ILRS SLR MISSION SUPPORT REQUEST FORM (January 2009)

SECTION I: MISSION INFORMATION:

General Information:

Satellite Name: Fifth KOrea Multi-Purpose SATellite (KOMPSAT-5)

Satellite Host Organization: Korea Aerospace Research Institute

Web Address: http://www.kari.re.kr

Contact Information:

Primary Technical Contact Information:

Name: Dr. Hak-Jung Kim

Address: Korea Aerospace Research Institute, 115 Gwahangno, Yuseong, Daejeon, Korea, 305-333

Phone No.: 82-42-860-2320

Fax No.: 82-42-870-3909

E-mail Address: hjkim@kari.re.kr

Alternate Technical Contact Information:

Name: Mr. Ok-Chul Jung

Address: Korea Aerospace Research Institute, 115 Gwahangno, Yuseong, Daejeon, Korea, 305-333

Phone No.: 82-42-860-2732

Fax No.: 82-42-870-3909

E-mail Address: ocjung@kari.re.kr

Primary Science Contact Information:

Name: Dr. Sungki Cho

Address: Korea Astronomy and Space Science Institute, 61-1 Hwaam-dong, Yuseong, Daejeon, Korea, 305-348

Phone No.: 82-42-865-3236

Fax No.: 82-42-861-5610

E-mail Address: skcho@kasi.re.kr

Alternate Science Contact Information:

Name: Mr. Jung Jo

Address: Korea Astronomy and Space Science Institute, 61-1 Hwaam-dong, Yuseong, Daejeon, Korea, 305-348
Phone No.: 82-42-865-3238
Fax No.: 82-42-861-5610
E-mail Address: jhjo39@kasi.re.kr

Mission Specifics:

Scientific or Engineering Objectives of Mission:

The main mission objectives of KOMPSAT-5 system are to provide the following applications (GOLDEN mission):

- Geographic Information System (GIS)
- Ocean Management
- Land Management
- Disaster Monitoring
- ENvironment Monitoring

The KOMPSAT-5 satellite will be delivered to low Earth orbit for all-weather day-night monitoring of Korean peninsula.

The primary mission of KOMPSAT-5 system is to provide High Resolution mode SAR image of 1 m resolution, Standard mode SAR image of 3 m resolution, and Wide Swath mode SAR image of 20 m resolution with viewing condition of the incidence angle of 45 degrees, using COSI (COrea SAR Instrument) payload, for meeting GOLDEN mission objectives.

The secondary mission is to generate the atmospheric sounding profile and support radio occultation science using AOPOD (Atmospheric Occultation and Precision Orbit Determination) secondary payload which is composed of dual frequency GPS receiver and Laser Retro Reflector Array (LRRA).

Satellite Laser Ranging (SLR) Role of Mission:

LRRA receives and reflects a laser beam from Satellite Laser Raging (SLR) Station to provide the ranging data for a high accuracy POD validation.

Anticipated Launch Date:

Launch will be occurred during the late of 2010 by Dnepr launch vehicle.

Expected Mission Duration:

The designed mission lifetime is 5 years.

Orbital Accuracy Required:

The precision orbit determination (POD) requirement is 20 cm (1σ) in 3-dimensional position.

Anticipated Orbital Parameters:

Altitude: 550 km

Inclination: 97.6 degree

Eccentricity: 0

Orbital Period: 95.78 minutes

Frequency of Orbital Maneuvers: Once per 10 days

Mission Timeline: Mean Local Time of Ascending Node is 06:00 am.

Tracking Requirements:

Tracking Schedule: SLR is complementary to onboard AOPOD GPS and is used for POD and validation

Spatial Coverage: Global

Temporal Coverage: All Times

Operations Requirements:

Prediction Center: KOMPSAT-5 Ground Segment (KGS) @ Korea Aerospace Research Institute

Prediction Technical Contact Information:

Name: Mr. Ok-Chul Jung

Address: Korea Aerospace Research Institute, 115 Gwahangno, Yuseong, Daejeon, Korea, 305-333

Phone No.: 82-42-860-2732

Fax No.: 82-42-870-3909

E-mail Address: ocjung@kari.re.kr

Priority of SLR for POD: Secondary Source for POD

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

Normal Point Time Span (sec): 5 seconds

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

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)?
<u>There are no equipments which might be damaged by such kind of irradiation.</u>

Are there times when the LRAs will not be accessible from the ground?
<u>The right looking roll angle is -33.7 degrees with respect to nadir direction and the left looking roll angle is +33.7 degrees with respect to nadir direction. The spacecraft bus maintains the roll</u>

tilt angle of -33.7 degrees for right looking mode. LRRA points to nadir direction (Earth center direction) in right looking configuration of spacecraft bus. Therefore, there are no restrictions for ground accessibility in right looking mode. However, based on geometric relationship between ground station and spacecraft bus, some SLR station may have problem to acquire the data in left looking mode of spacecraft bus.

