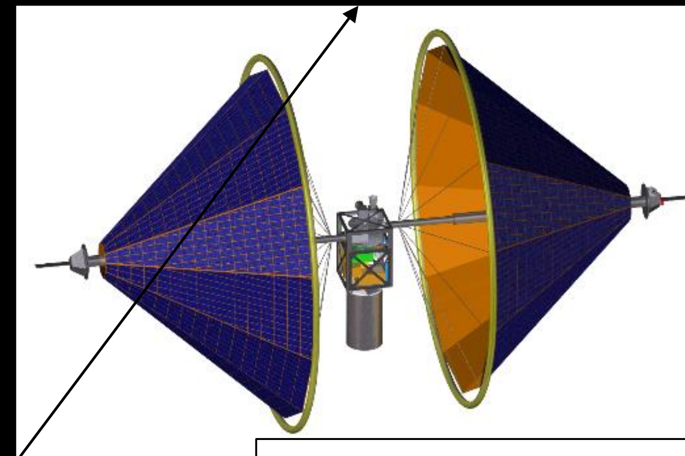
PROPULSION ENERGY 2015

Lightweight Integrated Solar Array (LISA): Providing Higher Power to Small Spacecraft

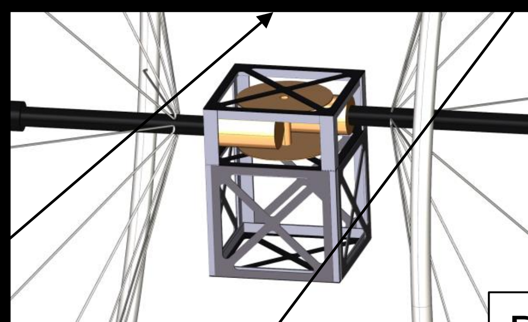
Les Johnson, John Carr, Leo Fabisinski, and Tiffany Russell-Lockett
(NASA MSFC)

What is LISA?

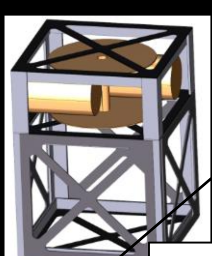
LISA is a launch stowed, orbit deployed structure upon which lightweight, flexible photovoltaic are embedded.



Conceptual application



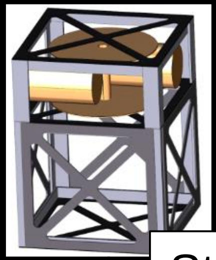
Deployed



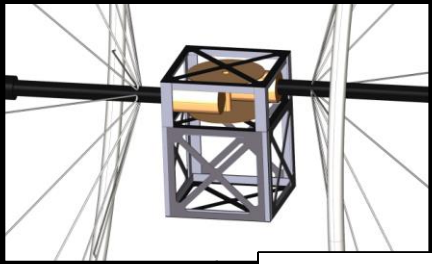
Stowed

LISA Will Provide Higher (Affordable) Power to Small Spacecraft and CubeSats

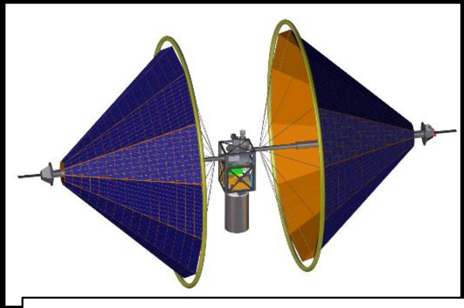
- Surface area, internal volume and mass allocation are limited resources; often driving competition between power, communications and GN&C.
- Most small-sats limited to 10’s of watts electrical power; what if we can increase this to 100’s of watts?
- What if we can ‘create’ real-estate on orbit while using only limited stowage volume?



