SECTION 3 - WORKING GROUP REPORTS

3.1 Missions Working Group

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INTRODUCTION

The Missions Working Group (MWG) was formed at the first ILRS meeting in Deggendorf, Germany in September 1998. Since then, the MWG has been interacting regularly is the execution of their duties to coordinate new and existing tracking campaigns and missions with the ILRS operations community. The MWG met formally twice in 2001, however the participation was limited in the Toulouse meeting due to the events of September 11, 2001. The first meeting was held in conjunction with the EGS meetings in Nice, France in March 2001 and the second during the SPIE meeting in Toulouse France in September 2001. Other than these meetings, the MWG has had many discussions either by phone or e-mail regarding a number of missions related topics. These topics included current or new missions and/or tracking campaigns, working with other ILRS working groups where the satellite, array or mission requirements impact other areas of analysis, engineering, network coordination, or other mission planning.

Several new missions were planned and launched during 2001 including Jason, Reflector, Meteor-3M, and three new GLONASS satellites.

Several tracking campaigns were proposed, planned and were executed during this period. They included the Etalon, LRE, and Reflector campaigns. STARSHINE-3 tracking also occurred on a temporary basis to determine the viability of SLR on such a low, quick-turnaround satellite.

Preparations are underway for the upcoming missions, GRACE A & B, ENVISAT-1, ICESat, and ADEOS-II scheduled to be launched in 2002.

CHARTER

A SLR system can only track one satellite at a time. There has been a steadily increase in the number of new satellites with different tracking requirements requesting SLR support. As this number has increased, the need has increased for an organized mechanism to review all requests for SLR support of future missions and campaigns and to ensure that the currently supported missions still require SLR tracking. The ILRS Missions Working Group is tasked to review the needs of current and future SLR missions and to make SLR tracking support and priority recommendations to the ILRS Central Bureau and Governing Board.

The Central Bureau refers Mission Support Request Forms submitted for new satellites to the MWG. The MWG reviews them for adequate scientific or engineering relevance and sufficient justification for laser tracking support. Additional requirements such as SLR temporal and spatial coverage, prediction services, data processing and community interest are reviewed. Special mission requirements such as time biases, drag functions, liberating functions, modes of calibration, accelerated data submissions, and organization of the data flow from the data centers to the mission analysis centers are reviewed for relevance and compliance with ILRS capabilities.

Whenever the normal procedures and formats are inadequate for proper support of a new mission, the MWG will tries work out possible solutions in cooperation with the Mission sponsor and the other Working Groups.

The MWG proposes to the ILRS Governing Board the acceptance or refusal of a new or modified mission, based on the documents submitted by the mission sponsor (including a mission plan and the current workload of the network).

The MWG recommendation to the ILRS Governing Board includes any changes in the current priority list required to accommodate the new missions

The full charter for the Missions working Group can be found at:

http://ilrs.gsfc.nasa.gov/missions_wg_charter.html

MISSIONS WORKING GROUP MEMBERSHIP

Table 3.1-1. Mission Working Group Members.

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ACTIVITIES

Meetings

Two MWG working group meetings were held in 2001: the first was held in Nice, France during the EGS meetings in March 2001 and the second at the SPIE meeting in Toulouse, France in September 2001. The following sections describe the important issues of each meeting.

The Nice Meeting

Highlights of the Nice meeting include the approval for an Etalon tracking campaign to support Earth Orientation Parameters and to improve station bias identification and resolution. Other campaign news included the continuation of the BEC campaign through 2001 and the US Navy elevated the GFO-1 mission from a campaign to full mission status following acceptance of the satellite. Also, the mislabeling of satellites continued with the GLONASS-84 satellite. The MWG adopted the policy of not accepting a new satellite without receiving a state vector from the mission owner for proper identification.

The Toulouse Meeting

Due to the events in of September 11, 2001, there was no NASA representation at the MWG meeting. However, a meeting was held in Toulouse and was well represented and attended. Highlights of the meeting include a status of the Etalon and LRE campaigns, a status report on upcoming missions and a discussion on whether to bring full-rate data back as a deliverable to support atmospheric modeling for low altitude satellites and for signal processing analysis.