KOMPSAT-5 will perform orbit maneuver about once per 10 days. The spacecraft bus has to execute the pitch direction tilting up to 90 degrees for thrust firing. SLR observation may be impossible for orbit control period.

(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? Not required. What altitude (degrees)?

Is there a need for a go/no-go tracking restriction? It might be required.

For what reason(s)? The reason is that there are times when the LRAs will not be accessible from the ground.

Is there a need for a pass segmentation restriction? It might be required.

For what reason(s)? The reason is that there are times when the LRAs will not be accessible from the ground.

Is there a need for a laser power restriction? Not required.

Under what circumstances? Not required.

What power level (mW/cm2)? Not required.

Is manual control of transmit power acceptable? It is 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: KARI agrees on above statement.

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:

Retro reflector Primary Contact Information:

Name: Dr. Sungki Cho

Address: Korea Astronomy and Space Science Institute, 61-1 Hwaam-dong, Yuseong, Daejeon, Korea, 305-348

Phone No.: 82-42-865-3236

Fax No.: 82-42-861-5610

E-mail Address: skcho@kasi.re.kr

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

Pyramid-shaped 4-prism array of CHAMP type

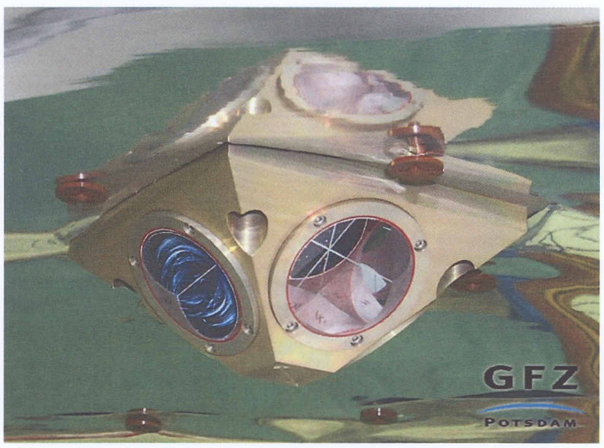


Figure 1. LRRA FM

Array manufacturer:

GFZ, Potsdam

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

GFZ, Potsdam

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

CHAMP, GRACE, TerraSar-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: Refer to Figure 2.

The 3-D location of the phase center of the LRA relative to a satellite-based origin: Refer to Figure 2.

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: Refer to Figure 2.

