ILRS Governing Board

Westin San Francisco Market Street
San Francisco, CA

December 06, 2011
19:00-21:30

ILRS Governing Board Agenda

1.	Opening Remarks	G. Appleby
2.	Central Bureau Update	M. Pearlman/C. Noll
3.	GGOS Activities	M. Pearlman
4.	Update on Missions	G. Appleby/S. Wettzell
5.	CRD Format Conversion	R. Ricklefs/C. Noll
6.	Quality Control Data Reports	T. Otsubo
7.	Analysis and Data Products	E. Pavlis
8.	Data Flow Issues	C. Noll/E. Pavlis/R. Ricklefs
9.	Task Force Reports	
	a. Communications	M. Torrence
	b. Spacecraft Center-of-Mass Corrections	G. Appleby/T. Otsubo
	c. Beam Divergence	M. Davis
	d. In Sky Safety	
10.	Station Status Reports	
	a. NGSLR	J. McGarry
	b. KASI	J. Park
	c. Other reports	
11.	Update on GNSS Ranging	G. Appleby
12.	Lunar Laser Ranging	J. Mueller
13.	Website Development	C. Noll
14.	ILRS Special Issue in Journal of Geodesy	E. Pavlis
15.	Bi-Annual Report	C. Noll
16.	Other Business	M. Pearlman

International Laser Ranging Service

ILRS Central Bureau Report

Westin San Francisco Market Street
San Francisco, CA

December 06, 2011
19:00-21:30

ILRS Governing Board 2011-2012

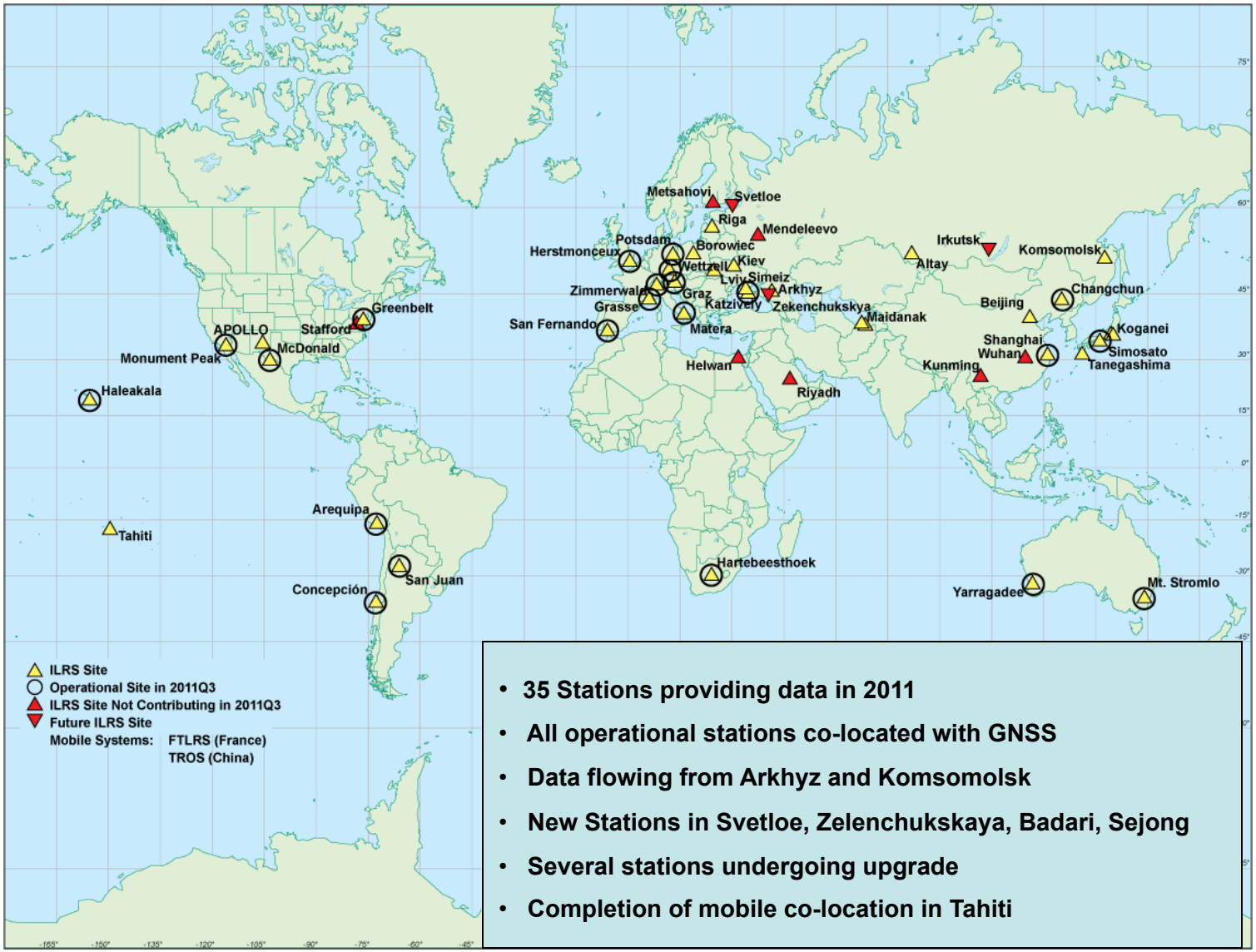
Director of the Central Bureau	Mike Pearlman (appointed)
Secretary of the Central Bureau	Carey Noll (appointed)
President of IAG Commission 1	Tonie Van Dam (appointed)
IERS Representative	Bob Schutz (appointed)
EUROLAS Network Representatives	Giuseppe Bianco, Francis Pierron
NASA Network Representatives	David Carter, Jan McGarry
WPLTN Network Representatives	Ramesh Govind. Hiroo Kunimori
Data Center Representative	Horst Mueller
LLR Representatives	Juergen Mueller
Analysis Representatives	Cinzia Luceri, Erricos Pavlis
At-Large Representatives	Graham Appleby*, Georg Kirchner

* Chair

ILRS Working Groups

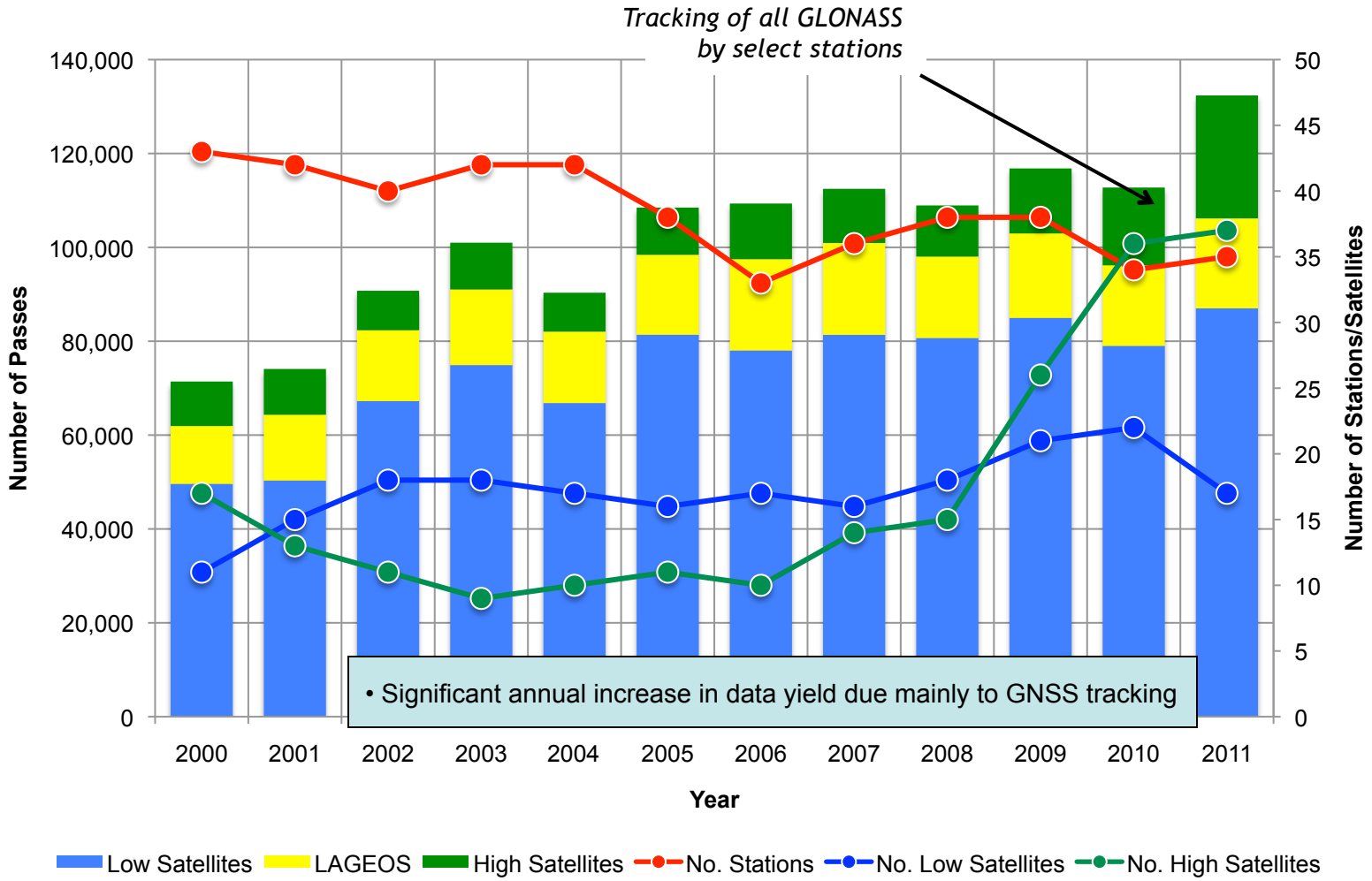
- Analysis
  - E. Pavlis/C. Luceri
- Missions
  - G. Appleby/S. Wetzel
- Data Formats and Procedures
  - H. Mueller/R. Ricklefs
- Networks and Engineering
  - G. Kirchner/M. Wilkinson
- Transponder
  - U. Schreiber/J. Degnan/J. McGarry

International Laser Ranging Service (ILRS) Network in 2011 Q3



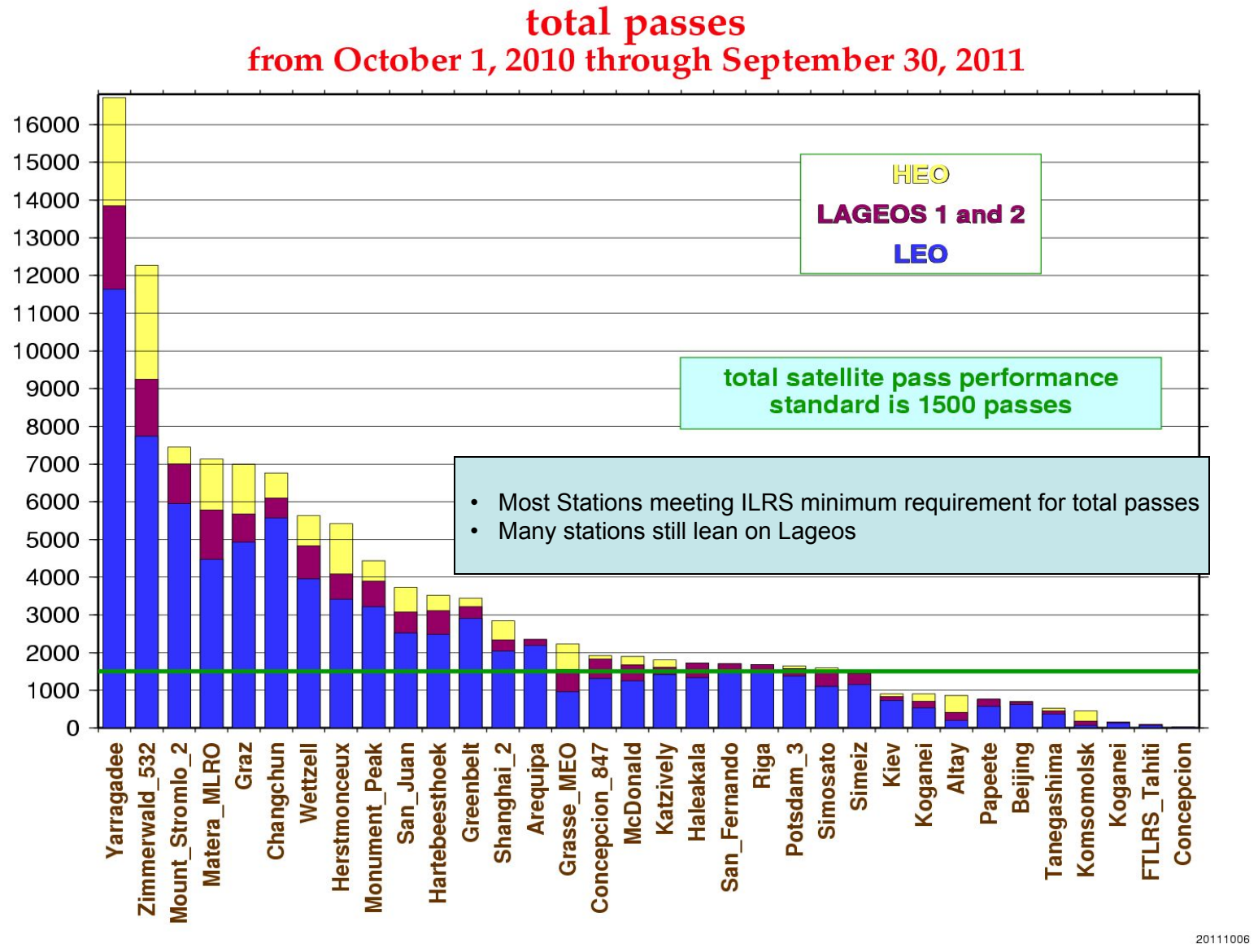
- **35 Stations providing data in 2011**
- **All operational stations co-located with GNSS**
- **Data flowing from Arkhyz and Komsomolsk**
- **New Stations in Svetloe, Zelenchukskaya, Badari, Sejong**
- **Several stations undergoing upgrade**
- **Completion of mobile co-location in Tahiti**

2011 Annual Data Yield

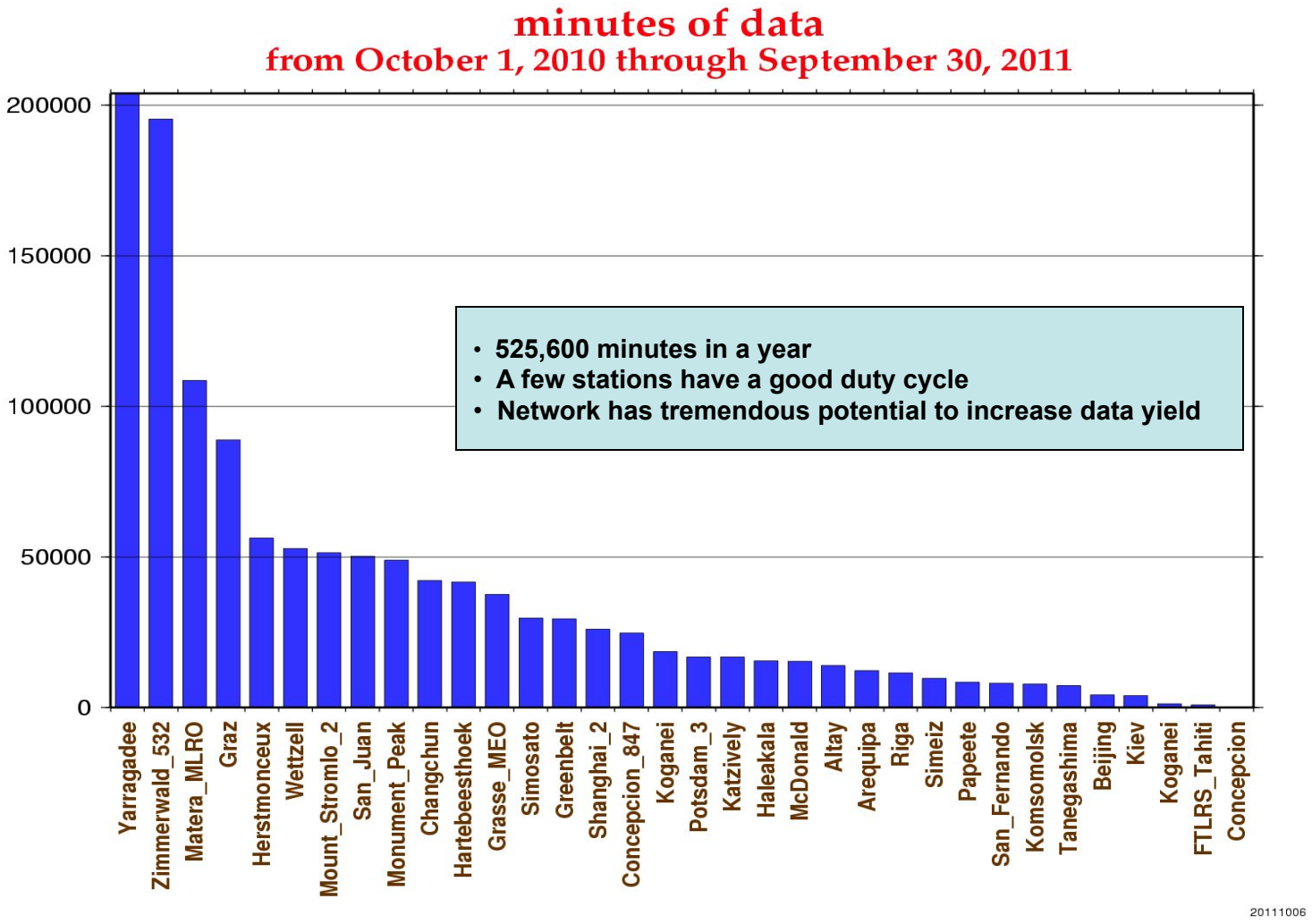


Note: 2011 totals pro-rated to full year

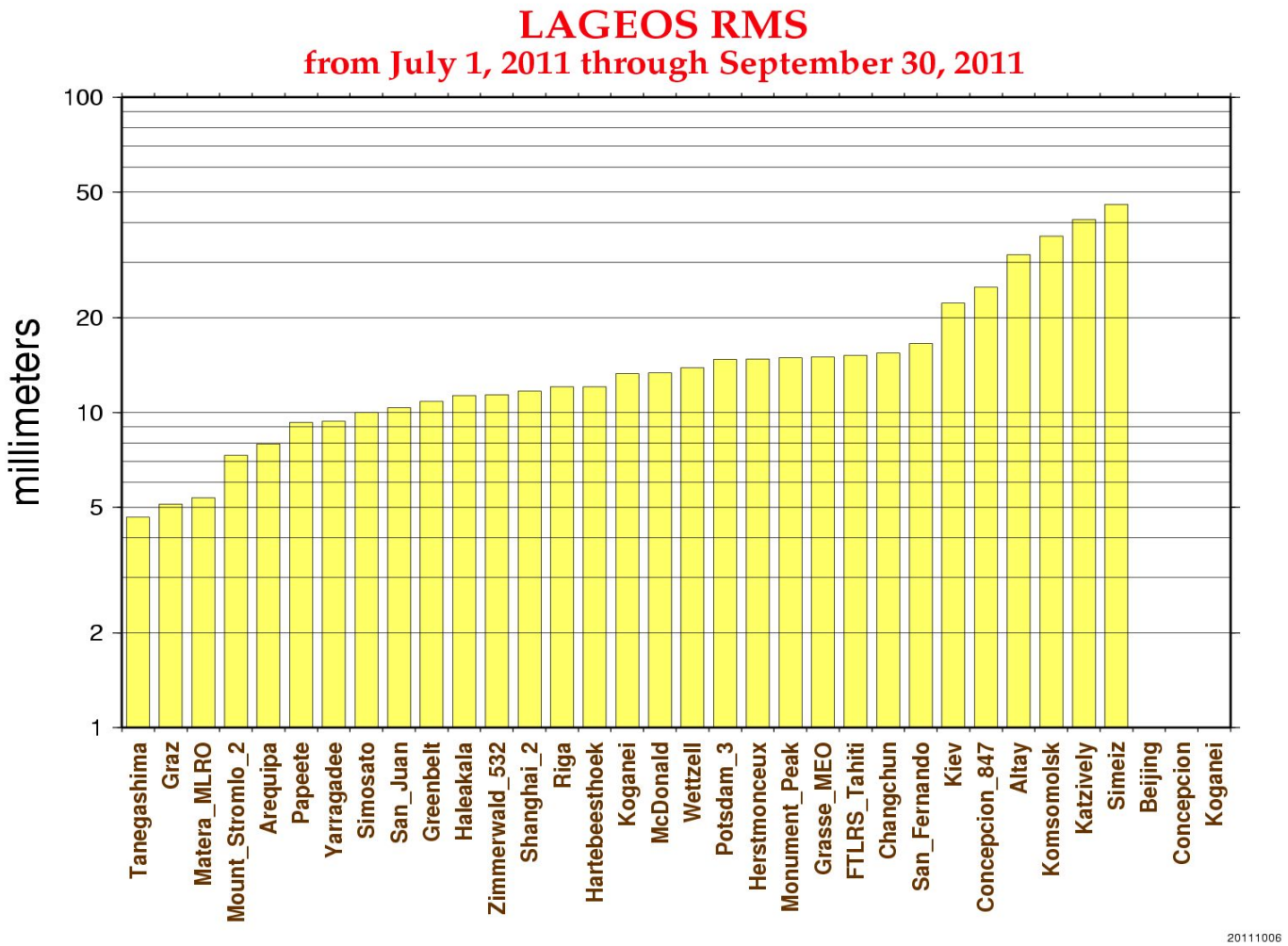
Station Performance (2011Q3)



Station Performance (2011Q3)

