ILRS Governing Board Meeting

held in conjunction with

15th International Workshop on Laser Ranging

and the

12th ILRS General Assembly

October 19, 2006
08:30 - 10:30

Canberra, Australia

ILRS Governing Board Meeting
Canberra, Australia

Thursday, October 19, 2006
08:30 – 10:30

Agenda

1.	Opening Remarks (5 min.)	W. Gurtner
2.	ILRS Status/Action Items (15 min.)	M. Pearlman
3.	ITRF2005 Issues (5 min)	E. Pavlis/W. Gurtner
4.	Working Group Recommendations and Requests to the Board (15 min)	WG Chairs
5.	Galileo Support (5 min.)	W. Gurtner
6.	Laser Retroreflector Recommendation (5 min.)	M. Pearlman
7.	Election of GB Chair (5 min.)	M. Pearlman
8.	Selection of Working Group Chairs and Co-chairs (15 min.)	M. Pearlman
9.	GGOS Activities (5 min.)	M. Pearlman
10.	New Business	W. Gurtner/WG Chairs
11.	Other Business	W. Gurtner

ILRS Governing Board

Ex-Officio Members:

Director, Central Bureau:	Mike Pearlman
Secretary, Central Bureau:	Carey Noll
President of IAG Commission I:	Hermann Drewes

Members Appointed or Elected by Organizations:

EUROLAS Network Representatives:	Giuseppe Bianco
	Werner Gurtner, Chair
NASA Network Representatives:	David Carter
	Jan McGarry
WPLTN Representatives:	Ben Greene (Yang Fumin)
	Hiroo Kunimori
IERS Representative:	Bob Schutz

Members Elected by their International Peers:

Analysis Representatives:	Graham Appleby (Vincenza Luceri)
	Ron Noomen (Erricos Pavlis)
Data Center Representative:	Wolfgang Seemueller
LLR Representative:	Peter Shelus (Juergen Mueller)
At-Large Representatives:	Georg Kirchner
	Ulrich Schreiber (Graham Appleby)

Note: Names in () are new members elected in fall 2006

Former Members:

Francois Barlier (former At-Large Representative, 1998-2000)
Gerhard Beutler (former CSTG President, 1998-1999)
John Bosworth (former Director, ILRS Central Bureau, 1998-2001)
John Degnan (former Chairman and NASA Network Representative, 1998-2002)
Richard Eanes (former Analysis Center Representative, 1998-2000)
Yang Fumin (former WPLTN Network Representative, 1998-2002)
John Luck (former At-Large Representative, 1998-2002)
Wolfgang Schlueter (former EUROLAS Network Representative, 1998-2002)

ILRS Status Review

Network Items:

- EUROLAS
  - Grasse MEO station (7845) down for system modifications 07/2005 for 12-18 months
  - FTLRS
    - New laboratory to be built at Grasse to house FTLRS for system improvements
    - Plan to work with colleagues at Canberra and Hobart universities to collaborate on FTLRS occupation in Tasmania for Jason-1 calibration/validation (occupation in 2007)
  - Concepcion
    - System upgrade; downtime (03/10-05/16/2006
- WPLTN
  - SALRO
    - Agreement between NASA and KACST underway
    - Interest in joint activity with IGN to house relocated DORIS beacon and perform site survey
  - Changchun
    - System upgrade; downtime (04/06-06/01/2006)
  - Wuhan
    - Station off-line since 12/18/2005 due to on-site construction, lack of staff, insufficient laser energy, bad weather
  - TROS
    - System upgrade by Institute of Seismology, China Earthquake Administration (IOSCEA)
    - 3+-month tracking campaign in Korea planned for 2007
  - Tanegashima
    - Controller problems (05/18-07/20/2006)
  - Simosato
    - Plan to submit GPS receiver (SHIM) data to the IGS
  - San Juan
    - Contacted 09/2006 about possible installation of GPS receiver; under consideration
- NASA
  - Maui
    - TLRS-4 hardware installation in Hawaii ongoing
    - Anticipate operations to commence in fall 2006
    - Survey of new location being scheduled
  - Arequipa
    - HTSI staff working on bringing system back online
    - Operations to resume in fall 2006
    - Site survey being scheduled
  - Monument Peak
    - DORIS and seismic instrument installation performed in December 2005
    - Hard weather conditions and subtle laser issue caused reduced tracking during winter
  - Greenbelt
    - Completed ALOS restricted tracking and Go/No Go testing and implementation
    - Shared operations with TLRS-4
  - SLR2000
    - Modifications underway to support LRO-LR
    - Recent tests with MOBLAS-7 have shown good SLR2000 receive system performance
- CB continues to coordinate with a few stations on implementation of CPF (see charts)

Site Surveys:

- Analysis of survey data from Hawaii, Arequipa, and GSFC in process
- Closeout survey of Haleakala performed by HTSI in late 2004; analysis underway
- South African and Shanghai survey reports completed by IGN

ILRS Status Review
(continued)

Mission Items:

- ALOS
  - First tracking campaign 08/14-31/2006 successful; 82 passes total
  - Additional campaigns planned
- Galileo
  - GIOVE-A
    - Official SLR tracking campaign 05/22-07/23/06; 156 passes from 14 stations total during campaign
    - Second campaign planned for this fall
  - GIOVE-B (GSTB v2/B) launch scheduled for 2007
  - Prediction generation process implemented by ESA (both TIRV and CPF)
- GPS satellites
  - Dialog with various agencies continues on reflectors on GPS-III satellites
  - Study underway at GSFC on hollow cube technology; D. Arnold working on array performance studies
  - INFN-LNF (Istituto Nazionale di Fisica Nucleare-Laboratori Nazionali di Frascati) in Italy also planning to test hollow cubes
  - Draft specification document created
- Meteor-3M
  - SLR tracking ended 03/03/06
- GP-B
  - SLR tracking ended 06/05/06
- ANDE
  - Tracking request approved by Governing Board February 2006
  - Launch from Space Shuttle, earliest would be mission 3 after return to flight (12/2006)
- OICETS
  - First tracking campaign: 04/18-06/06/06; 115 passes total
  - Additional campaigns planned
- MicroSCOPE
  - Tracking request approved by Governing Board March 2006
  - Launch planned for March 2009
  - Additional information on retroreflector array design needed
- TerraSAR-X
  - Approval still pending in MWG
  - Launch October 31, 2006
- LRO-LR
  - One-way range measurement to lunar orbiter
  - Launch March 2008
  - Support from selected stations (including SLR2000)
  - No mission support request submitted yet
- T2L2
  - Launch on Jason-2 planned for June 2008
  - Questionnaire on tracking capabilities sent to stations
  - No mission support request submitted yet

Analysis and Data Issues:

- Benchmark evaluation on GA and GRGS solutions underway
- All reports from CDDIS issue quantity values in passes (not pass segments) and minutes of data (normal points times bin size)
- Update of data archives with older data (BE-B, -C, GEOS-1, -2, -3, PEOLE, DIADEM-1C, -1D) underway
- Update of eccentricity files with new data from ITRF underway
- ITRF 2005 evaluation underway
- LAGEOS normal points from older data supplied by DUT (1983-1992) and DGFI (1983-1987)

ILRS Status Review
(continued)

ILRS Web Site:

- New versions of report card charts developed and available through ILRS Web site (linked to report cards); example shown here
- New plots of station performance now fully integrated into ILRS Web site structure (under Stations and linked to report cards); examples shown here
  - Station performance charts since last year and since 2000
- Plot of groundtrack of last seven days of geodetic satellite data available and updated daily (under Stations and What's New)
- New ILRS Satellite section completed
- CoM pages continue to be updated (new values for GLONASS and Galileo)

Meetings:

- October 8-9, 2006: GGOS Workshop, Munich Germany
- October 9-13, 2006: IAG Symposium on Geodetic Reference Frames, Munich, Germany
- October 16-20, 2006: 15th International Workshop on Laser Ranging, Canberra, Australia
  - October 17: ILRS SPWG meeting
  - October XX: ILRS DFPWG meeting
  - October XX: ILRS MWG meeting
  - October 19: ILRS GB meeting
  - October 20: ILRS AWG meeting
- December 11-15, 2006: Fall AGU in San Francisco, CA
  - IGS strategic planning retreat
  - GGOS Steering Committee meeting
- April 15-20, 2007: EGU, Vienna Austria
- July 2-13, 2007: IUGG General Assembly, Perugia, Italy

