Lightweight Integrated Solar Array (LISA): Providing Higher Power to Small Spacecraft
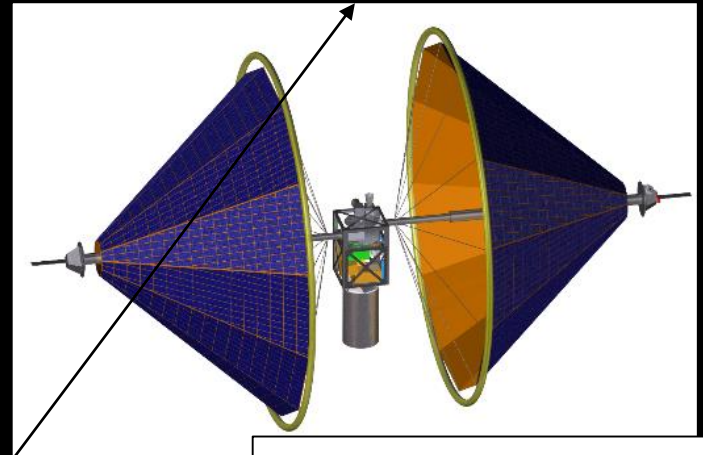
Les Johnson, John Carr, Leo Fabisinski, and Tiffany Russell-Lockett (NASA MSFC)
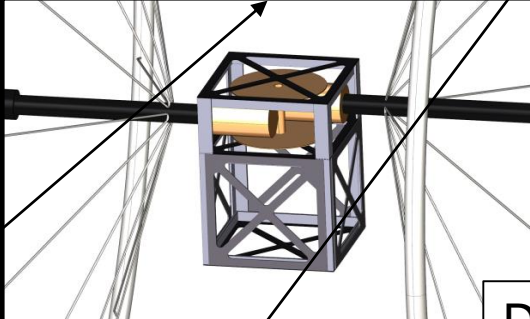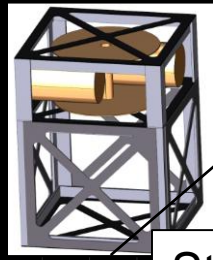
LISA is a launch stowed, orbit deployed structure upon which lightweight, flexible photovoltaic are embedded.
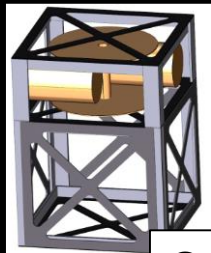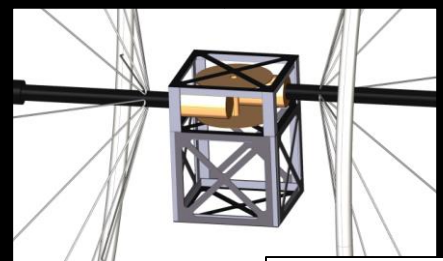

Conceptual application

Deployed

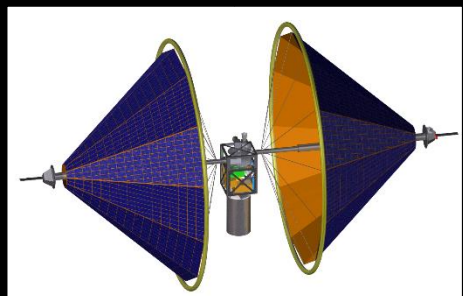

Stowed

– 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


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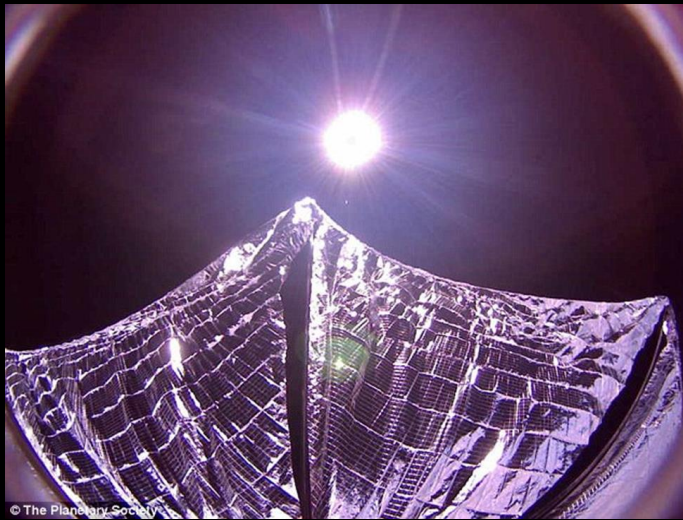
- NanoSail-D and LightSail solar sails demonstrated advancements in
  - Support booms
  - Thin-film substrates
  - Deployable mechanisms
- These are coupled with advancements in thin-film photovoltaics to form the basis of LISA

