GSFC IVS Technology Development Center Report

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Abstract

This report summarizes the activities of the GSFC IVS Technology Development Center from the establishment of IVS to the end of 2000. The report forecasts activities planned for the year 2001. The GSFC IVS Technology Development Center (TDC) develops station software including the Field System (FS), scheduling software (SKED), hardware including tools for station timing and meteorology, scheduling algorithms, operational procedures, and provides a pool of individuals to assist with station implementation, check-out, upgrades, and training.

1. Technology Development Center Operation

The GSFC IVS Technology Development Center (TDC) develops hardware, software, algorithms, and operational procedures. It provides manpower for station visits for training and upgrades. There are other techology development areas at GSFC covered by other IVS components such as the GSFC Analysis Center.

The current staff of the GSFC TDC consists of Tom Clark, Nancy Vandenberg, Ed Himwich, Chuck Kodak, Raymond Gonzalez, and William Wildes.

The remainder of this report covers the status of the main areas of development that are currently being pursued.

2. Field System

During this period two major new features were released: Y2K support and mode independent parity checks. Y2K support was of course necessary for continued operation of the FS in the year 2000 and beyond. Mode independent parity checks removed the need for stations to change parity check procedures for every experiment that used a different mode than the previous experiment.

In addition several new features under development during this period will be released in the next major release, 9.5. Some of the features included are: (1) Support for K4 systems, (2) support for sequential use of two longitudinal tape recorders, (3) better handling of default values for Mark III/IV IF attenuators, (4) a utility "msg" for sending Ready, Start, and End messages for geodetic sessions, (5) support for report logging maser offset data from a TAC, (6) support for NTP, (7) a command, "ifadjust" to automate determining the IF attenuator settings for a given mode, (8) an experimental tool for monitoring FS operation remotely, ARTS, (9) a command, "tnx" to disable reporting of an error message that can't be fixed, and (10) an experimental program, "erchk" to display only error messages to make it easier for the operator to keep track of them. This release is expected in the first quarter of 2001.

In the following FS release, 9.6, several other improvements are expected; among these are: (1) dual head recording for Mark IV and VLBA4, (2) support for the new Mark IV firmware, (3) onsource flagging formatted in AIPS flagging file format, (4) improved Tsys measurements with automatically generated procedure files, frequency dependent noise diode temperatures, and ANTTAB file format output, (5) faster set-up when the formatter set-up doesn't change between scans. The release is expected the third quarter of 2001.

3. SKED and DRUDG

The GSFC Technology Development Center is responsible for development, maintenance, and documentation of the SKED and DRUDG programs. These two programs operate as a pair for preparation of the detailed observing schedule for a VLBI session and its proper execution in the field. During 2000 SKED was enhanced to add new user interface features, the ability to write VEX files, and K4 and S2 scheduling support. Some bugs remain to be worked out before official release of the new SKED version. Meanwhile users are testing and using the available version.

- A Java-based user interface was added to SKED by Kristian Refinetti, a Chalmers University engineering student on a trainee program sponsored by NVI/GSFC. The SKED catalog files can now be accessed with a set of screens that make selection of sources, stations, observing modes, and scheduling parameters more powerful and flexible.
- New SKED commands to generate a VEX file from the schedule file were added. The VEX file is required as input to the Mark IV correlators. The native SKED format is still the standard schedule file format and the VEX file is only an output format.
- Scheduling support for K4 and S2 systems was added to SKED so that geodetic schedules could be easily generated for these recording systems. Displays of tape usage and tape speed are handled in the native units for each system.

4. VLBI Timing

At Goddard, we have continued to stress the development of high accuracy (~20 nsec for each day) GPS-based timing measurements at VLBI stations; this data is needed for several reasons:

- Correlator efficiency is improved significantly if the relative station clocks are known at the ~50 nsec level and clock drift rates are known at levels ~1:10^{13}.
- To produce accurate UT1 measurements, station clocks need to be tied to UTC(USNO) to a few hundred nsec.
- Discontinuities seen in timing data are an excellent diagnostic of performance problems in hydrogen masers.

  After much discussion we decided that the ideal timing system for VLBI stations would

- Run continuously, logging data between experiments,
- Be easily reproducible at all stations and be low cost,
- Produce daily timing accuracy of 20-30 nsec anywhere in the world.

