Analysis Coordinator Report

A. Nothnagel, C. Steinforth

Abstract

IVS analysis coordination issues in 2004 are reported here.

1. General Issues

The "Fifth IVS Analysis Workshop" was held at Lord Elgin Hotel in Ottawa, Canada, February 12, 2004. Detailed information on the presentations and discussions can be found in [2].

As of January 1, 2005, Mrs. Dorothee Fischer (dorothee.fischer@uni-bonn.de) will take over responsibility for the EOP combination activities at the IVS Analysis Coordinator's office. Unfortunately, Christoph Steinforth has to leave us due to German university regulations. He has done a very good job for the IVS since the very beginning of IVS EOP dissemination. For his new position we wish him the same success and fun as he had at our institute.

2. IVS Operational Data Analysis and Combination

2.1. Terrestrial Reference Frame

The year 2004 marked a considerable step forward in the maintenance of the terrestrial reference frame (TRF) from geodetic VLBI observations. For the first time not only groups using the Calc/Solve program were able to generate a TRF solution from almost all high precision geodetic VLBI observations. Now, TRF solutions can also be computed by the *Deutsches Geodätisches Forschungsinstitut* (DGFI) in Munich, Germany, using the OCCAM VLBI software together with a DGFI combination program called DOGS-CS. Another TRF realization has been computed by the *Main Astronomical Observatory* (MAO), Kiev, Ukraine, with the software package SteelBreeze.

First steps have been taken for a combination of a series of four TRF realizations (two from Calc/Solve, one from OCCAM and one from SteelBreeze) on the basis of coordinates, velocities and their formal errors. In order to map the results onto a common datum, the same procedures have been applied as described in [1]. After small global rotations and translations of only a few millimeters and a few μas, the solutions agree very well. In particular, the individual scales of the TRF realizations are very consistent indicating that the models of the three independent software packages agree rather well.

Only in rare cases the agreement in the station coordinates at a common reference epoch was not satisfactory. One of the reasons is that different data spans have been used for the computations leading to incomplete data sets for a few stations which observed only in the early 1980's. The other reason for unacceptable differences surfaced only after extensive investigations: Differences in the values for the antenna axis offsets (see 2.2).

The different lists of antenna axis offsets in use at the IVS Analysis Centers motivated the IVS Analysis Coordinator to compile and issue an official list of antenna axis offsets which is recommended for use by all IVS Analysis Centers. Currently, re-computations of TRF realizations using the recommended axis offsets are underway.

2.2. Antenna Axis Offsets

Only in very few cases do the two main axes of a radio telescope really intersect. Mostly, the distance between the two axes, called the VLBI antenna axis offset, is in the range of a few millimeters, mainly for azimuth-elevation mounts (see Figure 1), up to several meters, mainly for hour-angle-declination or X-Y mounts. The knowledge of the exact axis offset is of extreme importance. Each VLBI delay observation has to be corrected for the axis offset effect and any error in this directly affects the vertical component of a station's position.

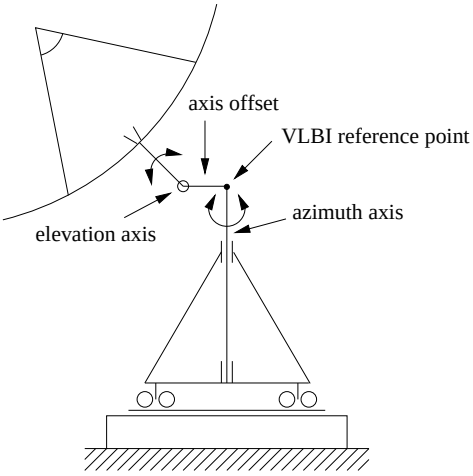

Figure 1. Axis offset of an azimuth-elevation mount (Courtesy R. Haas)

At the beginning of precision geodesy with VLBI the axis offsets have been taken from antenna construction drawings while later axis offsets were also estimated as global parameters from VLBI observations. In the meantime, the axis offsets of a very small number of telescopes have been measured locally with very high accuracy. A few of the results fit the estimates reasonably well but some of them don't at the level of up to 5 mm. Even more important is the fact that the measurements often do not match the values in the drawings. The reason for the discrepancies between measurements and estimates may be that the latter comprise any other residual effect which may have a cosine(elevation) signature.

