ILRS SLR MISSION SUPPORT REQUEST FORM (June 2011)

SECTION I: MISSION INFORMATION:

General Information:

Satellite Name: LightSail-A

Satellite Host Organization: The Planetary Society

Web Address: http://www.planetary.org

Contact Information:

Primary Technical Contact Information:

Name: David Spencer

Address: 270 Ferst Dr. SE

Atlanta, GA 30332-0150

Phone No.: 770-331-2340

Fax No.:

E-mail Address: david.spencer@ae.gatech.edu

Alternate Technical Contact Information:

Name: Riki Munakata

Address: 398 W. Washington Blvd, Suite 100

Pasadena, CA 91103

Phone No.: 916-719-1349

Fax No.:

E-mail Address: rmunakata@eclipticenterprises.com

Primary Science Contact Information:

Name: David Spencer

Address: 270 Ferst Dr. SE

Atlanta, GA 30332-0150

Phone No.: 770-331-2340

Fax No.:

E-mail Address: david.spencer@ae.gatech.edu

Alternate Science Contact Information:

Name: ______________________________

Address: ______________________________

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Phone No.: ______________________________

Fax No.: ______________________________

E-mail Address: ______________________________

Mission Specifics:

Scientific or Engineering Objectives of Mission:

LightSail-A will demonstrate the deployment of a 32 m2 solar sail from a 3-unit CubeSat platform.

Satellite Laser Ranging (SLR) Role of Mission:

SLR will be utilized to perform spacecraft orbit determination before and after solar sail deployment. Without an onboard GPS receiver, SLR is the primary orbit determination method.

Anticipated Launch Date: May 2015

Expected Mission Duration: 6 weeks

Orbital Accuracy Required: 25 m

Anticipated Orbital Parameters:

Altitude: 350 km x 700 km

Inclination: 55 deg

Eccentricity: 0.0253

Orbital Period: 5708.0 s

Frequency of Orbital Maneuvers: N/A

Mission Timeline: From Launch (L) to L+28 days, spacecraft checkout. Solar panels and solar sail deploy at L+28 days. S/C re-entry occurs 2-10 days following sail deployment.

Tracking Requirements:

Tracking Schedule: Launch to L+28 days: 1 track/day. L+28 - re-entry: 3 tracks/day

Spatial Coverage: Global coverage is requested

Temporal Coverage: Launch to L+28 days: 1 track/day. L+28 - re-entry: 3 tracks/day

Operations Requirements:

Prediction Center: Georgia Tech

Prediction Technical Contact Information:

Name: David Spencer

Address: 270 Ferst Dr. SE

Marietta, GA 30332-0150

Phone No.: 770-331-2340

Fax No.:

E-mail Address: david.spencer@ae.gatech.edu

Priority of SLR for POD: SLR is the only source of POD for LightSail. Highest priority

Other Sources of POD (GPS, Doppler, etc.):
N/A

Normal Point Time Span (sec): 30

Tracking Network Required (Full/NASA/EUROLAS/WPLTN/Mission Specific):
Any network that can provide global coverage is sufficient.

SECTION II: TRACKING RESTRICTIONS:

Several types of tracking restrictions have been required during some satellite missions. See *http://ilrs.gsfc.nasa.gov/satellite_missions/restricted.html* for a complete discussion.

1) Elevation restrictions: Certain satellites have a risk of possible damage when ranged near the zenith. Therefore a mission may want to set an elevation (in degrees) above which a station may not range to the satellite.
2) Go/No-go restrictions: There are situations when on-board detectors on certain satellites are vulnerable to damaged by intense laser irradiation. These situations could include safe hold position or maneuvers. A small ASCII file is kept on a computer controlled by the satellite's mission which includes various information and the literal “go” or “nogo” to indicate whether it is safe to range to the spacecraft. Stations access this file by ftp every 5-15 minutes (as specified by the mission) and do not range when the flag file is set to “nogo” or when the internet connection prevents reading the file.
3) Segment restrictions: Certain satellites can allow ranging only during certain parts of the pass as seen from the ground. These missions provide station-dependent files with lists of start and stop times for ranging during each pass.
4) Power limits: There are certain missions for which the laser transmit power must always be restricted to prevent detector damage. This requires setting laser power and beam divergence at the ranging station before and after each pass. While the above restrictions are controlled by software, this restriction is often controlled manually.

