



**International Laser Ranging Service**  
**Eleventh General Assembly**  
**Eastbourne, UK**  
**October 7, 2005,**  
**09:00 - 12:30**  
**Agenda**

<b>Introductory Remarks</b>	W. Gurtner	5 min
<b>Report from ILRS Governing Board Meeting</b>	W. Gurtner	5 min
<b>ILRS Status Report</b>	M. Pearlman	10 min
<b>Working Group Reports</b>		5 min each
<ul style="list-style-type: none"> <li>• Missions</li> <li>• Networks &amp; Engineering</li> <li>• Data Formats &amp; Procedures               <ul style="list-style-type: none"> <li>• Refraction Study Group</li> <li>• Prediction Format</li> </ul> </li> <li>• Analysis</li> <li>• Signal Processing A/H</li> <li>• Transponder A/H</li> </ul>	H. Kunimori/P. Shelus G. Kirchner/U. Schreiber W. Seemueller/J. McGarry S. Riepl R. Ricklefs R. Noomen/G. Appleby G. Appleby/T. Otsubo U. Schreiber/J. Degnan	
<b>Network Reports</b>		3-5 min each
<ul style="list-style-type: none"> <li>• Restricted tracking</li> <li>• NASA Network</li> <li>• Grasse Update</li> <li>• Shanghai Update</li> <li>• LLR Update</li> </ul>	W. Gurtner/H. Kunimori D. Carter F. Pierron Y. Fumin P. Shelus	
<b>Mission Reports</b>		3-5 min each
<ul style="list-style-type: none"> <li>• ERS-2, GRACE, CHAMP</li> <li>• ALOS</li> <li>• Envisat, Jason, T2L2</li> <li>• GFO, TOPEX, GP-B, GPS Retros</li> <li>• ICESat</li> <li>• GLONASS</li> <li>• Luneberg Satellite</li> </ul>	L Grunwald H. Kunimori F. Pierron M. Pearlman P. Shelus V. Glotov V. Vasiliev	
<b>GGOS Update</b>	M. Pearlman	10 min
<b>Fifteenth Int'l Workshop on Laser Ranging</b>	J. Luck	5 min
<b>Discussions, Next Meeting</b>	M. Pearlman	5 min
<b>Closing Comments and Resolutions</b>	M. Pearlman	10 min

**Rules:**

1. Time limits are firm. Presentations must be concise. Use only a few summary charts. Tell us what's new. Don't rehash old things. Additional charts may be included with the meeting report.
2. Copies of your charts must be given to Mike Pearlman at the time of the meeting. Softcopy version should be e-mailed to [Carey.Noll@nasa.gov](mailto:Carey.Noll@nasa.gov) by October 21, 2005.



# ILRS Status Report

11<sup>th</sup> ILRS General Assembly  
October 07, 2005  
Eastbourne, UK

# ILRS ACTIVITIES

SLR Workshop  
Eastbourne, UK  
October 3 - 7, 2005

# 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:

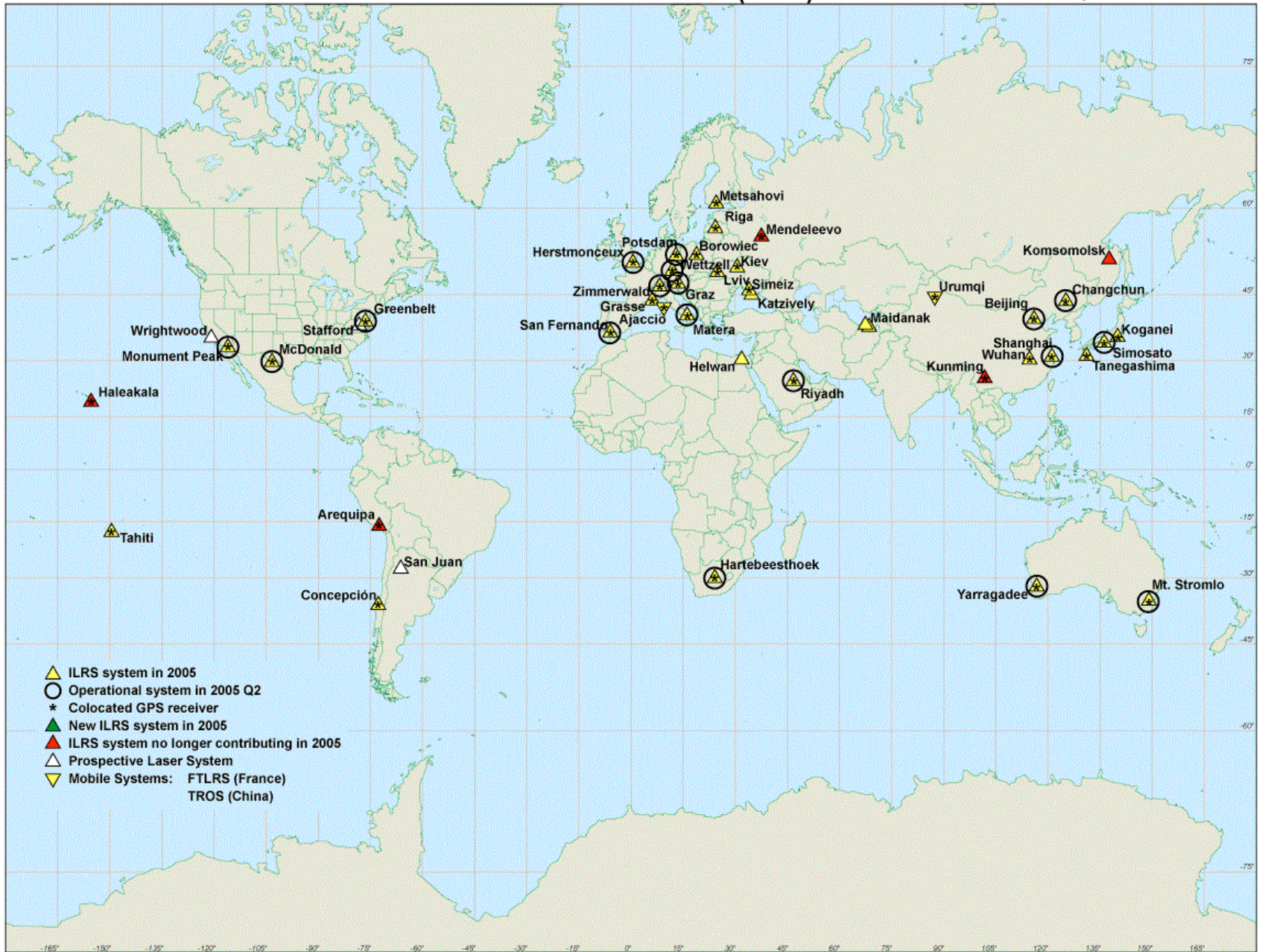
- **EUROLAS Network Representatives:** **Giuseppe Bianco, Werner Gurtner (Chair)**
- **NASA Network Representatives:** **David Carter, *Randy Ricklefs***
- **WPLTN Representatives:** **Ben Greene, Hiroo Kunimori**
- **IERS Representative:** **Bob Schutz**

## Members Elected by their International Peers:

- **Analysis Representatives:** **Graham Appleby, Ron Noomen**
- **Data Center Representative:** **Wolfgang Seemueller**
- **LLR Representative:** **Peter Shelus**
- **At-Large Representatives:** **Georg Kirchner, Ulrich Schreiber**



# INTERNATIONAL LASER RANGING SERVICE (ILRS) NETWORK IN 2005 Q2



- ▲ ILRS system in 2005
- Operational system in 2005 Q2
- \* Colocated GPS receiver
- ▲ New ILRS system in 2005
- ▲ ILRS system no longer contributing in 2005
- △ Prospective Laser System
- ▼ Mobile Systems: FTLRS (France)  
TROS (China)

# ILRS Activities

## Outreach and Recognition:

- **Recommended citation posted for data and product users to use reports, presentations, papers, etc. (similar to the other services);**
- **Working with the missions to add ILRS recognition to their websites (already on Cryosat, GFO, Grace, Champ, etc.)**

## Organization

- **GB approved the establishment of the Transponder Ad hoc; website and exploder has been implemented;**
- **Draft ILRS – RSA agreement on cooperation on new Luneberg satellite(s) approved (Vasiliev).**

# ILRS Activities

- **Data reporting in passes and minutes of data;**
  - **Report Card has been updated and is current;**
  - **Some work still to be done at CDDIS here (two weekly reports currently issued; on-line forms);**
- **Update of data archives with older data (BE-B, -C, GEOS-1, -2, -3, PEOPLE, DIADEM-1C, -1D) underway;**
- **Update of eccentricity files with new data from ITRF underway;**
- **Dynamic Priorities developed by NSGF and implemented on the AIUB website;**
- **Procedure for approving ALOS qualified stations outlined, but implementation is unclear (Kunimori).**



# ILRS Reports

- **Draft of ILRS 2003/2004 report complete; editing underway;**
- **14th International Workshop Report in printing, to be issued in both hardcopy and electronic media;**
- **First two 2005 ILRS station report cards issued by RITSS;**
- **New plots of station performance available through ILRS website.**
- **Seminar at Geoscience Australia given by Pearlman, Altamimi, Pavlis, Lemoine, Ries gave seminar at GA 08/29/2005 stressing the importance of the station to the reference frame**  
See ( <ftp://cddis.gsfc.nasa.gov/pub/misc/ga0508>)

# Site Surveys

- **Analysis of survey data from Hartebeesthoek, Shanghai, Hawaii, Arequipa, and GSFC in process;**
- **Closeout survey of Haleakala performed by HTSI in late 2004; analysis underway;**
- **Riyadh and Changchun contacted several time on completing their local surveys; both say action is planned;**
- **IERS has established a Collocation/Survey Working Group to coordinate ground survey procedures for the IAG Space Geodesy activities (ILRS, IVS, IGS, and IDS).**



# ILRS Governing Board Report

11<sup>th</sup> ILRS General Assembly  
October 07, 2005  
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# ILRS Working Group Reports

11<sup>th</sup> ILRS General Assembly  
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*Network and Engineering WG*

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# **Network and Engineering Working Group**

## **NEWG**

Eastbourne,  
October 2005





## *NEWG: Metsahovi*

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- Metsahovi Station: Graz 10 Hz Quantel Laser
  - Transferred in Spring 2005 from Graz to Metsahovi;
  - Laser will be setup / operational soon (hopefully 😊 )
  - Trying to get some experience;
  - Next years: Ideas / plans for upgrade to kHz

Eastbourne,  
October 2005



## *NEWG: XML Files*

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- Operational now for routine Calibrations in:
  - Graz: Since 2003;
  - Wettzell: Since 2005;
  - Riga, Potsdam ?
  - Motivation ?

Eastbourne,  
October 2005





## *NEWG: Varias*

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- NP-Checks: Still any Problems in NPs ?
  - Trying to convince stations;
  - Checking software / demos available;
- Daylight Ranging: Make it essential requirement ...
  - Progress since San Fernando ?
  - Although pushed, stations do NOT even try ...
  - Even with personal exchange, technical assistance ...
  - Any idea ? Make it MANDATORY ???
  - Without stronger push: Not much will happen ...

Eastbourne,

October 2005



## *Personal visits / exchange*

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- Always a good idea; SLR Graz is open for that;
- During last 2 year2, we had visitors from:
  - Changchun (daylight SLR)
  - Herstmonceux (kHz)
  - Borowiec (Daylight, kHz, Image Processing)
  - Prag (several experiments)
  - Riga (XML Files)
  - Metsahovi (10 Hz Laser)
  - Potsdam (Riga ET)
  - H. Kunimori, P. Sperber, U. Schreiber etc. etc.

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October 2005

# **ILRS/AWG Benchmark Project**

- **evaluate performance of newcomers**
  - **format**
  - **blunders**
  - **parameters**
  - **corrections**
  - **quality**
- **open test + blind test**
- **BKG passed blind test in mid-2005**
- **GA and GRGS: benchmark in progress; CSR?**

# **ILRS/AWG “pos+eop”**

- **weekly station coordinates + EOPs**
- **operational since November 2003**
- **official since June 2004**
- **6 individual solutions**  
**(ASI, BKG, DGFI, GFZ, JCET, NSGF)**
- **2 combination solutions (ASI, DGFI)**
- **progress**

# **ILRS contribution to ITRF2004**

- **SLR unique for origin**
- **SLR important for scale**
- **SLR important for vertical**
- **time-series 1976-2005**
- **operational product January 2004 - now**
- **“backwards” analysis January 1993 - December 2003**
- **fine-tuning, re-analysis 1993-2005**
- **deadline November 7**

# International Laser Ranging Service

## Data Formats & Procedures Working Group Report

### ● Meetings

At this ILRS Workshop no official meeting was held, only an extra-ordinary meeting of the Data Formats and Procedures Working Group and the Refraction Study Group took place at October 5, after the last session. The result was:

#### ● Two personnel changes in the DF&P WG

- 1) Co-chair of DF&P WG: Randy Ricklefs (former Jan McGarry)
- 2) Chair of Refraction Study Group: Ericos Pavlis (former Stefan Riepl)

Thanks to Jan McGarry and Stefan Riepl for their excellent Work in the DF&P WG!

### ● Reports on activities of DF&P WG

- The former RSG chair Stefan Riepl gave a presentation at the Analysis Session on Monday, October 3
- Randy Ricklefs chaired a special session on New Prediction Techniques at October 6, and gave a short report at the General Assembly about the status of the new Prediction Format (see his charts of his report)



# CPF Status

- Predictions available from 4 centers
- Ranging with CPF occurring at 2 stations, with several more being converted
- CPF improves acquisition of satellites, particular LEOs
- Will be needed for all the transponders being planned

# CPF “To Do”

- Minor format changes
- Create targeted documentation; place on CDDIS
- Make sample code available on CDDIS
- Make predictions from all centers available on EDC and CDDIS
- Continue development work with transponders
- Transition all stations to CPF by 30 June 2006



# Network Reports

11<sup>th</sup> ILRS General Assembly  
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# NASA SLR Network Status

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- **NASA SLR Network Status:**
  - All NASA SLR stations are currently operational.
  - The contract for SLR operations in Peru for the Transportable Laser Ranging System (TLRS-3) will be signed in early November. Operations should begin in March 2006.
  - The contract for SLR operations in Hawaii using the TLRS-4 system will be signed in December. Operations should begin in March 2006.
  - Completed an Operational Readiness Review of the TLRS-4 in September. The system operated extremely well and the data has been released to the CDDIS. TLRS-4 will be shipped to Hawaii later this year.

# Grasse slr systems status - September 2005

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- Slr fixed station (7835) definitively stopped
  - » 30 years of fruitful operations
  - » Telescope and mount moved in the trailer waiting eventual collaboration abroad









GRGS

DAF

CF

KAS 50W 09

PORTS  
LETTI  
D DRAP  
9123 60  
39130 47  
401 071

K127412800





GRG

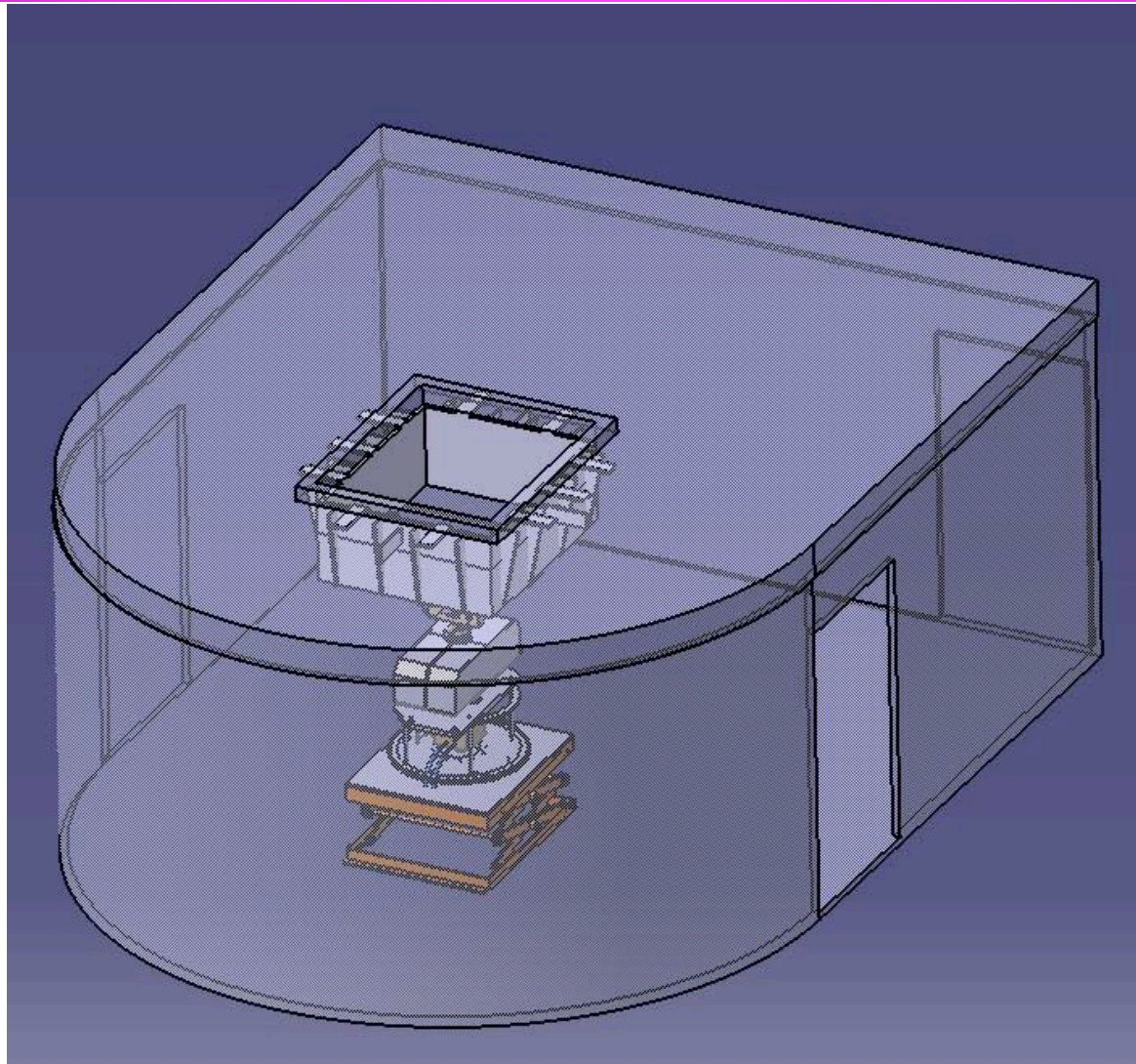


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- New laboratory build in this place for FTLRS
  - » Two position capability with elevator system and opening roof
    - » Technology developments
    - » Operation on satellites to Lageos.

# Ftlrs Laboratory – Summer 2006 –



# Grasse slr systems status - September 2005

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    - » Operation on satellites to Lageos.
- Old LLR Station renamed to MEO and completely relooked
  - » Earth satellite capability 800 to 36000 km
  - » Moon reflectors
  - » R&D studies and new experiments (Time transfer, transponder...)

# MeO Station

## A new generation of Laser Ranging station

- From 400 km to the Moon
- One Way Interplanetary mission
- Highly Automatic



### ● Instrumental Developments

- » Focus Laboratory
- » Motorisation of the telescope
- » Control Software
- » Automatisation

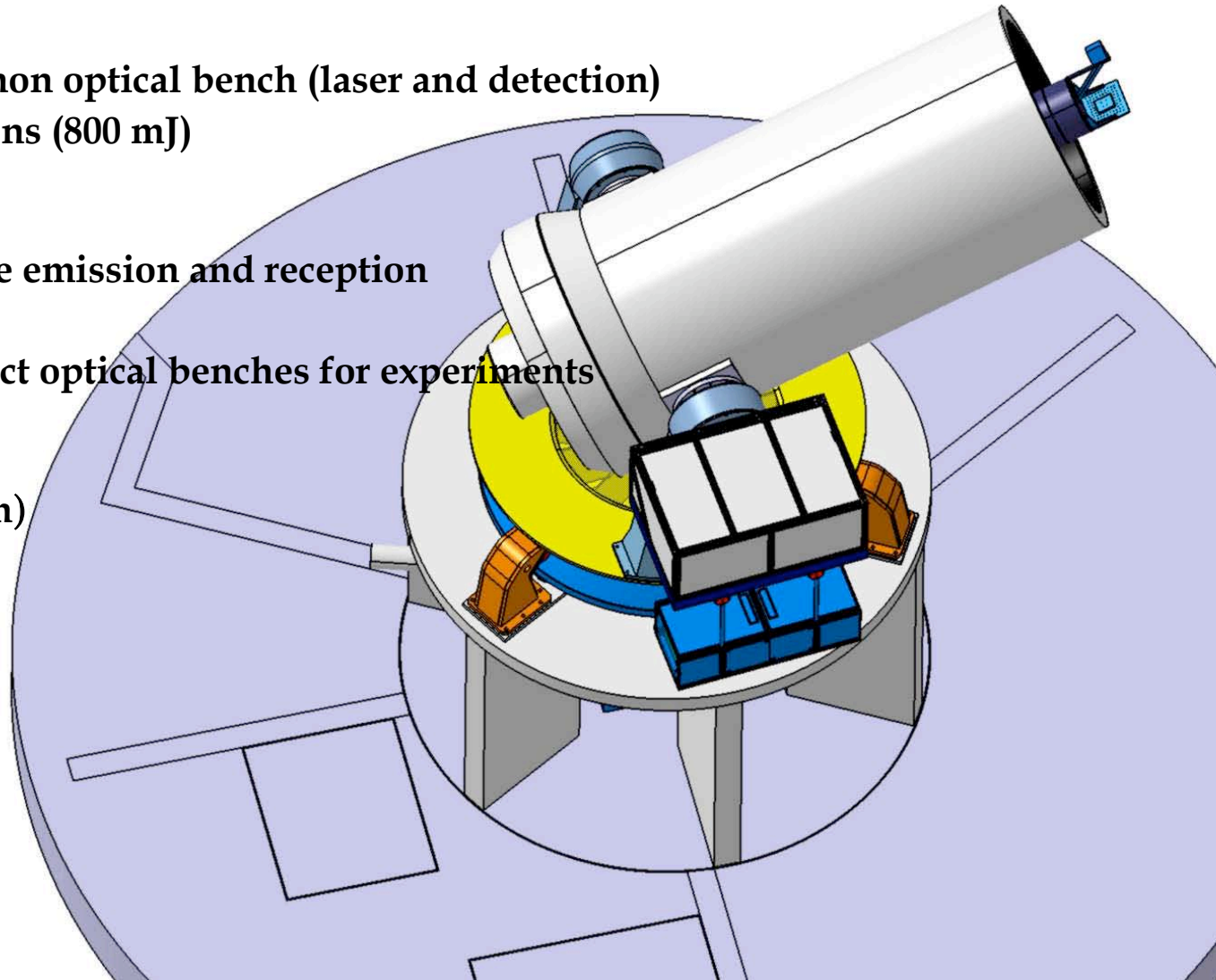
### ● Research & Development

- » New optical link
- » Detection, Event timer
- » 2 colors
- » atmosphere

# MeO Status

Stop: August 2005 – Restart: june 2006

- Laser (2005)
  - » Integrated on the new common optical bench (laser and detection)
  - » 3 cavities : 20 ps – 200 ps – 1 ns (800 mJ)
- Optics (2007)
  - » Common optical path for the emission and reception
  - » Laser commutation
  - » Flux distribution on 5 distinct optical benches for experiments
- Motorisation (end 2006)
  - » 2 torque motors ( $\Phi = 800$  mm)
  - » Direct coder
- Dome (june 2006)
  - » Electric motorisation
  - » New guidind device
- Building (june 2006)
- Software (2007)