The consequences of all this are twofold: On the one hand there is an enormous potential for improving the TRF results from VLBI observations. On the other hand earth orientation parameters (EOP) as determined by IVS Analysis Centers using different lists of axis offsets suffer from inherent systematic differences. The latter has not been very obvious and has, thus, not been considered yet.

Currently, all axis offsets measured or estimated reliably are being compiled for consistent use by all IVS Analysis Centers. For more details see the IVS Analysis Coordinator's web page (http://giub.geod.uni-bonn.de/vlbi/IVS-AC).

Compared to the general effort of VLBI observations, processing and analysis, the determination of the axis offsets does require relatively little work using standard surveying equipment and procedures. We strongly encourage the observatories with unreliable axis offset information to carry out the necessary measurements. Please contact the author if you need further advice.

2.3. IVS EOP Series

In 2004, six IVS Analysis Centers have again contributed routinely to the IVS Combined EOP series. However, in this year the Main Astronomical Observatory Kiev, Ukraine, has replaced the analysis center of St. Petersburg University, now adding the contribution of a third software package, SteelBreeze. This third software package, which has been developed completely independently, helps to make the combination products even more robust and broadens the basis for investigations of systematic effects.

In the course of the year the combination of the EOP series has been further refined through implementation of correlation information between analysis centers. Since all analysis centers use the same raw observation data for the computation of the EOP series, the input series cannot be considered independent. However, through quite a number of different reduction steps for the correction of the observables and the determination of the theoreticals, the O-C value for each observation is rather different for any of the analysis centers. The correlation coefficients are, thus, reduced quite a bit but are significant nevertheless. For more details see [3].

3. Combination of VLBI Sessions for the IERS Combination Pilot Project

In 2004 the IERS has issued a call to the IAG services/IERS Technique Centers to contribute input to the IERS Combination Pilot Project. The official input of IVS consists of SINEX files which are combined solutions of several IVS Analysis Centers. Each SINEX file contains a datum-free normal equation for a single session. Parameters are station coordinates and earth orientation parameters plus their time derivatives. In the course of the year, the first combined SINEX files have been compiled. At the beginning only SINEX submissions from the Calc/Solve software package (GSFC, USNO, BKG) were available. Now, also DGFI regularly submits SINEX files while MAO is preparing to do so after the procedure is set up properly.

The normal equations of these SINEX files are being scaled, added and resent to the IVS Data Centers and to the IERS CPP data base. So far about 70 VLBI sessions have been combined. Some feedback from the IERS Combination Centers shows the importance of IVS' contribution to this project. Furthermore, since the ITRF2004 will be computed by means of combination of normal equations this work is the only way for the IVS to contribute to the new terrestrial reference frame.

References

[1] Nothnagel A. (2003) *VTRF2003: A Conventional VLBI Terrestrial Reference Frame*; In: Proceedings of the 16th Working Meeting on European VLBI for Geodesy and Astrometry, held at Leipzig, May 09-10, 2003, edited by W. Schwegmann and V. Thorandt, Bundesamt für Kartographie und Geodäsie, Frankfurt/Leipzig, 2003, p. 195-205 (web-reference: http://giub.geod.uni-bonn.de/vlbi/IVS-AC/vtrf2003/vtrf2003.html).

[2] Nothnagel A. (2004) *Summary of the Fifth IVS Analysis Workshop*; In: IVS 2004 General Meeting Proceedings; NASA/CP-2004-212255, 509 - 513

[3] Steinforth C., A. Nothnagel (2004) *Considering a Priori Correlations in the IVS Combined EOP Series*; In: IVS 2004 General Meeting Proceedings; NASA/CP-2004-212255, 413 - 417