Many ILRS stations support some or all of these tracking restrictions. See xxx for the current list. You may wish to work through the ILRS with the stations to test their compliance with your restrictions or to encourage additional stations that are critical to your mission to implement them.

The following information gives the ILRS a better idea of the mission's restrictions. Be aware that once predictions are provided to the stations, there is no guarantee that forgotten restrictions can be immediately enforced.

Can detector(s) or other equipment on the spacecraft be damaged or confused by excessive irradiation, particularly in any one of these wavelengths (532nm, 1064nm, 846nm, or 423nm)?

No

Are there times when the LRAs will not be accessible from the ground?

No

(If so, go/nogo or segmentation files might be used to avoid ranging an LRA that is not accessible.)

Is there a need for an altitude tracking restriction? No What altitude (degrees)? ________

Is there a need for a go/no-go tracking restriction? No

For what reason(s)?

Is there a need for a pass segmentation restriction? No

For what reason(s)?

____

____

Is there a need for a laser power restriction? No

Under what circumstances?

____

____

What power level (mW/cm^2)? ____________

Is manual control of transmit power acceptable? ____________

For ILRS stations to range to satellites with restrictions, the mission sponsor must agree to the following statement:
"The mission sponsor agrees not to make any claims against the station or station contractors or subcontractors, or their respective employees for any damage arising from these ranging activities, whether such damage is caused by negligence or otherwise, except in the case of willful misconduct."

Please initial here to express agreement: ____________

Other comments on tracking restrictions:

N/A

SECTION III: RETROREFLECTOR ARRAY INFORMATION:

A prerequisite for accurate reduction of laser range observations is a complete set of pre-launch parameters that define the characteristics and location of the LRA on the satellite. The set of parameters should include a general description of the array, including references to any ground-tests that may have been carried out, array manufacturer and whether the array type has been used in previous satellite missions. So the following information is requested:

Retroreflector Primary Contact Information:

Name: Riki Munakata

Address: 398 W. Washington Blvd, Suite 100

Pasadena, CA 91103

Phone No.: 916-719-1349

Fax No.: __________

E-mail Address: rmunakata@eclipticenterprises.com

Array type (spherical, hexagonal, planar, etc.), to include a diagram or photograph:

LightSail-A has a total of 7 corner cubes attached to the spacecraft.

4x 10.0mm Corner Cube and 3x 12.7mm Corner Cube

Array manufacturer:

Edmund Optics. 10.0mm corner cube has been discontinued.

Link (URL or reference) to any ground-tests that were carried out on the array:

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The LRA design and/or type of cubes was previously used on the following missions:

N/A

____

For accurate orbital analysis it is essential that full information is available in order that a model of the 3-dimensional position of the satellite center of mass may be referred to the location in space at which the laser range measurements are made. To achieve this, the 3-D location of the LRA phase center must be specified in a satellite fixed reference frame with respect to the satellite's mass center. In practice this means that the following parameters must be available at mm accuracy or better:

The 3-D location (possibly time-dependent) of the satellite's mass center relative to a satellite-based origin:

Pre-Sail Deployment (Launch - L+28Days): X=0.26mm Y=-0.04mm Z=16.13mm

Post-Sail Deployment (L+28Days - reentry): X=0.44mm Y=-0.01mm Z=-32.78mm

The 3-D location of the phase center of the LRA relative to a satellite-based origin:

See table 1

However, in order to achieve the above if it is not directly specified (the ideal case) by the satellite manufacturer, and as an independent check, the following information must be supplied prior to launch:

The position and orientation of the LRA reference point (LRA mass-center or marker on LRA assembly) relative to a satellite-based origin:

