IVS Technology Coordinator Report

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Abstract

The efforts of the Technology Coordinator in 2009 include the following areas: 1) support of work to implement the new VLBI2010 system, 2) continued development and deployment of e-VLBI, 3) continuing development of global VLBI standards, and 4) digital-backend compatibility testing. We will briefly describe each of these activities.

1. VLBI2010 Progress

Progress continues towards the goal of a next-generation VLBI2010 system. Much more detailed information about VLBI2010 development is presented elsewhere in this report; here we briefly report some of the highlights.

1.1. Development of the VLBI2010 Broadband System

The VLBI2010 testbed using the 18-m antenna at Westford, MA and the 5-m MV3 antenna at NASA/GSFC continued to be developed. Among the highlights of 2009 are:

1. Development and checkout of a phase-calibration system for the VLBI2010 system.
2. Nearing the completion of RDBE, a next-generation digital-backend based on the ROACH FPGA-based board which accepts up to four 500 MHz-wide IFs and channelizes each into fifteen adjacent 32 MHz-wide channels using polyphase filter band (PFB) technology, although only every other channel is recorded. In the full-up demo system, four dual-polarization IFs of 500 MHz width each are processed through eight PFBs, each IF creating 1 Gbps of data for a total of 8 Gbps.
3. Nearing the completion of the 4 Gbps Mark 5C+ VLBI data system. The current Mark 5B+ systems being used for VLBI2010 experiments will be replaced with Mark 5C in 2010.
4. Development of the new 'eleven' broadband feed for VLBI2010 is currently underway at Chalmers University of Technology in Sweden.
5. 12-meter antennas from Patriot Antenna Systems have been installed in New Zealand and Australia, and one has been ordered for installation at NASA/GSFC in Greenbelt, MD in early 2010. Development of 13-m antenna systems continues under the leadership of Wettzell.
6. More than two dozen separate VLBI2010 data taking sessions were undertaken during 2009, a number of them 24-hour sessions. Typically, data were recorded onto four Mark 5B+ units at each station, for an aggregate data rate of 8 Gbps/station. Processing was done at reduced speed on the Mark IV correlator.

1.2. VLBI2010 Workshop

More than 50 people attended a highly successful VLBI2010 Workshop on Future Radio Frequencies and Feeds held 18-20 March 2009 near Wettzell, Germany. Presentations and discussions were included on the following topics:

- broadband observation strategy
- feed issues
- polarization
- broadband receiver design
- radio frequency interference (RFI)
- geodetic ties between VLBI and other techniques (GNSS, SLR, etc.)
- conclusions and recommendations to the IVS Directing Board

This VLBI2010 workshop was followed by a V2C meeting which focused on digital baseband converters and software correlators. As a result of these meetings, the following recommendations were made to the IVS Board and are now under consideration:

- The initial implementation of the VLBI2010 system needs to be capable of observing the broadband range of 2.2 to ∼14 GHz.
- The VLBI2010 system needs to be capable of S/X operation.
- The antenna should allow for a possible future inclusion of Ka-band (32 GHz) operation.
- The complete end-to-end operation of the VLBI2010 system should be demonstrated in a campaign in early 2012. As many antennas as possible should participate.
- A plan should be established for the transition from the legacy S/X system to the VLBI2010 broadband delay system. Such a transition plan can be beneficial for obtaining future funding and will support a timely changeover.

Figure 1. Attendees of the VLBI2010 Workshop on Future Radio Frequencies and Feeds held near Wettzell, Germany

2. e-VLBI Development

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

MPI continues 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

the K5 system at Tsukuba and Kashima are 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, Tsukuba and Ny-Ålesund are transferred to either MPI or the Washington correlator, which is now connected to the world at ∼600 Mbps! Welcome news! After a long and tortured process, connection of the Kokee station in early 2010 now seems likely. This connection will help lower the processing latency for time-critical UT1 data from days to hours.

2.2. 8th International e-VLBI Workshop Held at Madrid, Spain

The 8th International e-VLBI Workshop was held 22-26 June 2009 in Madrid, Spain, hosted by the Centro Nacional de Información Geográfica—Instituto Geográfico Nacional (CNIG-IGN) of Spain in cooperation with the EXPReS project. The workshop was attended by more than 80 participants from 19 countries.

Presentations at the workshop showed continuing 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 5-8 stations at data rates up to 1 Gbps/station, with some data connection speeds being as high as 10 Gbps (but without being correlated in real-time). Australia and Japan continue to make rapid progress in connecting telescopes. Korea is pursuing an aggressive e-VLBI plan as telescope construction continues there.

All presentations from the Madrid workshop are available at the on-line Proceedings of Science at *http://pos.sissa.it/cgi-bin/reader/conf.cgi?confid=82*. The 9th International e-VLBI Workshop will be held in Perth, Australia in 2010. We all look forward to another valuable and stimulating meeting.