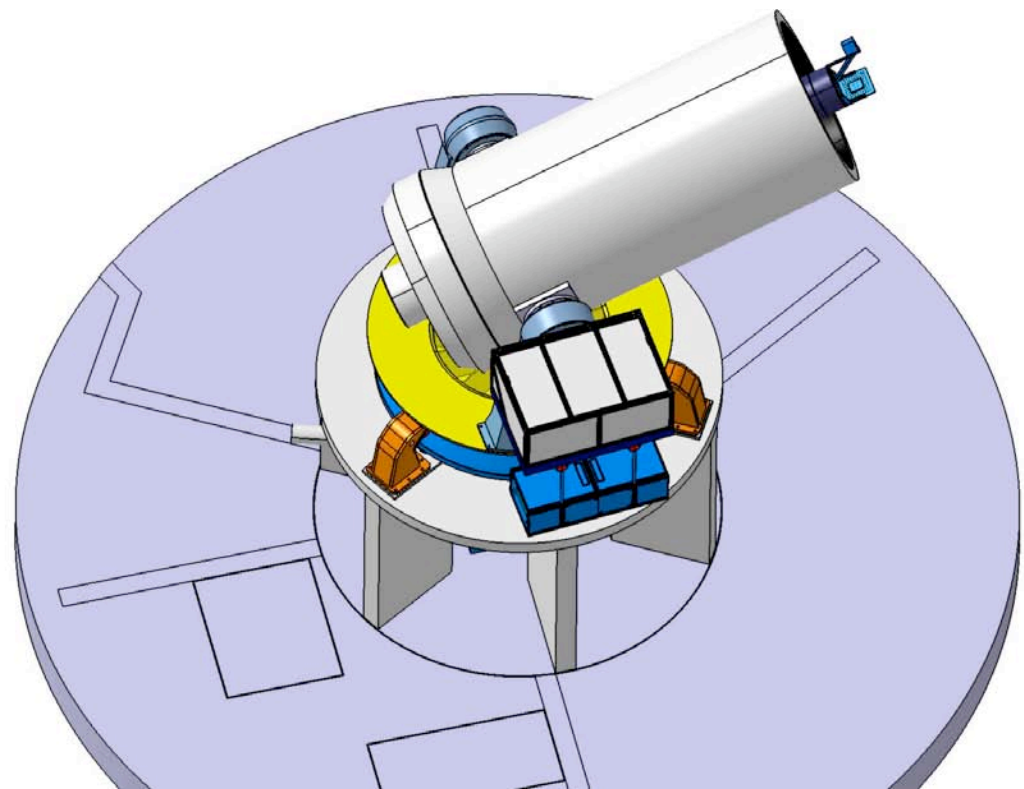
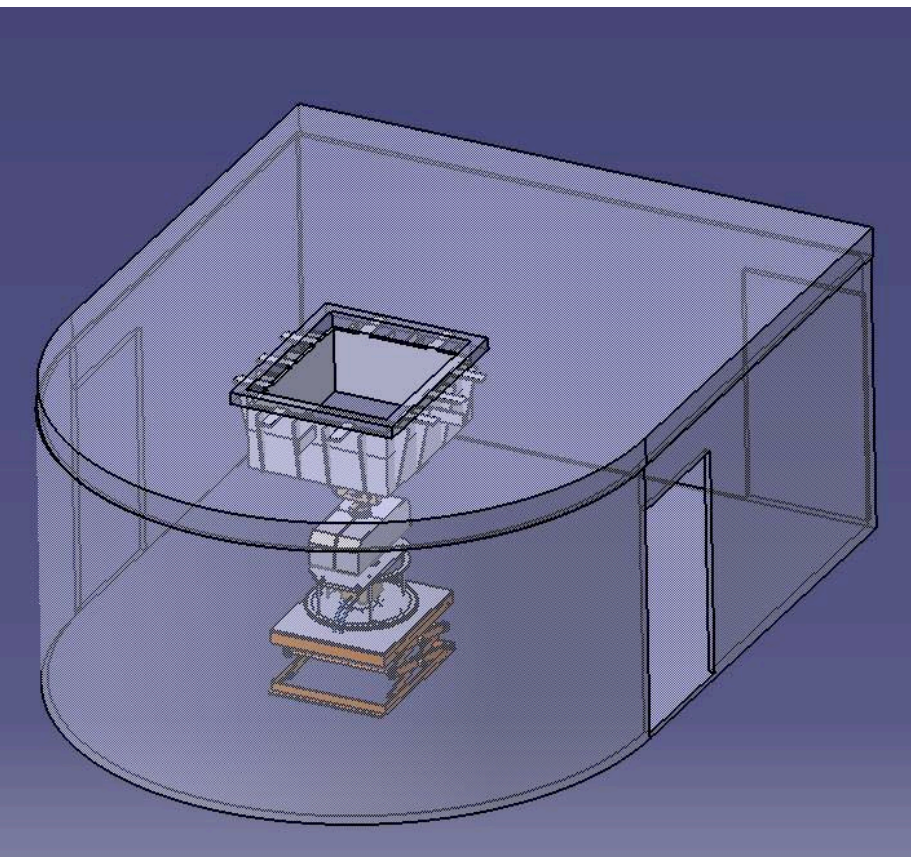
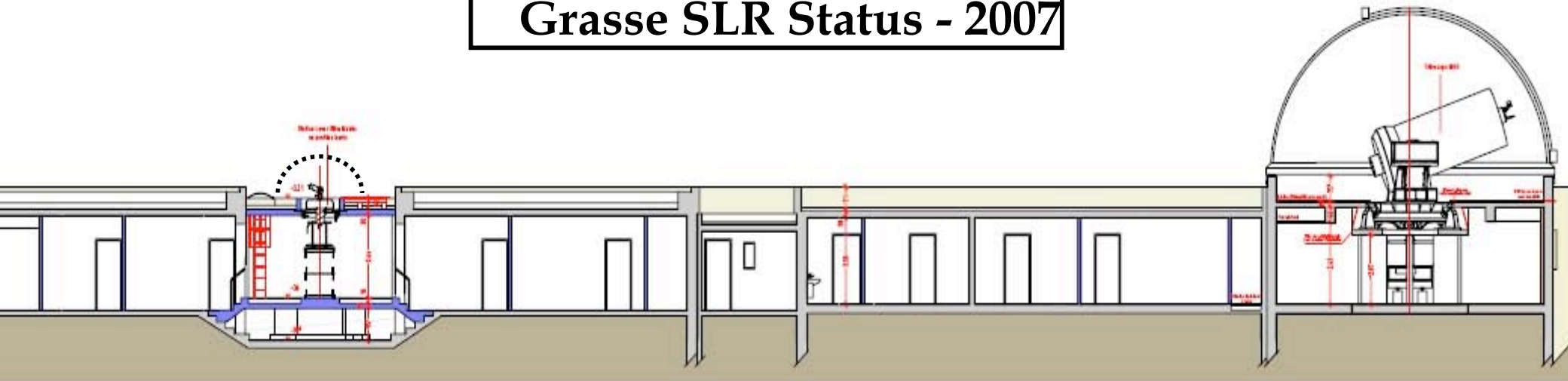




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  - » Moon reflectors
  - » R&D studies and new experiments (Time transfer, transponder...)
- New slr facilities in 12/18 months
  - » Two observing sytem (0,13 and 1,50 m telescopes) occasionally colocated
  - » Fields campaign for Ftlrs (maximum 6 months/year)

# Grasse SLR Status - 2007

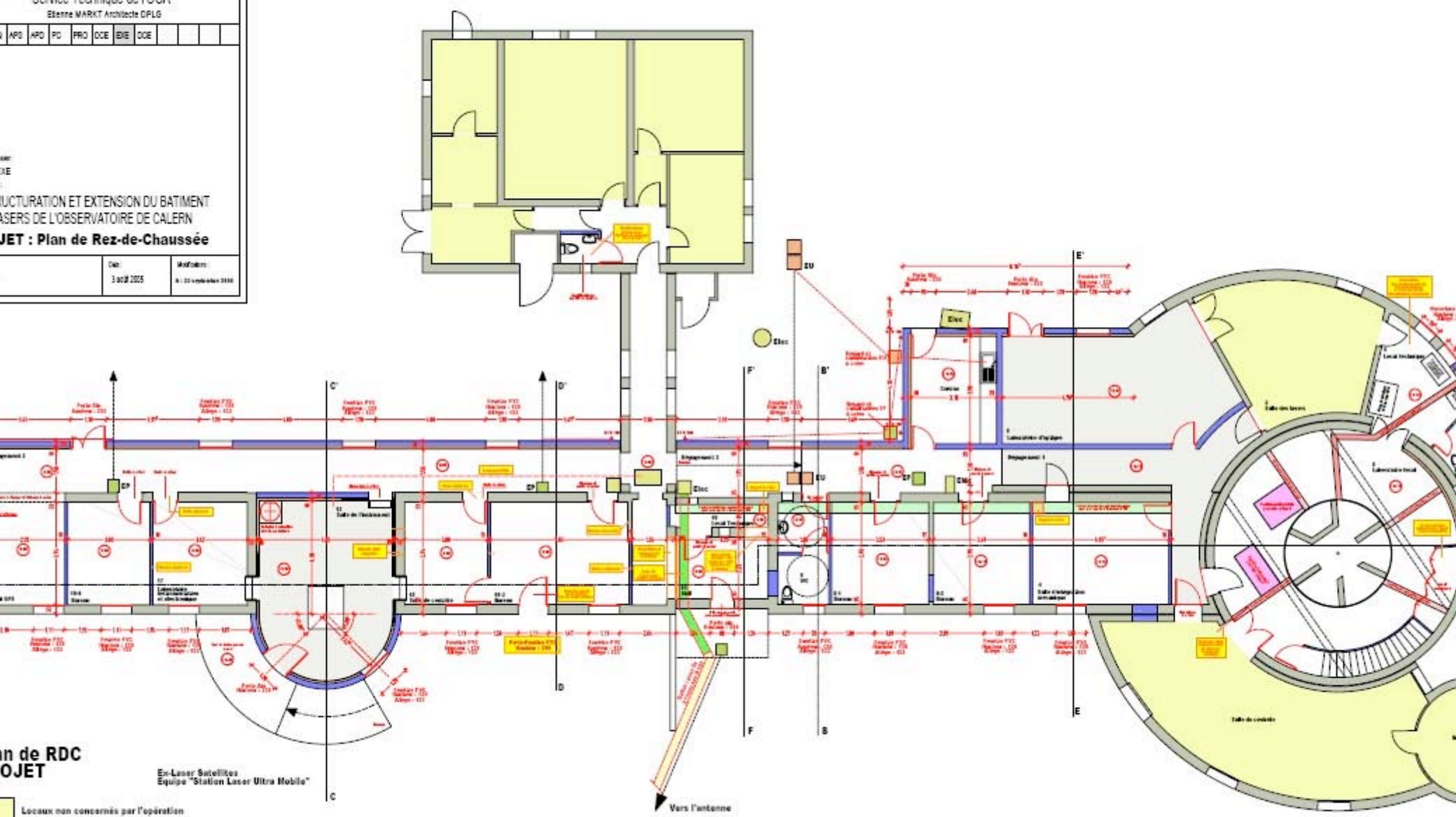


Observatoire de la Côte d'Azur  
 Service Technique de l'OCA  
 Etienne MARKET Architecte DPLG

APS	APD	PC	PRO	CCE	ENE	COE			
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OBJET : Plan de Rez-de-Chaussée

Date: 3 août 2005  
 Modifications: 4.11 septembre 2006



Plan de RDC  
 PROJET

En-Laser Satellites  
 Equipe "Station Laser Ultra Mobile"

Locaux non concernés par l'opération

Zone de plancher technique

Maçonneries créées

En-Laser Lune  
 Equipe "ME0"







# Announcement of opportunity for Scientific projects including FTLRS operations

**GRGS/OCA**

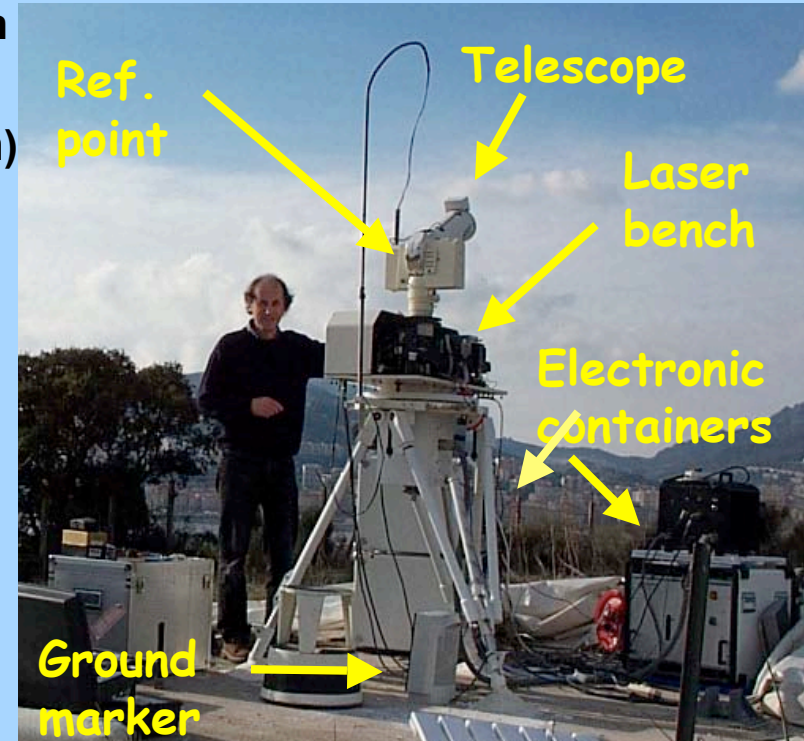
- **Completing geographical coverage for slr**
- **Reinforcing geodetic/geodynamic experiences**
- **Altimetric operations**
- **Co-location with other techniques or slr systems**
- **Contributing in new experiments**





# The French Transportable Laser Ranging System

- The smallest SLR system in operation
  - 350 kg
  - $\varnothing$  tel = 13 cm (emission/reception)
  - Time = GPS steered rubidium
  - LEO satellites to Lageos



# Status of last campaigns

## ■ Corsica April-September 2002

- Cost ~40 Keuros for deployment, travels, subsistence fees.
- 1600 passes with bias < 1cm



## ■ Crete April-October 2003

- 1400 passes with bias < 1cm
- Additional costs ~70 Keuros



## ■ San Fernando, June 2004

- One month colocation ( 204 passes)



## ■ Brest September-October 2004

- Two month for loading effects on ground with large ocean tides (204 passes)



## ■ Corsica May-October 2005

- Jason 1 calibration mission – About 1600 passes
- Additional cost ~ 60 KEuros





# Cooperation proposal

- **Proposal of scientific teams in charge of project needing FTLRS operations**
  - **Contribution of OCA :**
    - FTLRS use (exception of running costs)
    - Salaries of OCA technical teams for
      - Installation and maintenance
      - Operations
  - **Contribution of hosting laboratory (additional expenses):**
    - FTLRS transportation and infrastructure expenses for setup and removal
    - Transportation and mission fees for technical staff
    - Operational costs
      - Hardware maintenance (optic, flash, Yag rods,..)
      - Consumable, communications,...
      - Shelter installation
  - **Costs very depending on the place**
    - distance and difficulties to access site from France



***Complete proposal on draft here and on ILRS web soon...***

# The LLR Network

ILRS Workshop  
Herstmonceaux 2005  
Eastbourne, UK  
2005 October 4

# Lunar Laser Ranging Observing

- Presently LLR observations continue to be under severe pressure
- MLRS (USA) has not had an upgrade/refurbishment in almost 15 years with time, money and man-power being extremely limited
- OCA (France) is down for almost a year for a major refurbishment but should come back much improved
- MLRO (Italy) has great potential but has still not initiated an aggressive LLR observing strategy
- APOLLO (USA) is still under the final phases of construction and implementation but should be a premiere station when it is completed
- The potential for improvement exists, but only with money and effort.

# Apollo Project Timeline

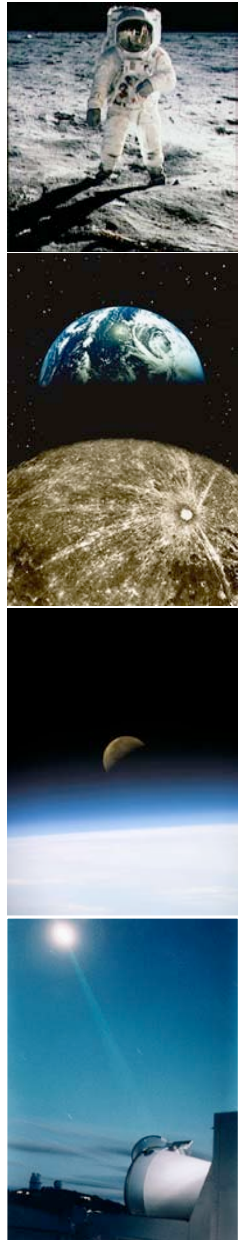
- Recently completed bulk of engineering effort:
  - Optical-mechanical engineering
  - APD characterization & electronics finalization
  - Software: user interface
  - Miscellaneous integration
- Initial external laser activity July 24, 2005
  - several preliminary runs in July, August, September to hammer out system integration issues and on-sky performance verification
- First science-quality data beginning fall 2005
  - final optics (microlens array: 14× gain) to be installed in October; expect lunar returns to follow
- Sufficient data for order-of-magnitude EP in ~1 year
- Model refinement/improvement campaign in parallel
- Continued data collection/analysis for years to come



First Light: July 24, 2005



## Recent Highlights of LLR Data Analysis



### ■ Lunar science:

- Developed a dynamical model for lunar core oblateness and made detection
- Dissipation in Moon is due to tidal dissipation and a fluid-core/solid-mantle interaction
- A fluid lunar core is indicated with a size about 20% of the Moon's dimension. An oblate core-mantle boundary can influence the determination of the lunar Love number  $k_2$  that was determined as  $k_2=0.0227 \pm 0.0025$ .
- Accurate numerically integrated lunar physical librations and orbit
- Determine accurate positions of retroreflector arrays on the Moon used for lunar geodesy

### ■ Geodesy and Geophysics

- The acceleration in mean longitude due to dissipative effects is  $-25.7 \text{ "/cy}^2$ , of which  $-26.0 \text{ "/cy}^2$  is due to tides on Earth and  $+0.3 \text{ "/cy}^2$  is due to tidal and fluid core dissipation in the Moon. The tidal increase in semimajor axis is 38 mm/yr.
- Determine geocentric station locations and rates
- Determine Earth rotation and orientation in space

### ■ Gravitational physics:

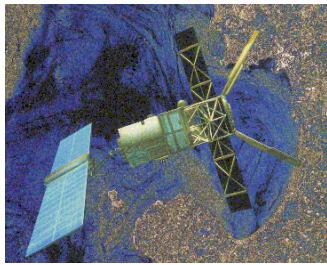
- The equivalence principle (EP) test indicates that the Earth and Moon are accelerated alike in the Sun's gravitational field to within  $1.4 \times 10^{-13}$ .
- The EP test limits the uncertainty in PPN beta parameter to 0.00011 and the gravitational constant  $G$  has no detectable rate for  $dG/dt / G$  within  $9 \times 10^{-13} \text{ /yr}$
- Tests of the relativistic geodetic precession (uncertainty, 0.006) and the PPN beta and gamma agree with general theory of relativity.

LLR strongly contributes in the areas of lunar science, geodesy and gravitation



# Mission Reports

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# ERS - 2

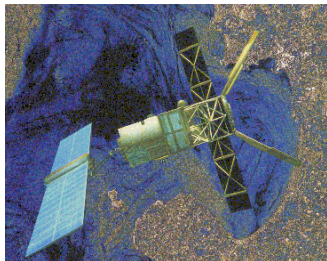
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## Status SLR-Tracking ERS-2 Mission

L. Grunwaldt, D. Koenig, F.-H. Massmann, R. Schmidt

GeoForschungsZentrum Potsdam (GFZ)  
Department I: Geodesy and Remote Sensing  
Telegrafenberg A17  
14473 Potsdam, Germany





# ERS - 2

## Mission Status, Role of SLR

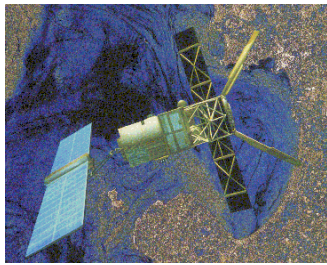
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### Mission Status

- ERS-2 is now in orbit for more than 10 years.
- In general the satellite and the payload are in good condition.
- ESA plans to operate ERS-2 at least for another two years.
- Due to funding reasons end of 2005 **GFZ will stop its predictions service for ERS-2.** Therefore the stations are asked to use other available sources (ESOC,..)

### Role of SLR

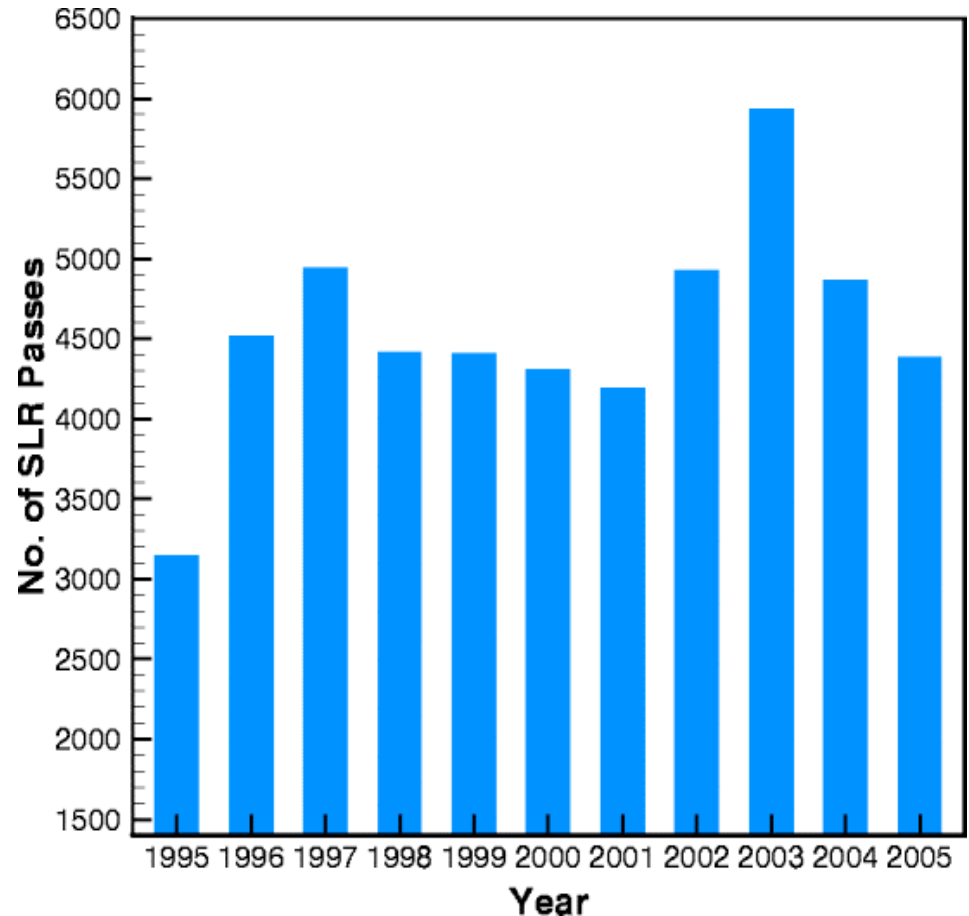
- SLR is the secondary tracking system, while PRARE is the primary one.
- Since 2003 the PRARE system is operated by GFZ on best effort basis due to stop of funding by DLR. This results in an increasing importance of SLR.
- Intensive ERS-2 SLR tracking will be required at least until end of 2007.



## ERS - 2

## SLR Data Quantity and Quality

- Since 2001 the SLR tracking clearly increased, 2001 showing the lowest, 2003 the best since start of the mission
- The data quality is in general very good
- Still sometimes large outliers when the normal point has been formed from one full-rate observation only



# Status SLR Tracking GRACE Mission

L. Grunwaldt, R. Schmidt, D. König, R. König, F.-H. Massmann

GeoForschungsZentrum Potsdam (GFZ)  
Department 1: Geodesy and Remote Sensing  
Telegrafenberg  
14473 Potsdam

## Status

- The twin GRACE satellites are more than three years in space. All sensors and instruments are operating in the science data collection mode. All scientific instruments (accelerometers, star cameras, GPS receivers, K-Band-Ranging system, Laser Ranging Reflector) are performing nominally. On GRACE-1 some instrument redundancy has been lost.
- Currently reprocessing activities at Science Data System teams at JPL, UT-CSR and GFZ to create next generation GRACE-only monthly and long-term static gravity models. Based on advances in the background modeling and processing strategies significant improvements in the models' quality to resolve the gravity field in space and time can be expected inferred from the first reprocessed months.



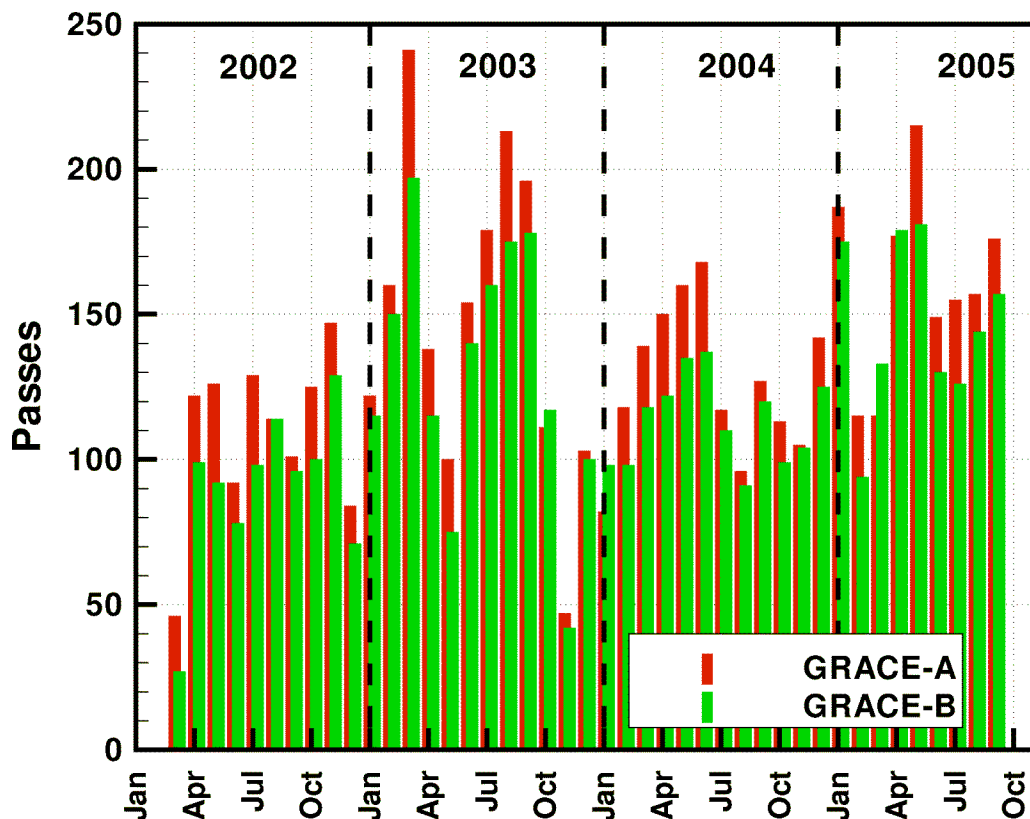
## GRACE Decay Scenario (End Sep 2005) & Mission Operations

- Current altitude ~ 475 km.
- Current separation of the twin satellites about 200 km.
- With the current decay of about 13 km/year nominal mission lifetime of 5 years in reach, respectively an extension of the mission's lifetime several year's beyond 2007 seems feasible.
- From time to time (some months) orbit manoeuvres in order to keep separation distance at  $220 \text{ km} \pm 50 \text{ km}$ .
- **Satellite swap manoeuvre (exchange of GRACE-A and GRACE-B as leading and trailing satellite) planned for December 2005 (tbc).** Manoeuvre will take about one week impacting the SLR operations. GFZ will inform stations and update predicts via ILRS exploders accordingly.

