

Report of AWG Meeting, Eastbourne, UK, October 2, 2005.

Note: since (the discussion of) some of the agenda items were moved to the "Analysis" session on Monday October 3, a brief summary of the outcome and resulting action items are attached at the end of these minutes.

Ad 1. Opening

The ILRS AWG members met during Sunday October 2, 2005, preceding the ILRS Workshop. The meeting began at 10.00 hrs. The agenda and list of attendance are given in Tables 1 and 2, respectively. Noomen welcomed the participants.

Ad 2. Announcements

On behalf of the CB, Pearlman also welcomed the participants.

Noomen made a remark about two ILRS papers during the IAG meeting in Cairns, August 2005: a paper by Pavlis on the status of the ILRS contributions to a new ITRF product, and a general ILRS poster by Pearlman, Noll, Gurtner and Noomen. In addition, Müller, Williams, Turyshev and Shelus had a paper on lunar science capabilities.

Ad 3. Pilot project "positioning + earth orientation"

This agenda item took most of the day.

Ad 3.1. Operational product

Noomen made a brief introduction on the current ILRS activities on this aspect. Weekly products on station coordinates and EOPs (1-day resolution) are generated by 6 individual analysis centers (ASI, BKG, DGFI, GFZ, JCET and NSGF), based on SLR data taken on LAGEOS-1 and -2 and Etalon-1 and -2. The current procedure is effectively working since November 2003, and official since June 2004. Official ILRS combination solutions are being produced by ASI (official primary) and DGFI (official backup) and are available on Wednesday of each week.

Mareyen made specific remarks about the harmonization of the "pos+eop" results, and would like to see more testing and evaluations of the scale and weighting aspects. *Action item Mareyen:* make a proposal for this.

Mareyen also brought up the apparent difficulty in obtaining the relevant information for the benchmark solutions and the operational "pos+eop" solutions. *Action item Pavlis:* update description of benchmark solutions and give better visibility. *Action item Noomen:* update description of "pos+eop" products and procedures and give better visibility. Both: send result and suggestions to Torrence.

Mareyen: there is serious concern about a so-called Sunday-effect: the relatively small number of (accepted) NPs available on this day. In particular, the situation is such that it results in poor solutions for the EOPs on that day (accompanied by large standard deviations), but that it also (potentially) affects the overall solution (including station coordinates and other EOP solutions). This is claimed to occur about once per month. Clearly, a reasonable amount of NPs is also required for the Sundays. Another issue appears to be the geometry of the (scarce) NPs: Pavlis showed plots of coverage of the globe from a north

pole and south pole perspective, which clearly shows the poor orbital coverage afforded by the network and of course exacerbated by significant numbers of stations not working 24/7 shifts.

König reported that this effect does not play a role for Champ and GRACE, since GPS is the main tracking technique here. Torrence mentioned that GFO and TOPEX/Poseidon would possibly be affected by this Sunday effect as well, since SLR is the main technique. However, so far there have been no signs of any (Sunday) dropoff. König mentioned that the situation for ERS-2 is similar to that of GFO and T/P. *Action item Noomen*: check out the situation for other satellites (status of tracking, requirements on SLR). *Action item Noomen*: convey this concern to the ILRS GB.

Ad 3.2. ITRF2004: status ILRS 1993-2003

As an introduction and representative for our customer IERS, Altamimi gave a presentation on our “pos+eop” results (both on the operational product and on the backwards solutions, covering the time-frame 1993-2003). He emphasized that IERS is interested in getting the best from SLR, and that SLR provides a unique contribution for the TRF origin and scale (scale shared with VLBI). Also, SLR is a unique contributor for providing information on the vertical position (and motions). The proposal for ITRF2004 is to convert the time-series of weekly combination solutions for station coordinates into a linear model for position and velocity, for each individual technique independently. As the next (final) step, the pos+vel models coming from the various techniques will be combined. The EOP information is also to be used for the combination.

Altamimi presented time-series of the solutions (individual and combination) of station coordinates. Issues addressed were outlier rejection and the correlation with the estimation of troposphere biases and range biases (which is not allowed for the core stations). A range bias problem with the Graz data (1993-October 1996) proved to cause unrealistic solutions for the vertical velocity; when a range bias for this station is estimated, the jump disappears and the vertical velocity for Graz improves, but the quality of the vertical solutions becomes weaker and the consistency of the global scale estimates becomes worse. Altamimi suggested that range biases are not estimated.