Reports:

- ILRS 2005-2006 annual report request for input to be issued 12/2006

Other Items:

- GGOS
  - Ground Networks and Communications Working Group is actively working on network designs
  - Network design simulations started; status report given at GN&C WG meeting held on April 5, 2006 at EGU
- INDIGO
  - Plan to utilize efforts made under SCIGN REASoN effort (*http://reason.scign.org /scignDataPortal/)*
  - User assessment performed to identify existing commonalities and opportunities in the IAG services (IGS, ILRS, IVS)
  - Survey of IAG service central bureaus and Web sites performed
  - Need AC "logs" for ILRS analysis centers to document analysis strategies, techniques, models, parameters (received logs from ASI, BKG, DGFI, GFZ)
  - Web site established *http://indigo.nasa.gov*

Remaining Governing Board Action Items

EGU, Vienna Austria (April 26, 2005):

1. CB will contact the IAG Outreach to suggest that the IAG make its participants aware of the issue of service recognition issue in publications, papers, reports, and presentations.
   - IGS, IVS, ILRS, and IDS continue to work on a joint activity to:
     - Jointly request that the IAG take positive action (Web site notice, messages to the community, etc) to activate its community;
     - Consider contacting relevant journals and journal referees to help enforce this citation.
2. CB will check if the local ties have been measured for the Riyadh and Changchun SLR stations. *(Done)*
   - Noll contacted both stations in January and September 2005; Changchun reports plans made but no survey yet
   - Survey activity under consideration in Riyadh in conjunction with a possible DORIS installation
3. CB should browse all existing mission Web sites and search for references to the service and information about the role of SLR for the mission; if not found, have webmasters add it.
   - Webmasters contacted; summary of results provided separately here
4. A subgroup of technology and science representatives should write a white paper on the future vision for SLR. *(assigned 04/2005)*
5. Appleby will provide station signal strength regimes to the CB for placement in the site logs with perhaps a separate table automatically updated/extracted and linked to the CoM pages on the ILRS Web site. The information is not in the site log now so the format will have to be modified. *(assigned 04/2005)*
6. An ILRS orbit product committee should be formed to develop a plan for the new product (Noomen). *(assigned 04/2005)*
7. Review data analysis/station feedback capabilities within the ILRS. *(assigned 04/2005)*
   - DGFI will propose a procedure to incorporate inputs from analysis groups, assess quality of stations, provide feedback to the station on a best-possible epoch station position and velocity (to be included in the site log, by the station), and report on plans in Canberra
   - ASI will use the combination results to develop a review process and develop a simple report which gives an overview of (LAGEOS) data production and their use for the pos+eop product, for submission to stations and managers (*Noomen, Luceri, Gurtner)*.

Eastbourne UK (October 10, 2005):

1. Examine the issue of the internal SLR reference frame. (Noomen) *(assigned 11/2005)*
2. Examine the eccentricity files to see if they could serve as a source for the list of key information. (Noomen) *(assigned 11/2005)*
3. Consolidate the presentations to Geoscience Australia into a 1 hour talk *(assigned 11/2005)*

Vienna, Austria (April 26, 2006):

1. Inform the IERS that the ILRS strongly recommends use current time-series of ILRS and IVS pos+eop solutions for definition of the origin and scale ITRF2005. (Noomen) *(assigned 04/2006)*
2. Inform the IERS that noting the difference between the scales derived by the ILRS and IVS, the ILRS recommends that the IERS investigate the difference and decide how this difference should be handled. (Noomen) *(assigned 04/2006)*
3. Send a message to the newly acknowledged ACs. (Pearlman) *(assigned 04/2006; done, 04-05/2006)*
4. Update the Web site, exploders, etc. to reflect the operational (and non-operational status) of ACs. (Noll) *(assigned 04/2006; done, 04/2006)*
5. Establish the ILRS Special Issue editorial board. (Noomen) *(assigned 04/2006)*
6. The Transponder Working Group will create requirements lists to give guidance to both transponder experiments and ground stations to promote compatibility with present and projected ILRS capability. (Schreiber) *(assigned 04/2006)*

ILRS Prediction Centers

Satellite	Prediction Provider (3-character code)								
	COD	**ESA**	**GFZ**	**GSF**	**HTS**	**JAX**	**MCC***	**SGF**	**UTX**
Ajisai					P	B		B	
ALOS						P			
Apollo 11/14/15									P
Beacon-C					P			B	
CHAMP			P						
Envisat		P			B			B	
ERS-2		P			B				
Etalon-1/-2					P			B	
GFO-1				P	B			B	
GIOVE-A		P			B				
GLONASS	P				B				
GPS-35/-36	P				B				
GRACE-A/-B			P						
ICESat									P
Jason-1					P			B	
LAGEOS-1/-2					P	B		B	
Larets					P		B	B	
Luna 17/21									P
Meteor-3M				P	B				
OICETS						P			
Starlette					P			B	
Stella					P			B	
Future Satellites									
ANDE					P?				
ETS-VII						P?			
Galileo		P							
GIOVE-B		P							
MicroSCOPE									
TerraSAR-X			P?						

Notes: All* centers providing predictions in CPF and TIRV format (*MCC only providing predictions in TIRV format)
P=primary prediction source; B=backup prediction source
No response from MCC
TIRV prediction generation to continue through October 2006
CNES should be asked to be the primary prediction center for MicroSCOPE

ILRS CPF Implementation Status
October 2006

Site Information

Location	Station	Not Started	Coding Started	Testing	Production	All Targets?	Comments
Beijing	7249				X	X	
Borowiec	7811				X	X	
Changchun	7237				X	X	
Concepcion	7405				X	X	
FTLRS	-				X	X	
Grasse	7845				X	X	
Graz	7839				X	X	
Greenbelt	7105			X			
Hartebeesthoek	7501			X			
Helwan	7831		X	X			
Herstmonceux	7840				X	X	
Katzively	1893						No response
Kiev	1824				X	X	
Koganei	7308						No response
Lviv	1831				X	X	
Maidanak	1864						No response
Matera	7941				X	X	
McDonald	7080				X	X	
Metsahovi	7806	X					Sys. upgrades
Monument Peak	7110			X			
Mt. Stromlo	7825				X	X	
Potsdam	7841				X	X	
Riga	1884		X				Ready 9/30
Riyadh	7832				X	X	
San Fernando	7824			X			
San Juan	7406				X	X	
Shanghai	7821				X	X	
Simeiz	1873				X	X	
Simosato	7838				X	X	
Tahiti	7124			X			
Tanegashima	7358				X	X	
TLRS-4	7130			X			
TROS	-						No response
Wettzell	8834				X	X	
Wuhan	7231	X					Sys. problems
Yarragadee	7090			X			
Zimmerwald	7810				X	X	

Provider Information

Source	Testing	Production	Targets
COD		X	All satellites
CSR		X	ICEsat
ESA		X	Envisat, ERS-2, GIOVE-A
GFZ		X	CHAMP, GRACE-A/B
GSFC		X	GFO
JAXA		X	Ajisai, LAGEOS-1/2, OICETS, ALOS
NSGF		X	All satellites
HTSI		X	All satellites
MCC	X		Larets

