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 2009 calendar year. Overall, the observing time loss was about 21.5%, an increase of about 6.4% from what was reported for the previous year. It should be noted that most of this increase may be due to changes in the accounting methods. The number of experiments scheduled was about 15% fewer than the previous year. However the number of stations per session increased from about 7.2 to 7.9, resulting in only about a 6% reduction in the number of station observing days. A table of relative incidence of problems with various subsystems is presented. The most significant identified causes of loss were antenna reliability (accounting for about 29.4% of losses), receiver problems (18.6%), and miscellaneous problems (15.3%) including scheduling conflicts, power failures, and weather. Unidentified problems accounted for about 14.2% of the loss. There are prospects for Korea, India, and Saudi Arabia to start contributing to IVS. New antennas have been or are being built by Australia, New Zealand, and the USA.

1. Network Performance

This network performance report is based on correlator reports for experiments in calendar year 2009. This report includes results for the 135 24-hour experiments that had detailed correlator reports available as of April 1, 2010. Results for 22 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 is not as detailed as from Mark IV correlators. The experiments that have not been correlated or do not have correlator reports available yet include all the OHIG experiments, astrometry experiments that will be correlated in Australia, two T2s, and IYA09. In summary, roughly 86% of the scheduled experiments for 2009 are included in this report. That is similar to 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 are beyond the control of the station, such as weather and power failures. Instead the results should be viewed in aggregate as an overall evaluation of what percentage of the observing time the network is collecting 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 about twice the average loss of observing time. This approximation is described in the Network Coordinator's section of the IVS 2001 Annual Report.

For the 135 experiments from 2009 examined here, there were 1,051 station days or about 7.9 stations per experiment on average. This compares to 155 experiments considered in the previous year's report for 2008, which included 1,121 station days with 7.2 stations per experiment. Of the station days for 2009 about 21.5% (or about 226 days) of the observing time was lost. 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

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

The lost observing time for 2009 was significantly more than for all other previous years. This may be to some extent an artifact due to a change in the way the master files are handled starting in 2009 compared to previous years. Beginning in 2009, stations that were unable to observe due to a long term problem were removed from the master file for individual experiments only if a suitable replacement was found. If no replacement was available, they were included as "failed" stations in the master file. This change was made so that the loss statistics would more accurately reflect losses in allocated observing time. For 2009, this primarily affected Fortaleza, which had an antenna failure, and Westford, which had several scheduling conflicts. The station days lost counted in this way nearly account for the increase in the percentage of station days lost. Looking at it in a different way, some of the apparent increase may be due to the fact that some losses in 2008 and previous years were not tracked in this more complete way. If the newer method had been used for 2008, it would have increased the percentage of data lost by a few percent, just for the effect of HartRAO (the most significant case that year). It is difficult to assess the overall effect of this change precisely because it would not be practical to reconstruct the changes that would have been made to the master files over a year ago. In the end, it seems safe to say that the data loss for stations without long term disabling problems is about the same for 2009 as it was for previous years. In addition, it appears that the more strictly accounted loss of observing time is somewhat higher than the 11-15% seen in previous years. The results for 2010 will provide additional information that may help to assess the variation in this statistic.

The loss of HartRAO, due to antenna problems, is not included in these results since it was never scheduled for 2009. The absence of HartRAO largely accounts for the reduction in the number of reported station days observed in 2009 (1,051) compared to 2008 (1,121). If HartRAO had been included in these results, the overall loss would have been about 25%.

An assessment of each station's performance is not provided in this report. While individual station information was presented in some of the 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 improve the individual 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 20 or more network experiments among those analyzed here, and **small N**: those in 16 or fewer experiments. (No stations were in 17-19 experiments.) 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, 20.5% versus 28.8%. The losses for both groups were larger than in previous years. There are many fewer station days in the small N group than the large N group—120 versus 931—so the large N group is dominant in determining the overall performance.

There are 15 stations in the large N group. Eight stations observed in 58 or more experiments. Of the 15, six stations successfully collected data for approximately 90% or more of their expected observing time. Five more stations collected 80% or more of the time. Four more stations collected data for more than 60% of their observing time. Fortaleza, due to its long term antenna problem, collected only about 40% of its scheduled data. Westford, due to its scheduling conflicts, collected only about 63% of its scheduled data. These statistics, with the exception of the losses for Fortaleza and Westford, are only slightly worse than last year's.

There are 20 stations in the small N group. The range of lost observing time for stations in this category was 1%-100%. The median loss rate was about 42%, much worse than last year. This was largely due to schedule conflicts at DSN stations and to weather and other problems at VLBA stations.

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 2009.

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

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

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.

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.

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, (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 didn't have a disk recording system or they did not have enough media. All tape operations have since ceased. This category is dominated by power, 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.

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 that some losses are probably mis-assigned between these categories.

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 that some losses are probably mis-assigned between these categories.

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.

