3.4.3 International VLBI Service (IVS)

IVS Organization and Activities

During 2012, the IVS continued to fulfill its role as a service within the IAG and IAU by providing necessary products for the maintenance of global reference frames: TRF, CRF, and EOP. Some highlights of the IVS organization and activities were:

- The VLBI2010 Workshop on Technical Specifications (TecSpec) was held on March 1–2, 2012 in Bad Kötzting, Germany.
- During March 4–9, 2012, the 7th IVS General meeting was held at the Royal Observatory of Madrid, Spain.
- The 13th IVS Analysis Workshop was held in Madrid (Spain) on March 8, 2012.
- The spring 2012 IVS Directing Board meeting (IVS DB #27) was held on March 9 in Madrid (Spain).
- The fall 2012 IVS Directing Board meeting (IVS DB #28) was held on October 20, 2012, at MIT Haystack Observatory, Westford, MA, USA.
- The 1st International VLBI Technology Workshop was held on October 22–24, 2012, at MIT Haystack Observatory, Westford, MA, USA.
- In the summer of 2012 the IVS published the 2011 Annual Report. Furthermore, three IVS newsletters were published in April, August and December to keep the community informed about IVS activities.

Network Stations

The IVS network operated well for most of 2012. The average single station data loss (scheduled versus correlated) is estimated to have been at the 10% level for stations that participated in 20 or more sessions; this loss number is similar to the ones for previous years. It should be noted that this number not only includes lost observing time due to interrupted or missed operations at the station, but it also factors in lost recording bits because of warm receivers or poor pointing that are subsequently converted into lost observing time (e.g., recordings with a warm receiver result in a two-third loss of the nominal observing time). In the analysis stage additional data may be edited out following quality-control criteria established at the analysis centers.

A total of 170 geodetic/astrometric 24-hour sessions were observed during the year 2012. The number of observing sessions coordinated by IVS was about ~3.3 days per week, similar to previous years. The major observing programs during 2012 were:

IVS-R1, IVS-R4 Weekly (Mondays and Thursdays) 24-hour, rapid turnaround measurements of EOP. Databases are available no later than 15 days after each session. The NASA Goddard Space Flight Center (R1) and the U. S. Naval Observatory (R4) coordinate these sessions.

Intensive Intensive: Daily 1-hour UT1 Intensive measurements are made on five days (Monday through Friday, Int1) on the baseline Wettzell (Germany) to Kokee Park (Hawaii, USA), on weekend days (Saturday and Sunday, Int2) on the baseline Wettzell (Germany) to Tsukuba (Japan), and on Monday mornings (Int3) in the middle of the 36-hour gap between the Int1 and Int2 Intensive series on the network Wettzell (Germany), Ny-Ålesund (Norway), and Tsukuba (Japan). Kokee replaced Tsukuba in the Int2 Intensives from the end of February to mid-April during the repair of the support pillars of the sub-reflector at Tsukuba.

IVS-T2 Bi-monthly sessions coordinated by the Institute of Geodesy and Geoinformation of the University of Bonn, Germany, with on average 17.5 stations per session. Seven of these sessions were observed to monitor the TRF with all IVS stations.

IVS-CRF The Celestial Reference Frame (CRF) sessions, coordinated by the U.S. Naval Observatory, provide astrometric observations that are required for improving the current CRF and in extending the CRF by observing 'new' sources. Sixteen sessions were observed for the maintenance of the ICRF in 2012.

VLBA The Very Long Baseline Array (VLBA), operated by the National Radio Astronomy Observatory (NRAO), continued to allocate six observing days for astrometry/geodesy. These sessions included the 10 VLBA stations plus up to 7 geodetic stations, providing state-of-the-art astrometry as well as information for mapping ICRF sources.

Europe The European geodetic network, coordinated by the Institute of Geodesy and Geoinformation of the University of Bonn, continued with six sessions in 2012.

IVS-OHIG The purpose of the IVS-OHIG (Southern Terrestrial Reference Frame) sessions is to tie together optimally the sites in the southern hemisphere. In 2012 six OHIG sessions were observed.

APSG The Asia-Pacific Space Geodynamics (APSG) program operated two sessions in 2012.

AUSTRAL In 2012 four Austral sessions were observed. The purpose is to determine the station coordinates and their evolution in the Australia (AuScope) and New Zealand geodetic VLBI network.

JADE The JApanese Dynamic Earth observation by VLBI (JADE) had eight sessions during 2012. These sessions included the dedicated 32-m dish at Tsukuba and are designed to monitor the domestic network within the ITRF.

IVS-R&D

Ten research and development sessions were observed in 2012. The goal of the 2012 R&D sessions was to determine the best choice for the minimum-angular-distance-to-the-sun scheduling parameter and to test the scheduling software VIE_SCHED in an operational setting.

