Network Coordinator Report

Mario Bérubé[1], Stuart Weston[2], Alexander Neidhardt[3]

Abstract This report includes an assessment of the IVS network performance in terms of lost observing time for calendar years 2021 and 2022. The observing losses were 19.0% in 2021 and 16.7% for 2022. The 2021 statistics are similar to the prior 2019–2020 period, but 2022 shows significant improvement. Various tables are presented to break down the relative performance of the network and the incidence of problems with various sub-systems. At the end of 2022, Stuart Weston discontinued to be the IVS Network Coordinator and he was succeeded in this role by Alexander Neidhardt.

1 Introduction

As described in more detail in the network station report for Warkworth Observatory, Auckland University of Technology divested itself of the station effective mid-December 2022. While a new funding mechanism was being negotiated, the then IVS Network Coordinator Stuart Weston decided to step down from his position by the end of 2022—also given the uncertain future outlook. The IVS Directing Board elected Alexander Neidhardt to become Stuart's successor, starting his tenure in January 2023.

1. NVI, Inc./NASA Goddard Space Flight Center
2. Institute for Radio Astronomy and Space Research, Auckland University of Technology
3. Forschungseinrichtung Satellitengeodäsie (FESG), Technische Universität München

IVS Network Coordinator

IVS 2021+2022 Biennial Report

In this report, we provide an assessment of the network performance of the IVS stations broken down by calendar year. We follow the same methodology that was used in previous reports. One major difference, however, is the inclusion of the VGOS stations, as a fledgling but growing VGOS network contributed to the IVS products over the entire reporting period.

2 Observing Network

The network consists of 45 IVS Network Stations as official member components of the IVS as well as several cooperating sites that contribute to the IVS observing program, in particular the ten VLBA stations and four NASA DSN stations. The VGOS network has been included in the global statistics, since it now contributes to the creation of IVS products. As a consequence, there are no individual statistics for the VGOS and legacy S/X networks. In 2021, Fortaleza was initially included in 100 sessions but could not observe; it was removed from any statistics.

3 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. But, 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.

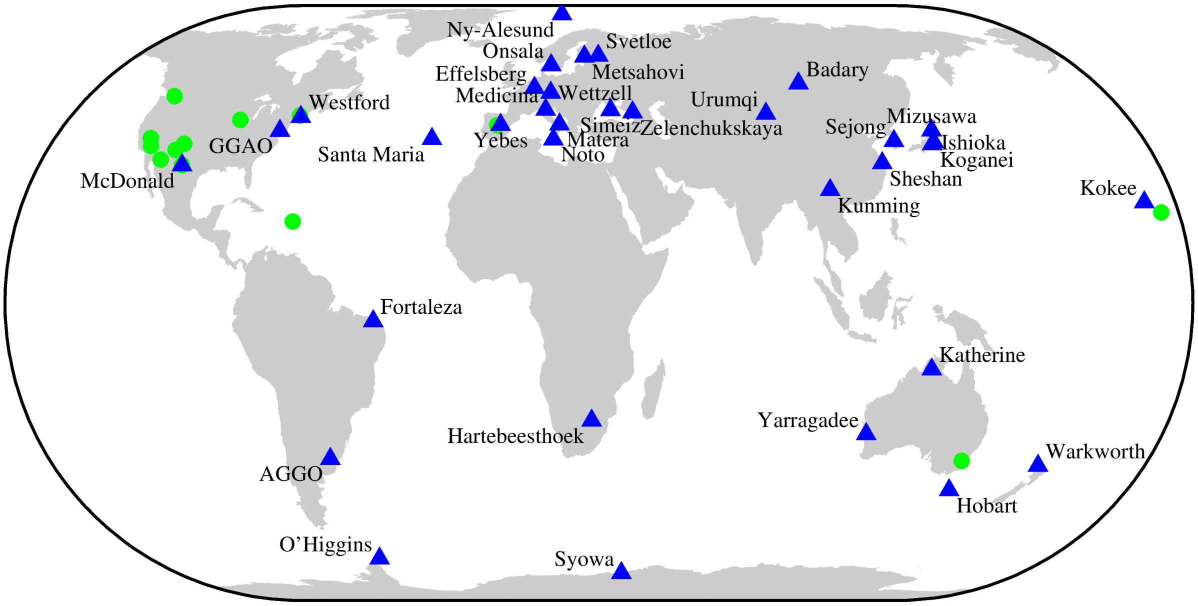

Fig. 1: Distribution plot of the VLBI stations that contributed to the 2021–2022 IVS Master Schedules. The IVS Network Stations are shown as blue triangles (▲), while the Cooperating Stations are indicated by green dots (●).

