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 years 2017 and 2018. Overall, the observing time losses were about 18.7% in 2017 and 21.5% in 2018. These high statistics are similar to the 2015–2016 period and are mainly due to stations that did not observe because of scheduling conflicts or maintenance but were not removed from the master schedule. A total of 120 (5.3%) and 123 (7%) station-days were in the master schedule but were not included in the final observing schedules in 2017 and 2018, respectively. RFI in S-band continues to be a significant source of data loss. A table of relative incidence of problems with various sub-systems is presented.

1 Observing Network

The 2017 and 2018 S/X observing network shown in Figure 1 consisted of 51 stations in total. The network includes 37 IVS Network Stations as official member components of the IVS as well as several cooperating sites that contributed to the IVS observing program, in particular the ten VLBA stations and four NASA DSN stations.

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IVS Network Coordinator

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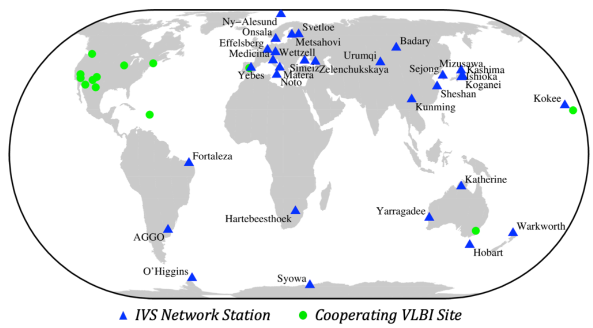

Fig. 1 Distribution plot of the VLBI stations that contributed to the 2017–2018 IVS Master Schedules.

2 Network Performance

The network performance is expressed in terms of lost observing time, or data loss. 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.

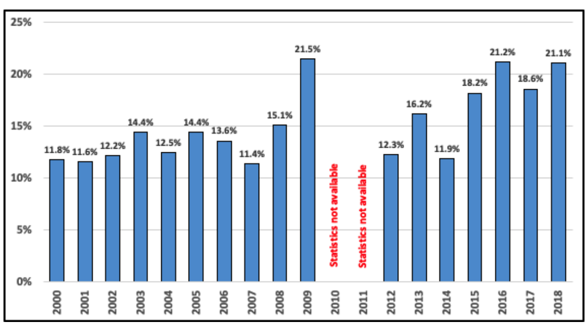

Fig. 2 Historical data loss since 2000.

The overall network performance for 2017–2018 is similar to 2015–2016 as shown in Figure 2. The results of this report are based on correlator and analysis reports for 376 24-hour sessions correlated as of June 7, 2019. The examined data set includes 2,534,980 dual-frequency observations. About 77% of these observations were successfully correlated, and over 70% were used in the final IVS Analysis Reports of 2017 and 2018. Sessions correlated at the VLBA were also included when data analysis reports were providing relevant information on reasons for data loss. A total of 19 T2, R&D, OHG, AOV, and AUM sessions have not been correlated yet.

Table 1 Data sets used for the 2017–2018 network performance report.

Year	Sessions	Station days	Observations	Correlated	Used
2017	202	2,246 (2,126)	1,533,182	78%	71%
2018	174	1,763 (1,640)	1,001,798	75%	68%

Table 1 summarizes the data set used for the 2017–2018 network performance report. The data in parentheses represent the station days processed by the correlators. The table also includes the percentage of successfully correlated and used observations. The reported successfully correlated observations have a higher loss than the lost observing time in Figure 2 because lost observing time at a station affects more than one baseline. The used observations have an even greater loss because there may be a mismatch between S and X successfully correlated single band observations. In addition, the analysts may remove observations for other reasons. The difference between successfully correlated and actually used represents a significant loss by itself. We plan to investigate the cause of this loss. This is probably due primarily to mismatched S and X observations. Possible causes include variations in the impact of RFI and source structure.

Table 1 also shows the number of sessions examined for this report. All 2017 sessions and 90% of the 2018 sessions were correlated at the time of writing this report. The average number of stations per session is 11.1 in 2017 and 10.1 in 2018 compared to 10.7 in 2016. More than 420 stations days (18.7%) were lost in 2017 and 379 (21.5%) in 2018. The observing time loss for 2017–2018 has been affected by stations that did not observe and were not removed from the master schedule. This loss accounted for 243 station-days, or 6%. Prior to 2015, this loss was smaller. When removing these non-observed station-days, the 2015–2018 data loss is around 14%, more in line with previous years. All data presented in figures and tables are uncorrected.

