

System Failure Operational Recovery

TOW 2019

VLBI data acquisition is a complex technical challenge for operators using various electronic data acquisition systems, large radio telescopes that use various drive systems with associated electronic controls, and many sub-system which provide auxiliary data, which support the science effort.

For example, in 2018 the IVS assigned over 1455 station days of observing and lost about 219 station days or 15% of the total due to station problems. One station day for this analysis is 24 hours of observing by one radio observatory in one IVS session. 1455 station days equals about 0.5 million scans (0.9 million observations) for all stations in the IVS network.

Thanks to Mario Berube for providing all of the statistics below:

CONT17 Legacy network statistics using 14 stations in IVS network

**BADARY FORTLEZA HOBART26 HART15M KASHIM11 KATH12M KOKEE MATERA NYALES20
ONSALA60 WARK12M WETTZELL YEBES40M ZELENCHK**

total sessions 15

total stations 14

total station days 255

average fit 32 ps

average corr loss 16%

total scheduled observation 175049

total station days lost 26

What we can provide, is training to recover from known failures, which happen from time to time at all stations. We will also provide operational guidelines to recover as quickly as possible and reduce the loss of data.

The most valuable contribution is feedback from operators by comments in the log, stations end messages, email and phone calls. This allows the IVS community to continue its high level of responsiveness in dealing with station and system issues. This effort is reflected in high quality data and accurate scientific solutions, which is necessary to keep the IVS observing program running smoothly into the future.

The following problems were assigned station data loss and the number of days in 2018.

Antenna- 63 days lost. This includes all possible problems with the movement or control of the antenna and is the majority of loss reported by most stations.

Misc- 44 station days lost. These are losses from all actions not caused by station activity such as weather or assigned developmental testing, etc.

Receiver- 41 days lost. This mostly includes station observing with a warm receiver which is an impact on overall sensitivity.

RFI- 29 days lost. RFI is location and station dependent. Local testing by station staff to identify sources and consultation with the IVS community may help provide solutions for your individual station.

Rack- 13 days lost. All backend equipment including station Mark4/5 Data Rack, VGOS hardware and systems

Oper errors - 10 days lost. Operator errors which caused data loss and proper reporting of errors will be reviewed.

Recorders - 6 days lost. Mark5, Mark6 system recovery while observing.

Shipping - 4 days lost. Data lost during shipping or erased after eTransfer.

Power failure and the **maser** accounted for 3 days loss – Problems with recovery from power failures and what to do if your maser has problems.

Power Failure:

Some sample guidelines:

Verify the AC utility and equipment power is stable.

Verify the antenna is operational and will slew.

Verify the Field System rebooted properly if not on a UPS.

Verify the DAT rack came up properly. No obvious alarms

Verify the Maser is running normally and system levels are normal

Verify the GPS system if is locked on the satellites.

Verify the receiver is cold.

Verify the power supplies appear normal and all fans are running.

Listen for any odd sounds or detect and strange odors.

It is now, understood that most devices will require reloading their operational software to recover from a power failure.

It should be standard practice to go through all of your station pre-checks prior to restarting the VLBI session after a power failure

Telescope:

Each observatory usually has a unique antenna and control system. Many of the procedures are also specialized, which require locally skilled personnel to repair and only qualified staff will operate the antenna.

Weather- Most stations have high winds and many Antenna Control Units have high wind stows automated. Antennas risk serious damage when moving in high winds. Snow load is another consideration and each station will have published guidelines when it is safe to operate during a snow storm. Lightning also may be an issue at some stations. In all cases, the operational directives at each station will dictate when the radio telescope can be used.

Mechanical- It is important for operators to recognize a problem such as an undefined noises and changes in speed as the antenna slews. It also may be recognized with bad pointing offsets or not able to hold a position on source.

Electrical- Most telescopes today use electric motors. Trained electricians on staff will often maintain the antenna control electronics, which moves the antenna. Some station will require that only trained staff are allowed to reset a main power breaker for the antenna.

Recovery from common antenna failures available for operators:

1. Antenna will not move or limited velocity.
 - Antenna control unit indicates a system fault. Software issues or interface to the Field System is not working. Possible re-boot of ACU needed?
2. Pointing Offsets are bad.
 - Check ACU time. Verify the telescope slews smoothly and the encoders are reading correctly. Possible power supply problems to the control electronics. Snow in dish.

Maser:

Recovery from a maser failure is probably the most difficult to recover from. Any loss of the timing standard for the station is the end of observing. The first step is to verify the maser has failed. Detecting either a large time offset, or drift with the GPS or a 2nd standard is helpful. Recognizing this quickly and reporting it to IVS-Ops starts the process. Often the observatory has the ability to monitor the maser with a separate maser PC that allows them to monitor the device independently of the PCFS.

Operators can monitor most masers by the monitor and control electronics at least once during the session. Often this includes the IF level, Voltage Controlled Oscillators, Phase lock voltages, and power supply voltages. They can also verify the maser chamber or room temperature is stable and normal. Preventive maintenance by reporting a problem with one or more parameters may prevent a complete failure.

Recovery options:

1. If possible Switch to a 2nd time standard and run through your full pre-checks listing confirming the operational state of all equipment. This may not be possible at some stations. Note: Only a properly operating hydrogen maser provides the level of stability required for VLBI.
2. Be prepared and call the experts, as only properly trained personnel should attempt to adjust or enter the commands necessary to maintain the maser.

