NERC Space Geodesy Facility **Annex to AR2005/06**

Report on operations for the period 2005 May to 2006 April

1. SLR Observations

1.1 Annual summaries

The focus for most of the SLR development work this year has been in preparation for the new event timing system (ET) and the new KHz laser. This has required a major re-write of a large part of our prediction, observing and reduction software. Unfortunately, building the ET has proved to be a longer task than anticipated and thus we have not been able to test fully the new laser at KHz rate. However we have been successful at tracking from LEO to MEO using the new laser at 10Hz. During the year the site also underwent a major refurbishment, the most significant part being to give us proper access to the cellar below the site, where the Gravimeter is to be housed.

We have ranged to the standard set of satellites, striving to produce a large quantity of high quality observational data. The Table gives total numbers of satellite passes obtained by SGF, categorised according to the prime scientific mission of each satellite. In common with general ILRS priorities, the NERC Space Geodesy Steering Committee recommended that the Facility place the highest priority on the LEO altimetry/SAR satellites, followed by sufficient tracking of the MEO and HEO geodetic satellites to contribute significantly to the maintenance of the global reference frame. The scale and origin of this frame is determined by analysis of laser observations, the orientation by VLBI and GPS.

Pass totals for the year 2005 April to 2006 March

Altimetry							
ERS-2	347	Envisat	361	Topex/P#	454	Jason-1	625
GFO-1	381						
Geodetic/Gravity							
Lageos-1	602	Lageos-2	432	Etalon-1	67	Etalon-2	84
Champ	131	Grace A	106	Grace B	91	Beacon-C	205*
Starlette	415	Stella	223*	Ajisai	439	Larets	317
Navigation							
GPS35	32	GPS36	48	Glonass	939***		
Other support							
Meteor#	81**	GravityB	107				

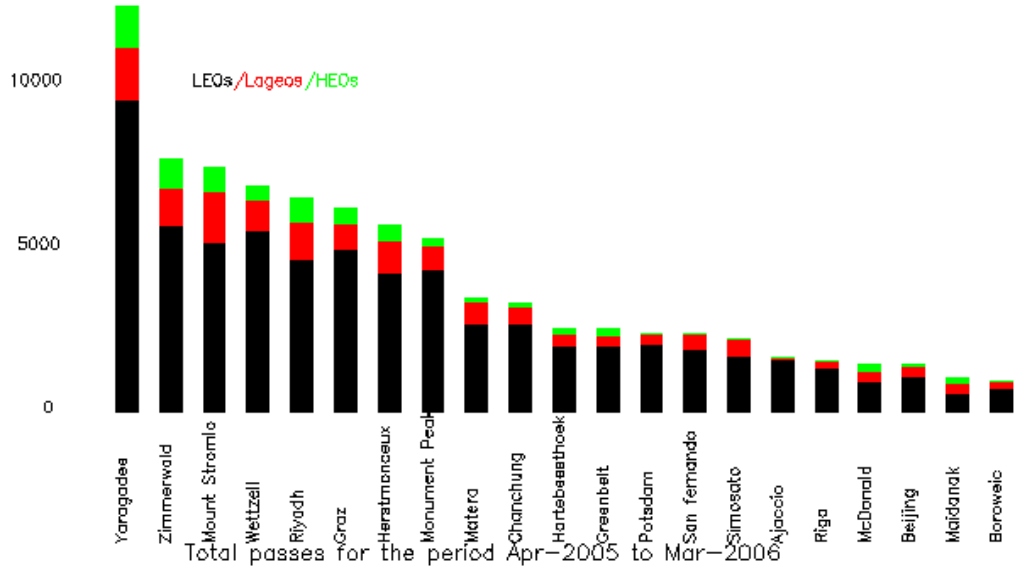
\# These satellites "died" during the year and have been removed from the list

