

Solar Sail Assembly/Deployment in Earth Orbit: An Enabling Capability for an Enabling Capability

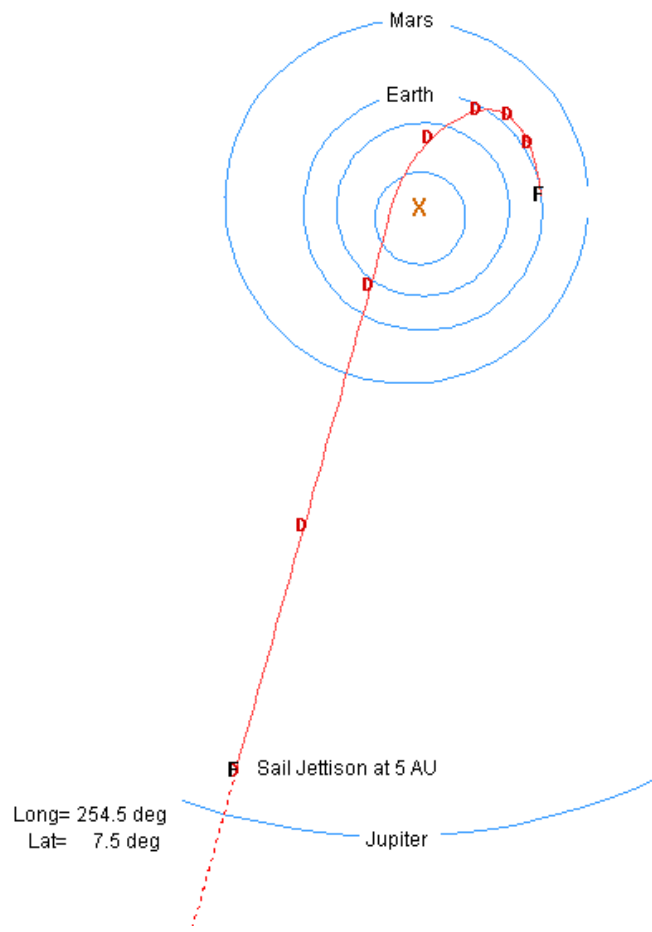
**International Workshop on
On-Orbit Satellite Servicing
Adelphi, Maryland, USA
24-26 March, 2010**

**Bruce Campbell
Tim Van Sant
NASA/GSFC**

What's a Solar Sail?



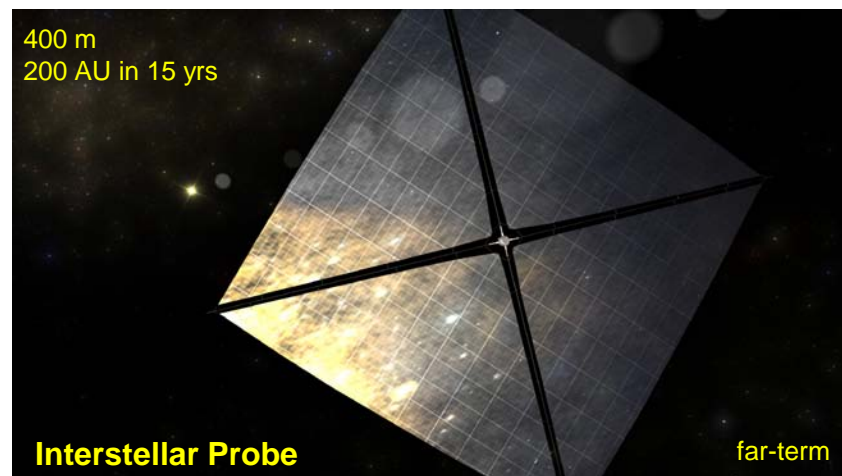
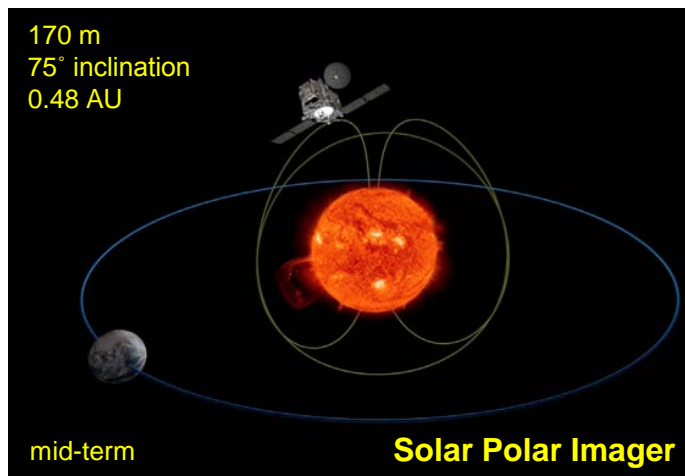
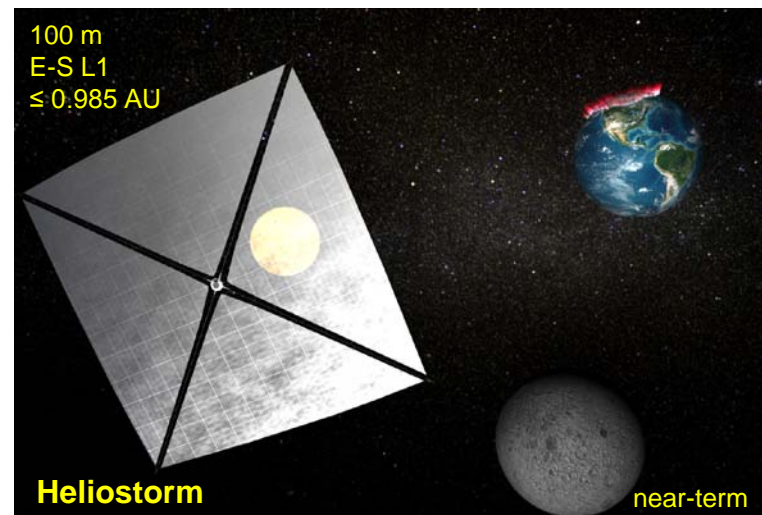
- Unique form of in-space propulsion that uses the reflection of photons of light from the Sun to produce thrust
- Potentially **continuous thrust** from solar radiation
 - Allows some orbits unobtainable by other forms of propulsion
- Potentially **unlimited delta-v**
 - Allows some performance unobtainable by other forms of propulsion