Mission Recognition of ILRS
October 2006

Agency	Contact	Mission	Status	Web Site
NASA	NASA GSFC	ICESat	Done	http://icesat.gsfc.nasa.gov/ under Mission Operations
	MacDonnell	Meteor-3M	Done	http://www-sage3.larc.nasa.gov/meteor-3m/
JAXA	Nakamura/Kudoh	ADEOS-1/-2	Done.	http://god.tksc.jaxa.jp/ad2/adeos2.html
		ALOS	Done	http://god.tksc.jaxa.jp/al/al.html
		ETS-VIII	Done	http://god.tksc.jaxa.jp/e8/e8.html
		OICETS	Done	http://god.tksc.jaxa.jp/oi/oicets.html
NRL	?	ANDE	No action	USNO amateur radio Web site, appropriate?
GFZ	Web masters	CHAMP	Done	http://www.gfz-potsdam.de/pb1/op/champ/orbit/orbit_CHAMP.html
		GRACE	Done	http://www.gfz-potsdam.de/pb1/op/grace/general/general.html
ESA	Web masters	CryoSat	Done	http://www.esa.int/SPECIALS/Cryosat/SEMRQ4908BE_0.html
		Envisat	Done	http://envisat.esa.int/instruments/lrr/ http://envisat.esa.int/dataproducts/ra2/CNTR2-8-4.htm http://envisat.esa.int/helpandmail/glossary.html#i
		ERS-1,-2	Done	http://earth.esa.int/ers/eeo3.324/ers_gs_products/er_part3.html#3.1.8
		GIOVE-A	Done	http://www.esa.int/esaNA/SEM8QOKKKSE_index_0.html
GFO	Finkelstein	GFO-1	Done	http://gfo.bmpcoe.org/Gfo/Exec_col/exec_col.htm
Stanford	Galal	GP-B	Done	http://einstein.stanford.edu/ (under What is GP-B -> Links)
AVISIO		Jason-1	Done	http://www.jason.oceanobs.com/html/missions/jason/ instruments/lra_uk.html (credit on map)
		TOPEX	Done	http://www.jason.oceanobs.com/html/missions/tp/ satellite_uk.html#LRA (needs improvement)
JPL	Web masters	Jason-1		http://topex-www.jpl.nasa.gov/technology/instrument-lra.html
		TOPEX	No action	

ILRS citations:

- Asked mission contacts to cite ILRS on mission Web sites that referenced SLR tracking or retroreflectors
- Typical citation lists ILRS and links to ILRS home page
- Suggested citation: Pearlman, M.R., Degnan, J.J., and Bosworth, J.M., "The International Laser Ranging Service", Advances in Space Research, Vol. 30, No. 2, pp. 135-143, July 2002.
- ILRS citation on following ILRS Web site pages
  - Home page
  - Data and products main page
  - Bibliography main page
  - Mission support request form
  - Analysis center response form

ILRS Satellite Tracking Priorities
September 2006

1. Priorities decrease with:
   a. increasing orbital altitude; and
   b. increasing orbital inclination (at a given altitude).
2. Priority of some satellites may then be increased to intensify support for:
   a. active missions (such as altimetry);
   b. special campaigns (such as IGLOS); or
   c. post-launch intensive tracking phases; and
3. Some slight reordering may be done to give higher priority missions with increased importance to the analysis community.

Priority	Mission	Sponsor	Altitude (km)	Inclination (degrees)	Comments
1	GRACE-A, -B	GFZ/JPL	485-500	89	Tandem mission
2	CHAMP	GFZ	429-474	87.3	
3	GFO-1	US Navy	790	108.0	Altimetry/no other tracking technique
4	Envisat	ESA	796	98.6	Tandem with ERS-2
5	ERS-2	ESA	800	98.6	Tandem with Envisat
6	Jason	NASA/CNES	1,350	66.0	
7	Larets	IPIE	691	98.2	
8	Starlette	CNES	815-1,100	49.8	
9	Stella	CNES	815	98.6	
10	Ajisai	NASDA	1,485	50	
11	LAGEOS-2	ASI/NASA	5625	52.6	
12	LAGEOS-1	NASA	5850	109.8	
13	Beacon-C	NASA	950-1300	41	Upgraded from campaign to ongoing mission (Jan-02)
14	Etalon-1	Russian Federation	19,100	65.3	
15	Etalon-2	Russian Federation	19,100	65.2	
16	GLONASS-89	Russian Federation	19,100	65	Replaced GLONASS-86 as of 20-Mar-03
17	GLONASS-87	Russian Federation	19,100	65	Replaced GLONASS-88 as of 20-Feb-02
18	GLONASS-95	Russian Federation	19,100	65	Replaced GLONASS-84 as of 26-Aug-05
19	GPS-35	US DoD	20,100	54.2	
20	GPS-36	US DoD	20,100	55.0	
21	GIOVE-A	ESA	29,601	56	
22	OICETS	JAXA	610	97.83	

Lunar Tracking Priorities

Priority	Retroreflector Array	Sponsor	Altitude (km)
1	Apollo 15	NASA	356,400
2	Apollo 11	NASA	356,400
3	Apollo 14	NASA	356,400
4	Luna 21	Russian Federation	356,400
5	Luna 17	Russian Federation	356,400

GIOVE-A Tracking Summary (May-September 2006)

Site Name	Station	Start Date	End Date	Number Passes
Yaragadee	7090	26-May-2006	23-Sep-2006	45
San Juan	7406	11-May-2006	23-Sep-2006	36
Zimmerwald	7810	03-Jun-2006	01-Sep-2006	33
Wettzell	8834	08-Jun-2006	01-Sep-2006	26
Monument Peak	7110	27-May-2006	21-Sep-2006	25
Herstmonceux	7840	11-May-2006	08-Sep-2006	22
Graz	7839	26-Jun-2006	01-Sep-2006	17
Mount Stromlo	7825	07-Jun-2006	30-Aug-2006	17
McDonald	7080	27-May-2006	29-Aug-2006	15
Changchun	7237	05-Jun-2006	26-Sep-2006	13
Matera	7941	01-Jun-2006	28-Aug-2006	10
Greenbelt	7105	06-Jun-2006	18-Aug-2006	3
Hartebeesthoek	7501	26-Jun-2006	26-Jun-2006	1
Riga	1884	24-May-2006	24-May-2006	1
14 stations				264

Laser Retro Arrays (LRA) – information required by ILRS prior to satellite launch

Graham Appleby

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:

1. Array type (spherical, hexagonal, planar, etc.), to include a diagram or photograph;
2. Array manufacturer;
3. Link (URL or reference) to any ground-tests that were carried out on the array;
4. The LRA design and/or type of cubes was previously used on the following missions:

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 centre 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 centre must be specified in a satellite fixed reference frame with respect to the satellite's mass centre. In practice this means that the following parameters must be available at mm accuracy or better:

5. The 3-D location (possibly time-dependent) of the satellite's mass centre relative to a satellite-based origin;
6. The 3-D location of the phase centre of the LRA relative to a satellite-based origin.

However, in order to achieve (6) 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:

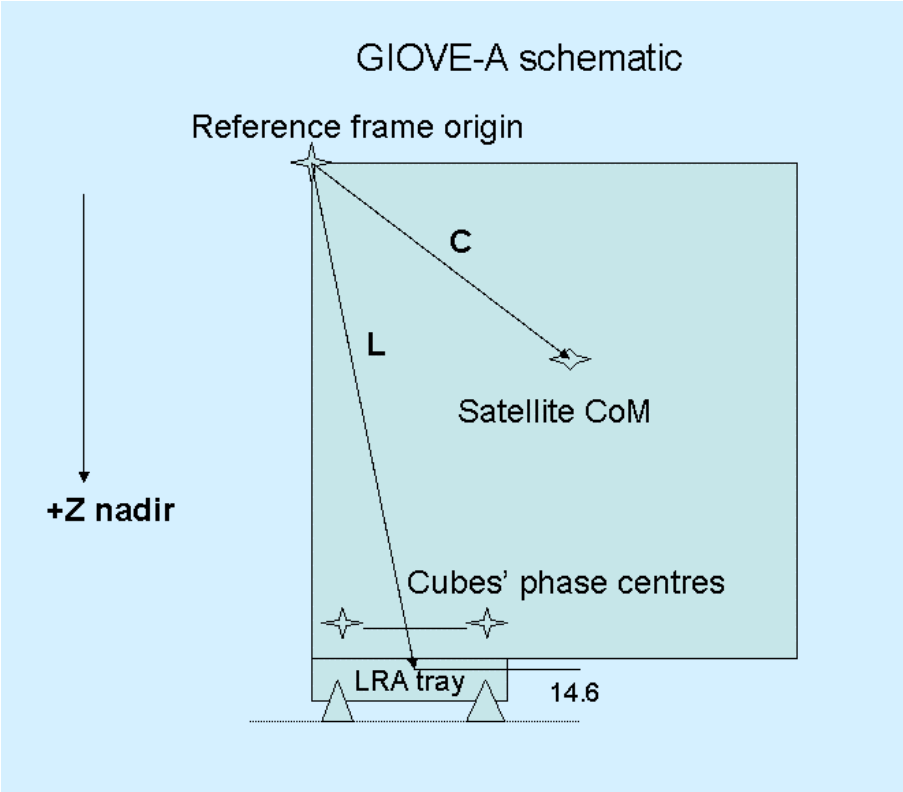
7. The position and orientation of the LRA reference point (LRA mass-centre or marker on LRA assembly) relative to a satellite-based origin;
8. The position (xyz) of either the vertex or the centre of the front face of each corner cube within the LRA assembly, with respect to the LRA reference point and including information of amount of recession of front faces of cubes;
9. The orientation of each cube within the LRA assembly (three angles for each cube);
10. The shape and size of each corner cube, especially the height;
11. The material from which the cubes are manufactured (e.g. quartz);
12. The refractive index of the cube material, as a function of wavelengths;
13. Dihedral angle offset(s) and manufacturing tolerance;
14. Radius of curvature of front surfaces of cubes, if applicable;
15. Flatness of cubes' surfaces (as a fraction of wavelength);
16. Whether or not the cubes are coated and with what material.

