IVS Technology Coordinator Report

Alan Whitney

Abstract

The efforts of the Technology Coordinator in 2007 included the following areas: 1) support of work to implement a new geodetic VLBI system as outlined in the IVS Working Group 3 "VLBI2010" study, 2) continued development and deployment of e-VLBI, 3) 6th annual e-VLBI workshop held at MPI in Bonn, Germany, and 4) TOW workshop at Haystack Observatory. We will briefly describe each of these activities.

1. VLBI2010 Progress

Progress continues towards the goal of a next generation geodetic VLBI system. Some of the highlights include:

1.1. Development of the First Demonstration Broadband System

A collaboration of Haystack Observatory, NASA/GSFC and Honeywell implemented the first demonstration broadband system on the 5 m MV3 antenna at NASA/GSFC. The system has the following characteristics:

1. A commercial dual linear polarization feed to cover ∼2-13 GHz, followed by two LNAs. The feed and LNAs are cooled to ∼20 K.
2. Optical transmission of the full RF bandwidth to 'up/down converters' (UDCs) in the base of the antenna. Each UDC selects an arbitrary 500 MHz slice of the RF band and translates it to the proper Nyquist zone for sampling.
3. A digital backend (DBE1) which accepts up to four 500 MHz-wide IFs and separates each into fifteen adjacent 32 MHz-wide channels using polyphase filter band (PFB) technology, though only every other channel is recorded. In the full-up demo system, four dual polarization IFs of 500 MHz width each will be processed through eight PFBs, each IF creating 1 Gbps of data for a total of 8 Gbps.
4. The data are recorded on Mark 5B+ recorders, each capable of supporting 2 Gbps. Current experiments use two Mark 5B+ systems at each site for a total of 4 Gbps. The full-up demo system will use four Mark 5B+ systems at each site for a total of 8 Gbps at each site.
5. The data are processed on a standard Mark IV correlator slowed down by a factor of 2 from the real-time rate.

In November 2007 a successful experiment was conducted using a broadband demonstration system at MV3 (dual linear polarization) and a standard S/X system at Westford (single circular polarization). Results from this experiment appeared as expected except for some unexplained phase differences between cross-correlations of different polarization; this phenomenon is being investigated.

Plans are in progress to also implement the broadband system on the Westford antenna to allow tests of a single baseline with complete broadband systems on both antennas.

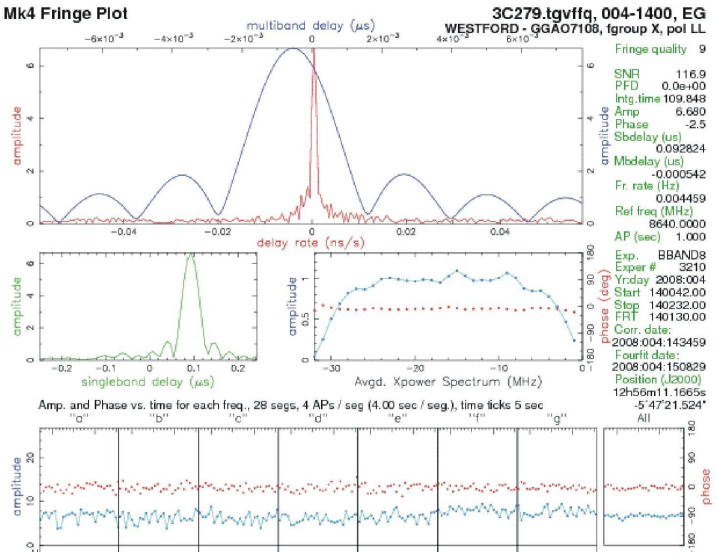

Figure 1. Fourfit plot of fringes from VLBI2010 demo experiment.

The characteristics of the commercial broadband feed currently being used are non-ideal for this work, and efforts are underway to have a new dual linear polarization feed designed by Per-Simon Kildal at Chalmers University, who has designed successful broadband feeds for other frequency ranges. This work is being partially supported by contributions from our Norwegian colleagues; others are expected to contribute to this effort as well. A new feed design could be ready within a year or so. The final VLBI2010 broadband system will broaden the IF bandwidths to 1 GHZ each and raise the data acquisition rate to at least 16 Gbps using a so-called 'burst-mode' technique where data for each individual scan, which may be 5-10 seconds in length, are buffered to high-speed electronic memory. Then, while the antenna is slewing for the next ∼30-45 seconds to the next source, the data are 'dribbled' off to a recording or data transmission system at a rate of ∼4 Gbps. This 4 Gbps rate will be supported by a single Mark 5C system (currently under development) or an e-VLBI data link at each site. One of the outstanding VLBI2010 system design issues is the specification and development of a delay/phase calibration sub-system. Work will proceed on this issue in 2008.