See table 2

The position (XYZ) of either the vertex or the center of the front face of each corner cube within the LRA assembly, with respect to the LRA reference point and including information of amount of recession of front faces of cubes:

See table 3

The orientation of each cube within the LRA assembly (three angles for each cube):

See table 4

The shape and size of each corner cube, especially the height:

Cube1-4:10mm diameter. Height 8.64mm. Cube5-7:12mm diameter. Height 10.16mm

The material from which the cubes are manufactured (e.g. quartz):

N-BK7

The refractive index of the cube material, as a function of wavelength λ (micron):

~1.519 @ 550nm

Dihedral angle offset(s) and manufacturing tolerance:

Radius of curvature of front surfaces of cubes, if applicable:

Flatness of cubes' surfaces (as a fraction of wavelength):

1/8

Whether or not the cubes are coated and with what material:

VIS 0 degree and Protected Silver

Other Comments:

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____

____

____

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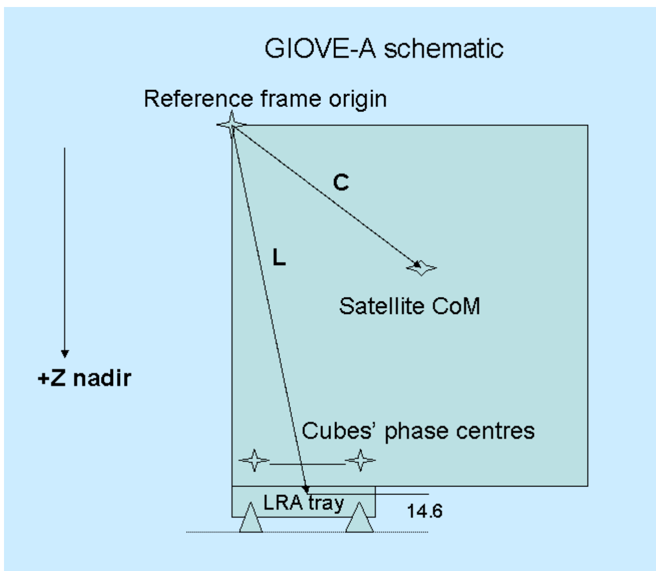
An example of the metric information for the array position that should be supplied is given schematically below for the LRA on the GIOVE-A satellite. Given the positions and characteristics of the cubes within the LRA tray, it is possible to compute the location of the array phase center. Then given the **C** and **L** vectors it is straightforward to calculate the vector from the satellite's center of mass (CoM) in a spacecraft-fixed frame to the LRA phase center. Further analysis to derive the array far-field diffraction patterns will be possible using the information given above.



A good example of a well-specified LRA is that prepared by GFZ for the CHAMP mission in the *paper "The Retro-Reflector for the CHAMP Satellite: Final Design and Realization", which is* available on the ILRS Web site at *http://ilrs.gsfc.nasa.gov/docs/rra_champ.pdf*.

The final and possibly most complex piece of information is a description (for an active satellite) of the satellite's attitude regime as a function of time, which must be supplied in some form by the operating agency. This algorithm will relate the spacecraft reference frame to, for example, an inertial frame such as J2000.

RETROREFLECTOR ARRAY REFERENCES

Two reports, both by David Arnold, are of particular interest in the design and analysis of laser retro-reflector arrays.

- Method of Calculating Retroreflector-array Transfer Functions, David A. Arnold, Smithsonian Astrophysical Observatory Special Report 382, 1979.
- *Retroreflector Array Transfer Functions,* David A. Arnold, ILRS Signal Processing Working Group, 2002. Paper available at *http://ilrs.gsfc.nasa.gov/docs/retro_transfer_functions.pdf*.

SECTION IV: MISSION CONCURRENCE

As an authorized representative of the LightSail-A mission, I hereby request and authorize the ILRS to track the satellite described in this document.

Name (print): David Spencer Date 11/17/2014

Signature: ______________________________

Position: Mission Manager

Send form to: ILRS Central Bureau
c/o Carey Noll
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Code 690
Greenbelt, MD 20771
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