Network Coordinator Report

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Abstract This report includes an assessment of the network performance in terms of lost observing time for the 2013 calendar year. Overall, the observing time loss was about 16.2%, which is about 4% higher than the previous year due primarily to scheduled antenna maintenance. A table of relative incidence of problems with various subsystems is presented. The most significant identified causes of loss were the scheduled antenna maintenance (accounting for about 40% of the losses), followed by electronics rack problems (20%), miscellaneous problems (9%), receiver problems (8%), and RFI (6%). About 6% 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. As was the case last year, we have returned to reporting a detailed assessment, which was not provided for 2010 and 2011.

This network performance report is based on correlator reports for experiments in calendar year 2013. This report includes results for the 159 24-hour experiments that had detailed correlator reports available as of March 4, 2014. The data set examined includes approximately 515,000 dual frequency observations. Results for 29 experiments were omitted because either they were correlated at the VLBA, they were not 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 were not correlated or did not have correlator reports available yet include some JADE, CRF, APSG, AUST13, OHIG, R&D, T2, and EUR experiments. In summary, roughly 90% of the data from scheduled 24-hour experiments for 2013 are included in this report. That is similar to the coverage of reports for many 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

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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 2013, this agrees reasonably well with the number of (single frequency: S or X) single baseline observations on which the correlator reported failure, approximately 36%, but other factors, particularly the dual frequency nature of useful geodetic observations, complicate the picture. For 2013, the actual percentage of data (dual frequency) that was not included by the analysts was approximately 41%. This is even larger (by approximately 5%) than the single baseline observations reported lost by the correlator. It is expected that this number should be higher both because of the dual frequency nature of the final observable and the fact that analysts use additional criteria beyond what is discussed here to decide when to exclude observations. However, it means in effect that only about 59% of the observations we attempted to collect were useful.

For the 159 experiments from 2013 examined here, there were 1,432 station days or approximately 9.0 stations per experiment on average. This compares to 148 experiments considered in the report for 2011, which included 1,261 station days with 8.5 stations per experiment. The increase in the number of analyzed experiments mostly reflects the increase in the number of experiments from 2013. The increase in the average number of stations per experiment is due to the scheduling of large networks in experiments. Of the station days for 2013, approximately 16.2% (or approximately 231 days) of the observing time was lost, which is about 4% higher than last year. For comparison to reports from earlier years, please see Table 1.

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
2013	16.2

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

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

The lost observing time for 2013 is in line with results from 2012 and 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 least, there seemed to be some interest in attempting to “game” the analysis methods to apparently improve individual 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 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 25 or more network experiments among those analyzed here and **small N**: those in 16 or fewer (no stations were in the 17-24 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, 14.6% versus 26.0%. There are many more station days in the large N group than the small N group, 1,306 versus 161, so the large N group is dominant in determining the overall performance.

There are 22 stations in the large N group. Ten stations observed in 50 or more experiments. Of the 22 stations, 13 successfully collected data for approximately 90% or more of their expected observing time. Four more stations collected 80% or more of the time. Four more stations collected data about 70% or more of the time. The remaining stations collected data for about 42% 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 15%, a little worse than last year.

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. It also includes scheduled antenna maintenance.

Clock This category includes situations where correlation was impossible because the clock offset either was not provided or was wrong, leading to “no fringes”. 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. DBBC clock errors are 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

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

Sub-System	2013	2012	2009	2008	2007	2006	2005	2004	2003
Antenna	39.6	18.1	29.4	19.2	34.6	19.0	24.4	32.9	17.8
Rack	19.5	21.8	6.6	8.7	11.4	16.3	5.1	6.8	5.0
Miscellaneous	9.4	6.9	15.3	12.8	7.6	18.0	8.0	8.0	6.0
Receiver	7.7	11.7	18.6	13.8	14.9	20.8	24.2	18.0	25.2
RFI	6.4	11.8	5.9	14.8	10.4	11.6	6.2	5.0	9.3
Unknown	5.7	14.2	14.2	17.7	14.9	4.0	3.3	10.1	12.6
Clock	3.5	1.8	1.9	0.5	0.3	4.9	14.5	0.5	3.4
Recorder	3.3	5.7	2.9	4.1	4.6	3.3	8.9	11.1	10.9
Operations	2.5	2.0	1.2	2.3	0.0	2.0	4.7	6.1	3.6
Software	1.0	0.3	0.1	0.1	0.4	0.1	0.5	0.1	0.1
Shipping	0.9	3.6	4.0	5.4	1.0	0.0	0.2	1.4	6.1
Power	0.4	2.1							

Percentages for 2010 and 2011 were not calculated.