DAQ RACK:

The IVS network is in transition from the Mark 4, VLBA DAQ racks to the digital back ends supported by the DBBC and the RDBE which are part of the new VGOS system. This new VGOS system are more digital and computer like than the older analog electronics and they require specialized procedures compared to the older systems

The original equipment was installed in a six foot by 19 inch rack with power supplies, 15 Base Band converters or video converters. Some older versions may still have the formatter, sampler and Mark IV decoder. The rack also has the IF electronics going to the receiver and the cable calibration ground unit. Often a second rack holds the counters, GPS system and spectrum analyzers and associated test equipment.

The phase calibration signal and cable cal, are used for an end-to-end check of all channels. The Field System can detect most channel failures and many DAQ rack issues and will report this to the operator.

Recovery from failures with legacy VLBI DAQ racks:

1. Lost channels.

-The most common problem. Each rack comes with a spare converter and this can be swapped into the system quickly. The order of lost channels is 6-7-11-2 then 5. It is important to have a working spare. The common failure for a converter is loss of the Total Power readings, communication to/from the converter or loss of the Local Oscillator signal either High or Low by failure of a tunnel diode.

2. Power supply failure.

- The most common system failure, except for operator error!! Often caused by heat or loss of a fan. Stations should have spares or a variable power supply on hand to quickly replace the bad unit. Power supplies usually fail over time by a large AC ripple in the output DC rail caused by bad filter capacitors. A blown fuse may be an indication of a bridge diode circuit has shorted.

3. Rack reset.

- The Field System will reload and service each module in the rack and confirm that it is operational and the operating parameters are correct. This may be necessary due to a momentary AC power interruption. Also it may be required to restore communications to the rack components by temporarily unplugging Video Converters to restore communication.

Recovery from Digital Back End terminals.

- Since most of the VGOS electronics are basically computers reloading the system's software by following your pre-ops setup procedures is the correct technique for recovery. These steps must be followed in very specific orders so to enable systems correctly.

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Other problems with these new systems like older systems have been cooling, power supplies, and bad or poor cable connections.

Most operator comments for DAQ rack issues reported are lost channels or power supplies.

Recovery from failures with VGOS DAQ racks:

-Within the new VGOS systems there are 4 major components:

- RF Distributer
- Up/Down Converter (UDC)
- RDBE
- Mark6

Rf Distributer has 1 Low band output and 4 high band outputs for both the horizontal and vertical polarizations. Low band outputs feed the Band A UDC and the high band outputs feed the Bands B, C, and D UDC's. These UDC's then feed the respective RDBE channels A, B, C, and D. The outputs of the RDBE's then go into the Mark6 system. This gives us 4 independent RF channels feeding the common Mark6 recording system.

Each of these components within the RF channels are complex computer systems. Unlike the older VLBI rack components were mostly analog circuits with just communications to the PCFS. Please refer to the PCFS VGOS Operations Manual 9-2018 within this package for the specific operational control procedures.

For the DBBC systems, Refer to "DBBC Recover from critical failure.pdf" in this document package

Mark5 recording system

The Mark5 system was a major upgrade from the tape based recording systems but now they are being upgraded by the Mark6 systems which allow higher data recording rates. The Mark5 system was more like tape drives as they were fairly simple and just recorded data after modules were inserted. We cannot prevent hardware failures within the device, but with the Mark5 and all other systems, it is most important to follow operational and setup procedures correctly. With training, and experience you will be able to recognize some failures and apply the correct solution quickly to continue data acquisition.

Normally recording failures can be divided into three categories. Module failure, Mark5 Hardware failure such as the power supply and software bugs requiring the operator to restart the control program.

Additional software is required to interface the Mark5B to the DBBC using the DBBC control program.

1. Module failures.

Often caused by a slow or failed disk drive. Usually necessary to change the module. Module swapping should be understood, and easily accomplished during any active VLBI session.

2. Hardware Failures.

Often the power supply or the DC power connections. The easiest way to look at the PS voltage and ripple is at an unused PATA disk drive power connector. These connectors are white and have 4 wires connected to them:

2 black for ground

1 red for +5 volts

1 yellow for +12 volts

3. Software and timing.

Often requires restarting the Mark5 with a hard reboot.

Scan checks are necessary to verify a good recording. The operator should monitor Scan_check results continuously during all vlbi operations.

If errors persist, follow your recovery and module swapping procedure:

RECOVERY PROCEDURE

(1)Wait for time between scans just after the last scan_check

In the FS operator input window:

halt This will stop the schedule from running!

- a. Confirm that the record lights are off on the module
- b. Turn key off and remove module then label it properly
- c. Insert prepared module spare into same location and Turn module on
 - i. If the module is unknown follow, pre-checks test recording procedure.
- d. Restart session
- e. Monitor scan_check results as normal

At the end of the session confirm both modules are labeled and prepare to ship them unless otherwise directed.

Mark6 recording system

The Mark6 system is a significant capability upgrade from the Mark5 recording systems. With that said, we must point out the Mark6 system is also much more complex. Procedures must be followed for everything included even changing the modules. These must be safely removed from the operational system using specific commands. These modules are actually installed drives within the system. Once these commands are executed and the module activity lights are off only then can the key be turned off and the module removed.

Please refer to the PCFS VGOS Operations Manual 9-2018 within the TOW package for the specific operational control procedures.

ADDITIONAL NOTES

If you have any problems, please note it within your station log and end message. An e-mail message, is also suggested, so to let us know what happened and how it was resolved. This will help us to develop a better understanding of the problem.