ILRS SLR MISSION SUPPORT REQUEST FORM (version: April, 2016)

SUBMISSION STATUS:

(●) 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: Geo-IK-2

Satellite Host Organization: JSC ARADEMISIAN M.F. RESHETNEV Information Satellite Systems (JSC ISS)

Web Address: iss-reshetnev.ru

Contact Information:

Primary Technical Contact Information:

Name: Mikhail Sadovnikov

Organization and Position: JC "RPC "Precision System and Instrument", Head of Division

Address: 53 Aviamotornaya st. Moscow, 11024, Russia

Phone No.: +7(495)673-30-11

E-mail Address: msadovnikov@gmail.com

Alternate Technical Contact Information:

Name: Natalia Parkhomenko

Organization and Position: JC "RPC "Precision System and Instrument", Lead Scientist

Address: 53 Aviamotornaya st. Moscow, 11024, Russia

Phone No.: +7(495)362-24-70

E-mail Address: parknataliya@yandex.ru

Primary Science Contact Information:

Name: Mikhail Sadovnikov

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Alternate Science Contact Information:

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E-mail Address: parknataliya@yandex.ru

Mission Specifics:

Scientific or Engineering Objectives of Mission:
(specify)

- construction of high-precision geodetic network in the geocentric coordinate system (reference frame);
- determination of the Earth's gravitational field parameters
- determination of continental plates movements;
- determination of the earth tide;
- determination of changes in the Earth's rotation speed and pole coordinates, solution of a number of applied problems that require the operative determination of the coordinates of ground stations, including:

a) creation of regional geodetic networks;
b) remote sensing of the Earth;
c) the definition of the marine geoid;
d) ice monitoring.

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

POD

Anticipated Launch Date: The launch occurred on June 4, 2016

Expected Mission Duration: 1 years

Required Orbital Accuracy: The accuracy of the orbit determination should be sufficient to provide round-the-clock tracking for SLR stations of the global network.

Anticipated Orbital Parameters:

Altitude (Min & Max for eccentric orbits): 958,5±15 km

Inclination: 99.47 degrees

Eccentricity: 0.001

Orbital Period: 6216.5 sec

Frequency of Orbital Maneuvers: It is not planned in advance

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

Immediately after approval (if any) of the ILRS Central Bureau

Tracking Requirements:

Tracking Schedule: (◉) horizon-to-horizon ( ) custom (specify: If possible)

Spatial Coverage: (◉) global ILRS network ( ) custom (specify: If possible)

Temporal Coverage: (◉) full-time ( ) custom (specify: If possible)

Normal Point Bin Size (Time Span): 30 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: The branch "Precision Navigation and Ballistic Support"(PNBS) of JC "RPC "PSI"

Prediction Technical Contact Information:

Name: Evgeny Titov

Organization and Position: Head of Department

Address: 12 Pionerskaya st., t. Yubileyny, Moscow region, 141092, Russia

Phone No.: +7(495)221-82-39

E-mail Address: titov@spnav.ru /parknatalia@yandex.ru

Priority of SLR for POD: (◉) Primary ( ) Secondary ( ) Backup

Other Sources of POD:

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

Other comments on mission information:

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

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 provide signature to express agreement to above statement:

Signature: ____

Date: ____________________________

Name (print): ____

Organization and Position: ____

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: Andrey Sokolov

Organization and Position: JC "RPC "Precision System and Instrument", Head of Subdivision

Address: 53 Aviamotornaya st. Moscow, 11024, Russia

Phone No.: +7(495)988-21-48 (16-53)

E-mail Address: alsokolov@bk.ru

Array type:

○ Single reflector ○ Spherical ○ Hemispherical/Pyramid ○ Planar

◉ other (specify: Two-cone LRA)

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:

Joint-stock Company “Research-and-Production Corporation “Precision Systems and Instruments”

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): Type of cubes been used Meteor-3, GOCHE, Proba – 2, Proba – V, Cryosat – 2, Sentinel 3 A&B and on other satellites)

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)

The satellite-body-fixed XYZ coordinate system: the origin is CoM of satellite, the X axis is to the zenith, the Y axis is along the orbital velocity vector, the Z axis is complementary to the right.