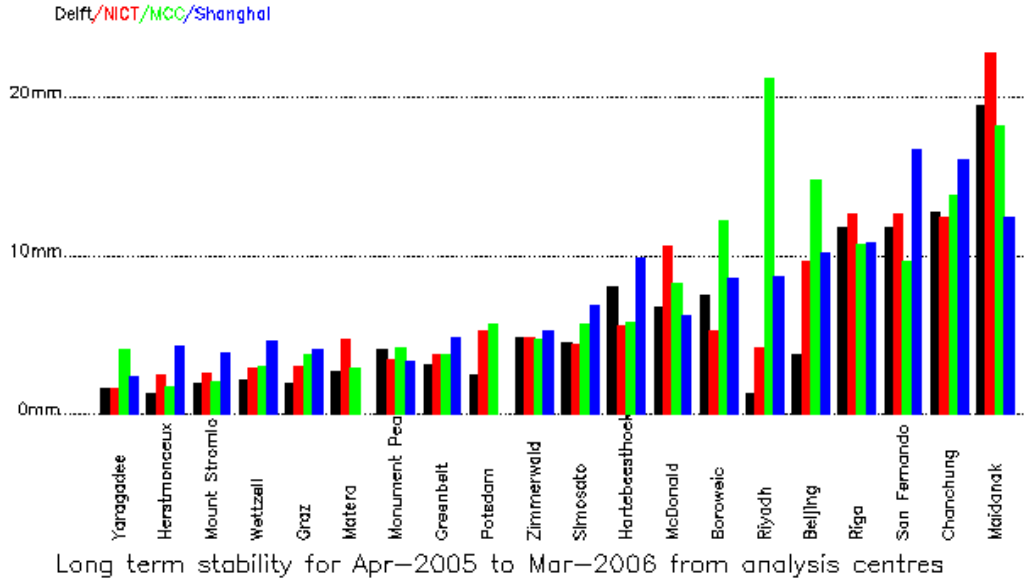
* These values have not changed due to reduced priority during scheduling, while all others have increased by ~35% due to especially good observing conditions in 2005.

** For 2005 only 367 passes were obtained globally, of which Yaragadee got 172, Herstmonceux 82 and Riyadh 58.

*** This has more than doubled from the 430 for the previous period.

The two summary plots below are based on data taken from the ILRS quarterly reports and show that SGF makes a major contribution to global tracking both in terms of quality and quantity of observations.





1.2 New launches

There were three new GLONASS satellites launched during the period (Numbered 98, 99, 100). Also launched during this period was OICETS (Optical Inter Communications Experiment Test Satellite) http://god.tksc.jaxa.jp/oi/oicets.html , ALOS (Advanced Land Observing System) http://god.tksc.nasda.go.jp/al/al.html and the first of the In-orbit validation vehicles of the new GALILEO system, GIOVE-A, built by SSTL, UK.

1.3. Laser sensitive satellites

There are currently two satellites on the ILRS list with laser-sensitive equipment on them, IceSat and ALOS. Only a few stations are allowed by the programme managers (at CSR, Texas) to track IceSat. As part of the upgrade to a KHz system and new SLR predictions we have re-written our prediction software to incorporate the observing requirements of IceSat (only track when below 70degs in elevation) and ALOS (only track for predetermined time periods sent out in advance by owner). For both of these satellites we also have to check via ftp at the start of the pass for an emergency stop/go flag. These observing limitations and checking of the stop/go flag all happen automatically and are designed as fail safe systems. For example - if the system cannot access the stop/go flag the system will not allow the observer to track the satellite. We have tested our software using Ajisai for both of these satellites and sent the resulting data to the satellite owners who have now given us permission to track the satellites. Tracking of IceSat commenced on 30th April 2006. For ALOS the Japanese owners drew up a contract exempting from responsibility those given permission to range should any damage to the satellite occur. The contract was cleared through NERC HQ, and we await instructions to begin ranging.
This new software is also used for Gravity-B and means we only attempt to observe when the reflectors are facing us.

