Optimast Asteroid Reconnaissance & Survey: Leveraging Optical Interferometry and In-Space Robotic Manufacturing and Assembly

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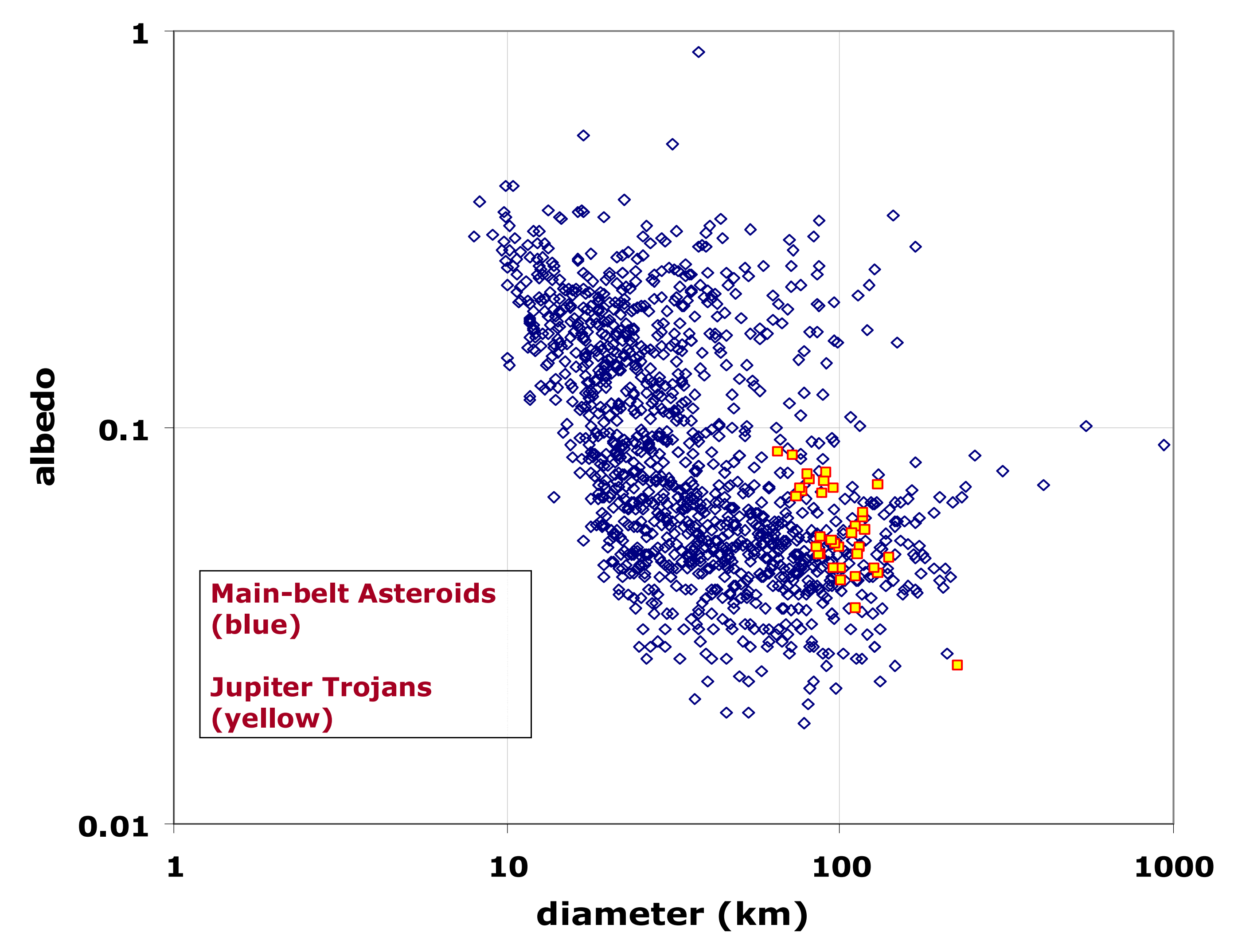
'Flyby Quality' Data for Bodies in the Main Belt, Jupiter Trojans, and NEOs

