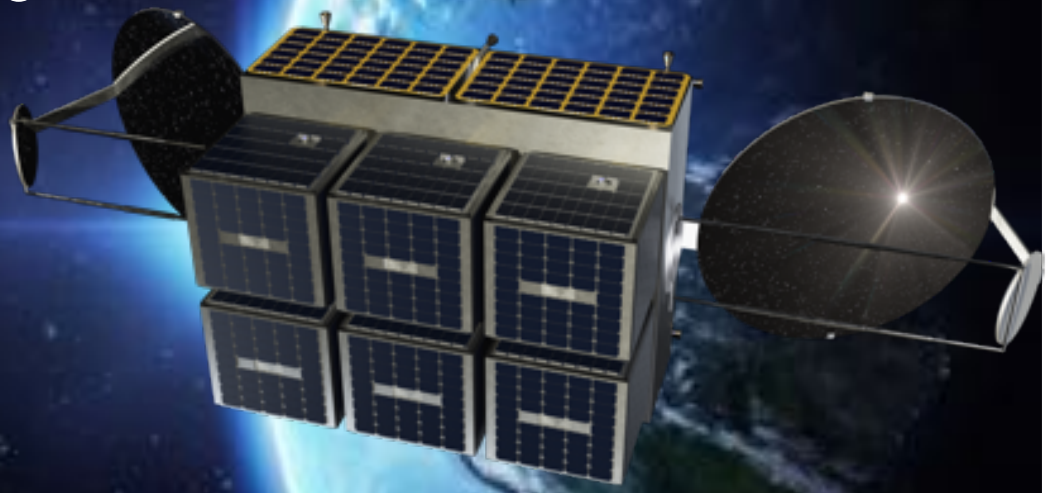
- Commercial Orbital Logistics*,
- Lunar Polar Power Towers*,
- Optical Mining of Asteroids*
- Telescopes to Prospect for ISRU**



Joel C. Sercel and Company
TransAstra Corporation

TRANSASTRA

XXII Space Resources Roundtable 6/7-10/22

* Patented
** Patent Pending

TransAstra:
Venture and NASA Funded Early Stage Startup

- 7,000 sf state-of-the-art lab in Los Angeles Area (*The Hive*)
- Team of 30 including world class engineers including scientists
- Network of Top University Professors as advisors and shareholders
- Skills and facilities for ISRU, propulsion, optics, microwave engineering, thermal engineering and design, space systems, trajectories