1.4 KHz laser

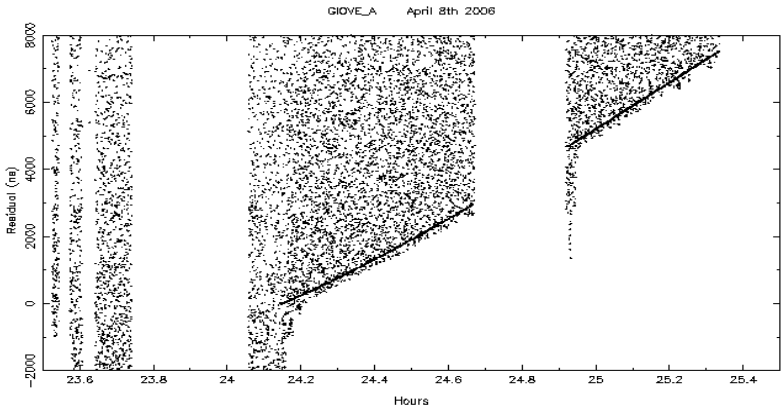
We have not been able to test the KHz laser fully as development of ET has taken longer than expected. However we have used the laser to track satellites at 10Hz for a few nights to confirm our ability to get data with the much weaker laser. Even with significant alignment problems we were still able to reach LAGEOS, Beacon-C, Envisat, Jason-1, ERS-2, GFO-1 and Ajisai.

For the LAGEOS pass we obtained ~500 points at 10Hz which should mean a return of 100,000 points at 2 kHz and with the system properly aligned.

As yet we have been unsuccessful in tracking HEOs as it is very difficult to distinguish track from noise at 10Hz

1.5 GALILEO (GIOVE-A)

Once GIOVE-A had reached its stable orbit, SSTL/ESA asked NSGF in February to attempt laser ranging. To help with acquisition ESA provided some predictions based on TLEs and broadcast data but due to the unreliability of TLEs these predictions were still poor. A combination of poor predictions, a very cloudy Spring and the limited availability at night due to its orbit (night time passes once every three days) meant we were able to track it successfully only once during April (and as of now twice in May).



The first pass of GIOVE-A, observed at Herstmonceux.

From the middle of May the ILRS has been asked to track GIOVE-A for a campaign period of 6-8 weeks to assist in validation of the onboard clock. We will use our orbit determination based on our laser data to assist in the prediction effort for the ILRS. An article describing the SGF ranging success and the SLR technique in general has been accepted for publication in *Inside GNSS* magazine.

1.5 Analysis

Automated global unconstrained solutions for station coordinates and EOPs are carried out each week two days after the observations (of LAGEOS 1/2 and ETALON 1/2) are made. The solutions, in SINEX format, are submitted to the ILRS Combination Centres where an official ILRS product is generated. Following discussions at an ILRS Analysis Working Group meeting prior to the Eastbourne Workshop, a complete re-analysis of LAGEOS 1/2 data from 1993 to date has been carried out, mainly to include new centre of mass values. These solutions, combined with those of other ILRS analysts, will be the SLR content in the new realization of the terrestrial reference frame ITRF2005. SGF has been awarded ILRS Analysis Centre status as a result of these efforts. An extensive analysis software comparison has been carried out between the SGF package (SATAN) and that of Newcastle University (FAUST). Some small differences were detected and corrected in each package, both of which comply with IERS2003 standards.

1.6 Global SLR network.

The NASA systems continue working on a reduced observing schedule whilst effort is dedicated to SLR2000 development (http://cddis.gsfc.nasa.gov/slr2000/slr2000_news.html). However, it is clear from discussions within the ILRS that NASA is committed to the technique, and the good news is that Hawaii and Arequipa are expected to resume operations in autumn, 2006.

A relocated Chinese system commenced operation at the beginning of 2006 at San Juan, S. America. The Shanghai station was relocated in autumn 2005 and recommenced in December 2005. We have assisted in checking the quality of the data and determining station coordinates on behalf of the ILRS for the San Juan system.