Solar Sail Strategic Missions



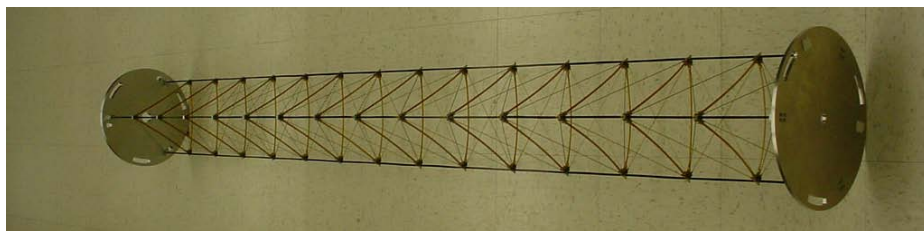
- Three strategic missions in earlier Heliophysics Roadmaps require solar sail propulsion.
 - Heliosstorm
 - Solar Polar Imager
 - Interstellar Probe
- The sail dimensions, orbital parameters, and notional timeframe are shown



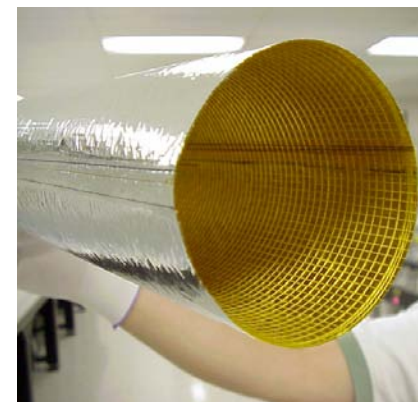
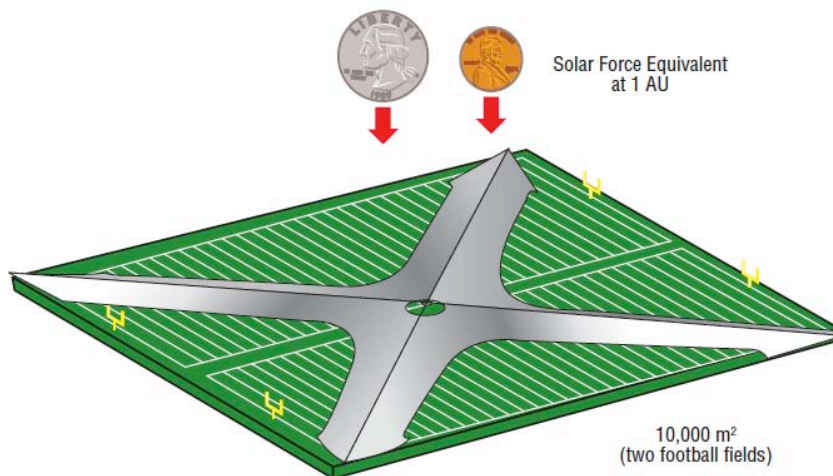
Solar Sail Characteristics