Stowed

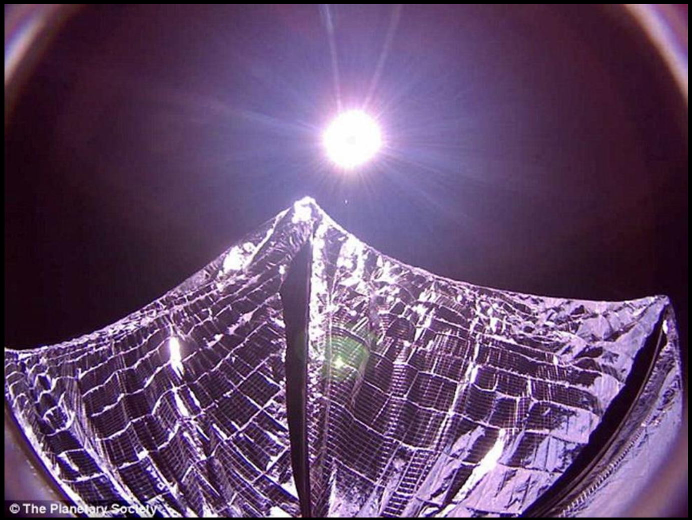


Deployed



Conceptual application

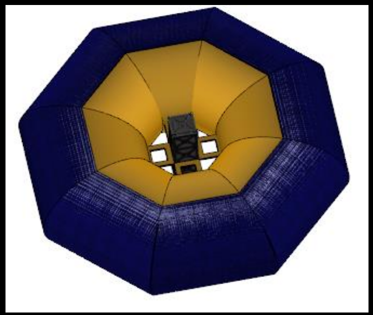
LISA Leverages Advancements in deployables, substrates and photovoltaics

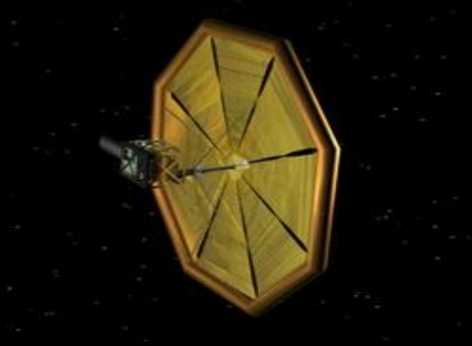


- NanoSail-D and LightSail solar sails demonstrated advancements in
  - Support booms
  - Thin-film substrates
  - Deployable mechanisms
- These are coupled with advancements in thin-film photovoltaics to form the basis of LISA

LISA Goals

- The initial emphasis for LISA is on stowed power density (W/m^3) coupled with simplicity and cost.
  - Not only increase power, but also change the way we think about space solar arrays:
  - Option for 3-D structure to collect photons no matter the array orientation.