Correlators

The correlator at Haystack Observatory (USA), the correlator at the U.S. Naval Observatory in Washington (USA), the BKG/MPIfR-correlator at the Max Planck Institute for Radioastronomy in Bonn (Germany) and the correlator at the Geographical Survey Institute (GSI) in Tsukuba, Japan continued their efficient processing of the data recorded for the IVS. The majority of the 24 hour sessions were processed by the Bonn and Washington correlators. The Bonn correlator used the DiFX software correlator and processed, e.g., the R1, EURO, T2, Int3, and OHIG sessions. The Washington correlator still used the Mark IV hardware correlator and processed, e.g., the R4, Int1, and CRF sessions. The Haystack correlator processed RD sessions and some T2 sessions. The Int2 and JADE sessions were processed at the Tsukuba correlator.

Data Centers

The IVS Data Centers continued to receive databases throughout the year and made them available for analysis within one day of correlation. The Data Centers also continued to receive solutions from Analysis Centers. All data and results holdings are mirrored several times per day among the three primary IVS Data Centers at BKG (Germany), Paris Observatory (France), and Goddard Space Flight Center (USA).

IVS Operational Data Analysis and Combination

Since October 1, 2009, the operational combination has been carried out by the IVS Combination Center at the German Bundesamt für Kartographie und Geodäsie (BKG) in Frankfurt a.M. The input to these combinations is datum-free (constraint-free) normal equation systems in SINEX format (Solution INdependent EXchange format) containing elements for radio source positions, Earth orientation parameters, and radio telescope coordinates.

The 13th IVS Analysis Workshop was held at the Royal Observatory of Madrid, Spain, on March 8, 2012, in connection with the 7th IVS General Meeting. In this workshop, the coordination of IVS routine data analysis was discussed as well as a number of individual items concerning geodetic and astrometric data analysis in the framework of the IVS. Due to personnel limitations at some of the analysis centers, the progress in improving the analysis software packages was slow. This is important for the necessary changes following the IERS Conventions 2010 in particular.

Concerning atmospheric gradient modeling, a decision was made by the attendees that the Chen and Herring (1997) model

should be the conventional model of the IVS, using the constant C = 0.0031 for estimating the hydrostatic gradient. Since the hydrostatic contribution is the biggest one and the coefficient for the total gradient contribution is only slightly different (C = 0.0032), no noticeable effect on the estimates is expected. The MacMillan (1995) model produces essentially the same results, but for consistency with the analyses of the IGS, the Chen and Herring (1997) model was adopted.

An unsolved problem is the issue of the sidelobe ambiguities resulting from loss of channels, e.g., due to radio frequency interference (RFI). For certain stations and sessions, this causes a loss of many observations. The only way to overcome this problem is by re-fringing the correlator output with a narrow search window (±10 ns).

Technology Development

The annual international e-VLBI workshop, the 10th of which was convened in 2011 in South Africa, was expanded in 2012 to include a broader scope of technical VLBI developments and was renamed 1st International VLBI Technology Workshop. It was held at Haystack Observatory 22–24 October 2012 and attended by 68 participants from 17 countries. The three-day workshop included sessions on antennas, receivers, digital backends, phase-calibration, recording, and e-VLBI, as well as some recent VLBI science achievements, and it was judged to be highly successful by all. The program and presentations from the workshop are available on-line at

<http://www.haystack.mit.edu/workshop/ivtw/program.html>.

The 2nd International VLBI Digital-Backend Intercomparison Workshop was held at Haystack Observatory immediately following the VLBI technical workshop. Participants from China, Europe, Japan, and the U.S. spent two days preparing equipment, recording wide-bandwidth correlated noise, and processing through the Haystack DiFX correlator to test the proper operation and intercompatibility of all the units under test.

At the end of 2012, IVS Technology Coordinator Alan Whitney stepped down from his position because of his retirement from MIT. He will be succeeded by Bill Petrachenko from Natural Resources Canada as the new IVS Technology Coordinator in 2013.

The Mark 6 VLBI data system is entering service at 8 Gbps. Several successful experiments have been conducted, and the system continues to be made more robust. Routine service at 8 Gbps is expected in the first half of 2013, with expansion to 16 Gbps by the end of 2013.

References

G. Chen, and T.A. Herring (1997). Effects of atmospheric azimuthal asymmetry on the analysis of space geodetic data. J Geophys Res, Vol. 102, No. B9, pp. 20489-20502, doi: 10.1029/97JB01739.

D. S. MacMillan (1995). Atmospheric gradients from very long baseline interferometry observations. Geoph Res Letters, Vol. 22, No. 9, pp. 1041-1044, doi: 10.1029/95GL00887.

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