Network Coordinator Report

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Abstract This report includes an assessment of the network performance in terms of lost observing time for calendar year 2014. Overall, the observing time loss was about 12%, which is an improvement of about 4% over the previous year due primarily to fewer antenna issues at the observatories and less data loss assigned to the DAS terminal. A table of relative incidence of problems with various subsystems is presented. The most significant identified causes of loss were the scheduled VGOS testing, which accounted for 28 IVS sessions being missed, and bad weather (accounting for about 35% of the loss assigned and reported as miscellaneous problems). After miscellaneous, antenna issues were next at about 15% of data loss, followed by receiver problems at 14%. RFI was 13%, which is 6.6% higher than in 2013. Problems with the electronics rack amounted to 12%. Less than 1.5% of the losses occurred for unknown reasons.

1 Network Performance

The overall network performance was for the most part very good. RFI in S-Band continues to be a source of loss and increased by 6.6%. Bad weather in the Pacific Rim caused wind stows. Antennas with moving parts fail or require system maintenance. The Mark 5 recording system accounted for 4% of data loss, and most of that can be assigned to failed disk modules. Overall, operator performance was very good with generally quick responses to system errors reported by the Field System or local station equipment such as their antenna control units.

This network performance report is based on correlator reports for experiments in calendar year 2014. The report includes results for the 154 24-hour sessions that had detailed correlator reports available as of January 27, 2015. The data set examined includes approximately 632,594 dual frequency observations. Results for 94 experiments were omitted because either they were correlated at the VLBA, they were not correlated yet by CRTN, 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, AUST14, OHIG, R&D, T2, RV, CRDS, EUR, and all the A14 sessions. In summary, roughly 70% of the data from scheduled 24-hour sessions for 2014 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-

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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.

Because 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 2014, this agrees very roughly with the number of (single frequency: S or X) single baseline observations on which the correlator reported failure, approximately 17%, but other factors, particularly the dual frequency nature of useful geodetic observations, complicate the picture. One significant issue this year was that the correlators did not report losses for some stations (notably Westford) that did not observe in experiments they were scheduled for. If we omit those losses from the observing time loss, the overall observing time loss is reduced (artificially) to about 10%. Twice that is closer to 17% than doubling 12% is, but the 17% value is still about 25% less than expected. A similar but somewhat smaller discrepancy also occurred for 2012. Some work would no doubt find the issues that caused this, but the factor of two is just a rough approximation, so not getting agreement is not too large an issue of concern.

For 2014, the actual percentage of data (dual frequency) that was not included by the analysts was approximately 23%. This is even larger (by approximately 7%) 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 77% of the observations we attempted to collect were useful.

For the 154 experiments from 2014 examined here, there were 1,404 station days or approximately 8.2 stations per experiment on average. This compares to 159 experiments considered in the report for 2013, which included 1,432 station days with nine stations per experiment. The number of analyzed experiments and the average number of stations per experiment has remained about the same for 2014. Of the station days for 2014, approximately 12% (or approximately 168 days) of the observing time was lost, which is about 4% lower than last year. Removing VGOS testing from this assessment the overall observing time loss for 2014 was 10%. This is 6% lower than in 2013, but 2013 included many sessions lost to scheduled antenna maintenance. Removing antenna maintenance as a loss reduces the year 2013 value by 3% to 13% overall loss. By this measure 2014 is about 3% lower than 2013. For comparison to reports from earlier years, please see Table 1.

The lost observing time for 2014 is in line with results from 2013 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

Table 1 Lost observing time. The percentage applies to a subset of the 1999-2000 experiments. Percentages for 2010 and 2011 are omitted but should be 10-20%.

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
2014	11.9

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 its own results 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 24 or more network experiments among those analyzed here and **small N**: those in 17 or fewer (no stations were in the 18-23 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, 11.9% versus 22.1%. There are many more station days in the large N group than the small N group, 1,025 versus 122, so the large N group is dominant in determining the overall performance.

There are 17 stations in the large N group. Ten stations observed in 49 or more experiments. Of the 17 stations, 13 successfully collected data for approximately 92% or more of their expected observing time. The four other stations collected 70%, 68%, 65%, and 42% or more of the time. These results are not significantly different from previous years.

There are 21 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 22%, 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 2014.

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 through 2013, and mechanical breakdowns of the antenna. It also includes scheduled antenna maintenance. Wind stows have been moved to Miscellaneous for 2014.

Clock This category includes situations in which 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 are also included in this category. Phase instabilities reported for Kokee are included in this category. DBBC clock errors are included in this category.