WORK IN PROGRESS

Continued efforts are required by the MWG to develop:

- A more automated and user friendly Mission Support Request Form
- A Mission Support Plan Template to help satellite hosts in mission planning. Efforts have been ongoing with the number of new launches that had occurred during 2001 to make mission planning activities smoother with the mission host.
- A procedure to periodically (1) review mission requirements and applicability of SLR to meeting these requirements and (2) require satellite owners or key science and technical contacts to justify continued SLR support

Issues such as SLR coverage and data volume will be reviewed; whole arc or pass segmentation may be planned to support a rapidly growing number of missions. Also considered is periodic intensive tracking campaigns to relieve the stress on the high priority missions.

UPCOMING MISSIONS

Table 1.3-1 summarizes the planned missions for 2002 and beyond

3.2 NETWORK AND ENGINEERING WORKING GROUP

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MEMBER LIST

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WORKING GROUP MEETINGS

In the year 2001 a working group meeting was held on March 27, 2001 in Nice, France during the XXVI General Assembly of the European Geophysical Society. The minutes of the working group meeting can be found on the ILRS web site at

http://ilrs.gsfc.nasa.gov/working_groups/networks_and_engineering/networks_activities

ACTIVITIES

Following the recommendations of the Working Group a new prediction mail exploder has been installed at CDDIS. It will allow for an easier backup. It will remove the necessity for all prediction providers to maintain their own distribution list and will help the stations to process the predictions automatically. Automated backup procedures at EDC have been defined, and will be invoked if the primary distribution system fails.

With a very few exceptions all station logs have been submitted. The station logs are screened for consistency, completeness, and format compliance by members of the Working Group. Van Husson is preparing summary spreadsheets for easy cross-comparison and evaluation of the log files.

The Working Group planned to hold a calibration follow-up meeting in Toulouse in late September 2001. The meeting had to be cancelled because of the serious travel restrictions after September 11. Some of the topics will be covered in a EUROLAS workshop to be held early 2002 in Herstmonceux.

Proposals for station qualification criteria were prepared by a small working group to be submitted to the Governing Board for approval.

3.3 DATA FORMATS AND PROCEDURES WORKING GROUP

Wolfgang Seem ller, *Deutsches Geod tisches Forschungsinstitut (DGFI)*

3.3.1 WORKING GROUP

Member List

Table 3.3.1-1. Data Formats and Procedures Working Group Membership

Name	email	responsibility
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Scott Wetzel	Scott.Wetzel@honeywell-tsi.com	CB Representative

Working Group Meetings

In 2001 only one Working Group meeting was held (the second planned meeting in autumn 2001 in Toulouse was cancelled) on Wednesday, April 24, in Nice, France.

Activities

A summary of activities is given at:

http://ilrs.gsfc.nasa.gov/ilrs/working_groups/dfpwg/data_activities.html

Most of the work was done in the Study Groups: the Prediction Formats of Randall Ricklefs and the Refraction Study Group of Stefan Riepl (see the following report).

3.3.2 REFRACTION STUDY GROUP (RSG)

Stefan Riepl, *Bundesamt f r Kartographie und Geod sie*

During the year 2001, the Refraction Study Group (RSG) continued to work on the remaining tasks to be solved according to the charter:

http: //www.wettzell.ifag.de/publ/rsg/charter.html

Member List

Table 3.3.2-1 Refraction Study Group Members.

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V. Mendes *(*Mendes, V. B., G. Prates, E. C. Pavlis, D. E. Pavlis, and R. B. Langley "Improved Mapping Functions for Atmospheric Refraction Correction in SLR" *GRL,* 29 (10), 2002.) provided a mapping function as well as FORTRAN source code for the algorithm. So the RSG made significant progress with respect to providing an atmospheric refraction model at the millimeter accuracy level for the commonly used laser ranging wavelength 532nm. Other topics of interest focused on:

- an INTAS research grant for clarifying laser pulse propagation aspects for wavelengths affected by anomalous dispersion, (INTAS - International Association for the promotion of Cooperation with scientists from the New Independent States of the former Soviet Union.)
- evaluation of numerical weather prediction data to test the significance of horizontal gradients, and
- evaluation of two color laser ranging data in order to test mapping functions and/or zenith path delay models.