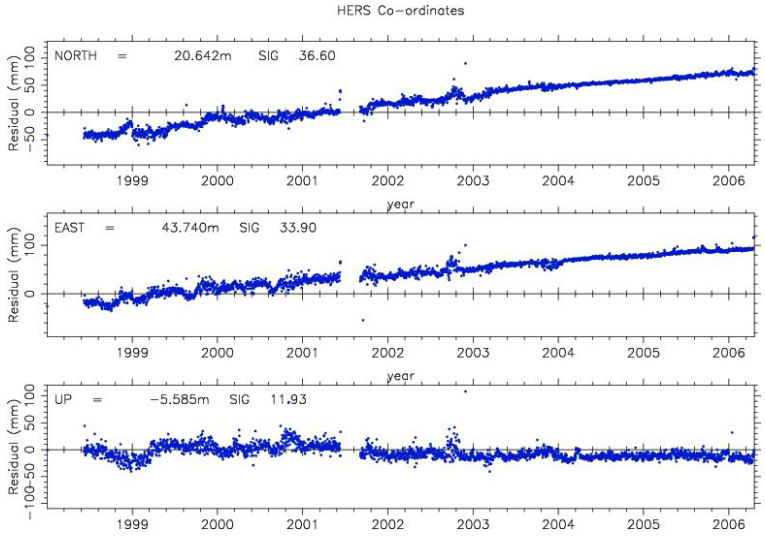
Matera has had funding problems and has been operating under restricted conditions. The old Grasse SLR has been closed down and the Grasse LLR is down for 12-18months for an upgrade. The upgraded LLR will do the observing currently undertaken by the SLR and LLR.

2. GPS and GLONASS Continuously Operating Receivers.

The Ashtech Z12 receiver (IGS station HERS) has continued throughout the period to contribute without any problems daily and hourly 30-second data to the international data centres in support of IGS and EUREF programs.

We suffered a fault to our joint GPS/GLONASS Z18 receiver (IGS HERT) in September. While the receiver is no longer supported by the manufacturer, we were able to find a company able to undertake the repair and were back in operation within a month. For the time being spares seem to be available for both the Z-12 and Z-18, but this incident reminds us that this situation will not prevail indefinitely. In addition firmware development for these models has ceased since active support was withdrawn by Ashtech. We are therefore beginning the process of planning replacements.

The on-site GPS Analysis continues with the aim of automatic processing for daily site coordinates and baselines and to extend the processing back to 1992 when the HERS site was first established. The work is summarised on the SGF GPS analysis webpages (http://nercslr.nmt.ac.uk/gnss/gps_sgf.html), which contains automatically-updated plots including the HERS coordinate plot shown below. This is an ongoing investigation into the quality of the NSGF GPS data and any features found within. This work was part of a poster presentation on GPS and Laser analysis at the EGU in Vienna in 2005.



3. Gravimeter.

The building works to create the new air-conditioned gravimeter room in the cellar and give safe access to it were originally scheduled to begin in November, but were delayed until February and then overran into April. Commissioning of the system is due to take place in May.

4. Facility maintenance and development

4.1 Event timer.
Work on the electronic construction of the timing device is nearing completion and it is hoped that the new timer will be ready by summer 2006. The device will eliminate the current need for range-dependent calibration of the existing counters, allow high-repetition ranging and significantly reduce the range error budget (jitter 5ps cf the Stanford's 35ps).

