3.4.3 International VLBI Service (IVS)

IVS Organization and Activities

During 2005, 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: ITRF, ICRF and EOP. In May 2005 IVS held its third Technical Operations Workshop at Haystack Observatory, Westford, MA, USA. Two IVS Directing Board meetings were held, one in April at Noto Observatory, Noto, Italy, and the other in September at USNO, Washington, DC, USA. IVS published its 2004 Annual Report in April 2005 and published three newsletter issues which keep the community informed about IVS activities. The IVS continued the systematic monitoring program of CRF sources to support the re-determination of the ICRF. The third IVS Working Group, chaired by Alan Whitney and Arthur Niell, finalized its work and prepared a final report on a vision for VLBI in 2010 (Niell et al., 2005). The report, which will serve as a guideline for the establishment of the next generation VLBI system, was approved by the Directing Board at its September meeting and a printed version can be obtained from the Coordinating Center upon request. The VLBI2010 Working Group was closed at the September Board meeting. At the same meeting the standing committee “VLBI2010 Committee”, chaired by Bill Petrachenko, was created and was tasked with encouraging the implementation of the recommendations of the VLBI2010 Working Group.

Network Stations

A total of 1344 station days were used in 187 geodetic/astrometric sessions during the year. Observing sessions coordinated by IVS remained at an average of ~3.5 days per week, similar to previous years. The number of station days increased with respect to the previous year due to the observation of the two-week long continuous VLBI campaign 2005 (CONT05). The major observing programs during 2005 were:

IVS-R1, IVS-R4

Weekly (Mondays and Thursdays) 24-hour, rapid turnaround measurements of EOP. Data bases are available no later than 15 days after each session. These sessions are coordinated by NASA Goddard Space Flight Center (R1) and the U. S. Naval Observatory (R4).

Intensive

Daily 1-hour UT1 Intensive measurements are made on five days (Monday through Friday) on the baseline Wettzell (Germany) to Kokee Park (Hawaii, USA) and on weekend days (Saturday and Sunday) on the baseline Wettzell (Germany) to Tsukuba (Japan). The daily sessions are recorded using Mark 5 (Wettzell-Kokee) and K5 (Wettzell-Tsukuba) technology. Comparisons of the two series showed good agreement with the IERS C04 series.

CONT05 A fifteen day campaign of continuous VLBI sessions, observed in the second half of September 2005 and coordinated by the IVS Coordinating Center at NASA Goddard Space Flight Center. The goal of the campaign was to acquire state-of-the-art VLBI data over a two-week period to demonstrate the highest accuracy of which VLBI is capable.

IVS-T2 Bi-monthly sessions coordinated by the Geodetic Institute of the University of Bonn with 16 stations per session. These sessions were observed to monitor the TRF and all stations were scheduled at least 3–4 times during the year.

IVS-E3 Monthly sessions using the Canadian S2 technology, coordinated by Natural Resources, Canada, designed to measure EOP and monitor TRF. The Canadian mobile antenna occupied a location at St. John’s (Newfoundland) all year.

IVS-CRF, IVS-CRD The Celestial Reference Frame (CRF) sessions and the CRF deep-south (CRD) sessions, both coordinated by the U.S. Naval Observatory, provide astrometric observations that are useful in improving the current CRF and in extending the CRF by observing “new” sources. Fifteen sessions were observed for the maintenance of the ICRF in 2005 primarily in the southern hemisphere. Nine of them were scheduled with emphasis on the far southern hemisphere (CRD).

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 10 geodetic stations, providing state-of-the-art astrometry as well as information for mapping ICRF sources.

Europe The European geodetic network, coordinated by the Geodetic Institute of the University of Bonn, continued with four sessions in 2005.

IVS-OHIG The IVS-OHIG (Southern Terrestrial Reference Frame) series, coordinated by the Geodetic Institute of the University of Bonn, was continued with six sessions in 2005. By optimally tying together the sites in the southern hemisphere a very accurate regional TRF around the South Pole is obtained.

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

JADE The JApanese Dynamic Earth observation by VLBI (JADE) had 12 sessions. 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 sessions were observed in 2005 using Gbit/s recording rates to demonstrate the highest data rate available today.