3.3.3. PREDICTION FORMAT STUDY GROUP (LYNX TEAM)

Randy Ricklefs, *University of Texas at Austin*

Member List

Table 3.3.3-1. Prediction Format Study Group Members.

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The study group was formed by the Data Formats and Procedures Working Group in Matera during the November 2000 meeting. The purpose was to create a consolidated format or formats for ranging predictions for all current and anticipated laser targets, including passive earth satellites, lunar reflectors, and transponders on or orbiting around the moon and other solar systems bodies or in transit.

During 2001, the group charter was finalized and a working document honed. The working document presented the current state of affairs for predictions in the SLR and LLR communities and tried to ask incisive questions as to the future of the process. As a result of ensuing email communications among study group members, several conclusions were reached:

- The predictions would be tabular in nature, so that an interpolator and not an integrator would generally be used;
- The elements of the predictions would be geocentric state vectors, possibly in the same reference frame as the existing IRV;
- Provision needed to be made for integrating or extrapolating past the end of the predictions for crew scheduling or in the event of an extended network communications failure;
- Geosynchronous satellites needed to be handled gracefully;
- New on-site and centralized prediction software would need to be developed; and
- Some type of file compression might be necessary due to the larger size of the prediction files.

SLR predictions would fit into the above specifications without difficulty. To identify any unique lunar prediction information to include, a feasibility study was begun, starting with modifications of existing lunar prediction code.

Not surprisingly, transponders present the largest source of uncertainty in terms of fields required in the format. Contacts were made in an effort to start solidifying the unique transponder requirements. Progress so far indicates a convergence on the format in the not-too-distant future.

3.4 ANALYSIS WORKING GROUP

Ron Noomen, *Delft University of Technology*
Peter Shelus, *University of Texas at Austin*

Introduction

The most important aspect of the SLR/LLR observation is its absolute accuracy. This makes it a perfect technique to monitor or study elements of system Earth like geocenter (motion), absolute scale, global plate tectonics and vertical station deformations, or, in the case of LLR, fundamental lunar constants. This aspect has led to the reliance on SLR for the definition of origin (fully) and scale (together with VLBI) for IERS ITRF2000 model for global station coordinates and velocities. The SLR community also produces other (geo)physical products like Earth Orientation Parameters (EOPs), time-variations of the long-wavelength components of the Earth's gravity field, satellite orbit solutions and others.

Member List

Table 3.4-1. Analysis Working Group Members.

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Robert Weber		

The ILRS has been given the official status of Technique Center in the new organization of the IERS. As such, the ILRS is expected to produce a unique and official product on a number of the parameters mentioned above; as a first target a coordinated and unique EOP contribution to the weekly IERS Bulletins A is expected.

The AWG is dealing with issues like product quality control, development of (an) official ILRS product(s) and others. More detailed information, also on its membership list, can be found on the relevant web pages:

http://ilrs.gsfc.nasa.gov/working_groups/awg/index.html.

Activities in 2001

An important instrument for contacts and discussions among analysts proved to be the AWG workshops; in 2001, two were organized, notably in March (Nice, France) and in September (Toulouse, France).

Through the series of workshops, various issues have been debated and resolved. One of them is the product format. The AWG adopted the SINEX V1.0 format initially, but with time this turned out to have a number of shortcomings w.r.t. specific SLR analysis demands. Proposals for modifications are included in its official successor SINEX V2.0.

To develop various analysis issues, the AWG has initiated a number of so-called Pilot Projects, each with the goal to improve specific elements of SLR/LLR analysis results. The status and results of each of these will be discussed below.