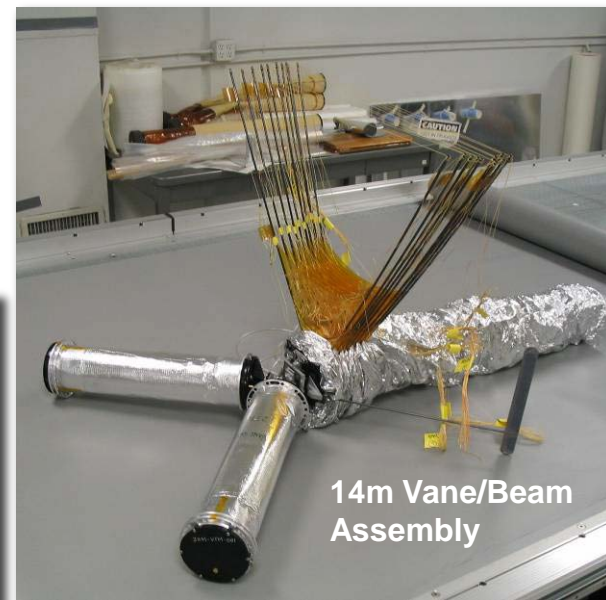
- Lightweight reflective material for sail
 - 1 micron, silver coating
- Lightweight booms/support