## Role of SLR data

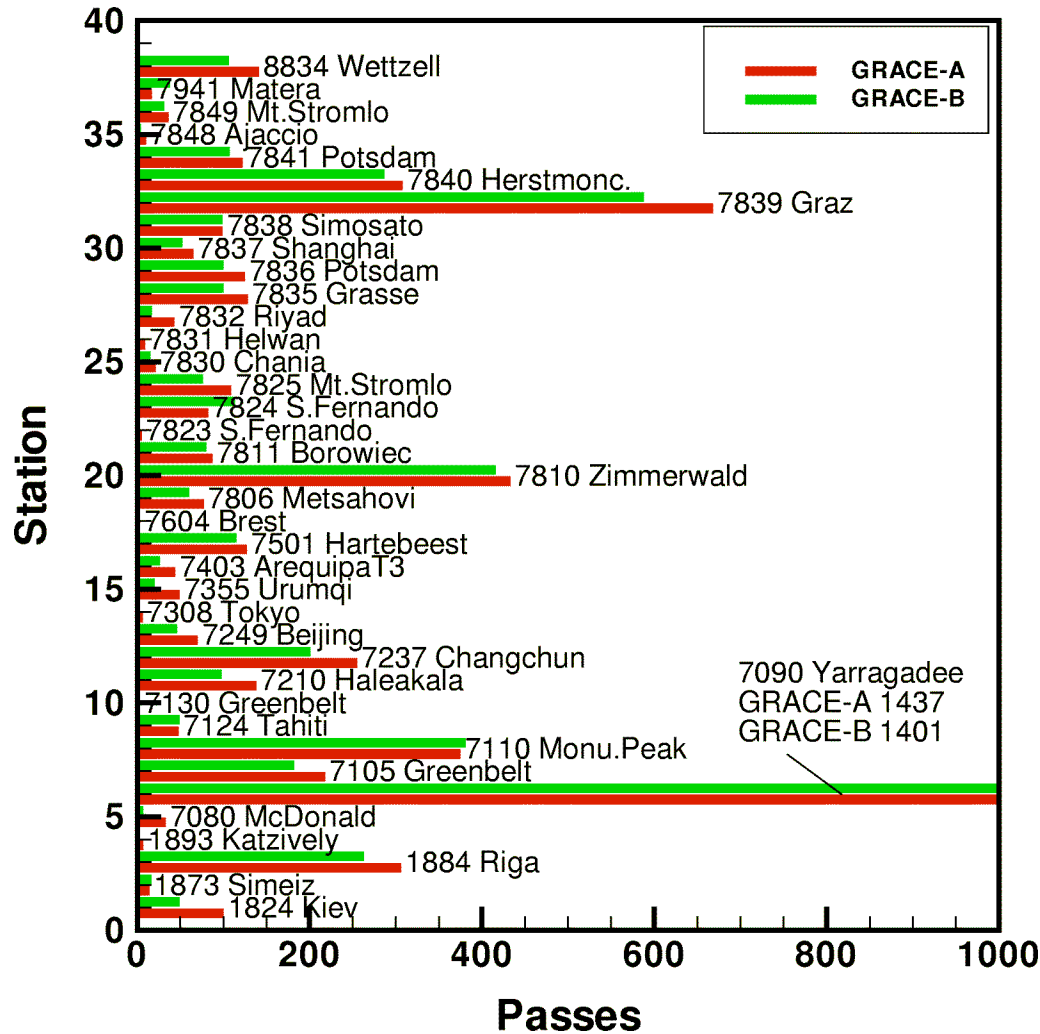
- At GFZ precise orbit predictions are generated from GPS navigation solution **and** the more accurate SLR data.
- Routinely used for the validation of the data of the onboard GPS receivers and K-Band-Ranging instrument in POD.
- SLR data is valuable data for the quality control of gravity field recovery from GRACE microwave satellite-to-satellite tracking data.
- GRACE SLR observations are integrated with GPS ground and on-board data for strengthening reference frame and long-wavelength part of the gravity field solutions.

## GRACE SLR-Tracking March 2002 - Sep 2005



- Total 10957 passes (GRACE-A: 5813, GRACE-B: 5144).
- Good amount of data per month and per satellite (as of Apr. 2002 in general  $\geq 100$  pass/month).
- In general stronger tracking of GRACE-A (except Aug 2002, Oct 2003, Jan 2004, Mar and Apr 2005). Differences vary from month to month. Some part is due to degraded predicts during orbit maintenance manoeuvres mostly performed on GRACE-B

## GRACE SLR-Tracking March 2002 - Sep 2005



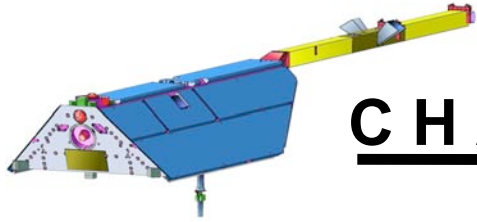
- Summary per stations also reveal stronger tracking of GRACE-A.
- However, majority of contributing ILRS stations show almost balanced statistics.
- The observed variations in the amount of tracking between GRACE-A and GRACE-B are acceptable.



## Summary

- Overall SLR tracking statistics quite satisfactory for the GRACE mission. Current statistics show almost balanced values for the majority of contributing ILRS stations. The deviations in tracking between GRACE-A/B are acceptable. The efforts taken for the twin-tracking are highly appreciated.
- The quality of GFZ orbit predictions and the update rate of 2 predicts/day seems to be sufficient. Therefore no increased update rate is planned in the near future.
- SLR data (for both satellites) play an important role:
  - for the generation of accurate orbit predictions,
  - for the calibration/validation of the microwave tracking systems onboard the GRACE satellites,
  - for the quality control of gravity field recovery,
  - for the combination with GPS observations for gravity variation recovery

**= > continued intensive SLR support is requested**



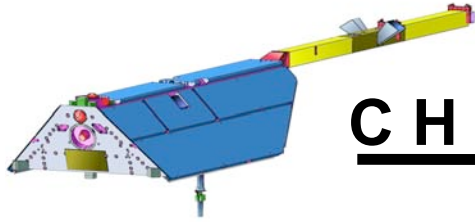
**CHAMP**

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# Status SLR-Tracking CHAMP Mission

L. Grunwaldt, R. Schmidt, D. König, R. König, F.-H. Massmann

GeoForschungsZentrum Potsdam (GFZ)  
Department 1 : Geodesy and Remote Sensing  
Telegrafenberg  
14473 Potsdam

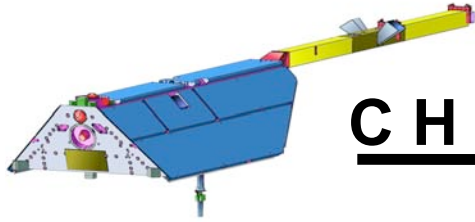


# CHAMP

---

## Status

- CHAMP is 1902 days in space on 29-Sep-2005. The satellite is in excellent condition. The scientific instruments - except the radial channel of the accelerometer - perform nominally. All scientific instruments are in almost continuous science data collection mode (> 98%). No aging effects visible.
- Continued computation of static long-wavelength gravity field (EIGEN models) based on data from the onboard GPS receiver and the precision accelerometer. Investigations of the temporal variability of the long-wavelength part of the gravity field are made from subset solutions and integrated solutions with GPS and SLR ground data. Intercomparison and combination of CHAMP-only and GRACE-only gravity models and combination with terrestrial gravity data.
- Accurate globally distributed atmospheric profiles (temperature, humidity) are routinely generated from the GPS-SST data for numerical weather prediction and climate studies.
- Based on the data from the magnetometer instruments onboard CHAMP accurate and homogeneous maps of the Earth's magnetic field are generated.



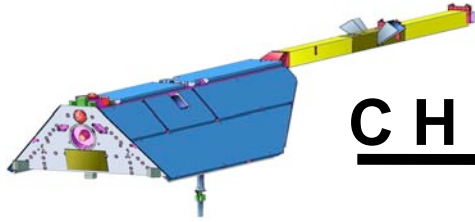
# CHAMP

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## CHAMP Decay Scenario (End Sep 2005)

- Current altitude ~ 350 km.
- Two apogee thruster burns (Mid 2002, End 2002) to rise altitude by 20 km each.
- No further apogee burn manoeuvres planned.
- Nominal lifetime of 5 years reached on July 15th, 2005.
- Current decay scenario even predicts extended lifetime to 2007/2008.



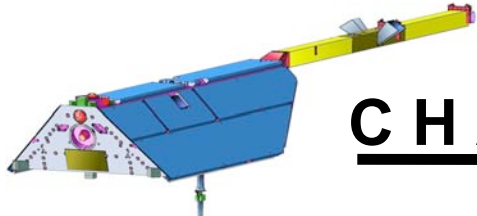


# CHAMP

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## Role of SLR Data

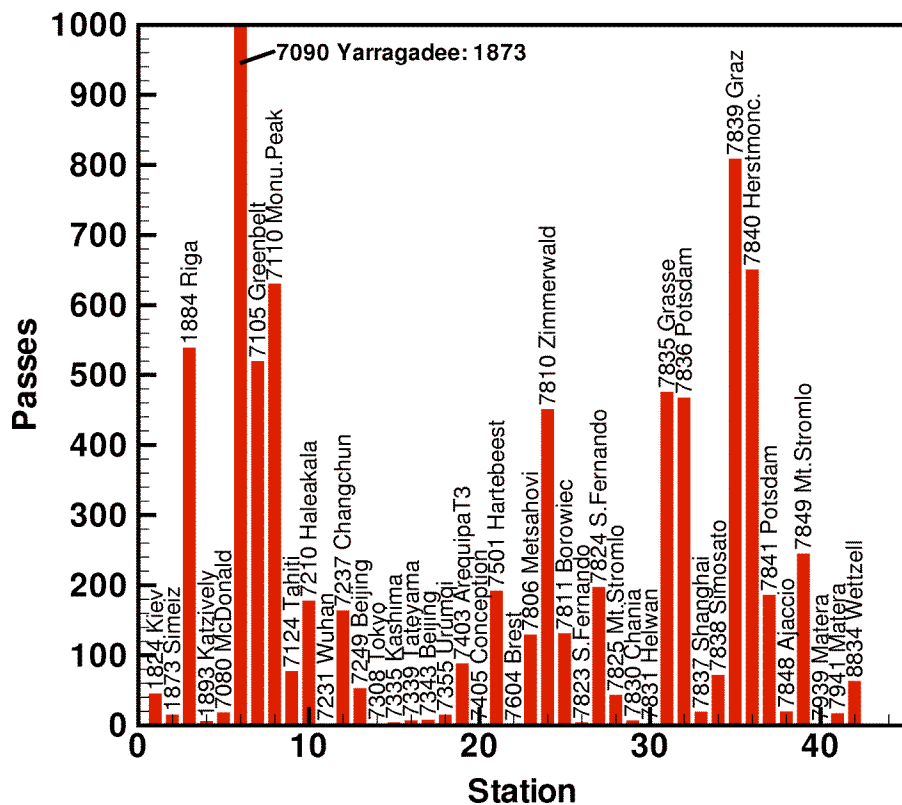
- GFZ orbit predictions are based on ephemeris from GPS navigation solution **and** the more accurate SLR data.
- Routinely used for the validation of the data of the onboard GPS receiver in POD.
- SLR data serve as independent quality measure of gravity field models derived from CHAMP microwave tracking data.
- CHAMP SLR data are combined with GPS ground and space-borne observations for studies of temporal variations of the long wavelength part of the gravity field and the reference frame.



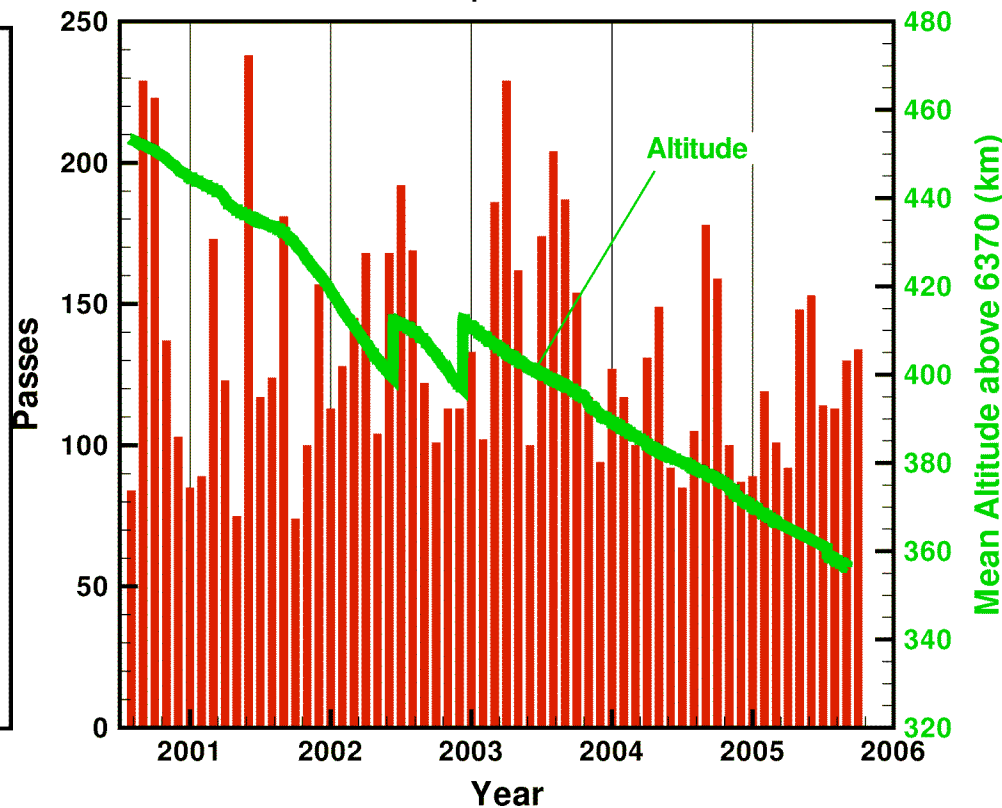
# CHAMP

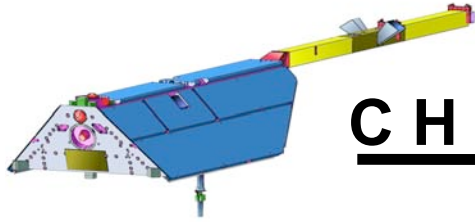
## SLR-Tracking Jul 2000 - Sep 29, 2005

Total per ILRS station



Total per Month





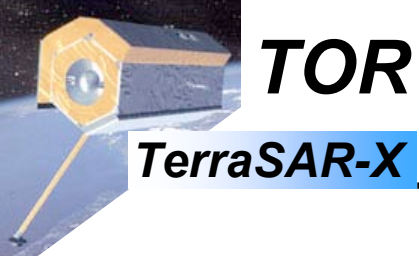
# CHAMP

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## Summary

- Overall tracking statistics are quite satisfactory for the CHAMP mission - in particular in view of the low (and further decreasing) altitude of CHAMP.
- Quality of CHAMP orbit predictions has been improved significantly by using a new GRACE-based gravity model in the operational processing chain. Thanks to this improvement the nominal operations of 3 predicts/day can be continued.
- Operational monitoring of CHAMP orbit predictions' quality. If indicated GFZ will increase the updates to 4-5 predicts/day (or more) as the orbit further decays.
- SLR data plays an important role:
  - for the generation of accurate orbit predictions,
  - for the continuous validation of CHAMP's microwave tracking systems,
  - for the quality control of gravity field modeling, and
  - for the combination with GPS data for reference frame and temporal gravity issues

**= > continued intensive SLR support is requested**



# The upcoming TerraSAR-X Mission

L. Grunwaldt, R. Schmidt, D. König, R. König, F.-H. Massmann

GeoForschungsZentrum Potsdam (GFZ)  
Department 1 : Geodesy and Remote Sensing  
Telegrafenberg  
14473 Potsdam





# Coming soon: TerraSAR-X



TerraSAR-X is the first German long-duration synthetic aperture radar (SAR) mission

Launch: mid 2006 from Baikonur cosmodrome

Orbit: sun-synchronous, circular dusk-dawn orbit at appr. 514 km altitude, 97.44° inclination

## Science objectives for X-band SAR:

- Landslide, rock fall and urban subsidence
- Ice sheet dynamics
- High-resolution Digital Terrain Models (DTM) for surface water availability modeling
- Seismic loading cycle studies

## GFZ / CSR secondary payload: TOR (Tracking, Occultation and Ranging)

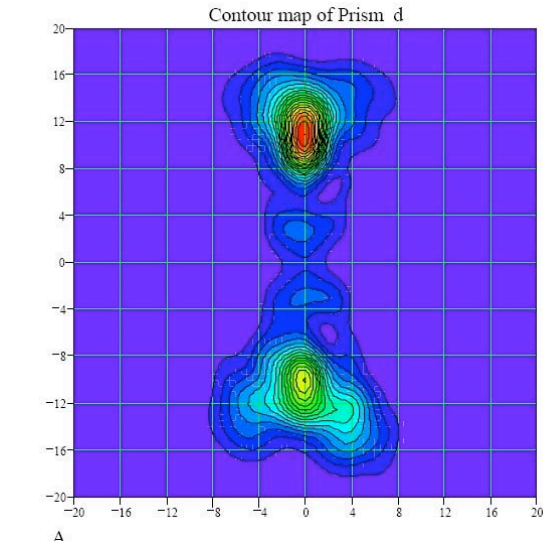
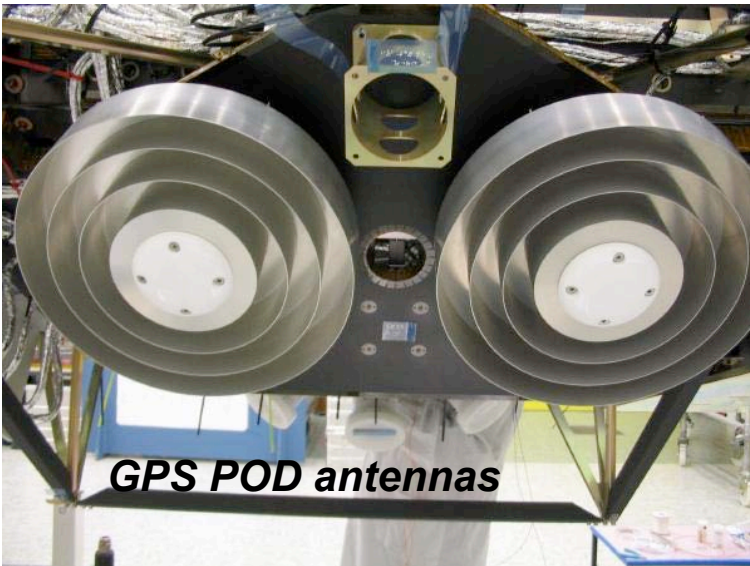
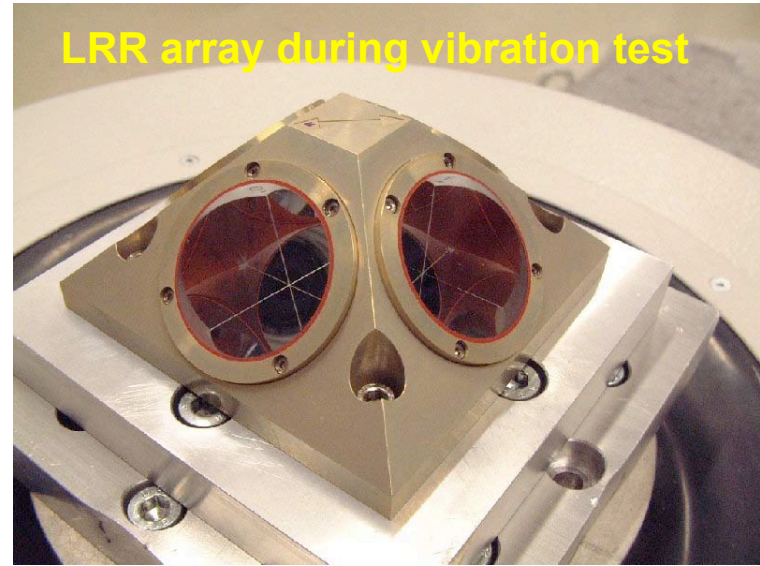
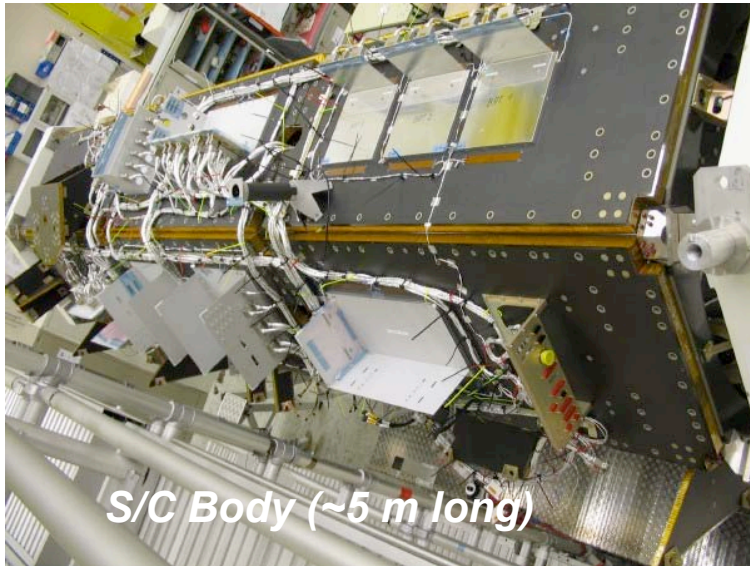
- Precise dual-frequency GPS receiver with POD and radio occultation capability
- CHAMP type LRR array for external calibration / validation of GPS orbits (GFZ Potsdam will deliver predictions)

SLR Coordinator: R. König, Technical Contact: L. Grunwaldt, Project Responsible: Ch. Reigber

SLR Tracking Request to ILRS in preparation



# TerraSAR-X Manufacturing

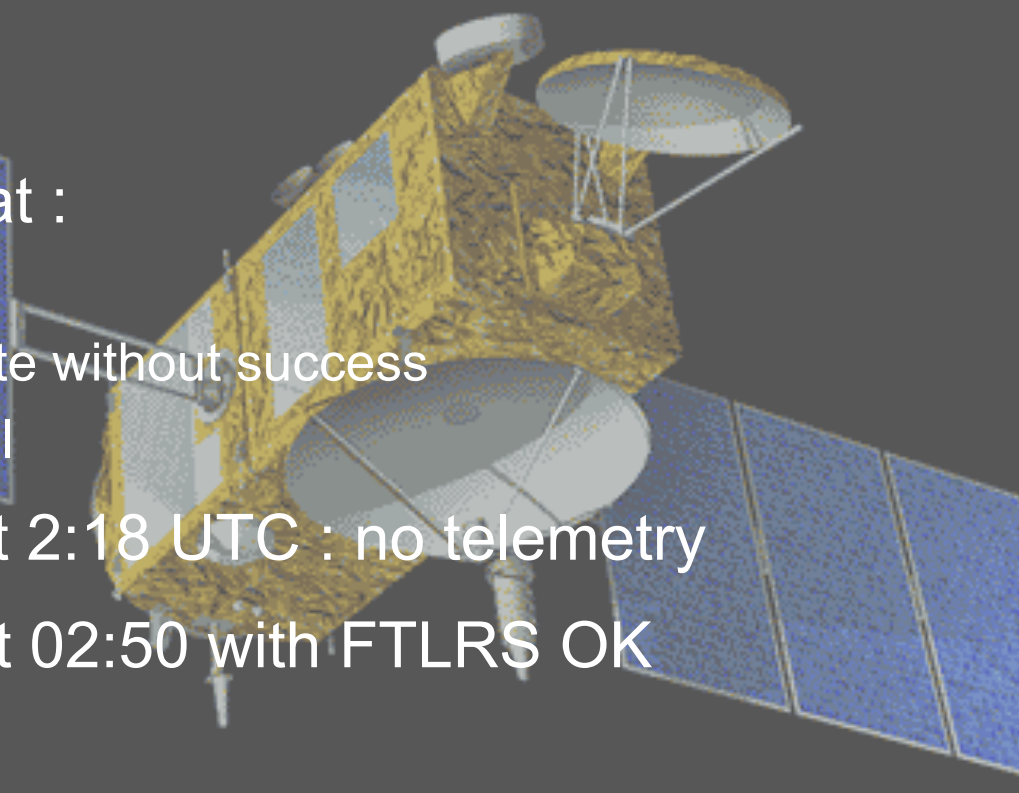


Two-spot far field for velocity aberration correction



# Incident Jason-1: D-day

- ◆ Poker Flat (Alaska) pass on 2005/09/20 at 19:00
  - ◆ OK : telemetry until 19:10
  - ◆ AGC nominal
- ◆ 2 following passes over Poker Flat :
  - ◆ 21:00 and 22:56 UTC no telemetry
  - ◆ Manual tracking to search the satellite without success
  - ◆ Spectrum analyzer showed no signal
- ◆ Aussaguel pass on 2005/09/21 at 2:18 UTC : no telemetry
- ◆ Ajaccio Slr pass on 2005/09/21 at 02:50 with FTLRS OK
- ◆ Hypothesis : transmitter failure
- ◆ Without any telemetry
  - ◆ Which is the spacecraft status?
  - ◆ Which attitude: nominal mode or safe mode ?