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.

Some detailed comments on the most significant issues for this year's data loss are given below.

- The largest source of data loss for 2013 was antenna related at 39.6%, up from 18.1% last year. This includes losses for antennas that were down for scheduled maintenance, particularly Tsukuba and Wettzell, which account for about 80% of the loss in this category. Both observatories are used in the R1 and R4 experiments each week. The losses due to these two scheduled maintenance periods account for most of the increase in this category from last year and most of the increase in the overall loss for the whole network.
- The data rack was the next largest source of loss at 19.5%, about the same as last year. This loss was usually caused by missing channels due to broken converters or samplers. Many were repaired this year after it was undertaken to bring all stations up to all 14 working converters. The increased availability of spare parts for old systems as stations make the switch to digital back-ends helped complete this project. AuScope and Warkworth contributed data rack loss caused by the DBBC. Early reports for 2014 indicate these systems are now stable.
- The Miscellaneous category is a little higher at 9.4% from 6.9% in 2012 due primarily to Westford's use for broadband testing of the new VGOS system. This added 12 station days of loss for 2013.
- Receiver problems contributed about 7.7% to the overall loss. The was mostly due to cryogenics issues at Fortaleza, which have since been repaired.
- RFI contributed about 6.4% — down from 11.8% of station days loss — almost all in S-band due to commercial systems. The stations with the most significant RFI losses are Fortaleza, Medicina, and Matera.
- The proportion of losses attributed to Unknown, RFI, and Receiver decreased this year, primarily because of improvements in classifying the cause of losses

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:

- Crimea had a problem related to a previous repair of a sampler. This caused the lower four channels of X-band to be lost in 2013. The problem was found and repaired.
- Fortaleza had a significant cryogenic problem, which has since been repaired.
- Hobart12 and Hobart26 have a new and serious RFI issue.
- Hobart, Katherine, and Yarragadee timing issues in the DBBCs have improved due to local maintenance work including improved grounding.
- Kokee Park had a power outage that caused some damage that was difficult to repair. The station was able to observe with somewhat reduced sensitivity until the repair was completed.
- Matera's Mark 5 samplers for S-band channels 5 and 6 were repaired. A rare and intermittent unidentified loss of fringes from 2012 and 2013 were diagnosed in 2014 as being due to the first LO unlocking and re-locking at the wrong frequency due to a power supply issue. This has been repaired.
- The cryogenic system in the receiver at Medicina was repaired on September 2013 (after initially failing in November 2011). The station is now able to observe with normal sensitivity.
- TIGO has shown higher than normal SEFDs for several years. There has been no success in resolving this issue.
- The Tskuba32 telescope underwent scheduled antenna maintenance for a period of several weeks.
- Warkworth lost a few station days due to a maser failure.
- The Westford azimuth antenna drives continue to trip off sometimes when the site is unattended. They also lost several days supporting broadband testing and a few days for a maser failure.
- The Wettzell telescope underwent scheduled antenna maintenance for a period of several weeks.
- Yarragadee lost several days due to a filter problem in their DBBC. This has been repaired.

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 Wettzell in Germany, the new Twin Telescope Wettzell (TTW) for VGOS has been commissioned.
- 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 system, it is expected that it will eventually join the network for regular observing.
- South Korea has a new antenna for geodesy at Sejong, built by the National Geographic Information Institute (NGII). There is also interest in geodetic use of the Korean VLBI Network (KVN), which consists of three stations intended primarily for astronomy.
- 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) is in the process of procuring a twin telescope.
- 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.
- 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 will 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
- Identifying network station issues and working with the IVS Coordinating Center and the stations to resolve them. This year these included:
  - Encouraging timely delivery of log files
  - Providing a DBBC Validation Plan
  - Maintaining the FS PC kernel
- Participating in development of the new VEX2 schedule file standard.
- Providing catalog update information for station equipment and track lay-outs.
- 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 IF failure.
- Troubleshooting power supplies and identifying the correct parts for shipping.
- Troubleshooting video converters and organizing shipments to stations.
- Providing telescope pointing analysis and advice.
- Support, including software development, for the 12-m antenna at GSFC and VGOS observing system.

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.
- Helping to coordinate a Mark 5A/5B firmware update for large module directories and bigger disks.
- Helping to plan and support CONT14 observing.
- Providing support, including software development, for the 12-m antenna at GSFC and the VGOS observing system.
- Other activities as needed.