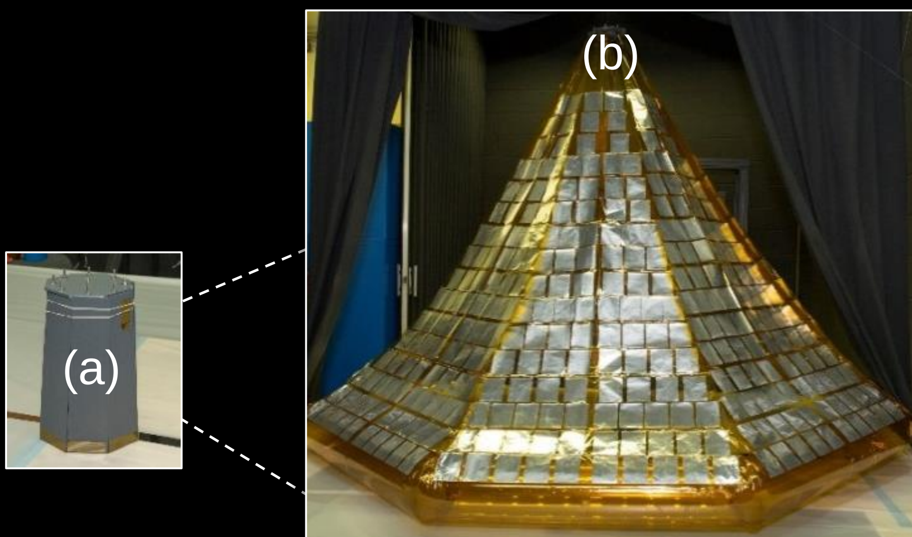




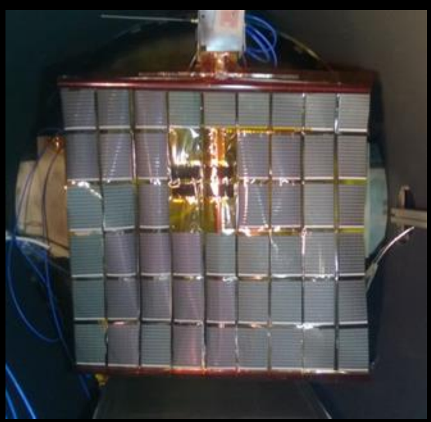
  - Option to leverage low cost PV options for cost benefits. (Requires a larger surface area to generate power; but LISA can supply just that).
- Initially targeting 200W electrical power deployed from 1U @ >250W/kg and >200kW/m^3.

LISA Technology Status

- Technology Readiness Levels (TRL) 4 & 5 achieved
- Currently funded by NASA for a TRL 6 demonstration in 2016.
  - Demonstrate scaled 3D test article deployment and power generation from 1U in simulated LEO conditions

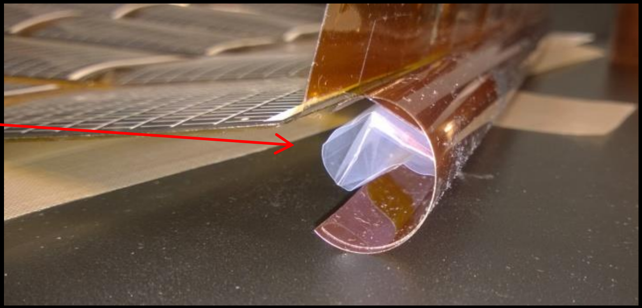


TRL-4 LISA test article (a) stowed and (b) deployed

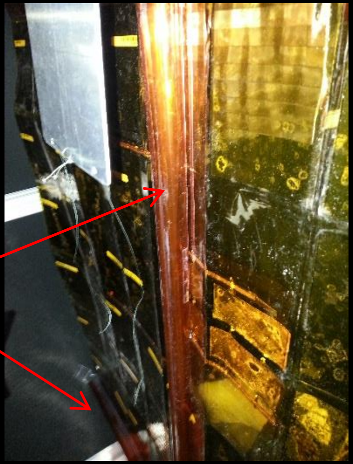


TRL-5 flat-panel LISA Array deployed and tested under simulated full sun vacuum conditions.

LISA TRL-5 Mechanical Subsystem

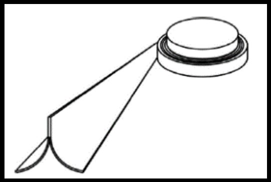


- 0.45m2 deployed
  - 1 mil Kapton substrate
  - Inflation assisted deployment
  - Rull-tube passive rigidization
- Packaged in <1/2 U
  - Spring loaded, remotely released via burn-wire
- Weight ~ 140g