Our R&D testing beginning in 1993 showed that we could meet the accuracy goal with a particular low-cost GPS receiver (the Motorola PVT-6) and by 1995, we distributed ~50 timing clocks for the community – for humorous reasons, these receivers were named the TAC – Totally Accurate Clock. The historical archives of the early TAC development are available at ftp://aleph.gsfc.nasa.gov/GPS/totally.accurate.clock. The current software package, called TAC32Plus is a VLBI "plug in". Some of the VLBI features are depicted in the final figure of this report ("Recommended Clock and Timing Setup for a Mark4 VLBI Station") and include:

- Full-time logging of Time Interval Counter (TIC) data to disk in a "friendly" format,
- Automatic application of corrections for quantization dither (amounting to 104 nsec peak-to-peak with the ONCORE) inherent in the GPS receivers,
- Providing smoothed TIC data to the VLBI system via a TELNET socket,
- Providing station-wide network computer synchronization using NTP,
- Access to timing data via FTP for remote maintenance and diagnostics.
- Full support for TIC+TAC+TAC32Plus system is included in the LINUX PC Field System.

Before May 2000, timing performance was limited by the U.S. Dept. of Defense through a process called Selective Availability (SA). With SA, the atomic clock onboard each GPS satellite was "diddled" with a pseudo-random code that spoiled the spectral purity of GPS timing signal in the range from a few seconds to ~1/2 hour. With the TAC, we provided some mitigation against SA by averaging the timing over all satellites in view, and by averaging timing over many minutes in the time domain. With this process, the ONCORE-based TACs routinely yield timing smooth at the 15-20 nsec level at all times from minutes to a day. After May 2nd when SA was turned off, the short-term stability, as judged by taking the RMS noise of all samples in a 5 minute window, improved from ~15 nsec to ~5 nsec. The dominant error source suddenly became the diurnal signature of the ionosphere, amounting to ~15 nsec peak-to-peak.

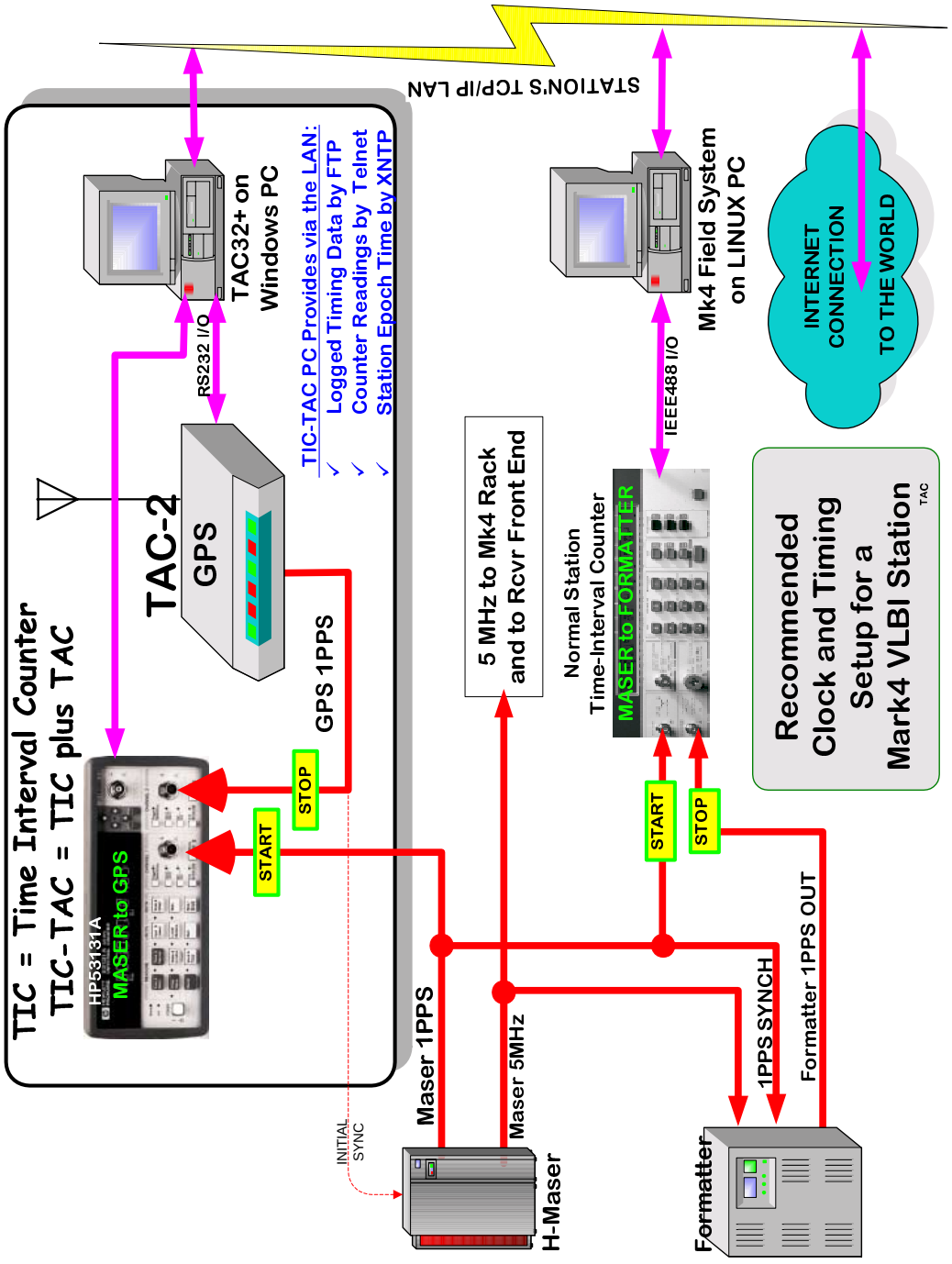
Data was logged during a 9 week period at the end of 2000 with an ONCORE receiver and the data system described above logging the H-Maser at GGAO in Greenbelt. The Maser had a rate offset of ~20 nsec/day (a frequency error of ~2.4 x 10-13). On Nov.22, the drift rate was observed to increase, which was subsequently traced to a temperature change at the H-Maser chamber. A figure demonstrating this is available at ftp://aleph.gsfc.nasa.gov/ivscc/annual_report/2000/oncore-ggao.ps.