- Low thrust



Solar Sail Technology – TRL 6-ish



14m Vane/Beam Assembly

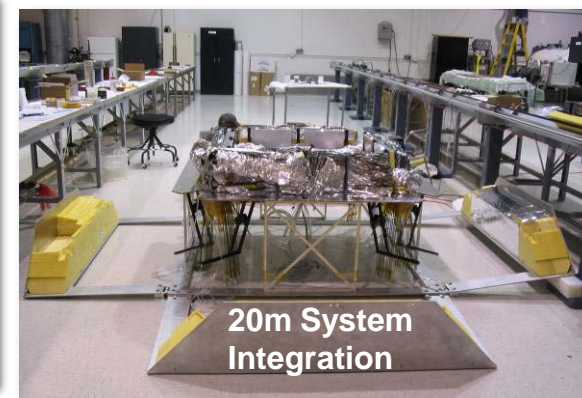


Membrane Quadrant Fabrication

14m Beam Fabrication

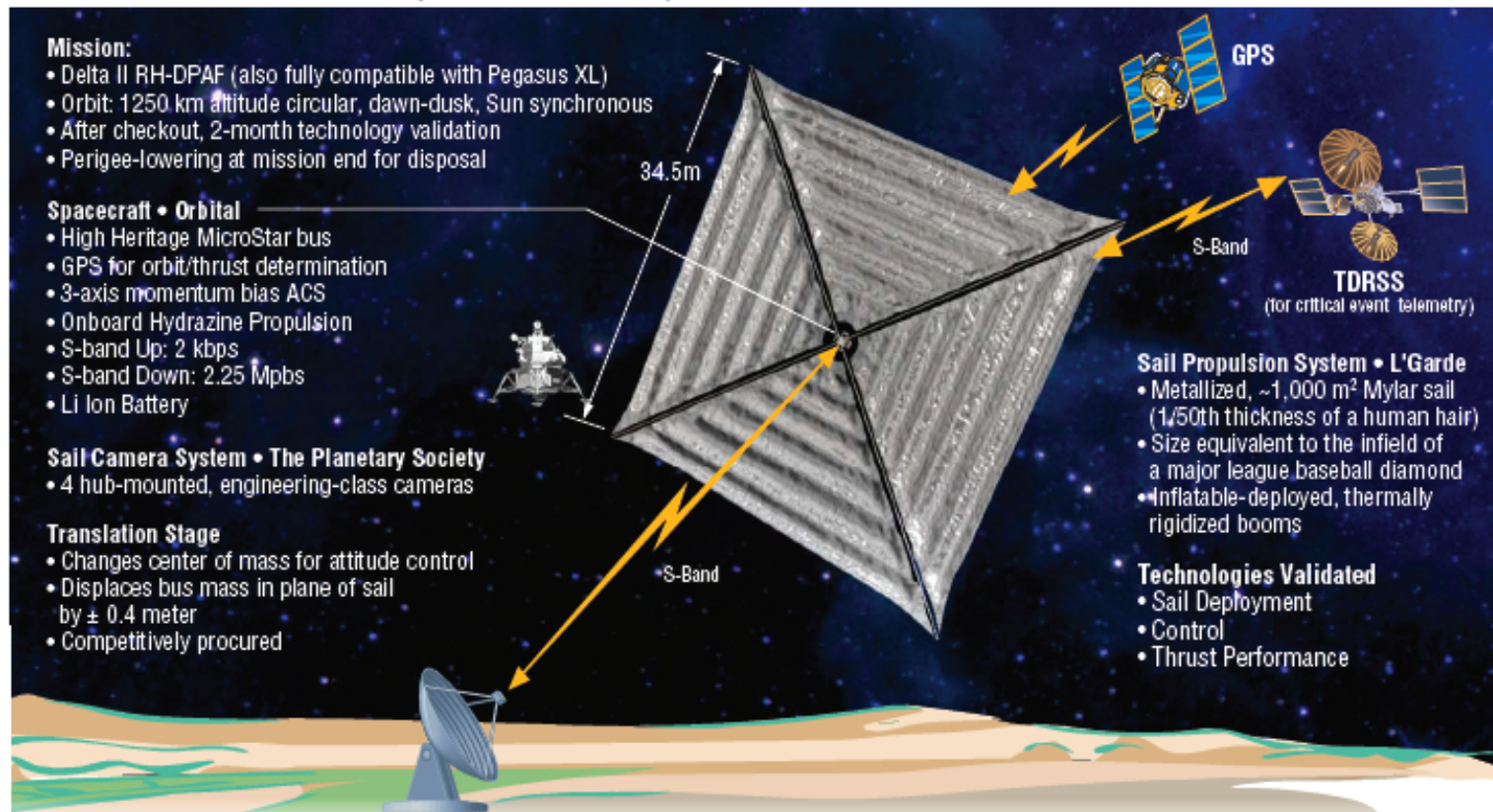


Quadrant Alignment



20m System Integration

ST9 Proposal – Ready for Validation

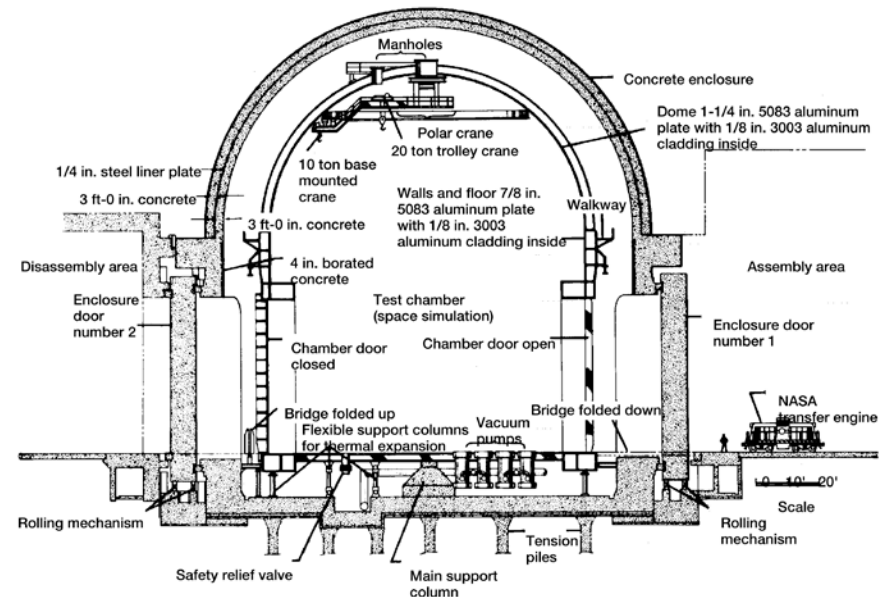
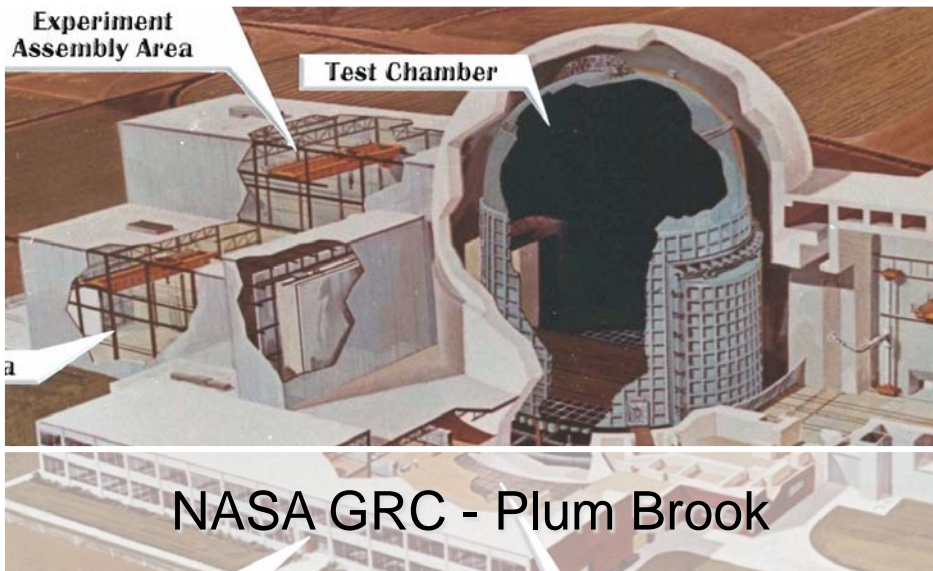