Single Object Targets Resolvable by *OARS* (N>1,000)



Core Science Program

Extreme optical resolution (~2mas) from a two-element optical space interferometer:
- Shapes, sizes of ~10^3 asteroids
- Orbit and mass determination for all known V<16 binaries
- Spatially resolved spectra-photometry in >10 wavelength bands
- Space-based operation enables **high sensitivity** for reflected light objects
- Application of ground-based interferometry techniques (well developed but limited to emitted light objects, i.e. stars)

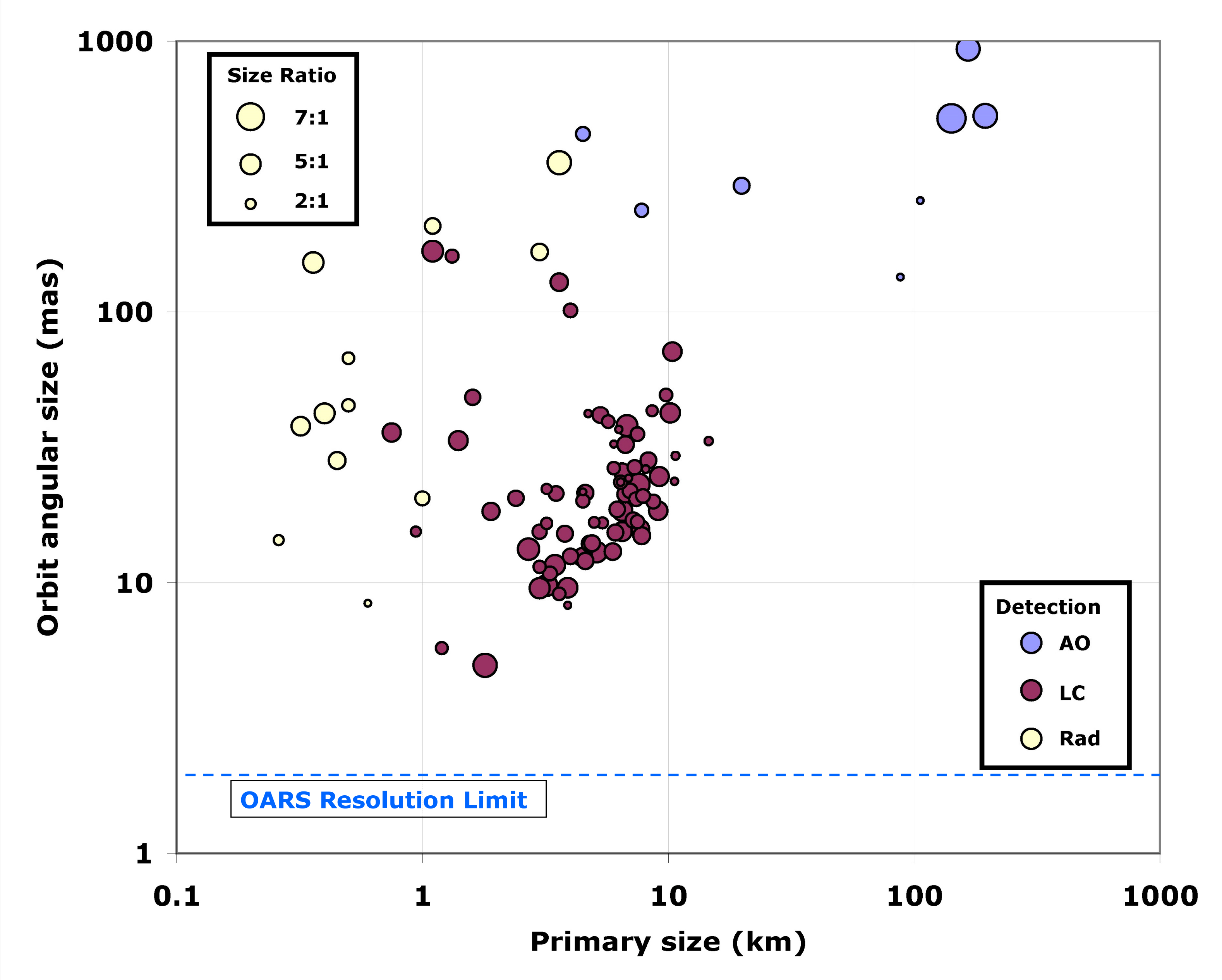
Main Belt Asteroids
- Sizes, shapes for any object > 10km (H<12.3)
- Resolved surface mapping for > 30 km
- Rotation > 6 hours (<5° 'smear' in 300sec)
- Detection of binaries, Keplerian solutions for binary orbits
- Hundreds of possible targets