# Incident Jason-1: day+1

## ◆ Hypothesis : transmitter failure

### ◆ Attitude control:

- Nominal mode: nadir-pointing (altimeter, antennae, laser retro-reflector) + yaw steering (solar array illumination)
- Safe-Hold-Mode: payload off, sun pointing (solar array illumination), rotating spacecraft (spin or gyroscopic stabilization but intermittent Earth pointing)

### ◆ Safe-Hold-Mode necessary in order to switch to a back-up equipment

### ◆ Sequence of Events:

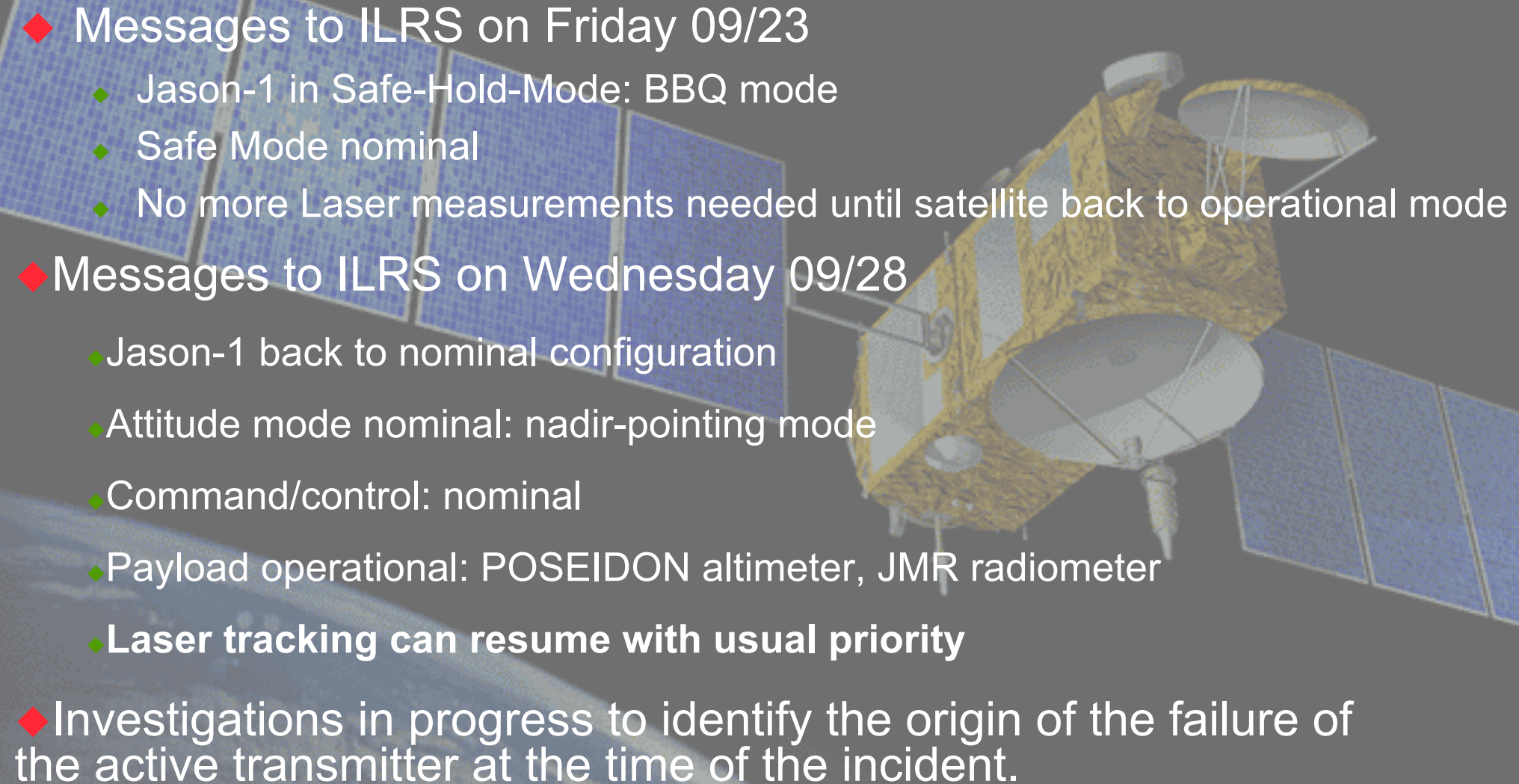
- Spacecraft attitude to be checked prior to Safe-Hold-Mode command
- Safe-Hold-Mode command (payload off)
- Spacecraft reconfiguration: back-up equipment
- TM/TC check
- Earth acquisition: nominal mode
- Payload on: full operational mode



# Incident Jason-1: day+1

- ◆ Spacecraft attitude?
  - ◆ Laser stations
  - ◆ NORAD: radar observations
- ◆ « urgent » message to ILRS ([urgent@dgfi.badw-muenchen.de](mailto:urgent@dgfi.badw-muenchen.de))
  - ◆ Wednesday 09/21 at 19:51: Moblas5 Yarragadee station, pass OK
  - ◆ Wednesday 09/21 at 23:05: TIGO/Concepcion station 3h44, 5h40, 20h09 UTC
  - ◆ Thursday 09/22 at 3:42: Postdam station OK despite low elevation (max 26°)
  - ◆ Thursday 09/22 at 8:16: Ajaccio ultra mobile station 2h50 UTC OK despite bad weather
- ◆ « urgent » Message to ILRS Thursday 09/22 at 11:18
  - ◆ Jason-1 in Safe-Hold-Mode : “BBQ” mode (sun pointing spin mode)
  - ◆ less Laser measurements expected, but still very usefull
  - ◆ Reconfiguration then telemetry recovery

# Incident Jason-1: day+2

- 
- ◆ Messages to ILRS on Friday 09/23
    - ◆ Jason-1 in Safe-Hold-Mode: BBQ mode
    - ◆ Safe Mode nominal
    - ◆ No more Laser measurements needed until satellite back to operational mode
  - ◆ Messages to ILRS on Wednesday 09/28
    - ◆ Jason-1 back to nominal configuration
    - ◆ Attitude mode nominal: nadir-pointing mode
    - ◆ Command/control: nominal
    - ◆ Payload operational: POSEIDON altimeter, JMR radiometer
    - ◆ **Laser tracking can resume with usual priority**
  - ◆ Investigations in progress to identify the origin of the failure of the active transmitter at the time of the incident.

# ILRS contribution to altimetry

## ◆ TOPEX/POSEIDON

- ◆ Laser and DORIS since August 1992
- ◆ Laser only since November 2004



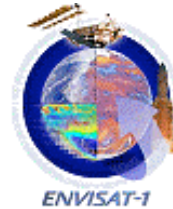
## ◆ Jason-1

- ◆ Laser, DORIS and GPS since December 2001



## ◆ ENVISAT

- ◆ Laser and DORIS since March 2002



## ◆ CRYOSAT :

- ◆ Laser and DORIS, to be launched October, 8th 2005



◆ Very fruitful contribution both on nominal and contingency situations

◆ **Thanks from ESA, CNES and NASA project, operation teams**

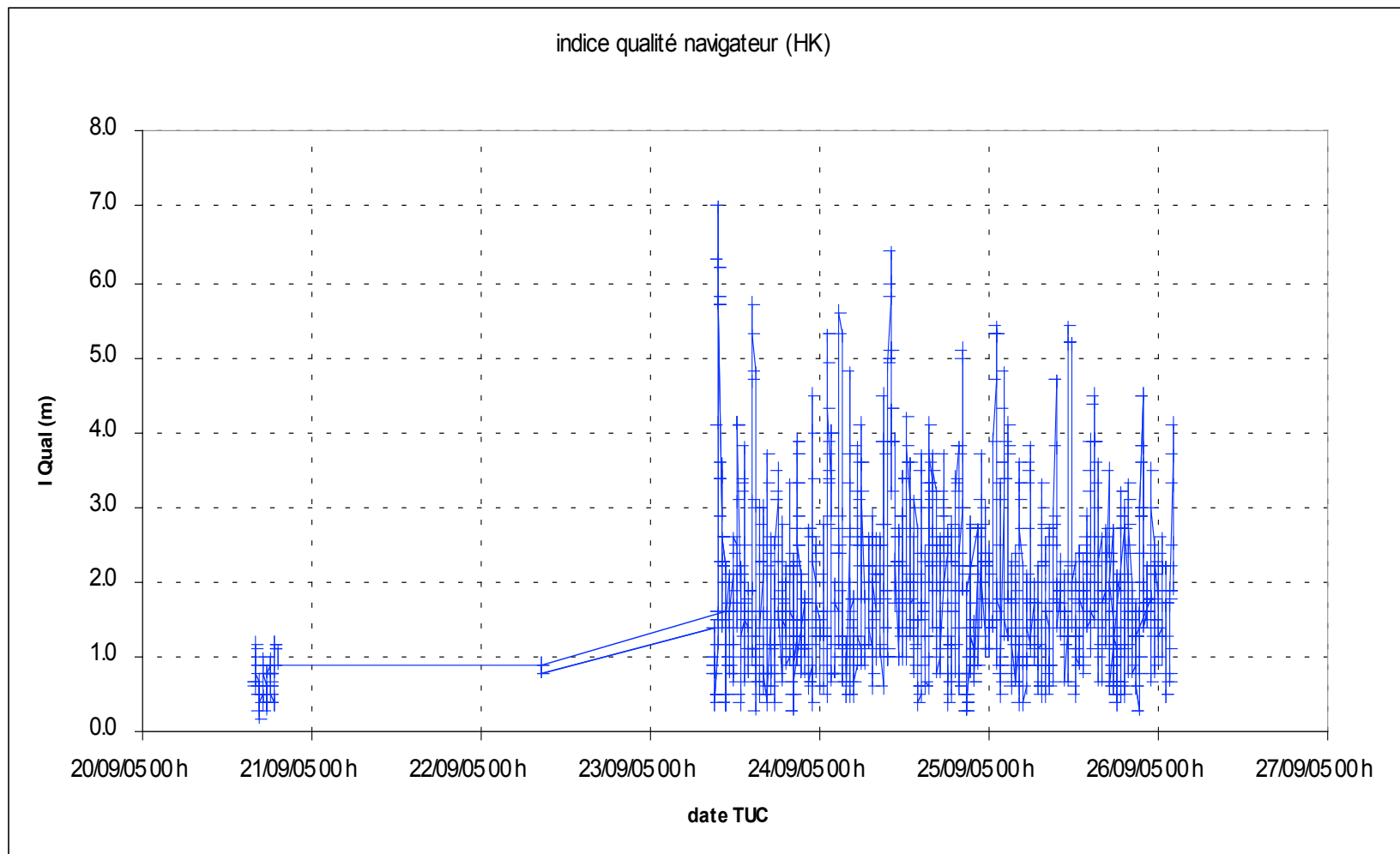


# The end and good luck

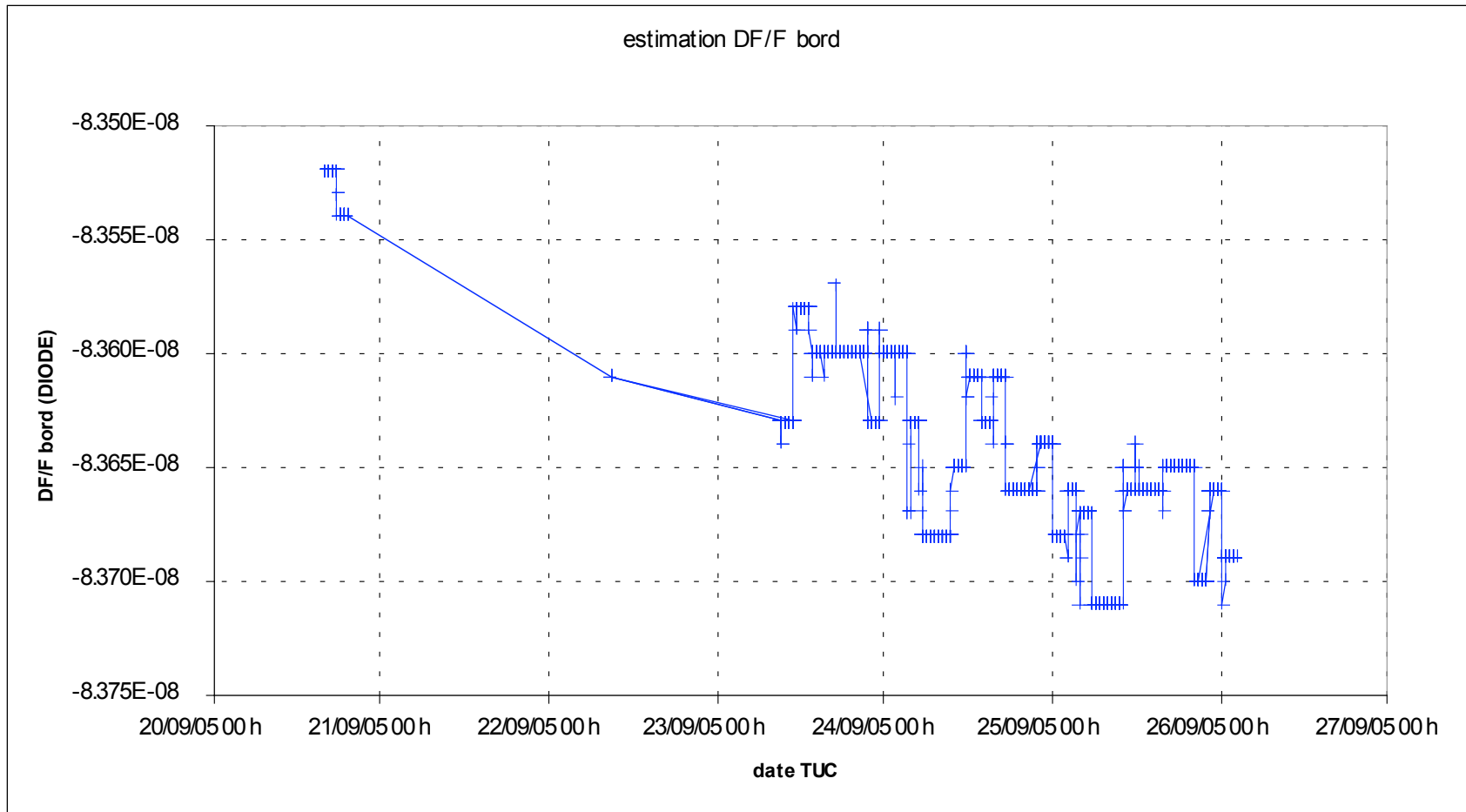




# Incident Jason-1: navigator quality index



# Incident Jason-1: On-board frequency estimation



# Incident Jason-1: day-2

- ◆ small orbit change on 2005/09/18 around 9:50 UTC:
  - ◆ No maneuver
  - ◆ No thruster activity (attitude control)
  - ◆ High DORIS rms residuals
  - ◆ Bad orbit overlapping
  - ◆ Orbit computed with GPS data also affected
  - ◆ «Micro maneuver» similar to another experienced on TOPEX/POSEIDON
  - ◆ Debris impact?
  - ◆ No obvious link with the incident 2 days later

# Incident Jason-1: D-day

- ◆ Poker Flat pass on 2005/09/20 at 19:00
  - ◆ OK : telemetry until 19:10
  - ◆ AGC nominal
- ◆ 2 following passes over Poker Flat :
  - ◆ 21:00 and 22:56 UTC no telemetry
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- ◆ Aussaguel pass on 2005/09/21 at 2:18 UTC : no telemetry
- ◆ Without any telemetry
  - ◆ Which is the spacecraft status?
  - ◆ Which attitude: nominal mode or safe mode ?

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- ◆ Spacecraft attitude?
  - ◆ Laser stations
  - ◆ NORAD: radar observations
- ◆ « urgent » message to ILRS ([urgent@dgfi.badw-muenchen.de](mailto:urgent@dgfi.badw-muenchen.de))
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  - ◆ Thursday 09/22 at 8:16: Ajaccio ultra mobile station 2h50 UTC OK despite bad weather
- ◆ « urgent » Message to ILRS Thursday 09/22 at 11:18
  - ◆ Jason-1 in Safe-Hold-Mode : “BBQ” mode
  - ◆ less Laser measurements expected, but still very usefull
  - ◆ Reconfiguration then telemetry recovery



# Incident Jason-1: day+2

- ◆ Messages to ILRS on Friday 09/23
  - ◆ Jason-1 in Safe-Hold-Mode: BBQ mode
  - ◆ Safe Mode nominal
  - ◆ No more Laser measurements needed until satellite back to operational mode
- ◆ Telemetry received on Friday 09/23
  - ◆ 2 DORIS UTs still in autonomous mode (no transit to waiting mode)
  - ◆ Navigator quality index: 0.4 to 7 m OK (1 to 3 m in nadir-pointing mode)
- ◆ Telemetry received until Monday 09/26
  - ◆ 2 DORIS UTs still in autonomous mode
  - ◆ Navigator quality index: a few m OK
  - ◆ On-board frequency estimation OK (Master Beacons received properly)

# Incident Jason-1: day+8

- ◆ Messages to ILRS on Wednesday 09/28
  - ◆ Jason-1 back to nominal configuration
  - ◆ Attitude mode nominal: nadir-pointing mode
  - ◆ Command/control: nominal
  - ◆ Payload operational: POSEIDON altimeter, JMR radiometer, precise TRSR GPS receiver
  - ◆ Laser tracking can resume with usual priority
  
- ◆ Investigations in progress to identify the origin of the failure of the active transmitter at the time of the incident.

# ILRS contribution to altimetry

## ◆ TOPEX/POSEIDON

- ◆ Laser and DORIS since August 1992
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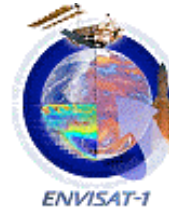
## ◆ Jason-1

- ◆ Laser, DORIS and GPS since December 2001



## ◆ ENVISAT

- ◆ Laser and DORIS since March 2002



## ◆ CRYOSAT :

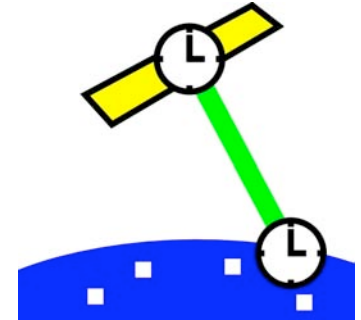
- ◆ Laser and DORIS, to be launched October, 8th 2005



◆ Very fruitful contribution both on nominal and contingency situations

◆ Thank you from ESA, CNES and NASA project and operation teams

# Time Transfert by Laser Link T2L2 On Jason 2



GEMINI  
UMR6203

OCA -UMR Gemini

Grasse - FRANCE

Email : [etienne.samain@obs-azur.fr](mailto:etienne.samain@obs-azur.fr)

E. Samain - Principal Investigator

D. Albanese : Optic

P. Exertier: Gemini Director

M. Furia : Electronic

J.F. Mangin : Laser

J. Paris : Software

J.M. Torre: Laser Station - ILRS

F. Pierron: FTLRS

P. Vrancken : Optical tests

J. Weick : error - link Budget - computation



CNES

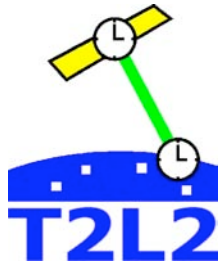
Toulouse - France

Email : [phillipe.Guillemot@cnes.fr](mailto:phillipe.Guillemot@cnes.fr)

P. Guillemot: System Engineer

I. Petitbon: Project Manager

K. Gasc : Optic



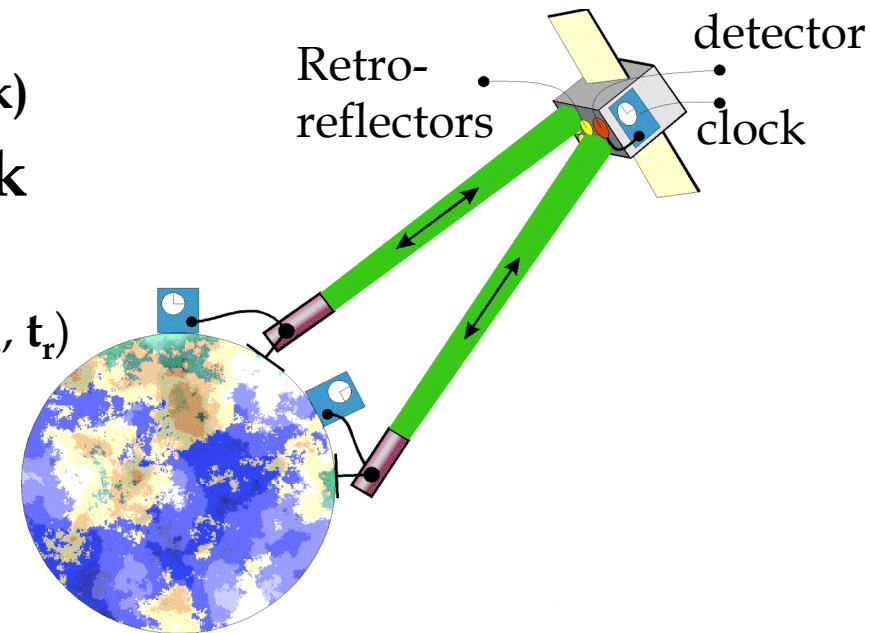
# Principle

- **Time Tagging of laser pulses emitted from a laser station in the satellite direction**

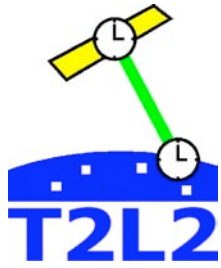
- » Start Time at ground Station  $t_d$  (ground clock)
- » Arrival time at satellite  $t_b$  (space clock)
- » Return Time at ground station  $t_r$  (ground clock)

- **Time Transfer between Ground clock and space clock**

- » Triplet Construction for each laser pulse ( $t_d, t_b, t_r$ )
- » Computation of the time offset :

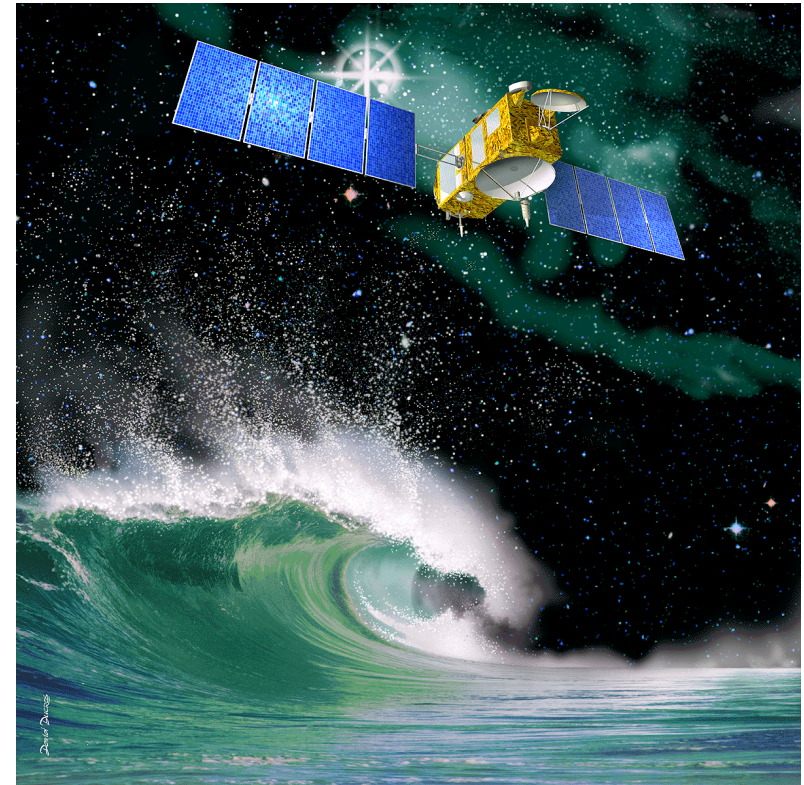


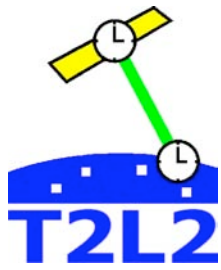




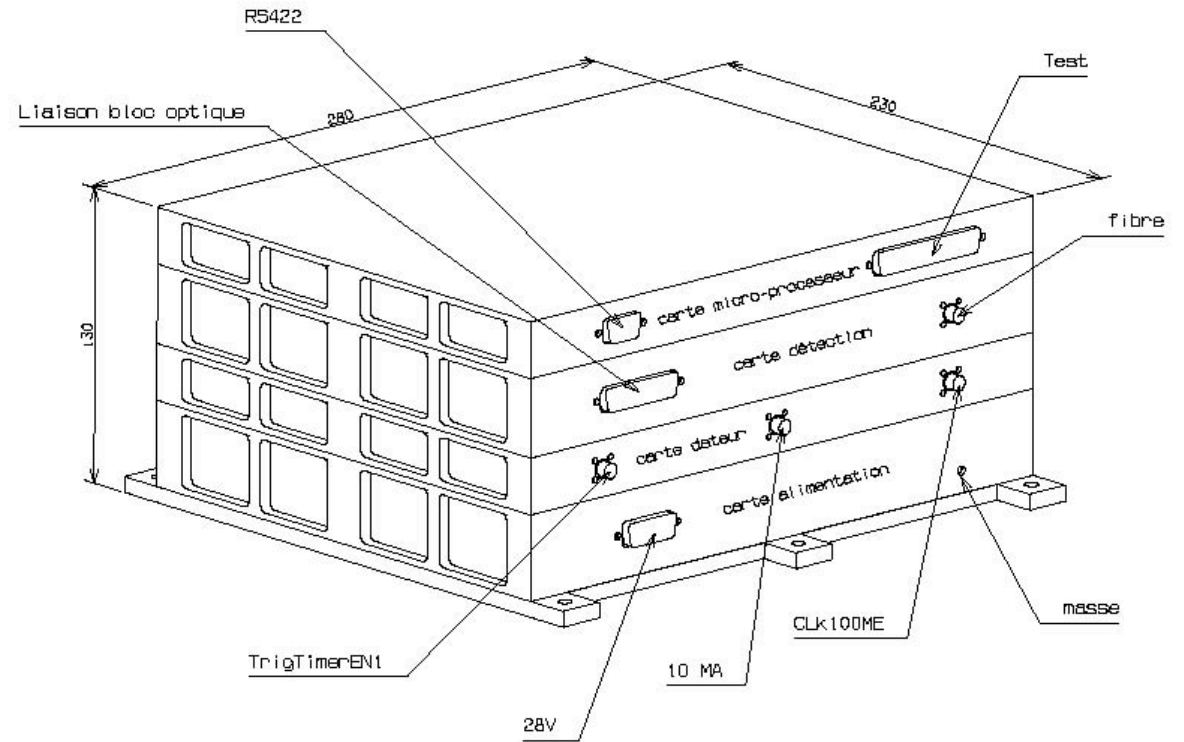
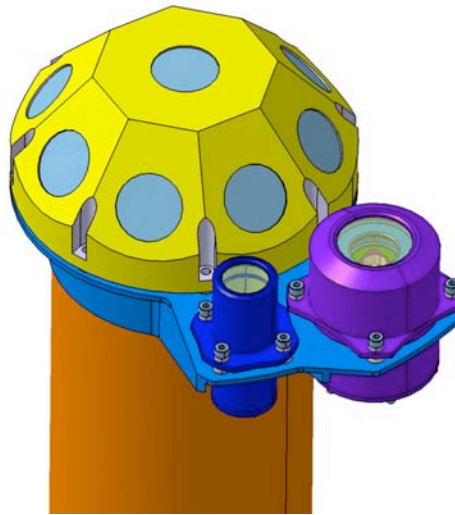
# Jason 2