An example of the metric information (points 5-8 above) 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 (points 8-12), it is possible to compute the location of the array phase centre. Then given the **C** and **L** vectors (points 5 and 7) it is straightforward to calculate the vector from the satellite's centre of mass (CoM) in a spacecraft-fixed frame to the LRA phase centre. Further analysis to derive the array far-field diffraction patterns will be possible using the information given in points 8-16.

Laser Retro Arrays (LRA) – information required by ILRS prior to satellite launch

Graham Appleby

(continued)



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 website at http://ilrs.gsfc.nasa.gov/docs/rra_champ.pdf

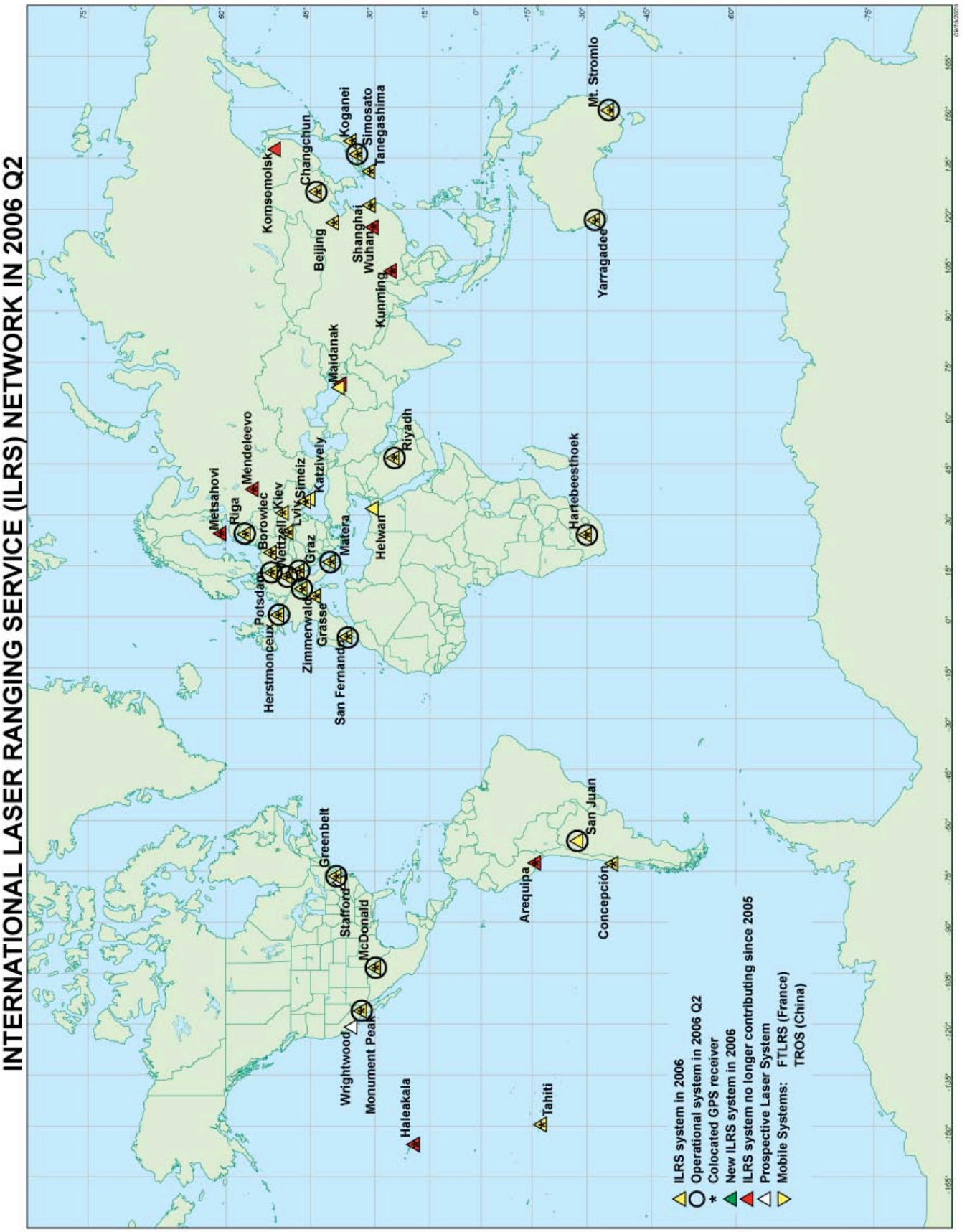
The final and possibly most complex piece of information is a description (for an active satellite) of the satellite's attitude regime as a function of time, which must be supplied in some form by the operating agency. This algorithm will relate the spacecraft reference frame to, for example, an inertial frame such as J2000.

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


INTERNATIONAL LASER RANGING SERVICE (ILRS) NETWORK IN 2006 Q2
Komsomolsk
Changchun
Koganei
Simosato
Tanegashima
Beijing
Shanghai
Wuhan
Kunming
Mt. Stromlo
Yarragadee
Maidanak
Riyadh
Metsahovi
Mendeleevo
Riga
Borowiec
Kiev
Lviv
Simeiz
Katzively
Matera
Graz
Helwan
Hartebeesthoek
Potsdam
Herstmonceux
Zimmerwald
Grasse
San Fernando
Greenbelt
Stafford
McDonald
Arequipa
San Juan
Concepción
Wrightwood
Monument Peak
Haleakala
Tahiti
ILRS system in 2006
Operational system in 2006 Q2
Colocated GPS receiver
New ILRS system in 2006
ILRS system no longer contributing since 2005
Prospective Laser System
Mobile Systems: FTLRS (France)
TROS (China)

ILRS Quarterly Report Card (Table 1a, 10/01/2005-09/30/2006)