TRANSASTRA

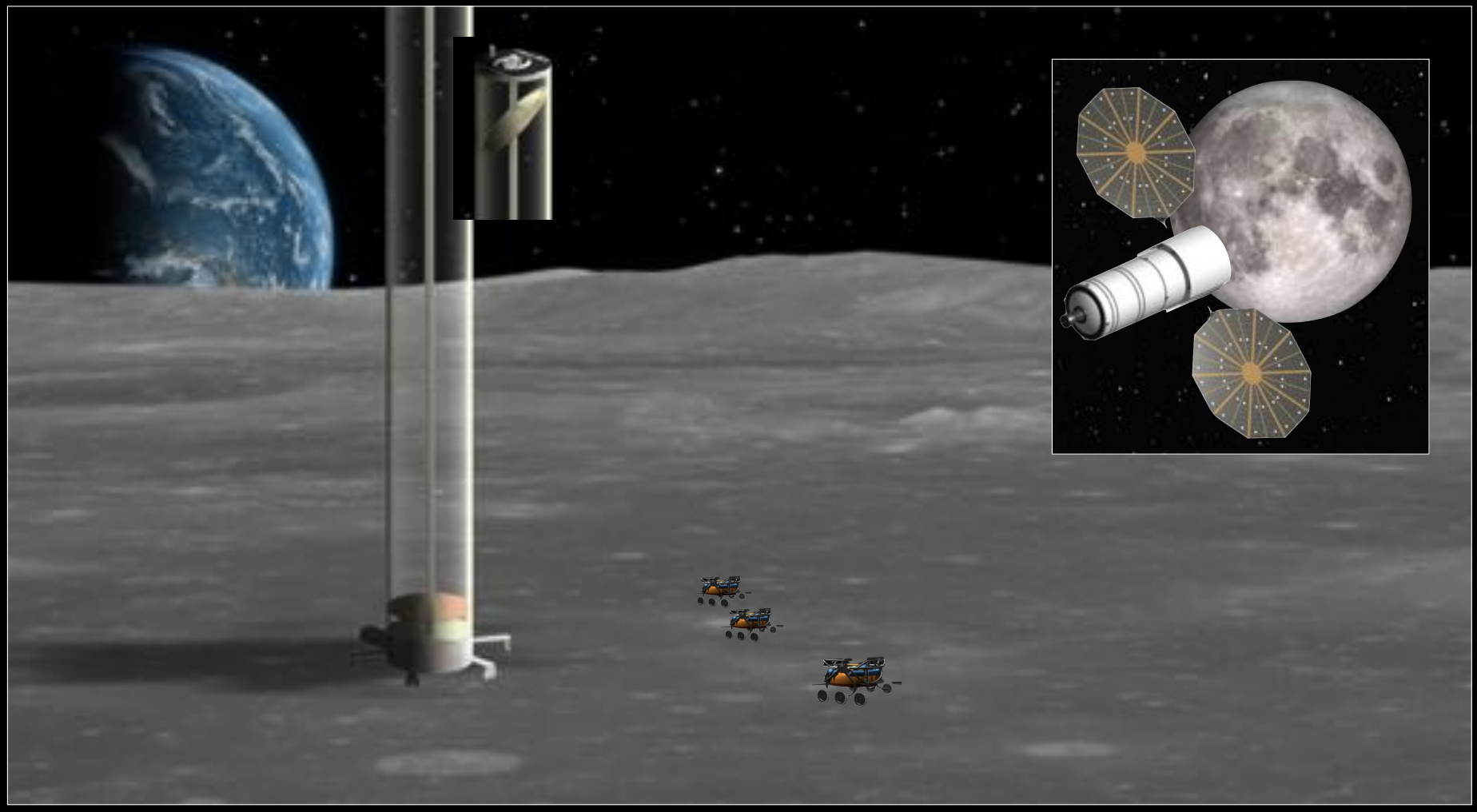
Topics

- Lunar Polar Mining Outpost ISRU Related Technologies
- Optical Mining™ and the Apis™ Architecture for Asteroid Mining
- The Sutter Telescope For Asteroid Prospecting and Space Domain Awareness
- TransAstra roadmap