He is particularly interested in receiving an official ILRS contribution for the ITRF2004 model, with the end of October as deadline. He made 3 suggestions to do so: (1) re-analyse 1993-2005 data, with a consistent strategy (now) for treating range biases; (2) redo the combinations only, with more strict outlier rejection; and (3) adopt the current v3 product as the ILRS contribution, and have ITRF/IERS do their editing at their own liking. He also suggested to document instantaneous station position shifts in a solution/discontinuity element in the SINEX files.

Bianco gave a series of presentations, also on behalf of Luceri and Sciarretta. The v2 combination product was affected by weak tracking data during the Christmas weeks, and errors in some of the contributions (5 JCET solutions with duplications of site ids, 2 DGFI solutions with too long EOP periods). The v3 combination solution, based on input from ASI, DGFI, GFZ, JCET and NSGF, was derived after rigorous editing (all parameters other than pos and EOPs were deleted) and a 5σ editing in the combination process. Consistency checks were done for both the individual solutions and for the combination product; they all yielded the presence of yearly signals.

In a second presentation, discontinuities in the time-series were addressed. Angermann (DGFI) had reported jumps in the station coordinates for Graz and Riga, and Appleby had done some test computations solving for RB for Graz. ASI found that this affected more stations: 1864, 1868, 1884, 7210, 7237, 7403, 7811, 7835, 7839 and 8834. The problem was aggravated by differences in treatment by the various analysis centers. Bianco concluded that a more coherent treatment is needed.

Next, ASI performed a new combination using different outlier-editing procedures: individual solutions were eliminated if (1) the estimate was too weak statistically; (2) there were too large differences w.r.t. a

reliable reference (ITRF2000) (how to handle stations that are not (good enough) in ITRF2000 was not addressed); (3) a 5σ outlier editing. In the result (v3.1), all problems that were reported by IGN were now captured and eliminated at the combination step already, suggesting that this is a better way to do the combination.

Finally, some ideas about the further development of the pos+eop product were aired: (1) re-analyse 1993-2003 (also until 2005?) with a more consistent treatment among analysts regarding RB; (2) also include other contributions; (3) apply the v3.1 procedures; (4) use a 2-digit version number (to allow more variations in the combination steps).

Pavlis gave an overview of the JCET procedure to obtain individual pos+eop solutions. He elaborated on the on-line monitoring of translation, scale, variance and observation statistics, that he is routinely generating from the ILRSA (i.e. ASI combination) solutions. This should be available as an open resource for anyone interested. *Action item Pavlis*: make this available (as a link) through CDDIS.

The solutions for the geocenter showed evidence of El Niño. Solutions for J_2 showed a good agreement between SLR and GRACE (as determined by CSR). To take the analysis back to 1976, Pavlis suggested that the inclusion of other satellites (Starlette and Ajisaj) is essential (LAGEOS-1 data are sparsely available; no LAGEOS-2 or any of the Etalons, prior to 1989).

Kelm reported about new features in the DGFI combination software and method. Some highlights: (1) A new rigorous variance component estimation technique is used, which will identify problems with the solutions of some of the (pos, EOP) parameter solutions; as a result, these parameter solutions are typically edited out. (2) A comparison of ILRSA and ILRSB results (coordinates, EOPs, Helmert parameters); a good consistency between ILRSA and ILRS is observed. (3) It is recommended that Graz becomes a core station only from October 1996 onwards. (4) Do not solve range biases for the core stations. (5) Include the solutions from Geosciences Australia. (6) Create an open directory for arbitrary users in which most recent ILRS solutions are stored without version number (to avoid confusion). *Action item Kelm*: rather than including the differences w.r.t. ITRF2000 in the ILRSB SINEX files, statistics on the differences w.r.t. some representative average is to be included.

On behalf of Eanes, Shelus gave an overview of recent pos+eop results at CSR. Eanes gets post-fit rms values of about 5 mm (probably on a subset of stations). Shelus report about bias results for a number of stations: SHO, Maui, Zimmerwald, Changchun, Riyadh and Yarragadee.

