ILRS SLR MISSION SUPPORT REQUEST FORM (version: March 2016)

SUBMISSION STATUS:

- [x] New Submission (default)
- [ ] Incremental Submission (accepted only for a follow-on mission; fill-in new information only)

(provide the reference mission and the date approved by the ILRS: ________________________)

SECTION I: MISSION INFORMATION:

General Information:

Satellite Name: LightSail 2

Satellite Host Organization: The Planetary Society

Web Address: www.planetary.org/explore/projects/lightsail-solar-sailing/

Contact Information:

Primary Technical Contact Information:

Name: David Spencer

Organization and Position: LightSail 2 Project Manager

Address: 701 W. Stadium Ave., W. Lafayette, IN 47907-2045

Phone No.: 765-494-8774

E-mail Address: dspencer@purdue.edu

Alternate Technical Contact Information:

Name: Alex Diaz

Organization and Position: Ecliptic Enterprises, Flight System Engineer

Address: 398 W. Washington Blvd. #100, Pasadena, CA 91103

Phone No.: 510-872-9051

E-mail Address: alex@eclipticenterprises.com

Primary Science Contact Information:

Name: Bruce Betts

Organization and Position: The Planetary Society, Director of Science and Technology

Address: 60 S. Los Robles Ave., Pasadena, CA 91101

Phone No.: 626-793-5100

E-mail Address: bruce.betts@planetary.org

Alternate Science Contact Information:

Name: ______

Organization and Position: ______

Address: ______

Phone No.: ______

E-mail Address: ______

Mission Specifics:

Scientific or Engineering Objectives of Mission:
(specify)

LightSail 2 will demonstrate controlled solar sailing in low-Earth orbit. A 32 m2 solar sail will be deployed from a 3U CubeSat, and the orientation of the solar sail will be controlled to raise orbit apogee and increase orbital energy. The expected rate of apogee increase is on the order of 500 m/day for up to 28 days following sail deployment.

Role of Satellite Laser Ranging (SLR) for the Mission:
(specify)

SLR will provide the primary validation that orbital energy is increased via harnessed solar radiation pressure. SLR will be used for orbit determination prior to solar sail deployment, and periodically following solar sail deployment, to provide a precise time history of the orbit evolution.

Anticipated Launch Date: 2nd half of 2018

Expected Mission Duration: 6 weeks

Required Orbital Accuracy: orbit knowledge of +/- 10 m (1-sigma) in altitude is desired

Anticipated Orbital Parameters:

Altitude (Min & Max for eccentric orbits): 720 km

Inclination: 24.0 degrees

Eccentricity: 0

Orbital Period: 5,951.5 s

Frequency of Orbital Maneuvers: No propulsive maneuvers, solar sailing

Mission Timeline:
(example)
Should include when SLR is to start within the mission timeline, such as "on insertion into orbit" or "launch +N" days.

L+0 days: Ejection of LightSail 2 (LS2) from the Prox-1 spacecraft
L+0 to L+5 days: Spacecraft checkout and orbit determination
L+5 days: Deploy solar panels
L+6 days: Deploy solar sail
L+6 to L+36 days: Controlled solar sailing (periodic ILRS measurements)
L+36 to L+42 days: Possible laser sailing experiment (ILRS measurements)

Tracking Requirements:

Tracking Schedule: ○ horizon-to-horizon ◉ custom (specify: 3 x 5 min passes/day)

Spatial Coverage: ○ global ILRS network ○ custom (specify: ________)

Temporal Coverage: ○ full-time ○ custom (specify: ________)

Normal Point Bin Size (Time Span): 1 5 seconds

(Choose one from 5, 15, 30, 120 and 300 seconds. Justify if other bin size is required.)
(See the "Bin Size" of other satellites on the ILRS Web site at *http://ilrs.gsfc.nasa.gov/missions/satellite_missions/current_missions/index.html* .)

Prediction Center: JSpOC Two-line element data will be provided

Prediction Technical Contact Information:

Name: ________

Organization and Position: ________

Address: ________

Phone No.: ________

E-mail Address: ________

Priority of SLR for POD: ◉ Primary ○ Secondary ○ Backup

Other Sources of POD:

☐ GNSS ☐ DORIS ☐ Accelerometer ☒ other (specify: JSpOC)

Other comments on mission information:

(specify) (list backup prediction centers and references/links to non-SLR techniques if available)

LightSail 2 expects to receive two-line element (TLE) data sets from the U.S. Joint Space Operations Center (JSpOC) every 2-3 days during the mission. The LightSail 2 navigation team will perform orbit determination utilizing TLE data and laser ranging passes. Orbit estimates will be distributed to ILRS for tracking on a regular basis.

ILRS tracking support is requested both before and after solar sail deployment. The frequency of tracking will be negotiated with ILRS. We are assuming three 300 s ILRS passes per day, which results in position errors of approximately +/- 10 m (1-sigma).

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. 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.

Are there any science instruments, detectors, or other instruments on the spacecraft that can be damaged or confused by excessive radiation, particularly in any one of these wavelengths (532nm, 1064nn, 846nm, or 432nm)?

◉ No ○ Yes (specify the instrument or detector in question, providing the wavelength bands and modes of sensitivity.)