Near-Earth Asteroids
- Direct size determination for >10m objects (H<26)
- Mapping of binary orbits

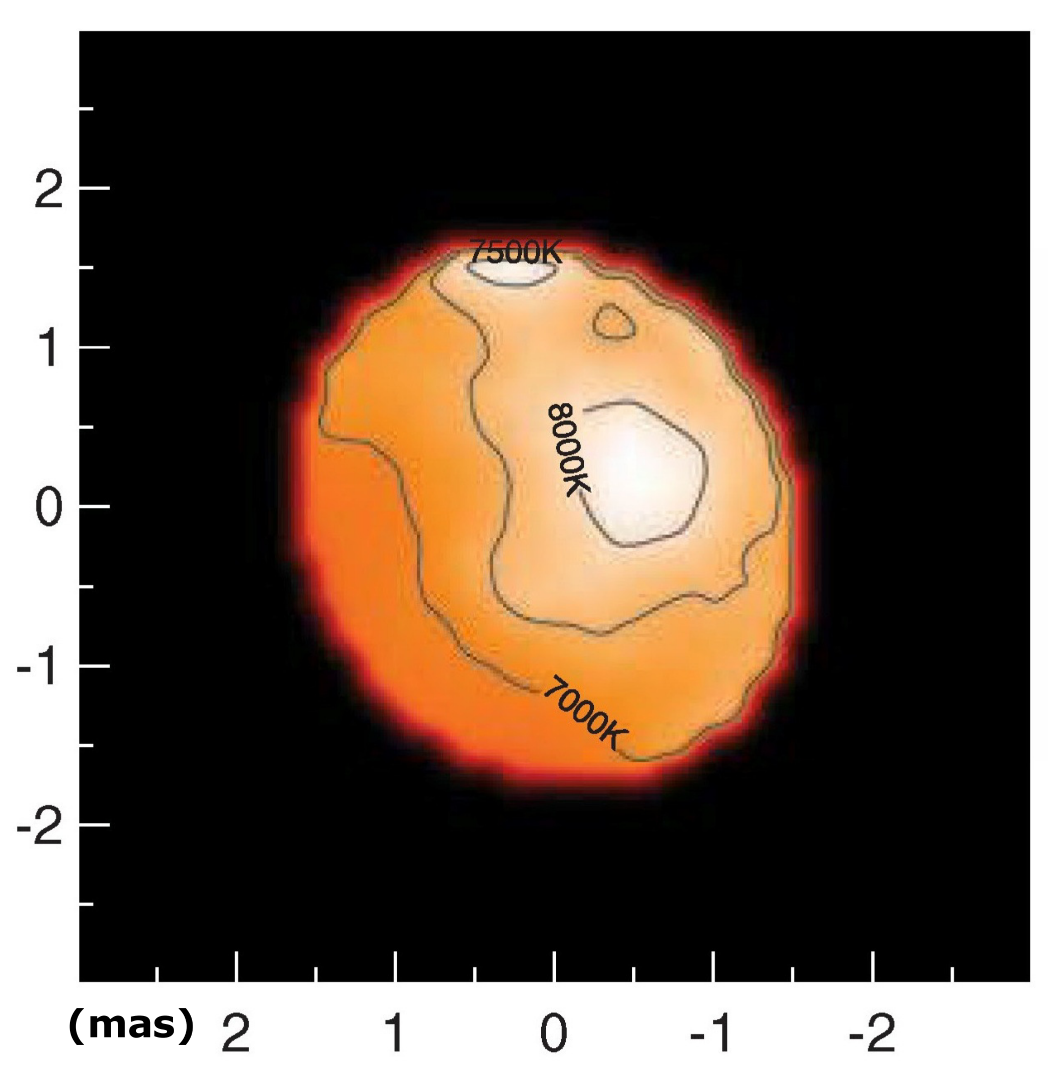
Jupiter Trojans
- H<9.2 (~36 known targets)
- Orbits / shapes for targets, binary detection