- Ocean altimetry at the centimeter level
- Native Instruments
  - » Altimeter: Poseidon 3
  - » Radiometer
  - » Positioning systems: Doris - GPSP- Laser ranging
- Passenger Instrument
  - » Radiation Measurements: LPT & Carmen 2
  - » **Time Transfer : T2L2**
- Orbit
  - » Altitude 1336 km,  $i = 66^\circ$ ,  $P = 6800$  s
  - » Max distance in a common view mode : 6500 km
  - » Time interval between pass  $2h < T < 14h$
  - » 3 to 6 passes per day

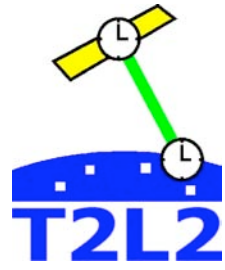




# T2L2 Space Instrument

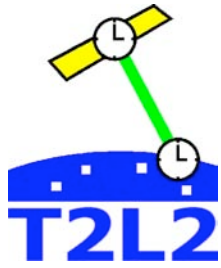


T2L2 - BOITIER ELECTRONIQUE



# Laser Station Specifications

- Wavelength 532 nm +/- 0.5 nm
- Pulse Width: 20 to 200 ps @ FWHM
- Minimum Energy per pulse : 10 mJ ; Nominal Energy: 50 mJ
- Maximum rate: above 1 kHz – Nominal rate: 10 Hz
- Elevation range: 5° to 90°
- No time synchronisation required



# Development plan

- B Phase: start 09/2005 ; end 01/2006
- CD phases : start 01/2006 ; end 11/06
- Jason2 integration : 01/2007
  
- T2L2 working group constitution 2006
- T2L2 Ground instrumentation 01/2007
- Laser ranging station upgrade : 2008
  
- Jason2 Launch : 06/2008
- End of exploitation : 2013



# GEOSAT Follow-On (GFO) Radar Altimeter Satellite

## **Satellite Laser Ranging (SLR) Tracking and Analysis Overview GSFC Report**

*ILRS Fall 2005 Workshop  
September 2005; Eastbourne, England*







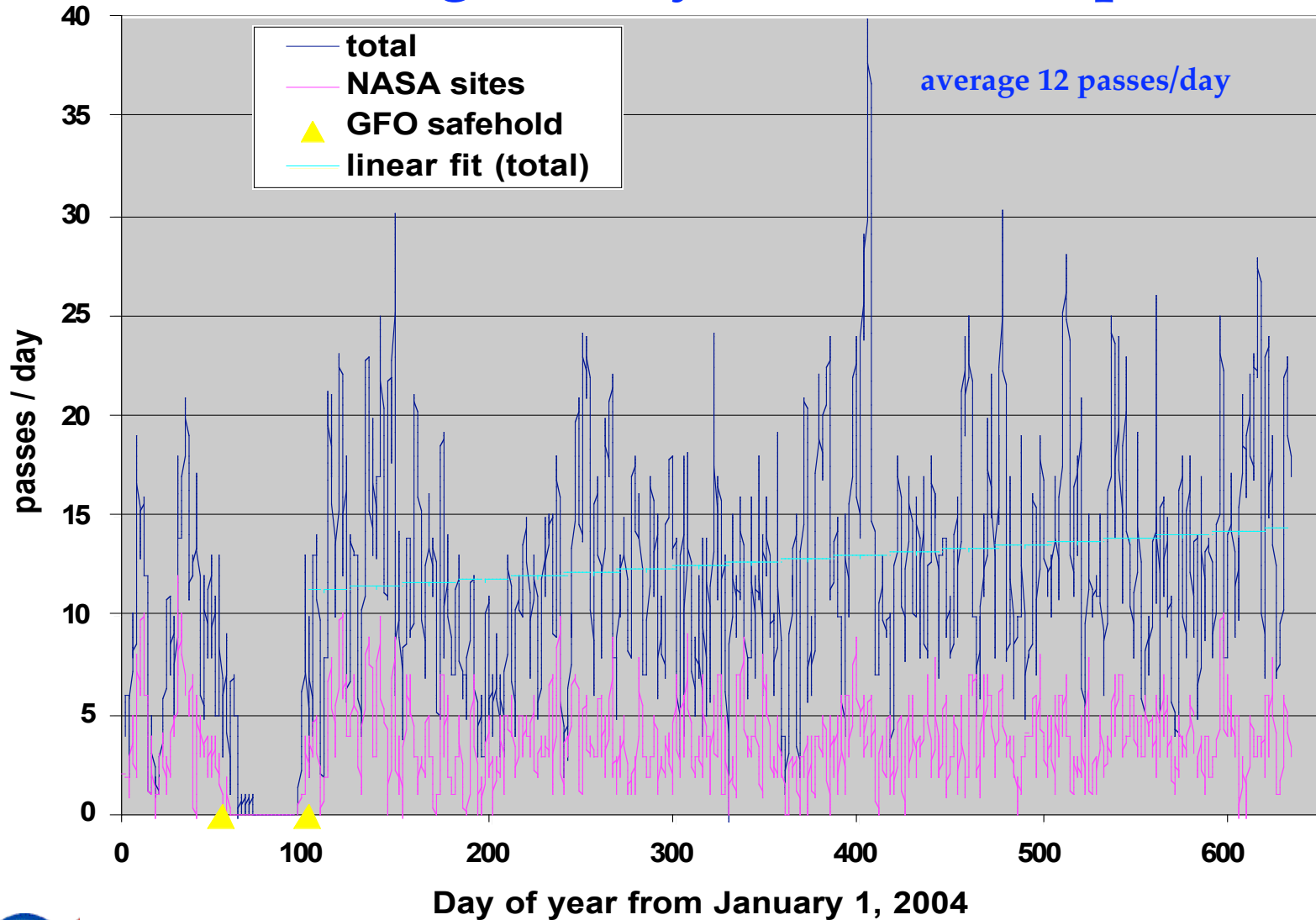
# Altimeter Error Budget

Component	Information source	Error (cm)
<b>Altimeter</b>		
<b>Instrument noise</b>	<b>Ball</b>	<b>1.9</b>
<b>Biases</b>	<b>Ball</b>	<b>3.0</b>
<b>Sea surface     (EM and skewness)</b>	<b>TOPEX</b>	<b>2.3</b>
<b>Troposphere</b>	<b>Ball</b>	<b>2.6</b>
<b>Ionosphere</b>	<b>Ball</b>	<b>1.7</b>
<b>SLR POD (radial orbit error)</b>	<b>GSFC</b>	<b>5.0</b>
<b>Total RSS</b>		<b>7.1</b>



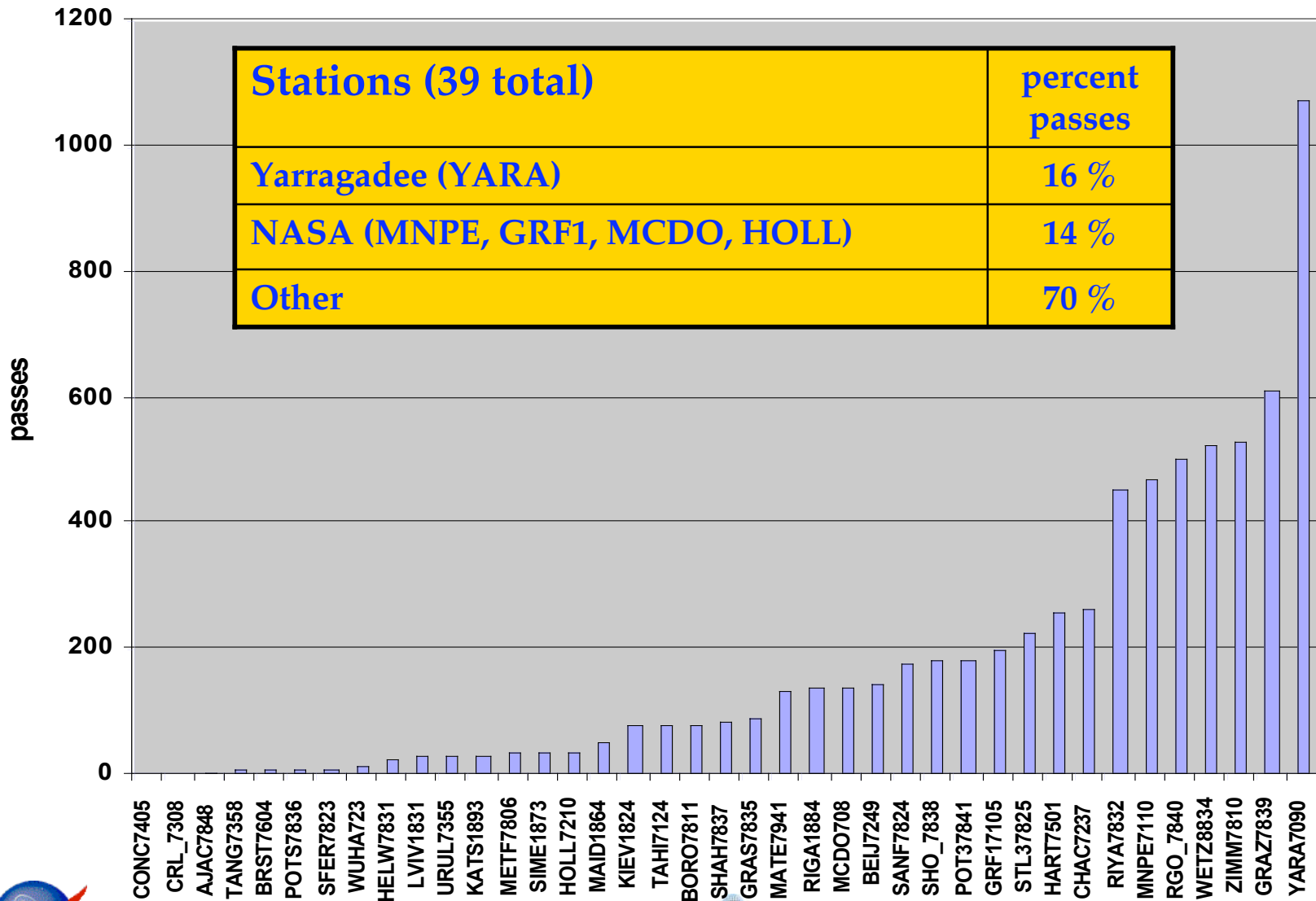


# SLR Tracking History: Jan 2004 - Sep 2005



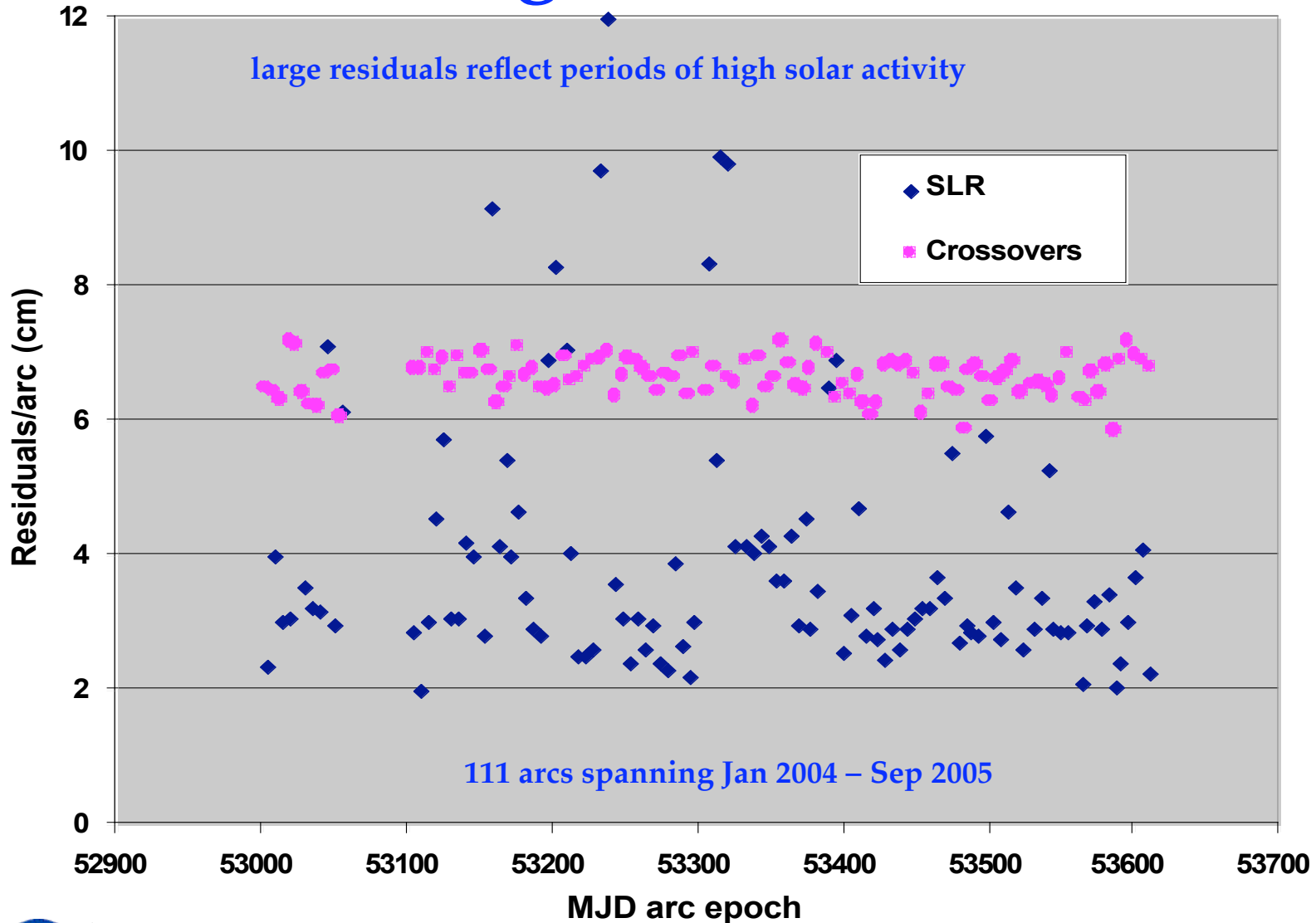


# SLR Station Tracking: Jan 2004 - Sep 2005





# Tracking Data Residuals





# GFO-1 Orbit Products

NASA GSFC computes two sets of orbits for GFO-1:

(1) daily Medium precision orbits (MOE's), exported daily to NOAA and NAVO (usually by COB local time, or ~21:00 to 22:00 UT).

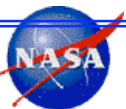
(2) precise orbits (POE's) are exported to NOAA with a latency of a few weeks, and are available via anonymous ftp.

All orbits rely on SLR, Doppler data, and altimeter crossovers. POE's have more crossover data due to altimeter data (IGDR) latency issues, and perhaps slightly more SLR data since they rely on a later import.

Orbits are available from [dirac.gsfc.nasa.gov](http://dirac.gsfc.nasa.gov) anonymous ftp:  
`cd pub/earth/gfo/moe/ & cd pub/earth/gfo/poe/` (TOPEX POE format).

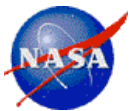
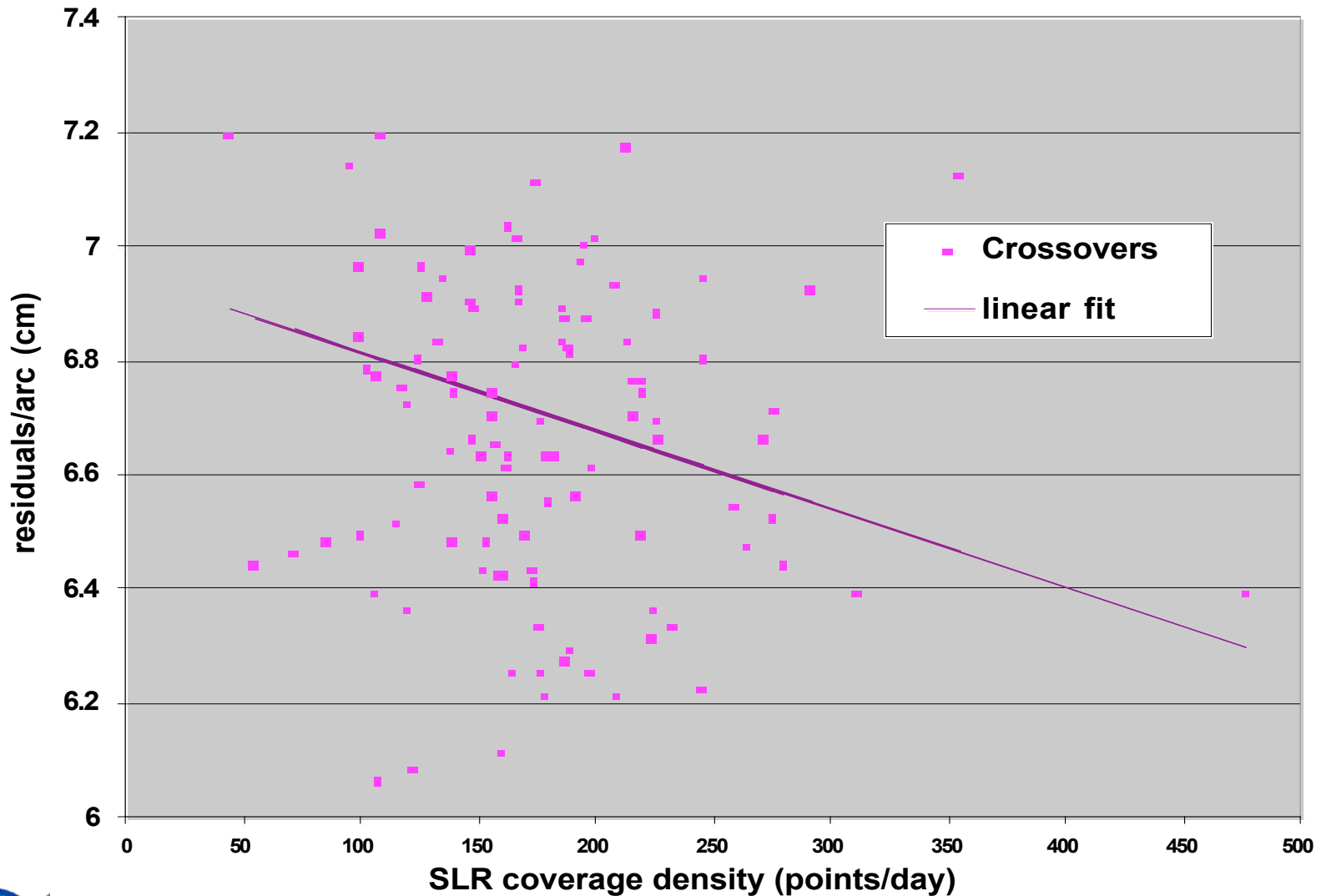
SLR predicts are sent to stations daily based on the MOE orbits. Special predicts are sent around spacecraft maneuvers, although sometimes we receive very late notification from the GFO Operations Team.

During approach of Hurricane Rita to Texas, MOE orbits were computed and sent to NOAA twice daily (morning and afternoon).





# GFO ~~Orbit quality improves with increased SLR coverage~~ coverage

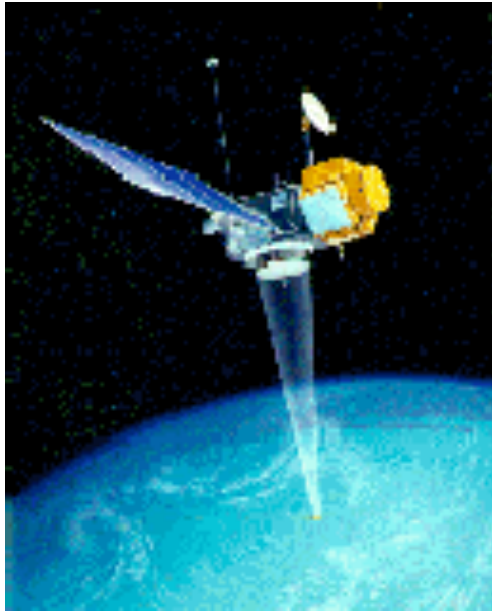




# GFO POD GSFC Points of Contact

- **Frank Lemoine**  
**Frank.Lemoine@gsfc.nasa.gov**
  
- **Nikita Zelensky**  
**nzelensky@sgt-inc.com**



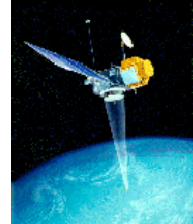


# TOPEX/Poseidon (T/P) Radar Altimeter Satellite

## **Satellite Laser Ranging (SLR) Tracking and Analysis Overview GSFC Report**

*ILRS Fall 2005 Workshop  
September 2005; Eastbourne, England*





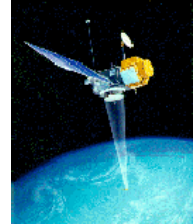
## Topex Mission status

The Topex/Poseidon altimeter is healthy and continues to return data from the interleaved orbit (ground tracks interleave with those of JASON-1).

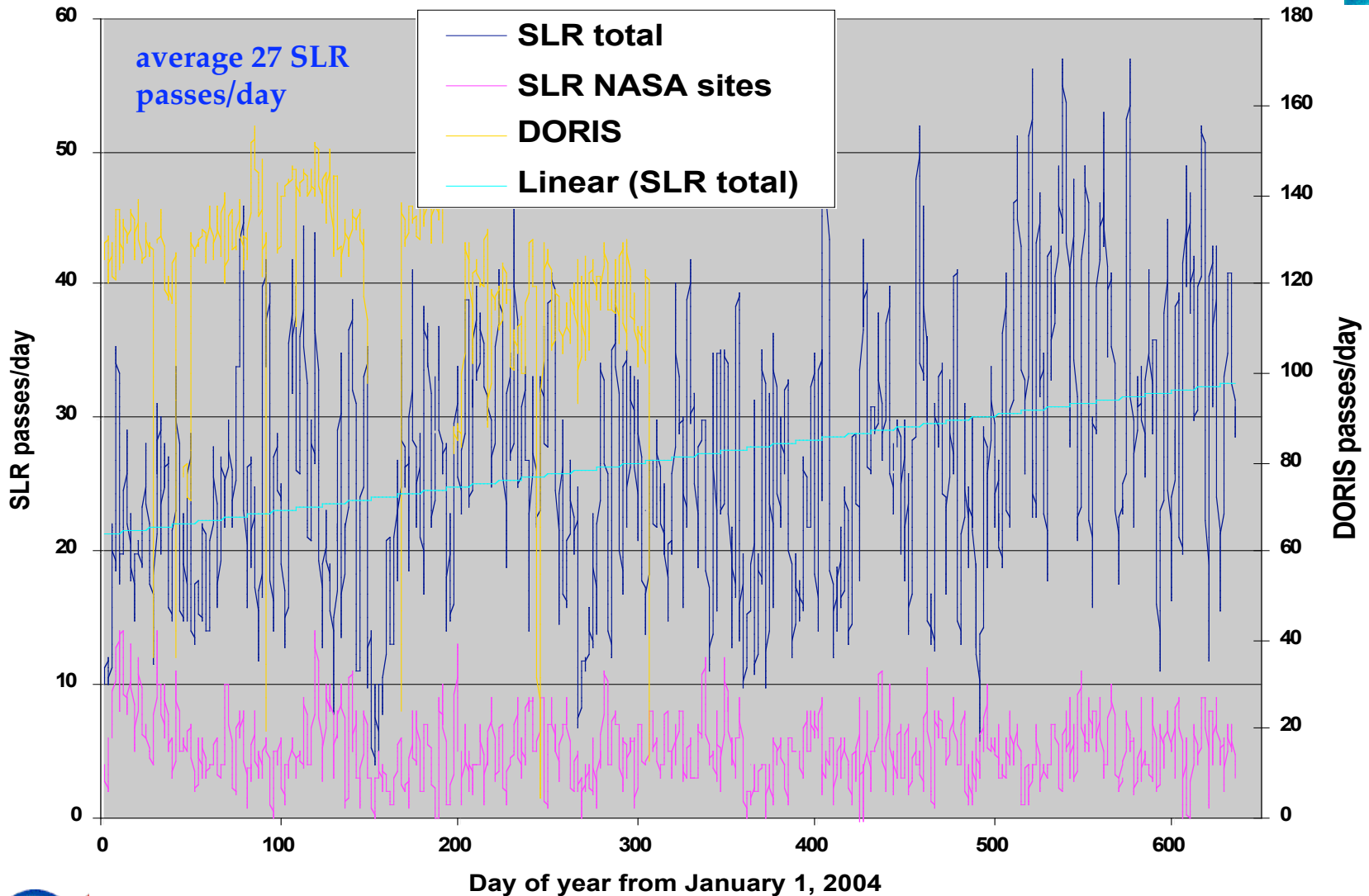
The second DORIS receiver failed in November 2004. POE's now rely on SLR data + altimeter crossovers.