Are there times when the LRA (Laser Retroreflector Array) will not be accessible from the ground?

◉ No ○ Yes (specify: ____________________

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

→ Skip the next questions and go directly to SECTION III if you answered "No" to both of the above questions.

Is there a need for an elevation tracking restriction?

○ No ○ Yes (What elevation (minimum to maximum in degrees)? _________ degrees)

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

○ No ○ Yes (Explain the reason(s) ____)

Is there a need for a pass segmentation restriction?

○ No ○ Yes (Explain the reason(s) ____)

Is there a need for a laser power restriction?

○ No

○ Yes (Under what circumstances? ____)

(What is the maximum permitted power level **at** the satellite (nJ/cm^2)? ___________)

(Is manual control of laser transmit power acceptable? ○ Yes ○ No)

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:

(specify)

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: Alex Diaz

Organization and Position: Ecliptic Enterprises Corporation, Senior Avionics Engineer

Address: 398 W. Washington Blvd. Suite 100, Pasadena,Ca, 91103

Phone No.: 510-323-4883

E-mail Address: alex@eclipticenterprises.com

Array type:

○ Single reflector ○ Spherical ⊗ Hemispherical/Pyramid ○ Planar

○ other (specify: ______________________)

Attach a diagram or photograph of the satellite that shows the position of the LRA, at the end of this document.

☒ Attached

Attach a diagram or photograph of the whole LRA at the end of this document.

⊗ Attached ○ Same as above, Not attached (acceptable only for a cannonball satellite)

Array manufacturer:

Ecliptic Enterprises Corporation

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

____

____

Has the LRA design and/or type of cubes been used previously?

⊗ No ○ Yes (List the mission(s): ______________________)

For accurate orbital analysis it is essential that full information is available in order that 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-body-fixed reference frame with respect to the satellite's mass center. In practice this means that the following parameters must be available at 1 mm accuracy or better.

Define the satellite-body-fixed XYZ coordinates (i.e. origin and axes) on the spacecraft:
(specify) (add a diagram in the attachment)

See attachment.

Relate the satellite-body-fixed XYZ coordinates to a Celestial/Terrestrial/Solar Reference Frame including the attitude control policy:
(specify) (add a diagram in the attachment)

The 3-D location of the satellite's mass center in satellite-body-fixed XYZ coordinates is:

◯ Always fixed at (0, 0, 0)
◯ Always fixed at (.52 , .24 , 185.83) in mm Stowed configuration
⊗ Time-varying by approximately (__________) mm during the mission lifetime.
Will a time-variable table of the mass center location be available on the web?
⊗ No ◯ Yes (URL: ____________________)

Z coordinate changes to 135.94 when solar array deploys

The 3-D location (or time-variable range) of the phase center of the LRA in the satellite-body-fixed XYZ coordinates:

(________, ________, ________) in mm

The following information on the corner cubes must also be supplied.

The XYZ coordinates referred to in the following are given in:

⊗ Satellite-body-fixed system (same as above)
◯ LRA-fixed system (specify below)
(specify the origin and orientation) (add a diagram in the attachment)

List the position (XYZ) of the center of the front face of each corner cube, and the orientation (two angles or normal vector) and the clocking (horizontal rotation) angle of each corner cube. Note that the angles should be clearly defined.

- [x] Attached at the end of this document
- [ ] Listed here (acceptable for small number (10 or fewer) of corner cubes)

(specify) (add a diagram in the attachment)

There are a total of 13 corner cubes - please see attachment.

Is the corner cube recessed in its container (i.e. can the container obscure a part of the corner cube)?

- [ ] No
- [x] Yes (specify below)

(specify) (add a diagram)

Corner cubes #5,6, and 7 are recessed

The size of each corner cube: Diameter (12.7) mm Height (10.6) mm

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

N-BK7

The refractive index of the cube material

= ____________ for wavelength $\lambda = 0.532$ micron

= ~1.519@550nm as a function of wavelength λ (micron):

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

= ____________ for wavelength $\lambda = 0.532$ micron

= ____________ as a function of wavelength λ (micron):

Dihedral angle offset(s) and manufacturing tolerance (in arcseconds):

____

Radius of curvature of front surfaces of cubes:

○ Not applied ○ Yes (specify: ______________________________)

Flatness of cubes' surfaces:

1/8

Back-face coating:

○ Uncoated (x) Coated (specify the material: VIS 0 degree and Protective Silver)

Other comments on LRA:

(specify) (add a reference to a study of the optical response simulation/measurement if available) (add a diagram if applicable)

SECTION IV: MISSION CONCURRENCE

As an authorized representative of the LightSail 2 mission, I hereby request and authorize the ILRS to track the satellite described in this document.

Name (print): David A. Spencer

Organization and Position: The Planetary Society/Purdue University, LightSail 2 Project Manager

Signature: David A. Spencer

Date: December 22, 2017

Send form to: ILRS Central Bureau
c/o Carey Noll
NASA GSFC
Code 690
Greenbelt, MD 20771
USA
301-614-6542 (Voice)
301-614-6015 (Fax)
Carey.Noll@nasa.gov

SECTION V: ATTACHMENT(S)