Additional targets: gas giant moons, ice dwarfs

Known Binary Targets for *OARS* Orbit Mapping (N>100)

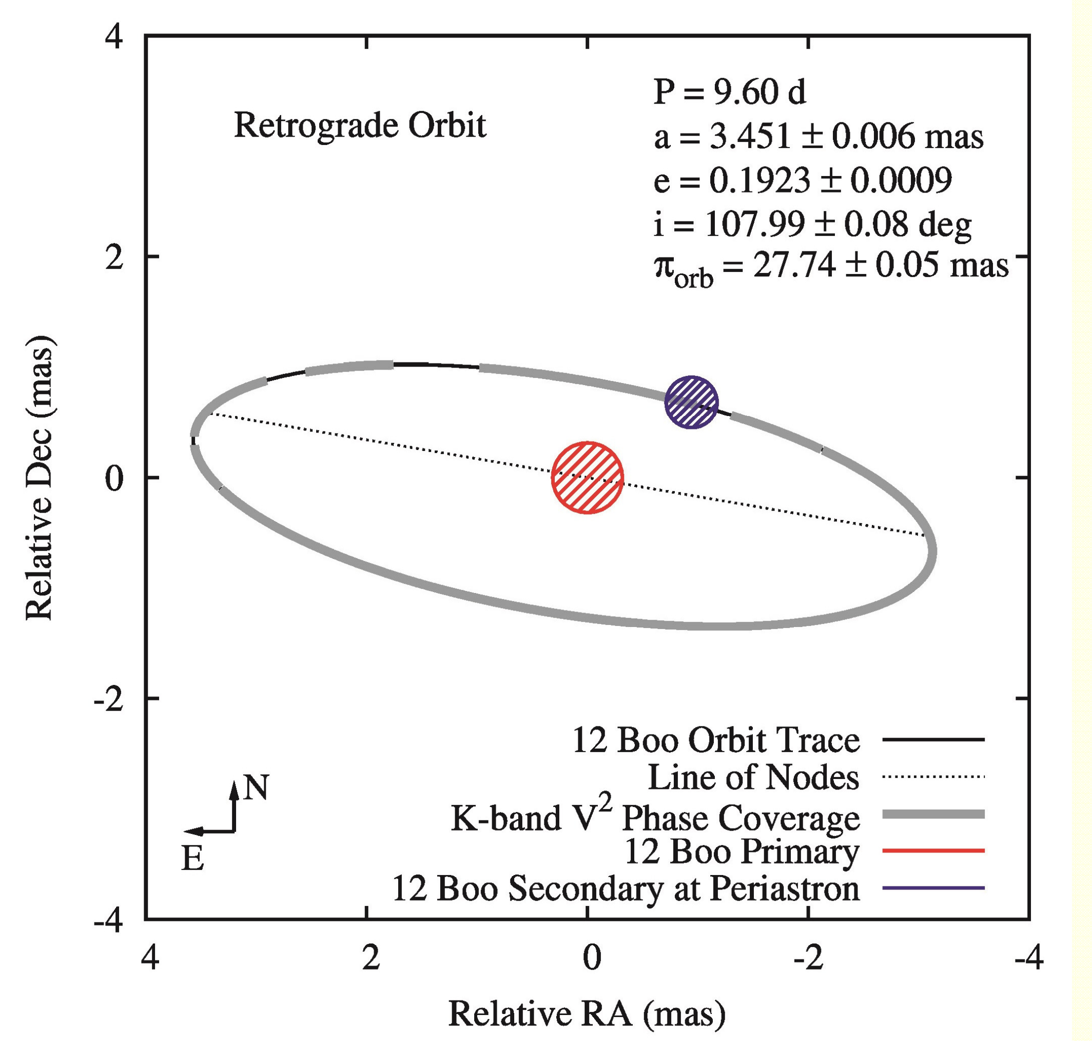


Examples Results of Size/Shape, and a Binary Orbit from Stellar Astronomy



Size, Shape of Altair from Monnier et al. 2007. Using the CHARA Array, Monnier et al. were able image the surface of Altair, illustrating (a) its 1.835±0.007 mas equatorial radius, (b) its 24.2±0.9% shape oblateness (due to rapid rotation), and (c) its pole-to-equator intensity profile (due to gravity darkening).

***OARS* will have similar performance for main belt asteroids.**



Orbit of 12 Boo from Boden et al. 2005. Using the Palomar Testbed Interferometer, Boden et al. were able to map the orbit of 12 Boo and fit a Keplerian orbit, resulting in ~0.33% mass determinations.

***OARS* will have the sensitivity, resolution and contrast to map the orbits of >100 binary asteroids.**

***OARS* Will Provide Comparable Results on Asteroids**

Full Orbit Characterization of Binaries
- Direct determination of masses
- Contrasts up to 100:1 easily detectable

Individual Component Characterization
- Linear size for primary, secondary objects: direct density measurement

Exploration of Binary Space
- New discovery space for companions, esp. for 10-100km primaries

