

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

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Affordable and convenient access to electrical power is essential for all spacecraft and is a critical design driver for the next generation of smallsats, including cubesats, which are currently extremely power limited. The Lightweight Innovative Solar Array (LISA), a concept designed, prototyped, and tested at the NASA Marshall Space Flight Center (MSFC) in Huntsville, Alabama provides an affordable, lightweight, scalable, and easily manufactured approach for power generation in space. This flexible technology has many wide-ranging applications from serving small satellites to providing abundant power to large spacecraft in GEO and beyond. By using very thin, ultra-flexible solar arrays adhered to an inflatable structure, a large area (and thus large amount of power) can be folded and packaged into a relatively small volume.

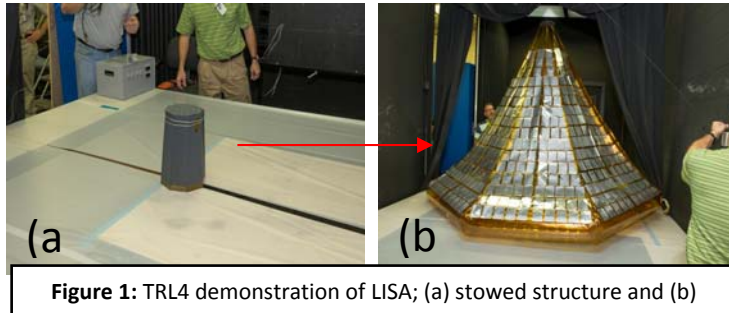
The LISA array comprises a launch-stowed, orbit-deployed structure on which lightweight photovoltaic devices and, potentially, transceiver elements are embedded. The system will provide a 2.5 to 5 fold increase in specific power generation (Watts/kilogram) coupled with a >2x enhancement of stowed volume (Watts/cubic-meter) and a decrease in cost (dollars/Watt) when compared to state-of-the-art solar arrays.

LISA will directly support:

- (i) High functionality small-scale satellites, such as micro- and nanosatellites where functionality is currently power-starved. Lighter weight, larger scale power generation with a smaller stowage footprint will enable more payload. This will advance the science capabilities of small-scale satellites not only for NASA, but also for commercial entities, academia and the like.
- (ii) High specific power missions, such as advanced solar-electric propulsion (SEP) vehicles, electrodynamic tethers and solar sails. LISA-T will provide an inexpensive solution which generates high power while adding little mass to the spacecraft – highly advantageous to SEP efficiency. LISA-T will also enable innovative solar sails, in which the flexible PV stack can be embedded within the sail itself; alleviating the need for additional power generating structures.
- (iii) Smaller budget missions, or more in general, a lower cost for any mission employing solar arrays. LISA systems are expected to reduce both the fabrication and launch cost of solar power space vehicles. This is especially so for small-scale and short term missions, such as academic science flights or ‘on-the-fly’ military missions.

LISA is currently at Technology Readiness Level (TRL) 4. In 2013, NASA MSFC demonstrated a low fidelity component-based test article, which was stowed and successfully deployed in a laboratory at

MSFC. The article comprised a thin-film (10 μm) polyimide substrate on which solar cell ‘stand-ins’ and an inflatable torus were mounted. The assembly was folded for stowage (Figure 1a) and the torus was then inflated for deployment (Figure 1b). A single, thin-film PV cell was also mounted on the article and was tested both before and after deployment; no changes in performance were noted. This basic functionality was coupled with an advanced concepts office design study of the array performance relative to a representative environment – a low Earth orbit observation nano-satellite; fully justifying TRL4.



In order to achieve the TRL 6, the team will perform the following development activities:

(i) Electrical development: Technology demands in a growing terrestrial industry have recently pushed the advancement of thin-film PVs. These innovative, flexible devices offer several advantages over their rigid counterparts, which enable the LISA system. However, in order to employ this PV, the gap between the terrestrial design and spaceflight environment must be bridged. The technologies must be vetted through environmental testing and the panels adapted for space use. Thin-film companies geared towards terrestrial use lack the resources and expertise to implement such testing. The MSFC team will perform pre-qualification testing to mature selected commercial cells through TRL 5. The team will use existing MSFC facilities to test the cells. Solar panel assemblies can be cycled through environments similar to those that they will experience on-orbit while monitoring PV performance and other electrical characteristics in situ. Test articles will then be fabricated and tested. Within the next year, we expect to have a functional electrical sub-system ready for integration and preliminary testing.

(ii) Materials development: in parallel to (i), the supporting and cover materials for the PV, which give structural support, coefficient of thermal expansion matching and elements protection while maintaining light weight and mechanical flexibility, will be developed. Several sub-coupons (small substrate + PV + cover assemblies) will then be fabricated and tested at MSFC. An analysis will be performed and the design cycle iterated. This effort will also be completed in year one, yielding a PV assembly ready for integration.

(iii) Mechanical development: the team will further develop the stowage, deployment, and overall structural aspects of the platform. A trade study will be conducted to determine the optimal method for deployment, with emphasis on weight, cost and complexity. PV layout, which adds constraint on stowage packing and folding, and vice versa, will be developed. The

design of the remote deployment mechanism will also be determined. This development will be done in parallel to (i) and (ii).

(iv) TRL 6 system demonstration in a relevant environment: with the completion of (i)-(iii), the team will then integrate the sub-systems to produce and test a high-fidelity system model in a relevant environment. Such testing will establish TRL 6.