Due to the significant losses due to antenna problems, the combined losses due to the "Antenna" (29.4%) and "Receiver" (18.6%) sub-systems was about 48%, up from last year's unusually low level (33%), but more like the typical value seen in prior years. This is primarily due to the significant losses due to Fortaleza's antenna problems. (Please note that the effect of HartRAO not being available for all of 2009 is not represented here. If it were included, it would increase the overall losses by about 4% and increase the antenna related losses to about 42%.) Stations that had significant antenna problems (excepting HartRAO) include Seshan, Fortaleza, and Svetloe. HartRAO is expected to return to limited operation by mid-2010. Fortaleza is not expected to return to operation until late 2010 at the earliest.

Stations with significant receiver problems include Ny-Ålesund, TIGO, and Matera. The most significant problems were LO and cryogenic failures. The harsh conditions at Ny-Ålesund can prevent timely receiver repair thus creating extensive losses for otherwise minor problems.

The "Unknown" category loss is somewhat smaller than last year's value and about the same as the year before that. In the years before those years, the level was lower. This may be a reporting problem due to the correlators being under increasing resource pressure and therefore not being free to chase down the cause of every particular problem. It is also extremely time consuming to do this when constructing this report. The impression created by the pattern of unknown losses does not suggest that it is due to any particular sub-system.

The "Miscellaneous" category loss is larger than last year and worse than the results in almost all other years. This year, in addition to weather and power related losses, some experiments were missed due to scheduling conflicts with other users of the stations. This was particularly true at Westford. The losses at Westford due to conflicts represents more than half of the loss in this category.

The "Rack" category loss was smaller this year and well below its peak levels a few years ago. In those years, losses were being suffered by Sheshan due to their rack not being fully populated with modules. This situation was corrected by the loan of modules by NASA. There has been some improvement in the BBC situation at Zelenchukskaya and Badary as well. Some losses may be mis-assigned between this category and the RFI category due to the difficulty in distinguishing BBC and RFI problems in the correlator reports.

The "RFI" category loss level is significantly lower than in previous years. This appears to be due primarily to a decrease in the RFI losses attributed to the three Russian stations: Svetloe, Zelenchukskaya, and Badary. In the case of Svetloe it seems that the increase in observing time lost to antenna and Maser problems reduced the opportunity for the station to suffer RFI problems. There is no clear explanation for why the other two stations suffered fewer RFI losses. Although RFI and BBC problems are sometimes confused, there was not enough increase in BBC attributed problems to explain the reduction in RFI problems at these stations (and actually, there was a decrease). It may be that the stations made changes to improve their reduction of RFI and/or that the correlators have been more sophisticated in their treatment of RFI and do not delete entire channels as often. Another possible contributing factor is that these stations have made improvements to their systems that eliminated BBC related losses that were being incorrectly identified as RFI. WACO confirmed that they noticed general improvements in the data from these stations, particularly for Badary (K. Kingham, USNO, personal communication), that are consistent with this interpretation. If this is correct, then the level of RFI seen has not suffered the apparent increase over the last few years that had been reported. It does however continue to be a significant source of loss.

The "Clock" category increased somewhat from last year. This appeared to be primarily due to a Maser problem at Svetloe.

The "Recorder" category decreased from the previous year and may represent more successful disk operations and fewer disk failures.

The "Shipping" category continued at nearly the same high level as had been seen last year. Presumably this increase over previous lower levels is due to the notable customs problems with disks that have been occurring recently.

In summary, the biggest single increase in losses in 2009 was due to antenna problems. There was also a significant increase in losses due to receiver problems. Unfortunately due to aging hardware we can expect these losses to continue, although we can hope that they will not be at quite such a high level, until hardware upgrades such as VLBI2010 are implemented. A bright spot is that RFI losses appear to be down, and this appears to be due to the fact that in previous years, some problems thought to be RFI related were not, and those problems have been reduced. We can however expect that RFI problems will continue while we use S- and X-band primarily.

2. New Stations

There are prospects for new stations on several fronts. In New Zealand, the station Warkworth has its antenna in place. In Australia, the new 12-m antenna at Hobart has been completed. New antennas at Katherine and Yarragadee are under construction. It is expected that all four of these antennas will start observing for IVS in 2010.

At GSFC in the USA, a new 12-m antenna will be erected in 2010. While this antenna is primarily for use in development of the VLBI2010 systems, it is expected that it will eventually join the network for regular observing. At Arecibo in Puerto Rico a new 12-m antenna has been erected and may be used for geodetic observing.

At Wettzell in Germany, construction of the new Twin Telescope Wettzell (TTW) for VLBI2010 has commenced. In Spain/Portugal, the RAEGE (Atlantic Network of Geodynamical and Fundamental Stations) project aims to establish a network of four fundamental geodetic stations including radio telescopes that will fulfill the VLBI2010 specifications: Yebes (1), Canary Islands (1), and Azores (2). In Norway, the Norwegian Mapping Agency (NMA) has applied for a project to establish a fundamental station at Ny-Ålesund, which will include a twin telescope of the Wettzell type.

In Russia, an effort is underway to get 12-m VLBI2010 antennas at some of the QUASAR network sites.

Korea is planning to build one antenna primarily for geodesy (Korea VLBI for Geodesy, KVG) at Sejong with construction to be completed in 2011. There is also interest in using the Korean VLBI Network (KVN), which will consist of three stations intended primarily for astronomy, for geodesy. 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.

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 VLBI2010.