

GSFC IVS Technology Development Center

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Abstract This report summarizes the activities of the GSFC Technology Development Center (TDC) and describes plans for the future. The GSFC TDC develops station software including the Field System (FS), Monitoring and Archiving System (MAS), IVS session Web pages, and scheduling software (*sked*); hardware including tools for station timing and meteorology; scheduling algorithms; and operational procedures. It provides a pool of individuals to assist with station implementation, check-out, upgrades, and training.

1 General Information

The GSFC IVS Technology Development Center (TDC) develops hardware, software, algorithms, and operational procedures. It provides manpower for station visits for training and upgrades. Other technology development areas at GSFC are covered by other IVS components such as the GSFC Analysis Center. The current staff of the GSFC TDC consists of John Gipson, Ed Himwich, Dave Horsley, and Mario Bérubé. The remainder of this report covers the status of the main areas supported by the TDC.

2 Field System

The GSFC TDC is responsible for the development, maintenance, and documentation of the Field System

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(FS) software package. The FS provides equipment control at VLBI stations. It interprets the `.snp` schedule and `.prc` procedure files (both as prepared by *drudg* from the `.skd` schedule). The FS controls the antenna, data acquisition hardware, and related ancillary equipment needed for making VLBI measurements. All major VLBI data acquisition backends are supported. The FS is customizable to allow it to control station specific equipment. It is used at almost all of the IVS Network Stations (more than 35) and also at many stations that perform VLBI only for astronomical observations. The only major VLBI facilities not using the FS are the LBO and VERA.

There are two major branches of the FS currently: the “main” branch, which is used for most operational observing, and the “VGOS” branch, which is used in the operational test observations at VGOS stations. During this period, there was one major release of the FS (9.13.0) for the main branch. Full details can be found in the FS release notes. The VGOS branch had two minor updates (9.12.12 and 9.12.13).

2.1 Main Branch Changes

In the main branch of the FS the most significant changes were:

- A display server was added as an option. If enabled, this separates the core of the FS from the user interface and makes it possible to run multiple independent instances of the user interface. This allows, for example, both local and remote interfaces to run at the same time—the latter typically via an *ssh* connection. Since the user interfaces run independently of the core of the FS, they

- can be started and stopped without affecting the operation of the FS. One advantage of this is that closing a window can now not accidentally kill the FS. This also includes implementation of a publication/subscription model for FS log display and error report output.
- Support for two VSI outputs for DDC racks that include a FiLa10G was added. This also includes support for output on either VSI1 or VSI2 for modes that have different track mappings between the two VSI outputs.
 - Improved support for configuration of recording modes for VDIF recorders running *jive5ab* was added. These changes include full 64-bit integer support (exact) for recording bit rates for all possible recording rates supported by *jive5ab*.
 - The VEX parser was updated to accept units for rates in the `clock_early` statements.
 - Support was added for user radiometry devices that cannot have a “zero” level measured.
 - Support for NMEA standard wind sensors was added.
 - Support for chopper-wheel and hot/cold load calibration methods.
 - A complete update to the documentation and conversion to a more modern format that will be easier to use and maintain.
 - Conversion of the FORTRAN source code to use the *gfortran* compiler, which will enable use of the source level debugger, *gdb*, for development and field debugging.
 - Support for 64-bit Linux OSs.
 - *Chekr* support for Mark 5A and Mark 5B systems.
 - FS Linux 10, based on Debian *Stretch*.
 - Support for periodic firing of the noise diode during observations.
 - Completion of the VEX2 standard and implementation of it.
 - Further unification of the Patriot 12-m (GGAO) and ISI 12-m (Kokee Park and McDonald) antenna interface code. This will allow a common code base to be used for the two very similar Antenna Control Units (ACUs).

2.2 VGOS Branch Changes

In the VGOS branch of the FS the most significant changes were:

- Support for a preliminary version of the Display Server (see above in the main branch changes) and eventually the full version was added.
- Support for DBBC3 BBC and IF device set-up and monitoring was added. This includes support for Tsys, pointing measurements (with *fivpt*), and SEFD measurements (with *onoff*). Currently, this does not include time setting and monitoring or VDIF output format control.

2.3 Plans for Next Year

Several other improvements are expected in future releases, including:

- Support for continuous calibration with the DBBC PFB personality.