In late 1999, Motorola announced that they were discontinuing the ONCORE VP receiver that had been used in the TAC-2 and CNS GPS clocks. We began to work with a software developer who had made an excellent timing receiver based on the SiRF-1 chipset. Where the ONCORE VP shows ~4 nsec noise in the 5 minute samples, the SiRF prototype shows ~650 psec of noise, a factor ~5 better. A figure demonstrating this is available at ftp://aleph.gsfc.nasa.gov/ivscc/annual_report/2000/sirf-ggao.ps.

A paper on these receiver developments was presented at the Sept.2000 ION meeting (T.Clark, R.Hambly and R.Abtahi "Low Cost, High Accuracy GPS Timing", Proceedings of Institute of Navigation GPS 2000, Salt Lake City, pp.905-913 (2000)) and copies are available on http://www.gpstime.com.

5. New Meteorological Sensors

GSFC has investigated new meteorological sensors to replace the aging standard CDP-era sensors in use at many sites. We are planning to provide FS support for the following devices: MET-3A Meteorological Sensor Part #1539-001 and Handar 425 Ultrasonic Wind Sensor (Model 425A/AH) both available from Paroscientific at http://www.paroscientific.com. We expect to install these at NASA supported sites within the next year.


STATION'S TCP/IP LAN
TIC = Time Interval Counter
TIC-TAC = TIC plus TAC
TAC32+ on Windows PC
RS232 I/O
TAC-2
GPS
TIC-TAC PC Provides via the LAN:
✓ Logged Timing Data by FTP
✓ Counter Readings by Telnet
✓ Station Epoch Time by XNTP
GPS 1PPS
HP53131A
MASER to GPS
STOP
START
5 MHz to Mk4 Rack and to Rcvr Front End
Mk4 Field System on LINUX PC
IEEE488 I/O
INTERNET CONNECTION TO THE WORLD
Normal Station Time-Interval Counter
MASER to FORMATTER
START
STOP
Recommended Clock and Timing Setup for a Mark4 VLBI Station TAC
Maser 1PPS
Maser 5MHz
INITIAL SYNC
H-Maser
1PPS SYNCH
Formatter 1PPS OUT
Formatter