GSFC Technology Development Center Report

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Abstract This report summarizes the activities of the IVS GSFC Technology Development Center (TDC) and describes plans for the future. The GSFC TDC develops station software including the Field System (FS), IVS session webpage software, 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 IVS GSFC Technology Development Center (TDC) develops hardware, software, algorithms, and operational procedures. It provides manpower for station visits for training and upgrades. Other 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, Mario Bérubé, Gönenç Moğol, and Karen Baver. 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 (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 file). 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 DSN, LBA, VLBA, and VERA.

2.1 Work This Period

Field System (FS) version 10.2 was released in December 2023. The most significant changes were:

- Support for FSL11. The FSL11 distribution is based on Debian “Bullseye” and is the latest FSLx Linux distribution.
- Increase of support for experiment names (session codes) to 16 characters or less. This enables use of the new IVS 12-character session codes.
- Extensive improvements in DBBC3 support. It is now roughly complete for the DDC firmware releases available as of June 2023. This work was funded by the EVN.
- Enabling the display server by default. There were also other changes to make the display server easier to use.
- Expansion and update of the *Plotlog* utility, for examining data in the log files. The changes include

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support for RDBEs, DBBC3s, and additional data types including recorder performance statistics.

The update instructions for FS 10.2 can be found at https://nvi-inc.github.io/fs/releases/10/2/10.2.html.

The Field System Linux 11 (FSL11) operating system (based on Debian "Bullseye") was released in April 2023 with a minor update in February 2024. FSL11 was developed by the EVN with support from GSFC. It provided a replacement for FSL10, the base Debian distribution for which, "Stretch", is no longer supported. The installation instructions for FSL11 can be found at https://nvi-inc.github.io/fsl11/.

A prototype satellite tracking capability for NASA 12-m antennas was developed. The prototype was used to characterize the performance of those antennas for tracking Low Earth Orbit (LEO) satellites.

2.2 Plans for the Future

At the time of this writing, there is active development for:

- Support for R2DBEs. This includes more complete support for RDBEs.
- Enhanced support for DBBC3s, including a firmware version with a different multicast format. This work is funded by the EVN.
- Linux operating system distribution, Field System Linux 12 (FSL12), based on Debian "Trixie". This will provide a replacement for FSL11. The latter's base distribution support is expected to end in August 2026. This is being developed by the EVN with support from GSFC.
- Numerous minor FS enhancements and bug fixes.
- Completing the satellite tracking capability for the NASA 12-m antennas.

3 Automation

The GSFC TDC is responsible for maintaining the IVS session webpages, displaying the Master Schedule, and providing information about the analysis and the scheduling of IVS sessions. A fully automated system has been operational for a few years with no major problems (see the 2019+2020 GSFC Technology Development Center Biennial Report at https://ivscc.gsfc.nasa.gov/publications/br2019+2020/tdgsfc.pdf for a detailed description of the system). Regular code maintenance was performed during 2023 and 2024.

4 Ingest

GSFC has supported the IVS Data Centers by providing the initial version of the "ingest" software used to validate files uploaded by the VLBI community. The operational version is maintained by GSFC and the IVS Data Centers. A new validation script for EOP products version 3.0 and 3.1 was developed with the BKG Data Center. A new script avoiding vgosDB's overwriting of files by old submissions was developed, but it has not been implemented yet.

5 VLBI Communication Center (VCC)

GSFC TDC has continued the development of the VCC concept (see the IVS 2021+2022 GSFC Technlogy Development Center Biennial Report at https://ivscc.gsfc.nasa.gov/publications/br2021+2022/tdgsfc.pdf for a detailed description of the system). The VCC client software was installed at ONSA13NE by Eskil Varenius for demonstration at the TOW2023. The VCC was demonstrated at TOW2023 but without real stations due to a lack of availability of stations. GGAO was used to test the vcc-client and improve re-connection after communication failures. More user application interfaces were developed with the Tkinter python package for better display of messages. The "Inbox" application was improved to keep a list of all messages until they are deleted by a user.