Site Information		Data Volume									Data Quality		
Column 1	2	3	4	5	6	7	8	9	10	11	12	13	14
Location	Station Number	LEO pass Tot	LAGEOS pass Tot	High pass Tot	Total passes	LEO NP Total	LAGEOS NP Total	High NP Total	Total NP	Minutes of Data	Cal. RMS	Star RMS	LAG RMS
Baseline		1000	400	100	1500								
Yarragadee	7090	9415	1974	1348	12737	181752	25820	14385	221957	108124	4.7	8.1	9.0
Mount_Stromlo_2	7825	5051	1485	723	7259	73010	18838	6072	97920	59366	3.3	5.7	8.0
Zimmerwald_423 Zimmerwald_846	7810	5199 5140	1141 1151	838 809	7178 7100	81039 80469	15643 17520	6192 6148	102874 104137	54643 56098	8.3 21.1	10.9 21.3	12.9 23.0
Wettzell	8834	4916	959	474	6349	63906	7326	2632	73864	28179	3.1	9.9	15.3
Riyadh	7832	4313	1078	751	6142	55117	9207	4058	68382	35603	9.5	12.5	15.3
Graz	7839	4342	714	401	5457	81550	7887	2945	92382	30295	2.3	4.1	7.9
Monument_Peak	7110	4172	872	286	5330	80305	9220	2552	92077	30362	5.6	13.2	14.7
Herstmonceux	7840	3788	997	403	5188	59808	12997	1952	74757	31619	8.3	12.7	15.7
Changchun	7237	3184	542	230	3956	37044	4733	1128	42905	18898	10.9	12.2	13.9
San_Juan	7406	2580	799	509	3888	34799	9864	2439	47102	21350	12.5	11.0	13.3
Hartebeesthoek	7501	2699	705	216	3620	39939	7384	2015	49338	19706	5.4	8.2	9.6
Matera_MLRO	7941	2620	803	183	3606	36239	8816	1398	46453	22070	2.0	4.6	5.4
Greenbelt	7105	2060	334	153	2547	44717	3528	1035	49280	13804	5.0	9.2	9.4
Potsdam_3	7841	2056	310	4	2370	40545	3773	26	44344	9239	12.0	10.2	13.3
Simosato	7838	1758	487	7	2252	32207	6740	62	39009	15199	5.4	5.6	7.5
San_Fernando	7824	1670	370		2040	25199	2973		28172	7881	5.8	10.8	13.2
McDonald	7080	961	351	232	1544	11779	3491	1126	16396	10216	12.3	11.7	11.5
Riga	1884	1226	167	8	1401	25729	2229	44	28002	5589	7.1	12.8	13.2
Beijing	7249	1079	249	53	1381	13420	2413	362	16195	7521	14.1	139.8	20.2
Maidanak_1	1864	744	269	228	1241	7207	2141	817	10165	6638		47.5	50.2
Shanghai_2	7821	919	85	4	1008	11538	786	30	12354	2437	12.5	18.1	21.9
Borowiec	7811	744	140		884	11273	1406		12679	3571	23.5	30.6	28.5
Papeete	7124	604	137		741	9354	1130		10484	2712	4.3	13.7	13.6
Katzively	1893	494	63	12	569	8347	483	75	8905	1507	30.7	41.1	39.7
Simeiz	1873	423	113	3	539	4970	1008	18	5996	2481			57.5
Tanegashima	7358	349	46	42	437	4356	328	185	4869	2061	2.8	4.2	5.6
Ajaccio	7848	283	10		293	5022	20		5042	1657			
Concepcion_423 Concepcion_847	7405	232 957	44 533	26	276 1516	2079 12159	346 5771	170	2425 18100	939 10029	4.5 6.5	12.7 22.0	11.2 74.0
Koganei	7308	160	54	3	217	2116	555	20	2691	1174	16.0	20.8	24.8
Lviv	1831	89	44		133	1416	418		1834	1251	9.8		
GrnBlt_TLRS4	7130	92	32		124	1676	309		1985	552			
Wuhan_2	7231	61	14		75	618	77		695	374			
Kiev	1824	45	14		59	390	72		462	279			
Helwan	7831	52			52	430			430	123			

ILRS Quarterly Report Card (Table 1b Lunar, 10/01/2005-09/30/2006)

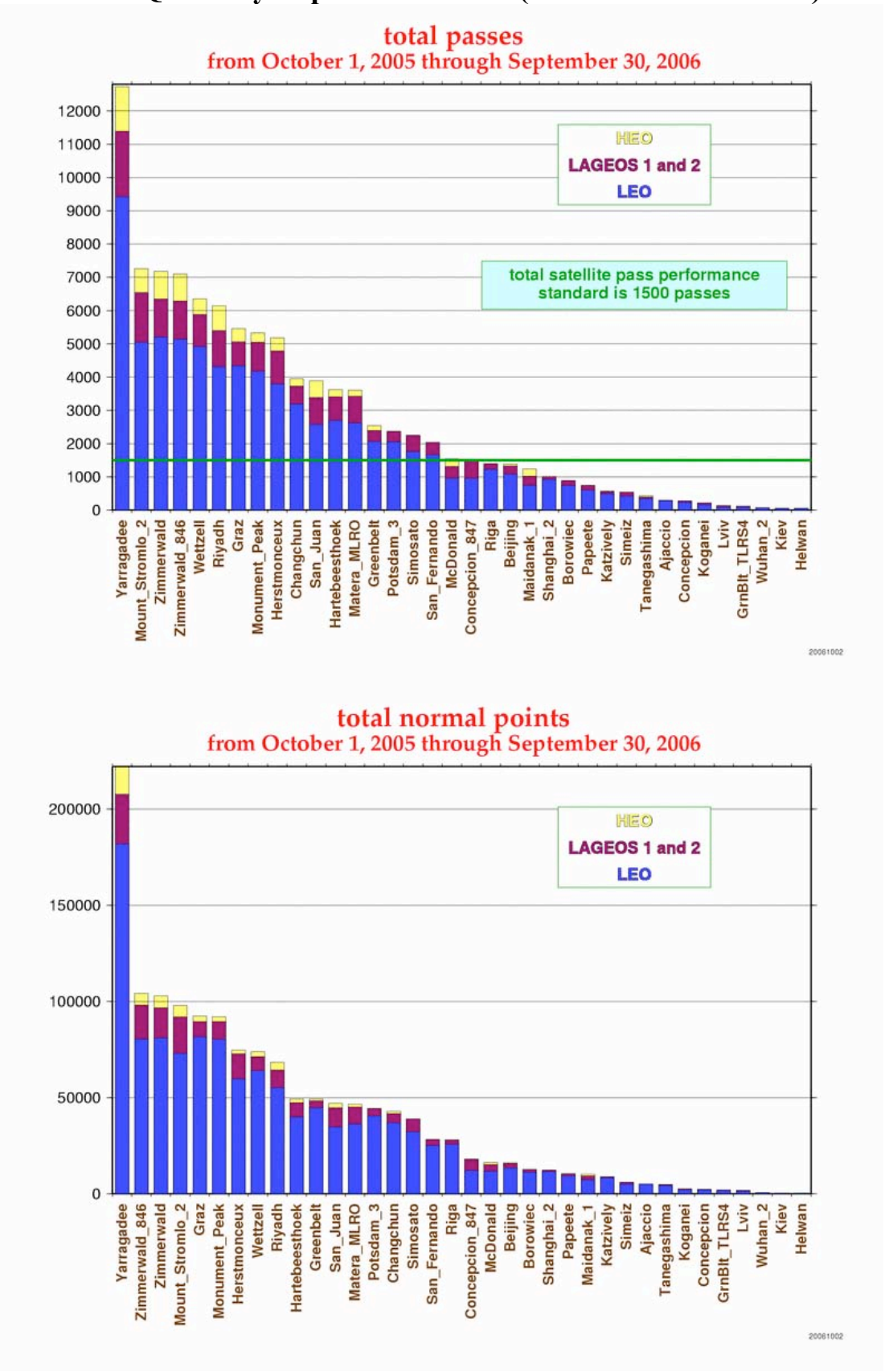
(continued)

Site Information		Data Information			
Column L1	L2	L3	L4	L5	L6
Location	Station Number	num nights tracking last 12 mon	num npt last 12 mon	num npts last 3 mon	ave npt rms last 3 mon
McDonald	7080	57	102	14	69.0

ILRS Quarterly Report Card (Table 2, 10/01/2005-09/30/2006)