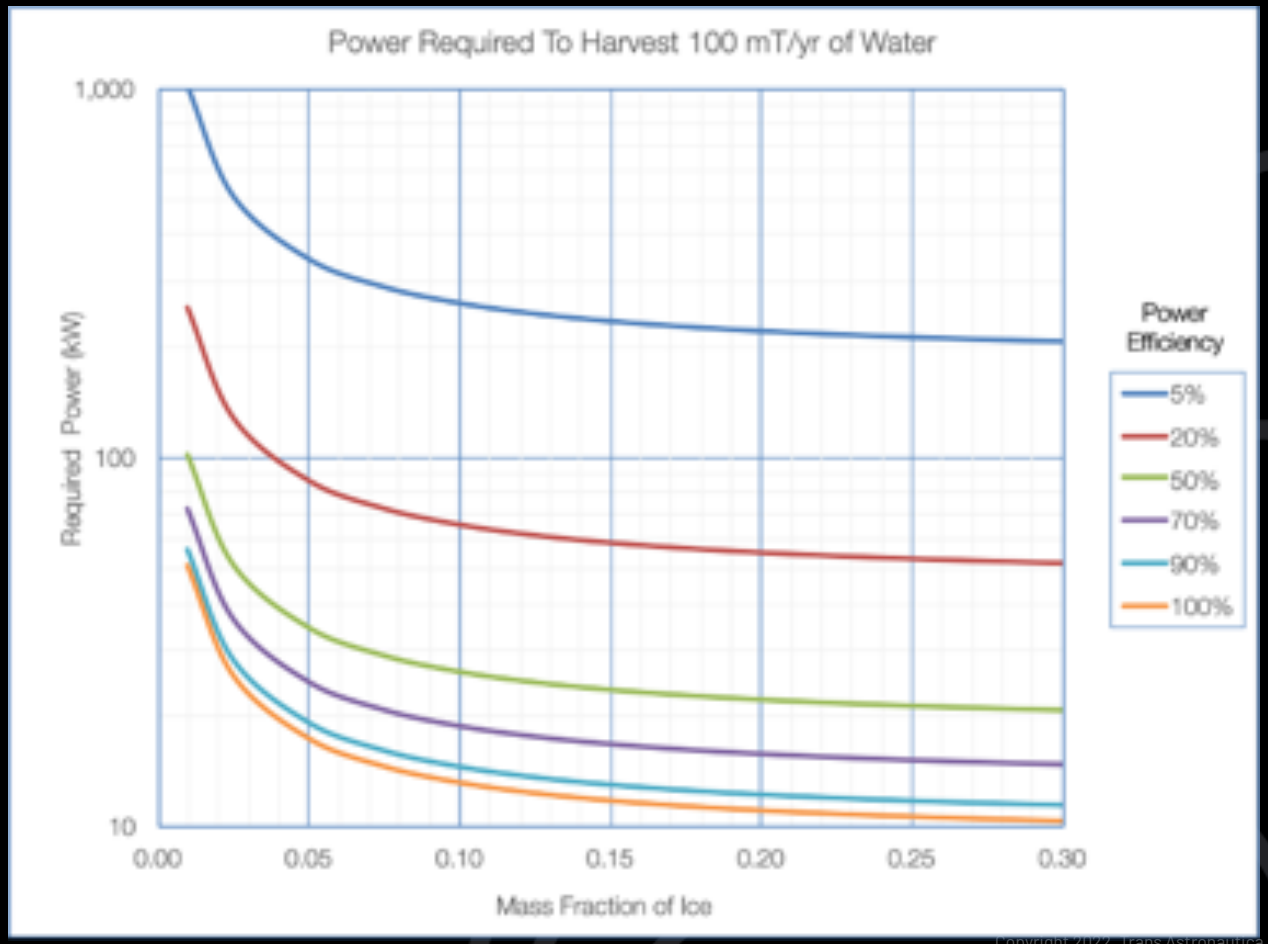
TRANSASTRA

NIAC Phase 2: Lunar Polar Propellant Mining Outpost (LPMO): A Breakthrough for Lunar Exploration & Industry

TRANSASTRA



Energy is the Key to Exploiting Lunar Polar Water



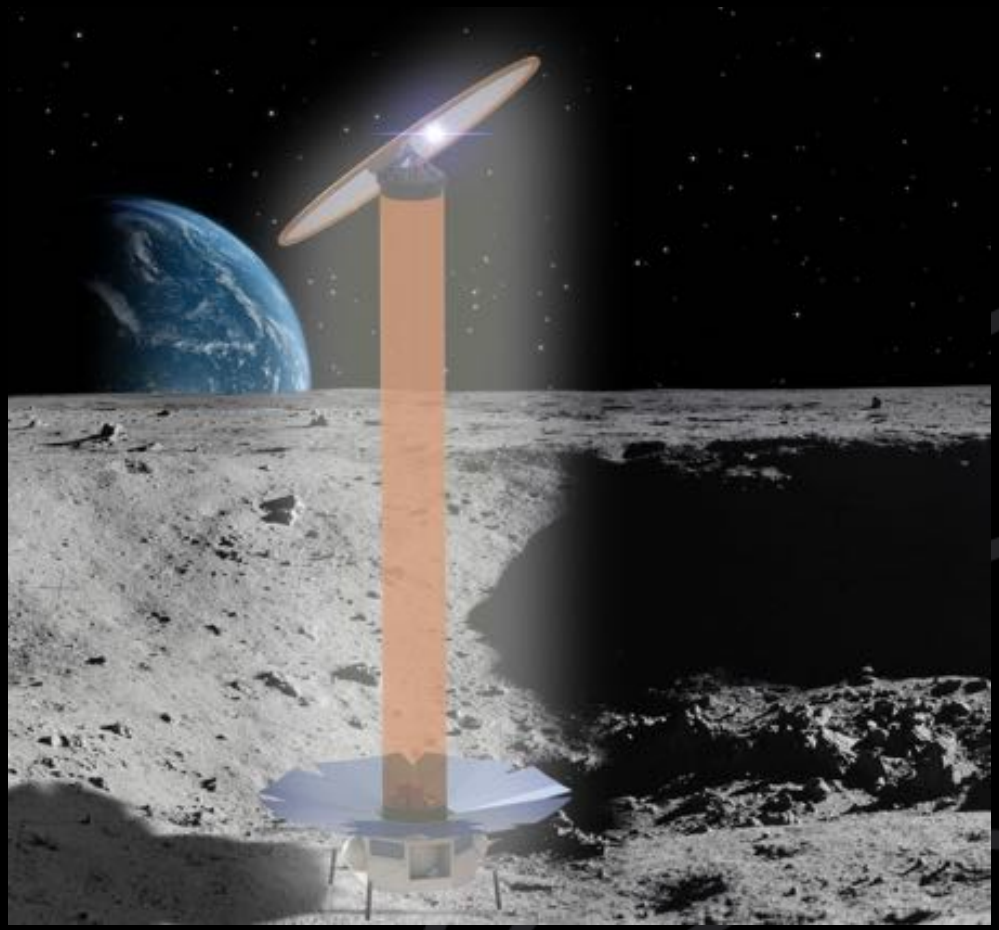
Sun Flower™ Tower Demonstrations

Sun Flowers can provide MegaWatt levels of solar power required to energize lunar polar mining operations by hoisting heliostats (directing sunlight onto surface solar arrays) to altitudes with nearly continuous sun exposure at the lunar poles.