LISA Goals

– The initial emphasis for LISA is on stowed power density (W/m³) 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.
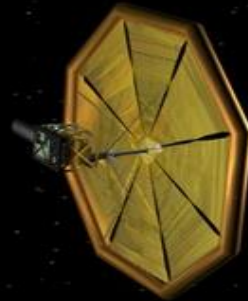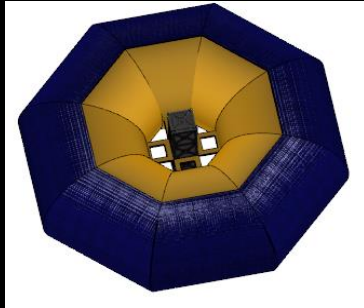

- Option to leverage low cost PV options for cost benefits. (Requires a larger surface area to generate power; but LISA can supply just that).

– Initially targeting 200W electrical power deployed from 1U @ >250W/kg and >200kW/m³.

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

(b)

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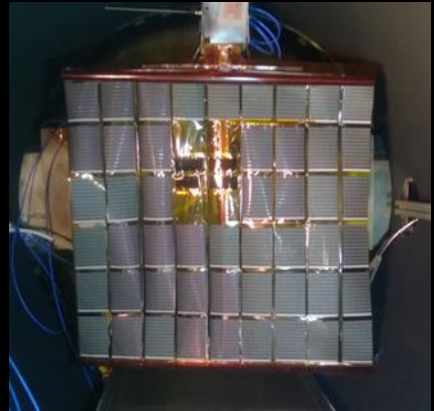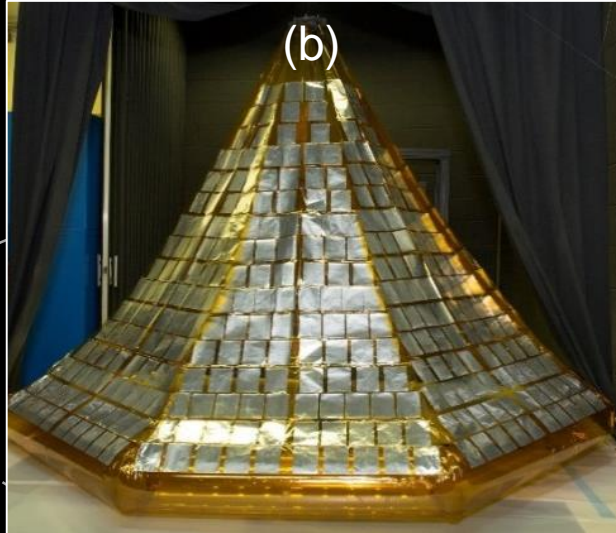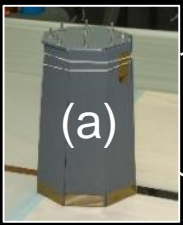
TRL-4 LISA test article (a) stowed and (b) deployed
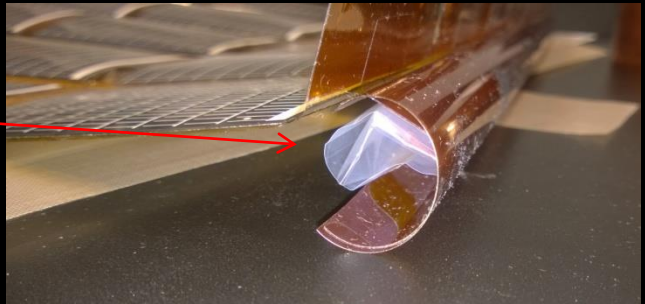

TRL-5 flat-panel LISA Array deployed and tested under simulated full sun vacuum conditions.