The VCC server was moved from the NVI server to the cloud to provide https or ssl access to users. The VCC server scans the IVS Data Centers to detect any new data files. Specific messages are sent when new master schedule, skd, vex, and log files are detected.

At the moment, accounts have been provided to NVI users for testing. A development Field System has been hosting the vcc-client software simulating the K2 station for the last three years. The vcc-client has been receiving hundreds of messages and has downloaded

and drudged all schedule files during that period. The vcc-client version for Operation Centers and the Coordinating Center was tested on Ubuntu, MacOS, and Windows (WSL). Some people requested a special account to receive messages through their e-mail or SMS on their cell phone.

The vcc-client software is available from the github NVI account, and it requires python 3.9 or higher. Contact Mario Bérubé at mario.berube@nviinc.com or Gönenç Moğol at gonenc.mogol@nviinc.com to obtain a user key and instructions.

6 *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 a geodetic schedule that is written with *Sked*, *Sked* is ran first at an Operation Center to generate the .skd file that contains the full network observing schedule. Then each station uses the .skd file as input to *Drudg* to make the Field System schedule and procedures for that station. Catalogs are used to define the equipment, stations, sources, and observing modes that are selected when writing a schedule with *Sked*. Changes to *Sked* and *Drudg* are driven by changes to equipment and by feedback from the users.

The following sub-sections summarize some of the important changes to these programs during the report period. This summary includes only the most important bugs that were found and fixed over this period. A more complete summary of the changes can be found in the changelog.txt files associated with *Sked* and *Drudg*.

6.1 *Drudg* Changes

We only made minor changes to *Drudg* during 2023–2024. This included:

- Allowing longer schedule names in support of the new (January 2023) IVS naming convention.
- Supporting longer rack names.
- Fixing minor bugs.

6.2 *Sked* Changes

We only made minor changes to *Sked* during 2023–2024. This included:

- Allowing longer schedule names in support of the new (January 2023) IVS naming convention.
- Adding extra digits in writing out the station position to VEX files to be consistent with the *Sked* station position catalog.
- Supporting longer rack names.
- Fixing minor bugs.

7 *Sked* Catalogs

The GSFC TDC is responsible for maintaining the *Sked* catalogs that are used in scheduling VLBI sessions. These catalogs include information about sources, antennas, equipment at stations, and observing modes. These catalogs are used by both *Sked* and *VieSched++*.

In general, the *Sked* catalogs are updated whenever changes are made to station equipment, with one exception. The flux.cat catalog, which has simple models of source fluxes, is updated on a monthly basis. Timely updates are crucial because the source fluxes change with time. Other catalogs (e.g., equip.cat, lo.cat, modes.cat, rx.cat, rec.cat) are updated as necessary, e.g., if equipment at a station changes or if a mode was not defined for a station. The equip.cat catalog contains information about station SEFDs, so it is also updated when a station starts to run warm (or must be treated as running warm due to equipment failure) and then when the station runs cold again.

We made the following changes to the *Sked* catalogs in 2023–2024:

- Regular updates of the flux catalogs.
- Changes of station SEFDs due to equipment failures and repairs.
- Addition of many new VGOS stations: SESHAN13, TIANMA13, URUMQI13, HARTVGS.
- Addition of stations to existing modes.
- Modification of slew speed and antenna limits based on feedback from stations.

Any time a change is made, it is first tested locally at GSFC, and then the change is pushed to

Github. The *Sked* catalogs are available via Github, at https://github.com/nvi-inc/sked_catalogs.

In early February 2025, Baver will begin to take over maintenance of the *Sked* catalogs from Gipson. Station representives with information about changes to their antennas should e-mail both Karen Baver (karen.d.baver@nasa.gov) and John Gipson (john.gipson@nviinc.com) with a description of the changes.