- Laboratory deployment testing completed on:
  - 4 m tensegrity structures (far right) and
  - 2 m inflatable structures (near right).
- Load bearing evaluation of 2 m. Kapton inflatable structures performed in the laboratory (near right)
- Initial studies determined inflatable structures capable of higher payload mass fraction:
  - Enabling greater lifting capacity while requiring lower total system mass.
  - Micrometeorite damage analysis based on lunar flux show little concern for gas loss.

4 meter tensegrity tower deployed with intern for scale.

Lunar Polar Power via Sun Flowers™

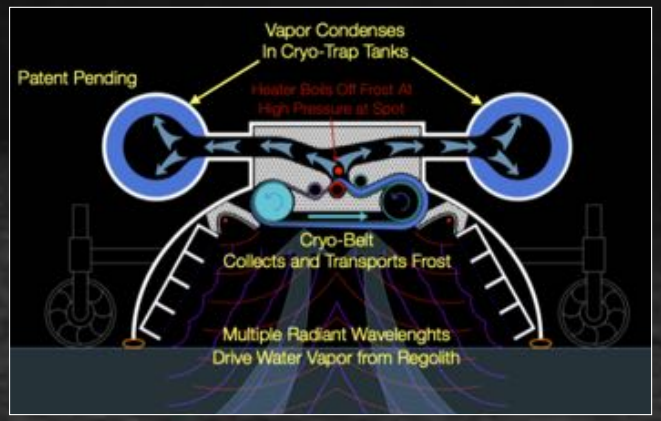


Sun Flower Power Tower redirects light solar arrays in shadowed lunar polar regions
10 m. Demonstration tower shown.

Radiant Gas Dynamic (RGD) Mining

TRANSASTRA

- Beetle™ Rover lowers dome over area selected for extraction
- Multiple techniques are used to heat the subsurface and drive out volatiles
- Cryo-belt captures volatiles and transfers them to cryotrap tanks for return to central propellant processing facility

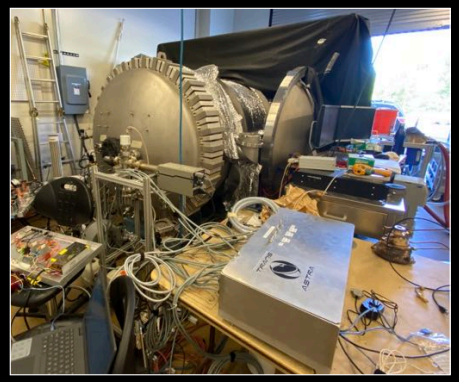


Mission: To Extract Volatile Materials In Asteroids

TRANSASTRA

- 10-50% of known large asteroids are likely hydrated CI-CM-like
- Carbonaceous chondrites
  - typically 10-20% water by weight in the form of hydrated minerals
  - friable and may be in rubble piles with regolith or in blocks

Asteroid Mining Using Optical Mining™ Technology



Optical Mining Test Bed™

Demonstrated Asteroid Spallation
Using Concentrated Light

- Highly concentrated solar energy, spallation allows volatiles to be extracted
- Volatiles and debris separated using low-G auger feeds and cryotrap freezing storage
- Successfully demonstrated using the Optical Mining Test Bed™
  - Up to 32 kW Xe-arc lamp
  - vacuum to 10^{-6} torr

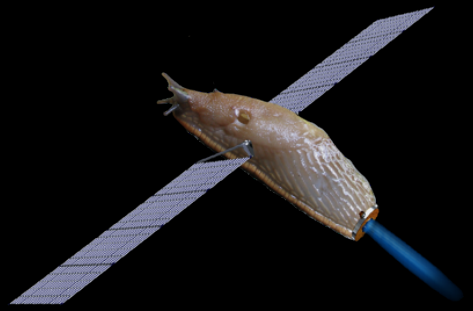
NIAC Phase 3: Mini Bee Prototype To Enable Demonstration Flight in LEO

