Canadian VLBI Technology Development Center

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Abstract

The Canadian VLBI Technology Development Center has been active in a number of areas during 2001.

The S2 Geodetic VLBI program continues to make significant advances on many fronts, including development of the frequency switched S2 VLBI data acquisition system, enhancement of the S2 correlator capabilities, utilization of a transportable antenna and the expansion of capabilities for scheduling, data processing and analysis. A number of experiments have been conducted using the Algonquin, Yellowknife and the Canadian Transportable VLBI Antenna (CTVA).

The next-generation, S3, VLBI system continues to be under active development at the Space Geodynamics Laboratory. It is capable of 1 Gbit/sec recording with unattended record times as long as 160 hours (depending on system configuration) using robotic tape changers.

1. Introduction

The Canadian VLBI Technology Development Center is a collaborative effort of the Space Geodynamics Laboratory of the Center for Research in Earth and Space Technology, (SGL/CRESTech), the Geodetic Survey Division of Natural Resources Canada (GSD/NRCan) and the Dominion Radio Astrophysical Observatory (DRAO) of the Herzberg Institute for Astrophysics of the National Research Council of Canada, (DRAO/HIA/NRC).

2. S2 VLBI Geodesy

Introduction

The Canadian S2 geodetic VLBI program is developing a complete "end-to-end" geodetic VLBI system and operational capability. This effort involves a wide range of activities including development of the frequency switched S2 VLBI data acquisition system, enhancement of the S2 correlator capabilities to process frequency switched VLBI observations, utilization of a transportable antenna and the expansion of capabilities for scheduling, data processing and analysis.

S2 VLBI Data Acquisition System (S2-DAS)

The S2 VLBI data acquisition system is being jointly developed by SGL and the GSD. The S2-DAS is designed to accomodate up to four VLBA/MkIV-type single sideband baseband converters (BBCs), each with a local oscillator (LO) independently frequency switchable under computer control. The objective of the development of the S2-DAS is to enable high sensitivity group delay measurements without appealing to a more costly parallel IF/baseband sub-system.

There are currently four S2 DASs in use with an additional three in final operational testing: two for GSD and one for BKG. We intend to update all of the DASs during 2002 with all hardware modifications and improvements that have occurred as a result of recent tests.

The DAS Operating System (DASOS) has seen extensive development in the past few years. The first official release occurred on August 31, 2001. This release contained all functionality for full use of the DAS features. Further development continues. Much effort has gone into the preparation of the user's manual, which is expected to be complete in March 2002.

DAS-PCFS communication has advanced considerably with modifications to the local version of the PCFS at the three Canadian stations. We have begun discussion with the IVS and NASA/GSFC regarding incorporating these software modifications into the official PCFS releases.

S2 VLBI Correlator

The Canadian Correlator is an (expandable) six station correlator using S2 playback terminals and is designed to handle S2 frequency switched bandwidth synthesis data. Recent activity has focussed on the development of post processing software to enhance system performance monitoring.

Canadian Transportable VLBI Antenna (CTVA)

The CTVA is a 3.6m radio telescope acquired to facilitate densification of the terrestrial reference frame in remote regions. The antenna will be colocated with GPS elements of the Canadian Active Control System (CACS) to provide fiducial station positions. The GSD is responsible for CTVA system development.

Figure 1. Jacques Lafrance with the CTVA - ready for a 3000km drive.

In June 2001 the antenna left Penticton, B.C. on its way to Shirley's Bay (near Ottawa). This provides us with an opportunity to give the antenna some maintenance as well as allowing us to investigate issues related to antenna re-locating/surveying. We anticipate that the antenna will be moved to St. John's, Newfoundland, in the spring of 2002.

Extensive testing through CGLBI (S2) experiments has occurred. Seven experiments were conducted before the antenna left Penticton and an additional eight were conducted while it was at Shirley's Bay. The CTVA is expected to debut in the official IVS operations in 2002, as part of the IVS E3 network. We anticipate applying to have the CTVA accepted as an official IVS Network Station soon.

We have obtained a robotic tape changer that interfaces to the S2 recording terminal. This

tape changer appears to be a promising tool for the future to minimize on-site staff requirements. The tape changer may be located at Yellowknife or used with the CTVA.

S2 Geodetic Experiment Scheduling, Operations and Analysis

The Canadian Geodetic VLBI program involves all aspects of geodetic VLBI operations, from experiment design through analysis.

The official release of the scheduling software (SKED/DRUDG) now includes support for the S2 system.

The analysis software was updated throughout the year. No changes to SOLVE are now necessary for CGLBI data to be analyzed. Special software to create Mk3-type databases from (S2) frequency-switched experiments (CGLBIDB) is used on a regular basis.

A number of S2 VLBI experiments have taken place in the reporting period (see below).

An investigation into multi-beam VLBI (several small antennas co-observing with large ones) is underway.

We are considering the possibility of writing a new object-oriented software scheduling tool.

The GSD has produced a CGLBI website which is regularly updated to reflect experiment activity (www.vlbi.ca). An analysis website is also supported which documents SOLVE: f-SOLVE is documented elsewhere.