LISA TRL-5 Mechanical Subsystem

Inflation tube

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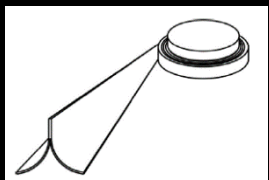 - Spring loaded, remotely released via burn-wire
- Weight ~ 140g

Roll-tube

– Build higher-fidelity TRL 5 test article

– Consider alternate deployment mechanisms

– Consider multiple deployed geometries

TRAC boom

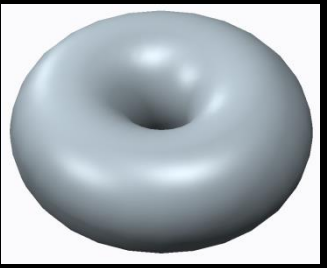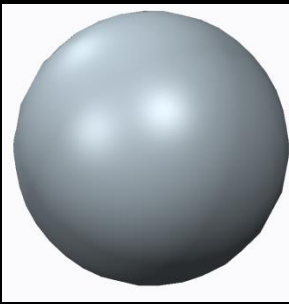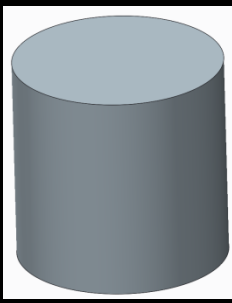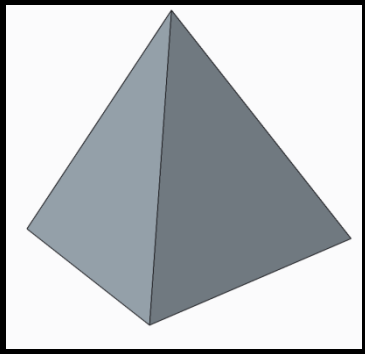Telescoping tube mast

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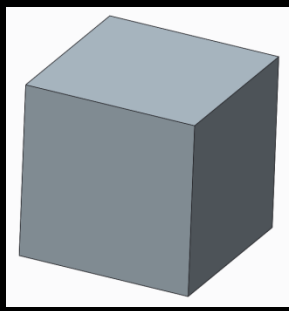
Results from a geometric trade study for a deployed array capable of generating 200 W.

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

IMM

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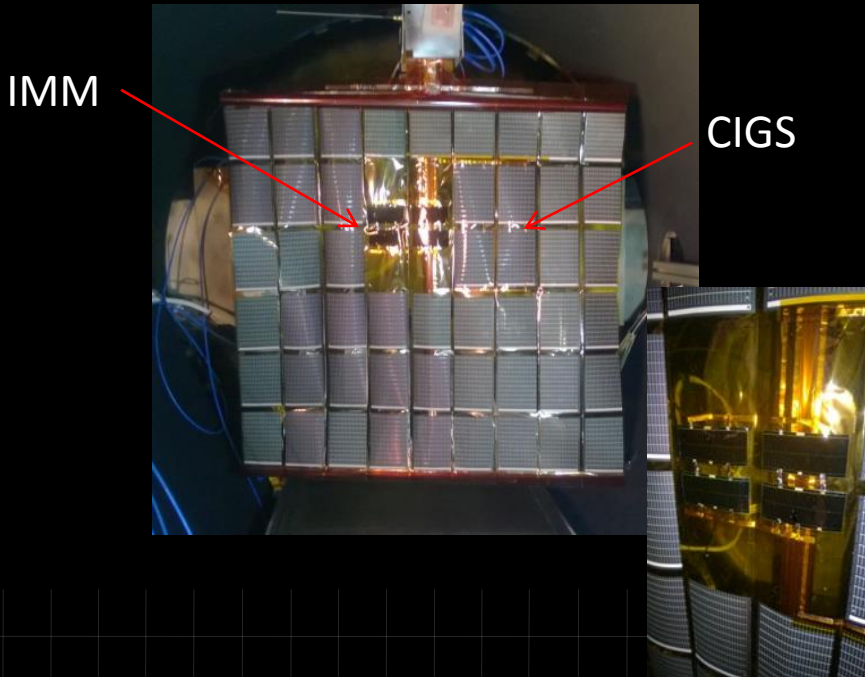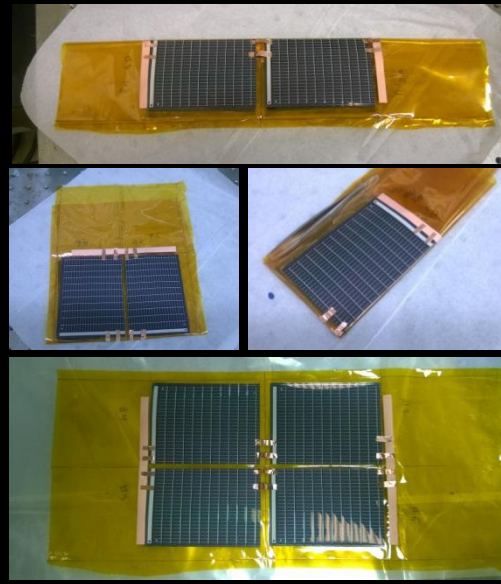
- 2x2 sub-coupons included on deployed article
- 3-4% pre/post loss in current noted
  -Micro-abrasions on surface from folding / deployment.