In 2017–2018, the network lost over 20% of its data as shown in Figures 3 and 4. To better understand this global performance, the network has been analyzed by

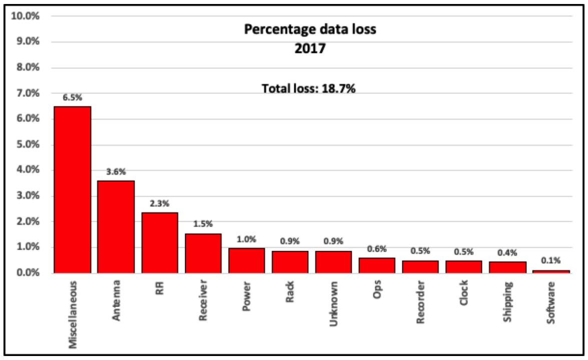

Fig. 3 Percentage of data loss for each sub-system in 2017.

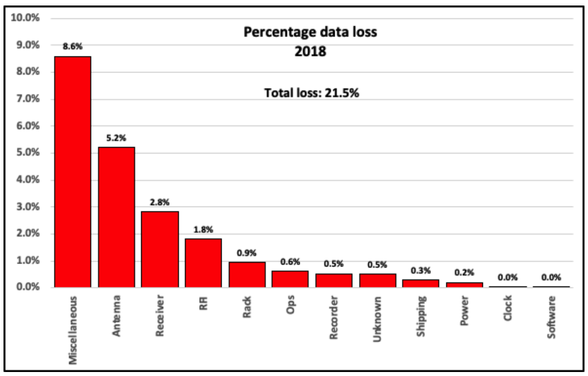

Fig. 4 Percentage of data loss for each sub-system in 2018.

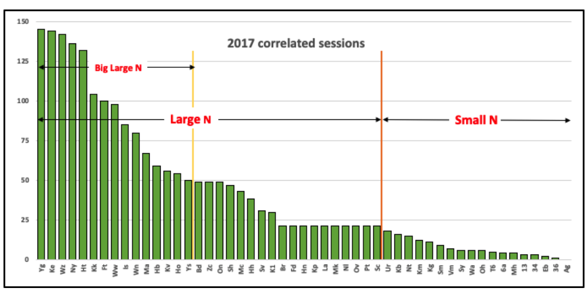

Fig. 5 Number of 24-hour sessions correlated in 2017.

Table 2 Group analysis for 2017.

Category	#stat	#days	Average	Median	>92%	<70%
Big Large N	16	1,568	15.4%	11.8%	7	2
Large N	33	2,068	15.5%	11.5%	13	4
Small N	17	133	41.8%	24.6%	1	12
Full network	50	2,201	18.7%	20.4%	14	16

groups based on the station usage as shown in Figures 5 and 6. Tables 2 and 3 provide information on the three groups: **Big Large N** (stations that were used in 51 or more sessions), **Large N** (stations that were used in 21

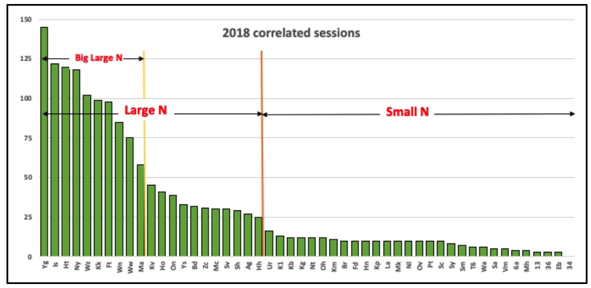

Fig. 6 Number of 24-hour sessions correlated in 2018.

Table 3 Group analysis for 2018.

Category	#stat	#days	Average	Median	>92%	<70%
Big Large N	11	1,167	17.4%	8.7%	3	2
Large N	22	1,529	20.0%	20.8%	4	6
Small N	28	242	30.9%	23.9%	6	12
Full network	50	1,771	21.5%	21.5%	10	18

or more sessions), and **Small N** (stations that were used in 20 or fewer sessions). The distinction between these groups was made on the assumption that results will be more meaningful for the stations with more sessions. The **Big Large N** group is a subset of **Large N** and is used to show the performance of the busiest IVS stations.

As expected, the 2017–2018 average observing time loss from the **Large N** group was much smaller than the average from the **Small N** group, 15% and 20% versus 42% and 31%. The **Large N** group accounts for more than 90% of the station days, so the **Large N** group is dominant in determining the overall performance. The last two columns of the group analysis tables indicate the number of stations that yield more than 92% and less than 70% of their data.

The higher number of stations in the 2017 **Large N** is due to CONT17 and CONTV17 involving 18 IVS Network stations and 10 VLBA stations. The stations in that group are more reliable, given that a good number of stations (seven in 2017 and four in 2018) had more than 92% of their recorded data make it through the correlators. Only a few stations in the 2017–2018 **Large N** groups collected less than 70% of the scheduled data. The statistics of the **Big Large N** group show very good results for IVS stations that participated in more than 50 sessions.