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.

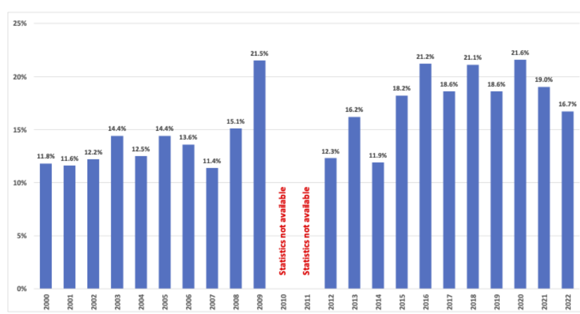

Fig. 2: The historical data loss since 2000.

The overall network performance for 2021–2022 has improved when compared to the 2019–2020 period, as can be seen in Figure 2. The results of this report are based on correlator and analysis reports for 456 correlated 24-hour sessions. The examined data set includes 4,028,539 observations. Approximately 74% of these observations were successfully correlated, and over 64% were used in the final IVS Analysis Reports for 2021 and 2022. Sessions correlated at the VLBA were also included when data analysis reports provided relevant information about reasons for data loss.

Table 1 summarizes the data set that was used for the 2021–2022 network performance report. The data in parentheses represent the station days processed by the correlators. The table also includes the percentages of successfully correlated and used observations that are comparable to the previous period. The average number of stations per session is 9.7 in 2021 and 9.5 in 2022, compared to 9.6 in 2020.

Table 1: Data sets used for the 2021–2022 network performance report.

Year	Sessions	Station days	Observations	Correlated	Used
2021	219	2,135 (1,968)	1,867,875	75%	61%
2022	237	2,247 (2,114)	2,160,664	74%	66%

More than 405 station days (19.0%) were lost in 2021, and 375 (16.7%) days were lost in 2022. The observing time loss for 2021–2022 has been affected by stations that did not observe and were not removed from the master schedule. This loss accounted for 167 station days, or 7.8%, in 2021 and 133 stations days, or 5.9%, in 2022.

Figures 3 and 4 are showing detailed data loss by sub-system for 2021 and 2022. As shown in Figure 2, the 2021 network lost over 19.0% of its data, a slight improvement over 2020. With a network loss of 16.7%, 2022 was also showing improvement over the previous year.

To analyze this global performance, the network has been analyzed by groups: Figure 5 shows 2021, and Figure 6 shows 2022. Tables 2 and 3 provide information on the three groups: **Big Large N** (stations that were used in 55 or more sessions), **Large N** (stations that were used in 24 or more sessions), and **Small N** (stations that were used in 23 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. The **Big Large N**

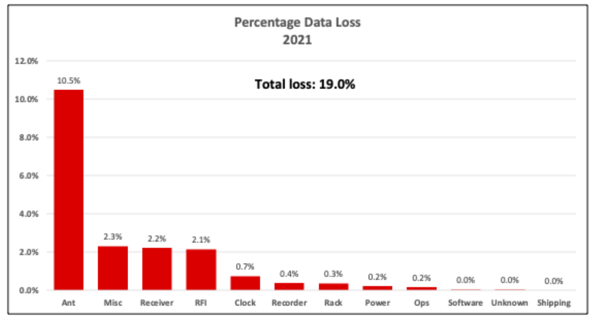

Fig. 3: Percentage of data loss for each sub-sytem in 2021.

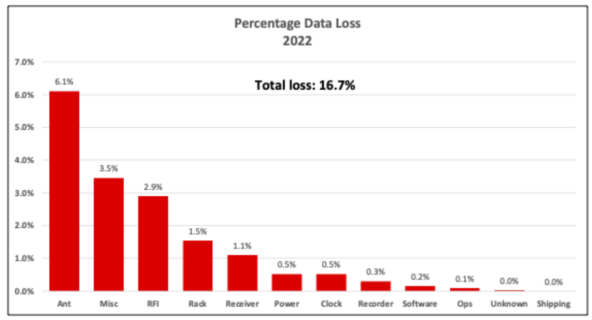

Fig. 4: Percentage of data loss for each sub-sytem in 2022.

