3.4.3 International VLBI Service (IVS)

IVS Organization and Activities

During 2006, 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 January 2006 IVS held its fourth General Meeting in Concepción, Chile. Two IVS Directing Board meetings were held, one in January at the University of Concepción, Concepción, Chile, and the other in September at Haystack Observatory, Westford, MA, USA. IVS published its 2005 Annual Report in April 2006, the proceedings volume of the fourth General Meeting in July 2006, and three newsletter issues which keep the community informed about IVS activities. A joint IERS/IVS Working Group on the Second Realization of the ICRF, chaired by Chopo Ma, was created and was tasked with generating ICRF-2 from VLBI observations of extragalactic radio sources. The goal is to present the second ICRF to relevant authoritative bodies, e.g. IERS and IVS, and submit the revised ICRF to the IAU Division I Working Group on the Second Realization of the ICRF for adoption at the 2009 IAU General Assembly.

In 2006, IVS had to face two events that had an impact on the service products. First, the Network Station at Gilmore Creek discontinued its VLBI operations in January 2006 and the telescope—located in Fairbanks, Alaska—was mothballed for an undetermined period of time. The second event was the cessation of the Canadian VLBI operations by Natural Resources Canada in October 2006. In both events, various reasons contributed to the termination of the observations; however, the costs for required upgrades of the worn-out telescopes played a major role in both cases. Today's VLBI network is not sufficiently robust to simply compensate such events without an impact on the final products. Due to the location on the North American continent, the "lost" stations have been of extreme importance to the IVS and, accordingly, their contribution to the IVS observing program was significant. The influence on the product quality could be mitigated to some extent with stations that came online recently such as Zelenchukskaya, Russia.

Network Stations

A total of 1124 station days were used in 174 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 major observing programs during 2006 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.

IVS-T2 Bi-monthly sessions coordinated by the Institute of Geodesy and Geoinformation 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. Following the cessation of VLBI operations in Canada, the series was discontinued in September 2006.

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 2006 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 Institute of Geodesy and Geoinformation of the University of Bonn, continued with six sessions in 2006.

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 2006 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 13.6%, slightly better (1%) compared to 2005. The most significant causes of data loss were receiver problems (21%), antenna reliability (19%), data acquisition system problems (16%), and RFI (12%). The RFI contribution has roughly doubled from the previous year, possibly due to more uniformity in attributing amplitude fluctuations to this cause.

Correlators

The correlators at Haystack Observatory (USA), the U.S. Naval Observatory (USA), and at Max-Planck-Institute for Radioastronomy (Germany) further increased their efficiency in processing data recorded on Mark 5 disk media. Several 24-hour sessions can now be correlated in less than a day. The correlator at MPIfR Bonn was connected at 1 Gbps in the later part of 2006. This connection will allow data to be transferred directly from connected network stations to the MPIfR correlator. Tests of this new link have started and production use of the connection is expected for 2007.

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

A large portion of the work in the year 2006 was devoted to the generation of the IVS input to ITRF2005. In the case of IVS, the IERS asked for individual data sets for each VLBI observing session of 24 hours duration in Solution INdependent EXchange (SINEX) format. SINEX files permit the transmission of the full variance/covariance information to interpret the quality of the solution to its full extent or to further combine the results with other solutions. This can be realized through reporting either the full variance/covariance matrix or the normal equation matrix of a solution setup pre-reduced for technique-specific parameters (e.g. clock parameters). The latter option is mainly meant for further combinations but, if required, variance/covariance information can easily be extracted through an inversion procedure which may have to include a datum definition if necessary.

In order to facilitate combination steps through a procedure which may be completely free of any datum definition, the IVS had decided that IVS Analysis Centers report datum-free normal equation matrices in their SINEX files to the IVS Analysis Coordinator. Consequently, the IVS input to ITRF2005 was also based on datum-free normal equations.