A number of analysis institutes evaluate the SLR measurements on various satellites on a routine basis. The satellites include: ERS-2, ENVISAT, TOPEX/Poseidon, Jason-1, Stella, Starlette, Ajisaj, LAGEOS-1/2, GPS-35/36, and Etalon-1/2. The results are distributed in a rather uncoordinated way, i.e. each analysis center produces its own unique analysis report, which is made available to customers (stations, satellite managers) typically without comparison or checking with results obtained by others. The Pilot Project 1 *Unification of Fast-Turnaround Analysis Results* aims at the improvement of the interpretation of the "quality verdict" in the various analysis results, e.g. by looking at time-series of range and/or time biases, rather than at absolute values. Furthermore, it is the intention that all individual analysis results will be merged into a single report, with a unique assessment of the data problem(s) and its uncertainty. It is obvious that (differences in) station coordinates play a major role in the (dis)agreement of such QC results; consequently, all analysis groups involved are strongly encouraged to use ITRF2000.

The Pilot Project 2 *Computation of Station Positions and EOPs* deals with two of the fundamental analysis products of ILRS: station coordinates and EOPs. One of the goals is the development of a unique, best-possible (in terms of quality) analysis product which can be used by (specific elements of) the science community.

The project has seen a strong development with time. Initially, it dealt with a small (28 days) dataset of LAGEOS-1 observations only. At this moment, the participants work with SLR observations on LAGEOS-1 and -2, and also on Etalon-1 and -2. The project nicely illustrates the shift in emphasis, from procedures and formats to quality and contents. The Etalon spacecraft are expected to contribute to EOP products, global scale, station characterization, temporal variations in zonal terms of the gravity field and others. In Nice (March 2001), the AWG requested an intensive tracking campaign for the latter two spacecraft, initially for a duration of 6 months. The campaign has seen two extensions so far, and preliminary results have been reported at the AWG workshop in Nice (April 2002), whereas "final" results are expected to be presented at the next AWG workshop in Washington (October 2002). In spite of these efforts, the contribution of the Etalon satellites is limited in terms of data quantity (compared to LAGEOS); the preliminary analyses have shown quite varied contributions to analysis products.

Another aspect which has been resolved is the question on UT versus LOD. After many and lengthy discussions, the analysts have come to the consensus that the UT parameter is by definition indistinguishable from the (absolute orientation of the) ascending node of the satellite orbit, and therefor should be considered as a nuisance parameter. The estimation of LOD parameters is recognized as a useful analysis activity, however.

Although proposed and adopted by the AWG, the Pilot Project 3 *Orbits* has not really gained much momentum yet. The project will focus on a future analysis product, and is expected to stimulate improvement of the quality of solutions.

The Pilot Project 4 *Software Benchmarking* is aimed at quality control of the software in use at the various analysis centers. This pilot project deals with typical analysis results (orbits, parameters) obtained at different institutes, and strives for a thorough understanding of the differences. The goal of this project is to make sure that the various software packages in use at different analysis groups are free of errors

Outlook for 2002 and beyond

During the year 2002, significant developments of the various pilot projects can be expected. The results seen so far for the "harmonization" project are quite encouraging, and the "orbits" and "benchmarking" projects are in good starting positions. The progress of the "positioning + earth orientation" project is steady and significant.

3.5 SIGNAL PROCESSING *AD HOC* WORKING GROUP

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MEMBER LIST

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OVERVIEW OF PROGRESS DURING 2001

GLONASS

- We have acquired details of precise location and characteristics of each CCR, thanks to Missions WG;
- Attitude-dependent impulse functions have been computed for GLONASS and tested against single-photon range data;
- Demonstration that large (20-40mm) ambiguity exists in Center of Mass (CoM) correction for high-energy systems;
- Through the work of MWG, we now have an accurate geometry of the three types of LRA on the GLONASS satellites and have concluded that:
- The apparent mean radial bias in the GLONASS microwave-derived orbits was caused by a combination of incorrect information on the location of LRA plus the 'large array' effect;
- Details of the GLONASS arrays are now on the ILRS website.

GPS

The radial bias (~50mm) of the GPS microwave-derived orbits persists - we should re-visit the current understanding of the locations of the GPS LRAs.