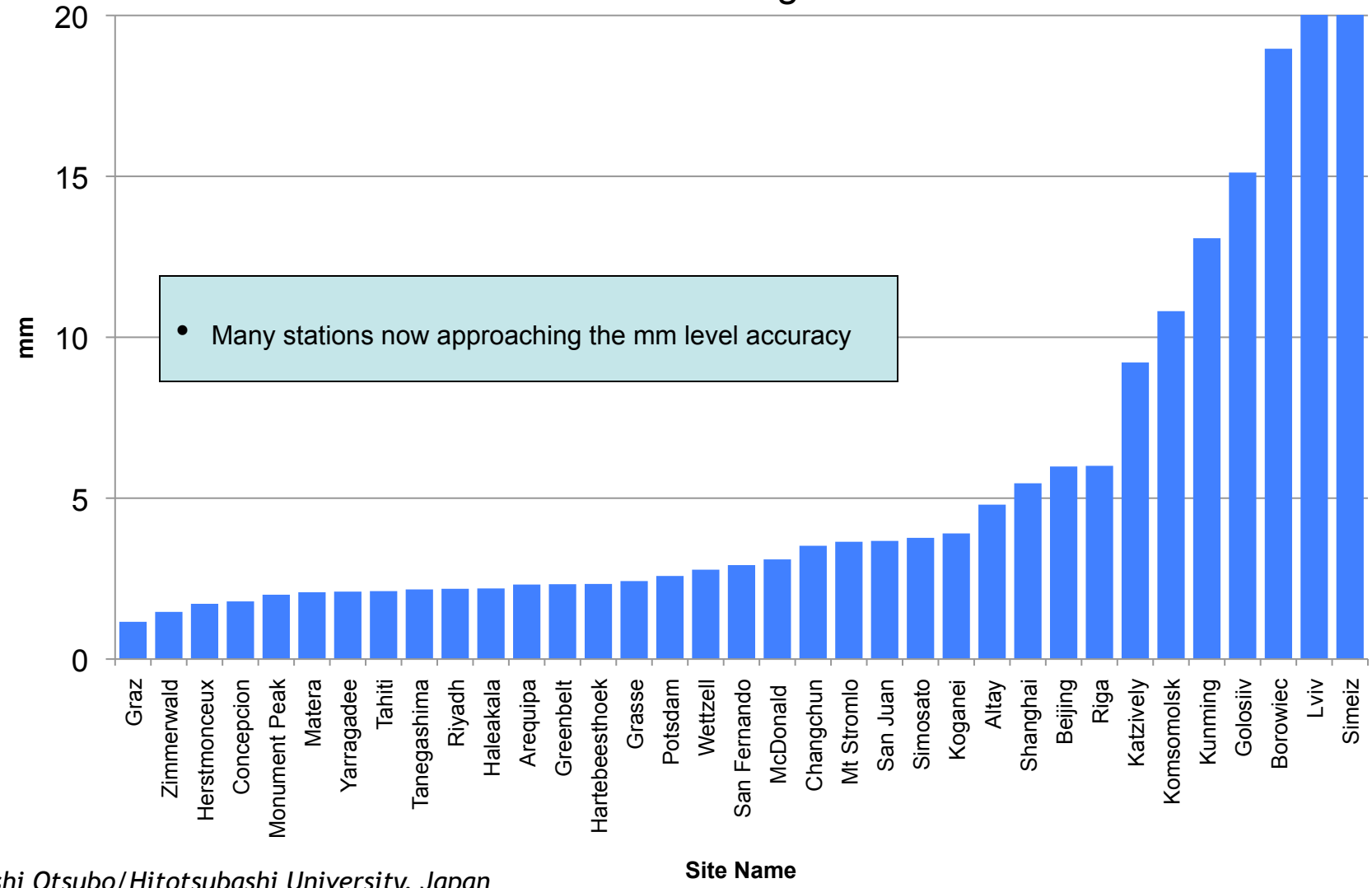


Station Performance (2011Q3)

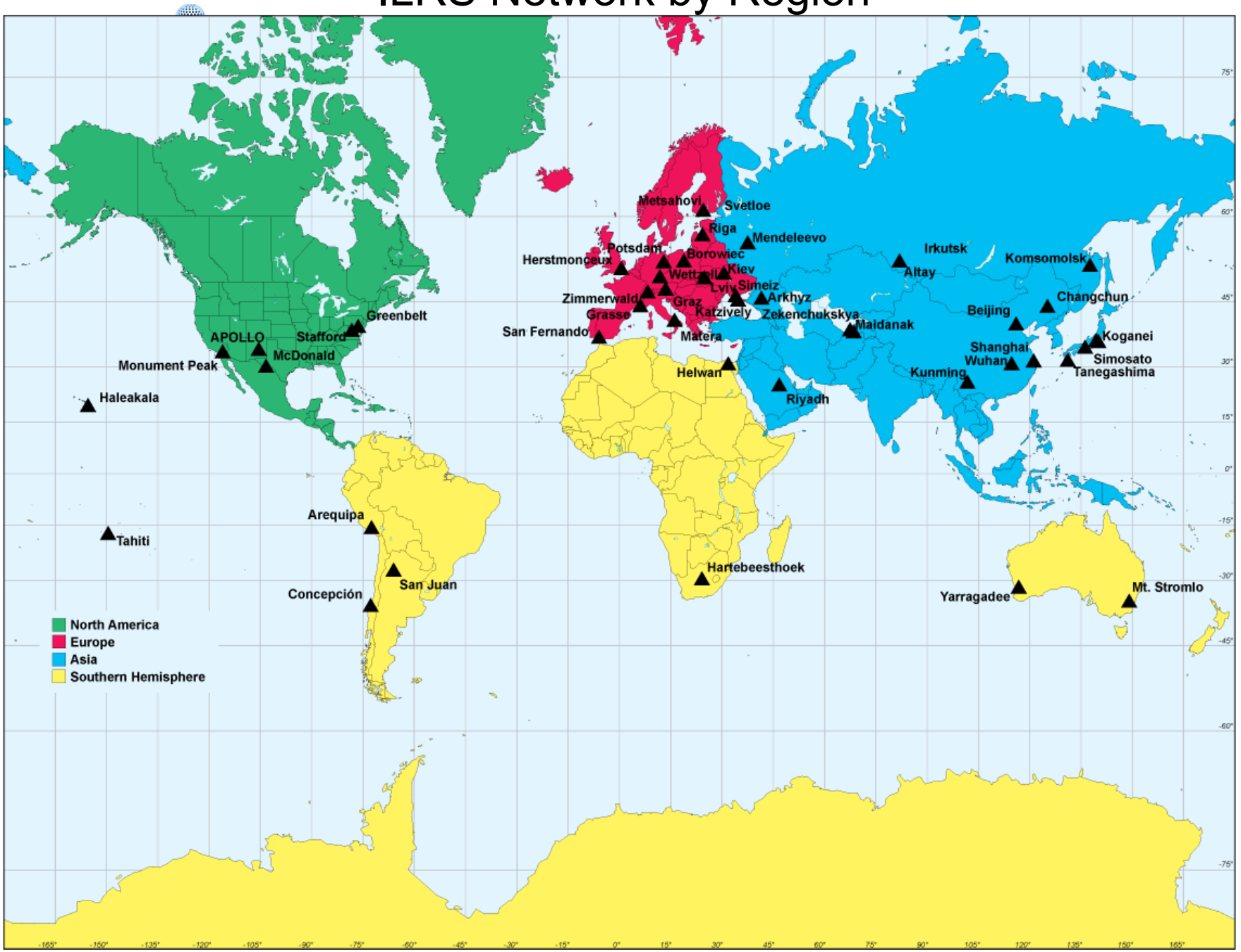


Station Performance

Estimated Range Bias

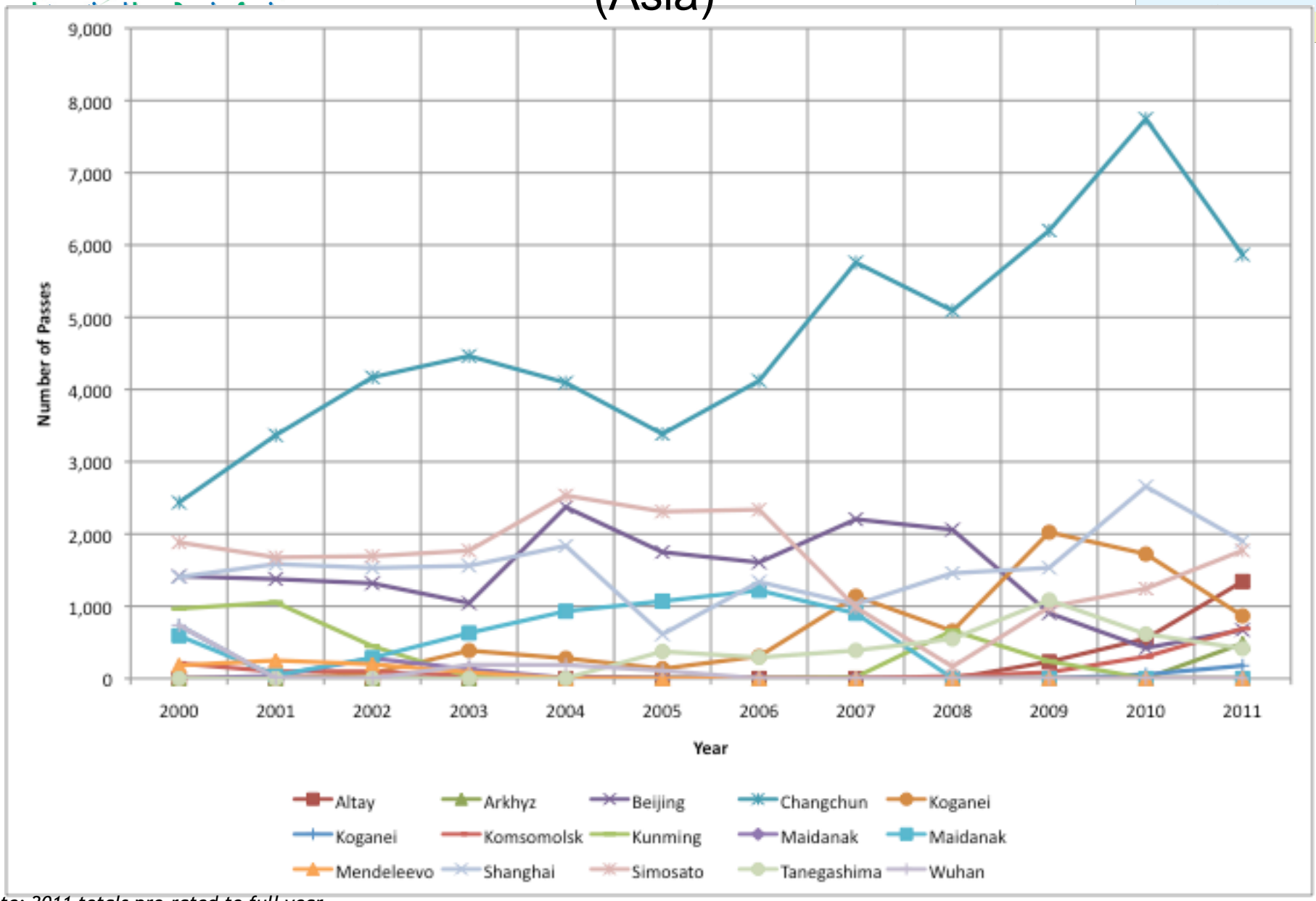


ILRS Network by Region



Yearly Pass Totals

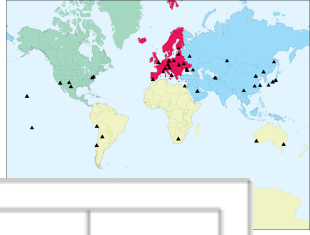
(Asia)

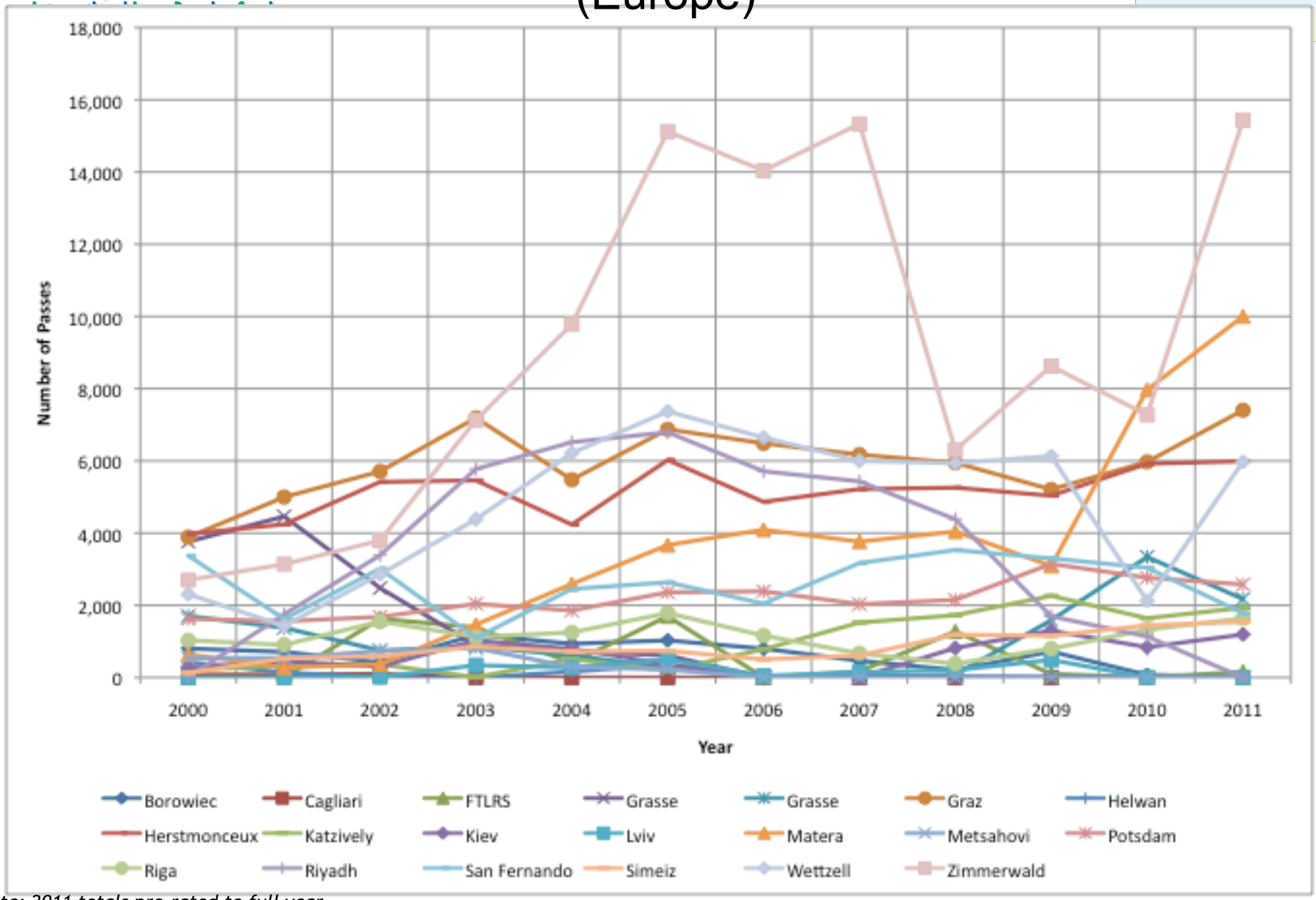


Note: 2011 totals pro-rated to full year

Yearly Pass Totals

(Europe)

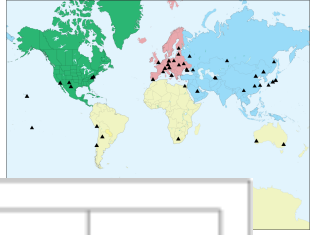


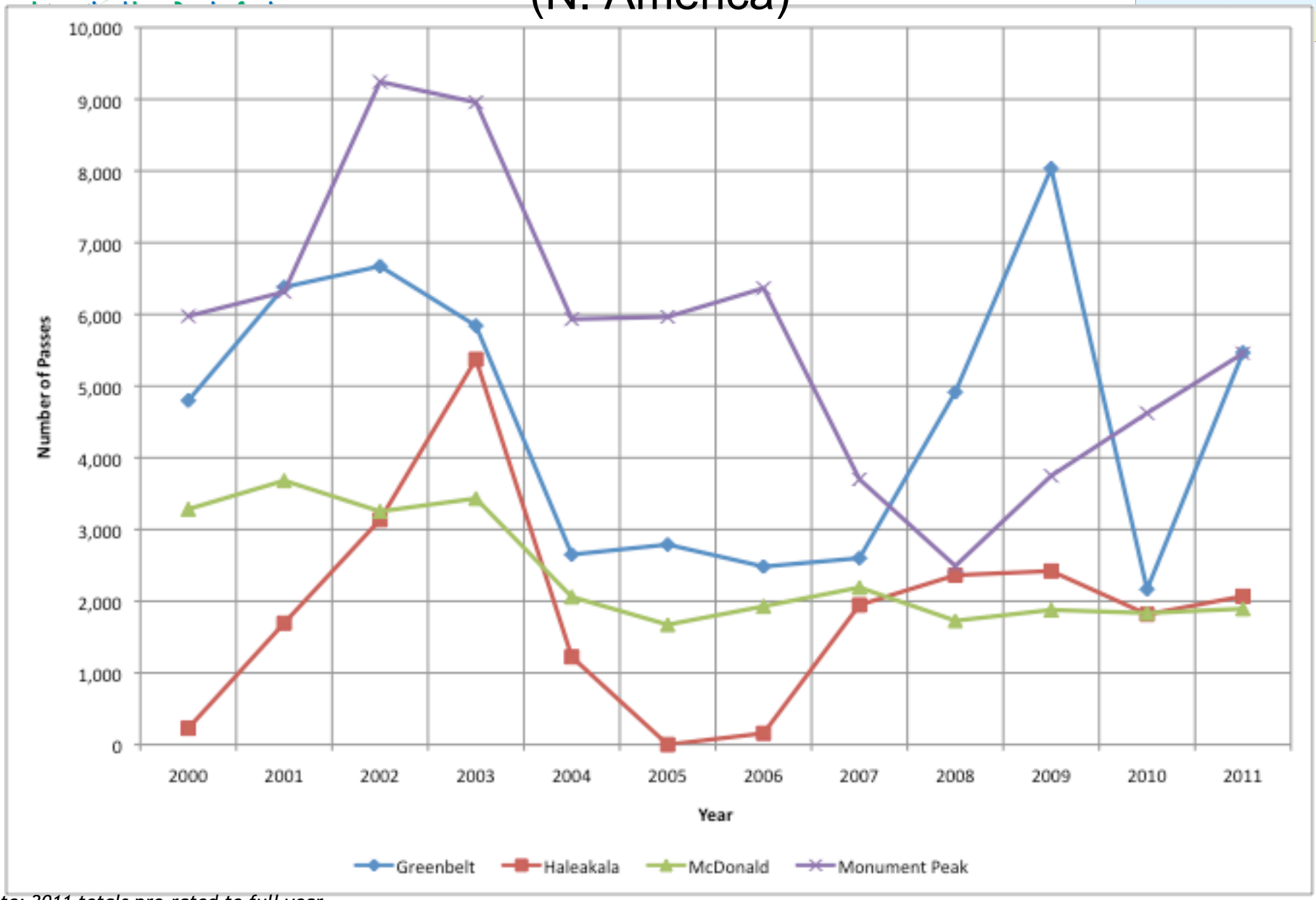


Note: 2011 totals pro-rated to full year

Yearly Pass Totals

(N. America)

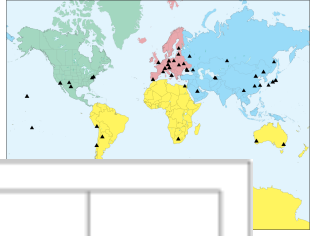


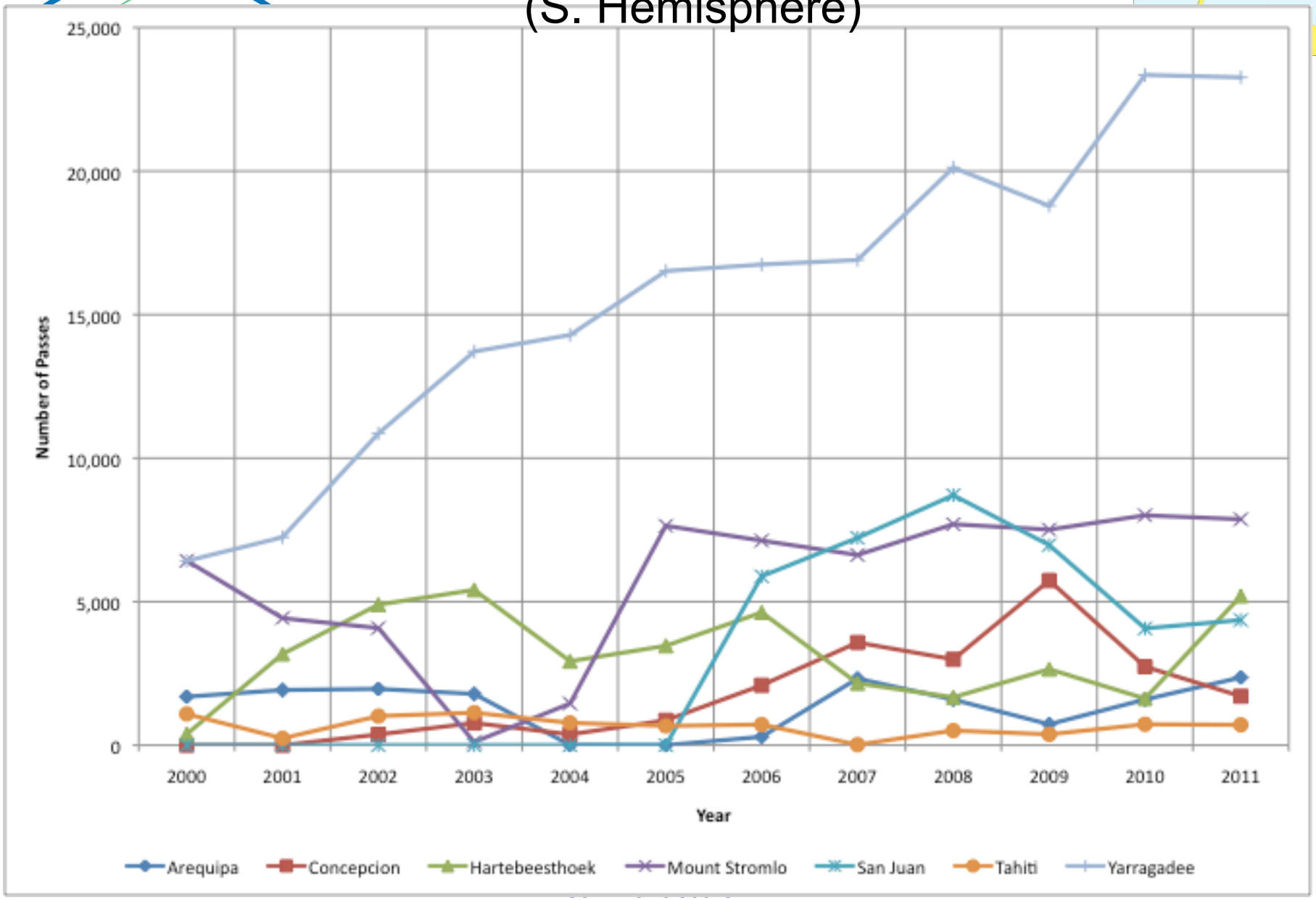


Note: 2011 totals pro-rated to full year

Yearly Pass Totals

(S. Hemisphere)