3. Global VLBI Standards

3.1. VLBI Data Interchange Format (VDIF) Task Force

One important outcome of the 7th International e-VLBI Workshop in Shanghai in 2008 was the creation of a task force to study and recommend a universal VLBI data format that is suitable for both on-the-wire e-VLBI data transfer, as well as direct disk storage. This task force, called the VLBI Data Interchange Format (VDIF) Task Force, was envisioned as the first part of a two part effort, the second of which will address standardization of e-VLBI data-transmission-protocols (so-called VTP). The VDIF Task Force, consisting of Mark Kettenis (JIVE), Chris Phillips (ATNF), Mamoru Sekido (NICT), and Alan Whitney (MIT Haystack, chair), presented a proposed VDIF specification at the June 2009 Madrid meeting. The Task Force was gratified that the proposed specification was well-received and, after some discussion, ratified by the attendees. The VDIF specification is discussed in detail in other papers in this report and is available on-line at *http://vlbi.org*. A VTP Task Force, led by Chris Phillips of ATNF, was appointed to lead the development of the second half of this standardization effort, which is now an on-going effort.

3.2. VEX2 Task Force

The VEX file format was invented by Alan Whitney in 1995 as a standardized method to prescribe a complete description of a VLBI experiment, including setup, scheduling, data-taking and correlation, independent of any particular VLBI data-acquisition system or correlator. VEX has gained quite broad acceptance and is used to support a very large fraction of global VLBI observations. However, as VLBI technology and data-taking methods have marched on since 1995, VEX is now in need of a significant globally coordinated update. At a U.S. VLBI technology meeting in November 2009, and in collaboration with international colleagues, a VEX2 Task Force was created to undertake this job. The members of the VEX2 Task Force are Walter Brisken (NRAO, chair), Ed Himwich (NASA/GSFC), Mark Kettenis (JIVE), Cormac Reynolds (Curtin University), and Alan Whitney (MIT Haystack). This group will be working over the next 6-12 months to craft the needed standardized updates and to incorporate them into several VLBI-support software packages.

4. VLBI Digital-Backend Intercomparison Testing

On 4-5 May 2009, the first intercomparison zero-baseline correlation testing was done between digital backends (DBEs) that have been independently designed at different organizations. The results of this testing are the first step in a more thorough investigation that also includes actual VLBI observations.

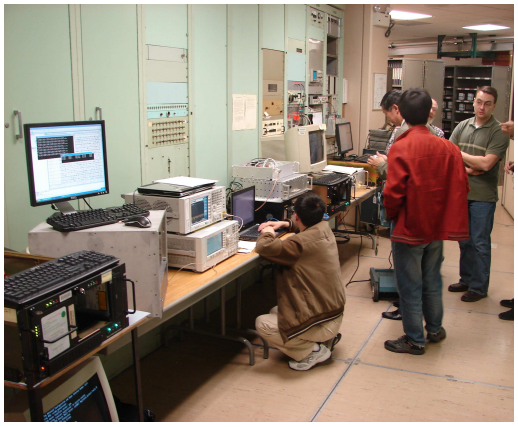

Figure 2. DBE intercomparison test setup at Haystack Observatory

Three systems were brought together at Haystack for testing:

1. A European “dBBC”system configured with polyphase filter bank (PFB) firmware. The dBBC was accompanied by Gino Tuccari of INAF/IRA.
2. A Chinese “CDAS” (Chinese Digital Data Acquisition System), configured with eight tunable dual-sideband digital BBCs. The CDAS was accompanied by Drs. Wenren We, Li Bin, Wu Yajun, and Zhu Renjie of Shanghai Observatory.
3. A Haystack “DBE1” system based on the Berkeley-designed hardware and Haystack firmware, configured with PFB firmware. The DBE1 was accompanied by Haystack staff Arthur Niell, Chris Beaudoin, and Alan Whitney.

The testing was done by injecting correlated broadband noise into the digital backends, both with and without local-oscillator offsets, and then cross-correlating all three combinations of units on the Haystack Mark IV correlator.

4.1. Testing Results

The testing of the units went well, with only the usual sort of small difficulties that occur when such tests are done with complicated equipment. It was fortunate that we had three DBE units to test, as it greatly eased diagnosing the effects of any particular DBE unit; without three units, testing would have been much more difficult.

The testing indicated full compatibility between the dBBC and DBE1 units, with minor problems discovered in the CDAS unit. These minor problems have subsequently been fixed. Further compatibility tests are planned using real VLBI observations. A full report on the DBE compatibility testing is available at *http://www.haystack.edu/geo/vlbi_td/BBDev/036.pdf*.