L'Garde	Orbital	Goddard Space Flight Center		Jet Propulsion Laboratory	In-Space Propulsion Technologies Project		The Planetary Society
Tustin, CA • Solar Sail • Sail Electronics and Structure	OSC Mission Operations Center Dulles, VA • Spacecraft Bus • System Integration and Test • Mission Operations	NASA Ground Network • 11 m Dishes - Alaska - Wallops	Greenbelt, MD • Project Management • Systems Engineering • Mission Assurance • Technology Validation • Education/Public Outreach	Pasadena, CA • Thrust Estimation • Inflation/Deployment Modeling	LaRC Hampton, VA • Structural Modeling	MSFC Huntsville, AL • Control Modeling • Design Validation and Test • Space Environment Test	Pasadena, CA • Sail Camera System • Education/Public Outreach

Greatest Challenges to Solar Sail Mission Development



- Ground testing
 - Accommodation of large sail sizes
 - Gravity

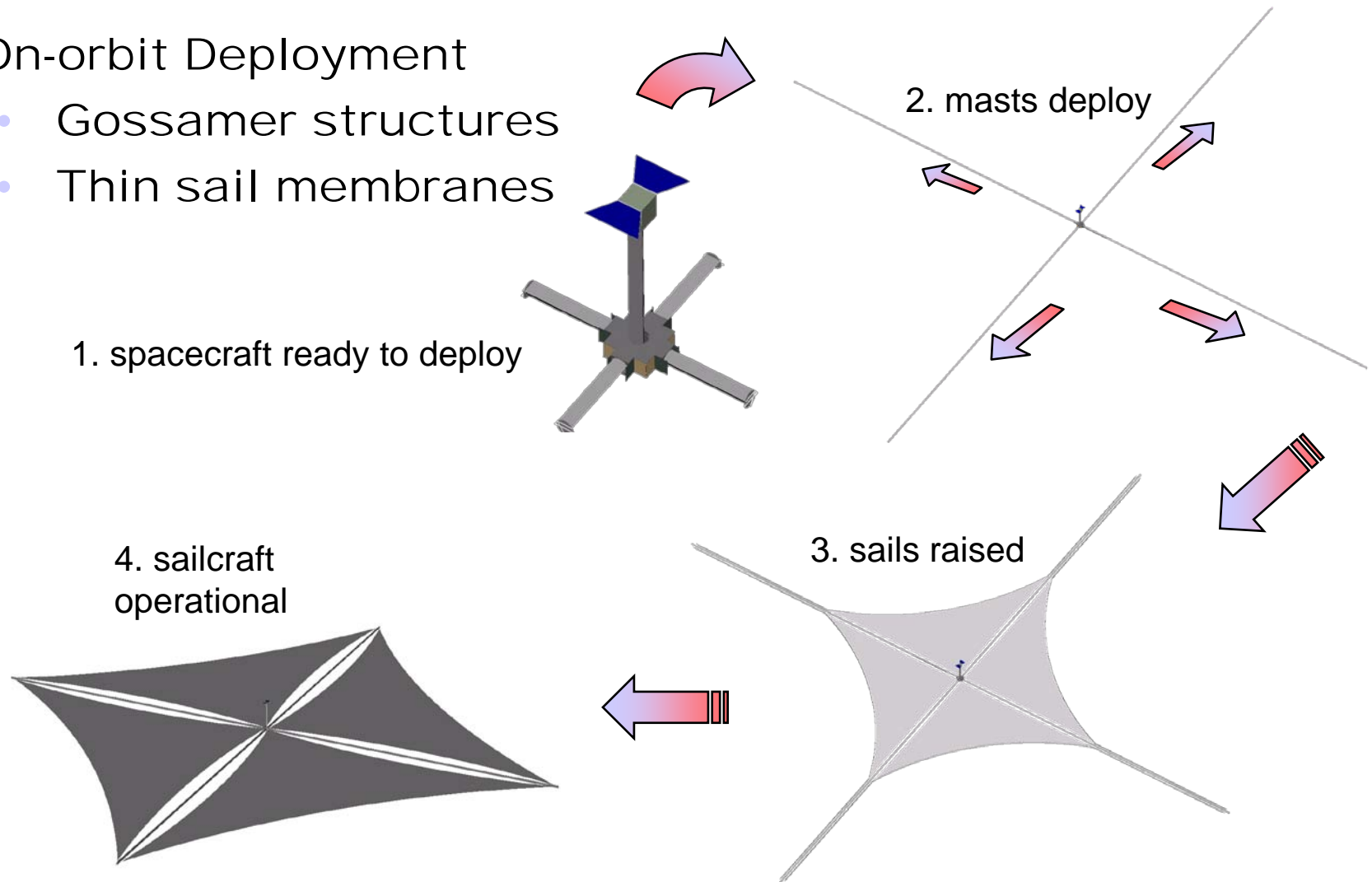


Cutaway view of test chamber.