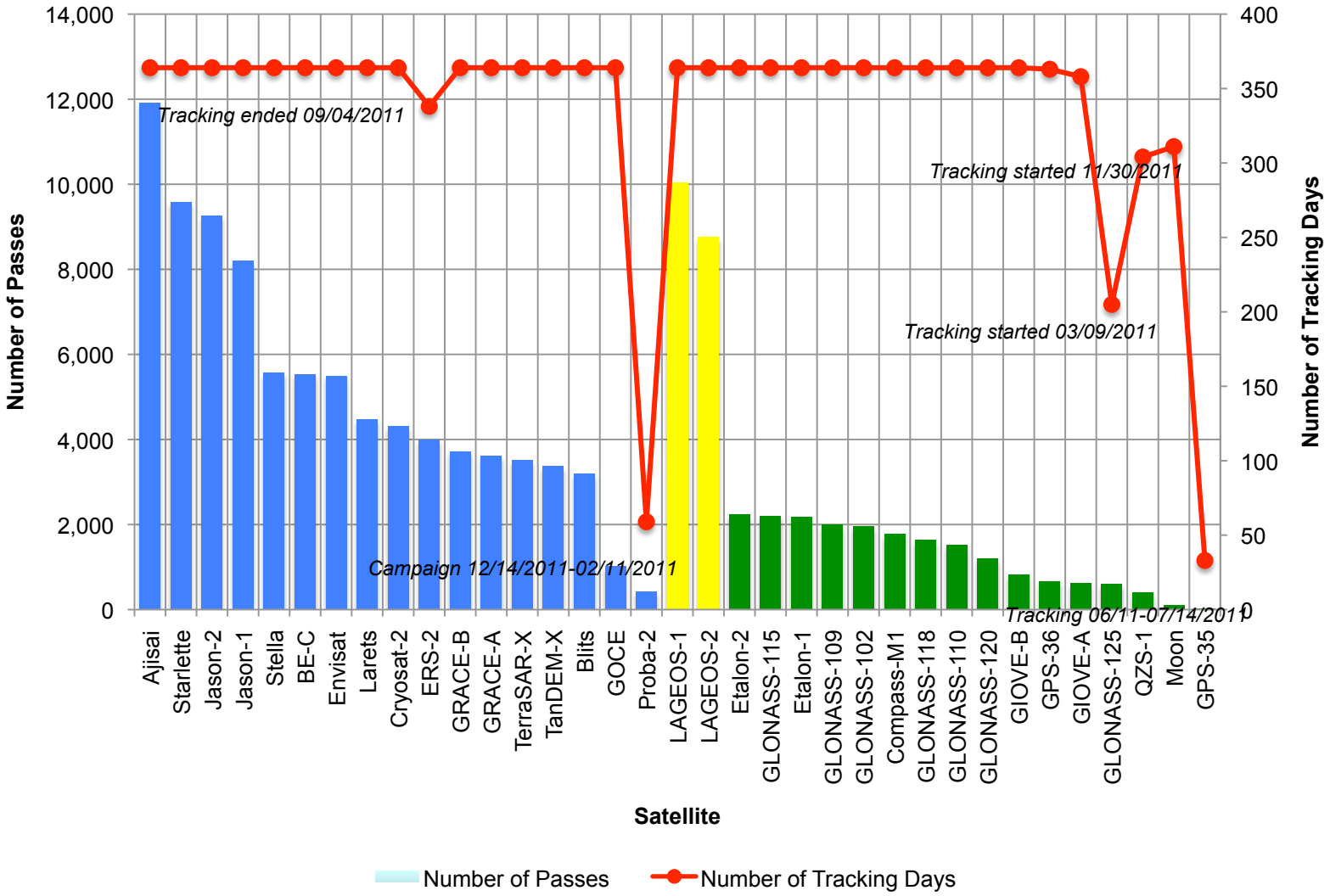


Note: 2011 totals pro-rated to full year

Mission Developments

- Currently supporting 57 missions (includes 26 GLONASS satellites) and lunar tracking
- Recent launches:
  - Radioastron (18-Jul-2011)
  - HY-2A (16-Aug-2011)
  - GLONASS-126 (02-Oct-2011) GLONASS-M satellite
  - Galileo-101 and -102 (21-Oct-2011)
- Upcoming :
  - LARES: Jun-2012
  - IRNSS (ISRO): mid-2012 (needs GB approval)
  - ZY-3 (CASM): Jan-2012 (needs GB approval)
  - SWARM (ESA): Jul-2012 (needs GB approval)
  - KOMPSAT-5 (KARI): 2012
  - SARAL (CNES/ISRO): 2012

Satellite Tracking (2011Q3)



Central Bureau Items

- **CDDIS and EDC data center structures, Q/C, and quarantining procedures supporting CRD-formatted data are being harmonized**
- **New normal point population recipe under review to take advantage of the high repetition systems**
- **All stations encouraged to submit full-rate data (including kHz) to be archived by the Data Centers**
- **Trying to strengthen the timely feedback and response procedures from the stations on maintenance, modification, and upgrades**
- **Adherence to processes for certification of new stations and requalification of stations after upgrading or significant downtime required**
- **Simplified algorithm to encourage stations to better distribute tracking efforts perhaps using the real-time web facility at AIUB needs to be developed**
- **ILRS 2009-2010 Report continues in preparation**
- **Proceedings from 17th International Laser Ranging Workshop in preparation**
- **Re-design of ILRS website underway to make it more responsive to user needs**
- **Deadline for CRD conversion has been pushed to March 15, but some stations have not been answered our continuous inquiries**

Revised Definition of the Normal Point (Draft)

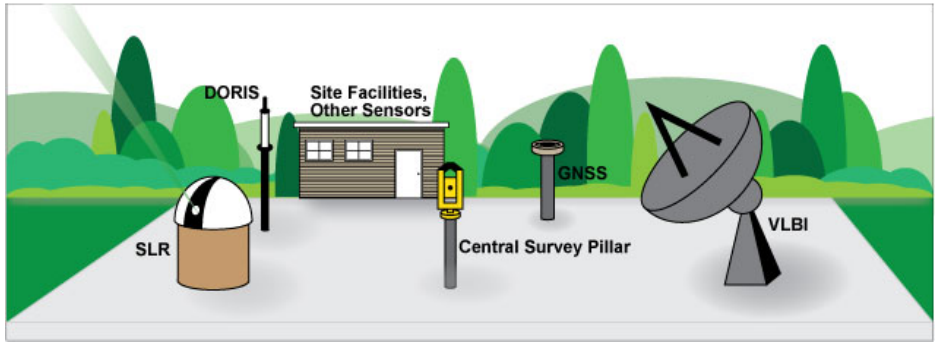
- Current Definition of the Normal Point specifies a standard normal point interval (SNPI) based on satellite altitude;
- Issue – some of the newer systems achieve plenty of FR data in far less time that the current FR interval;
- Task – New definition of the NP to accommodate this;
- Formula under discussion:
  - Target mm precision
  - The Normal Point is complete on Satellite 1 when either (1) 1000 **valid** FR points have been taken or (2) the SNPI has elapsed, whichever comes first;
  - Do not return to Satellite 1 until at least the SNPI has elapsed;
  - The “new normal points” can start at any time;
  - The epoch of the normal is that of a central FR data point.
- Task Committee: Georg Kirchner, Mike Pearlman, Jan McGarry, Graham Appleby, etc.

Meetings

- March 04-09, 2012: 7th IVS General Meeting, Madrid Spain
- **April 22-27, 2012: EGU General Assembly, Vienna,Austria**
- **April 20, ILRS AWG Meeting, Vienna, Austria**
- **April 21, GGOS Coordinating Center, Vienna, Austria**
- July 23-27, 2012: IGS Analysis Center Workshop, Olsztyn Poland
- August 13-17, 2012: AOGS-AGU Joint Assembly, Singapore
- August 20-31, 2012: XXVIII IAU General Assembly, Beijing China
- September 25-26, 2012: IDS Workshop, Venice Italy
- **December 06-10, 2012: AGU Fall Meeting, San Francisco CA**
- **Fall 2013: 18th International Workshop on Laser Ranging, Japan**

GGOS Bureau for Networks and Communications

Bureau Lead: Michael Pearlman



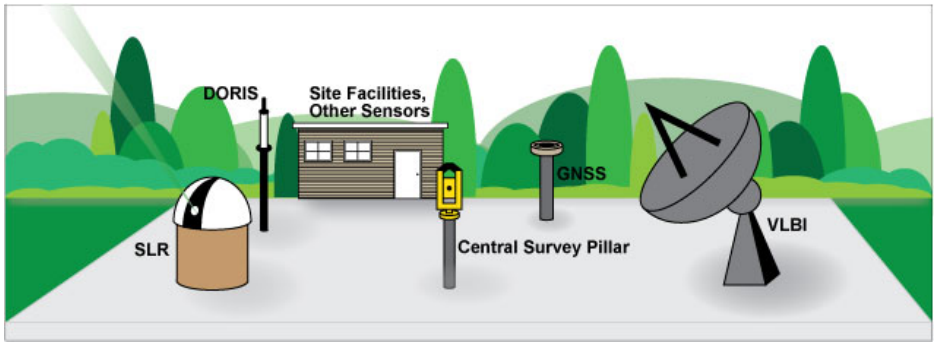
December 3, 2011

GGOS Meetings
San Francisco, CA

What is a Core Site?

(Terrestrial Reference Frame)

- A ground site with co-located SLR, VLBI, GNSS and DORIS (where available) so that their measurements can be related to sub-mm accuracy
- Why do we need multiple techniques?
  - Measurement requirements are very stringent
  - Each technique makes its measurements in a different way and therefore each measures something a little different:
    - Terrestrial (satellite) verses celestial (quasar) reference
    - Range verses range difference measurements
    - Broadcast up verses broadcast down
    - Radio verses optical
    - Active verses passive
    - Geographic coverage
  - Each technique has different strengths and weaknesses
  - The combination allows us to take advantage of the strengths and mitigate the weaknesses

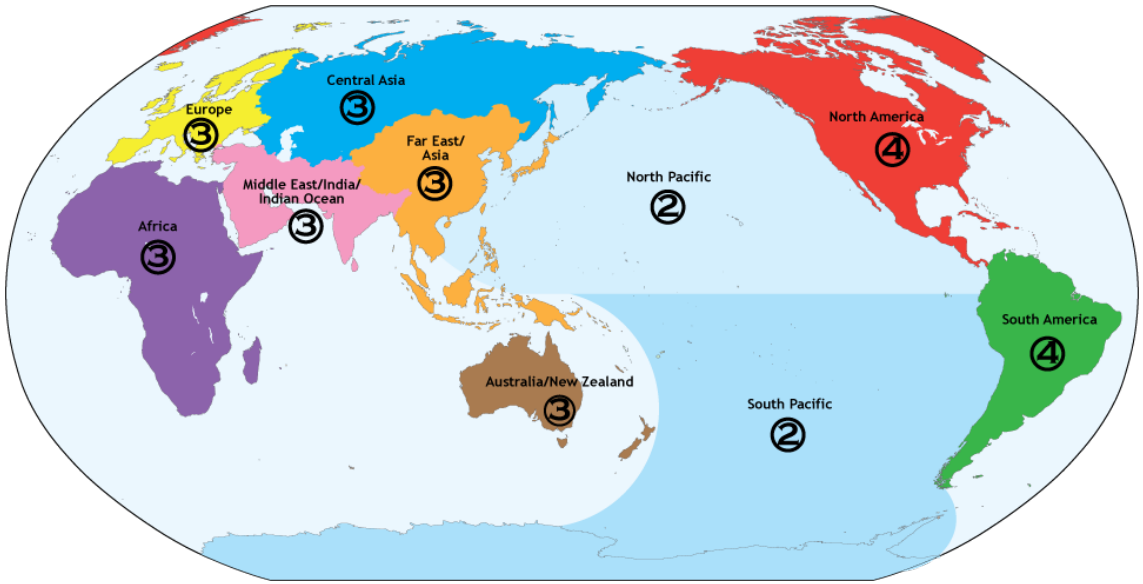


Simulation Studies to Scope the Network

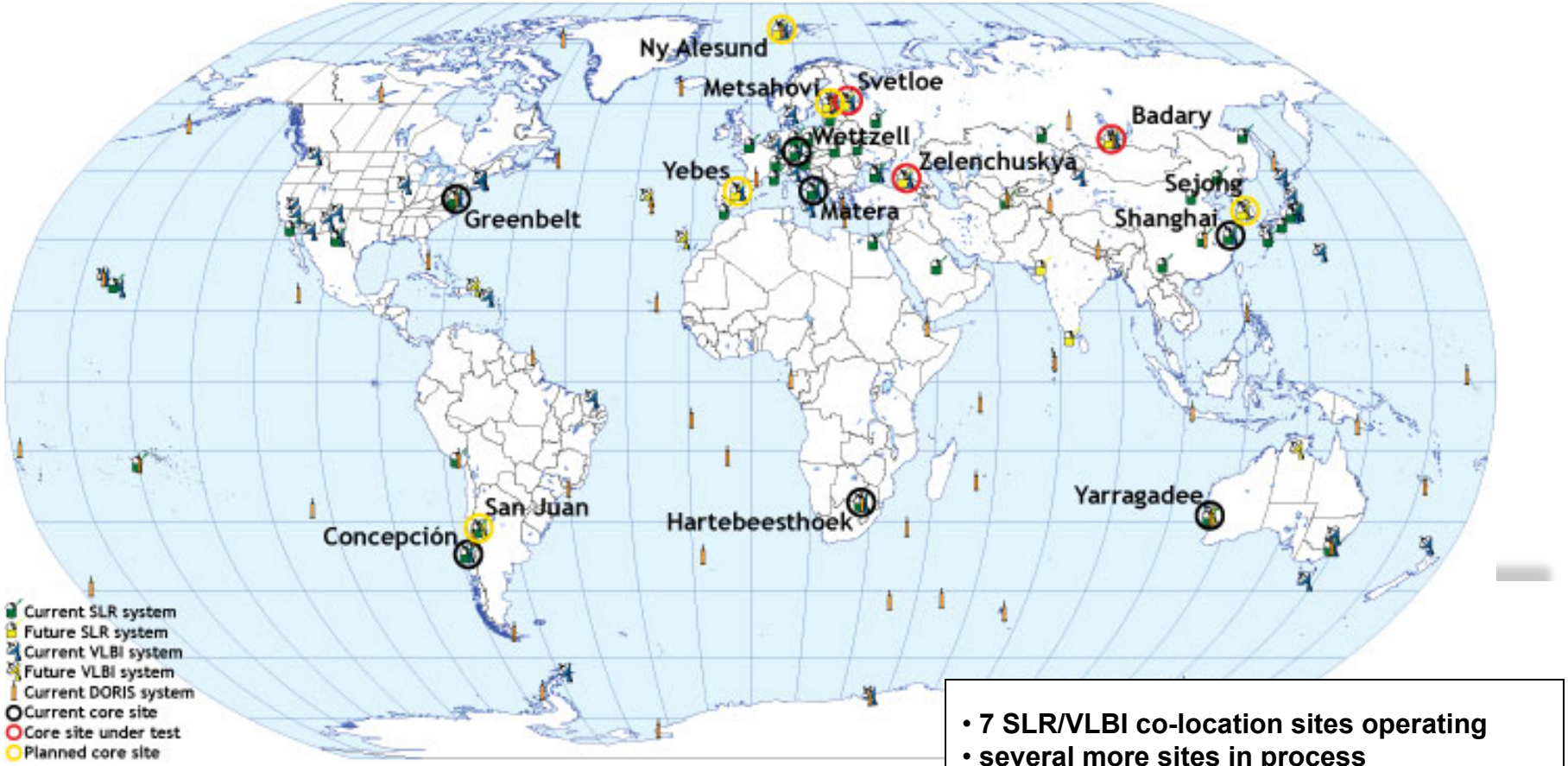
(Erricos Pavlis)

- **First Phase completed**
  - **~30 globally distributed, well positioned, co-location Core Sites with proper conditions;**
  - **16 of these Core Sites must track GNSS satellites with SLR to calibrate the GNSS orbits;**

- **Follow-on Phases (Impact on the ITRF)**
  - **Sensitivity to intersystem vector accuracy**
  - **Phased deployment; evolution of the products**
  - **Impact of errors and outages;**
  - **Additional space objects**
  - **Tracking scanarios**
  - **Impact of GRASP**



Co-located VLBI, SLR, GNSS
(Some with DORIS)



- 7 SLR/VLBI co-location sites operating
- several more sites in process
- Several more sites in planning

Techniques are all Making Progress

- **Satellite Laser Ranging**
  - **Several systems working in the Khz regime;**
  - **Increased data yield and daylight ranging on the GNSS satellites**
  - **Steady progress on the new SLR prototype at GSFC;**
  - **Progress on the GPS-3 arrays;**
- **VLBI**
  - **Prototype VLBI 2010 in testing at GSFC**
  - **New Systems Systems**
    - **Tasmania, Katherine, Yarragadee Stations**
    - **Wettzell twin telescopes are being constructed;**
- **GNSS**
  - **Multiple constellations**
  - **Additional frequencies**
  - **New ground stations**
- **DORIS**
  - **Nearly complete network already**
  - **Additional satellites**
  - **New beacons**
- **Calibration**
  - **GRASP Concept**

GGOS Site Requirements Document

(http://cddis.gsfc.nasa.gov/docs/GGOS_SiteReqDoc.pdf)

Global Geodetic Observing System (GGOS)

Site Requirements
for
GGOS Core Sites

August 1, 2011

Contributors:

Howard Donovan	HTSI
Scott Wetzel	HTSI
Chopo Ma	NASA GSFC
Hayo Hase	TIGO BKG
Dirk Behrend	NASA GSFC
Michael Pearlman	CfA
Carey Noll	NASA GSFC
Erricos Pavlis	UMBC
Jim Long	NASA GSFC
David Stowers	JPL
David McCormick	NASA GSFC
Curtis Emerson	NASA GSFC

- **Introduction and Justification**
  - **What is a Fundamental Station?**
  - **Why do we need the Reference Frame?**
  - **Why do we need a global network?**
  - **What is the current situation?**
  - **What do we need?**
- **Site Conditions**
  - **Global consideration for the location**
  - **Geology**
  - **Site area**
  - **Weather and sky conditions**
  - **Radio frequency and optical Interference**
  - **Horizon conditions**
  - **Air traffic and aircraft Protection**
  - **Communications**
  - **Land ownership**
  - **Local ground geodetic networks**
  - **Site Accessibility**
  - **Local infrastructure and accmmodations**
  - **Electric power**
  - **Site security and safety**
  - **Local commitment**

GGOS Call for Participation;
The Global Geodetic Core Network:
Foundation for Monitoring the Earth System

We seek proposals from organizations that would participate in the development, implementation and maintenance of the GGOS Global Geodetic Core Network:

- **To implement and operate core space geodesy stations including:**
  - **existing stations that already have the four techniques implemented and plan for upgrade to the next generation systems;**
  - **existing stations that have one or more techniques operational, are planning for upgrade to the next generation systems and for the implementation of the remaining techniques;**
- **To support the network design and planning activity with analysis, simulations, site research (geology, weather, logistics, personnel, etc). To help design and develop the inter-technique vector systems and operational procedures.**
- **To provide applicable space geodetic instruments for implementation at a GGOS Global Geodetic Core Site in cooperation with a local organization.**
- **To implement and operate core stations offered by others;**
- **Call for Participation has been issued through the Services and the IAG.**

Call for Participation

http://www.ggos.org/ (news page)

- **CfP Issued 8/15/11; Responses due 11/15/11;**
- **11 responses received covering 17 stations;**
- **Several more in process;**
- **Responses span include;**
  - **Current Legacy Core Sites**
  - **Current Legacy sub-core sites**
  - **Good intentions**
  - **Land**
- **Evaluations and answers scheduled for 12/31/11**
- **Members of the Review Team include:**
  - **Mike Pearlman**
  - **Zuheir Altamimi**
  - **Erricos Pavlis**
  - **Richard Gross**
  - **Representatives from the Services**
- **Meeting of core group scheduled for 12/7/11**

GGOS Bureau for Networks and Communications
Call for Participation

Responses Received

- Herstmonceux, GB
- Shanghai, Beijing, Changchun, Wuhan, Kunming, Urumqi,
- Wettzell, Germany
- Metsahovi, Finland
- Borowiec, Poland
- Yebes, Spain
- Onsala, Sweden
- Toro, Nigeria
- Medicini/Noto, Italy
- Pecny/Skalka, Czech Rep
- Yarragadee and Mt. Stromlo, Australia

Responses in Process

- Matera
- Hartebeesthoeck, South Africa
- NASA
- Warkworth, New Zealand

Not heard from:

- Russian Stations
- Sejong, Korea
- San Juan (China)

GGOS Bureau for Networks and Communications
Call for Participation
Issues and Steps Forward

- Decide on strategy of CfP acceptance and send out responses;
- Articulate description (or guidelines) for a Core Site both Legacy and "Ultimate";
  - system performance,
  - site conditions,
  - local reference network, etc,
- Encourage more groups to participate;
- Encourage stations to upgrade to newer technologies;
- Task Services with identification of proper reference point access;
- Task the Services with Technique Acceptance Criteria for Operational Stations;
- Decide how much "local motion" we can accept – what can we model?

NASA Space Geodesy Project

- Provide NASA's contribution to a worldwide network of modern space geodesy Core Sites;
- Phase 1 Proposal developed for a 2–year activity:
  - Complete network simulations to scope the network and examine geographic, operational and technical tradeoffs based on LAGEOS and GNSS tracking with SLR;
  - Complete the prototype SLR (NGSLR) and VLBI (VLBI 2010) instruments;
  - Co-locate these instrument with the newest generation GNSS and DORIS ground stations at GSFC;
  - Implement a modern survey system to measure inter-technique vectors for co-location;
  - Develop generalized station layout considering RFI and operations constraints;
  - Undertake supporting data analysis;
  - Begin site evaluation for network station deployment;
  - Develop a full network implementation plan;
- Follow-on phase for deployment for up to 10 stations;

NASA Space Geodesy Project

Network Site Criteria/Evaluation Task

- Develop Site Selection Requirements Document
- Evaluate current NASA Sites as candidate

  Core Sites;
- Begin discussions with existing and possible new partners on Core Sites
- Work with GGOS (IAG) and other international organizations to develop plans for international participation and partnerships;

ILRS Missions Working Group

Report to Governing Board
Tuesday December 6, 2011

Graham Appleby, Scott Wetzel

Mission support requests

- Mission sponsors fill in the ILRS web-based request forms
  - A general mission description, need for SLR, etc.
  - A detailed description of the LRA
- MWG then asked to comment via email
  - Includes AWG, SP, NEWG, DFPWG chairs
- Recommendation then to GB

Recent missions

- RadioAstron
  - In-space VLBI
  - Highly-elliptical, apogee at 350,000km
  - Link estimates (Davis) put returns in reach of several stations
  - Mission publishes regular station-schedules
  - GRASSE-MEO so far only station to track successfully
  - LLR-capable stations in particular are encouraged to track

Recent missions

- Galileo (101 and 102)
  - Support approved, launched October 21
  - Tracking commenced mid-November
- GRASP
  - Letter of support written on behalf of ILRS

- Under review:
  - Swarm (ESA. magnetic field, three LEO satellites)
  - IRNSS (India, Regional GEO GNSS)
  - ZY-3

General remarks

- Quite a lot of new missions applying for support;
- Need a more-responsive MWG
  - Full membership participation, timely
- To be discussed within MWG:
  - Should future general availability of mission data (e,g., onboard GPS) be an issue when ILRS is deciding whether or not to recommend tracking support?