Interferometric Experiments

Fifteen developmental experiments (CG029/January through CG043/November) have been performed in 2001 using the S2 VLBI system, ALGOPARK and the CTVA. Seven experiments were conducted before the antenna left Penticton and eight were conducted while it was at Shirley's Bay. Many of these were system tests. Yellowknife participated in nine of these experiments.

The measured baseline length between ALGOPARK and PENTICTN using the S2 system has been repeatable within 5 mm. A similar repeatability is seen at Shirley's Bay, with much less data available.

In 2002 we anticipate the introduction of the IVS E3 network, based on the S2 equipment. In this, the first year, we will conduct monthly experiments using the Canadian antennas, Kokee and TIGO (when it is on-line in Concepcion, Chile).

We wish to encourage further usage of the S2 equipment. To facilitate this, in some cases, we may be able to provide a short term loan of equipment in order to give any interested station an opportunity to join the S2 network on a trial basis.

3. S3 Wide Bandwidth VLBI Data Record/Playback System Development

VLBI applications to geodesy and astrophysics can benefit from higher signal to noise ratio observations. The most attractive means of achieving large factor improvements in SNR in geodetic VLBI observations is by developing wide bandwidth VLBI data record/playback/correlation systems.

The Space Geodynamics Laboratory (SGL) located on the campus of York University in Toronto, Canada is developing a family of wide bandwidth VLBI data record/playback systems designated "S3", as a next generation follow-on to the "S2".

The S2 VLBI data record/playback system is a 128 Mbit/sec, Mostly-Off-The-Shelf (MOTS) VLBI data record/playback system based on an array of eight video tape transports together with custom designed signal channel cards and a single board control computer housed in a standard

VME enclosure. The S2 is specified to operate without error correction coding at a Bit Error Rate (BER) of the order of 10^{-4}; however typical BER performance in the S2 is of the order of 10^{-5}. The extensive use of MOTS hardware in the S2 design resulted in a low cost, high performance, VLBI data record/playback system of which more than 50 have been fabricated at SGL and are now in use in a variety of radio astronomy and VLBI applications in more than a dozen countries around the world.

The S3 VLBI data record/playback system is the next generation MOTS VLBI system. It has inherited a significant amount of its architecture from the S2 although the VME backplane has been replaced with a wide bandwidth Compact PCI backplane. In addition the interface for the S3 will be compatible with the VLBI Standard Interface (VSI) specification. The S3 is constructed as an array of eight JVC "Digital-S" (now designated "D9") digital video tape transports, each of which is able to record/playback VLBI data at a rate of 150 Mbit/sec, of which 128 Mbit/sec is "user data", for an overall user data rate of 1024 Mbit/sec (1 Gbit/sec). Recent S3 system tests at SGL in which pseudo-random digital data was written to and read from the S3 tape transport indicate that the signal to noise ratio on the S3 eye pattern is comparable to that of the S2. The S3 is expected to provide a BER performance that is comparable to the S2.

The tape change interval for the S3 tape array is 2.5 hours at a data rate of 1024 Mbit/sec (1 Gbit/sec) with longer tape change intervals being possible when operating the S3 at reduced data rates. The cost of recording media for the S3 is expected to be $150 (US) per hour at a data rate of 1024 Mbit/sec (1 Gbit/sec).

The S3 VLBI data record/playback system is designed for system upgrades based on the recently introduced JVC High Definition TV "D9-HD" tape transport, which in the S3 context will record/playback VLBI data at a rate of 300 Mbit/sec. The D9-HD will enable the fabrication of the "Compact" version of the S3 system, the "S3-C", which will record/playback VLBI data at a rate of 1024 Mbit/sec (1 Gbit/sec) on a compact array of only four tape transports.

The D9-HD will also enable the fabrication of the "Extended" version of the S3 system, the "S3-E", which will record/playback VLBI data at a rate of 2048 Mbit/sec (2 Gbit/sec) on an array of eight tape transports. Dual operation of the S3-E will provide for VLBI data record/playback at data rates as high as 4096 Mbit/sec (4 Gbit/sec).

SGL has implemented a TiltRac robotic tape changer for the S3 family of VLBI data record/playback systems. The tape changer is a true Commercial-Off-The-Shelf (COTS) system developed especially for use with the JVC D9 and D9-HD tape transports. The robotic tape changer is available in single-bay, dual-bay, and triple-bay configurations. SGL has implemented a dual-bay configuration in its development system. The robotic tape changer provides the option of long unattended operation intervals with the S3 family of VLBI data record/playback systems.

Refer to the 2000 IVS Annual Report of the Canadian Technical Development Center for a table giving the different data rates for the S3 product family. This table includes the associated tape durations and the unattended operating times when utilizing a robotic tape changer. Further information can be obtained from the authors.

Design effort on the S3 system by SGL and Crossbow Electronics Ltd during 2001 has improved the S3 robotic tape handling procedures by the introduction of "TeraPods", briefcase sized containers, complete with a carrying handle, that contain the S3 tape cassettes. They are opened and closed automatically by the S3 robotic tape changer and the user never needs to handle individual cassettes, unless they are damaged and require replacing. Two TeraPods per day are all that need be shipped to and from the correlator in order to support 24 hour observation at 1024 Mbit/sec.