After this, a lengthy discussion ensued on how to proceed further. In summary:

The operational product will continue, albeit with more strict procedures. For the core stations (currently, these are Graz, Greenbelt, Hartebeesthoek, Herstmonceux, McDonald, Monument Peak, Mt Stromlo, Riyadh, Wettzell, Yarragadee and Zimmerwald, as determined during the 2002 AWG meeting in Lanham). No bias will be modeled and/or estimated, but time-series from these stations will be kept under review in order to identify potential problems. For the non-core stations, an inventory will be made for which station biases are needed and for which stations they are not. *Action item Noomen and Bianco*: do this on the basis of statistics from the ILRSA combination solutions (1992-2005). Level of significance for bias jumps / height shifts: 15 mm. All analysts have to do their re-analysis according to this standard. *Action item AWG*: re-assess the choice for AWG core stations (at next AWG workshop).

Backwards analysis (1993-2003): similar approach, similar action item by similar people. Problems have been identified for the core stations Graz and Wettzell. *Action item Noomen*: obtain realistic estimates for the bias (jumps) from station representatives.

Combination products. *Action item ASI, DGFI*: apply their new criteria and techniques.

Troposphere: for the time being (that is: the ITRF2004 contribution), we stick to the Marini-Murray model (cf. agenda item 3.4).

Deadlines for various actions: October 15 for the reporting of the bias values for Graz and Wettzell, as well as for the assessment of non-core stations with a necessity to use biases and those without. October 31 for individual analysts to provide their new solutions (*action item ACs*). November 7 for the combination solutions (*action item CCs*).

The analysis of pre-1993 data (input for ITRF2004) is not within practical reach at this moment, but is left for the future (cf. agenda item 3.5).

Satellites other than the LAGEOS and Etalons are not included in the 1993-2005 re-analysis.

Labeling: *action item Noomen*: ask Noll and Seemüller to generate 1 directory that is open to arbitrary users where the most recent ILRS solutions (individual and combination) will be stored. Without a version number in the name (it is present, directly or indirectly, in the contents description). Other solutions are to be stored in a separate, secluded sub-directory (with label numbers). This means there will be a one-on-one copy in 2 subdirectories.

Ad 3.3. Implementation station/satellite signature

Considering the time, this item is deferred to the more general discussion on Wednesday Oct 5.

Ad 3.4. Implementation new troposphere model

A discussion ensued about the value of the Mendes model as compared to the older Marini-Murray model. The latter has the drawback that it has a bias of about 1 mm at zenith, whereas the Mendes model is most likely better suited to deal with the infrared frequencies of the MLRO system. Initial tests (4 weeks) have shown that the Mendes model would result in slightly larger values for the rms-of-fit, which is most likely due to the fact that other elements of the computation model are unadjusted; in particular, GM should have to be increased from .4415 to .4416 km³/s² (fraction given here only). After some discussion, it was decided to stay with the use of the Marini-Murray model for the time being.

Ad 3.5. ITR2004: plans ILRS 1983-1992

Procedures and parameters were suggested during the AWG meeting in Vienna. However, considering the time at the current meeting and the large amount of work needed to be done for the 1992-2005 re-analysis and the expected complications for handling this historic data, it was decided to leave this interval to another round in the ITRF solutions. Altamimi agreed.

Ad 3.6. New products

No new developments on this aspect.

Ad 3.7. Other issues

Nothing is reported here.

Ad 4. Benchmark project: status

BKG has passed the blind test in the middle of 2005, and has been accepted as an official ILRS analysis “pos+eop” contributor. GA and GRGS are in the process of doing this blind test, and are expected to hand in their results to Pavlis by the end of October. *Action item Govind, Exertier, Pavlis.*

Ad 5. Miscellaneous

Various brief agenda items.

Ad 5.1. Status SLR tracking network

The current situation with the NASA stations working only five-day shifts was particularly detrimental to the products of the AWG and all efforts should be made to rectify the situation and return to full 24/7 operations. NASA is in the process of bringing TLRs-4 to Maui. TLRs-3 is being brought back into operational status at Arequipa. The French system 7835 has officially stopped its operations. The lunar system 7845 is being redesigned at this moment, and will not be able to track anything (operationally) for the coming 1-2 years (report Exertier). To fill in the gap in the LLR tracking, MLRO (Matera) is requested to concentrate more on lunar tracking than on the low-flying satellites. *Action item Noomen:* convey this to the ILRS GB.