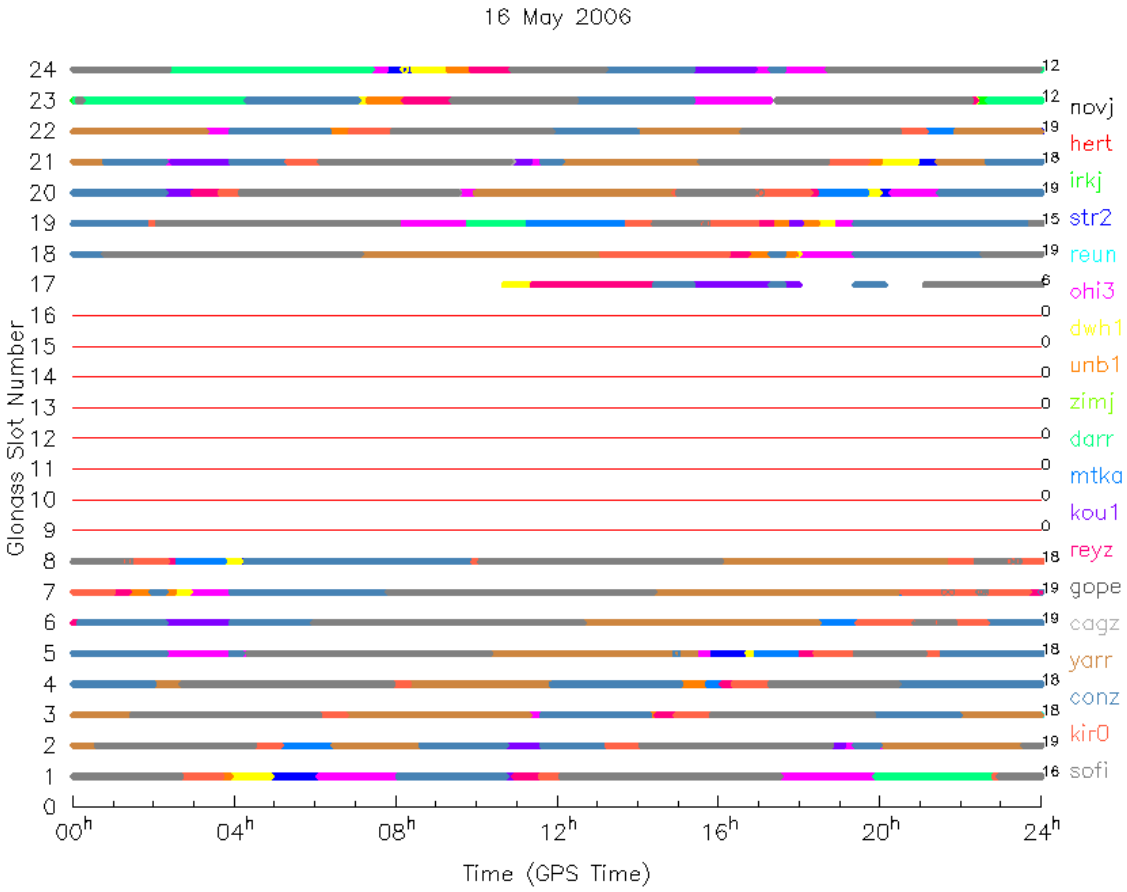
4.2 Infrastructure at Herstmonceux
NERC Estates' Management carried out a program of work which included a new entrance to the cellar, refurbishment and new electrical services to the cellar, while also giving us an air-conditioned room for the gravimeter and a meeting room in the cellar.
Work in the offices and main building included replacing electrics, sealing asbestos-tiled floor, double glazing, a new heating system and general decoration.
External work included pointing, cleaning and painting the dome, re-surfacing the car park.
The project was timetabled for six weeks but overran significantly to ten weeks. Conditions for a large proportion of this time were naturally very unpleasant and disruptive.

4.3 Website

The NSGF web site (http://nercslr.nmt.ac.uk/) has continued to be upgraded and now has a section on the automatic daily GPS analysis being carried out at Herstmonceux at: (http://nercslr.nmt.ac.uk/gnss/gps_sgf.html). We would always welcome comments about the website.

4.4 GNSS status monitoring

Following a request from our MOD funding partner, we have built a GNSS satellite health monitoring system. The idea was to provide independent information on satellite health based on when ground stations were receiving data, rather than relying on operator-published outage statistics. We ended up with a system that downloads data files from a subset of IGS joint GPS/GLONASS stations every day and produces plots of whenever each satellite was being tracked somewhere in the world. Obviously the limiting factor in providing full coverage was geographical location of suitable sites. When all selected stations are operational, coverage is very good, but there are still areas in the southern hemisphere such that if one or two isolated stations become inactive the system will be adversely affected.