Quite a lot of effort had to be spent on eliminating problems originating from peculiarities of certain sessions which inhibited a combination in a straight forward way. Noteworthy is the fact that the Japanese regional network is linked to the global network of ITRF sites only insufficiently. This situation should be addressed in future session plans. Several sites with only very few observing days of the past (1980s) were eliminated from the station list for ITRF2005.

The final IVS data set was combined from data of Deutsches Geodätisches Forschungsinstitut (DGFI), of Bundesamt für Kartographie und Geodäsie (BKG), of NASA Goddard Space Flight Center (GSFC), of Shanghai Astronomical Observatory (SHAO), and of U.S. Naval Observatory (USNO). Unfortunately, the data of Geoscience Australia (GA) and of Kiev Main Astronomical Observatory (MAO) could not be used due to incompatibility of the data sets. For the next realization of the ITRS, however, we are confident that these difficulties will be overcome.

In parallel to the ITRF2005 investigations, a new combination strategy for the two IVS EOP series (rapid and quarterly solutions) has also been developed and tested. Preparations were made for a change from a combination of EOP on the basis of results to a combination on the basis of datum-free normal equations in SINEX format. The advantage of the new combination strategy is that one common terrestrial reference frame (e.g. ITRF2005) can be applied after the combined datum-free normal matrix is generated. This helps to avoid that systematic differences caused by different TRF used in the individual contributions enter the combination. Due to the complicated dependency on several observatories participating in the sessions in a variety of configurations, the TRF effect is almost impossible to eliminate from EOP-only solutions afterwards. For testing purposes, the application of an identical TRF to all contributions also allows a better investigation in remaining systematic effects.

Technology Development

Routine use of e-VLBI continued to grow. All data recorded on K5 systems at Tsukuba and Kashima was transferred via e-VLBI to Haystack Observatory, where it was transferred to Mark 5 disk modules and then correlated or sent to target correlators at USNO or MPIfR. Also the Syowa (Antarctica) data was transferred to Haystack from Japan, after the Syowa K5 disk media had been physically shipped to Japan. MPIfR Bonn is expected to have operational connectivity in 2007, so that the intermediate step of e-transferring data to Haystack will become superfluous for sessions that are to be correlated at Bonn. All of Wettzell's daily UT1 Intensive data was transferred via e-VLBI, either directly to the correlator at the Geographical Survey Institute, Tsukuba, Japan (Saturday–Sunday) or to a site near USNO in Washington, D.C. (Monday–Friday), where it was picked up and taken to USNO for correlation.

During 2006, a number of e-VLBI tests and experiments were conducted with the Ny-Ålesund station—one of the most remote stations in the VLBI network. Courtesy of arrangements between NASA and Norway, which jointly own an undersea fiber-optic cable from Svalbard to the mainland, these tests allowed a significant amount of data to be transferred from Ny-Ålesund to Haystack Observatory, where they were recorded on Mark 5 disk modules and shipped to the target correlator. The speed of the connection was limited to less than 100 Mbps, but plans were being discussed to increase the speed to ~300 Mbps, which would be suitable to transferring essentially all data from Ny-Ålesund via e-VLBI. Since Ny-Ålesund media have traditionally been among the most difficult to transport rapidly and reliably, the new e-VLBI connection promises a real step forward.

The VLBI2010 Committee continued the work of conceiving the next generation VLBI system. The main thrusts lay on Monte-Carlo-type simulations to determine system critical parameters as well as on prototyping and proof-of-concept efforts for the broadband delay. The strawman system is envisioned to consist of fast-slewing, 12-m diameter class antennas. The system should cover a continuous band of ~2-15 GHz and record at high data rates of possibly up to 32 Gbps. These high rates may be attained by a 'burst mode' type of operation, in which source data is captured into high-speed RAM for maybe 5 sec and then either recorded or transmitted while the antenna is slewing to the next source in the following 20 sec. Repeating this cycle continuously over a 24-hour session, a significantly higher number of observations can be collected (possibly up to 100,000). Besides rapid sky coverage, this mode of operation will quickly sample the atmosphere in all directions to allow better determination of changing atmospheric parameters.

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