1.2. Antennas for VLBI2010

A 12 m diameter seems to have been pretty much selected for the VLBI2010 application, although at least two designs have been developed:

1. Patriot Antenna of Albion, Michigan, USA offers a 12 m antenna with an azimuth rate of 5 deg/sec and an elevation rate of 1 deg/sec. Australia and New Zealand have both placed orders for this antenna with deliveries expected in 2008. Some debate remains regarding whether these slew speeds are adequate; studies into this subject are still on-going.
2. Wettzell/BKG is developing a high slew speed 12 m antenna for use in their 'twin-antenna' project.

1.3. VLBI2010 Studies

A well-attended VLBI2010 workshop was held on 15 April 2007 in Vienna, Austria in conjunction with the EVGA meeting. Many papers relating to all aspects of VLBI2010 were presented, and many lively and fruitful discussions took place. In general, there was much enthusiasm and support for continued work and much interest in the development of demonstration and prototype hardware and software systems to support the goals of VLBI2010. The next VLBI2010 workshop will be held in March 2008 in St. Petersburg, Russia.

A number of studies related to VLBI2010 are still underway, some of which are attempting to determine the necessary minimum antenna slew speeds needed to create an observing program that will meet the VLBI goal of 1 mm accuracy in 24 hours with 12 m antennas and the associated data acquisition systems that are contemplated. At present, there are no clear-cut answers, but the studies do not seem to indicate that higher slew speed antennas are necessarily substantially better.

2. e-VLBI Development

2.1. New or Enhanced Connections

Additional stations continue to be connected for e-VLBI. Among the notable new connections are Svetloe and, expected soon, Badary. Among the notable upgraded connections are 10 Gbps connections at Onsala, Metsahovi, Westford and the Haystack correlator. Wettzell has upgraded its link to ∼600 Mbps. TIGO has recently upgraded its link to at least 32 Mbps for short periods of time and is pursuing a more permanent upgrade. Hobart's connection to the University of Tasmania has been upgraded to 1 Gbps with new fiber, but the connection from Tasmania to mainland Australia is still somewhat of a bottleneck. Fiber to the Fortaleza station has been installed, and Fortaleza's connectivity to the global network is anticipated soon.

2.2. Continuing Expansion and Development of Routine e-VLBI Data Transfers

MPI now conducts regular e-VLBI transfers of data for which the Bonn correlator is the correlation target. This includes data from Japan, Onsala, Ny-Ålesund, and Wettzell. All data recorded on K5 systems at Tsukuba and Kashima are now transferred either to MPI or Haystack depending on the target correlator. Syowa K5 data are physically shipped to Japan and electronically transferred to Haystack or MPI. UT1 Intensive data from Wettzell, Japan and Ny-Ålesund are transferred to either MPI or a site near the Washington correlator (where the last couple of km is currently handled via sneakernet!), depending on the target correlator for the data.

2.3. 6th International e-VLBI Workshop Held at MPI, Bonn, Germany

The 6th International e-VLBI Workshop was hosted by MPI and held 17-18 September 2007 in Bonn, Germany. The workshop was attended by some 60 participants from 15 countries. Presentations at the workshop showed rapid progress in e-VLBI on several fronts. In Europe, the JIVE EXPReS project continues to connect European astronomical VLBI telescopes in real-time and conducts regular scientific e-VLBI experiments with up to 5-6 stations at data rates nearing 1 Gbps/station. Australia continues to make rapid progress in connecting its telescopes and has also developed a software correlator system to support real-time observations. A Japanese-Finnish

team delivered the database of an Intensive (one hour) session to the analysts only 20 minutes after the conclusion of the observations. A panel discussion on VSI-E led to a charge to re-invigorate the VSI-E working group and to finalize the VSI-E specification within a year. Alan Whitney, as chair of that group, accepted the charge but has since had to pass the baton to Dr. Chester Ruszczyk of Haystack due to a change in Alan's position at Haystack Observatory. All presentations from the Bonn workshop are available at *http://www.mpifr-bonn.mpg.de/div/vlbi/6th_evlbi/*. The next e-VLBI workshop will be held 16-17 June 2008 in Shanghai, China. We all look forward to another valuable and stimulating meeting.

3. TOW2007 Workshop at Haystack Observatory

The 4th IVS Technical Operations Workshop (TOW) was held 30 April—3 May 2007 at Haystack Observatory. The TOW is intended to provide hands-on training and problem resolution in VLBI operations primarily for the technical staff of the stations. The curriculum included operations and maintenance workshops such as equipment operation and checkout, Mark 5A and Mark 5B operations, cryogenic system maintenance, RFI identification and mitigation, and general station troubleshooting. Seminars on such subjects as correlator theory and operations, introduction to Linux, timing systems, phase calibration basics, e-VLBI overview, introduction to the K5 system, and H-maser monitoring and maintenance helped to further inform the participants. And various lectures on 'how VLBI works', science overview, Mark 5 system operation, and impact of operations on data analysis helped to broaden the view of all attendees. All TOW2007 workshop presentations are available at *http://ivscc.gsfc.nasa.gov/meetings/tow2007/notebook.html*.