Special OTST (ocean topography science team) meeting in Venice, March 2006.



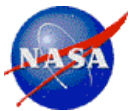
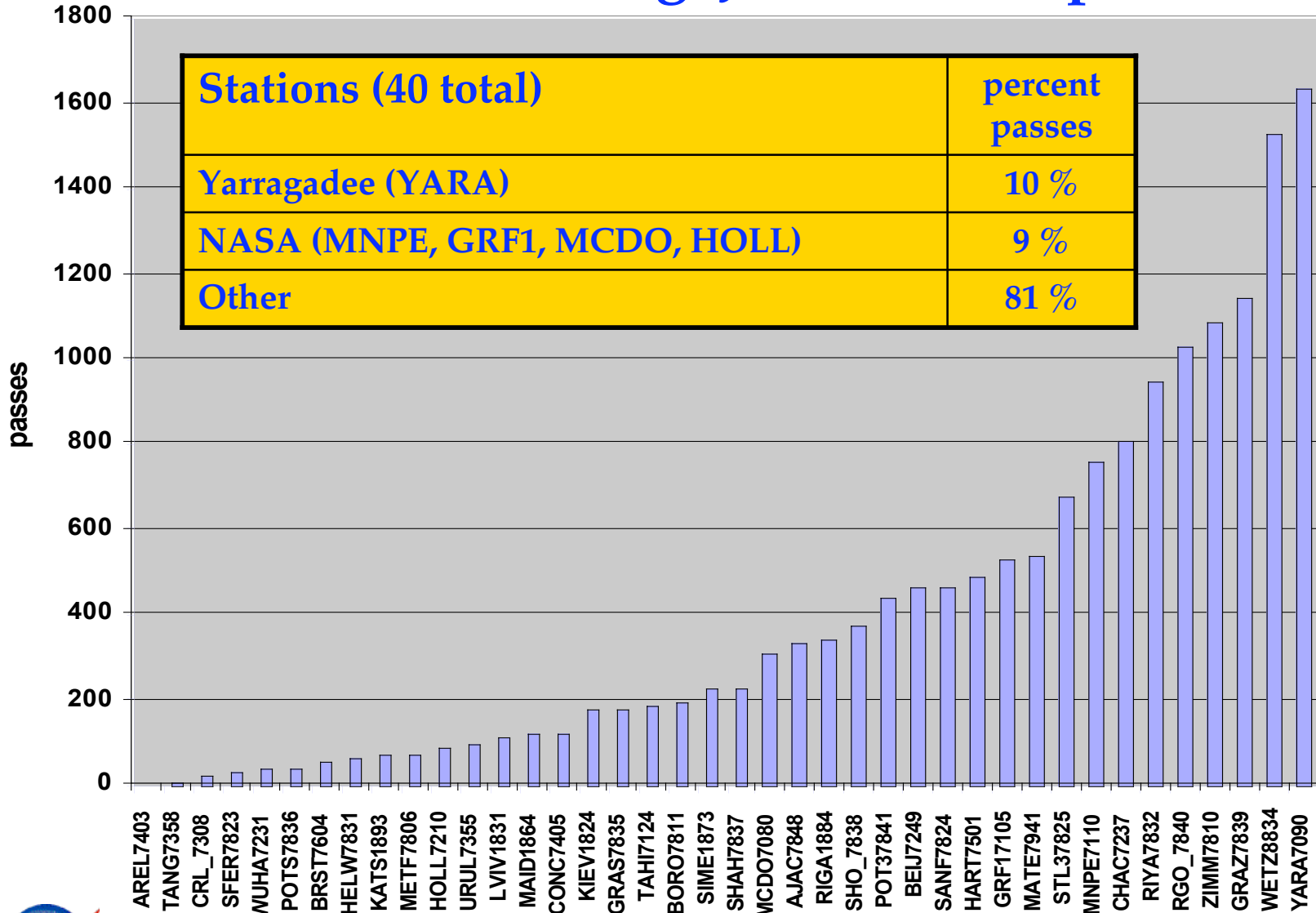
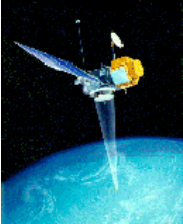


# Tracking History: Jan 2004 - Sep 2005

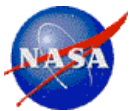
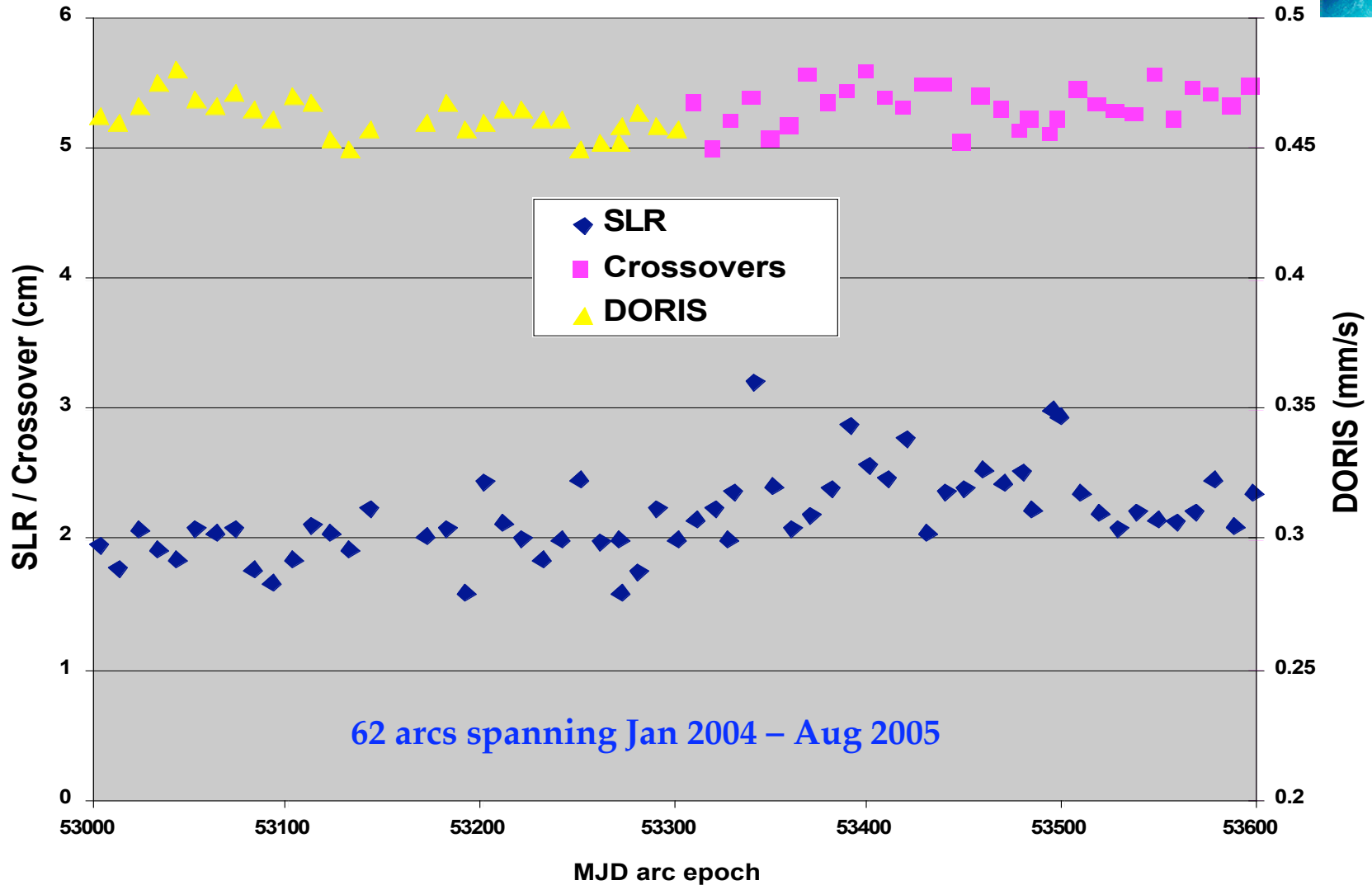
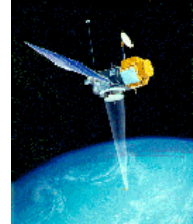


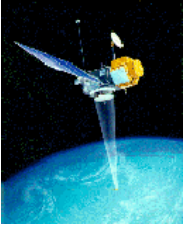


# SLR Station Tracking: Jan 2004 - Sep 2005



# Tracking Data Residuals / arc





# T/P POD GSFC Points of Contact

- **Frank Lemoine**  
**Frank.Lemoine@gsfc.nasa.gov**
  
- **Nikita Zelensky**  
**nzelensky@sgt-inc.com**



## Retro-Reflector Array for GPS Series III Satellites

- NASA is requesting new GPS satellites carry retro-reflectors (Mike Moreau and Yoaz Bar-Sever are making the science arguments). Launch now 2013.
- We have been told that space and mass will have tight constraints.
- Need to make the lidar cross-section for these new satellites at least 10x what existing GPS array has – to allow more stations to range and more daylight ranging.
- To gain more return energy while not increasing the mass, we are looking at hollow Beryllium cubes:
  - ~ 5 cm diameter
  - 40 cubes with holder would weigh ~ 1.2kg (same weight as existing GPS arrays)
  - lidar cross section = ~ 250 Million (or ~ 10 X existing GPS arrays)
- Hollow Beryllium cubes have been flown before: ADEOS-RIS & RME (Air Force) – both manufactured by PLX. RME cube was thermally stabilized. Difficult to gauge the cubes performance over time on both of these satellites.
- Concern about hollow cube integrity and performance over thermal cycling and gradients has prompted us to begin simulation testing. Currently being performed by Goddard's Mechanical Analysis Branch. Preliminary results indicate that (1) we need to add a thermal engineer to team, and (2) cube integrity may be too close to call with simulation – need to do laboratory testing.

# GLAS/ICESat

- A laser altimeter satellite, launched by NASA on January 13, 2003; SLR observations are used to verify and confirm GPS-based POD
- Instrument vulnerability and prudent operation that is oriented toward spacecraft safety has, so far, restricted SLR activity to a subset of the full ILRS network, presently 7 stations
- Automated go/nogo and maximum elevation restrictions have been implemented successfully
- Predictions are now distributed by UT/CSR in the CPF system, as well as standard TIV's
- We have requested Ajisai-like priority when the laser altimeter is not firing and normal ILRS priority, based upon inclination and altitude, when it is
- There have been 805 passes observed, comprised of 23,006 normal points, as of 29 September 2005
- Pre-fit SLR observations fit the GPS-derived orbit with an rms better than 2 cm





# **GLONASS Status. ILRS support for GLONASS.**

**V. D. Glotov**

Russian Mission Control Center

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**ILRS Fall 2005 Workshop**  
October 2-7, 2005, Eastbourne

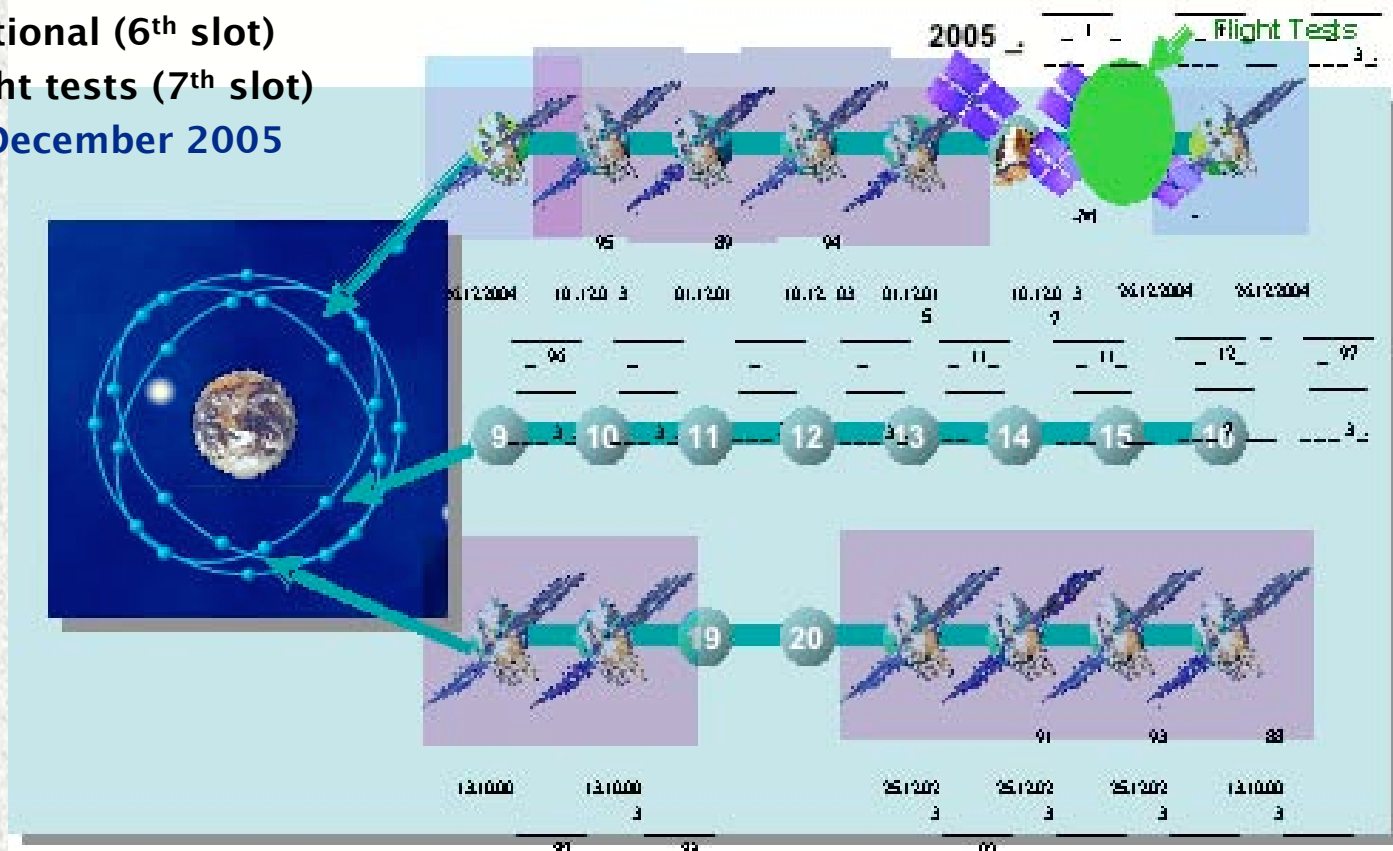
## Outline

- **GLONASS Status**
- **The IGS IGLOS – PP (Goals)**
- **GLONASS SLR data analysis**
- **Conclusions**

## 14 SV in orbit, 13 operational

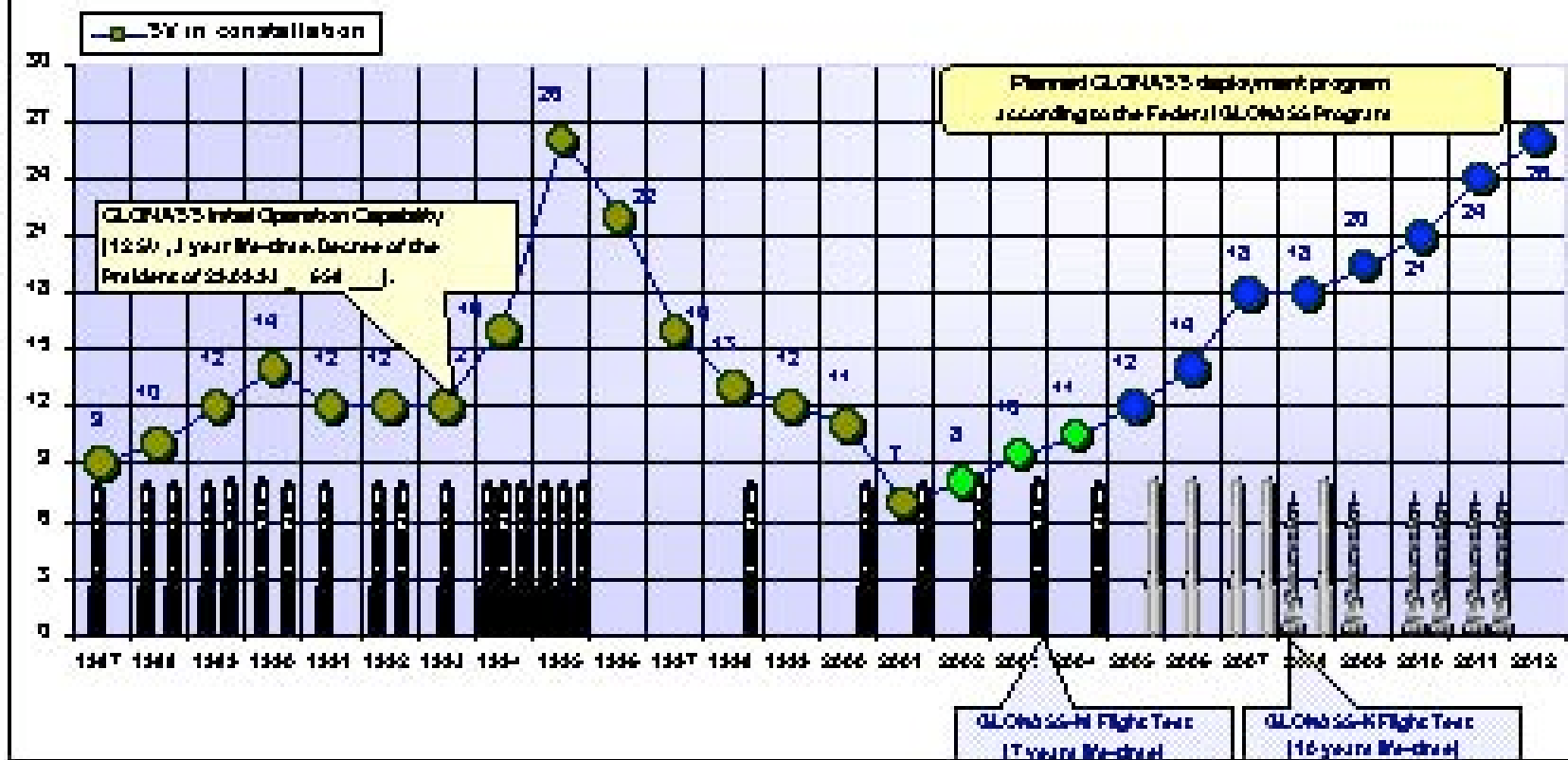
- 12 satellites «Glonass» (3 years life-time):
  - ❑ All operational
- 2 satellites «Glonass-M» (7 years life-time)
  - ❑ One operational (6<sup>th</sup> slot)
  - ❑ One in flight tests (7<sup>th</sup> slot)
- Next launch - December 2005

Block 34  
Launch:  
December



# History and Perspectives of the GLONASS Constellation

GLONASS Deployment Program. History and Progress.

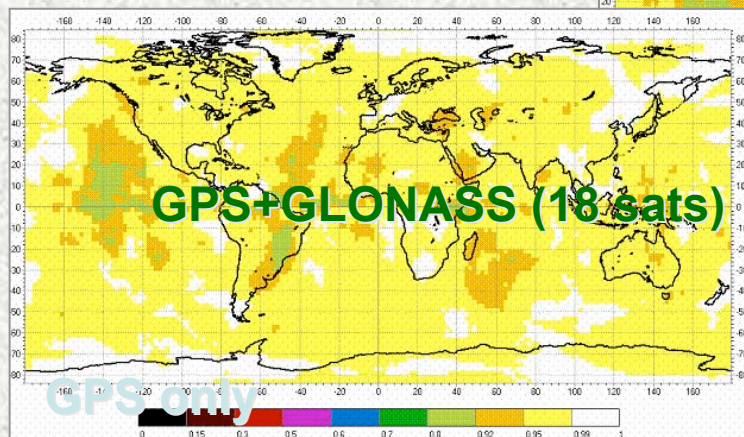
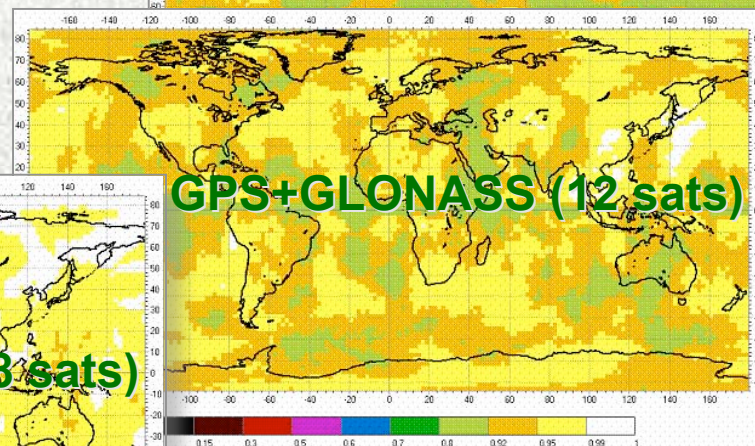
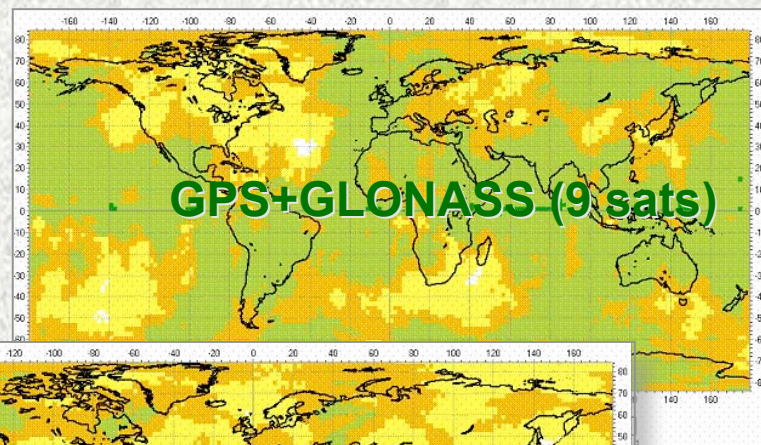
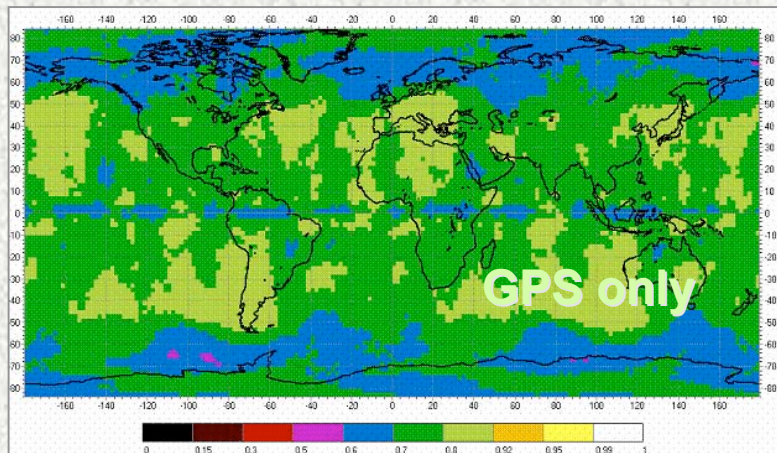


## GLONASS deployment milestones:

- ❑ 18 satellites in constellation - 2007
- ❑ 24 satellites in constellation - 2010-2011



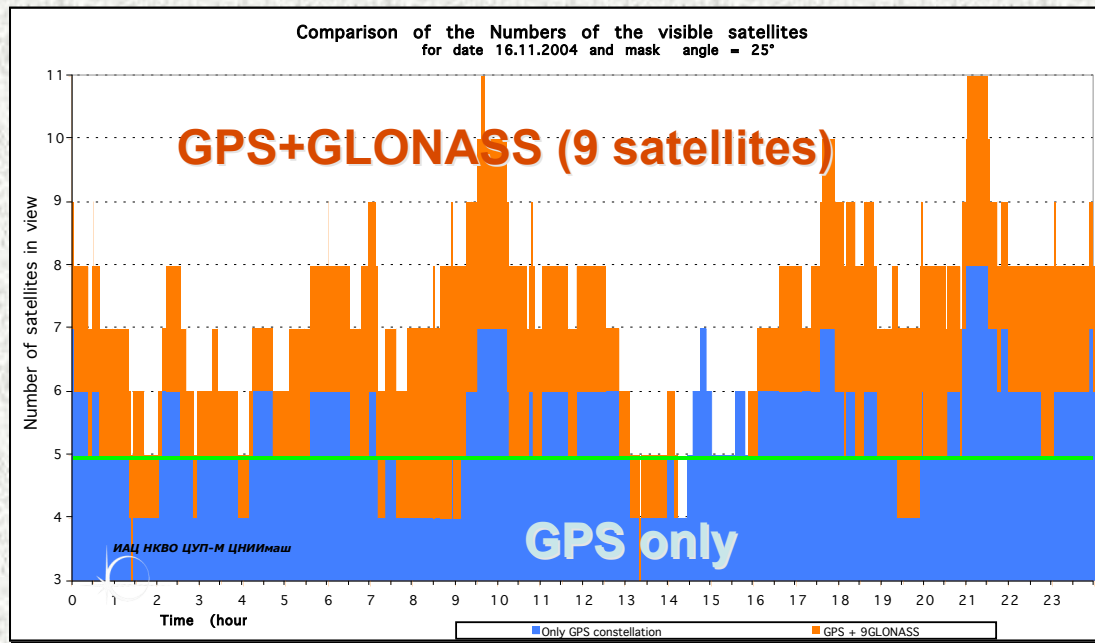
## Advantage of Positioning Availability for Urban and Canyon Conditions (GDOP < 5, mask angle 25°)





## Real-Time Precision Navigation for construction and geodesy (GDOP<5, угол места 25°)

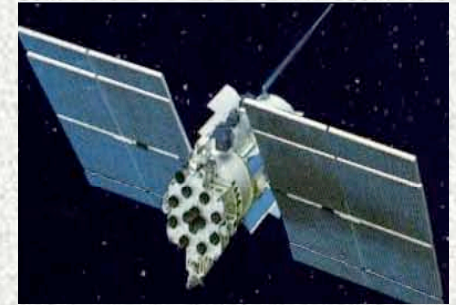
### Number of satellite visible for Moscow region during a day