Site Information		Delft Orbital Analysis				NICT Orbital Analysis				MCC Orbital Analysis				SHAO Orbital Analysis			
Station Location	Station Number	LAG NP RMS (mm)	short term (mm)	long term (mm)	% good LAG. NP	LAG NP RMS (mm)	short term (mm)	long term (mm)	% good LAG. NP	LAG NP RMS (mm)	short term (mm)	long term (mm)	% good LAG. NP	LAG NP RMS (mm)	short term (mm)	long term (mm)	% good LAG. NP
Baseline		10.0	20.0	20.0	95	10.0	20.0	20.0	95	10.0	20.0	20.0	95	10.0	20.0	20.0	95
Yarragadee	7090					1.7	7.7	1.6	100.0	2.2	14.0	5.0	99.6	1.8	14.8	2.1	95.3
Mount_Stromlo_2	7825					3.9	7.4	1.9	99.8	3.8	10.6	1.6	97.8	3.0	14.6	3.4	94.2
Zimmerwald_423 Zimmerwald_846	7810					1.9 2.7	5.5 6.2	9.0 4.3	100.0 99.9	2.9	9.0	10.7	98.4	1.8 2.9	10.0 11.4	6.0 3.3	95.4 95.5
Wettzell	8834					2.8	11.2	5.3	100.0	3.1	14.0	5.5	98.8	2.8	16.6	5.5	96.0
Riyadh	7832					2.9	15.2	5.1	99.6	3.2	16.4	7.2	98.0	2.7	22.9	6.3	95.3
Graz	7839					1.1	6.8	4.7	100.0	1.8	8.4	3.7	99.6	1.2	12.2	5.4	96.5
Monument_Peak	7110					2.4	9.4	2.0	100.0	2.8	16.0	3.8	99.1	2.1	17.3	3.1	95.5
Herstmonceux	7840					1.9	5.2	2.7	100.0	2.4	7.6	2.1	99.8	1.8	12.1	3.6	96.0
Changchun	7237					6.9	24.1	1.7	99.8	8.0	25.4	7.6	97.7	6.5	21.5	13.3	97.1
San_Juan	7406					2.7	15.5		99.9					3.6	19.9		94.8
Hartebeesthoek	7501					1.8	11.8	3.9	99.9	2.5	19.9	6.6	99.9	2.1	22.1	9.6	96.8
Matera_MLRO	7941					2.8	9.4	9.0	99.9	3.1	14.1	7.4	98.9				
Greenbelt	7105					2.1	7.8	2.6	100.0	2.8	11.5	4.6	99.3	1.9	14.7	3.3	93.5
Potsdam_3	7841					4.0	12.6	8.7	99.6	4.1	15.1	8.2	96.9				
Simosato	7838					2.3	14.4	10.2	99.8	4.6	20.6	10.9	99.0	4.3	19.4	12.7	95.5
San_Fernando	7824					2.6	11.9	11.6	100.0	3.2	13.8	12.4	99.9	4.1	22.6	12.1	94.7
McDonald	7080					2.0	9.2	6.6	100.0	3.1	15.2	9.0	99.5	1.7	17.7	6.8	95.3
Riga	1884					3.8	26.4	21.6	100.0	3.4	21.2	24.3	99.0	5.0	17.1	15.6	96.9
Beijing	7249					8.5	19.2	12.6	94.8	28.3	43.3	27.0	89.9				
Maidanak_1	1864					13.7	22.0	15.9	98.1	16.0	25.1	12.3	96.8	17.7	26.4	13.9	81.3
Shanghai_2	7821					10.4	31.6	18.4	99.2					7.2	27.4	10.5	94.6
Borowiec	7811					11.2	15.8	6.0	100.0	11.9	14.1	13.0	98.6	9.4	15.8	9.2	93.3
Papeete	7124					2.7	18.0	9.5	99.7	4.0	26.9	8.9	97.8	3.9	24.1	8.9	97.3
Katzively	1893					9.6	24.8	12.1	98.1	10.7	26.8	12.6	94.3	8.7	18.2		93.1
Concepcion_423 Concepcion_847	7405					1.3 2.4	7.0 12.2	7.9	100.0 99.8	3.3	39.7	6.5	99.3	2.7	19.9		97.7

ILRS Quarterly Report Card Plots (10/01/2005-09/30/2006)



Satellite GIOVE-A

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Satellite GIOVE-A

ILRS Home → Satellite Missions → List of Satellites → GIOVE-A

Satellite list can be sorted by: Name OR COSPAR ID

Current Missions

- ALOS (ALOS)
- Ajisai (AJIS)
- Apollo11 Sea of Tranquility (AP11)
- Apollo14 Fra Mauro (AP14)
- Apollo15 Hadley Rille (AP15)
- Beacon-C (BEAC)
- CHAMP (CHAM)
- ERS-2 (ERS2)
- Envisat-1 (ENV1)
- Etalon-1 (ETA1)
- Etalon-2 (ETA2)
- GFO-1 (GFO1)
- GIOVE-A (GIOA)
- GLONASS-87 (GL87)
- GLONASS-89 (GL89)
- GLONASS-95 (GL95)
- GPS-35 (GP35)
- GPS-36 (GP36)
- GRACE-A (GRAA)
- GRACE-B (GRAB)
- ICESat (ICES)
- Jason-1 (JAS1)
- LAGEOS-1 (LAG1)
- LAGEOS-2 (LAG2)
- Larets (LARE)
- Luna17 Sea of Rains (LU17)
- Luna21 Sea of Serenity (LU21)
- Meteor-3M (ME3M)
- OICETS (OICE)
- Starlette (STAR)
- Stella (STEL)

Past Missions

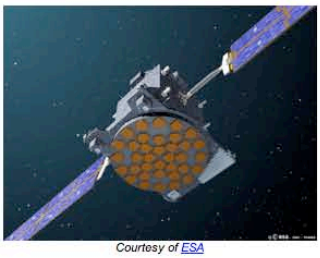
- ADEOS-1 (ADE1)
- ADEOS-2 (ADE2)
- CryoSat (CRYO)
- DIADEME-1C (DIAC)
- DIADEME-1D (DIAD)
- ERS-1 (ERS1)
- GEOS-3 (GEO3)
- GFZ-1 (GFZ1)

General | RetroReflector Info | ILRS Mission Support | Center of Mass Info

GIOVE-A

Jump to: Mission Objectives, Mission Instrumentation, Mission Parameters, Additional Information

Mission Photos:



Courtesy of ESA

Mission Objectives:

Galileo is a satellite radio navigation system initiative launched by the European Union and the European Space Agency. Galileo consists of a constellation of 30 satellites and ground stations providing position information to users in many sectors (transportation, social services, justice system, custom services, public works, search and rescue, etc.).

Two experimental spacecraft will be launched in 2005 and 2006 as part of the Galileo System Test Bed V2: GIOVE-A (Galileo In-Orbit Validation Element, formerly GSTB-V2/A) and GIOVE-B (formerly GSTB-V2/B). The objectives of this mission are:

- to secure the Galileo frequency allocations by providing a signal in space
- on-board clock characterization
- MEO radiation environment characterization
- additional experimentation

The GIOVE-A and -B satellites are equipped with LLR arrays to provide precise orbit determination. Both routine SLR tracking and occasional campaigns with more intense tracking will be required. By June 2006, a sufficient number of receivers were deployed to allow ESA to begin microwave orbit determination. Therefore, an initial SLR tracking campaign began in June 2006 and lasted for eight weeks; further campaigns are planned for later in 2006. Predictions are based on these microwave-determined orbits; prediction accuracy is on the order of 30 meters. GIOVE-A tracking is comparable to GLONASS and GPS tracking (perhaps up to 40 percent more return energy than GPS).

Mission Instrumentation:

GIOVE-A has the following instrumentation onboard:

1. Phased array antenna of individual L-band elements
2. Signal generation units to create two representative Galileo signals
3. Two redundant rubidium atomic clock
4. Retroreflector array

Mission Parameters:

Galileo Parameters			
	GIOVE-A (GSTB-V2/A)	**GIOVE-B (GSTB-V2/B)**	**Galileo**
Sponsor:	EU/ESA	EU/ESA	EU/ESA
Expected Life:	2 years	2 years	years
Primary Applications:	Positioning	Positioning	Positioning
COSPAR ID:	0505101	TBD	TBD
SIC Code:	7001	TBD	TBD
NORAD SSC Code:	28922	TBD	TBD
Launch Date:	26-Dec-2005	April 2006	late 2007
RRA Size:	308mm x 408mm x 48 mm	305mm x 305mm x 42 mm	435mm x 540mm x 53mm
RRA Shape:	trapezoidal	trapezoidal	trapezoidal
Reflectors:	76 corner cubes	67 corner cubes	78 corner cubes
Size of Reflector:	27 mm	27 mm	27 mm
Orbit:	near-circular	near-circular	near-circular
Inclination:	56 degrees	56 degrees	56 degrees
Altitude:	23,916 km	23,916 km	23,916 km
Eccentricity:	0.002	0.002	0.002

Additional Information:

- Web sites:
  - ESA Galileo Home Page
  - ESA GIOVE-A Home Page
  - European Union Galileo Home Page
  - Galileo Joint Undertaking Home Page
- Publications:
  - Appleby, G. and Gibbs, P. "First Laser Range Measurements to GIOVE-A", Inside GNSS, May/June 2006.