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 (__________, __________, __________) in mm
- ○ 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: ____)

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

(-1555, 640, -645) 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)

LRA-fixed XYZ coordinate system: the origin is center of mounting surface C (0, 0, 0), the X axis is to the zenith, the Y axis is along the orbital velocity vector, the Z axis is complementary to the right.

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.

- (●) 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)

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

(●) No ( ) Yes (specify below)

(specify) (add a diagram)

LRA has a protective screen with a thermal stabilizing coating, which repeats the outer shape of the LRA and is 12 mm apart from it, with circular holes above each CCRs which is functionally equivalent to the installation of circular cylindrical blends on the CCRs. Additional elements of the design of the LRA or SC, shielding CCRs, no.

The size of each corner cube: Diameter (28.2) mm Height (19.1) mm

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

quartz optical glass

The refractive index of the cube material

= 1.4607 for wavelength λ = 0.532 micron

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

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

= 1.4860 for wavelength λ = 0.532 micron

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

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

2.5 - 4

Radius of curvature of front surfaces of cubes:

(•) Not applied ( ) Yes (specify: ____________________)

Flatness of cubes' surfaces:

N= 0.1; ΔN= 0.1

Back-face coating:

( ) Uncoated (•) Coated (specify the material: aluminium)

Other comments on LRA:

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

Table of position of the phase center LRA from the center of the mounting surface , depending on the zenith angle (Attachment 4)

SECTION IV: MISSION CONCURRENCE

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

Name (print): Victor Shargorodskiy

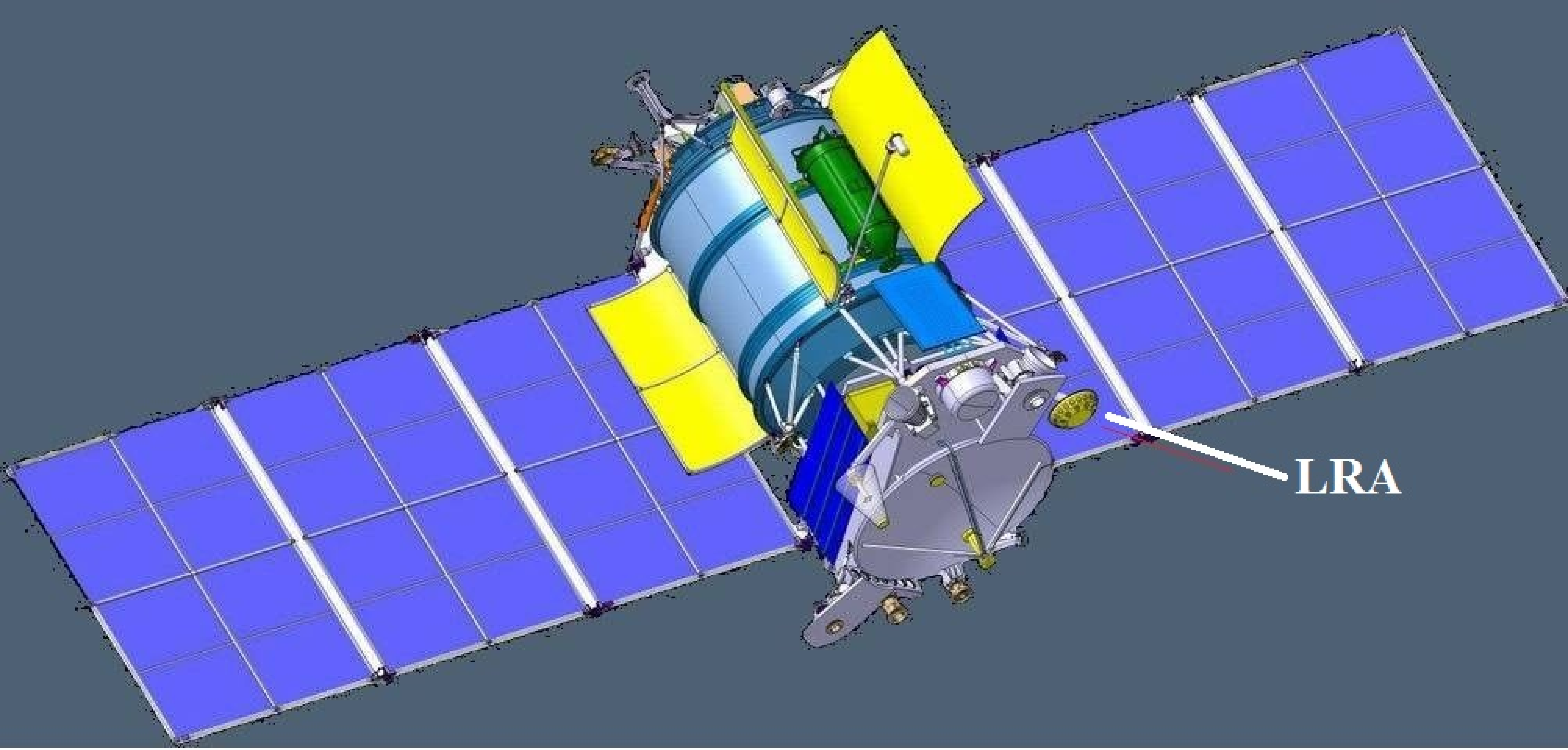
Organization and Position: JC "RPC "PSI", Chief Designer