- **Continuous navigation during a day:**
  - ❑ With GPS only **83.1%**
  - ❑ With GPS + GLONASS (9 satellites) **100%**

## IGLOS Pilot Project

The International GLONASS – Pilot Project (IGLOS–PP) is a pilot service of the International GPS Service (IGS) to track and analyse data from the Russian GLONASS satellite constellation. The products from the Service should facilitate the use of combined GLONASS and GPS observations for scientific and engineering applications, and allow users to experiment with the combined systems



**as a prototype Global Navigation Satellite System.**

The **ILRS** supports this effort by a continuous tracking of three GLONASS satellites as part of their standard tracking protocol and by delivering precise GLONASS orbits through one of its Analyses Centers (MCC)

## GLONASS satellites currently tracked by ILRS stations

**GLONASS-87**

**Plane 1 Slot 3**

**GLONASS-84 (95)**

**Plane 3(1) Slot 24 (7)**

**GLONASS-89**

**Plane 3 Slot 22**



Time interval: 07.08.2005 – 03.09.2005

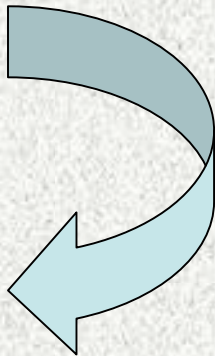
SC	Passes	Stations
GLONASS-24	172	16
GLONASS-22	188	14
GLONASS-03	167	12
Total	527	18

## STATISTICS

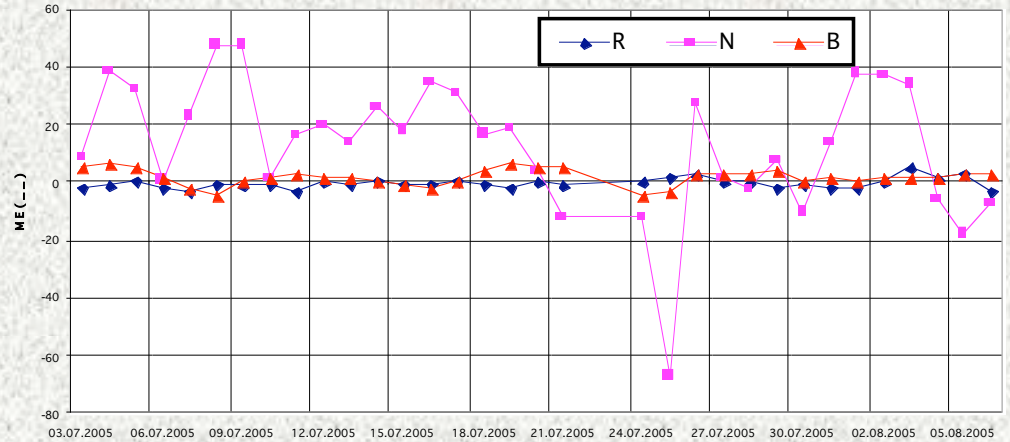
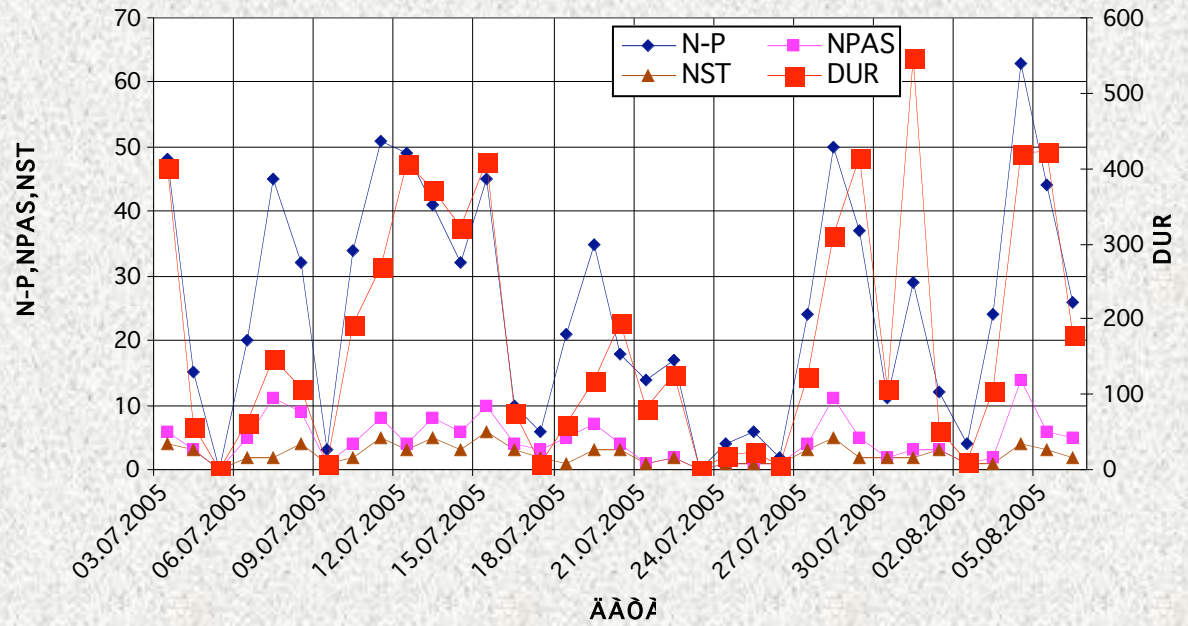
DATE	N - P	NPAS	NST	DUR	GPS WK	COMMENTS
2005.08.07	28	5	4	122	13350	
2005.08.08	34	9	4	262	13351	
2005.08.09	44	7	3	325	13352	
2005.08.10	66	9	5	531	13353	
2005.08.11	91	7	4	894	13354	
2005.08.12	19	2	2	195	13355	BAD
2005.08.13	44	5	4	591	13356	
2005.08.14	3	1	1	12	13360	BAD
2005.08.15	7	2	2	29	13361	BAD
2005.08.16	19	5	3	158	13362	
2005.08.17	42	5	2	318	13363	



SLR data

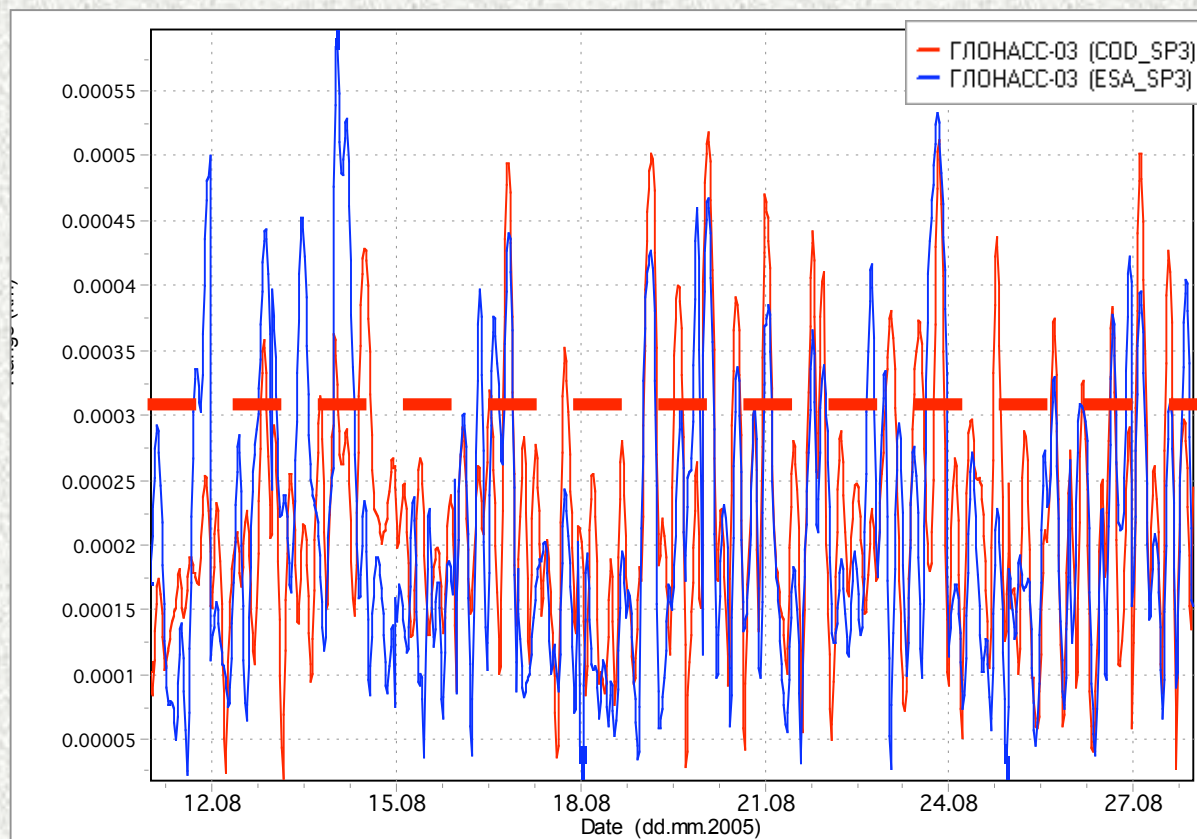


Orbit accuracy



## ➤ GLONASS orbit based on IGS data

- ❑ IAC – Mission Control Center (Korolyov)
- ❑ CODE – European Orbit Determination Center (Bern)
- ❑ ESOC – European Satellite Operation Center (Darmstadt)



**30 cm**

**Deviation of post-processing orbit between three centers**

## Conclusions

- **ILRS support is very important for GLONASS modernization**
- **Need to continue/increase tracking of GLONASS satellites by ILRS:  
Collocation in space (Microwave / Laser)**
- **IGLOS-PP demonstrates the extensibility of IGS to accommodate other microwave systems (GLONASS, GALILEO).**



# Thank you for your attention!

Vladimir Glotov  
Satellite Navigation Department of the Mission Control Center of  
the Central Research Institute of Machine Building,  
FEDERAL SPACE AGENCY

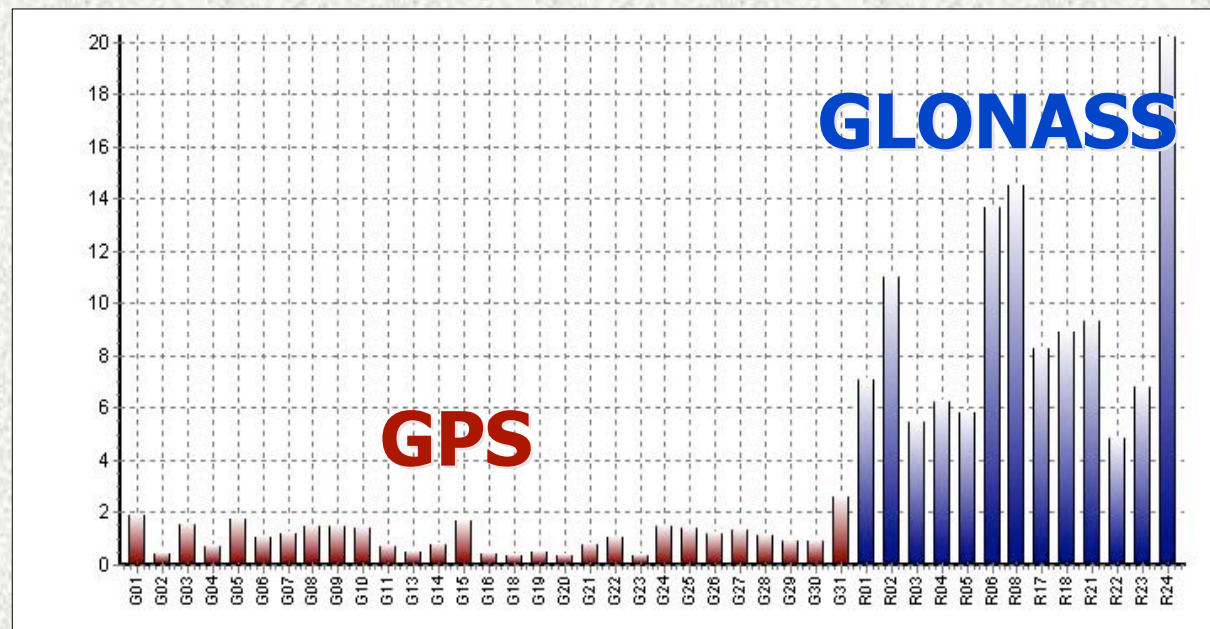
[vladimir.glotov@mcc.rsa.ru](mailto:vladimir.glotov@mcc.rsa.ru)

fax: +7 095 586 8380

- Problems of pure present GLONASS performances
  - ❑ New satellite – outdated ground control assets
  - ❑ Limited area for orbit tracking (Russian territory)
  - ❑ Time keeping system needs to be modernized