Miscellaneous This category includes 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 through 2013, wind stows (moved here from the Antenna category starting in 2014), 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.

Table 2 Percentages of observing time lost by sub-system. Percentages for 2010 and 2011 were not calculated.

Sub-System	2014	2013	2012	2009	2008	2007	2006	2005	2004	2003
Miscellaneous	35.11	9.4	6.9	15.3	12.8	7.6	18.0	8.0	8.0	6.0
Antenna	14.81	39.6	18.1	29.4	19.2	34.6	19.0	24.4	32.9	17.8
Receiver	13.89	7.7	11.7	18.6	13.8	14.9	20.8	24.2	18.0	25.2
RFI	13.24	6.4	11.8	5.9	14.8	10.4	11.6	6.2	5.0	9.3
Rack	12.02	19.5	21.8	6.6	8.7	11.4	16.3	5.1	6.8	5.0
Recorder	4.10	3.3	5.7	2.9	4.1	4.6	3.3	8.9	11.1	10.9
Operations	4.08	2.5	2.0	1.2	2.3	0.0	2.0	4.7	6.1	3.6
Unknown	1.3	5.7	14.2	14.2	17.7	14.9	4.0	3.3	10.1	12.6
Power	0.4	2.1								
Clock	0.2	3.5	1.8	1.9	0.5	0.3	4.9	14.5	0.5	3.4
Software	0.17	1.0	0.3	0.1	0.1	0.4	0.1	0.5	0.1	0.1
Shipping	0.0	0.9	3.6	4.0	5.4	1.0	0.0	0.2	1.4	6.1

Westford VGOS testing, 28 station days, has been assigned to Miscellaneous for this year, 2014.

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 are 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.

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

- The largest source of data loss for 2014 was Miscellaneous at 35% which was due to moving wind stows and weather related issues into this category. VGOS testing at Westford was also assigned to Miscellaneous as that station did not participate in 28 previously scheduled R1 sessions.
- The Antenna was the next largest source of loss at 14.8%, and the Receiver was next at 13.9%, with Fortaleza observing warm for 28 scheduled days.
- RFI contributed about 13%, almost all in S-band due to commercial systems. The stations with the most significant RFI losses are Fortaleza, Medicina, and Matera.

- The data rack was the next largest source of loss at 12%, about 7.5% lower than in 2013. This improvement is the result of bringing all stations up to 14 working converters and what seems like a better operational handle on digital back-ends and better grounding at the sites.
- The proportion of losses attributed to Unknown, 1.3%, decreased this year, primarily because of improvements in classifying the cause of losses. Assigned maintenance for this year was 22 station days, 14%, with about half for repair of the antenna across the network.

Overall, while the network operated well for the most part, there are a few notable issues (in alphabetical order of station), for stations that lost more than 120 total observing hours regardless of the number of scheduled sessions for 2014.

- Fortaleza had a significant cryogenic problem again this year, and a new compressor was shipped to the station in 2015.
- Hobart12 and Hobart26 have a new and serious RFI issue. Hobart12 had multiple wind stows, and Hobart26 had DAS issues.
- Katherine12 had wind stows and DBBC issues since repaired.
- Matera had serious RFI and DAS issues since repaired.
- Medicina had required antenna maintenance and weather issues.
- Warkworth had multiple antenna controller issues and antenna repair.
- Westford lost scheduled R1 sessions due to VGOS testing.
- Yarragadee had Mark 5 module and timing issues.
- Yebes40 lost data due to their data rack until repaired.

2 CONT14

The CONT14 session ran from May 6—20, 2014. There were 15 sessions using 17 stations for a total of 114,522 scans in 255 station days. 18 station days were lost, 7% overall. RFI accounted for 3%, and the weather caused 2.5% data loss, usually due to wind stows.

3 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 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). This antenna is now used for normal operations. There is also interest in geodetic use of the Korean VLBI Network (KVN), which consists of three stations intended primarily for astronomy.
- 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 civic construction phase for a twin telescope system.
- In Sweden, Onsala Space Observatory has ordered a twin telescope system.
- In Russia, VGOS antennas have been built at the QUASAR sites Badary and Zelenchukskaya.
- 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.

4 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
  - Validating DBBCs replacing existing systems
  - 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.
- Resolving Kokee GPS/NTP timing issues.
- 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 the VGOS observing system.

5 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.
- Providing support, including software development, for the 12-m antenna at GSFC and the VGOS observing system.
- Other activities as needed.