Signature: [signature]

Date: 31. 08. 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)



Attachment 1

Geo-IK-2 satellite

ATTACHMENT 2

LRA of Geo-IK-2 satellite

The coordinates of the centers of the front face of each corner cube reflector (CCR) with respect to the center of mounting surface of the LRA on the spacecraft.

The first cone, 10 pcs. CCRs				
№ CCR	*X, mm*	*R, mm*	*φ, deg.*	*θ, deg.*
1	57	97.5	0	30
2	57	97.5	36	30
3	57	97.5	72	30
4	57	97.5	108	30
5	57	97.5	144	30
6	57	97.5	180	30
7	57	97.5	216	30
8	57	97.5	252	30
9	57	97.5	288	30
10	57	97.5	324	30
The second cone, 20 pcs. CCRs				
11	32	128	9	52
12	32	128	27	52
13	32	128	45	52
14	32	128	63	52
15	32	128	81	52
16	32	128	99	52
17	32	128	117	52
18	32	128	135	52
19	32	128	153	52
20	32	128	171	52
21	32	128	189	52
22	32	128	207	52
23	32	128	225	52
24	32	128	243	52
25	32	128	261	52
26	32	128	279	52
27	32	128	297	52
28	32	128	315	52
29	32	128	333	52
30	32	128	351	52

LRA-fixed XYZ coordinate system:
the origin is center of mounting surface C (0, 0, 0), the X axis is to the zenith, the Y axis is along the orbital velocity vector, the Z axis is complementary to the right.

Definition in Table:
X is the coordinate of the center of the CCR front face along the X axis (the distance from mounting plane *УZ*).

R is the radius of the circle on which the centers of front faces of the CCR are located in a plane parallel to the mounting plane YZ.

φ is the angle between the Y axis and the radius vector of the center of the front face CCR (polar angle) in a plane parallel to the mounting plane YZ.
θ is the angle between the normal to the front face CCR and the X axis.

ATTACHMENT 4

Table of the positions of the phase center the Geo-IK-2 LRA from the center of the mounting surface in the direction of location Δc (Correction for range measurement) (Topocentric (local) coordinate system of the station)

The zenith angle on the traverse, deg.	The zenith angle, deg.	Azimuth, deg.	Δ_c, mm
0	0	0	29.4
	10	0	40.5
	20	0	51.0
	30	0	60.3
	40	0	68.3
	50	0	76.5
	60	0	84.4
	70	0	90.5
10	10	0	40.5
	20	60.8	51.1
	30	71.9	59.7
	40	77.4	68.3
	50	80.8	76.6
	60	83.3	84.4
	70	85.1	90.5
20	20	0	51.2
	30	50.4	60.3
	40	63.4	68.3
	50	71.0	77.2
	60	76.1	84.3
	70	80.0	90.2
30	30	0	59.7
	40	45.4	68.4
	50	59.3	76.5
	60	68.0	84.4
	70	74.2	90.1
40	40	0	68.2
	50	43.2	76.6
	60	57.6	84.4
	70	67.2	90.1
50	50	0	77.2
	60	42.7	84.3
	70	57.8	90.3
60	60	0	84.4
	70	43.6	90.3
70	70	0	90.0

Δ_c is the distance along the direction of the beam from the center of the mounting surface of the LRA to the phase center.