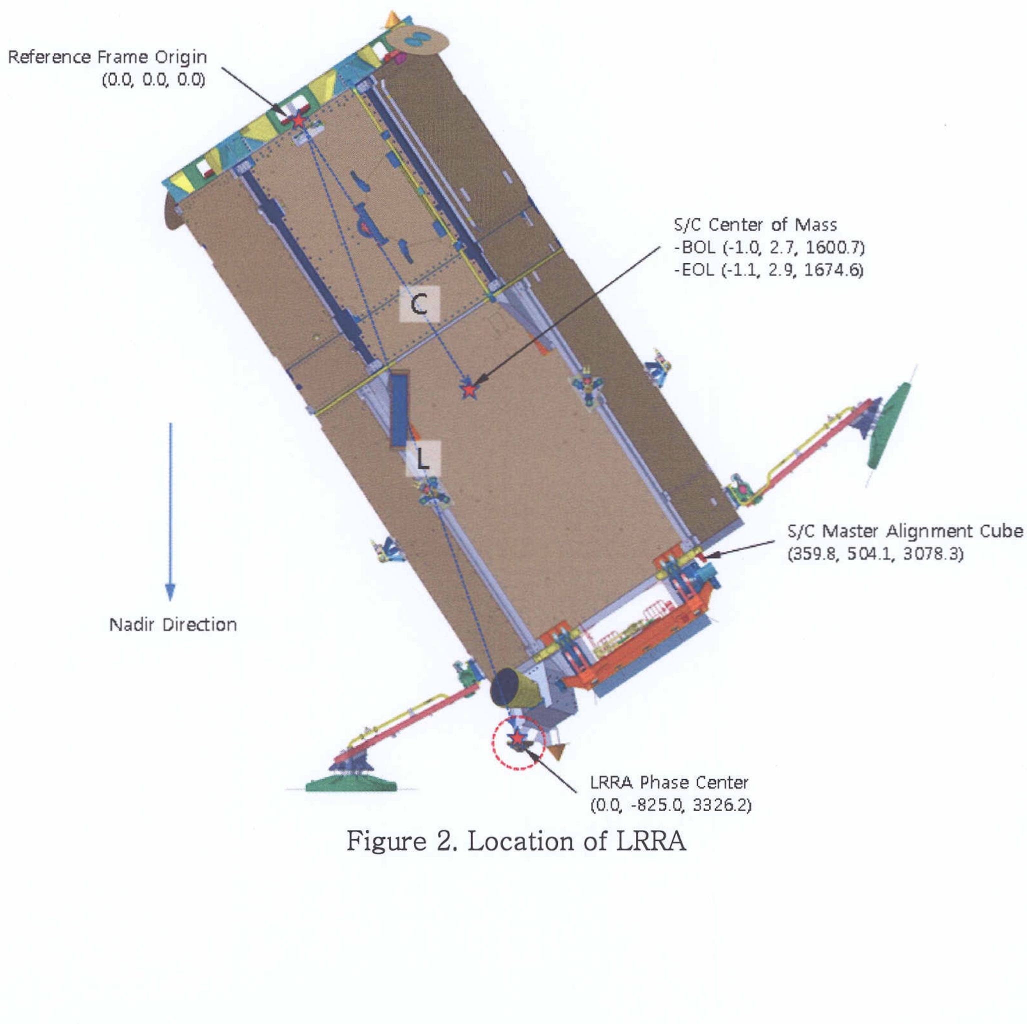


Figure 2. Location of LRRA

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:

For position and orientation of the prisms within the array see http://ilrs.gsfc.nasa.gov/docs/rra_champ.pdf

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

For position and orientation of the prisms within the array see http://ilrs.gsfc.nasa.gov/docs/rra_champ.pdf

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

Clear aperture of front face 38 mm; vertex length 28 mm

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):

1.461 @ 532 nm

Dihedral angle offset(s) and manufacturing tolerance:

-3.8 arcseconds

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

+ 500 meters

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

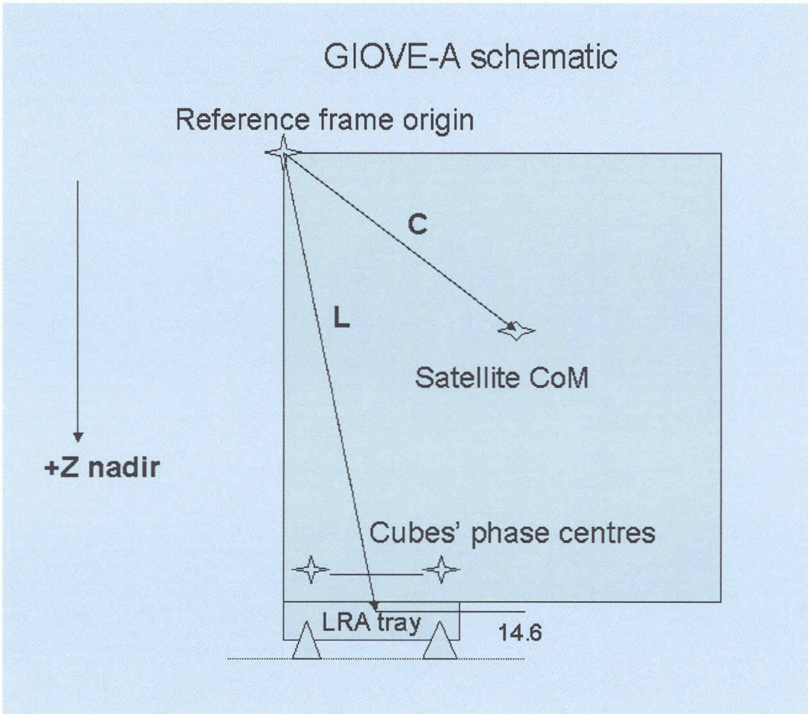
N/A

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

Reflecting surfaces coated by aluminum; front face uncoated

Other Comments:

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 farfield 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 retroreflector 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 KOMPSAT-5 mission, I hereby request and authorize the ILRS to track the satellite described in this document.

Name (print): Yong-Sik Chun Date Oct. 8, 2009

Signature: [signature]

Position: Director of Satellite Operations & Applications Division

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