General remarks

- Levels of support?
  - **Full support** when whole network is tasked
  - '**recognized mission**' when a sub-set is required?
  - For example IRNS (GNSS GEO, over India, asking for a few specific stations)
    - Then more onus on mission to solicit tracking support
    - ILRS provides data archive for ranges, predictions

CRD Format Implementation

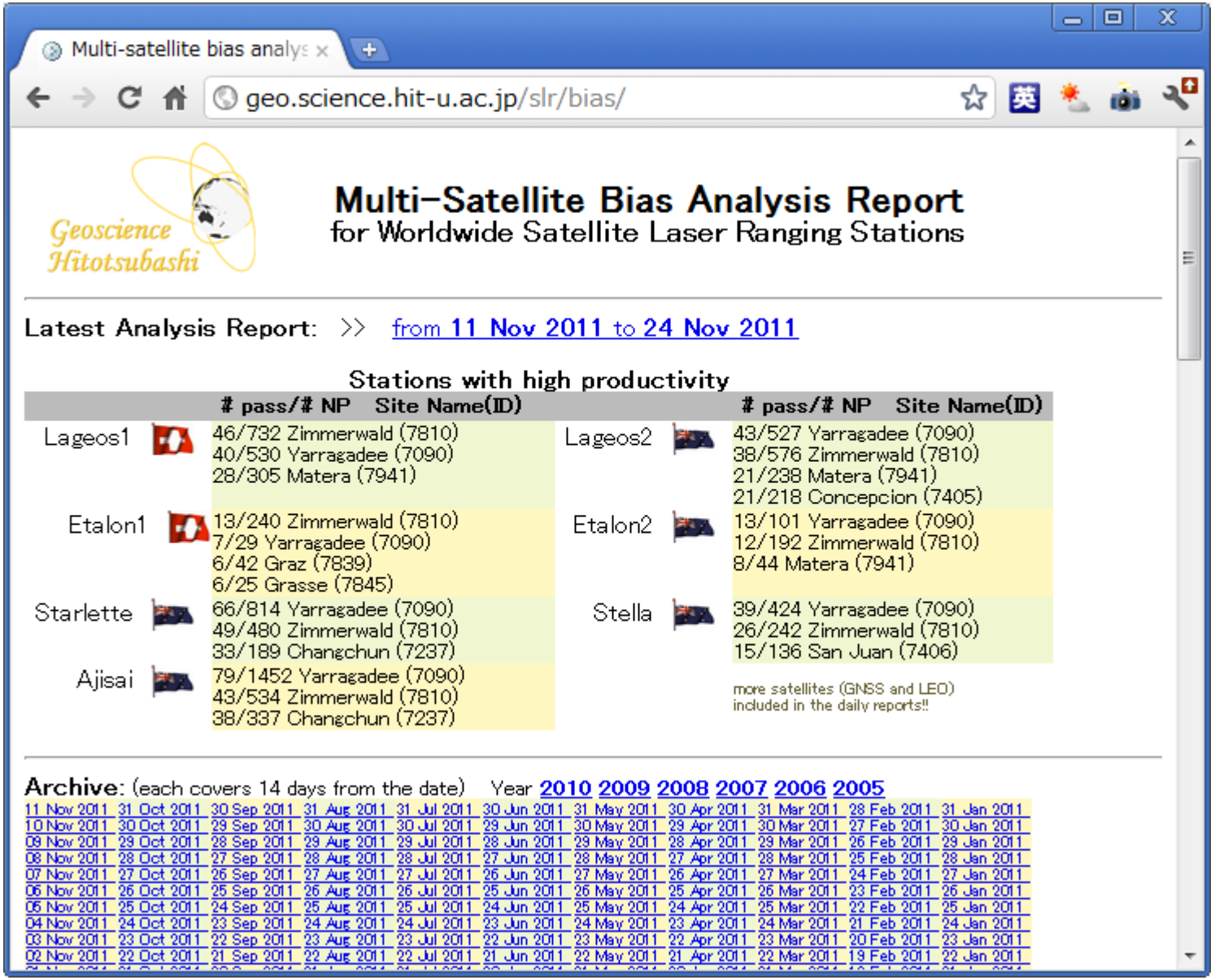
- **Currently, there are 34 stations validated, and 3 awaiting validation; 7 have not been heard from.**
- **All AWG ACs are able to ingest CRD data.**
- **There are concerns about some stations taking shortcuts ("cheating"), by simply converting legacy data to CRD format, thereby loosing any advantages of the new format.**
- **Final transition date has been delayed several times due to lack of stations and recently to transitions at the Ocs...**
- **Both OCs are on track to make ALL new data available in both legacy and CRD formats by January 1, 2012.**
- **During January and February, 2012, one of the analysis centers will confirm the consistency of data (CRD vs legacy) at both Data Centers.**
- **The goal is to have these checks done by March 1, 2012. When they are done, the ILRS CB will announce the completion of transition to the CRD format.**
- **After transition, validated stations will stop sending legacy format data, and OCs will stop back-converting CRD data. *All new data will be available in the CRD format only.***

Quality Control Data Reports

Toshimichi Otsubo (Hitotsubashi Univ, Japan), and
Horst Mueller (DGFI, Germany)

ILRS Governing Board Meeting, San Francisco, 6 Dec 2011.

Quality Control Reports (HIT-U)



Multi-satellite bias analys

geo.science.hit-u.ac.jp/slr/bias/

Geoscience Hitotsubashi

Multi-Satellite Bias Analysis Report
for Worldwide Satellite Laser Ranging Stations

Latest Analysis Report: >> from 11 Nov 2011 to 24 Nov 2011

Stations with high productivity

	# pass/# NP Site Name(ID)		# pass/# NP Site Name(ID)
Lageos1	46/732 Zimmerwald (7810) 40/530 Yarragadee (7090) 28/305 Matera (7941)	Lageos2	43/527 Yarragadee (7090) 38/576 Zimmerwald (7810) 21/238 Matera (7941) 21/218 Concepcion (7405)
Etalon1	13/240 Zimmerwald (7810) 7/29 Yarragadee (7090) 6/42 Graz (7839) 6/25 Grasse (7845)	Etalon2	13/101 Yarragadee (7090) 12/192 Zimmerwald (7810) 8/44 Matera (7941)
Starlette	66/814 Yarragadee (7090) 49/480 Zimmerwald (7810) 33/189 Changchun (7237)	Stella	39/424 Yarragadee (7090) 26/242 Zimmerwald (7810) 15/136 San Juan (7406)
Ajisai	79/1452 Yarragadee (7090) 43/534 Zimmerwald (7810) 38/337 Changchun (7237)		

more satellites (GNSS and LEO) included in the daily reports!!

Archive: (each covers 14 days from the date) Year 2010 2009 2008 2007 2006 2005

11 Nov 2011	31 Oct 2011	30 Sep 2011	31 Aug 2011	31 Jul 2011	30 Jun 2011	31 May 2011	30 Apr 2011	31 Mar 2011	28 Feb 2011	31 Jan 2011
10 Nov 2011	30 Oct 2011	29 Sep 2011	30 Aug 2011	30 Jul 2011	29 Jun 2011	30 May 2011	29 Apr 2011	30 Mar 2011	27 Feb 2011	30 Jan 2011
09 Nov 2011	29 Oct 2011	28 Sep 2011	29 Aug 2011	29 Jul 2011	28 Jun 2011	29 May 2011	28 Apr 2011	29 Mar 2011	26 Feb 2011	29 Jan 2011
08 Nov 2011	28 Oct 2011	27 Sep 2011	28 Aug 2011	28 Jul 2011	27 Jun 2011	28 May 2011	27 Apr 2011	28 Mar 2011	25 Feb 2011	28 Jan 2011
07 Nov 2011	27 Oct 2011	26 Sep 2011	27 Aug 2011	27 Jul 2011	26 Jun 2011	27 May 2011	26 Apr 2011	27 Mar 2011	24 Feb 2011	27 Jan 2011
06 Nov 2011	26 Oct 2011	25 Sep 2011	26 Aug 2011	26 Jul 2011	25 Jun 2011	26 May 2011	25 Apr 2011	26 Mar 2011	23 Feb 2011	26 Jan 2011
05 Nov 2011	25 Oct 2011	24 Sep 2011	25 Aug 2011	25 Jul 2011	24 Jun 2011	25 May 2011	24 Apr 2011	25 Mar 2011	22 Feb 2011	25 Jan 2011
04 Nov 2011	24 Oct 2011	23 Sep 2011	24 Aug 2011	24 Jul 2011	23 Jun 2011	24 May 2011	23 Apr 2011	24 Mar 2011	21 Feb 2011	24 Jan 2011
03 Nov 2011	23 Oct 2011	22 Sep 2011	23 Aug 2011	23 Jul 2011	22 Jun 2011	23 May 2011	22 Apr 2011	23 Mar 2011	20 Feb 2011	23 Jan 2011
02 Nov 2011	22 Oct 2011	21 Sep 2011	22 Aug 2011	22 Jul 2011	21 Jun 2011	22 May 2011	21 Apr 2011	22 Mar 2011	19 Feb 2011	22 Jan 2011

Quality Control Reports (HIT-U)

# sat	site	date	time	dur	rb mm	error	tb us	error	prec	bad	total
AJI1	7090	2011/11/23	01:20	1	-17	(7)	------.-	(----.-)	2	0 /	5
STRL	7090	2011/11/23	03:03	1	9	(6)	------.-	(----.-)	3	0 /	4
AJI1	7090	2011/11/23	03:20	5	5	(6)	-2.5	(4.2)	2	0 /	13
LAG2	7090	2011/11/23	03:41	28	11	(3)	-0.5	(2.4)	1	0 /	10
STEL	7090	2011/11/23	05:06	1	27	(2)	------.-	(----.-)	0	0 /	5
AJI1	7090	2011/11/23	05:19	12	21	(5)	-4.3	(1.5)	4	0 /	27
STEL	7090	2011/11/23	06:42	7	1	(3)	-7.4	(0.8)	1	0 /	15
LAG1	7090	2011/11/23	07:03	16	10	(8)	6.9	(7.2)	3	0 /	10
AJI1	7090	2011/11/23	07:21	14	18	(3)	1.2	(0.7)	1	0 /	26
LAG2	7090	2011/11/23	08:09	18	4	(4)	1.0	(7.4)	3	0 /	11
LAG1	7090	2011/11/23	10:35	33	-12	(3)	-4.7	(1.7)	2	0 /	17
LAG2	7090	2011/11/23	12:09	47	-4	(3)	6.9	(1.5)	3	0 /	13
ETA2	7090	2011/11/23	13:53	2	-26	(18)	------.-	(----.-)	3	0 /	2
GL02	7090	2011/11/23	14:09	31	-19	(27)	-71.2	(102.2)	3	0 /	8
STRL	7090	2011/11/23	16:16	8	-7	(4)	2.5	(0.8)	1	0 /	14
STEL	7090	2011/11/23	16:19	1	-13	(5)	------.-	(----.-)	1	0 /	4
GP36	7090	2011/11/23	16:48	157	-14	(5)	10.2	(15.0)	3	0 /	8
STEL	7090	2011/11/23	17:56	5	-26	(8)	12.3	(2.1)	3	0 /	12
STRL	7090	2011/11/23	18:05	8	-3	(3)	-4.3	(1.0)	2	0 /	18
AJI1	7090	2011/11/23	20:16	6	32	(4)	-3.3	(2.6)	1	0 /	14

Quality Control Reports: Worldwide

Table 1 Analysis institutes providing quality control information. *All: The Satellite and Duration should done publicly to the community, not what you did privately or you can potentially do. Are these info all co*

Institute	Software	Output	Satellites	Update
Astronomical Institute, University of Bern, Switzerland	Bernese 5.1	Range bias	GPS and GLONASS	Daily
Crustal Dynamics Data Information System, NASA, USA *(Torrence: Inst Name ok? ILRS CB?)*	-	Performance card	All	Quarterly
DGFI, Germany	DOGS 5.1	Range & time bias	ETALON and LAGEOS	Daily
Hitotsubashi University, Japan	concerto 4.10	Range & time bias	GPS, GLONASS, ETALON, LAGEOS and LEOs	Daily
Joint Center for Earth Systems Technology, USA	GEODYN II and SOLVE II	Range & time bias, Residual map	ETALON, LAGEOS and LEOs	Daily
Information-Analytical Center, Russia	STARK-C 7.7	Range & time bias	LAGEOS	Daily
NERC Space Geodesy Facility, UK	SATAN_SX	Residual map	ETALON and LAGEOS	Daily
Shanghai Astronomical Observatory, China	SHORD-II	Range & time bias	ETALON and LAGEOS	Weekly

“RapidServiceMail”

New framework proposed by H Mueller at AWG, Bad Koetzting

- Mailing list for alerting bias issues
- Common header

E-Mail Address: rapidservicemail@dgfi.badw.de

Web: http://rapidservicemail.dgfi.badw.de/

(Largely supported by Christian Schwatke, DGFI)

12 alerts released since June 2011.

- 7 from DGFI and 5 from HIT-U.

“RapidServiceMail” : Example (Message 0011)

Date: Thu, 10 Nov 2011 15:34:59 +0900
Subject: Rapid Service Mail (HITU) 1824 large range bias due to no calibration
From: Toshimichi Otsubo <t.otsubo@r.hit-u.ac.jp>
To: medved@mao.kiev.ua, RapidServiceMail@dgfi.badw.de
Subject: Rapid Service Mail (HITU) 1824 large range bias due to no calibration

****

ILRS/AWG Rapid Service Mail (HITU) Message 0011
1824 large range bias due to missing calibration

****

Dear Mikhailo and Golosiiv (Kiev) staff,

A series of large range bias (> 30 metres) were detected in your data obtained on 8 Nov. It is very likely that it is linked with the missing calibration data (= zero).

Please visit:
http://geo.science.hit-u.ac.jp/slr/bias/ (and check Latest Analysis Report) and consider resubmitting the data if possible.

Best Regards,
Toshi

Ongoing and Future issues

Writing a paper for Journal of Geodesy

"Data Quality Control Service for the ILRS Tracking Network" by Otsubo, Mueller, Pavlis, Torrence, Thaller, Glotov, Xiaoya and Appleby.

Ideas for the future?

Faster/more frequent reporting?

More satellites? Multi-technique?

Automatic anomaly detection?

ILRS Analysis Working Group Report to

ILRS Governing Board Meeting

San Francisco, CA, Dec. 6, 2011

Erricos C. Pavlis and Cinzia Luceri

Analysis Coordinators

ILRS AWG Update

- **Analysis:**
- Operational products (weekly & daily) delivered routinely and on time from all nine ACs:
  - **ASI** (AC & CC), BKG, DGFI, ESA, GA, GFZ, GRGS, **JCET**(AC & CC), & NSGF
- New CoG model for LAGEOS & ETALON (*site- and time-dependent with few mm accuracy*) adopted and tested in current Pilot Project
- Once this PP is completed, the DAILY analysis product will become the "official" ILRS product and the WEEKLY product will be used in several PPs to test improved modeling and new analysis products (*atmospheric gravity and loading, low degree harmonics, orbits, etc.*)
- All PPs are expected to be finalized by Spring of 2012
- JCET/GSFC AC will have to move between Dec. 23, 2011 and Jan. 3, 2012 to a new on-campus location, implying delays and down-time until the new facility is operational again (mid-January at best)

ILRS AWG Update – cont.

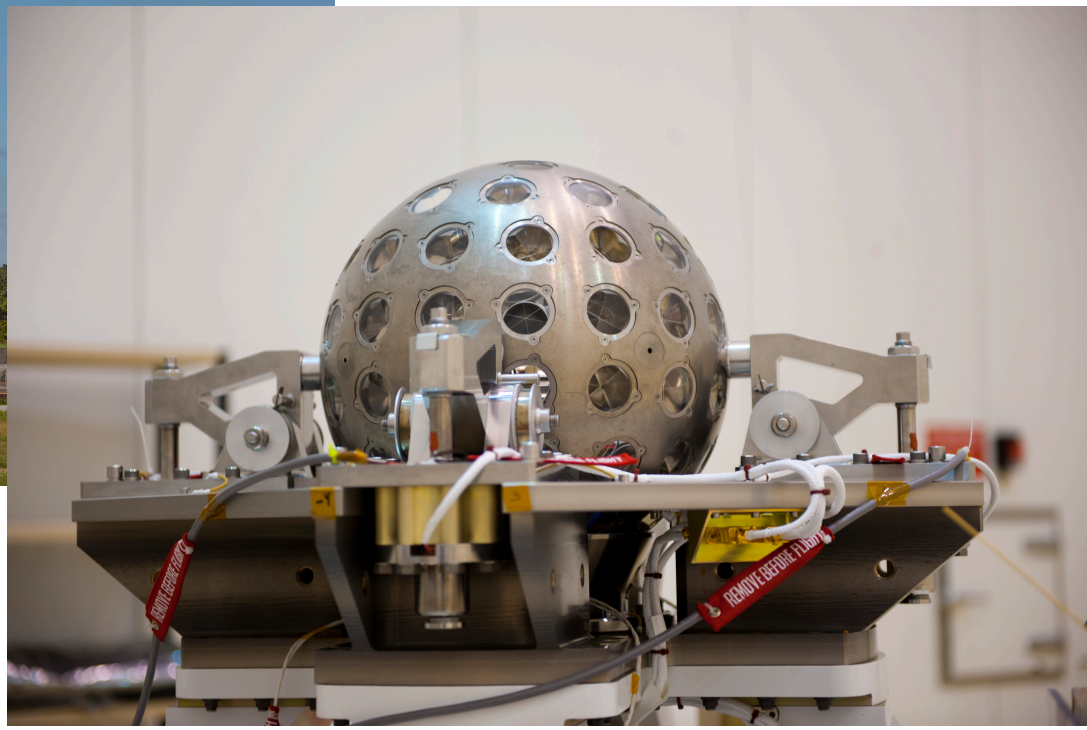
- **Analysis (cont.):**
- Re-analysis for 1983 to present to begin once all improvements have been checked and validated by all ACs (*Spring/Summer of 2012*)
- The ILRS AWG will continue validating the implementation of the new format at sites which have not yet implemented the CRD format (their data will be reformatted to CRD by the OCs until they pass validation tests)
- The AWG held a brief meeting at the 17th ILRS Workshop in Bad Kötzting, Bavaria, and a full-day meeting in Zürich, CH, the day before the UAW.
- ILRS had strong participation in the last UAW
- The next ILRS AWG all-day meeting will take place in Vienna, Austria, prior to the EGU 2012 (Saturday, April 21) at TUW

Publications

- **ILRS Special Issue in the Journal of Geodesy:**
- Progressing slowly mainly due to the editors' limited amount of time for this task
  - Over 24 submissions, three abstracts pending finalization, selection process in January 2012
  - Planning for a completed review process by end of summer 2012
- **Future Meetings:**
- 18th International Workshop on Laser Ranging will be held in Tokyo in the fall of 2013, and an ILRS AWG meeting is planned to occur prior to the workshop week (TBD).