Above is an example plot from May this year. As the data from each station is read we plot which slots that station was observing for each epoch through the 24 hours. So the plot below is built up, where for most active satellites (slots without an active satellite are the thin red lines) there is continuous observation from one of the stations throughout the 24 hour period. The sites used are listed to the right in the same colour their observations are plotted. The number in black to the right of the data line is the number of stations that observed that slot in the 24 hours. We have found that some satellites are consistently observed by fewer stations than others. For example, the new GLONASS-M satellites in slots 23 and 24 are not observed by the whole network. These variations seem to be due to receiver type and firmware, with differences in

performance between models being quite marked. This insight will be of use when we are looking at manufacturers for any future receiver upgrades on site. The other point to note is that data for slot 17 only begins at around 10:30. This feature is showing the satellite in that slot coming back into operation following an outage and is the very information the system was designed to show. The same plots are produced for the GPS satellite constellation, although we have spent more time studying the GLONASS data for obvious operational reasons.

5. International Workshop

NSGF hosted in Eastbourne in October the biannual ILRS workshop. The workshop was well attended and successful. Matthew Wilkinson was the local organiser and designed the website which included the program, online registration and within two weeks of the workshop, the proceedings. All of the SGF staff attended and contributed a considerable amount to the general discussion within the workshop format. A trip to NSGF was organised for one evening during which time we were able to fire the KHz laser. Unfortunately the weather was against us and we could not do any tracking.

6. SGF Staff

Muriel Ravet joined for a few months from March 2005 as an (unpaid) work experience student having worked at the French SLR station in Grasse. We were able to extend through NERC S&F her contract until the beginning of December, NERC employing her on a casual-staff basis to take on a large proportion of the office hours laser observing, particularly valuable during this period of development She also helped investigate various aspects of our laser and telescope optics, in order that we better understand any losses in the system. This effect will become more significant for the lower power Kilohertz system. Since her departure David Benham has kept in contact on matters of optical design.
G Appleby is deputy analysis coordinator for the ILRS, and thus sits on the ILRS governing board. He also is a member of the UK Inter-Agency Debris Committee.

7. Public Outreach

We continue to host evening visits from various astronomical societies. We also gave a number of tours of the site, arranged through the Herstmonceux Science Centre. Students and Faculty members from the International Study Centre, Queen's University at Herstmonceux are regular visitors to the SGF.
A couple of lectures on space geodesy and the work of the SGF were given to ISC students taking an undergraduate astronomy option.
We are involved in the school work-experience project and take in a few 15-year-old students for a week's work experience during June.

8. Publications (in house)

M. Greaves, R Bingley, D Baker and G Appleby, 2005. National Geodetic Report of Great Britain, **EUREF**, June 2005.
G. Appleby, M Wilkinson and P Gibbs, 2005. The Role of Space Geodesy in Underpinning Space-based Earth Observation. Abstract and poster presentation at the **NERC EO Conference**, Portsmouth, Sept 2005.
G. Appleby, P. Gibbs, R. Sherwood and M. Wilkinson, 2006. Streaming GNSS Data via the Internet from the NERC Space Geodesy Facility, Herstmonceux, UK. Proceedings of the **NTRIP Symposium and Workshop**, BKG, Frankfurt, Germany, February 2006.
G. Appleby and M. Wilkinson, 2006. Local Surface Deformation at Herstmonceux from SLR and GPS analyses (Abstract and Poster), **Geophysical Research Abstracts**, Vol 8, EGU, 2006.
G. Appleby and T. Otsubo, 2006. Monitoring the Accuracy of IGS GNSS Orbital Solutions using ILRS Laser Range Observations (abstract and poster), **Geophysical Research Abstracts**, Vol 8, EGU, 2006.
T. Otsubo, G. Appleby, T. Gotoh and T. Kubo-oka, 2006. Potential TRF Improvements Through Better Understanding of Laser Ranging Target Signature Effects, (abstract and oral presentation), **Geophysical Research Abstracts**, Vol 8, EGU, 2006.