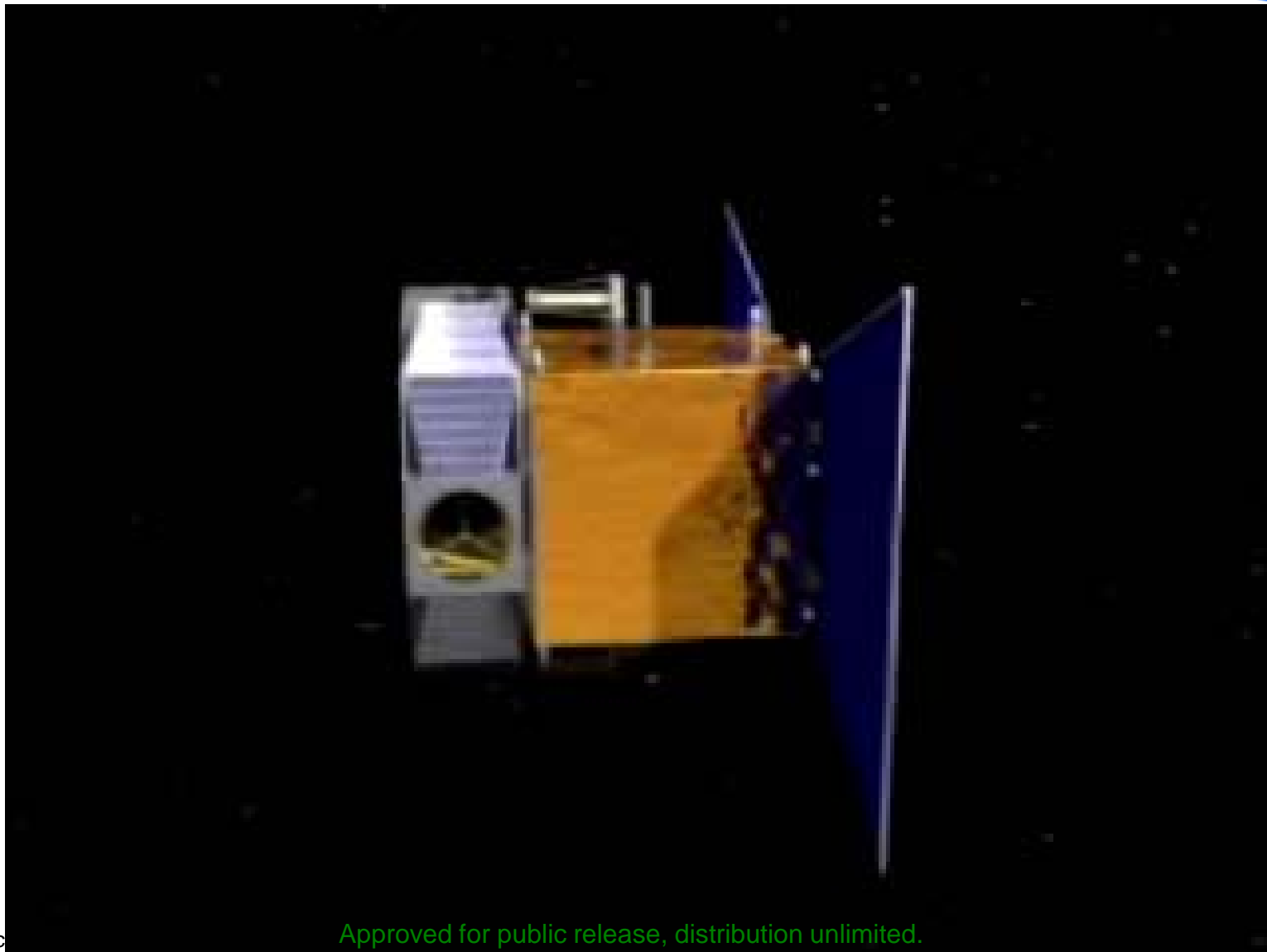
Greatest Challenges to Solar Sail Mission Development (cont.)



