

# Network Coordinator Report

*Ed Himwich, Richard Strand*

## Abstract

This report includes an assessment of the network performance in terms of lost observing time for the 2012 calendar year. Overall, the observing time loss was about 12.3%, which is in-line with previous years. A table of relative incidence of problems with various subsystems is presented. The most significant identified causes of loss were electronics rack problems (accounting for about 21.8% of losses), antenna reliability (18.1%), RFI (11.8%), and receiver problems (11.7%). About 14.2% of the losses occurred for unknown reasons. New antennas are under development in the USA, Germany, and Spain. There are plans for new telescopes in Norway and Sweden. Other activities of the Network Coordinator are summarized.

## 1. Network Performance

The overall network performance was for the most part good. This year we return to reporting a detailed assessment, which was not provided for the two previous years.

This network performance report is based on correlator reports for experiments in calendar year 2012. This report includes results for the 148 24-hour experiments that had detailed correlator reports available as of March 8, 2013. The data set examined includes approximately 500,000 dual frequency observations. Results for 16 experiments were omitted because either they were correlated at the VLBA, they have not been correlated yet, or correlation reports were not available on the IVS data centers. Experiments processed at the VLBA correlator were omitted because the information provided for them is not as detailed as that from Mark IV correlators. The experiments that have not been correlated or do not have correlator reports available yet include some JADE, JAXA, OHIG, R&D, T2, and EUR experiments. In summary, roughly 90% of the data from scheduled 24 hour experiments for 2012 are included in this report. That is similar to, and actually a little more complete than, the coverage of reports for previous years.

An important point to understand is that in this report, the network performance is expressed in terms of lost observing time. This is straightforward in cases where the loss occurred because operations were interrupted or missed. However, in other cases, it is more complicated to calculate. To handle this, a non-observing time loss is typically converted into an equivalent lost observing time by expressing it as an approximate equivalent number of recorded bits lost. As an example, a warm receiver will greatly reduce the sensitivity of a telescope. The resulting performance will be in some sense equivalent to the station having a cold receiver but observing for (typically) only one-third of the nominal time and therefore recording the equivalent of only one-third of the expected bits. In a similar fashion, poor pointing can be converted into an equivalent lost sensitivity and then equivalent fraction of lost bits. Poor recordings are simply expressed as the fraction of total recorded bits lost.

Using correlator reports, an attempt was made to determine how much observing time was lost at each station and why. This was not always straightforward to do. Sometimes the correlator notes do not indicate that a station had a particular problem, while the quality code summary indicates a significant loss. Reconstructing which station or stations had problems—and why—in these circumstances does not always yield accurate results. Another problem was that it is hard to determine how much RFI affected the data, unless one or more channels were removed and that

eliminated the problem. It can also be difficult to distinguish between BBC and RFI problems. For individual station days, the results should probably not be assumed to be accurate at better than the 5% level.

The results here should not be viewed as an absolute evaluation of the quality of each station's performance. As mentioned above, the results themselves are only approximate. In addition, some problems such as weather and power failures are beyond the control of the station. Instead the results should be viewed in aggregate as an overall evaluation of what percentage of the observing time the network is collecting data successfully. Development of the overall result is organized around individual station performance, but the results for individual stations do not necessarily reflect the quality of operations at that station.

Since stations typically observe with more than one other station at a time, the average lost observing time per station is not equal to the overall average loss of VLBI data. Under some simplifying assumptions, the average loss of VLBI data is roughly twice the average loss of station observing time. This approximation is described in the Network Coordinator's section of the IVS 2001 Annual Report. For 2012, this agrees reasonably well with the actual number of (single frequency: S or X) single baseline observations on which the correlator reported failure, approximately 21.1%, but other factors, particularly the dual frequency nature of useful geodetic observations, complicate the picture. For 2012, the actual percentage of data (dual frequency) that was not included by the analysts was approximately 28.1%. This is even larger (by approximately 34%) than the single baseline observations reported lost by the correlator. It is expected that this number should be higher because the analysts use additional criteria beyond what is discussed here to decide when to exclude observations. However, it means in effect that only about 72% of the observations we attempted to collect were useful.

For the 148 experiments from 2012 examined here, there were 1,261 station days or approximately 8.5 stations per experiment on average. This compares to 135 experiments considered in the report for 2009 (the most recent year with a detailed report), which included 1,051 station days with 7.9 stations per experiment. The increase in the number of analyzed experiments essentially just reflects that the results for more experiments were available for consideration at the time the report was written. However the increase in the number of stations per experiment is probably due to a concerted effort by the IVS Coordinating Center to make the networks in the experiments larger. The onset of operations by the AuScope and Warkworth stations helped to make this possible. Of the station days for 2012, approximately 12.3% (or approximately 155 days) of the observing time was lost. For comparison to reports from earlier years, please see Table 1.