Responsible Government Official: Carey Noll
NASA's Privacy, Security, Notices

Send us your comments

Author: Mark Torrence
Maintained by: Carey Noll

Satellite GIOVE-A

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Satellite GIOVE-A

ILRS Home ➔ Satellite Missions ➔ List of Satellites ➔ GIOVE-A

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- Etalon-2 (ETA2)
- GFO-1 (GFO1)
- GIOVE-A (GIOA)
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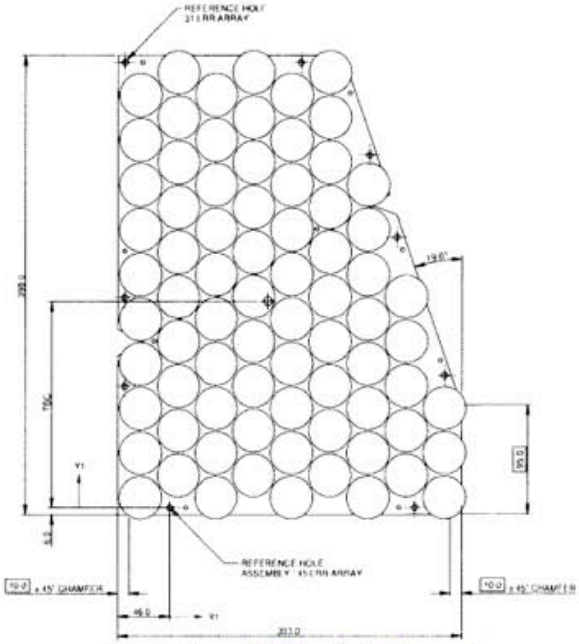
- GLONASS-89 (GL89)
- GLONASS-95 (GL95)
- GPS-35 (GP35)
- GPS-36 (GP36)
- GRACE-A (GRAA)
- GRACE-B (GRAB)

General | RetroReflector Info | ILRS Mission Support | Center of Mass Info

GIOVE-A

RetroReflector Array (RRA) Characteristics:



Extracted from of ESA Specification Document

Specifications for the GIOVE-A retroreflector array have been extracted from industrial documentation. (RD-11):

- Size: 305mm x 305mm x 42 mm
- Number of prisms: 76
- Prism diameter: 27 mm (light area)
- Material: optical grade fused silica, aluminium-coated
- Temperature range: from -125°? to +125°?
- Field of view: 12 degrees (half-cone)

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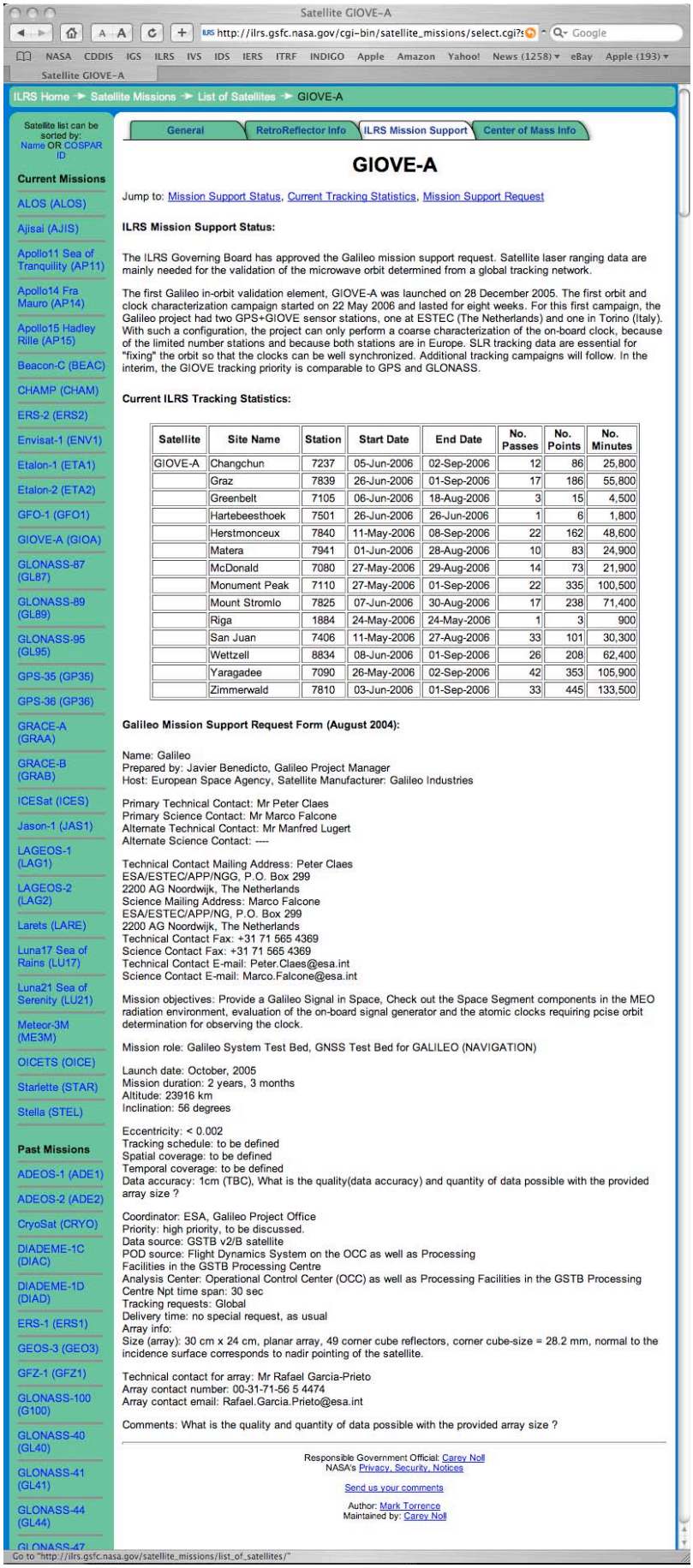
Author: Mark Torrence
Maintained by: Carey Noll



Satellite GIOVE-A

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- GLONASS-89 (GL89)
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- DIADEME-1D (DIAD)
- ERS-1 (ERS1)
- GEOS-3 (GEO3)
- GFZ-1 (GFZ1)
- GLONASS-100 (G100)
- GLONASS-40 (GL40)
- GLONASS-41 (GL41)
- GLONASS-44 (GL44)
- GLONASS-47

General | RetroReflector Info | ILRS Mission Support | Center of Mass Info

GIOVE-A

Jump to: Mission Support Status, Current Tracking Statistics, Mission Support Request

ILRS Mission Support Status:

The ILRS Governing Board has approved the Galileo mission support request. Satellite laser ranging data are mainly needed for the validation of the microwave orbit determined from a global tracking network.

The first Galileo in-orbit validation element, GIOVE-A was launched on 28 December 2005. The first orbit and clock characterization campaign started on 22 May 2006 and lasted for eight weeks. For this first campaign, the Galileo project had two GPS+GIOVE sensor stations, one at ESTEC (The Netherlands) and one in Torino (Italy). With such a configuration, the project can only perform a coarse characterization of the on-board clock, because of the limited number stations and because both stations are in Europe. SLR tracking data are essential for "fixing" the orbit so that the clocks can be well synchronized. Additional tracking campaigns will follow. In the interim, the GIOVE tracking priority is comparable to GPS and GLONASS.