Breaking News

- Cannonball constellation will soon acquire a new member – LARES
- LARES launch set for January 29, 2012 from Kourou (on VEGA)



Data Flow Issues

111129_daily_sate_stats.txt Tue Dec 06 13:10:04 2011 1

RESIDUAL SUMMARY STATISTICS FOR ARC 111129 BY DAY AND BY TRACKING STATION

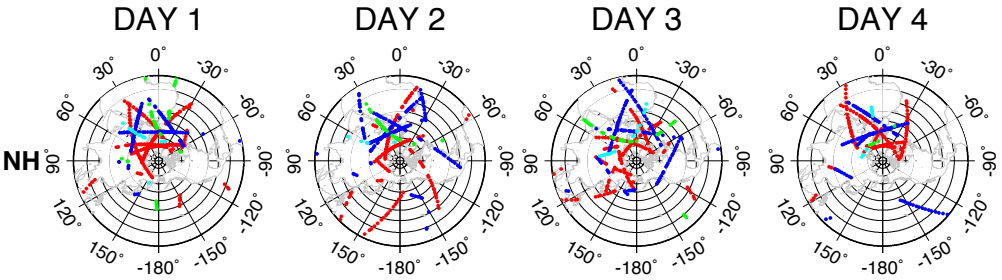
		11/11/29			11/11/30			11/12/01			11/12/02			11/12/03			11/12/04			11/12/05			TOTAL		
SITENAME	SITE_NUM	AVG	STD	NPTS	AVG	STD	NPTS	AVG	STD	NPTS	AVG	STD	NPTS	AVG	STD	NPTS	AVG	STD	NPTS	AVG	STD	NPTS	AVG	STD	NPTS
Kiev	18248101				5.5	21.8	10				-10.9	14.6	5										0.0	20.8	15
Katzivel	18931801	7.4	11.8	18	-25.3	17.4	11	3.1	8.6	9	2.3	23.3	40	3.2	16.8	18	-1.3	24.9	25				0.0	21.5	121
Mcdonald	70802419	6.2	25.6	7	0.9	9.7	9	-1.4	11.0	36													0.0	13.5	52
Yarragad	70900513	9.6	12.8	56	-1.2	17.6	74	1.3	10.9	57	0.1	20.2	53	-3.2	9.8	16	-14.2	21.3	25	-3.2	19.3	23	0.2	17.3	304
Monument	71100412	-16.9	15.9	7	14.4	22.2	31				-5.8	28.7	19							-11.0	7.0	20	0.0	23.9	77
Papeete	71240802				0.0	25.7	11																0.0	25.7	11
Changchu	72371901	-5.9	11.3	27	-3.9	5.1	18	-0.1	14.5	62				-8.7	15.9	6	32.2	53.6	9				0.0	20.7	122
Koganei	73085001																			0.0	10.2	23	0.0	10.2	23
Conc@847	74057914	-2.7	17.0	24	0.7	18.6	74	-10.9	1.2	7							12.3	4.3	7				0.0	17.5	112
San Juan	74068801	2.2	20.8	20	49.0	8.1	5	-10.8	18.6	18	21.3	13.6	10	-28.6	25.4	14							-1.4	28.8	67
Hartebee	75010602	0.0	3.8	4										0.0	16.3	17							0.0	14.7	21
Zimm@532	78106821	2.8	16.5	142	1.5	12.1	131	-1.7	12.1	142	-4.8	13.7	89				2.4	13.4	4				-0.1	14.0	508
Shanghai	78212801										-27.1	15.5	12	6.8	27.5	45							-0.3	28.9	57
Mount St	78259001										4.3	4.0	3	-12.9		1							0.0	9.2	4
Simosato	78383603				0.0	16.4	19																0.0	16.4	19
Graz	78393402	0.0	16.3	15																			0.0	16.3	15
Herstmon	78403501	0.1	16.8	30	1.1	11.1	27										-8.3	24.0	15	2.2	26.6	43	0.0	21.0	115
Potsdam	78418701	-3.5	14.7	77	5.9	6.4	33				9.8	15.3	13	-2.5	16.8	23							0.0	14.4	146
Grasse	78457801	-2.2	15.7	45	23.3	1.4	3																-0.6	16.5	48
Matera	79417701	-8.4	13.8	52	2.2	16.2	63	-2.5	15.7	67	3.0	20.6	83	7.0	4.0	7							-0.6	17.5	272
Wettzell	88341001	-2.8	16.1	48	3.3	4.1	5	2.2	5.4	15	3.0	8.7	28										0.0	12.7	96
GRAND TOTAL	21	-0.2	16.2	572	1.9	17.0	524	-1.5	13.1	413	-0.4	19.7	355	-1.1	22.6	147	-1.5	29.7	85	-1.9	20.1	109	0.0	17.9	2205

NEW PERSEUS-SERIES2010 2008 RESULTS FOR ARC: o11129

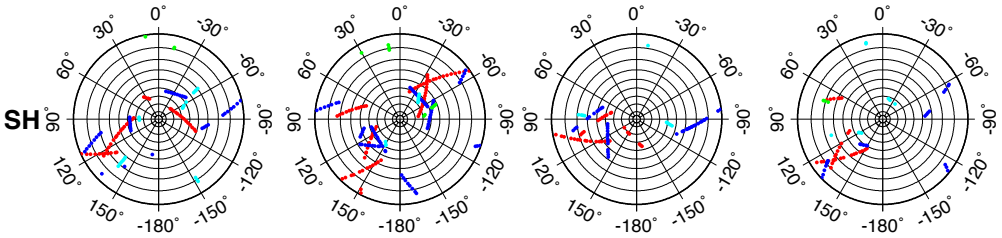
MJD	X	Y	UT1-UTC	SIG_X	SIG_Y	SIG_UT1	RMS	NS	NNP	ND
55894.5007	0.16246	0.28749	-0.385335	0.00006	0.00007	0.001177	16	16	572	1
55895.5007	0.16097	0.28633	-0.386308	0.00006	0.00006	0.001177	17	16	524	1
55896.5007	0.16006	0.28476	-0.387421	0.00006	0.00008	0.001177	13	10	413	1
55897.5007	0.16009	0.28425	-0.388673	0.00007	0.00009	0.001177	20	11	355	1
55898.5007	0.15962	0.28228	-0.389800	0.00017	0.00020	0.001177	23	9	147	1
55899.5007	0.15837	0.28332	-0.390971	0.00027	0.00029	0.001177	30	7	85	1
55900.5007	0.15742	0.27956	-0.391425	0.00023	0.00032	0.001177	20	5	109	1

International Laser Ranging Service

North H.

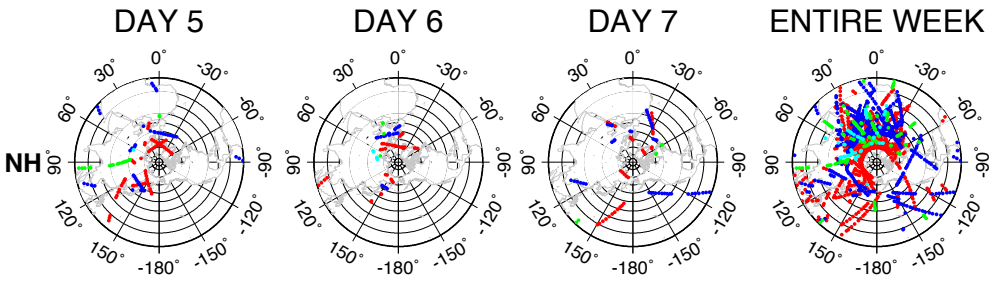


South H.

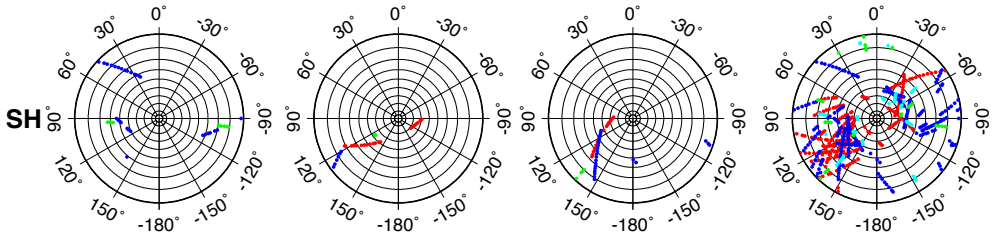


11/29/2011 **11/30/2011** **12/01/2011** **12/02/2011**

North H.



South H.



12/03/2011 **12/04/2011** **12/05/2011** **11/29/2011 - 12/05/2011**

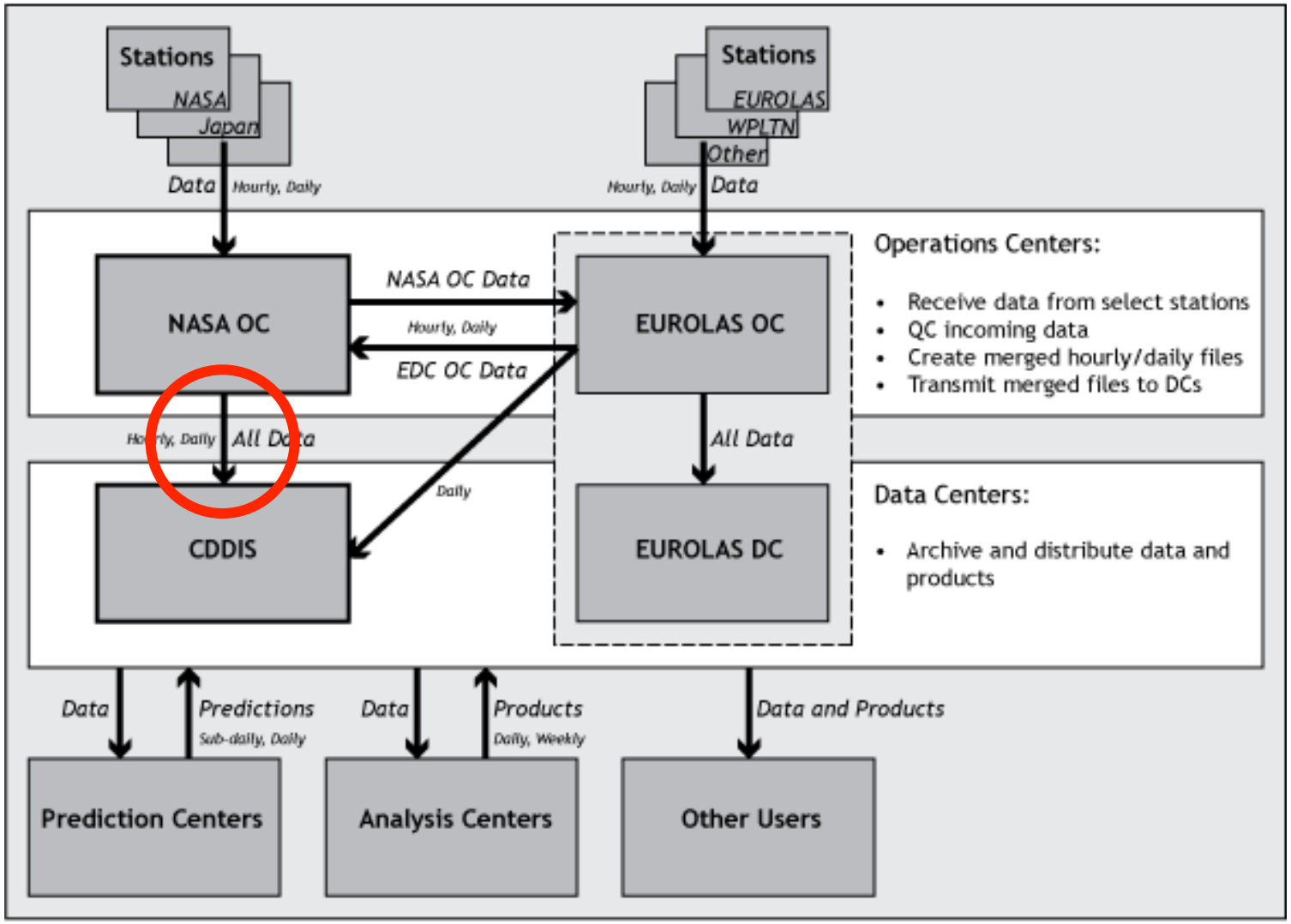
red = L1 **blue = L2** **green = ETA1** **cyan = ETA2**

ILRS Data Flow Issues

ILRS CB

ILRS Governing Board Meeting
San Francisco, CA
December 07, 2011

ILRS Data Flow



Issues

- Two ILRS Operational Data Centers, NASA and EDC, collect data from sub-networks
- Two ILRS Global Data Centers, CDDIS and EDC, provide user access to data and products
- In April 2011 NASA SLR operations center contractor changed
- New group still coming up to speed with this unique task
- Data flow, and therefore, ILRS operations, have not been smooth:
  - Flow of operational data set (i.e., old format) has problems:
    - EDC data not correctly incorporated into daily deliveries to CDDIS ==>
      - Missing data in operational files
      - EDC and CDDIS data holdings are not identical
    - Quarantined data released in operational files
    - Data flow inconsistent and not reliable
      - NPT data arrive late or not at all
      - FR data flow stopped for several weeks
      - ==> Impact to routine AC operations
  - CRD data flow working well for most part
  - Flow of FR data from EDC to CDDIS resumed and old data pushed

Resolution?

- NASA contractor installed new network and new servers
- Putting new automated checks in place to monitor data flow
- Puts more work on CDDIS and EDC (as data centers) to ensure data are archived properly
- CDDIS and EDC need to compare data holdings

Task Force-1

Charter:

Address concerns about inadequate two-way communication between the stations and the analysis centers to provide:

(a) unambiguous, timely reports to the stations regarding data quality and bias information, and

(b) timely reports to the analysis centers on configuration changes and other events that could affect system biases.

Task Force-1

- Methodologies and parameterization information obtained from each “quick-look” analysis center (QLAC) are available at the ILRS web site
- Communication of bias observation by QLAC’s is ongoing by T. Otsubo and H. Muller through direct email contact with the station(s).
- The number of data anomalies has been steadily decreasing

Task Force-1

Status:

(a) unambiguous, timely reports to the stations regarding data quality and bias information addressed by T. Otusbo rapid identification and communication of anomalies; the AWG is constantly updating the bias files. “keep the ILRS routine product to a high quality standard in close contact with the site engineers.”

(b) timely reports to the analysis centers on configuration changes and other events that could affect system biases: are the stations are changing the SCF and SCH? Are the AC’s are using this information - historically, yes.

Spacecraft Centre of Mass Corrections ILRS Task Force II

Graham Appleby[1], Toshi Otsubo[2]

1 SGF Herstmonceux, UK

2 Geoscience Laboratory, Hitotsubashi University, Kunitachi, Japan

NATURAL ENVIRONMENT RESEARCH COUNCIL

Background

* A strength of the LR technique is its longevity;
* Data at few cm-level of precision is available from launch of the LAGEOS in 1976
* But requirement now is for mm-level products, so:
* Can we improve satellite centre-of-mass models for all historical data, one of the key *accuracy* issues, impacting scale determination and GM;
* And, importantly, is the ground-segment technology going in the right direction to improve this issue for the present and the future

Satellite signature effect

* The satellite signature effect needs careful station/ epoch-dependent treatment in order to refer range measurements to the centres-of-mass of the geodetic satellites
* Up to 10mm station-dependent differences for LAGEOS, 30mm for Etalon (Otsubo & Appleby, 2003)
* These effects are similar to the antenna phase-centre effects on GNSS satellites and receivers, as being addressed in IGS

New CoM values for L&E

* ILRS stations' site logs are a valuable source of relevant information:
* Detectors, laser pulse-length, operational practices (return-energy regimes), etc.
* Used to derive time-series of CoM corrections and their uncertainties for each station for LAGEOS and for Etalon
  * - using the published models and comparison with LAGEOS-2 pre-launch tests for some station configurations

New CoM values for L&E

* Results released in September 2011 to the analysis community for evaluation;
* AWG weekly pilot solutions since October 2011 include use of new LAGEOS and Etalon CoM values
* SGF AC recent (Aug-Sep 2011) 7-day arc, 4-satellite solutions for coordinates and EOP show small improvement in post-fit WRMS at sub-mm level;
* Residual mean value changes ± 0.2mm
* Plus some suggestion that LAGEOS-2 solutions worse (Pavlis, AWG Sept 2011)

Detail from CoM table for LAGEOS

Station	Time-span		detector info	CoM min, max, adopted (mm)
7838	01 04 2008	31 12 2050	20 MCP CSM	3.0 6 15 252 248 **250**
7838	01 07 1990	01 04 2008	100 MCP CSM	3.0 20 40 252 248 **250**
7839	01 01 1983	31 12 2000	300 PMT NC	3.0 120 150 245 241 **243**
7839	01 11 1981	08 10 2003	35 CSP NCM	2.2 3 9 255 250 **252**
7839	09 10 2003	31 12 2050	10 CSP NSF	2.2 3 9 255 250 **252**
7840	01 02 2007	31 12 2050	10 CSP CS	2.5 3 9 245 245 **245**
7840	31 03 1983	31 03 1992	100 PMT NCF	3.0 35 45 252 244 **248**
7840	31 03 1992	31 12 2050	100 CSP CS	3.0 6 15 246 244 **245**
7841	20 07 2001	31 12 2050	50 PMT CSF	2.5 10 18 254 248 **251**

Availability of CoM data tables

* Complete for LAGEOS and Etalon for 1980s onwards;
* Some missing stations/epochs discovered during discussions within AWG have been included;
* Some conflicts for stations with multi-configurations
  * Have implemented use of system configuration flags
* Almost ready to release data for Ajisai
* Starlette/stella under preparation
* Fortran code and two text files released

conclusions

* CoM corrections for LAGEOS and Etalon for all stations and for period 1980s onward completed
  * Software and text files released during Sept 2011
  * Evaluation by ACs underway
* New ILRS stations tending towards high-rate, lower energy
  * -> Less systematic problems wrt CoM values

ILRS Task Force Report: Beam Divergence

Mark Davis

ILRS GB/AGU December 6, 2011

- Procedure developed and presented at the Bad Kötzting Workshop in May 2010
  - Available at http://cddis.gsfc.nasa.gov/lw17/docs/presentations/session10/01a-Session10_DavisDivergence.pdf
- Received divergence tests data from Stafford, Herstmonceux, Graz, Shanghai, Changchun and Yunnan(?)
  - Processing data and interpreting results
  - Need greater participation by ILRS sites
  - Possible ILRS sponsored campaign
- Continuing to develop format for divergence test data
- Developing a spreadsheet to calculate divergence
  - Stations can use to determine system divergence based on “Davis Divergence” procedure
- Need to develop data archival procedure and format and establish repository at the CDDIS

ILRS Task Force Report: Beam Divergence

6-Dec-2011

Summary of Issues

- Crew Procedure
- Reporting uniformity
- Results Interpretation
- Archiving efforts
- Proposed Format
- Utilization of measurements for guidance future daytime GNSS array design
- Timeline

Crew Procedure

- This is outlined in Bad Kotzting workshop ppt
  - Session 10 – Wednesday
  - http://cddis.gsfc.nasa.gov/lw17/docs/presentations/session10/01a-Session10_DavisDivergence.pdf

- Minimum step guidance
  - is 1/20th expected beam size or 1 arcsec –
    - practically achievable by KHz
  - Likely will be atmospheric jitter limited
  - Measure the time to make the measurement
  - Realtime Automatic return rate computation logging
    - Duration over each step uniform to keep the rate data consistent
      - Graz used 0.1 sec
      - Hz uses 1.0 sec for kHz and 8 sec for Hz
    - Realtime Signal vs Dark Noise separation needed for the realtime rate computation

- Pairs of Measurements
  - Same sky conditions
  - Same hardware configuration

- Station Practices
  - Many will haven additional practices or observations which will be useful to future measurements at other stations
  - Verbose area for comments

Reporting Uniformity: Proposed Format

- Each File is a measurement on a particular satellite
- Standard Required information
  - Epoch
  - Satellite
  - Station
    - We can get most of this from the matching normal point file
  - Average range
  - Minimum step used
  - Steps from “barely there to barely there”
  - Duration for measurements
  - Time between final centering and final measurements
- Optional
  - Weather conditions
  - Sky clarity
  - System dependent variable parameters
    - Divergence
    - Tx power
    - Fireing rate

- Optional station specific measurements
  - To permit the automatic return rate and angle offset logs from Herstmonceaux and Graz

Results Interpretation

- Requires Pairs of Satellites at the same elevation
  - Same sky conditions
  - Ideally Starlette/Stella/Ajisai and Lageos I/II combinations
  - Getting ok results with Lageos and GNSS
- Stability of result as function of centering
  - Time consuming part is the boresite finding
    - this can be done with much bigger steps
    - Area of research to see how sensitive this will be to final result
- Measured Steps Interpretation
  - Excel worksheet is available to convert from steps to size
  - Will likely evolve as we get better
  - Will need to accommodate the time to make the measurement
    - There are beam offsets in boresite center as the pass occurs
    - There is going to be changed in atmosphere
      - Elevation changes
      - Even the high light clouds
      - Stability of the return rate is likely going to play a role

Archiving Efforts

- If the stations make the measurements
  - Record what was OBSERVED
  - Do not mix final interpretation with observations
  - Different operators at the same station will be useful
    - (but don't mix them up until shown compatable)

- Similar to Sitelog updates
  - (is this just simply mail them to the CB address?)

- Set up a tree that is parallel to the CRD normal point archive
  - Divergence / yyyy / satellite / unique naming .divergence
  - There can be more than one measurement in the file
  - Make the unique name close enough to actual normal point file name so they can be used together for automatic assessment

Utilizing Measurements

- MAD to add a summary chart

Timeline and Participation

- Very enthusiastic responses from Stafford, Herstmonceaux, Graz, Shanghai, ChangChun and Yunnan prior to the workshop in May
- Other stations have expressed interest
  - No responses yet
- Need participation from the key contributing sites and typical configurations envisioned for GNSS support in 5+ years
  - Performance data for GNSS array design finalization is the key driver

NGSLR UPDATE

Jan McGarry

ILRS GB Meeting

December 6, 2011

NGSLR Activities under SGP

- Will be moving to a non-eyesafe laser for future of NGSLR – dictated by need for 24/7 GNSS ranging. Have ordered a Photonics Industries (PI) 2.5+ mJ/pulse 50 ps pulsewidth 2 kHz laser.
- Modifying NASA built mJ laser to improve stability so it can be used in interim until PI laser is delivered. Plan is to perform intercomparison with MOBLAS-7 using this laser in early 2012.
- Replacing current NGSLR optical bench with new design and new parts. Reasons for replacement include: improved alignment capability, space for automated controls, improved isolation between Xmit/Rcv, higher damage threshold optics. Design complete – parts (make/model are being identified).
- NGSLR Development Lab in back of 1.2 m Telescope Facility has been setup and is in use to do software development, optical bench build and alignment, and automation testing. We will build up and test the new (automated) optical bench there before moving to NGSLR.
- Final parts of the NGSLR automation software are being worked. Automated ground calibration software has been written and is in testing. Closed loop tracking design has been started.

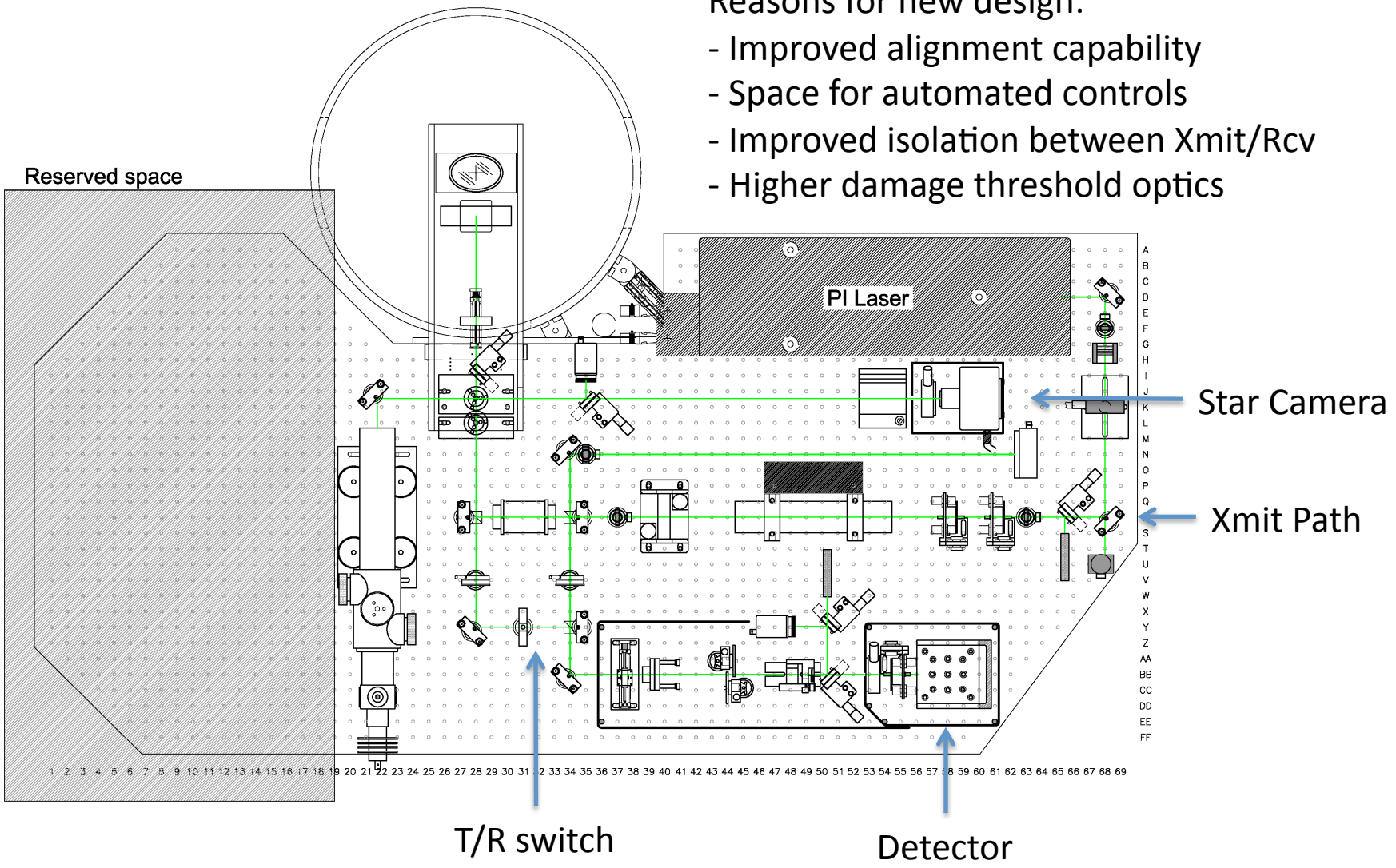
Procuring Higher Power Shorter Pulse Laser

Photonics Industries Short Pulse, Hi Energy, Hi Rep Rate Laser: Conversations with vendor have led to final laser specifications and configuration changes needed for new optical bench.