Legacy Propulsion

TRANSASTRA

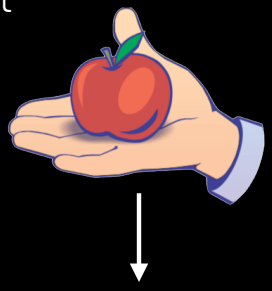
Chemical Thrusters

Electric Propulsion



$10 Million in solar arrays power less than 1 Newton of thrust

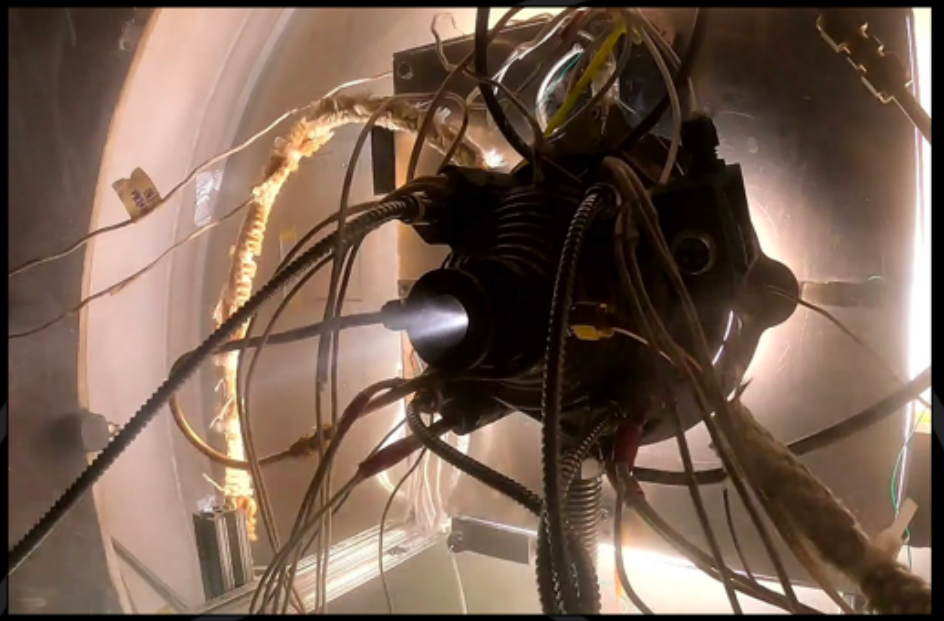
Electric Propulsion Burns Cash



1 Newton Force

Omnivore™ Solar Thermal Rocket Engine

Why Omnivore?

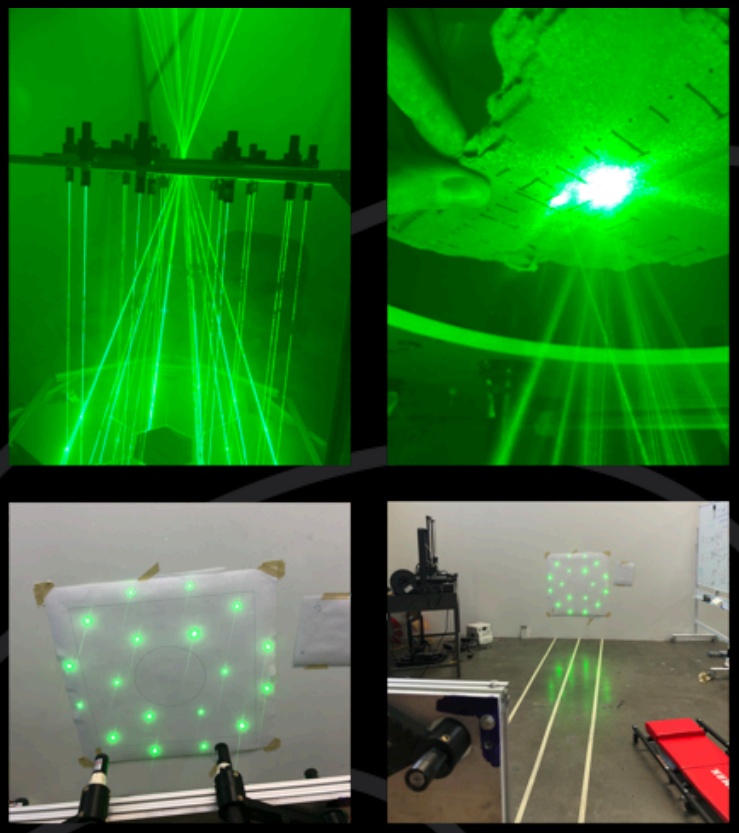


Omnivore Mk I Solar Thermal Rocket Water Propulsion Tests in the Lab

Optical Systems Alignment

Additional work on alignment and control of the optical elements that focus sunlight for both the Omnivore™ and the Optical Mining™ system is ongoing

- Integration, alignment, and initial testing of the optical system has begun as shown in the images to the right.
- Upon completion of those tests, integration with the omnivore test unit and the final system level tests will be performed later this year.
- Alternative approaches using fewer mirrors are under study for application to the Worker Bee OTV and may be adapted for use in the planned Mini Bee LEO demonstration Mission