3 Monitor and Archiving System (MAS)

The GSFC TDC is also responsible for development, maintenance, and documentation of the Monitoring and Archiving System (MAS) software package—formerly named TIG after its components: Telegraf, InfluxDB, and Grafana—and hardware specification. The MAS provides a system for collecting, storing, processing, and visualizing time-series data collected from various components of a VLBI station. The software suite is comprised of several open-source packages along with some custom software specific for VLBI stations. The system is capable of collecting data from the Field System and PC diagnostic subsystems as well as certain meteorological devices, back-ends, and antennas. The suite can easily be expanded to include site-specific data. Currently the system is deployed at the NASA managed stations, and the hardware specification and software are available to the community.

The most significant changes were:

- The MAS was expanded to include an operating system and hardware configuration guideline. The suite was developed to monitor more station com-

ponents of both general and site specific functionality.

4 IVS Session Pages

The GSFC TDC is responsible for development and maintenance of the IVS session pages. The pages display the master schedule and session files in a human friendly format.

The most significant changes of the IVS session pages were:

- The IVS session pages were updated to be generated using a more modern, Python-based framework.

5 *sked* and *drudg*

The GSFC TDC is responsible for the development, maintenance, and documentation of *sked* and *drudg*. These two programs are very closely related, and they operate as a pair for the preparation of the detailed observing schedule for a VLBI session and its proper execution in the field. In the normal data flow for geodetic schedules, first *sked* is run at the Operation Centers to generate the `.skd` file that contains the full network observing schedule. Then stations use the `.skd` file as input to *drudg* for making the control files and procedures for their station. Catalogs are used to define the equipment, stations, sources, and observing modes which are selected when writing a schedule with *sked*.

Changes to *sked* and *drudg* are driven by changes in equipment and by feedback from the users. The following summarizes some of the important changes to these programs during 2017–2018 and plans for the future. This list includes only the most important bugs which were found and fixed over this period. A more complete summary of the changes can be found in the *change_log.txt* files associated with *sked* and *drudg*.

5.1 *sked* Changes and Bug Fixes

Enhancements:

- Skeleton support for TWIN telescopes. We put in the bookkeeping for *sked* to recognize that a station is part of a pair of TWINS, but we have not modified the scheduling algorithms yet.
- Removal of numerous (although not all) tape related information. For example, *sked* will no longer write out the obsolete HEAD_POS or PASS_ORDER information.
- Modification so that bandwidth can vary from station to station.
- Modification so that *sked* can now compile under *gfortran*. In the process, numerous sleeping bugs were fixed.
- Second personality. Previously supported DBBC equipment as only the DDC personality. Now *sked* supports DBBC.DDC and DBBC.PFB.

Important bug fixes:

- If there was a problem with Cable-Wrap, *sked* would write out the wrong station.
- In tag-along mode, *sked* was not calculating the SNR correctly.

5.2 *drudg* Changes

The most significant changes in *drudg* were:

- Ad-hoc support for *sched* “staggered start mode” was added. In this mode, scans start at different times for different stations and the data valid time is when the antenna is expected to reach the source. This mode violates the observation time-line that *drudg* assumes, so it is not possible to fully support this mode. But, the added support eliminates useless data recording while slewing, takes calibration data after the antenna is expected to be onsource, and marks the data valid after the calibration is finished. These changes were accomplished with a minimum loss of data due to calibration (10 seconds or less).
- Support for modes that use VSI2.
- Reporting an error for a VEX file if a station is in a scan but was not defined previously. This occurred with a schedule that was modified ‘by hand.’
- Numerous minor changes to support changes in the SNAP language.
- Better debugging information if *drudg* cannot find an allowed mode for DBBCs.

5.3 Catalog Changes

The *sked* catalogs were updated during 2017–2018 to reflect the new stations coming on line: RAEGS-MAR, NYAL13S, NYALE13N, ONSA13NE, and ONSA13SW. The catalogs were also updated to reflect equipment changes, as more and more stations switched to digital equipment and as new kinds of digital equipment came into use.

5.4 Plans for Next Year

Plans for next year include the following:

- Make VEX/VEX2 the native format for *sked*: no more `.skd` files.