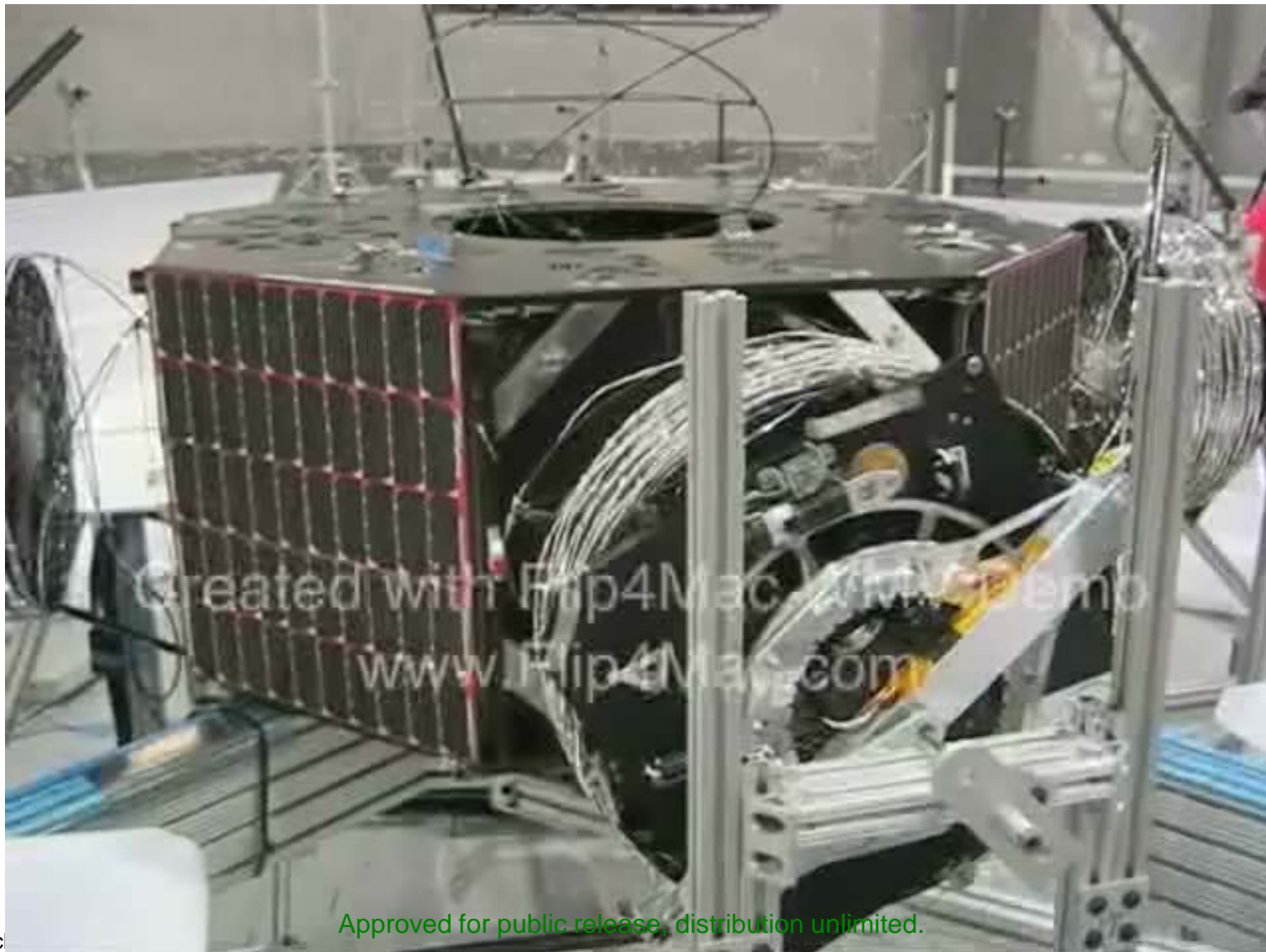
- On-orbit Deployment
 - Gossamer structures
 - Thin sail membranes



Very Nice Deployment Video



REAL Ground Deployment Video



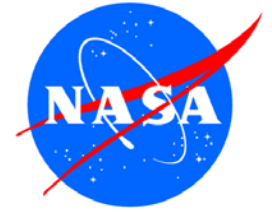
**20 – meter (on a side) square solar sail.
Largest possible for ground deployment and testing under
environmental conditions ...**

... not quite big enough for missions currently envisioned.