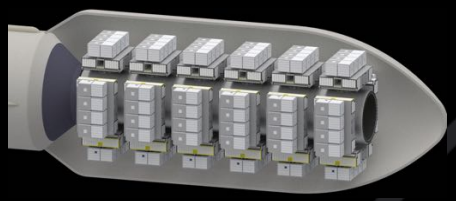


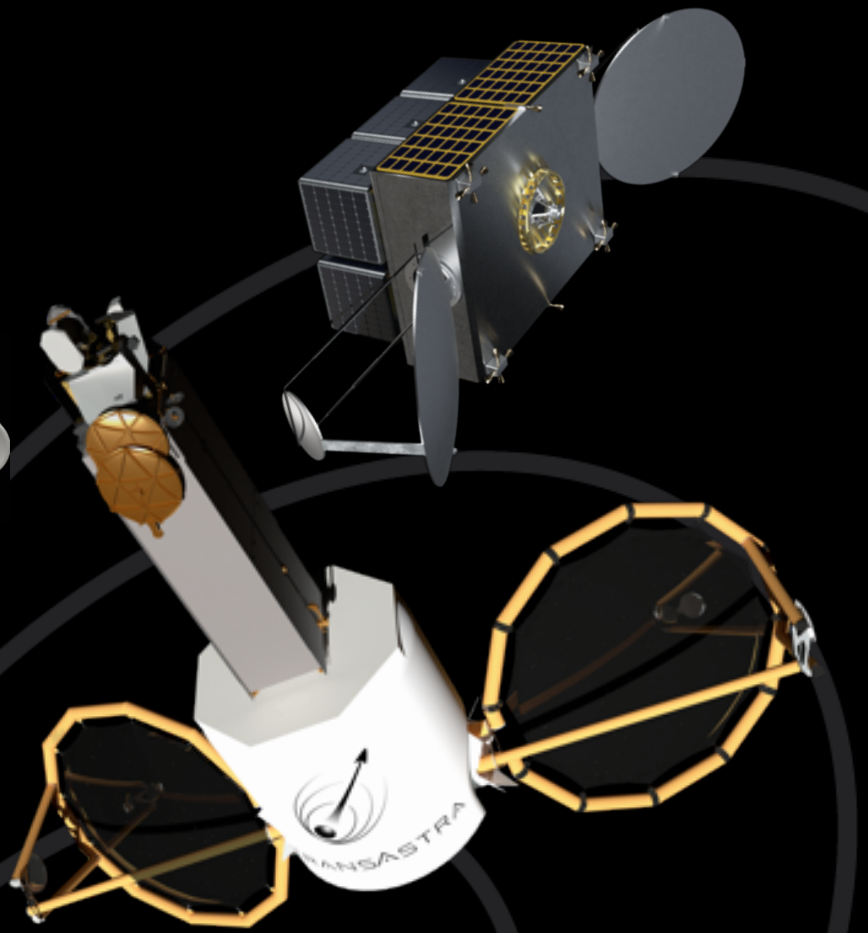
Primary Optical Mirror precision validation testing in the lab

Worker Bee OTV Version 1

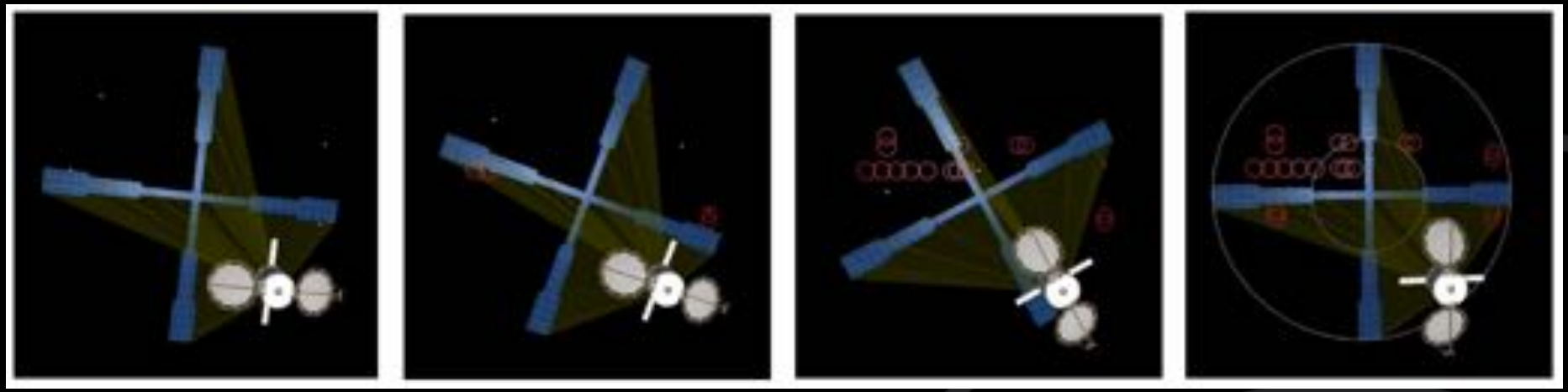
Worker Bee™ is the backbone of a fleet of space logistics vehicles designed to:

- Deliver satellites,
- Deploy constellations, and
- Host payloads in LEO to Lunar and even Near Earth Asteroidal (NEA) orbits.
- Worker Bee 1 is compatible with:
  - various small,
  - most medium, and
  - all large launch vehicles (ride share)
- Carries 25 kg (e.g, to NEA) to 200 kg (e.g., in LEO) depending on the launch vehicle and destination orbit.
- Greatly reduces trip time compared to EP
- Less costly than conventional chemical propulsion





Asteroid Prospecting Using the Sutter System



Sutter's unique stop/stare/turn approach to observation, where the rotating FOV is arranged in a cross pattern, increases the likelihood of multiple detections of moving objects.

Arrow points to asteroid Suzhou detected by the Sutter System

Current demonstration unit of 4 10" telescopes in operation at Winer Observatory.

Asteroid Prospecting Using the Sutter System

TRANSASTRA

Combined Innovations and Cumulative Benefit on Finding & Tracking on Cost per Target		
Technology	Cost Benefit	Cumulative Advantage
Matched Filter Tracking (MFT)	100X	10^2
Compound Telescope Benefit	10X	10^3
Rotate-Stop-Rotate Observations	10X	10^4
Single Moving Part	10X	10^5
Optimal Orbit	3X	3×10^5

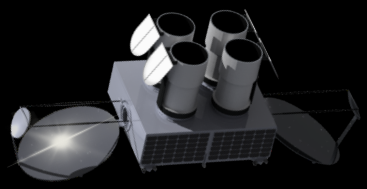
Video Link

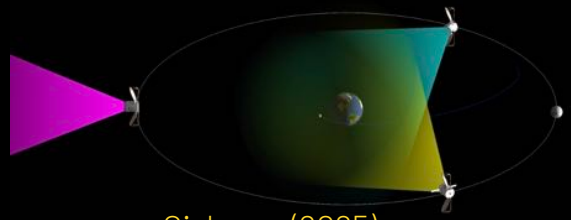
Roadmap: Fast Path to Revenue… Trillion Dollar Vision

Sutter Space Telescopes: Breakthrough for Finding What Moves in Space

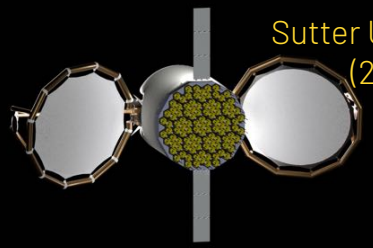
Ground Demo (Now)

Sutter Flight demo (2024)



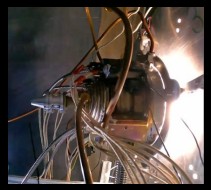


Cislunar (2025)



Sutter Ultra (2028)

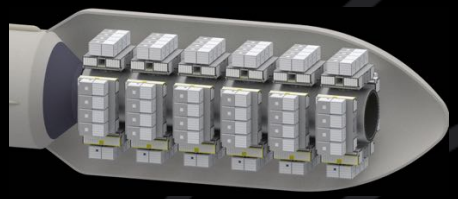
Worker Bee Space Trucks: Revolutionary Orbital Logistics

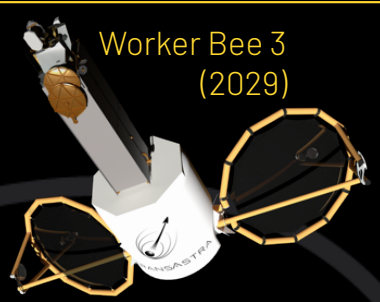


Omnivore (Now)

Worker Bee 1 (2024)

Worker Bee 2 (2027)

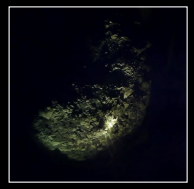


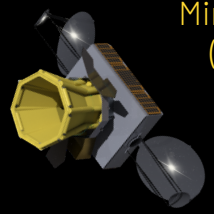


Worker Bee 3 (2029)

Apis™ Asteroid Mining: Harvest The Asteroids for a Trillion Dollar Industry

Proven Breakthrough





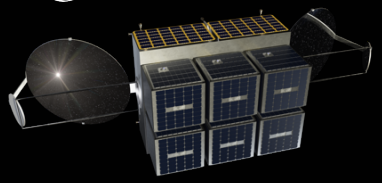
Mini Bee (2024)