LAGEOS, Etalon and Ajisai

We know the precise location and characteristics of each CCR.

Impulse response functions have been computed, where the reflection intensity is modeled as a function of effective reflection area, CCR reflectivity and diffraction effects. (Figure 3.5-1.)

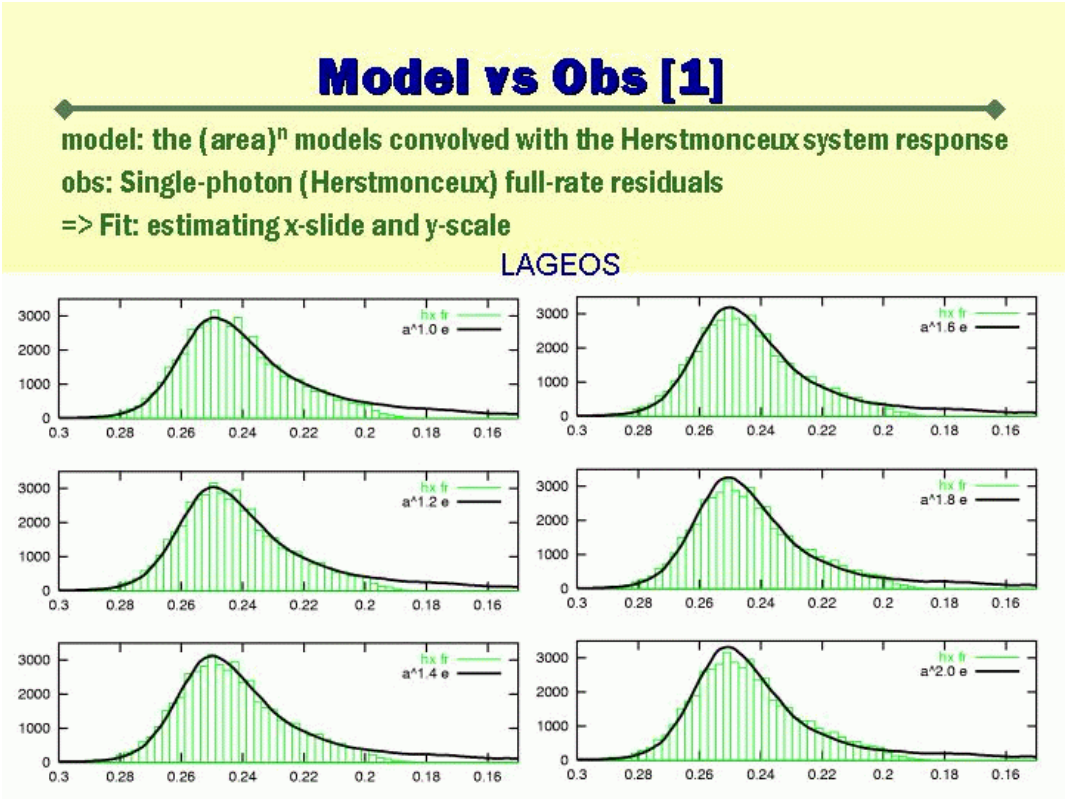

Figure 3.5-1. Calculated CCR Response.

Tested against single-photon range data; crucial to this stage is understanding the particular power law applicable to each satellite. The fit of the models to Herstmonceux single photon data can be used as a powerful indicator of this, as shown in the results for LAGEOS over a range of power-law models.

Further

We have demonstrated that the use of system-dependent CoM values is crucial for mm-level accuracy (e.g. the use of CSPAD at single- and multi-photon levels can influence appropriate CoM corrections by up to 5mm);

Discussions are underway with Honeywell colleagues on details of the NASA systems' CFD/MCP combinations, with a view to deriving appropriate CoM values for this important group of systems.

We plan soon to provide estimates of CoM values, or ranges of values, for the broad classes of systems (single-photon, multi-photon with C-SPAD, multi-photon with MCP/CFD) for LAGEOS, Ajisai and Etalon.

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