Solar Sail Mission Size Comparison

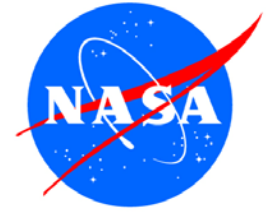


In-Space Deployment/Assembly Benefits



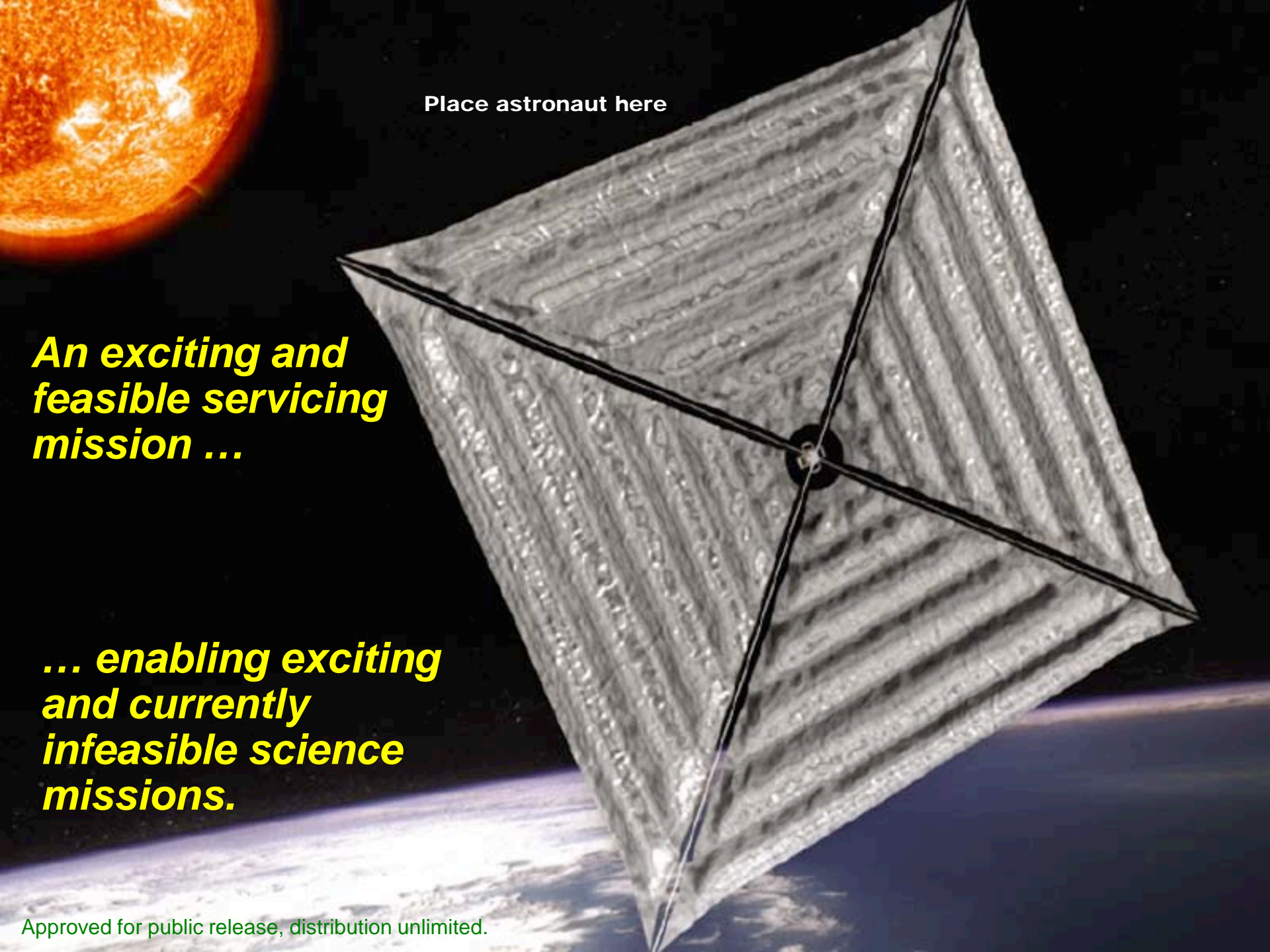
- Tended Deployment:
 - Stable platform from which to deploy
 - No thrust/attitude control complications
 - On-site monitoring and control
 - Start, stop, reverse as needed
 - Intervention and assistance during deployment
 - Sticky boom or sail material, mechanisms
 - Post-deployment repairs
 - Rips/tears
 - Complete system check-out
 - Payload as well as sail system
 - Positive mission launch

In-Space Deployment/Assembly Benefits (cont.)



- In-Space Assembly:
 - Same benefits as Tended Deployment, PLUS:
 - Larger sail sizes possible
 - Modular components assembled to large size
 - More mission capability (bigger is better)
 - NOT designed for gravity loads
 - Lighter booms and sail materials
 - NOT designed for deployment
 - As above, lighter, more efficient booms and sails designed only for in-space performance
 - Packaged for transport & assembly
 - No need for deployment-associated systems

In-space assembly would enable design and use of solar sail systems capable of performing game-changing science missions.



Place astronaut here

***An exciting and
feasible servicing
mission ...***

***... enabling exciting
and currently
infeasible science
missions.***