Honey Bee (2027)

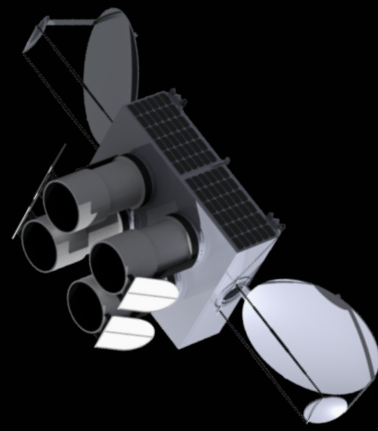
Queen Bee (2029)

TRANSASTRA

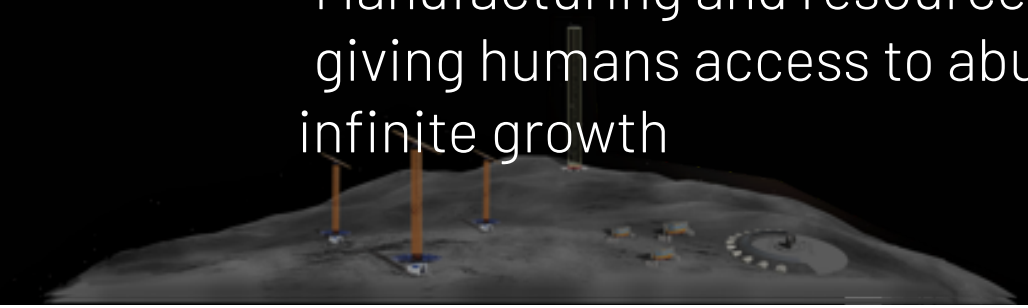
TRANSASTRA

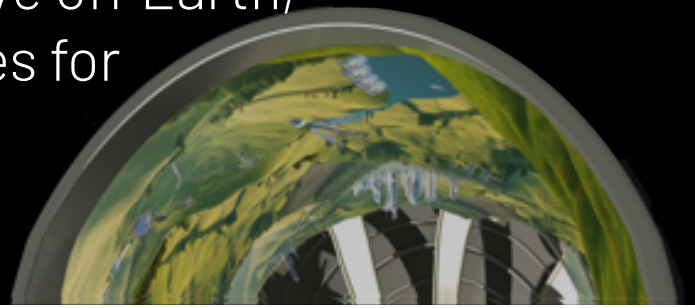


An Unlimited Future



- Now (Today's Business Plan):
  - TransAstra leads in space logistics and space domain awareness, with Omnivore, Worker Bee and Sutter.
- Next (Phase 2)
  - Optical Mining and Sun Flower technologies open up trillions of dollars of new revenue streams
- Vision (Beyond That)
  - Manufacturing and resource mining will move off Earth, giving humans access to abundant resources for infinite growth





[1] Sercel, J.C., et al., (2017) Emerging Space Office Grant (ESO), "Stepping Stones: Economic Benefits of Asteroid Mining for Exploration of Deep Space" NASA Report, Contract No. NNX16AH11G.

[2] Sercel, J.C., "Asteroid Provided In-situ Supplies (APIS): A Breakthrough to Enable an Affordable NASA Program of Human Exploration and Commercial Space Industrialization," NIAC Phase 1 Final Report, 2016.

[3] Sercel, J.C., Dreyer, C. B., and A. Abbud-Madrid, "Demonstration of "Optical Mining" For Excavation of Asteroids and Production of Mission Consumables", Phase I SBIR NASA Contract No. NNX15CJ35P December 16, 2015, ICS Associates Inc.

[4] Sercel, J.C., Optical Mining to For Sustainable Space Exploration and Industrialization: Phase 2 Final Report, 2017

[5] Sercel, J.C., "LPMO NIAC Phase 2 Result: 100 m Class Sun Flower™ Demonstrated on the Moon", https://vimeo.com/518261297/aa27531f20

[6] Sercel, J.C., Peterson, C,E, Longman, A. "Method and Systems for Obtaining Solar Power in Permanently Shadowed Lunar Craters," Provisional Patent January 2020.

[7] Sercel, J.C., Jedicke, R., "Space Mission Roadmap to Prospecting Thousands of Asteroids " NIAC Symposium, Denver, October 2017

[8] Gural, P., "Sutter Ultra: Breakthrough Space Telescope for Prospecting Asteroids" NIAC Proposal. https://www.nasa.gov/directorates/spacetech/niac/2021_Phase_I/Sutter_Ultra/ 2021.