- Model RGL532-2.5
- Maximum Energy = 3 mJ
- Pulse Width FWHM = 50 ps
- Repetition Rate = Single Shot to 5 kHz
- Beam Divergence < 1 mR
- Output Beam Diameter = 1.7mm
- Spatial Mode Profile = TEM_{00}
- Long Term Stability < +/- 2%
- Pulse to Pulse Stability < 2% RMS

Building a New Optical Bench Design

Reasons for new design:
- Improved alignment capability
- Space for automated controls
- Improved isolation between Xmit/Rcv
- Higher damage threshold optics



Very Preliminary NGSLR Schedule

Major milestones under SGP

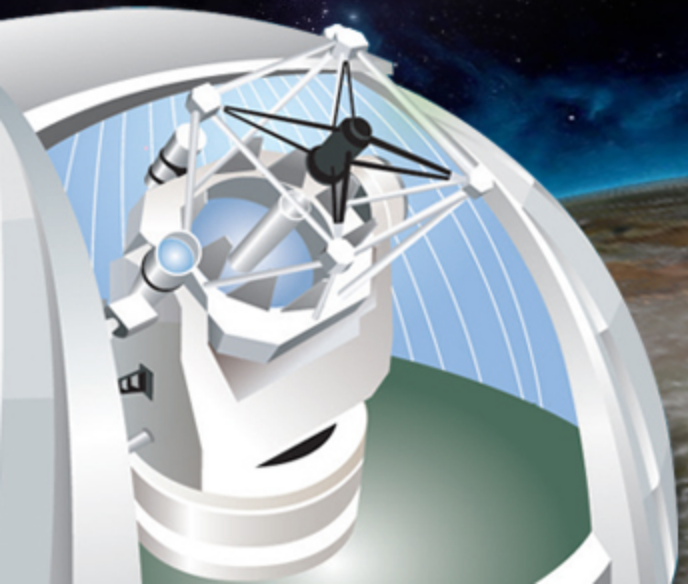
Complete prep for Inter-Comparison	Feb 2012
Inter-Comparison with MOBLAS-7 done	Mar 2012
New optical bench build/testing done	Mar 2012
Complete move of optical bench to NGSLR & test w/system	Aug 2012
Complete automated system checkout	Nov 2012
Collocation w/MOB-7 complete	Apr 2013

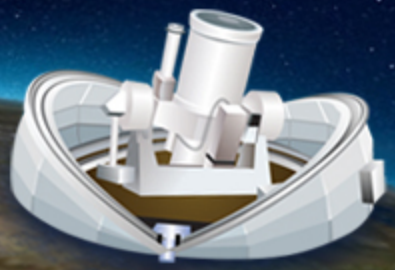
KASI 한국천문연구원
Korea Astronomy & Space Science Institute

Status and Progress of ARGO-M System Development

2011. 12. 06

Korea Astronomy & Space Science Institute(KASI)





ARGO
Accurate Ranging system for Geodetic Observation

KASI KIMM KAERI SaTReC

Overview of ARGO Program

- **ARGO** (**A**ccurate **R**anging system for **G**eodetic **O**bservation)

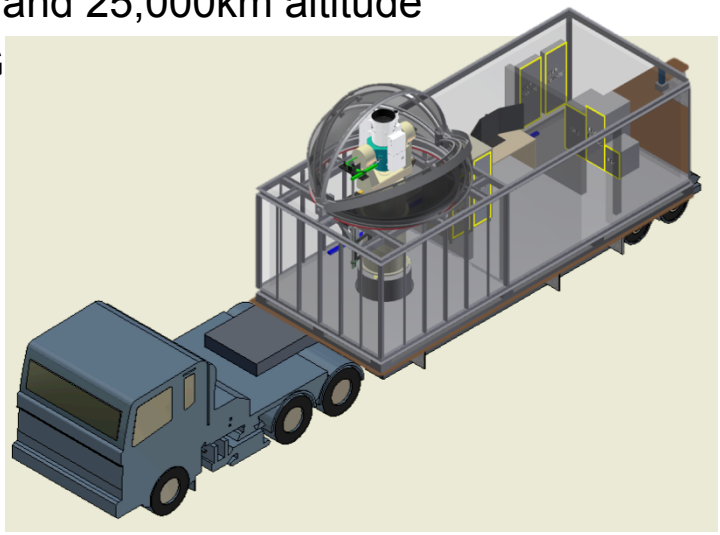
- **Development Phase**
  - 2008 - 2014 (7years)

- **Final Goal**
  - One mobile system(40cm/10cm) : ARGO-M
  - One fixed system(1m) : ARGO-F
- **Objectives**
  - Space geodesy research and GEOSS/GGOS contribution by laser ranging for satellites with LRA
  - Precise obit determination(POD) through laser ranging measurement with mm level accuracy
  - Contribution to international SLR societies and ILRS network participation

- **Development Strategies**
  - **KASI and other governmental institutes in developing the ARGO-M system**
    - KIMM (Korean Institute of Machinery & Materials) : Tracking Mount
    - KRISS (Korea Research Institute of Standards and Science) : Telescope Mirrors
  - **(Semi) Turnkey based system with SLR/LLR capability for ARGO-F**
  - Cooperates with foreign institutes in China, Austria, Swiss and other countries

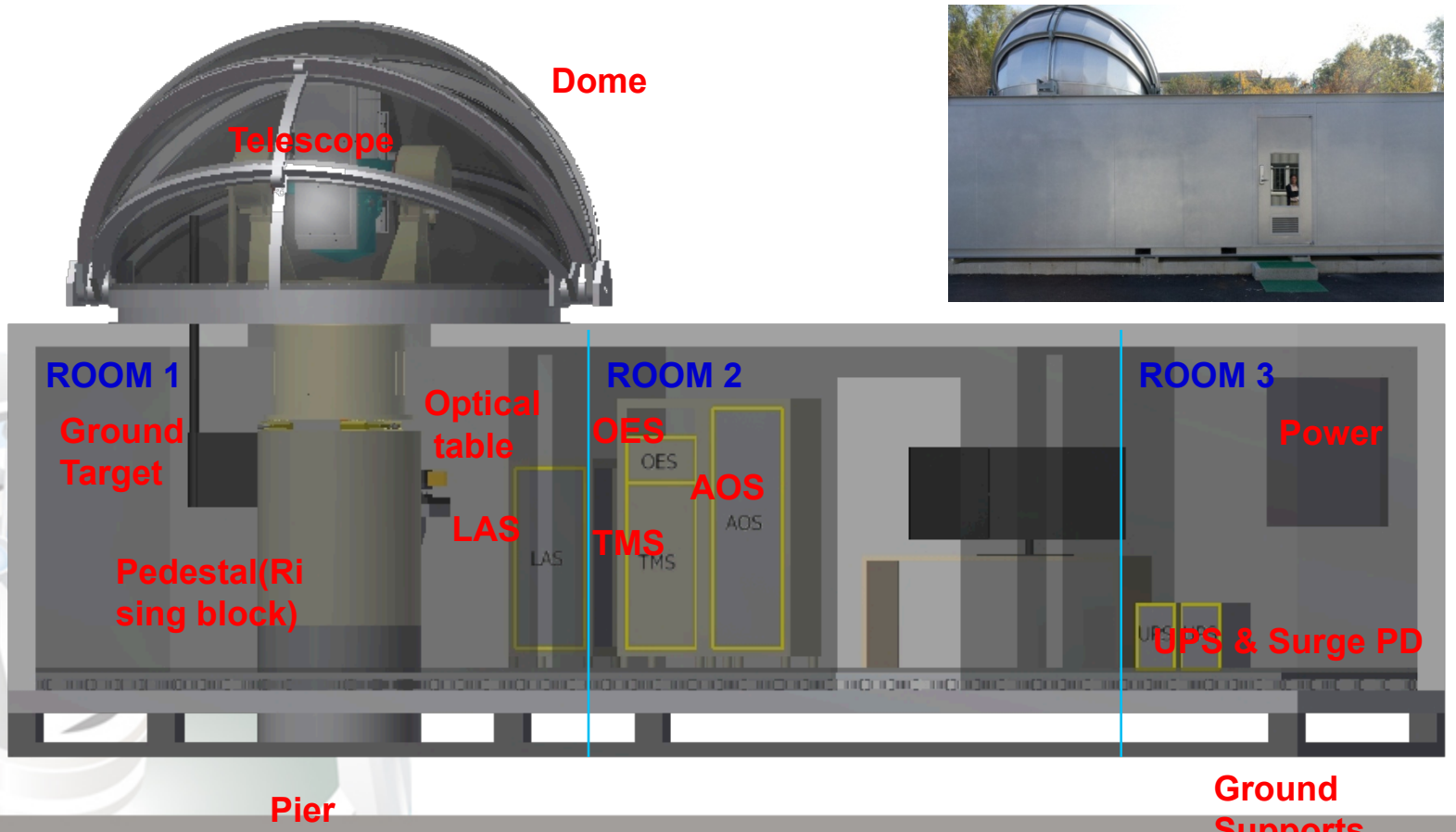
Major Characteristics of ARGO-M

- **ARGO-M Structure (6 subsystems)**
  - **OPS**(OPtics System), **TMS**(Tracking Mount System), **OES**(Opto-Electronic System), **CDS**(Container-Dome System), **LAS**(Laser System), **AOS**(ARGO-M Operation System)
- **Tracking Capability**
  - Capable of tracking satellites between 300km and 25,000km altitude
    - STSAT-2(300x1,500km), KOMPSAT-5, G
  - KHz laser ranging
  - Daylight and night tracking
- **Ranging Accuracy**
  - Lageos : 10mm(SS), 5mm(NP)
  - Ground Target : 3mm(SS), 1mm(NP)
- **Operational Functions**
  - Can be controlled from the remote site
  - Automated scheduling, planning and orbit prediction capability
  - Automatic ranging based on schedule and aircraft detection(using radar)
  - Automated diagnostic warning to monitoring system
- **Etc**
  - Container and central locking dome (move by using a trailer)



ARGO-M System Integration

- **ARGO-M Structure**
  - Room1(Laser room) : TMS, LAS, optical table, ground target
  - Room2(Operation room) : OES, TMS, AOS devices
  - Room3(Accessory room) : Power distribution panel, UPS, Surge protection devices



ARGO-M System Integration


PDU

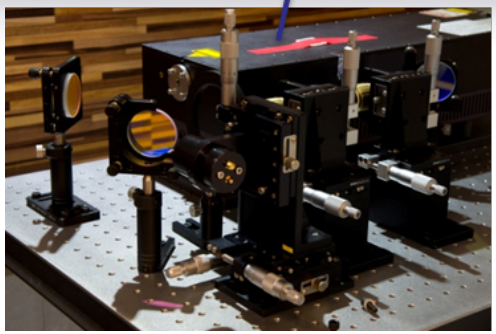

Event Timer


XLi

C-SPAD


SPD


FPGA Board


Laser head


Pedestal


Dome & Container


Telescope Tracking Mount


TMS xPC

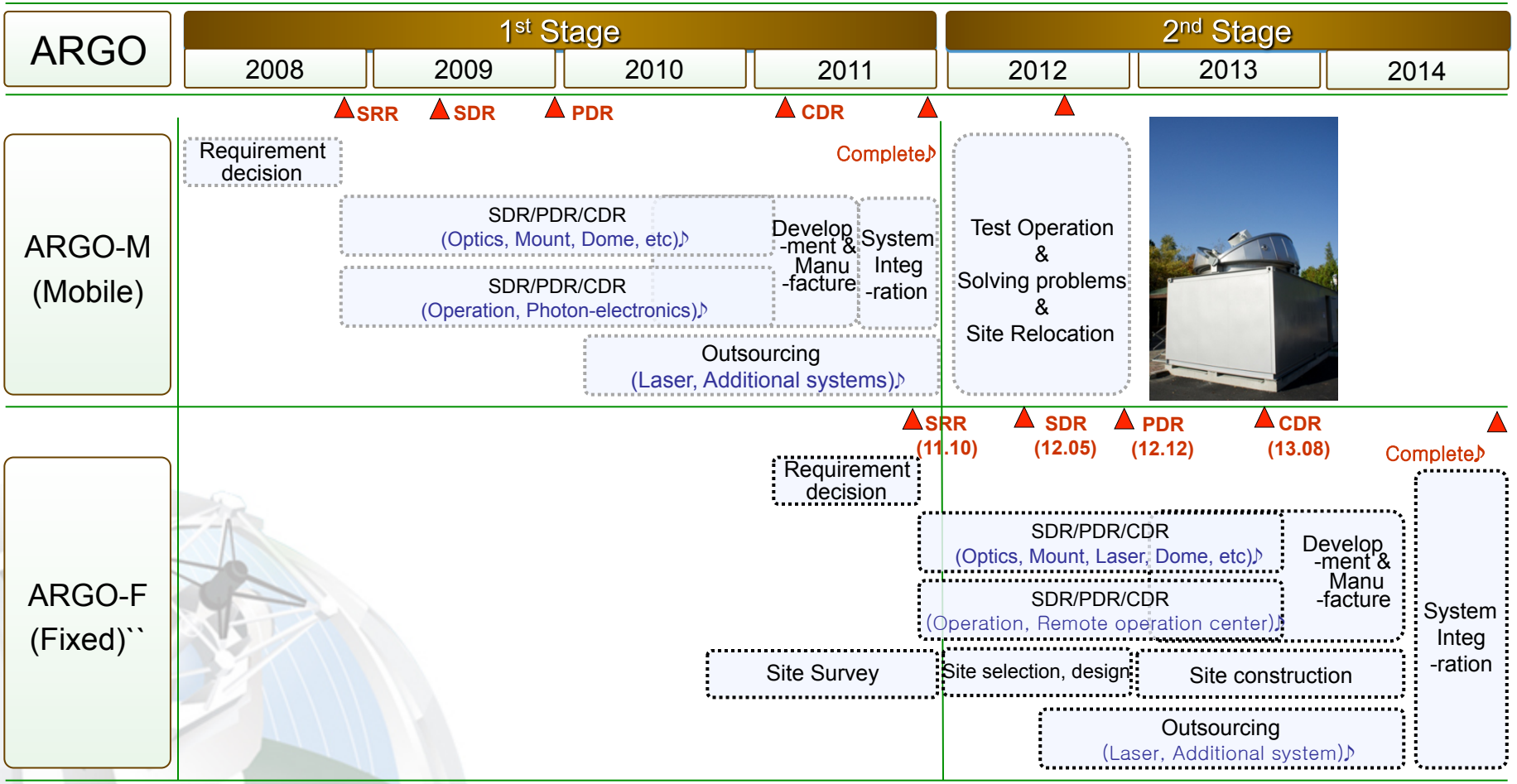
TMS controller


AOS


Laser control

Laser chiller

Milestone of ARGO-M Program



Milestone of ARGO-M Program

- **ARGO-M Design Review**
  - System Requirement Review : 2008.09
  - System Design Review : 2009.05
  - Preliminary Design Review : 2009.12
  - Critical Design Review : 2011.03
- **ARGO-M System Integration**
  - Container for ARGO-M site installation : 2011.08.05
  - Dome installation : 2011.09.22
  - Telescope, tracking mount installation : 2011.10.05

  ~Present
  - Tracking mount, dome, laser interface
  - Alignment Telescope, coudé light path
- **ARGO-M System Test Operation**
  - test operation and resolving problems (~ 2012.07)
  - Relocate ARGO-M system to official site (~ late 2012, Sejong city with VLBI)
  - Official Operation for ILRS Societies (late 2012 ~)

ILRS Support for GALILEO: first impressions

Report to Governing Board
Tuesday December 6, 2011

Graham Appleby

ILRS tracking to date

(Nov 28 – Dec 5)

GALILEO-101

Sat	Station	PAD_ID	Wave	Passes	Points
GALILEO	Yarragad	7090	5320	3	16
GALILEO	Mt Strom	7825	5320	1	4
GALILEO	Herstmon	7840	5320	1	6
GALILEO	Matera	7941	5320	6	20
				11	46

ILRS tracking to date

(Nov 28 – Dec 5)

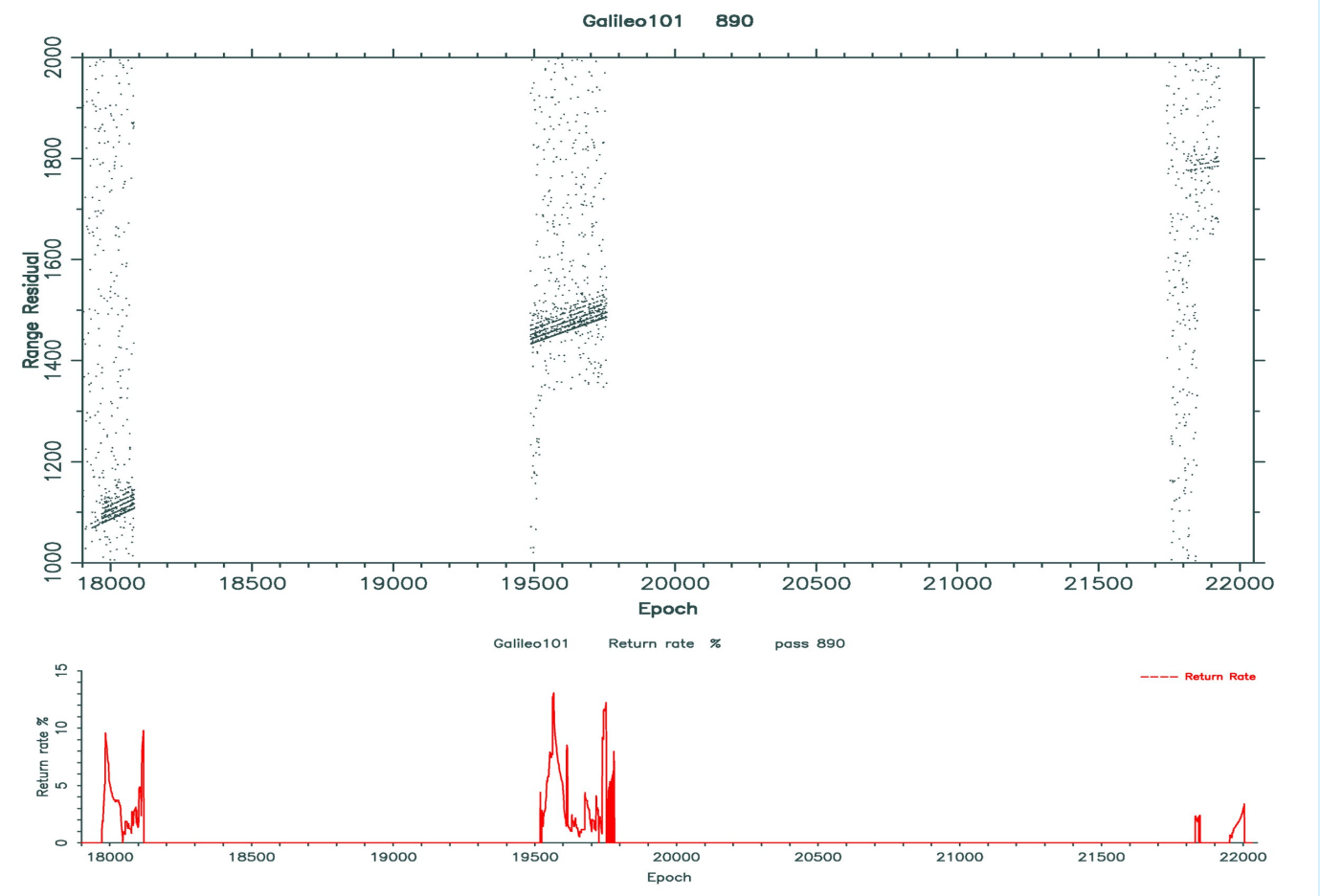
GALILEO-102

Sat	Station	PAD_ID	Wave	Passes	Points
GALILEO	Yarragad	7090	5320	2	11
GALILEO	Concepci	7405	8470	1	10
GALILEO	Mt Strom	7825	5320	1	3
GALILEO	Herstmon	7840	5320	2	9
GALILEO	Matera	7941	5320	1	3
				7	36