Reference: W. R. Johnston archive

Basic *OARS* Parameters

Two-element interferometer
- 2x25m booms from 2 ESAMM units
  - Baselines selectable from 1 to 50m by running booms in & out
- **Resolution limit: 2.1 mas** @ 0.55μm
- Spacecraft coherence time: >1800sec
  - NB. Typical ground-based atmospheric coherence time: 1-10ms
- **Sensitivity: $m_V \leq 16$ in 300sec**
  - Out-performs all ground facilities
- Two 6" collecting apertures
- **Visible bandpass: 0.2 – 1.1μm** separated into 10+ wavelength bands

Orbit: non-LEO, nominally Earth-Sun L1
- Thermally quiet, with Earth look-back for NEOs

SmallSat Spacecraft
- ESPA-class for volume & mass (~125kg)
- Under development for a 2020 SIMPLEx proposal submission

***Made In Space* Flight Units for Zero-G 3D Printing**

Flown Units aboard ISS
Technology Demonstrator 3D Printer (2014)
- Demonstrated fused deposition modeling process in a microgravity environment

Additive Manufacturing Facility (2016)
- Permanent commercial manufacturing facility
- Current materials: ABS, Green PE, PEI/PC

MIS Fiber Optics (2017)
- Successfully pulled ZBLAN in microgravity

***Flight-Qualified*: ESAMM**
- Thermal-vac tested for flight: TRL 6
- Guinness World Record for longest single 3D printed piece: 37 meter boom (print terminated when shop space limit reached)

