ILRS SLR MISSION SUPPORT REQUEST FORM (June 2011)

SECTION I: MISSION INFORMATION:

General Information:

Satellite Name: Swarm A, Swarm B, Swarm C (3 identical satellites)

Satellite Host Organization: European Space Agency - ESA

Web Address: http://www.esa.int/esaLP/LPswarm.html

Contact Information:

Primary Technical Contact Information:

Name: Ralf Bock

Address: ESA-ESTEC, Keplerlaan 1, PO Box 299
2200 AG Noordwijk, The Netherlands

Phone No.: +31 71 565 4908

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E-mail Address: Ralf.Bock@esa.int

Alternate Technical Contact Information:

Name: Marc Loiselet

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2200 AG Noordwijk, The Netherlands

Phone No.: +31 71 565 5919

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E-mail Address: Marc.Loiselet@esa.int

Primary Science Contact Information:

Name: ____________________

Address: ____________________

____

Phone No.: ____________________

Fax No.: ____________________

E-mail Address: ____________________

Alternate Science Contact Information:

Name: ____________________

Address: ____________________

Phone No.: ____________________

Fax No.: ____________________

E-mail Address: ____________________

Mission Specifics:

Scientific or Engineering Objectives of Mission:

To provide the best ever survey of the geomagnetic field and its temporal evolution.

Satellite Laser Ranging (SLR) Role of Mission:

Support to precise orbit determination (main instrument for POD is GPS receiver) .
Calibrate the GPS receiver system in the initial phase of the mission and to maintain external reference afterwards

Anticipated Launch Date: 16 July 2012

Expected Mission Duration: 3 months commissioning + 4 years nominal operations

Orbital Accuracy Required: ____________________

Anticipated Orbital Parameters:

Altitude: Swarm A = 460 km , Swarm B = 460 km, Swarm C = 530 km (all TBC)

Inclination: A: 88.35 deg., B: 88.35 deg., C: 88.95 deg. (all TBC)

Eccentricity: 0.00139 (frozen orbit, TBC)

Orbital Period: A: 5618 sec, B: 5618 sec, C: 5795 sec (all TBC)

Frequency of Orbital Maneuvers: ____________________

Mission Timeline: ____________________

Tracking Requirements:

Tracking Schedule: ESA requests SLR tracking of Swarm throughout the entire mission on a best effort basis.

Spatial Coverage: ______

Temporal Coverage: ______

Operations Requirements:

Prediction Center: ESA ESOC

Prediction Technical Contact Information:

Name: Ruaraidh Mackenzie

Address: Robert-Bosch-Str. 5

64293 Darmstadt, Germany

Phone No.: +49 6151 902595

Fax No.: TBD

E-mail Address: Ruaraidh.Mackenzie@esa.int

Priority of SLR for POD: High, due to low orbit

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

GPS, 8-channel, L1+L2 receiver

Normal Point Time Span (sec): 5 seconds (TBC)

Tracking Network Required (Full/NASA/EUROLAS/WPLTN/Mission Specific):

Full

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)? n.a.

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

For what reason(s)?

n.a.

Is there a need for a pass segmentation restriction? No

For what reason(s)?

n.a.

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: Y.M.

Other comments on tracking restrictions:

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: Dr. Ludwig Grunwaldt

Address: Telegrafenberg

14473 Potsdam, Germany

Phone No.: +49 331 288 1733

Fax No.: +49 331 288 1733

E-mail Address: grun@gfz-potsdam.de

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

Regular 45 degrees pyramid

Array manufacturer:

GeoForschungs Zentrum at Potsdam, Germany

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

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

CHAMP, GRACE, TerraSAR-X, TanDEM-X

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:

Boom deployed configuration (approx 2 days after Launch):

X = -2000 mm , Y = 0 mm , Z = -300 mm (all TBC !)

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

X = TBD mm , Y = TBD mm , Z = TBD mm (all TBD !)

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:

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:

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

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

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

Fused quartz glass

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

1.461 @ 532 nm

Dihedral angle offset(s) and manufacturing tolerance:

-3.8” (smaller than 90 deg)

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

+500 m (convex)

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

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

Cube front face uncoated. Reflecting surfaces coated with aluminum and protective SiO_2 layer.

Other Comments:

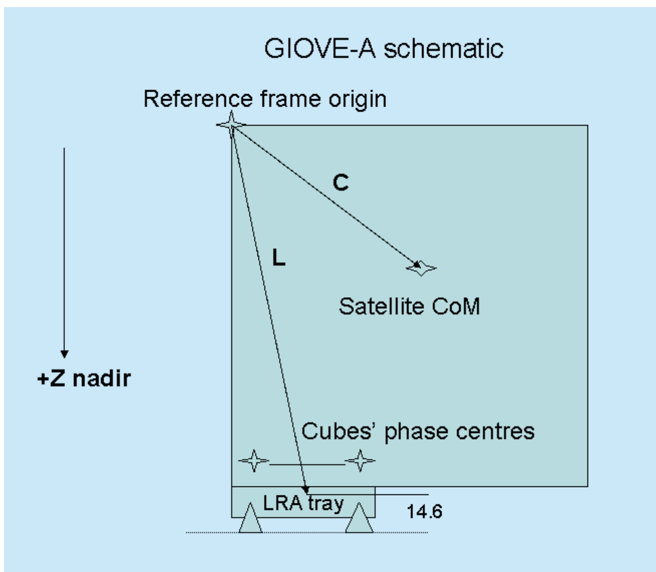
The Swarm Laser Retroreflector is a rebuild of the ones used on various missions:

CHAMP, GRACE, TerraSAR-X, TanDEM-X

See also related ILRS webpages for laser reflector description:

http://ilrs.gsfc.nasa.gov/satellite_missions/list_of_satellites/

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 Swarm mission, I hereby request and authorize the ILRS to track the satellite described in this document.

Name (print): Yvon Menard Date 17.11.2011

Signature:

Position: Swarm Project Manager

Send form to:

ILRS Central Bureau
c/o Carey Noll
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Greenbelt, MD 20771
USA
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301-614-6015 (Fax)
Carey.Noll@nasa.gov