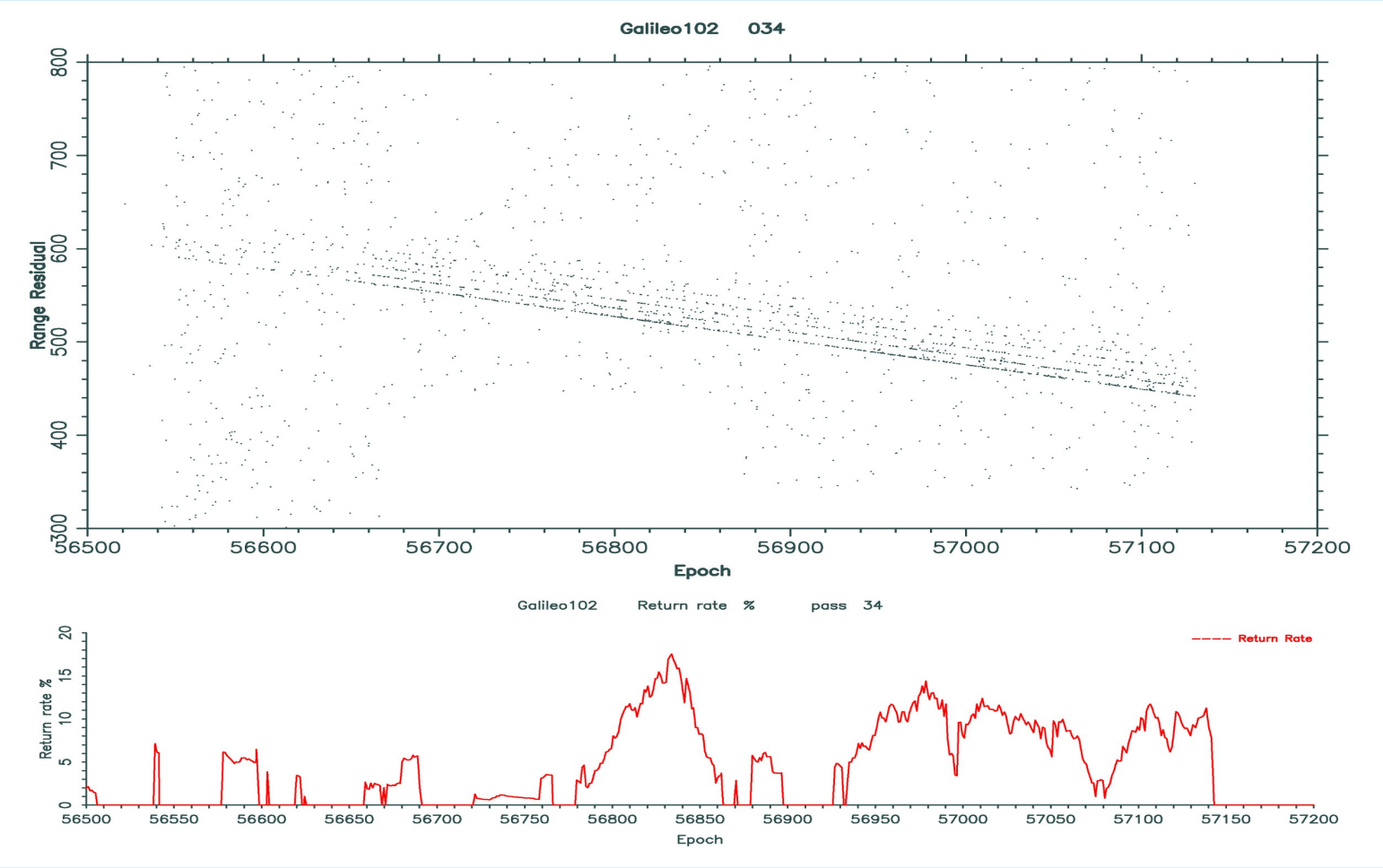
Some statistics from Herstmonceux

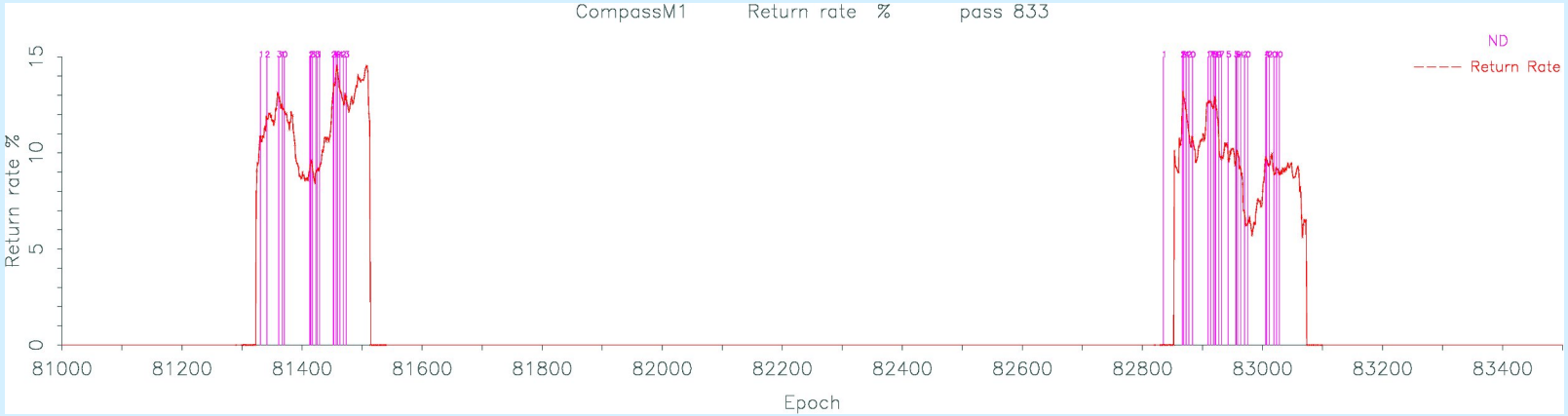
- Tracking achieved in daytime as well as at night
- Impression is that signal strength is at least as good as COMPASS-M1:
  - A detailed published study (ASR, 2011) using return-signal showed that the COMPASS-M1 cubes are the most efficient currently in GNSS orbit
  - Average return-rate for Hx 14Hz system:
  - COMPASS-M1: 5-15%; GALILEO: 5-15%

Tracking O-C plot for GALILEO 101



Tracking O-C plot for GALILEO 102




CompassM1 Return rate % pass 833
ND
Return Rate
Return rate %
0
5
10
15
81000
81200
81400
81600
81800
82000
82200
82400
82600
82800
83000
83200
83400
Epoch

Some relative statistics

- There are 42 cubes on COMPASS-M1, diameter 33mm, un-coated;
- There are 84 similar cubes on GALILEO 101 and 102

- Extra height of GALILEO implies a signal 0.75 x that from COMPASS (23,200 vs 21,500 km)
- 2x number of cubes on GALILEO then implies 2x0.75 = 1.5x signal of that from COMPASS
- Very early results from SGF do not contradict this analysis

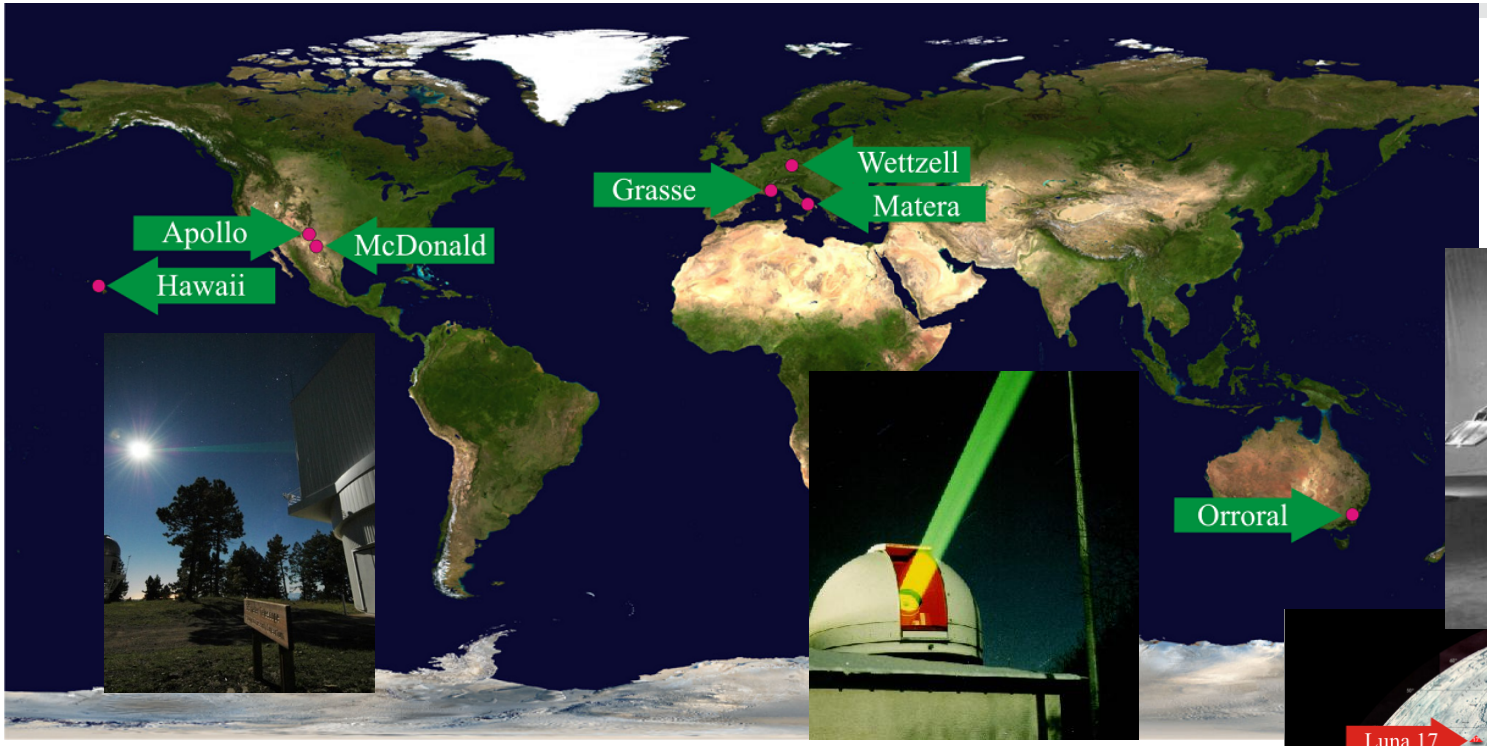
LLR – Status Report

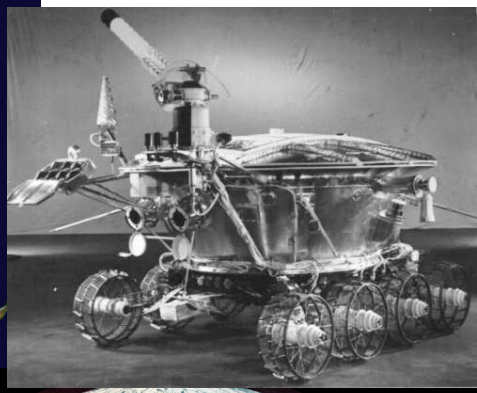
Jürgen Müller

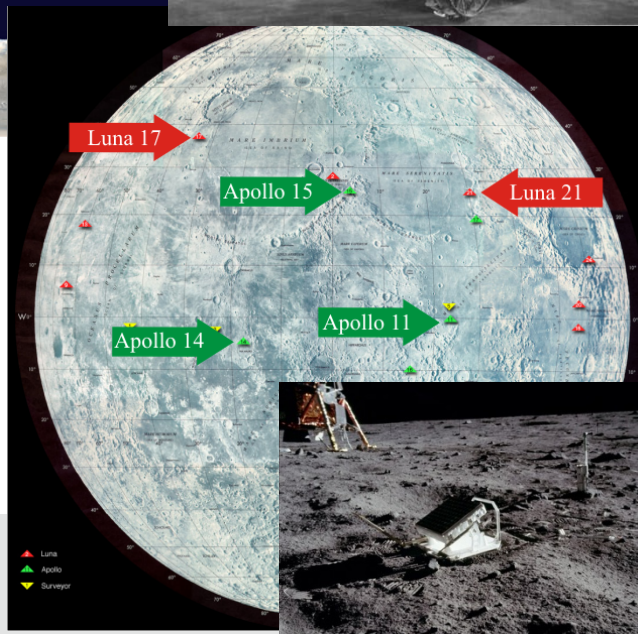
Institut für Erdmessung
(Institute of Geodesy)

Leibniz Universität Hannover
(University of Hannover)

Lunar Laser Ranging – in general



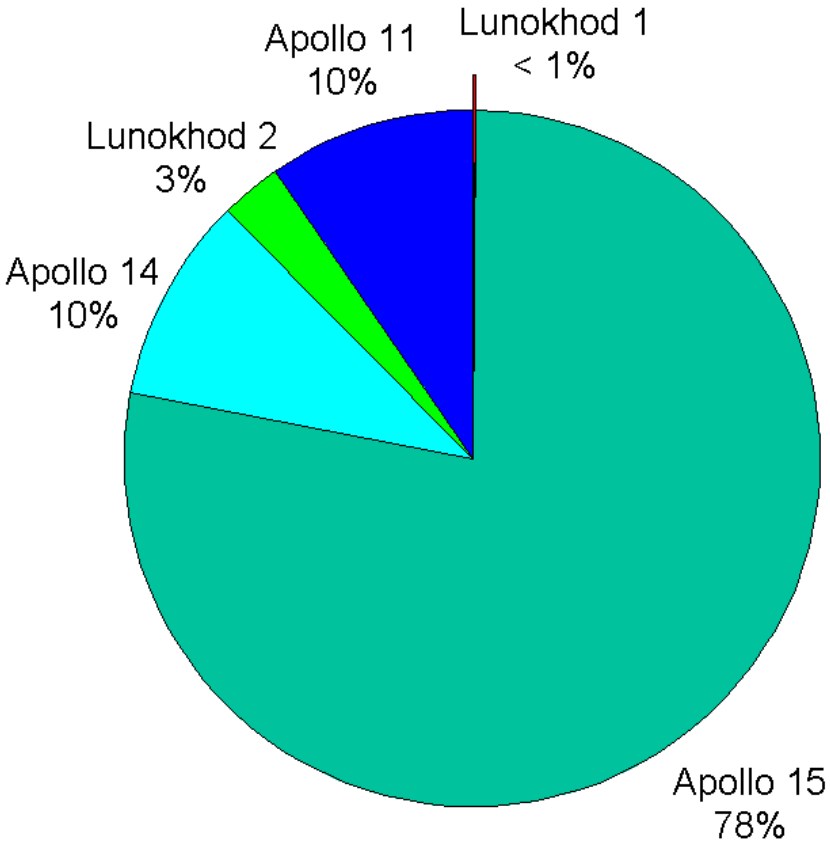


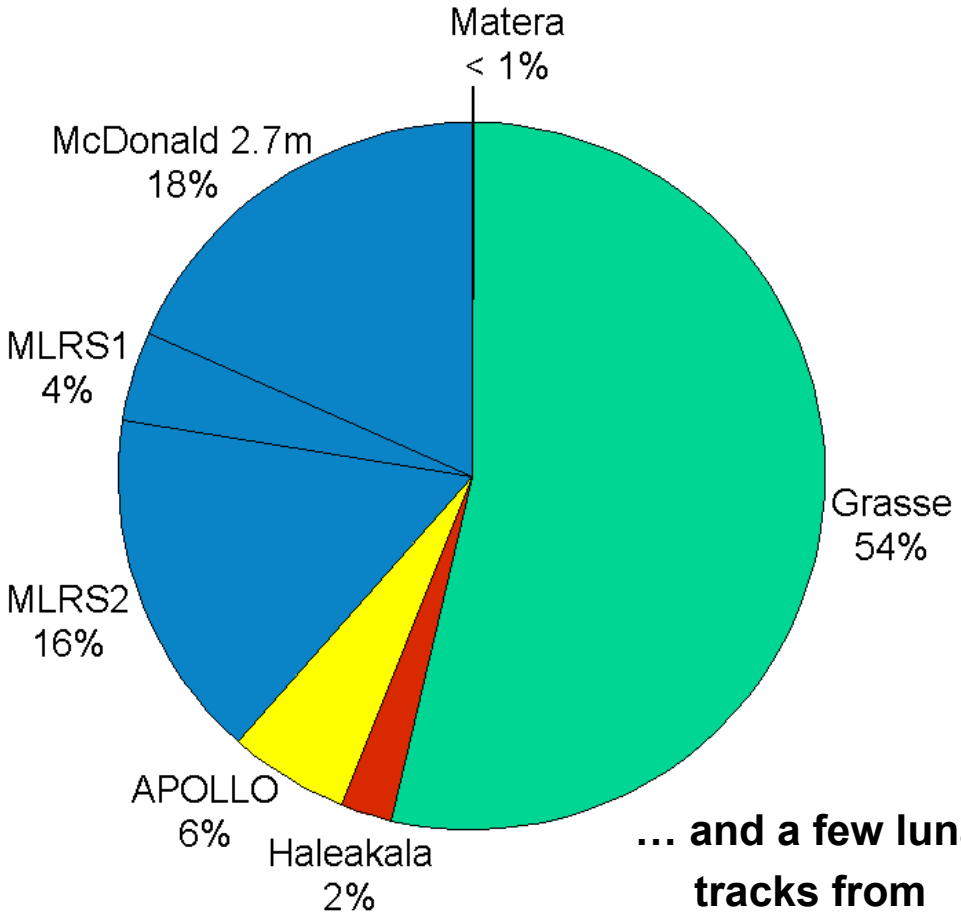


- 42 years of observations
- Post-newtonian model at cm level
- high long-term stability (orbit, reference frames, Earth orientation)
- relativity tests