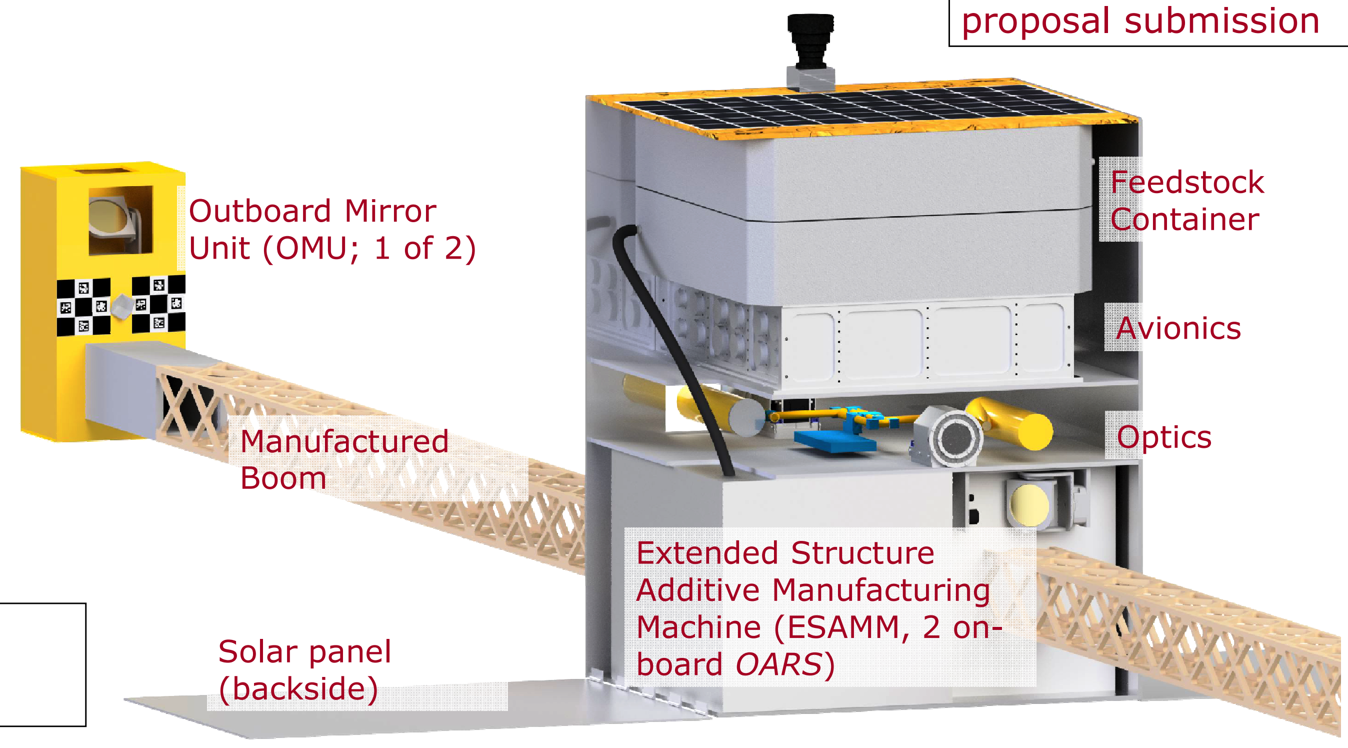
***Selected*: Archinaut One (2022)**
- $74M flight mission, printing solar array structures

Why Additive Manufacturing in Space?

Weight savings
- Structures do not have to be hardened for launch

Volume savings
- Structures to not need to fit within launch shroud
- No complex 'origami' deployment mechanism
- Increased packing efficiency

Cutaway view of the *OARS* design. Two outboard mirrors feed light to a beam combiner aboard the central spacecraft, synthesizing a large (50m), sparse aperture telescope. The bottom level is the additive manufacturing ESAMM units. The lower middle level is the optics bay; the upper middle level is the avionics bay, under the feedstock container on top.



***Optimast-SCI* is currently a NASA SBIR-funded Phase 2 study of a space-based optical interferometer enabled by in-space manufacturing. *OARS* builds on this technology for an unprecedented exploration of asteroids.**

***Interested?* The *OARS* Science Team needs you!**

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