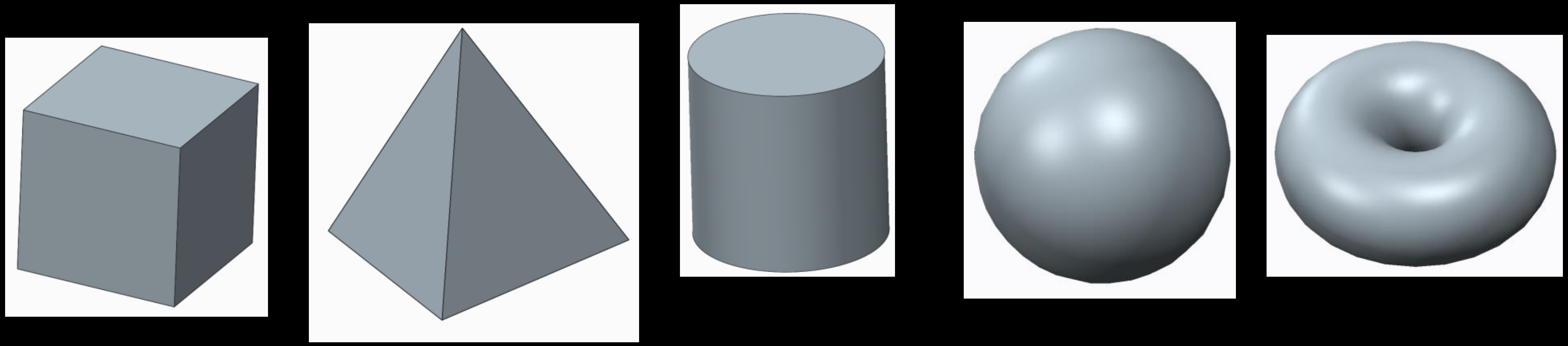
LISA Near Term Work

- Build higher-fidelity TRL 5 test article
- Consider alternate deployment mechanisms
- Consider multiple deployed geometries


TRAC boom


Telescoping tube mast


NANOstem



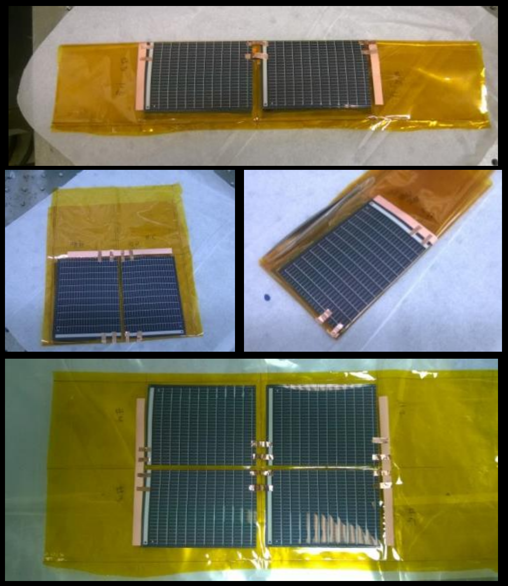
Results from a geometric trade study for a deployed array capable of generating 200 W.

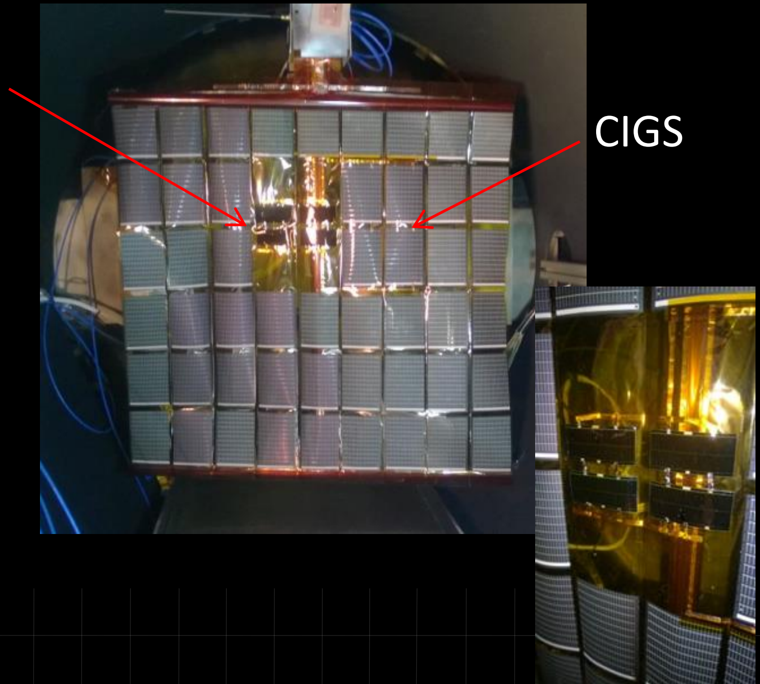
Shape	Packing density (%)	Area (m^2)	Configuration Factor	Total Area Required (m^2)
Cube	90	0.65	5.00	3.25
Pyramid	80	0.79	3.00	2.36
Cylinder*	80	0.92	3.14	3.61
Sphere	80	0.92	4.00	3.66
Torus**	80	0.92	2.00	2.88