The lost observing time for 2012 is more in-line with results from years before 2009. The results for 2009 may be artificially high due to a change in the way the results were tabulated for that year. We believe this year's calculations are more in-line with how they were made before 2009.

An assessment of each station's performance is not provided in this report. While individual station information was presented in some previous years, this practice seemed to be counter-productive. Although many caveats were provided to discourage people from assigning too much significance to the results, there was feedback that suggested that the results were being over-interpreted. Additionally, some stations reported that their funding could be placed in jeopardy if their performance appeared bad, even if it was for reasons beyond their control. Last and not least, there seemed to be some interest in attempting to "game" the analysis methods to improve station results. Consequently, only summary results are presented here. Detailed results are presented to the IVS Directing Board. Each station can receive the results for their station by contacting the

Table 1. Lost observing time.

Year	Percentage
1999-2000*	11.8
2001	11.6
2002	12.2
2003	14.4
2004	12.5
2005	14.4
2006	13.6
2007	11.4
2008	15.1
2009	21.5
2012	12.3

\* The percentage applies to a subset of the 1999-2000 experiments.

Percentages for 2010 and 2011 are omitted, but should be 10-20%.

Network Coordinator (Ed.Himwich@nasa.gov).

For the purposes of this report, the stations were divided into two categories: **large N**: those that were included in 20 or more network experiments among those analyzed here and **small N**: those in 11 or fewer (no stations were in the 12-19 experiment range). The distinction between these two groups was made on the assumption that the results would be more meaningful for the stations with more experiments. The average observing time loss from the large N group was much smaller than the average from the small N group, 10.6% versus 25.7%. There are many more station days in the large N group than the small N group, 1,125 versus 136, so the large N group is dominant in determining the overall performance.

There are 19 stations in the large N group. Nine stations observed in 50 or more experiments. Of the 19, eight stations successfully collected data for approximately 90% or more of their expected observing time. Nine more stations collected 80% or more of the time. The two remaining stations collected data for more than about 60% of their observing time. These results are not significantly different from previous years.

There are 24 stations in the small N group. The range of lost observing time for stations in this category was 0%-100%. The median loss rate was approximately 11.3%, better than previous years.

The losses were also analyzed by sub-system for each station. Individual stations can contact the Network Coordinator (Ed.Himwich@nasa.gov) for the sub-system breakdown (and overall loss) for their station. A summary of the losses by sub-system (category) for the entire network is presented in Table 2. This table includes results since 2003 sorted by decreasing loss in 2012.

The categories in Table 2 are rather broad and require some explanation, which is given below.

**Antenna** This category includes all antenna problems, including mis-pointing, antenna control computer failures, non-operation due to wind, and mechanical breakdowns of the antenna.

Table 2. Percentage of observing time lost by sub-system.

Sub-System	2012	2009	2008	2007	2006	2005	2004	2003
Rack	21.8	6.6	8.7	11.4	16.3	5.1	6.8	5.0
Antenna	18.1	29.4	19.2	34.6	19.0	24.4	32.9	17.8
Unknown	14.2	14.2	17.7	14.9	4.0	3.3	10.1	12.6
RFI	11.8	5.9	14.8	10.4	11.6	6.2	5.0	9.3
Receiver	11.7	18.6	13.8	14.9	20.8	24.2	18.0	25.2
Miscellaneous	6.9	15.3	12.8	7.6	18.0	8.0	8.0	6.0
Recorder	5.7	2.9	4.1	4.6	3.3	8.9	11.1	10.9
Shipping	3.6	4.0	5.4	1.0	0.0	0.2	1.4	6.1
Power	2.1							
Operations	2.0	1.2	2.3	0.0	2.0	4.7	6.1	3.6
Clock	1.8	1.9	0.5	0.3	4.9	14.5	0.5	3.4
Software	0.3	0.1	0.1	0.4	0.1	0.5	0.1	0.1

Percentages for 2010 and 2011 were not calculated.

**Clock** This category includes situations where correlation was impossible because the clock offset either was not provided or was wrong, leading to the “no fringes” case. Maser problems and coherence problems that could be attributed to the Maser were also included in this category. Phase instabilities reported for Kokee were included in this category.