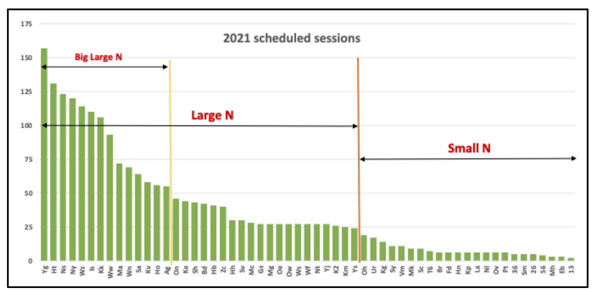

Fig. 5: The number of 24-hour sessions correlated in 2021.

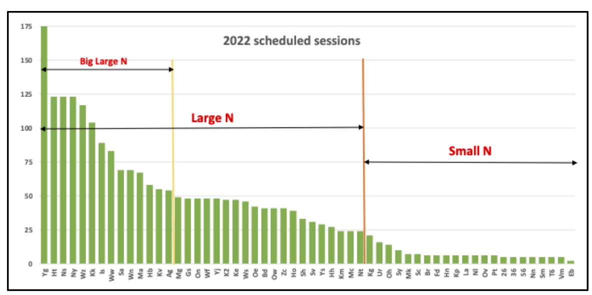

Fig. 6: The number of 24-hour sessions correlated in 2022.

Table 2: Group analysis for 2021.

Category	Number stations	Station-days	Average	Median	>92%	<70%
Big Large N (>55)	14	1328	22.6%	20.5%	6	9
Large N (≥24)	34	1963	19.4%	10.5%	11	26
Small N (<24)	23	172	18.6%	16.8%	10	18
Full network	57	2135	19.0%	11.0%	21	44

Table 3: Group analysis for 2022.

Category	Number stations	Station-days	Average	Median	>92%	<70%
Big Large N (>55)	14	1310	12.2%	8.2%	7	13
Large N (≥24)	34	2087	11.9%	9.6%	13	31
Small N (<24)	22	160	19.5%	8.1%	11	17
Full network	56	2247	16.7%	9.6%	24	48

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

Sub-System	**2022**	**2021**	**2020**	**2019**	**2018**	**2017**	**2016**	**2015**	**2014**	**2013**	**2012**	**2009**	**2008**	**2007**	**2006**	**2005**	**2004**	**2003**
Antenna	6.1	10.5	6.4	2.5	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
Miscellaneous	3.5	2.3	7.1	5.1	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
RFI	2.9	2.1	1.5	1.5	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	1.5	0.3	0.9	1.1	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
Receiver	1.1	2.2	3.5	4.7	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
Power	0.5	0.2	0.2	0.3	0.2	0.9	0.4	0.2	0.0	0.3								
Clock	0.5	0.7	0.1	1.2	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
Recorder	0.3	0.4	0.6	0.5	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
Software	0.2	0.0	0.1	0.1	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
Operations	0.1	0.2	1.0	0.6	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
Unknown	0.0	0.0	0.2	0.7	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	0.0	0.0	0.1	0.3	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

groups in Tables 2 and 3 are showing higher than expected averages, even though many stations have delivered more than 70% and 92% of their data. This is mainly due to few stations being down for many days.

Table 4 is providing a detailed breakdown of data loss by sub-system or categories since 2003. These categories 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 schedules 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.

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 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 apparently improve individual station results. Consequently, only summary results have been presented here.

Some detailed comments on the most significant issues for the 2021–2022 data loss are given below.

- Once again, the two largest sources of data loss for 2021–2022 are Antenna and Miscellaneous. The Antenna sub-system loss is mainly due to repairs/maintenance at antennas that took more time than expected. The high values of Miscellaneous are highly affected by stations having other commitments and bad weather. Many hours were lost by antennas being stowed due to high winds or thunderstorms.
- The Receiver sub-system data loss is mainly due to a few stations observing a total of 52 station days with warm receivers.
- Operator performance is very good with less than 0.2% of data loss.
- RFI due to commercial systems continues to be an important factor of data loss for S/X stations. The impact on data loss for VGOS stations is minimal due to higher number of channels.

4 Summary and Outlook

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 many stations have been doing well in 2021–2022.

Alexander Neidhardt will start his activities as IVS Network Coordinator in 2023. His planned work will include the following items:

- update the static network information;

- provide more dynamic feedback to the IVS Directing Board and the IVS Network Stations (using web services);
- contribute to ad hoc working groups on frequencies including fixed observation frequencies for VGOS;
- discuss better feedback structures in the project group on "IVS Success Analysis and Station Feedback."