Ad 5.2. Consistency QC reports

This is left to the open discussion on Monday Oct 3.

Ad 5.3. Analysis center categorization

Recognizing the activities of a number of institutes to pass the benchmark test, this issue is deferred to a next meeting.

Ad 5.4. Procedure for assessing quality of new SLR system

In the AWG meeting in Vienna (2005), DGFI volunteered to do this task. A secondary aspect is the generation of station coordinates, which can be used for QC evaluations. These should be consistent within the ITRF2000 frame. If possible, use should be made of ITRF2000 information on related sites (e.g. GPS occupations), or a common and reliable solution should be estimated otherwise (including position and velocity). This solution is to be used (and kept fixed) by the QC centers.

Ad 5.5. Station performance card

This is a continuing activity at ILRS CB. It is used as input for the evaluations of the stations for AWG-Core status evaluations.

Ad 5.6. Analysis documentation

Driven by financing from the INDIGO project, CDDIS has been asked to document the various analysis standards (and approaches?) of the various individual pos+eop contributors. The choice is between something that comes out directly of our SINEX files (the description block), and the use of the format that is in use by IGS and IDS already. The former has the advantage of being a minimum effort; the latter provides consistency all over the geodetic services (it is mainly aimed at external users that are not

familiar with any of the techniques). It was decided to go for the latter option, since this is (in principle) a one-time effort. *Action item Noomen*: complete the empty standard format as much as possible, and send this to the analysis centers contributing. *Action item ACs*: complete and send to Noll. *Action item ACs*: keep up-to-date. This is not relevant for the combination product, CCs.

Ad 5.7. IERS EOP Prediction Comparison Campaign

This was initiated by the IERS. Some people have expressed their doubts about the procedures proposed for this project. There is no official ILRS involvement here, although individual analysis centers are encouraged to get involved.

Ad 5.8. CONT'05 Campaign

This IERS project evolved from an IVS project. It basically aims at intensified SLR tracking of radionavigation satellites and satellites that are equipped with multiple tracking techniques. Essentially, this is to be done for the period September 1-28. No further official analysis involvement of ILRS (individual groups may do their analysis, of course).

Ad 5.9. Galileo

The ILRS will introduce the tracking of the two Galileo test bed satellites (GSTB-V2/A and -V2/B) in the tracking schemes. These are due for launch in December 2005 and February 2006. In the future, it may very well be possible that ILRS is asked to range on the full constellation of some 30 operational Galileo satellites.

Ad 6. Next meeting

A new venue in connection with the AGU meeting in San Francisco was proposed, but it turns out that we have a very limited representation of ILRS analysts. Instead, it was decided to organize a (full-day) AWG meeting in conjunction with the next EGU meeting in Vienna, April 3-7, 2006.

Ad 7. Action items

See Table 3. Standing action items from the meeting in Vienna 2005 are not addressed.

Ad 8. Closure

The meeting adjourned at 18.30 hrs. The chairman thanked the participants for their input in presentations and discussions.

Analysis session ILRS Workshop, October 3: relevant aspects

Stations, when going after financial arrangements with funding agencies, can ask the ILRS (CB, chairman, analysis coordinator) and/or IERS (chairman, Altamimi, Noomen) for a letter of support. They can also use the science material that is available on the ILRS web pages. Pearlman noted that an overview paper on the value of SLR, given for GA managers in August 2005, was well received and would be similarly useful for "selling" SLR to others.

In a discussion about the contribution of SLR to the TRF (introduction Pavlis), Pavlis emphasized the need for implementation of atmospheric pressure loading. Altamimi stressed not to do this for the ILRS ITRF2004 contribution.

It was remarked by various people that the ILRS (analysts) should be more aggressive in highlighting problems, so that external people are aware of the importance of activities and products. Full operations (“24-7”) by the global network is a good example, and should be strongly recommended to the stations. After introductions on the error budget of SLR observations (Schillak) and the modeling of tropospheric corrections (Riepl), a long discussion on the latter ensued. The importance of two-color ranging was recognized. The value of truly differential observations, using a streak camera, is of utmost importance. Since MLRO is the only system currently capable to obtain such measurements, this station was encouraged to range on those LEO satellites with a unique and unambiguous CCR signature: CHAMP, GRACE-A and GRACE-B (*i.e.* single-reflector satellites). More studies should be done on various aspects of the tropospheric delay (gradients, wavelength dependencies, etc.).