**Miscellaneous** This category includes several small problems that do not fit into other categories, mostly problems beyond the control of the stations, such as power (only prior to 2012), (non-wind) weather, cables, scheduling conflicts at the stations, and errors in the observing schedule provided by the Operation Centers. For 2006 and 2007, this category also includes errors due to tape operations at the stations that were forced to use tape because either they did not have a disk recording system or they did not have enough media. All tape operations have since ceased. This category is dominated by weather and scheduling conflict issues.

**Operations** This category includes all operational errors, such as DRUDG-ing the wrong schedule, starting late because of shift problems, operator (as opposed to equipment) problems changing recording media, and other problems.

**Power** This category includes data lost due to power failures at the sites. Prior to 2012, losses due to power failures were included in the Miscellaneous category.

**Rack** This category includes all failures that could be attributed to the rack (DAS) including the formatter and BBCs. There is some difficulty in distinguishing BBC and RFI problems in the correlator reports, so some losses are probably mis-assigned between the Rack category and the RFI category.

**Receiver** This category includes all problems related to the receiver, including outright failure, loss of sensitivity because the cryogenics failed, design problems that impact the sensitivity, LO failure, and loss of coherence that was due to LO problems. In addition, for lack of a more clearly accurate choice, loss of sensitivity due to upper X band Tsys and roll-off problems were assigned to this category.

**Recorder** This category includes problems associated with data recording systems. Starting with 2006, no problems associated with tape operations are included in this category.

**RFI** This category includes all losses directly attributable to interference, including all cases of amplitude variations in individual channels, particularly at S-band. There is some difficulty in distinguishing BBC and RFI problems in the correlator reports, so some losses are probably mis-assigned between the Rack category and the RFI category.

**Shipping** This category includes all observing time lost because the media were lost in shipping or held up in customs or because problems with electronic transfer prevented the data from being correlated with the rest of the experiment's data.

**Software** This category includes all instances of software problems causing observing time to be lost. This includes crashes of the Field System, crashes of the local station software, and errors in files generated by DRUDG.

**Unknown** This category is a special category for cases where the correlator did not state the cause of the loss and it was not possible to determine the cause with a reasonable amount of effort.

Interesting results for 2012 include the fact that the largest source of losses was due to "Rack" problems, (21.8%). About half the loss in this category is associated with DBBCs, which were in use at several stations in the Southern Hemisphere. The remaining rack problems were largely due to problems at stations with aging racks for which replacement parts are hard to find. However, significant improvements were made at two of the three stations with these problems by the end of the year.

The next largest area of loss was "Antenna" problems (18.1%). This is down significantly from previous years and reflects the fact that there were no lengthy outages due to catastrophic antenna failures. Stations with significant antenna problems were Matera, Svetloe, Tsukuba, and Yarragadee.

The "RFI" losses (11.8%) were more back in-line with years before 2009. The higher value in 2009 may be related to differences in how the losses were treated that year. The stations with the most serious RFI problems were Fortaleza and Matera.

"Receiver" sub-system problems (11.7%) was lower than in previous years. For 2012 this is probably due to fewer cryogenic problems, due partly to several new stations having uncooled receivers.

The "Miscellaneous" category loss was smaller than previous years. This was to a small extent due to the fact that "Power" was broken out as a separate category this year, but this does not account for the majority of the change.

Overall, while the network operated well for the most part, there are a few notable issues (in alphabetical order of station), while some situations improved from the previous year:

- Fortaleza RFI for channel SR4U caused almost 15% data loss for that station over the year. An attempt to fix this by bandpass filtering the RFI signal in the station's S-band IF did not work.
- Hobart26 is now observing without a phase calibration antenna unit.
- Hobart, Katherine, and Yarragadee have timing issues with the DBBC back-ends. These cause occasional clock breaks and data gaps when they occur. The manufacturer is investigating this issue.

- Kokee Park's damaged gearbox was repaired and was re-installed. This improved the antenna's pointing and its SEFDs but did not return them to their normal levels. There are still problems with both azimuth gearboxes, which will need to be repaired. The station replaced the AC wiring going to the telescope to prevent the cryogenic compressor from tripping off.
- The receiver at Medicina warmed up in November 2011. It is not clear when it will be repaired.
- Matera's Mark 5 samplers for S-band channels 5 and 6 have failed. Efforts are being made to locate replacements. Matera had an antenna failure that was repaired.
- After completion of its bearing repair, the Noto antenna started observing again in May 2012. Noto also repaired its BBCs, so that it has at most one or two bad BBCs now. In any event, it is expected that Noto will replace its aging VLBA4 rack with a DBBC in 2013.
- Ny-Ålesund's receiver communications were repaired using the system that the TIGO station developed for their receiver, which had the same original design.
- Svetloe had intermittent antenna problems that caused occasional data losses. Badary and Zelenchukskaya's antenna reliability has improved.
- TIGO has shown higher than normal SEFDs for several years. There has been no success in resolving this issue.
- The Tskuba32 telescope had a major structural failure and was repaired.
- Warkworth lost most of the scans scheduled for 2012 because of a maser failure, now repaired.
- The Westford azimuth antenna drives continue to trip off sometimes when the site is unattended.
- Yarragadee solved its antenna problems by installing a bandpass filter in a diplexer to eliminate the need to stow the antenna when a satellite up-link is active.