The Network Coordinator's data base of station performance showed a data loss of 14.4%, slightly worse (2%) compared to 2004, but has returned to the level of loss seen in 2003. The most significant causes of data loss were antenna reliability (about 25%), receiver problems (24%), recorder problems (9%), and RFI (6%).

Correlators

The correlators at Haystack Observatory (USA), the U.S. Naval Observatory (USA), and at Max-Planck Institute for Radioastronomy (Germany) continued to expand their processing of data recorded on Mark 5 disk media, with a corresponding increase in efficiency. Some 24-hour sessions can now be correlated in less than a day.

Data Centers

The IVS Data Centers continued to receive data bases 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.

Analysis Coordinator

In early 2005, several realizations of terrestrial reference frames (TRF) have been made available by different IVS Analysis Centers, i.e. by Deutsches Geodätisches Forschungsinstitut (DGFI) in Munich, Germany, using the OCCAM VLBI software together with a DGFI combination program called DOGS-CS, by Geoscience Australia (GA), Belconnen, Australia, using the OCCAM software with a Kalman Filter setup, by the Main Astronomical Observatory (MAO), Kiev, Ukraine, with the software package SteelBreeze as well as by Bundesamt für Kartographie und Geodäsie (BKG) and NASA Goddard Space Flight Center (GSFC) both using the Calc/Solve software package. A combination has been carried out on the basis of coordinates, velocities and their formal errors mapping them onto the ITRF2000 datum using only those sites which carry the largest amount of the observing load today (Nothnagel, 2005a). The resulting coordinates and velocities (VTRF2005) are now widely used for EOP and atmosphere parameter estimation.

During 2005 quite some effort was invested into the ITRF2005 project in order to deliver combined datum free normal equations of all high precision geodetic VLBI sessions to the IERS in SINEX format. Datum free normal equations are the purest way of transferring the inherent information of the solutions like the covariances to further combination steps. Unfortunately, software packages which do not use normal equations, e.g. Kalman filter and Square Root Information filter software, cannot yet produce some of the statistical information which is necessary for the combination on the basis of normal equations. For this reason the combination had to be restricted to contributions which use least-squares algorithms based on the solution of normal equations.

The “Sixth IVS Analysis Workshop” was held at Noto, Italy, on May 21–22, 2005. Detailed information on the presentations and discussions can be found in Nothnagel (2005b).

Technology Development Centers

Routine use of e-VLBI continued to grow. All data recorded on the Japanese K5 systems at Tsukuba and Kashima were transferred via e-VLBI to Haystack Observatory, where it was transferred to Mark 5 disk modules and sent to target correlators at Haystack, USNO or MPIfR. Approximately 100 TB have been transferred over the last year, including all Tsukuba data from the CONT05 experiment. The weekday UT1 Intensive data from Wettzell were transferred via e-VLBI to a site near USNO in Washington, D.C., where it was picked up and taken to USNO for correlation. Wettzell’s weekend UT1 Intensive data were e-transferred to the correlator at the Geographical Survey Institute, Tsukuba, Japan.

Transfer rates, especially across international networks continued to improve. Japan–U.S. transfer rates as high as ~900 Mbps have been observed, with sustained rates as high as ~700 Mbps. Real-time e-VLBI experiments were conducted within the U.S. and between Europe and U.S. In November 2005 a successful 3-station real-time e-VLBI demonstration was conducted by sending data at 512 Mbps from Westford, GGAO and Onsala to the Mark IV correlator at Haystack Observatory. The biggest impediment to rapid e-VLBI expansion continues to be station connectivity to high-speed networks, but the situation is improving. Tsukuba, Kashima, Onsala, Westford and Medicina are all connected with 1 Gbps links, though some issues remain in actually using some of the links at full speed. Wettzell is connected at ~30 Mbps and TIGO at ~2 Mbps. Projects are underway to connect Ny Ålesund, Hobart, Fortaleza and Svetloe in 2006.

A reference implementation of the proposed international standard for VSI-E (VLBI Standard Interface for E-VLBI) specification has been developed. The VSI-E framework provides signaling, control, framing and statistics support and is an extension to the Internet standard RFC3550. Life testing of VSI-E was initiated between Kashima and Haystack as an ideal testbed since Kashima employs the K5 system whereas Haystack uses Mark 5A, enabling testing on heterogeneous systems. Once the reference implementation is fully checked out, attention will be turned to optimizing the code for high-speed operation and broader deployment.

References

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