ILRS SLR MISSION SUPPORT REQUEST FORM (January 2009)

SECTION I: MISSION INFORMATION:

General Information:

Satellite Name: CryoSat-2

Satellite Host Organization: ESA

Web Address: http://www.esa.int/livingplanet/cryosat

Contact Information:

Primary Technical Contact Information:

Name: Richard Francis

Address: ESA/ESTEC, Keplerlaan 1

2201AZ Noordwijk, The Netherlands

Phone No.: +31-71-565-4460

Fax No.:

E-mail Address: Richard.Francis@cryosat.esa.int

Alternate Technical Contact Information:

Name: Christoph Götz

Address: ESA/ESTEC, Keplerlaan 1,

2201AZ Noordwijk, The Netherlands

Phone No.: +31-71-565-6240

Fax No.:

E-mail Address: Christoph.Goetz@esa.int

Primary Science Contact Information:

Name: Duncan Wingham

Address: UCL London

Phone No.: +44-20-767-97870

Fax No.:

E-mail Address: djw@cpom.ucl.ac.uk

Alternate Science Contact Information:

Name: S. Laxon

Address: UCL, London

Phone No.:

Fax No.:

E-mail Address:

Mission Specifics:

Scientific or Engineering Objectives of Mission:

A mission to measure change in the cryosphere, CryoSat-2 will measure the thickness of sea-ice and the surface elevation of ice sheets in both Northern and Southern hemispheres. For this, it uses an advanced radar altimeter combined with Precise Orbit Determination.

Satellite Laser Ranging (SLR) Role of Mission:

As the mission is intended to measure small changes in a distance measure it is necessary to use laser ranging for (1) calibration of the altimeter and (2) support to the POD. POD will be primarily done with DORIS, but SLR data are used both in the final orbits and as quality control for DORIS-only orbits.

Anticipated Launch Date: Late 2009

Expected Mission Duration: 6 months commissioning + 5 years

Orbital Accuracy Required: <5 cm and < 1 cm drift

Anticipated Orbital Parameters:

Altitude: 720 km

Inclination: 92°

Eccentricity: close to 0.0

Orbital Period: 5960 s

Frequency of Orbital Maneuvers: 3 to 10 weeks

Mission Timeline: initial orbit acquisition during first 30 days, then regular orbit maintenance

Tracking Requirements:

Tracking Schedule: ______

Spatial Coverage: global

Temporal Coverage: full mission lifetime

Operations Requirements:

Prediction Center: ESOC

Prediction Technical Contact Information:

Name: Xavier Marc

Address: ESOC

Phone No.: ______

Fax No.: ______

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

Priority of SLR for POD: 2nd priority

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

DORIS

Normal Point Time Span (sec): 10 s (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)?

Obviously yes in the limiting case (e.g. GW of power). However, direct solar illumination is OK. What is the irradiation level at 720 km?

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

Only under multiple failure conditions

(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:

We have no restrictions, but anyway we will not make such claims.

____

____

____

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: C. R. Francis

Address: __________

Phone No.: __________

Fax No.: __________

E-mail Address: __________

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

7 cubes arranged on a spherical surface

Array manufacturer:

IPIE Moscow

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

Document to be attached

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

It's a duplicate of the array on CryoSat-1. The same basic design is on GOCE (TBC). Russian satellites (e.g. Meteor) as well.

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:

A full document was produced with this information for CryoSat-1. This will be updated soon for CryoSat-2.

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

See above

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:

All of the information requested in this section will be provided in the updated version of the CryoSat reference information.

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:

19.1 mm from front face to vertex

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

fused quartz

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

Dihedral angle offset(s) and manufacturing tolerance:

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

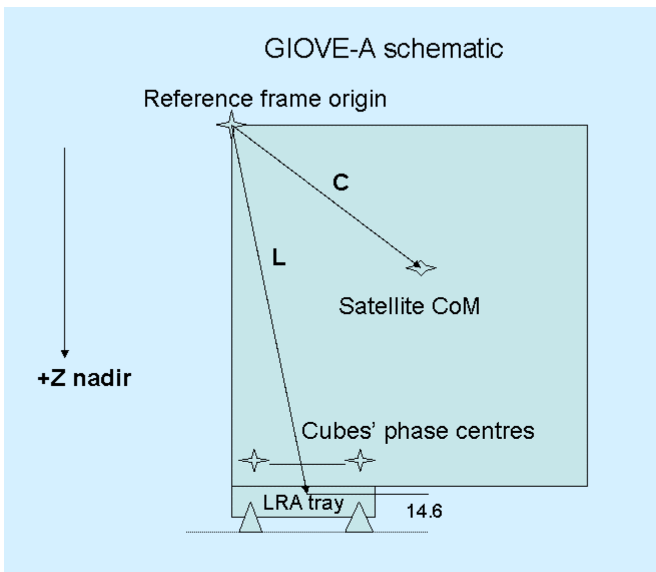
Flatness of cubes' surfaces (as a fraction of wavelength):

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

Other Comments:

Separate documentation is provided, attached. The unit under test was the CryoSat-1 LRR, but the units are identical.

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://nercslr.nmt.ac.uk/sig/signature.html*.

SECTION IV: MISSION CONCURRENCE

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

Name (print): C. R. Francis Date 6 Aug 2009

Signature: ______________________________

Position: Project Manager

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