## 2. New Stations

There are prospects for new stations on several fronts. These include (in approximate order of how soon they will start regular observations):

- At GSFC in the USA, a new 12-m antenna has been erected and is undergoing testing. While this antenna is primarily for use in the development of the VGOS systems, it is expected that it will eventually join the network for regular observing.
- At Wettzell in Germany, construction of the new Twin Telescope Wettzell (TTW) for VGOS is underway and is expected to be commissioned in April 2013.
- At Arecibo in Puerto Rico a new 12-m antenna has been erected and is expected to be used for geodetic observing.
- In Spain/Portugal, the RAEGE (Atlantic Network of Geodynamical and Space Stations) project aims to establish a network of four fundamental geodetic stations including radio telescopes that will fulfill the VGOS specifications: Yebes (1), Canary Islands (1), and Azores (2).

- In Norway, the Norwegian Mapping Authority (NMA) has received initial funding for a project to establish a fundamental station at Ny-Ålesund, which will include a twin telescope of the Wettzell type.
- Onsala has applied for funds for a twin telescope system.
- In Russia, an effort is underway to get 12-m VGOS antennas at some of the QUASAR network sites.
- Korea is planning to build one antenna primarily for geodesy (Korea VLBI system for Geodesy, KVG) at Sejong. There is also interest in geodetic use of the Korean VLBI Network (KVN), which will consist of three stations intended primarily for astronomy.
- There is interest in India in building a network of four telescopes that would be useful for geodesy.
- Saudi Arabia is investigating having a combined geodetic observatory, which would presumably include a VLBI antenna.
- Colombia is investigating having a combined geodetic observatory, which would presumably include a VLBI antenna.

Many of these antennas may become available for use in the next few years. Efforts are being made to ensure that these antennas will be compatible with VGOS.

### 3. Network Coordination Activities

Network coordination involved dealing with various network and data issues. These included:

- Reviewing all experiment “ops” messages, correlator reports, and analysis reports for problems and working with stations to resolve them
- Responding to requests from stations for assistance
- Providing AuScope staff with a technical operations workshop (“Mini-TOW”) for training
- Making station visits to Hobart and Warkworth for software updates and training
- Identifying network station issues and working with the IVS Coordinating Center and the stations to resolve them. This year these included:
  - Dealing with Mark 5B/5B+ “,E” scan\_check errors
  - Dealing with Mark 5B/5B+ time issues
  - Preparing Mark 5 modules for use and correcting VSN problems
  - Helping stations avoid the Linux “day 49” kernel problem
  - Maintaining the FS PC kernel
- Reviewing RFI sources, selecting bandpass filters, and providing them to the sites
- Participating in development of the new VEX2 schedule file standard

- Updating RDV experiment VEX files to allow proper operation with the VLBA correlator, updating the notes file to reflect equipment set-up at different stations, and encouraging timely shipping of data
- Recognizing and reporting DBBC issues to station observing staff
- Reviewing Mark 5 recording error checks for problems and informing correlator staff and station staff
- Assisting in troubleshooting the Kokee X-band dewar failure
- Troubleshooting power supplies and identifying the correct parts for shipping
- Troubleshooting video converters and organizing shipments to stations
- Coordinating shipment of phase calibration sync trigger units to each station with a Mark 5B/5B+
- Troubleshooting phase calibration issues and coordinating parts shipments
- Providing telescope pointing analysis and advice.

#### **4. Future Activities**

Network coordination activities are expected to continue next year. The activities will largely be a continuation of the previous year's activities:

- Reviewing all experiment "ops" messages, correlator reports, and analysis reports for problems and working with stations to resolve them
- Responding to requests from stations for assistance
- Identifying network station issues and working with the IVS Coordinating Center and the stations to resolve them
- Updating Network Station configuration files
- Planning for and teaching at TOW 2013
- Other activities as needed.