– Example: a square side of a cube resembles a more traditional solar panel and cells can be packed to cover ~90% of the surface area. With an average power generation from a 25% efficient cell of ~307 W/m^2 at the module level, ~0.65 m^2 must be illuminated at any given time to produce 200 W of continuous power.

LISA Photovoltaics

- IMM and CIGS technologies used
- Electrical pathfinders used to identify initial issues
  - Bonded to 1mil Kapton
  - Pressure sensitive adhesive
  - Epoxy and welded copper & silver ribbon

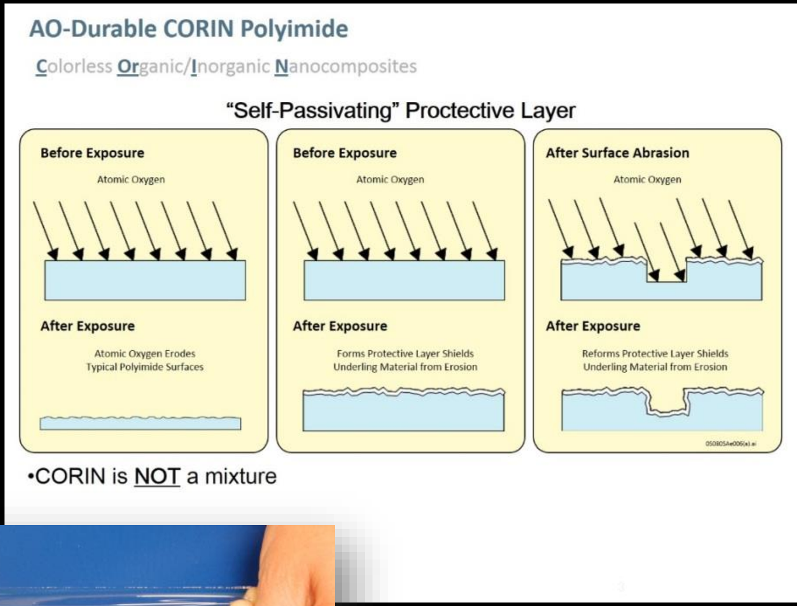


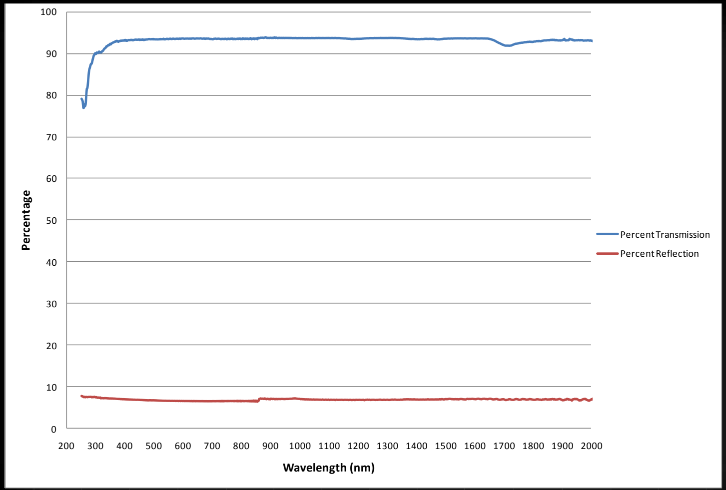


- 2x2 sub-coupons included on deployed article
- 3-4% pre/post loss in current noted
  - Micro-abrasions on surface from folding / deployment.