Range Finding Ny:YAG Laser System (JK Lasers)
KHz Laser system
Controlled Atmosphere Tent
Laser Emitting & Receiving Telescope (Contraves)
Telescope Control Unit (Heasons)
Tip/Tilt Mirror Mounting And Controller
Compensated SPAD Detector (PESO)
Spare SPAD (PESO)
CCD TV Camera + Frame Grabber
ISIS Camera

S Band Radar System
Oscilloscope For Radar
4x Oscilloscopes

FG5 Absolute Gravimeter (Micro-G)

Z12 GPS Receiver (Ashtech)
Z18 GPS Receiver (Ashtech)

3x Timing Modules (Stanford)
2x Four Channel Digital Time Interval Generator
Event Timer (Thales, SGF)
Disciplined Frequency Standard
2x Universal Time Interval Counters (Stanford)

2x LINUX Dual Processor PC servers
Laptop
Digital Projector

Workshop lathe

CCTV Security System

Central Bureau
International Laser Ranging Service
NASA Goddard Space Flight Center
Code 920.1
Greenbelt, MD 20771
USA

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April 28, 2006

Dr. Graham Appleby
NERC Space Geodesy Facility(NSGF)
Herstmonceux Castle
Hailsham, East Sussex BN27 1RN
UNITED KINGDOM

Subject: Recognition of NSGF as an ILRS Analysis Center

Dear Dr. Appleby:

It is a pleasure to inform you that the NERC Space Geodesy Facility (NSGF) has been recognized by the Governing Board of the International Laser Ranging Service (ILRS) as one of the official ILRS Analysis Centers. The appointment of the Analysis Centers follows the very rigorous Pilot Project for "Positioning and Earth Orientation" to select only those centers that provide solutions of sufficient quality and timeliness to be included in the production of the ILRS Combination Product. The Analysis Centers were appointed based on their demonstrated performance in both the rigor of their analyses and the punctuality with which their weekly solutions are being submitted to the ILRS Combination Centers at ASI and DGFI.

The solutions from the Analysis Centers are the basis upon which the ILRS Combination Solution, the first official ILRS data product, is now produced. It has taken us several years to reach this achievement, but the process has been thorough and has given us a product that is now well respected and appreciated by the international community.

Once again, we congratulate you on becoming an official ILRS Analysis Center and we look forward to your continued participation.

Sincerely yours,

Michael R Pearlman

Dr. Michael Pearlman
Director
ILRS Central Bureau

Publications in space geodesy, with at least one UK-based author. Annex to AR 2005/06

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Annex to AR 2005/06

NERC SPACE GEODESY FACILITY

MISSION STATEMENT

- To make laser range measurements to the special satellites that carry retro-reflectors, according to priorities assigned by the NERC Space Geodesy Steering Committee, and in accordance with international projects and priorities.
- To ensure that the range measurements are of the highest possible accuracy.
- To contribute the data promptly to the international SLR data centres.
- To operate geodetic GPS and GLONASS receivers on the site and contribute the data regularly to the international GPS/GLONASS data centres
- To maintain and develop the software and hardware of the systems in order to give high reliability and to keep the precision of the systems at the current state of the art.
- To achieve a high productivity level of numbers of satellite passes tracked.
- To assist and collaborate with UK analysts in their use of satellite tracking and related data.

In order to fulfil its mission the Space Geodesy Facility will:

- maintain an up-to-date knowledge of international developments of hardware and software in satellite tracking technology
- contribute to the international advancement of the technology, particularly in the areas of orbital predictions, software data processing, timer technology and the use of photo-diode detectors
- maintain a constant vigilance for sources of measurement error
- participate fully in UK and international co-ordination of SLR and GPS/GLONASS activities
- carry out data analysis and research, in order to maintain a real awareness of what the users require from the data

User Communities:

The observations from the facility are contributed to international data centres, together with data from other geodetic facilities around the World. The data are used in combination with data from all precise space geodetic techniques by analysis groups world-wide and within the UK for a variety of studies, including oceanography, glaciology, the gravity field of the Earth, tides in the Earth and oceans, a global reference frame, and crustal motion. These data products are used widely by the oceanographic and solid earth science groups within the UK and world-wide.

Membership of the NERC Space Geodesy Facilities Steering Committee

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