The 2017 **Small N** group has worse median loss than the 2018 **Small N** group. This is probably due to

Table 4 Percentages of data loss by sub-system. Percentages for 2010 and 2011 were not calculated.

Sub-System	2018	2017	2016	2015	2014	2013	2012	2009	2008	2007	2006	2005	2004	2003
Miscellaneous	8.6	6.5	3.3	4.7	4.2	1.5	0.8	3.3	1.9	0.9	2.4	1.2	1.0	0.9
Antenna	5.2	3.6	9.2	3.6	1.8	6.4	2.2	6.3	2.9	3.9	2.6	3.5	4.1	2.6
Receiver	2.8	1.5	0.6	1.8	1.7	1.2	1.4	4.0	2.1	1.7	2.8	3.5	2.3	3.6
RFI	1.8	2.3	2.3	1.6	1.6	1.0	1.5	1.3	2.2	1.2	1.6	0.9	0.6	1.3
Rack	0.9	0.9	0.6	2.3	1.4	3.2	2.7	1.4	1.3	1.3	2.2	0.7	0.9	0.7
Operations	0.6	0.6	0.5	1.1	0.5	0.4	0.2	0.3	0.3	0.0	0.3	0.7	0.8	0.5
Recorder	0.5	0.5	0.5	1.2	0.5	0.5	0.7	0.6	0.6	0.5	0.4	1.3	1.4	1.6
Unknown	0.5	0.9	1.0	1.1	0.2	0.9	1.7	3.1	2.7	1.7	0.5	0.5	1.3	1.8
Shipping	0.3	0.4	0.3	0.2	0.0	0.1	0.4	0.9	0.8	0.1	0.0	0.0	0.2	0.9
Power	0.2	0.9	0.4	0.2	0.0	0.3								
Clock	0.0	0.5	2.3	0.2	0.0	0.6	0.2	0.4	0.1	0.0	0.7	2.1	0.1	0.5
Software	0.0	0.1	0.1	0.1	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0

the VLBA stations that were moved to the 2017 **Large N** group due to the 15 CONTV17 sessions.

The losses were also analyzed by sub-system (category) as shown in Figures 3 and 4 for the 2017–2018 network. A summary of the percentage of losses by sub-system (category) for the entire network is presented in Table 4. This table includes results since 2003 sorted by decreasing loss in 2018.

The categories in Table 4 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 starting in 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.

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.

Table 5 Stations most affected by RFI in 2018.

Station	Data loss	Most affected channels (frequencies given in MHz)
Sejong	18.0%	SR4U (2295 MHz), SR5U (2345 MHz), SR6U (2365 MHz)
Kunming	13.9%	SR5U (2345 MHz), SR6U (2365 MHz), SR1U (2225 MHz)
Zelenchukskaya	13.0%	SR2U (2245 MHz), SR3U(2265 MHz), SR4U(2295 MHz)
Koganei11	12.5%	No fringes in some sessions due to weak S band signal affected by RFI
Yebes 40m	8.7%	SR2U (2245 MHz), SR4U (2295 MHz)
Medicina	6.0%	SR6U (2365 MHz)
Hobart26	5.1%	SR5U (2272 MHz) SR6U (2288 MHz) – AOV sessions
		SR5U (2281 MHz) SR6U (2297 MHz) – CRDS sessions
		SR5U (2345 MHz) SR6U (2365 MHz) – CRF, RD sessions
Matera	4.1%	SR6U (2365 MHz)
Wark12m	3.8%	SR5U (2345 MHz), SR6U (2365 MHz) – Intermittent
Fortaleza	3.1%	SR4U (2295 MHz) – Mostly in September–December

Channels: SR1U = band|polarization|BBC#|sideband

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 session'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.

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 have been 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).

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

- The two largest sources of data loss for 2017–2018 are Miscellaneous and Antenna. The high values of Miscellaneous are highly affected by broadband testing at some stations and bad weather. Many hours were lost by antennas being stowed due to high winds, snow, hurricanes, thunderstorms, or typhoons. The Antenna sub-system loss is mainly due to repairs at antennas that were delayed by months waiting for replacement parts.
- The Receiver sub-system is mainly due to few stations observing a total of 136 station-days with warm receivers while waiting for replacement parts.
- Operator performance is very good with less than 0.6% of data loss.
- RFI due to commercial systems continues to be an important factor of data loss mostly in S-band given that correlators dropped over 2.1% of the recorded channels. RFI is mainly evaluated from dropped channels at correlation, but there are some difficulties in distinguishing BBC and RFI problems. Some stations were contacted to confirm RFI presence at their site. See Table 5 for a list of stations that were most affected by RFI in 2018.

3 Summary

Estimating station data losses could be subjective and some times approximative, but this is a useful tool for evaluating the health of the IVS network over the years. A station yielding over 80% of data is considered very good, and the statistics of the Large N group show that stations have been doing well in 2017–2018.