Statistics – retro-reflectors and observatories

Time span **1970-2011**



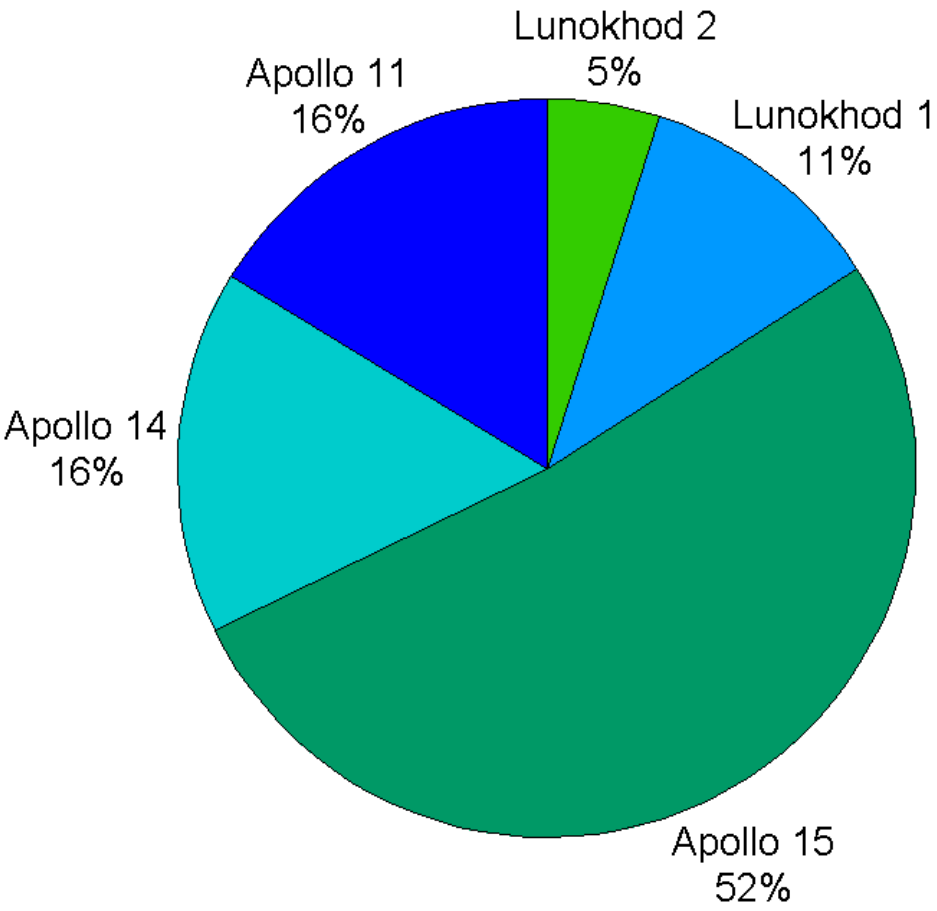


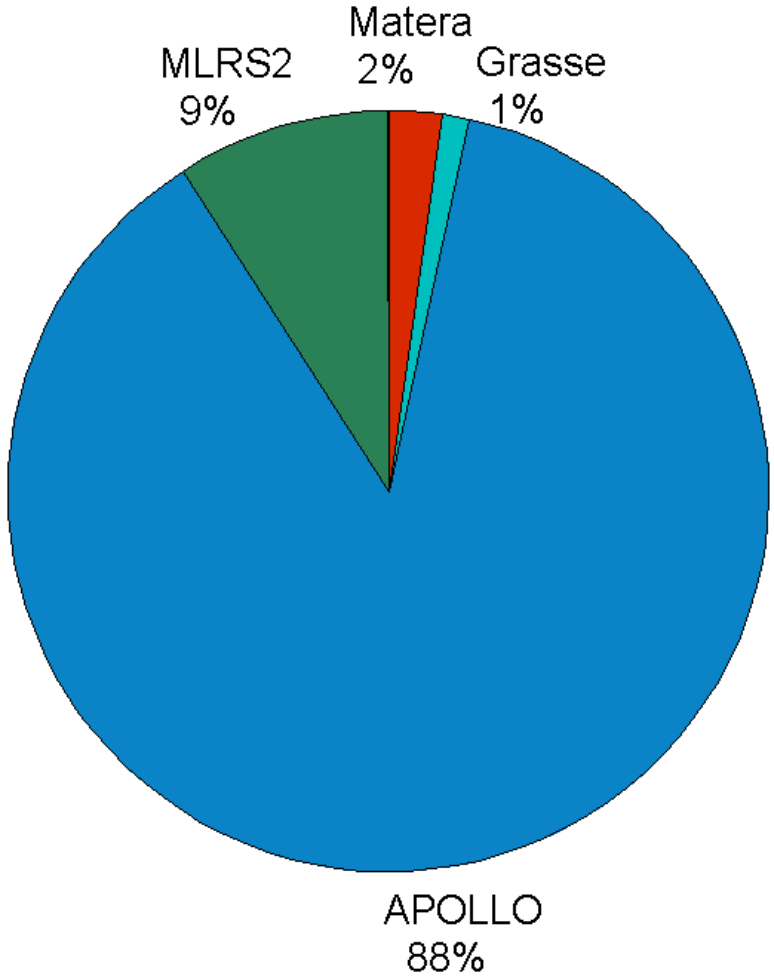
… and a few lunar tracks from

- **Orroral**
- **Wettzell**

Statistics – retro-reflectors and observatories

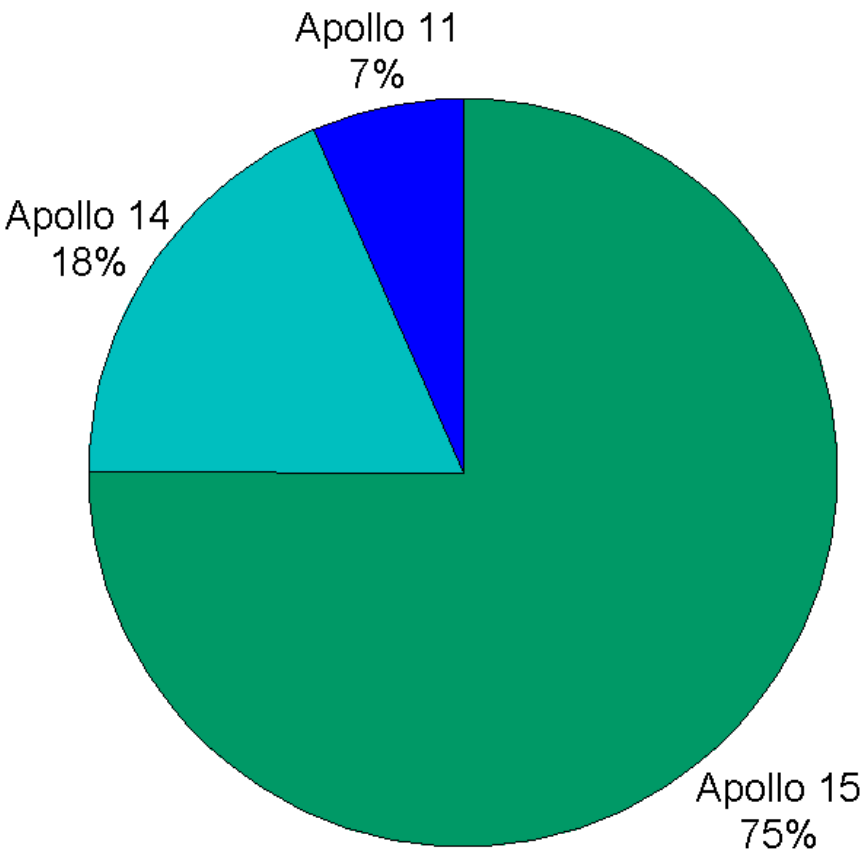
Only **2010**

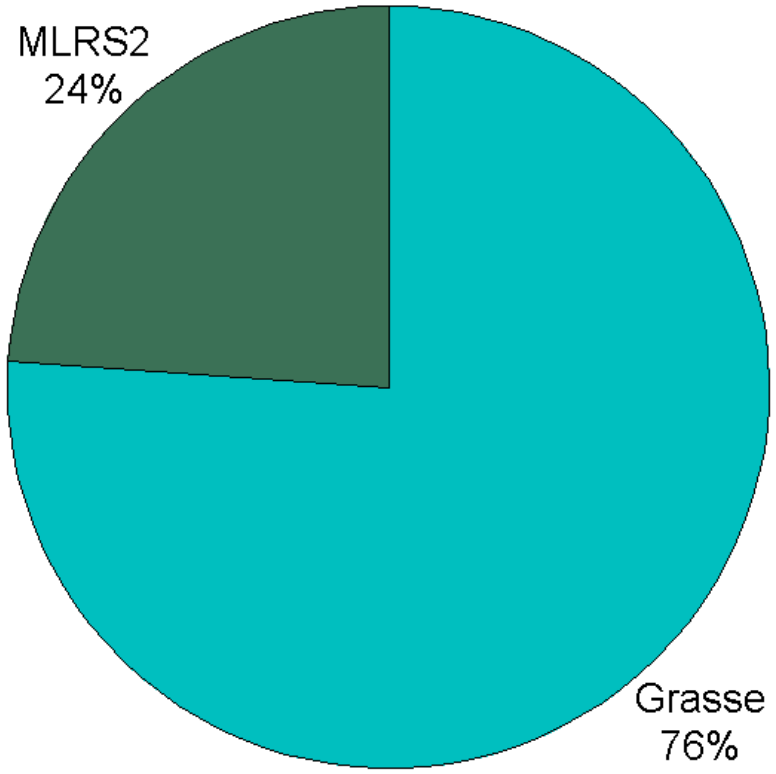




Statistics – retro-reflectors and observatories

Only **2011**



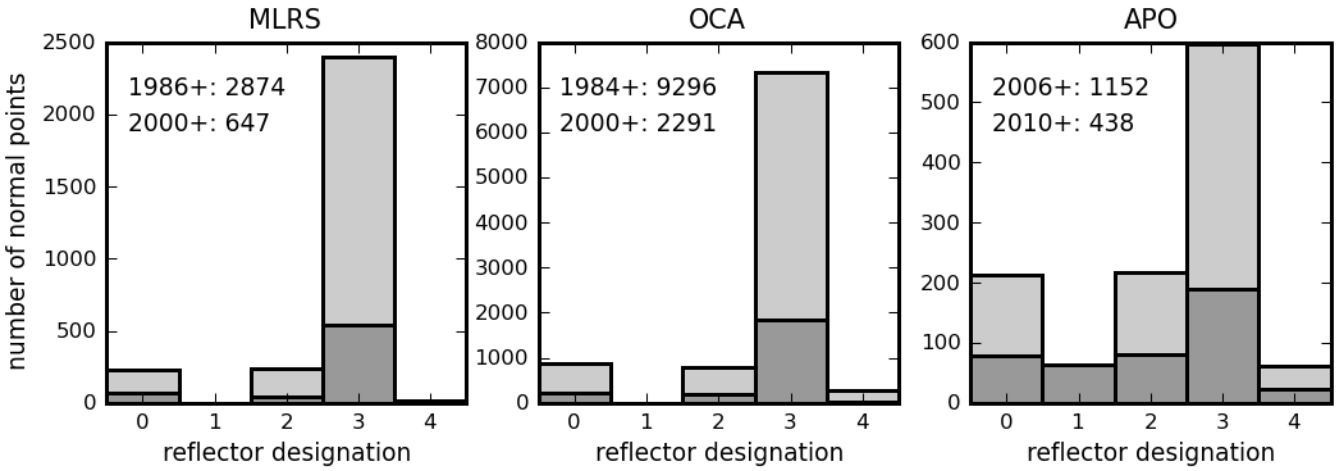


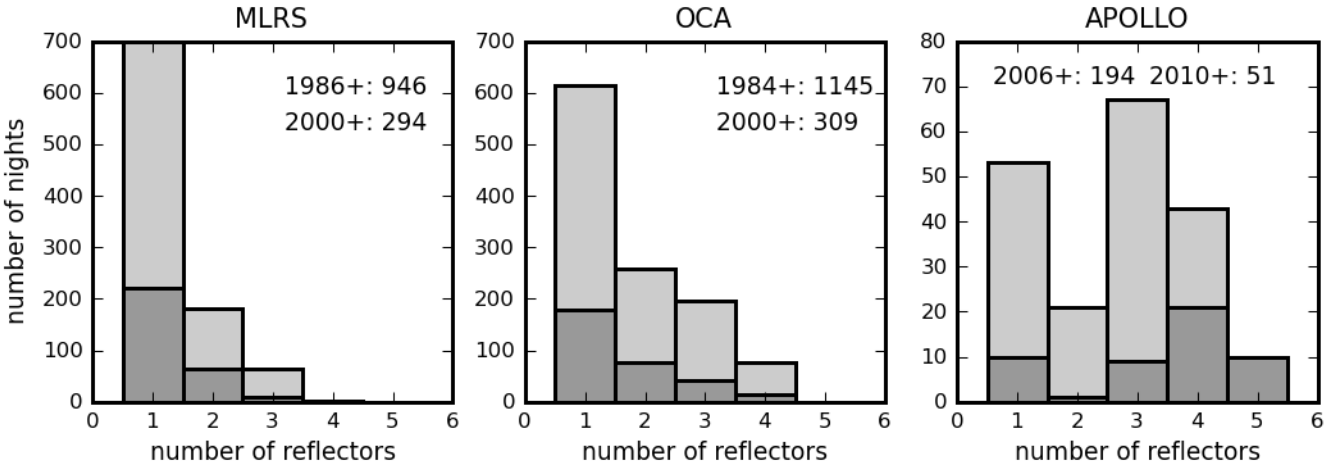
No APOLLO tracks and
no tracks to Lunokhod 1 and 2
in the archive for 2011.

Statistics – retro-reflector acquisition

Number of normal point measurements per reflector for the major LLR sites

dark shade is only “recent years”



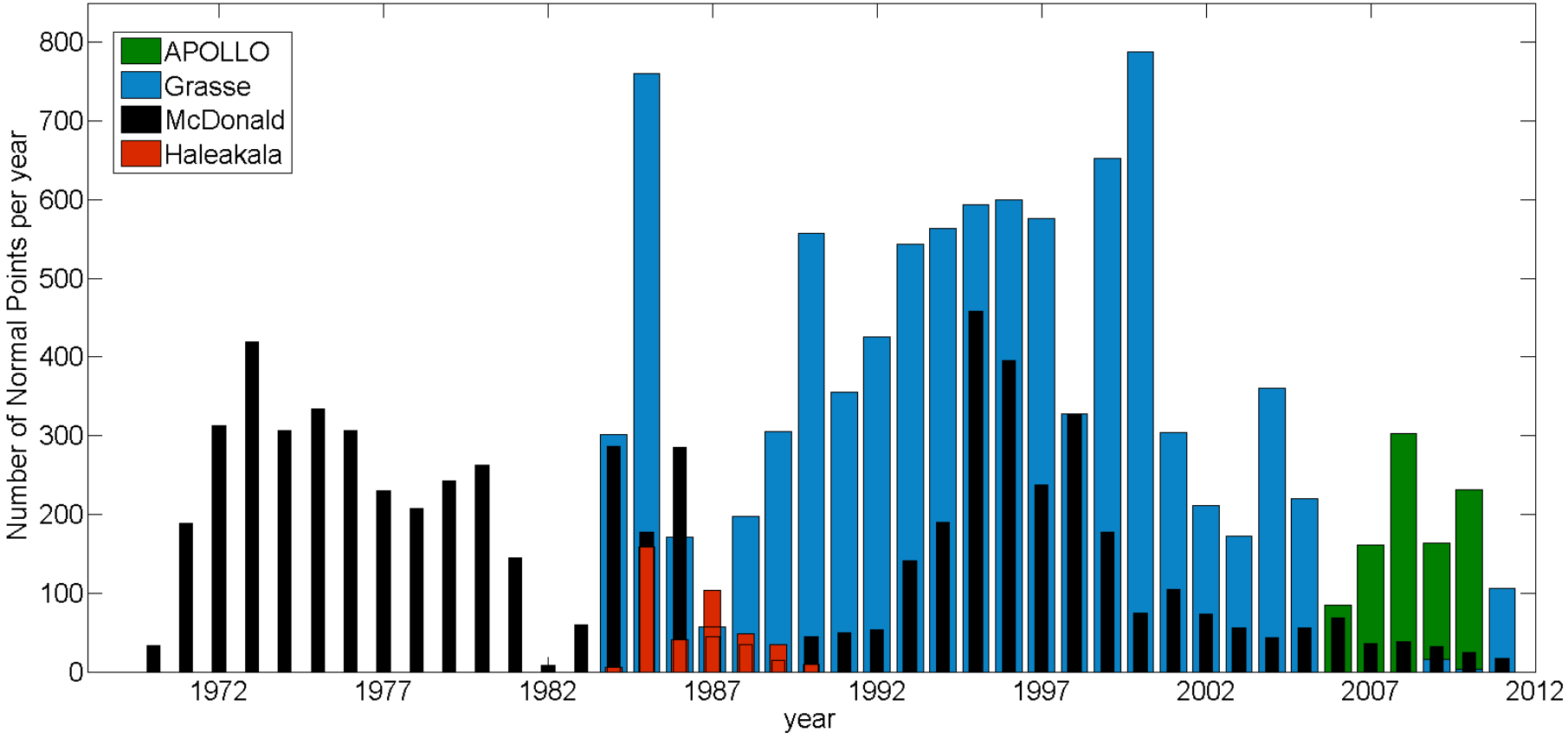


Number of reflectors acquired per night of observation

dark shade is only “recent years”

Number of normal points

- 1970 - 2011: ca.17,000 normal points



Status, perspective at the LLR sites

- McDonald continued lunar tracking (at low level only) as well as LRO tracking
- APOLLO - good LLR data, also LRO tracking
- Grasse is back into the game since end of 2009, but less LLR tracking in 2010
- Matera re-started LLR tracking in spring 2010, but not routinely at the moment
- Wettzell will soon resume – first attempts have been made

Perspective for the LLR retro-reflectors

- Future lunar missions, e.g., pushed by Google Lunar X Prize (http://en.wikipedia.org/wiki/Google_Lunar_X_Prize) may damage the retro-reflectors on the moon in the *worst case* (casting of dust onto, shift of retro-reflectors, etc.).
  In the *best case*, those missions could also be helpful for us (visual inspection or even "cleaning" of retro-reflectors, …).

- NASA report (NASA-USG_lunar_historic_sites.pdf) shows awareness of the ongoing LLR effort and the importance of the LLR sites on the moon.

- Position of ILRS?
  ILRS should support appropriate treatment of retro-reflectors.

Further activities

- ISSI workshop series on LLR modelling and analysis (start 2009), final meeting in spring 2012
- Boston workshop 2010 on comparison of LLR software packages
- ILRS initiative on LLR data qualification
- In Germany: New DFG Research unit “Reference systems” (speaker A. Nothnagel, Bonn) with 2 LLR related projects
  - Moon related systems
  - Barycentric ephemeris

  will start in spring 2012.

Available software at the analysis centers

Software packages for LLR data analysis

- Hannover: LUNAR
- Paris: INPOP
- Pasadena: JPL software (cooperation with NAOJ)
- Harvard CFA: PEP
- MIT: PEP
- Austin, Univ. Texas: a version of PEP (in the past)

Comparison of post-fit residuals in 2010 (ISSI inspired and Boston workshop) showed major differences.

Main research at lunar analysis centers

- Jet Propulsion Laboratory (JPL)
  - lunar interior, lunar core
  - relativity
- Paris Observatory Lunar Analysis Center (POLAC)
  - libration theory
  - reference frames
- Institute of Geodesy (IfE)
  - Earth orientation
  - lunar interior
  - relativity
- Others: special topics ...

LLR tests of general relativity

Strong equivalence principle

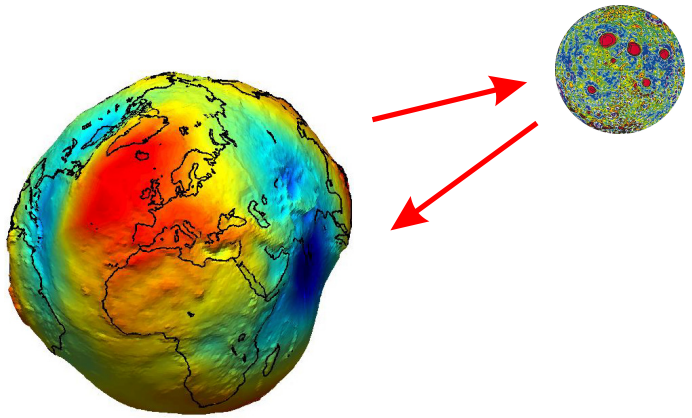
$$\eta = (1 \pm 5) \times 10^{-4}$$

$$\left[\frac{M_G}{M_I}\right]_{SEP} - 1 = (-0.5 \pm 2.3) \times 10^{-13}$$

Temporal variation of the gravitational constant

$$G = G_0 \left(1 + \frac{\dot{G}}{G} \Delta t + \ldots\right)$$

$$\frac{\dot{G}}{G} = (1 \pm 4) \times 10^{-13}\,\mathrm{yr}^{-1}$$



Factor 2 improvement due to refined modelling and more LLR data

Hofmann, Müller, Biskupek, Astron. & Astroph., 2010

Grasse/MEO and tracking RadioAstron in November 2011

F. Pierron and Grasse Laser staff

Observatoire de la Côte d'Azur

Grasse/Meo Laser Ranging station

for Operations from 400 km to the Moon..

- Specific configuration for poor orbit predictions like Radioastron
  - -Large Field of view and very sensitive camera
  - -Spad detector with gating high voltage tuned to decrease dark noise
    - » Range gate of 30m (100 ns) on standard target .
    - » Range gate of some kilometers with gating voltage decreased

      Real time tunable when echoes detected..

Grasse/MEO and tracking RadioAstron in November 2011

Observatoire de la Côte d'Azur

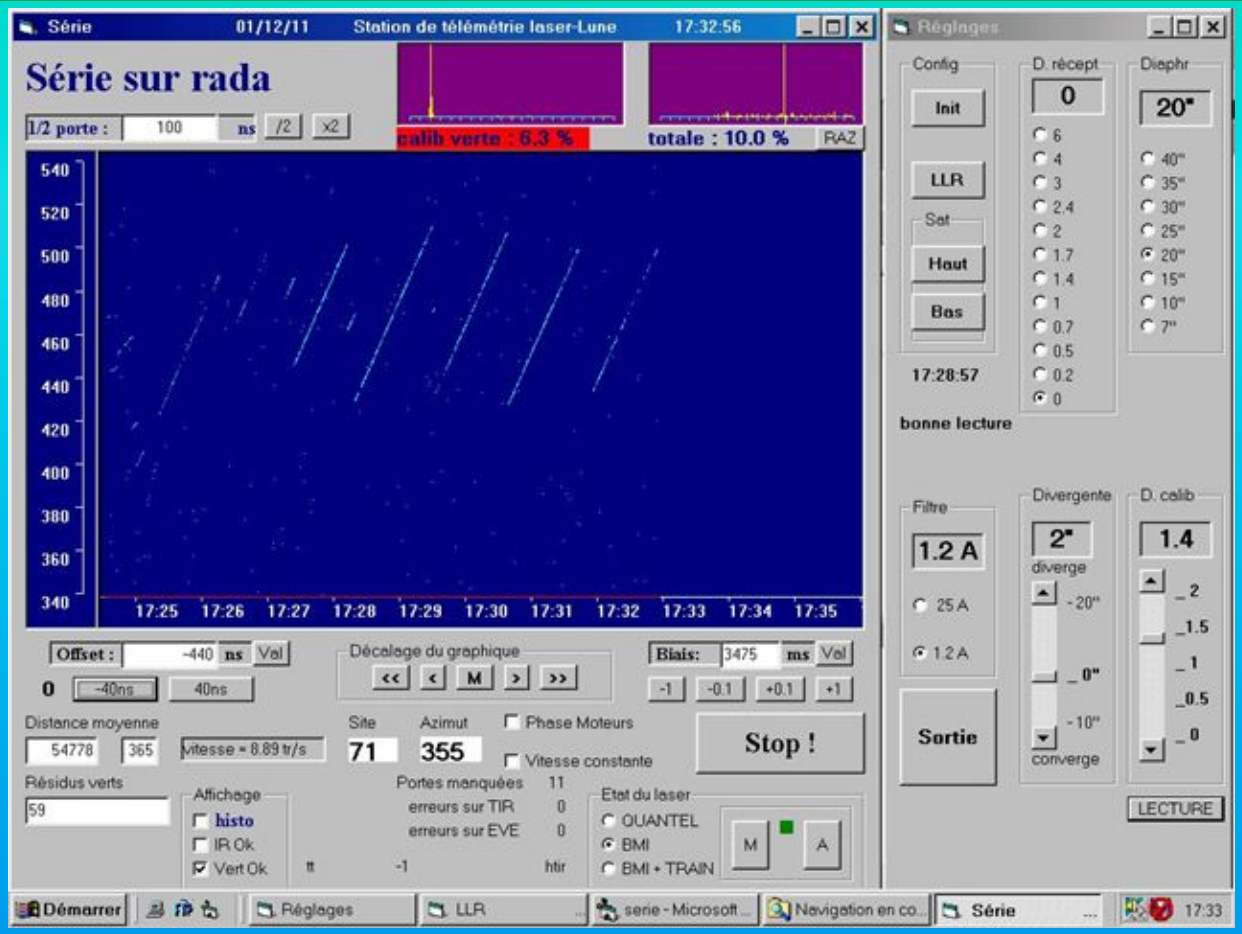
Usual RadioAstron Range :

50 000 km/300 000 km

Predictions accuracy :

Time Bias :
~ 1 to some sec of time

Visibility with camera :
-easy with Meo system
-Very Helpful



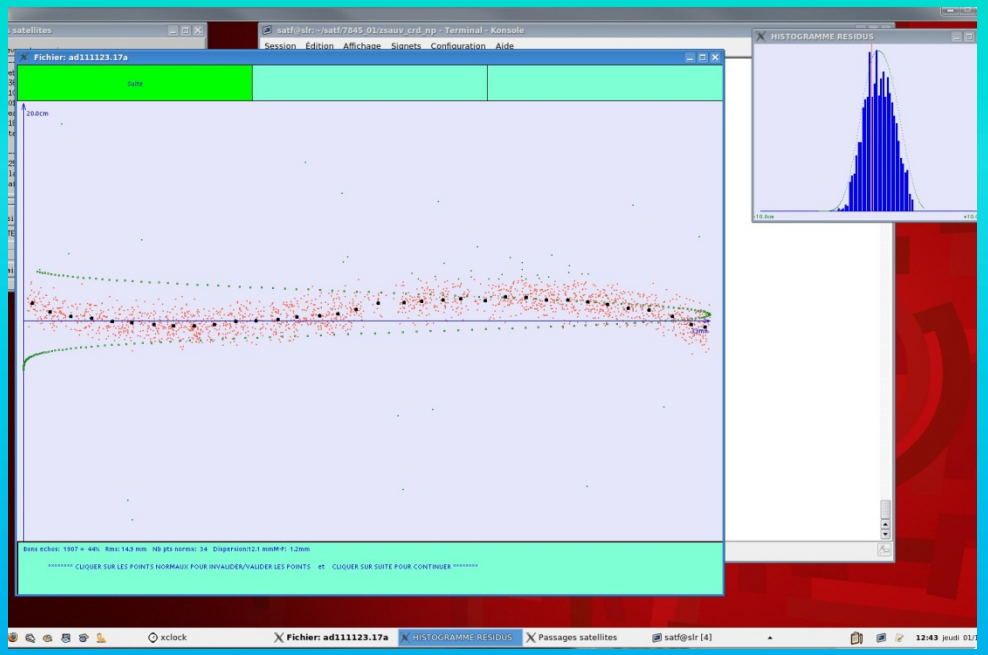
Real Time display on Meo software with :

TB: 3457 ms and steps of 80 ns/every minute of time

Grasse/MEO and tracking RadioAstron in November 2011

Preprocessing and normal points computation

Observatoire de la Côte d'Azur



Plot with no corrections in Time or Range Bias (Vertical Scale: +/- 4 km)

Final iteration with orbit adjustment and Normal points computation

- -Vertical scale : 20 cm
- -Returns number : 2000
- -RMS : 12 mm
- -Normal points : 1900 in 33 minutes

First Radioastron echoes with Meo on November 15 th 2011
~ five 30 mn sequences from the beginning