**SISRE, m**

**20.03.2005 –  
20.06.2005**

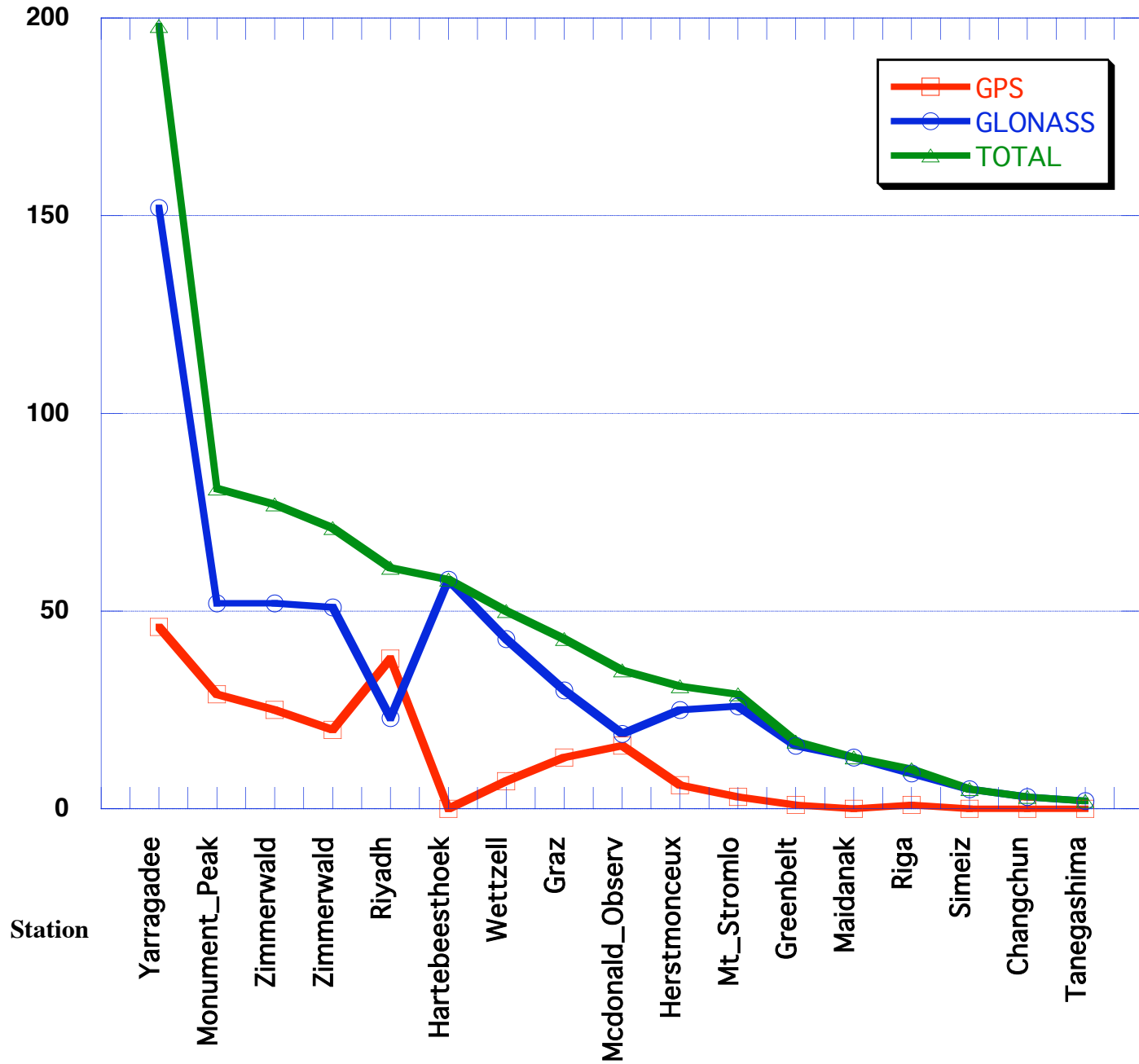


**The GLONASS Accuracy Improvement Program  
is in implementation**

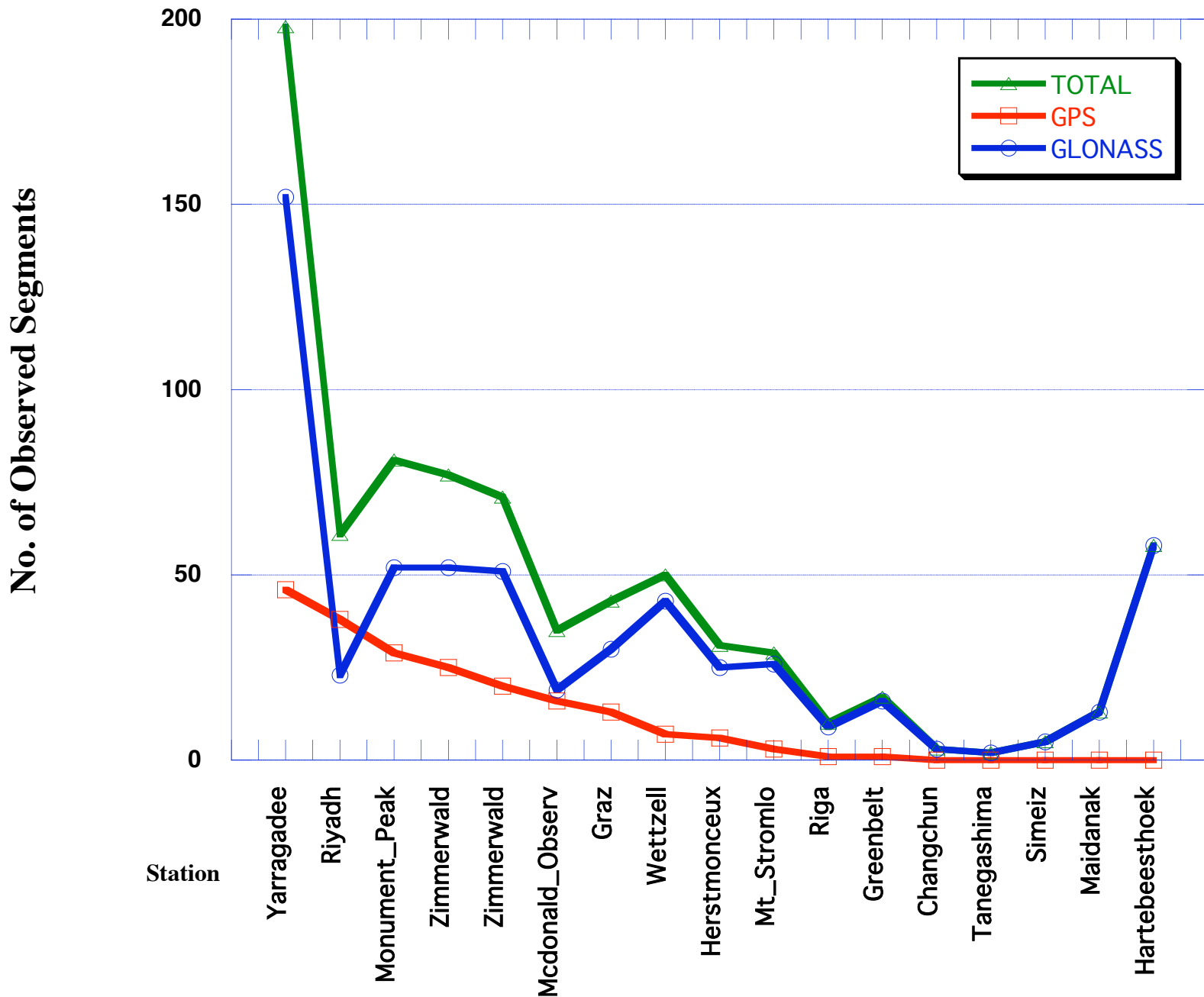


# No.6106 - CONT05 by TOTAL

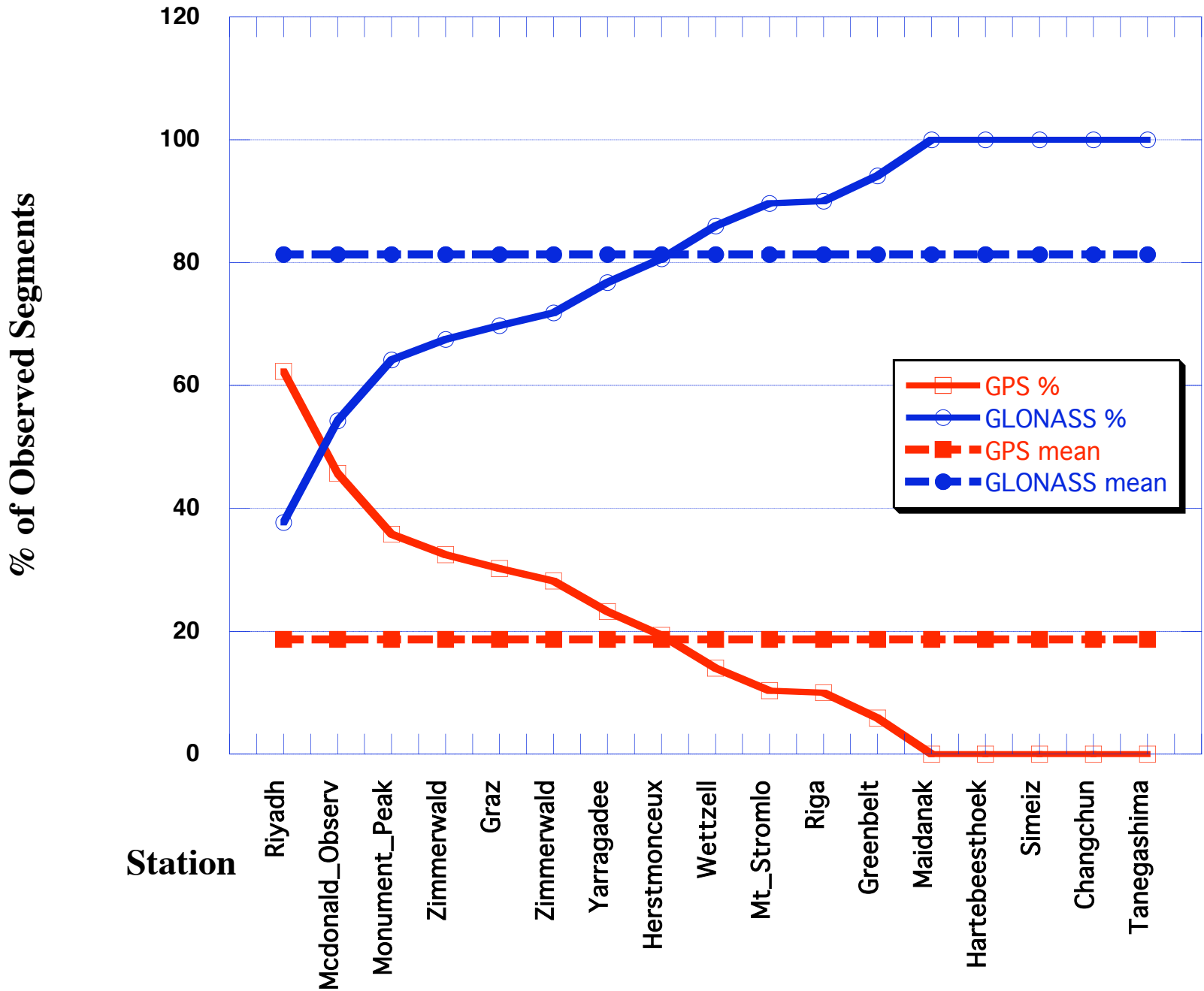
No. of Observed Segments



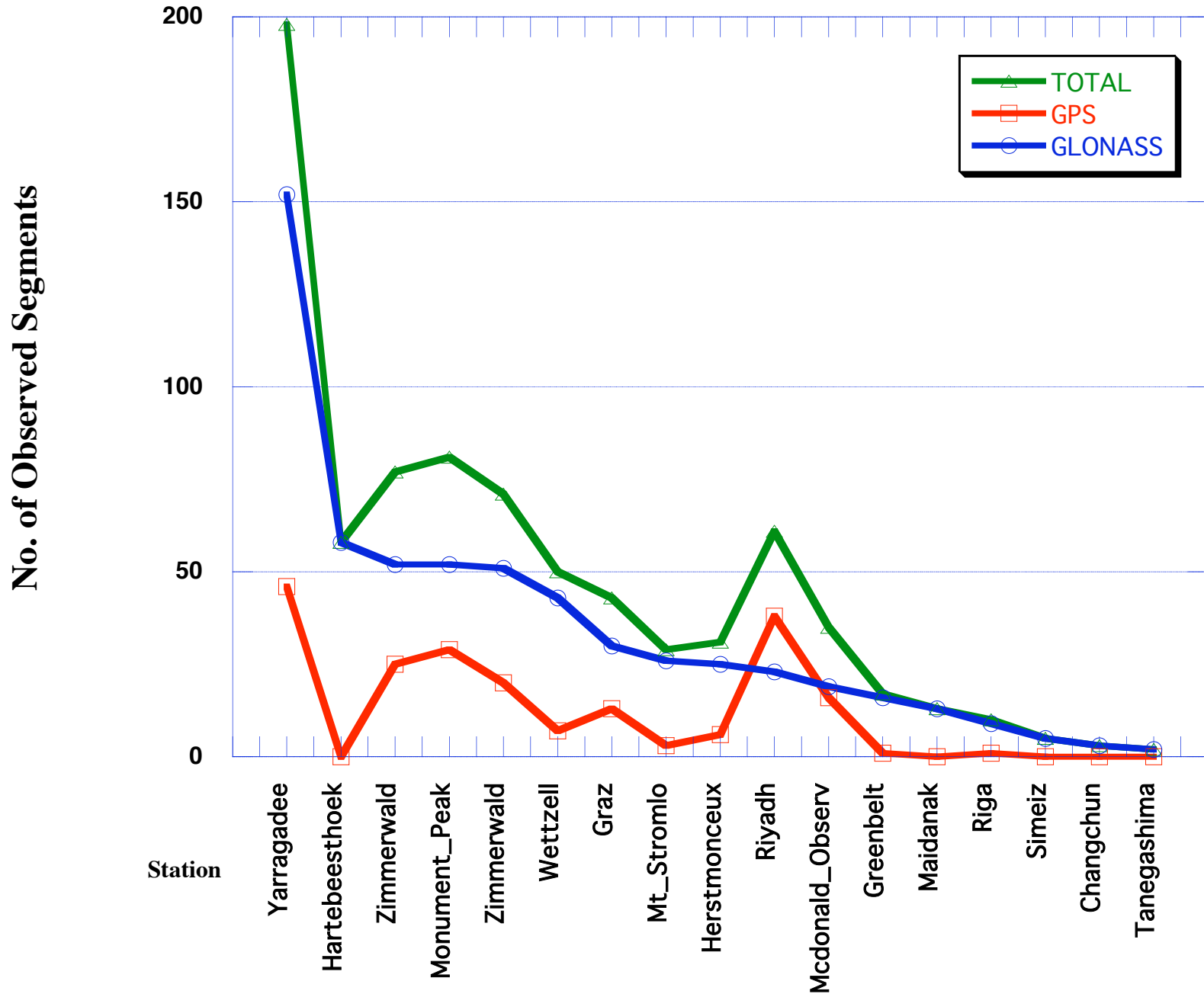
# No.6106 - CONT05 by GPS



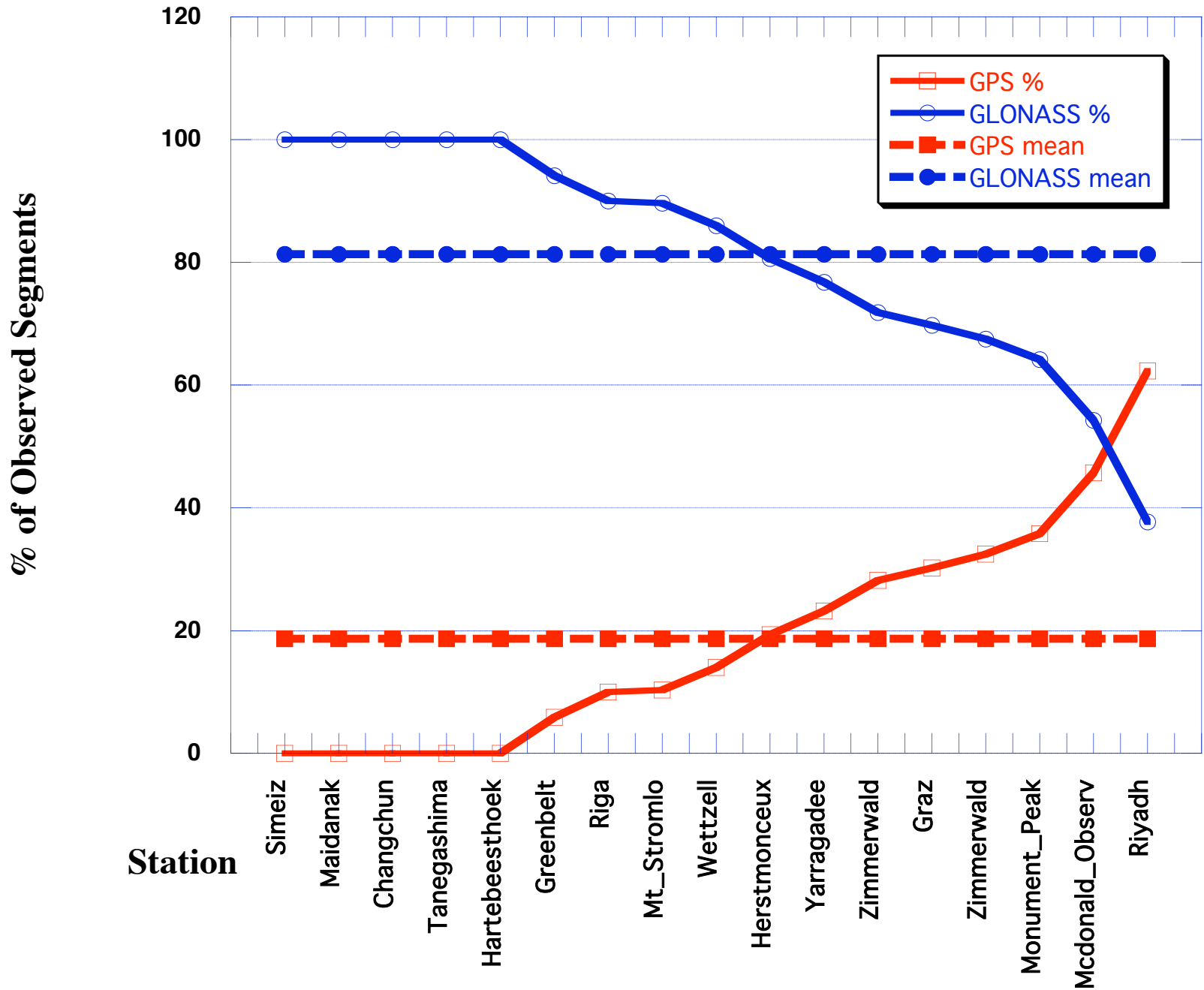
# No.6106 : CONT05 - GPS %



# No.6106 - CONT05 by GLONASS



# No.6106 : CONT05 - GLONASS %







# **Zero-Signature Spherical Retroreflector Micro-Satellite**

## **Current Status of Device and Mission**

**V.D. Shargorodsky and V.P. Vasiliev  
Institute for Precision Instrument Engineering  
Moscow, Russia**

# Zero-Signature Spherical Retroreflector Micro-Satellite

## Microsatellite parameters

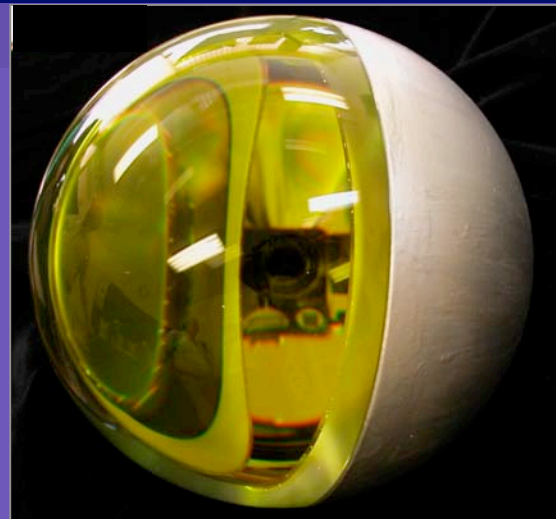
- Diameter: 17 cm
- Mass: 7.46 kg
- Cross-section: ~100,000 sq. m at  $\lambda=532$  nm

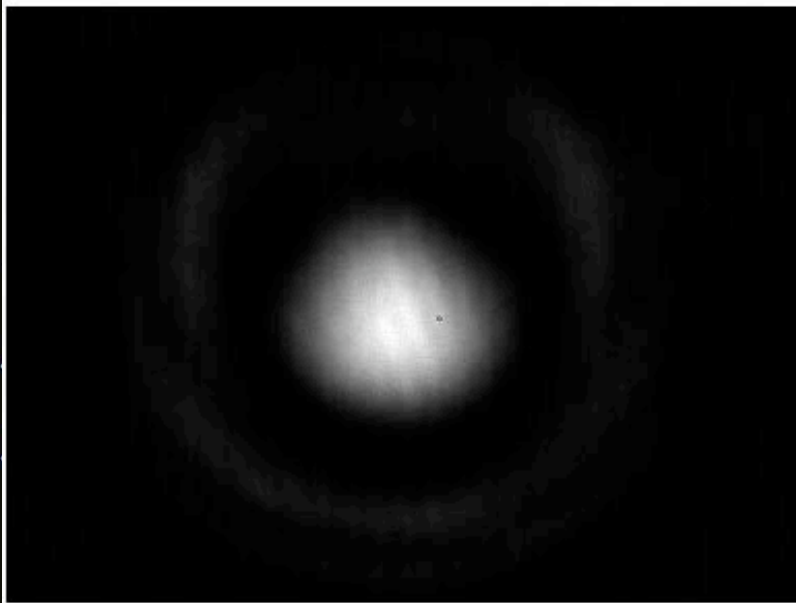
## Current status

- Return pattern measurement under varying ambient conditions
- Separation system development

## Mission

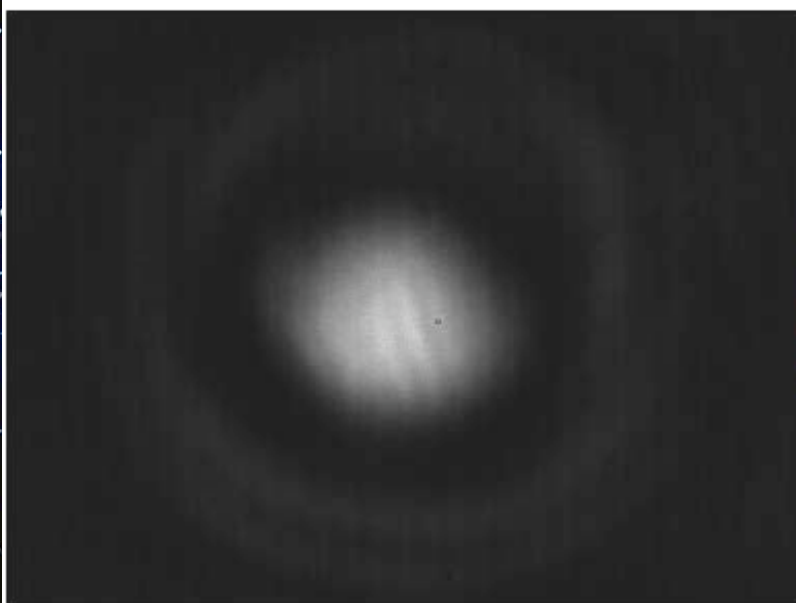
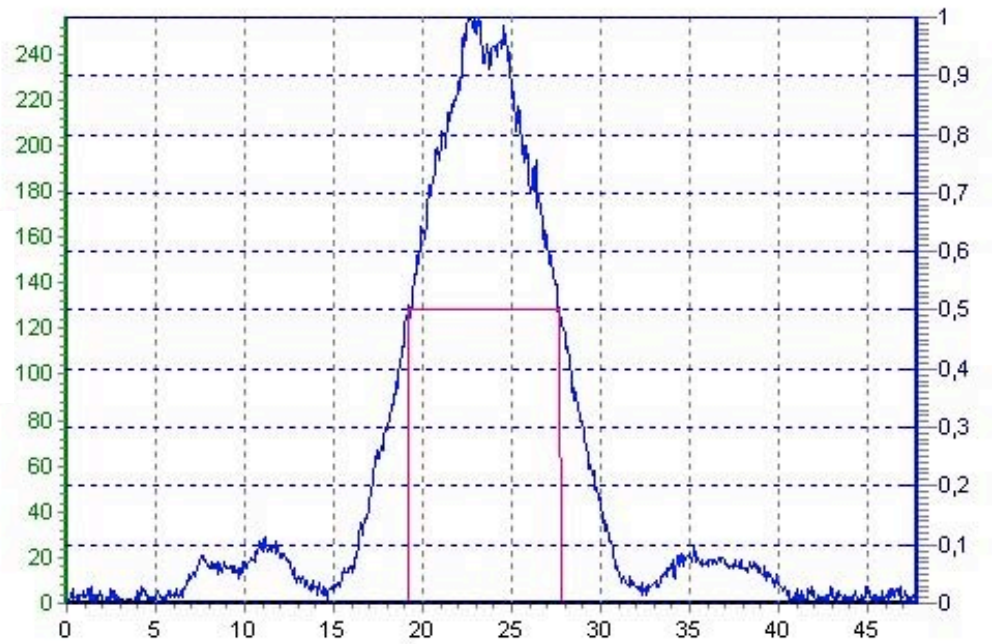
- Carrier satellite: CORONAS-PHOTON
- Carrier satellite orbit parameters: Height: ~600 km (circular)  
Inclination: 82.5°
- Planned launch date: September 2007





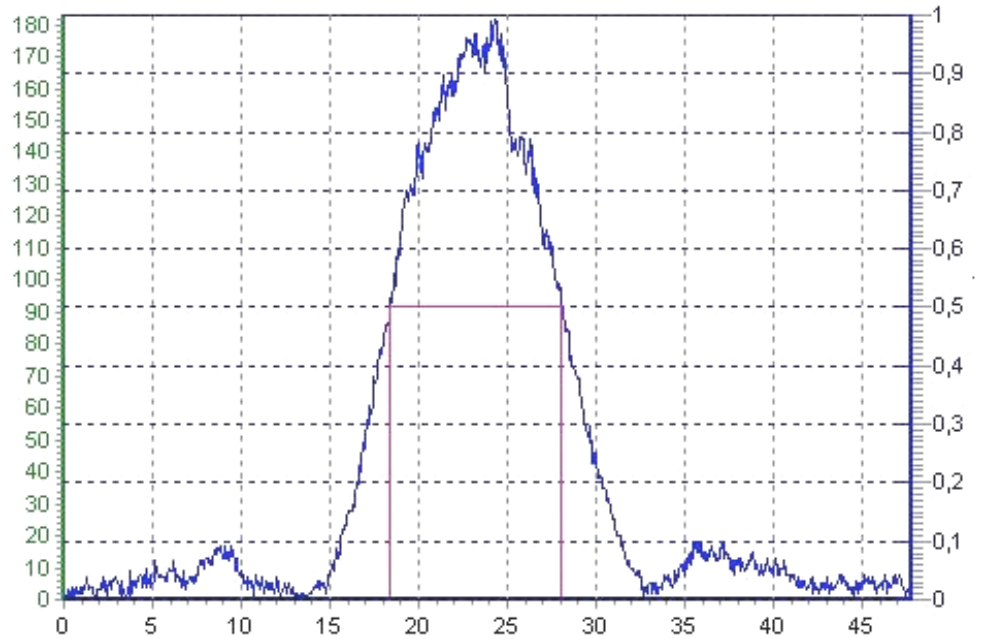
0 deg

FWHM 8.5 arcsec



80 deg

FWHM 9.6 arcsec



# “Easy-Deployment” Tracking Station



## BASIC PARAMETERS

- Wavelength: 532 nm
- Pulse repetition rate: 300 pps
- Pulse energy: 3 mJ
- Pulse duration: 250 ps
- TX/RX telescope diam: 25 cm
- Detector: MCP PMT
- Modular design:  
each module <50 kg

## First Tracking Results

Return rate:

- ERS-2 : up to 200 pps
- GLONASS: up to 3 pps



# GGOS Update

11<sup>th</sup> ILRS General Assembly  
October 07, 2005  
Eastbourne, UK



# Global Geodetic Observing System (GGOS)

A project of the IAG

# **Global Geodetic Observing System (GGOS) Mission**

- **Ensure the collection, archiving and accessibility of all geodetic observations and models as well as the robustness of the estimated parameters in the three fields of geodesy (1) geometry and kinematics, (2) orientation and rotation, and (3) gravity field of the Earth.**
- **Emphasize the consistency between the different geodetic standards, models and products, and the maintenance of stable geometric and gravimetric reference frames.**
- **SLR is a key element for these objectives because it contributes to all three fields. Due to the very long observation and derived parameter series it guarantees the long-term stability more than any other geodetic technique.**

# Global Geodetic Observing System (GGOS) Structure (Status: 02 March 2005)



# GGOS Highlights over the Last Year

- **Activities underway to get GGOS integrated with several international science and political activities**
- **GGOS website at <http://www.ggos.org>**
- **Preliminary Draft Plan accepted at the GGOS Session at IAG in Cairns in August 22 – 26**
- **Presentations and Working Group Posters given at IAG**
- **New leadership – Retiring Chair Chris Reigber replaced by Marcus Rothacher**
- **Ruth Neilan and Han-Peter Plag chosen as Co-chairs**
- **Mike Pearlman, Ruth Neilan, C.K. Shum, Hermann Drewes, Susanna Zerbini, Bernd Richter, and Chris Rizos selected as IAG representatives to GEO (GEOSS)**

# **GGOS Ground Networks and Communications Working Group**

- **Task: “working with the IAG Measurement Services to develop a strategy for building, integrating, and maintaining the fundamental network of instrument and supporting infrastructure in a sustainable way to satisfy the long-term (10 – 20 years) requirements identified by the GGOS Science Council.”**
- **Early stops in this process:**
  - **quantify the “quality” of what the current networks are producing**
  - **settle on a strategy to design the geodetic network using our understanding of where we are, where the techniques are going, and what future scientific requirements we will be asked to support.**



## Members of the Working Group

- GGOS: Marcus Rothacher, Ruth Neilan
- IVS: Chopo Ma, Zinovy Malkin
- IGS: Angie Moore, Norman Beck
- ILRS: Mike Pearlman, Werner Gurtner
- IDS: Pascal Willis
- IGFS: Rene Forsberg, Steve Kenyon
- Data Centers: Carey Noll
- ITRF and Local Survey: Zuheir Altamimi, Jinling Li
- Analysis: Erricos Pavlis, Frank Lemoine, John Ries
- Oceanography: Wolfgang Bosch

# How do we optimize the networks?

- Focus primarily on the Reference Frame;
- Target (initially) mm accuracy for relatively short time periods;
- Long time series of data is critical to the stability of the reference frames; maintain high-producing, well-established;
- Degradation of the reference frames may be slow as networks degrade; the “memory factor” may be strong;
- Reference Frame relies on collocation of techniques with accurate intertechnique ground surveys;
- Using the most recent International Terrestrial and Celestial Reference Frames (ITRF, ICRF), examine the contribution of each technique;
- Optimize each network (SLR, VLBI, DORIS, GPS/GNSS based on its strongest or unique contributions to the reference frames and the other required geodetic products.
  - VLBI : Nutation, UT1, Polar Motion
  - SLR: Earth Center of Mass, Scale, POD on passive satellites, etc
  - GPS: Station position and motion; POD for LEO satellites, Navigation
  - DORIS: POD for DORIS satellites
- Using simulation techniques examine how the key products for each technique improve as
  - Network geometry improves;
  - Station performance improves;
  - Satellites are added
- **Commitment: Provide first report on network design at EGU in Vienna in April 2006**

# Anticipated Technique Improvements

## SLR

- Better global distribution;
- KiloHertz ranging
- Autonomous operations
- Improvements in control systems for better interleaving of satellites
- Inter-station scheduling to enhance satellite coverage
- More compact retroreflector arrays to improve accuracy
- Continuous data flow and more rapid availability of products
- Transponder operations for terrestrial and extraterrestrial applications
- Communications applications

## GPS

- New satellites with GNSS signal
- GLONASS and Galileo
- Improved processing (to provide near real time orbits?)

## VLBI

- Improve automation to overcome observation gaps
- Improvements in the recorders

## DORIS

- Smaller antenna and fully digitized back-ends
- DORIS
- G3 Beacons
- Launch of additional satellites with DORIS tracking (e.g., Cryosat);
- Dual channel tracking capability allowing a densification of the network

## Poster Papers Presented at Cairns

- “The International Laser Ranging Service and its Support for GGOS”, M. Pearlman, C. Noll, W. Gurtner, R. Noomen,  
( [http://cddis.gsfc.nasa.gov/docs/ILRS\\_IAG\\_0508.pdf](http://cddis.gsfc.nasa.gov/docs/ILRS_IAG_0508.pdf))
- “GGOS Working Group on Networks, Communication, and Infrastructure”, M. Pearlman, et al,  
([http://cddis.gsfc.nasa.gov/docs/GGOS\\_IAG\\_0508.pdf](http://cddis.gsfc.nasa.gov/docs/GGOS_IAG_0508.pdf))

## **Upcoming Meetings:**

**October 10-11, 2005: IERS Combination Pilot Project Workshop in  
Potsdam, Germany**

**December 5-9, 2005: Fall AGU in San Francisco, CA**

**February 27-March 03, 2006: IGS Workshop in Darmstadt, Germany**

**April 3-7, 2006: EGU in Vienna, Austria**

**October 16-20, 2006: 15th International Workshop on Laser Ranging  
in Canberra, Australia**





**EOS**

**15<sup>th</sup> ILRS WORKSHOP  
CANBERRA, AUSTRALIA  
16 – 20 OCTOBER 2006**

# 15<sup>th</sup> WORKSHOP



- DATES:** Mon 16 to Fri 20 October 2006
- VENUE:** National Convention Centre, Civic  
Booked.
- HOTEL:** Crowne Plaza, Binara St., Civic  
100 rooms reserved. It is the nearest  
hotel to the venue.
- WEBSITE:** Draft site has been set up.  
Internet address to be advised when  
it has real information in it.

# 15<sup>th</sup> WORKSHOP



## **PROPOSED THEME: “EXTENDING THE RANGE”**

(ranging distance to & beyond lunar; scope, e.g. debris tracking, transponders, satellite attitudes,..; geographic coverage; etc.)

## **RECOMMENDED PROGRAM COMMITTEE**

Ben Greene (Chair)

Ramesh Govind

Hiroo Kunimori

Ron Noomen

Mike Pearlman

Peter Shelus

Mark Torrence

Georg Kirchner

Ulrich Schreiber

# 15<sup>th</sup> WORKSHOP



## LOCAL ORGANIZING COMMITTEE

Ron Thompson (Chair)

Ben Greene

Craig Smith

John Luck

Chris Moore

Ramesh Govind

Jennifer Mullaney

[jmullaney@eos-aus.com](mailto:jmullaney@eos-aus.com)

COME TO CANBERRA  
16 – 20 October, 2006



Tie your schedule down, sport,  
Come to Canberra Town.  
It's in October next year, sport,  
So come on down, come on down!!!

PLEASE



**Resolutions**  
**ILRS General Assembly**  
**Eastbourne, UK**  
**October 4, 2005**

- 1. Recognizing the degradation of SLR products including EOP, POD, etc, that occurs as a result of the lapse of data suffered during weekends (especially Sundays):**

*The ILRS requests that all stations strive toward 24 –7 operations. In the meantime, stations should make every effort to expand operations to include at least one shift of operations on Saturdays and Sundays.*

- 2. Recognizing the essential role of accurate ground survey at each station for both ground control (including ground targets) and inter-technique vectors in the quality of the ranging data and the terrestrial reference system:**

*The ILRS reminds stations that they have the responsibility of assuring that ILRS mandated ground surveys are conducted, analyzed, and properly reported at the prescribed quality and frequency.*

# Resolutions (continued)

3. Recognizing the importance of (a) improved predictions accuracies and (b) the need to go to extended ranges (transponders, etc), the ILRS will transition to Consolidated Prediction Format (CPF) by mid-2006 and therefore:

*The ILRS recommends that stations transition to the CPF in an expeditious manner.*

4. Recognizing the severe lack of global distribution in the laser ranging network:

*The ILRS urges stations and operating groups to consider relocating laser ranging stations from densely occupied areas to areas without coverage.*

5. Recognizing the need to reach 1 mm accuracy ranging:

*The ILRS encourages the continued development of zero-signature targets for geodetic satellites.*

# Resolutions (continued)

6. Recognizing the need for mm ranging and operations to targets at extended range:

*The ILRS recommends that stations strongly consider including event timers in their upgrading plans.*

- 7 Recognizing the importance of bias-free SLR data to the quality of the ILRS data products:

*The ILRS requests that all laser stations strive to reduce variable systematic effects in their range measurements.*

8. Recognizing the limitations imposed by the atmospheric refraction on the ultimate accuracy of laser ranging and that the Matera Laser Ranging Station is in a unique position to pursue two-wavelength refraction recovery studies:

*The ILRS strongly recommends that the Matera Station continue two-wavelength studies with the intent of verifying refraction recovery to an accuracy of better than 1 mm.*

## Resolutions (continued)

9. Recognizing the current dearth of both high satellite and lunar ranging data:

*The ILRS requests that the Matera Station put special emphasis on high satellites and lunar ranging to help fill the current severe void in these areas.*

10. Recognizing the lack of any lunar ranging data in the Southern Hemisphere:

*The ILRS strongly supports the activities of the Hartebeesthoek Observatory toward the implementation of Lunar Ranging in South Africa and cooperative plans with other organizations that may help to provide hardware and other support.*

11. Considering the importance of (a) locating geodetic observatories in the Southern Hemisphere and (b) colocating three or more geodetic techniques for the development and implementation of the Terrestrial Reference Frame:

*The ILRS strongly supports the continued development and operation of the TIGO system in Concepcion.*

## Resolutions (continued)

12. Recognizing the recent significant progress in the development of SLR2000 and the potentially significant improvement in network capability offered by this system:

*The ILRS urges NASA to bring the prototype system to fruition as soon as practically possible.*

13. The ILRS endorses and welcomes the EOS/GA organization of the Fifteenth International Workshop in Canberra, Australia, on October 16 – 20, 2006 and encourages ILRS members to participate.
14. The ILRS recognizes the very important work done by the Refraction Study Group and expresses its appreciation to Stefan Riepl for his leadership of the Study Group.
15. The ILRS and the meeting participants express their sincere gratitude to the Organizers and NERC Space Geodesy Facility at Herstmonceux for their kind hospitality and organization of the Eastbourne Workshop.