The next generation VLBI system, VLBI2010

In September 2005 the IVS Directing Board accepted the final report of its Working Group 3 (WG3) entitled “VLBI2010: Current and Future Requirements for Geodetic VLBI Systems” (Niell, 2006) which recommended a review of all current VLBI systems and processes from antennas to analysis and outlined a path to a next-generation system with unprecedented new capabilities: 1 mm position and 0.1 mm/yr velocity accuracy on global scales, continuous measurements for time series of station positions and Earth orientation parameters, and a turnaround time to initial geodetic results of less than 24 hours.

As a consequence, the IVS established the VLBI2010 Committee (V2C) to carry out a series of studies and to encourage the realization of the new vision for geodetic VLBI. Making rational design decisions for VLBI2010 requires an understanding of the impact of new strategies on the quality of VLBI products. To serve this purpose, Monte Carlo simulators were developed which have been used to study the effects of the dominant VLBI random error processes (related to the atmosphere, the reference clocks, and the delay measurement noise; Pany, 2010) and new approaches to reduce them, such as decreasing the source-switching interval and improving analysis and scheduling strategies. Shortening the source-switching interval results in a higher number of observables leading to a significant improvement in station position accuracy (Petrachenko, 2009). In any case, the simulators confirm that the dominant error source is the troposphere. It is recommended that research on analysis strategies for the atmosphere continues to be a priority for the IVS. Based on the findings from the Monte Carlo studies, the source-switching interval should be reduced. This includes decreasing both the on-source time needed to make a precise delay measurement and the time required to slew between sources. From these two somewhat competing goals, recommendations for the VLBI2010 antennas are emerging, e.g., either a single ~12 m diameter antenna or larger with very high slew rates, e.g., $12^{\circ}/\rm{s}$ in azimuth, or a pair of ~12 m diameter antennas (or larger), each with more moderate slew rates, e.g., $5^{\circ}/\rm{s}$ in azimuth (Petrachenko, 2009).

In order to reduce the on-source observing time, it is important to find a means for measuring the delay with the requisite precision even at a modest signal-to-noise ratio. To do this a new approach is being developed in which several widely spaced frequency bands are used to unambiguously resolve the interferometric phase. The new observable is being referred to as the broadband delay. A four-band system is recommended that uses a broadband feed to span the entire frequency range from 2 to 14 GHz (Petrachenko, 2009). A total instantaneous data rate as high as 32 Gbps and a sustained data storage or transmission rate as high as 8 Gbps are necessary to detect an adequate number of high-quality radio sources (Petrachenko, 2009). NASA is funding a proof-of-concept effort till 2012 to test the broadband delay technique, and first fringes have been already detected in all bands. In addition to random errors, systematic errors need to be reduced, too. For example, updated calibration systems are being developed to account for electronic biases. Conventional surveying techniques have to be refined to observe antenna deformations, and the application of small reference antennas is considered for generating deformation models and establishing site ties. Furthermore, corrections based on images derived directly from the VLBI2010 observations are under study to mitigate errors due to source structure (Petrachenko, 2009).

The progress report of the IVS VLBI2010 Committee (Petrachenko, 2009) recommends that a globally distributed network of at least 16 VLBI2010 antennas observes every day to determine Earth orientation parameters, and that other antennas be added as needed for the maintenance of the celestial and terrestrial reference frames. Antennas with access to high-speed fiber networks are also required to enable daily delivery of initial IVS products in less than 24 hours. A high priority is placed on increasing the number of stations in the Southern hemisphere. Since IVS products must be delivered without interruption, a transition period to VLBI2010 operations is required in which there will be a mix of antennas with current and next-generation receiving systems. For this period a compatibility mode of operation has been identified and tested to a limited extent with the NASA proof-of-concept system. In order to increase reliability and to reduce the cost of operations, enhanced automation will be introduced both at the stations and in the analysis process. Stations will be monitored centrally to ensure compatible operating modes, to update schedules as required, and to notify station staff when problems occur. Automation of the analysis process will benefit from the work of the current IVS Working Group 4, which is updating data structures and modernizing data delivery (Petrachenko, 2009).

For more details the authors refer to various reports, memos, and other documents describing the concept and realizations of VLBI2010. Many of those are accessible via the webpage of the IVS at http://ivscc.gsfc.nasa.gov/.

| <= back |