LISA Photovoltaic Bonding

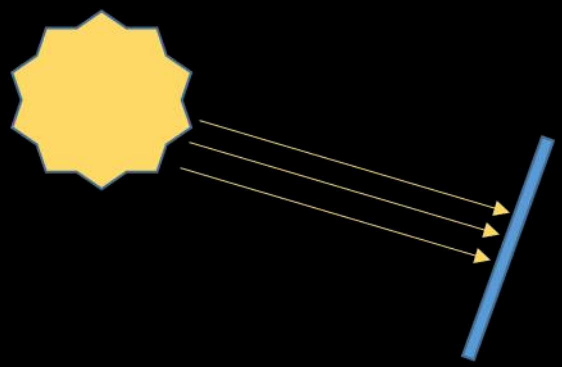
- Higher fidelity bonding on 5μm colorless polyimide 1 (CP1)
  - Nusil adhesive bond
  - Adhesiveless solvent weld
- Flexible cell cover
  - Optinox
  - Colorless organic inorganic nanocomposite (CORIN)

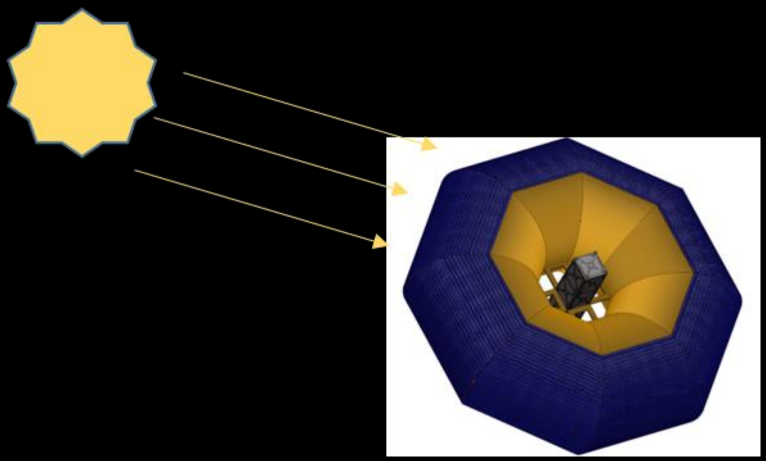




LISA Power Regulation

- The power regulation subsystem is integrated into the LISA array package:
- Array Regulation: Converts power from solar arrays to stable voltage sources





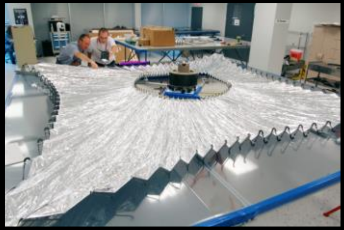
- Battery Charge Control: Charges batteries for use in dark periods when arrays do not produce power
- Fully configurable under program control: buses to provide any voltage 0V-50V. Battery charge controllers may be configured to charge any battery type.

LISA Partners and Relationships

- ManTech\NeXolve: Industry tech development partner
  - CP1 and CORIN (potential substrate materials).
  - TRAC booms (potential deployable support structure).
- MicroLink Devices, SolAero and Ascent Solar Technologies
- Funded by NASA Space Technology Mission Directorate and MSFC Technology Investment Program

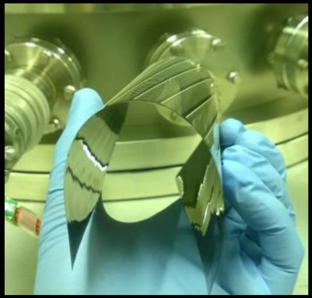
ManTech International Corporation

NeXolve Technology for Today & Tomorrow



MicroLink DEVICES

SolAero TECHNOLOGIES



Ascent SOLAR