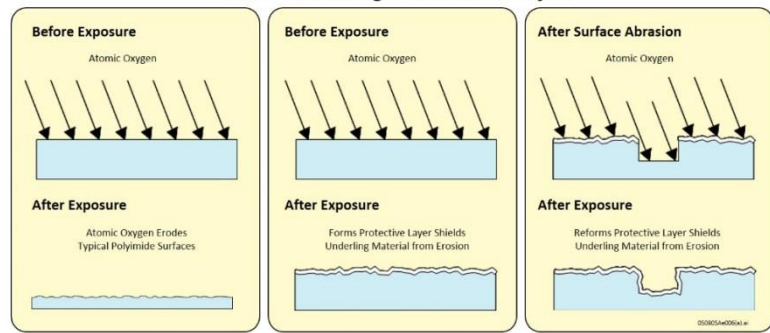– Higher fidelity bonding on 5µm colorless polyimide 1 (CP1)

- Nusil adhesive bond
- Adhesiveless solvent weld

– Flexible cell cover

- Optinox
- Colorless organic inorganic nanocomposite (CORIN)

AO-Durable CORIN Polyimide

Colorless Organic/Inorganic Nanocomposites

"Self-Passivating" Proctective Layer

Before Exposure	Before Exposure	After Surface Abrasion
Atomic Oxygen	Atomic Oxygen	Atomic Oxygen
After Exposure	After Exposure	After Exposure
Atomic Oxygen Erodes Typical Polyimide Surfaces	Forms Protective Layer Shields Underling Material from Erosion	Reforms Protective Layer Shields Underling Material from Erosion

•CORIN is **NOT** a mixture
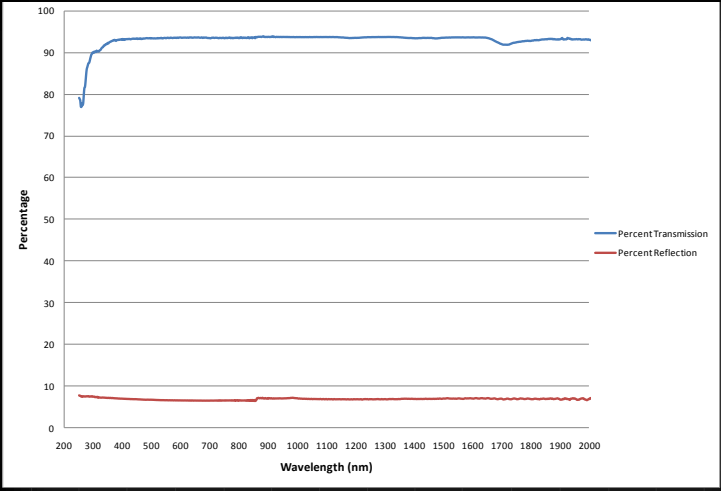
LISA Power Regulation

- 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.

- 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