Next the subject changed to the semi real-time quality control activities of a number of analysis centers (introduction Noomen), the results and the interpretation of that. Range biases as “observed” by different analysis centers may show remarkable differences. This may be due to a number of aspects, of which station coordinates is a reputed one. To improve upon this, (1) these centers should all use ITRF2000 for now; (2) stations either not included or poorly-determined in ITRF2000 should be analysed with a consistent and common (new) position/velocity solution; (3) the development of ITRF2004 will of course also result in a new, SLR-only position+velocity model for use by these QC centers (consistent with current reference frame); updates should be made with a frequency of e.g. once per year, to also include new stations (but with a consistent reference frame) (recommendation Altamimi). As a general advice, stations are advised to ignore (absolute) reported biases smaller than about 30 mm.

Gurtner gave a brief presentation of a recent manoeuvre of GPS-35, which was observed by station Herstmonceux and analysed by the CODE group.

October 28, 2005

R. Noomen, G. Appleby, P.J. Shelus

Table 1: Agenda

(Note: ordering slightly adapted w.r.t. original agenda)

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2. announcements
3. pilot project "positioning + earth orientation"
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 - 3.2. ITRF2004: status ILRS 1993-2003
 - 3.3. implementation station/satellite signature
 - 3.4. implementation new troposphere model
 - 3.5. ITRF2004: plans ILRS 1983-1992
 - 3.6. new products
 - 3.7. other issues
4. benchmark project: status
5. miscellaneous
 - 5.1. status SLR tracking network
 - 5.2. consistency QC reports
 - 5.3. analysis center categorization
 - 5.4. procedure for assessing quality of new SLR system
 - 5.5. station performance card
 - 5.6. analysis documentation
 - 5.7. IERS EOP Prediction Comparison Campaign
 - 5.8. CONT'05 Campaign
 - 5.9. Galileo
6. next meeting
7. action items
8. closure

Table 2: Attendance

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Table 3: action items

(Note: some of these action items remain after the AWG meeting in Vienna; others are the result of the Eastbourne workshop)

ACs	submit new individual pos+eop solutions 1993-2005 (deadline: Oct 31)
ACs	complete INDIGO description analysis and submit to CDDIS and EDC
ACs, CCs	general: submit solutions to both CDDIS and EDC
Appleby	extend table with CoM values
ASI	apply new combination approach
AWG	re-assess AWG core stations status
CCs	generate new combination pos+eop solutions 1993-2005 (deadline: Nov 7)
DGFI	apply new combination approach
Exertier	submit blind test benchmark project
Govind	submit blind test benchmark project
Gurtner	develop proposal for orbit product (with Ries, Müller, Sciarretta, König)
Kelm	include residuals in ILRSB summary files w.r.t. combined solution
Mareyen	develop proposal for testing and evaluating scale and weighting aspects of pos+eop solutions
Noomen, Gurtner, Shelus	develop new AC/AAC categorization
Noomen, Pearlman, Gurtner	homogenization of QC reports
Noomen	update description of pos+eop products and procedures
Noomen	make inventory of Sunday effect for different geodetic missions
Noomen, Bianco	make assessment of bias-need for core and non-core stations 1993-2005
Noomen	obtain realistic estimates for bias jumps for Graz and Wettzell (1996) (deadline Oct 15)
Noomen	ask Noll and Seemüller to “redesign” pos+eop subdirectories, plus change in naming and handling
Noomen	complete INDIGO description analysis as much as possible and submit to ACs
Noomen	make and distribute list for unambiguous station treatment for ITRF2004 contribution
Pavlis	update description of pos+eop products and procedures
Pavlis	make pos+eop statistics from ILRSA available through CDDIS link
Pavlis	evaluate blind test benchmark project results GA and GRGS
Pearlman	convey MLRO tracking priorities to GB (<i>i.e.</i> LAGEOS and higher)
Pearlman	convey concern on Sunday effect to GB

Actions items after “Analysis” session on October 3:

AWG	make overview of station activities 1993-2005, based on eccentricity file and “pos+eop” info
AWG	develop yearly linear SLR-only position model for QC purposes
Glotov	use ITRF2000 in QC analyses
Müller	use ITRF2000 in QC analyses
Noomen	get letter expressing general support for ILRS activities from IERS chairman