Current ILRS Tracking Statistics:

Satellite	Site Name	Station	Start Date	End Date	No. Passes	No. Points	No. Minutes
GIOVE-A	Changchun	7237	05-Jun-2006	02-Sep-2006	12	86	25,800
	Graz	7839	26-Jun-2006	01-Sep-2006	17	186	55,800
	Greenbelt	7105	06-Jun-2006	18-Aug-2006	3	15	4,500
	Hartebeesthoek	7501	26-Jun-2006	26-Jun-2006	1	6	1,800
	Herstmonceux	7840	11-May-2006	08-Sep-2006	22	162	48,600
	Matera	7941	01-Jun-2006	28-Aug-2006	10	83	24,900
	McDonald	7080	27-May-2006	29-Aug-2006	14	73	21,900
	Monument Peak	7110	27-May-2006	01-Sep-2006	22	335	100,500
	Mount Stromlo	7825	07-Jun-2006	30-Aug-2006	17	238	71,400
	Riga	1884	24-May-2006	24-May-2006	1	3	900
	San Juan	7406	11-May-2006	27-Aug-2006	33	101	30,300
	Wettzell	8834	08-Jun-2006	01-Sep-2006	26	208	62,400
	Yaragadee	7090	26-May-2006	02-Sep-2006	42	353	105,900
	Zimmerwald	7810	03-Jun-2006	01-Sep-2006	33	445	133,500

Galileo Mission Support Request Form (August 2004):

Name: Galileo
Prepared by: Javier Benedicto, Galileo Project Manager
Host: European Space Agency, Satellite Manufacturer: Galileo Industries

Primary Technical Contact: Mr Peter Claes
Primary Science Contact: Mr Marco Falcone
Alternate Technical Contact: Mr Manfred Lugert
Alternate Science Contact: ----

Technical Contact Mailing Address: Peter Claes
ESA/ESTEC/APP/NGG, P.O. Box 299
2200 AG Noordwijk, The Netherlands
Science Mailing Address: Marco Falcone
ESA/ESTEC/APP/NG, P.O. Box 299
2200 AG Noordwijk, The Netherlands
Technical Contact Fax: +31 71 565 4369
Science Contact Fax: +31 71 565 4369
Technical Contact E-mail: Peter.Claes@esa.int
Science Contact E-mail: Marco.Falcone@esa.int

Mission objectives: Provide a Galileo Signal in Space, Check out the Space Segment components in the MEO radiation environment, evaluation of the on-board signal generator and the atomic clocks requiring pcise orbit determination for observing the clock.

Mission role: Galileo System Test Bed, GNSS Test Bed for GALILEO (NAVIGATION)

Launch date: October, 2005
Mission duration: 2 years, 3 months
Altitude: 23916 km
Inclination: 56 degrees

Eccentricity: < 0.002
Tracking schedule: to be defined
Spatial coverage: to be defined
Temporal coverage: to be defined
Data accuracy: 1cm (TBC), What is the quality(data accuracy) and quantity of data possible with the provided array size ?

Coordinator: ESA, Galileo Project Office
Priority: high priority, to be discussed.
Data source: GSTB v2/B satellite
POD source: Flight Dynamics System on the OCC as well as Processing
Facilities in the GSTB Processing Centre
Analysis Center: Operational Control Center (OCC) as well as Processing Facilities in the GSTB Processing Centre Npt time span: 30 sec
Tracking requests: Global
Delivery time: no special request, as usual
Array info:
Size (array): 30 cm x 24 cm, planar array, 49 corner cube reflectors, corner cube-size = 28.2 mm, normal to the incidence surface corresponds to nadir pointing of the satellite.

Technical contact for array: Mr Rafael Garcia-Prieto
Array contact number: 00-31-71-56 5 4474
Array contact email: Rafael.Garcia.Prieto@esa.int

Comments: What is the quality and quantity of data possible with the provided array size ?

Responsible Government Official: Carey Noll
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Send us your comments

Author: Mark Torrence
Maintained by: Carey Noll

Go to "http://ilrs.gsfc.nasa.gov/satellite_missions/list_of_satellites/"

Satellite GIOVE-A

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Satellite GIOVE-A

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Satellite list can be sorted by: Name OR COSPAR ID

Current Missions

- ALOS (ALOS)
- Ajisai (AJIS)
- Apollo11 Sea of Tranquility (AP11)
- Apollo14 Fra Mauro (AP14)
- Apollo15 Hadley Rille (AP15)
- Beacon-C (BEAC)
- CHAMP (CHAM)
- ERS-2 (ERS2)
- Envisat-1 (ENV1)
- Etalon-1 (ETA1)
- Etalon-2 (ETA2)
- GFO-1 (GFO1)
- GIOVE-A (GIOA)
- GLONASS-87 (GL87)
- GLONASS-89 (GL89)
- GLONASS-95 (GL95)
- GPS-35 (GP35)
- GPS-36 (GP36)
- GRACE-A (GRAA)
- GRACE-B (GRAB)
- ICESat (ICES)
- Jason-1 (JAS1)
- LAGEOS-1 (LAG1)
- LAGEOS-2 (LAG2)
- Larets (LARE)
- Luna17 Sea of Rains (LU17)
- Luna21 Sea of Serenity (LU21)

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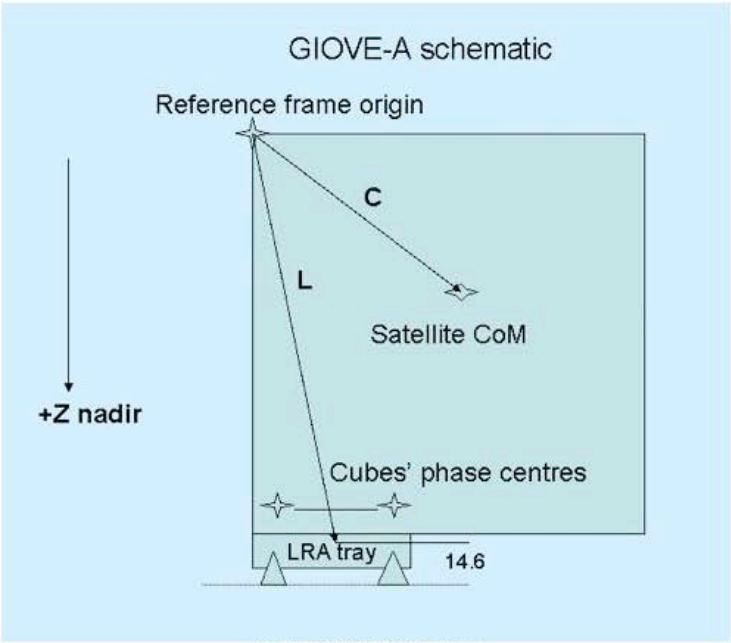
GIOVE-A

Center of Mass Information:

The ESA publication "Specification of Galileo and GIOVE Space Segment Properties Relevant for Satellite Laser Ranging" provides retroreflector and spacecreft information. Center of mass information can be found below (provided by NERC/G. Appleby):

Position of the GIOVE-A laser retro phase center



Courtesy of NERC/G. Appleby

Vector **C** is from the spacecraft reference point to the satellite's centre of mass CoM.
Vector **L** is from the spacecraft reference point to the mass centre of the tray containing the 76 corner cubes.
From the ESA document '*Specification of GALILEO and GSTB-V2 Space Segment Properties Relevant for Satellite Laser Ranging*, ESTEC, Nov 2005':
C = (-4, +1, +788) mm,
L = (-832, -654, +1489) mm

The plane of the front faces of the cubes is +14.6mm in the Z direction from the LRA mass centre (V. Vasiliev, IPIE, Russia);
The cubes' phase centres are -h*n in the Z direction from the plane of the front faces of the cubes;
For the GIOVE-A cubes, h=19.1mm, n=1.46. So phase centres are -27.9mm in Z.
So z-component of array phase centre is (-27.9 +14.6) = -13.3mm from LRA mass centre.
So defining vector **L'** as the vector from the spacecraft reference point to the phase centre of the retro array, we have
L' = (-832, -654, (+1489– 13)), i.e. **L'** = (-832, -654, +1476)

Finally, the vector **CP** from the spacecraft centre of mass to the phase centre of the retro array is **CP** = **L'** – **C**
So **CP** = (-832, -654, +1476) - (-4, +1, +788) = (-828, -655, +688) in satellite fixed frame.

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