Network Coordinator Report

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Abstract This report includes an assessment of the S/X network performance in terms of lost observing time for calendar years 2019 and 2020. It also presents some new initiatives being taken to improve the IVS service. For this period, the observing losses were 18.6% in 2019 and 21.6% for 2020; these statistics are very similar to the prior 2017–2018 period. Various tables are presented to break down the relative performance of the network and the incidence of problems with various sub-systems.

1 Introduction

During 2020 we had a transition of the Network Coordinator role from Ed Himwich [1] to Stuart Weston of AUT University, New Zealand [2]. This transition was made more challenging by events during 2020 eliminating international travel.

This report covers three items :

- Observing Network
- Network Performance
- New Initiatives

concluding with a summary. The item "New Initiatives" is a departure from previous reports and aims to highlight initiatives being taken by the Network Coordinator in cooperation with others in enhancing the IVS service.

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IVS Network Coordinator

IVS 2019+2020 Biennial Report

2 Observing Network

The S/X station network for 2019–2020, consisting of 51 stations in total, is shown in Figure 1. The VGOS network has not been included in this report, as the legacy S/X network remained the production system. The network consists of 37 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.

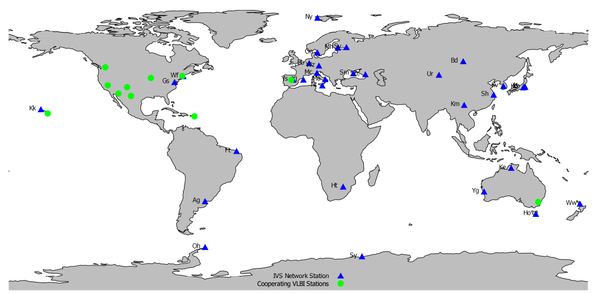

Fig. 1: Network map showing stations that participated in IVS Master Schedule sessions during 2019–2020 marked with blue triangles; other cooperating stations are marked with green circles. This uses the station coordinates from the associated SKD files.

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. 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.

The overall network performance for 2019–2020 is very similar to the prior 2017–2018 period as shown in Figure 2. The results of this report are based on correlator and analysis reports for 341 24-hour correlated sessions. The examined data set includes 2,315,499 dual-frequency observations. Approximately 75% of these observations were successfully correlated, and over 66% were used in the final IVS Analysis Reports for 2019 and 2020. These numbers are slightly down

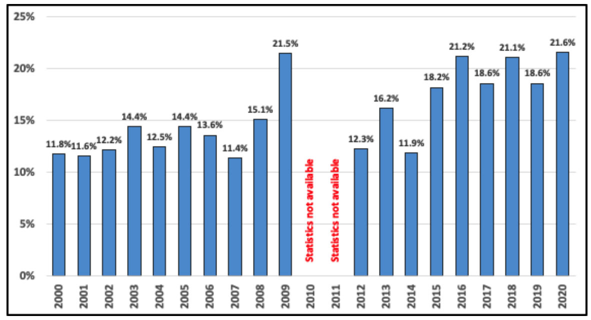

Fig. 2: The historical data loss since 2000.

from the prior 2017–2018 period. Sessions correlated at the VLBA were also included when data analysis reports provided relevant information about reasons for data loss.

Table 1: Data sets used for the 2019–2020 network performance report.

Year	Sessions	Station days	Observations	Correlated	Used
2019	182	1,875 (1,780)	1,276,954	76%	67%
2020	159	1,520 (1,388)	1,038,545	74%	66%

Table 1 summarizes the data set used for the 2019–2020 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. We see a decrease in sessions from the previous 2017–2018 period; the decrease was 10% in 2019 compared to 2017 and 9% for 2020, resulting in a corresponding drop in station days and observations. The percentage correlated was comparable to the previous period but with a drop in the percentage used (from 71% in 2017 and 68% in 2018); this decrease in the percentage used warrants further investigation. The average number of stations per session is 10.3 in 2019 and 9.6 in 2020 compared to 10.1 in 2018.

More than 349 station days (18.6%) were lost in 2019, and 328 (21.6%) days were lost in 2020. The observing time loss for 2019–2020 has been affected by stations that did not observe and were not removed from the master schedule. This loss accounted for 227 station days, or 7%.

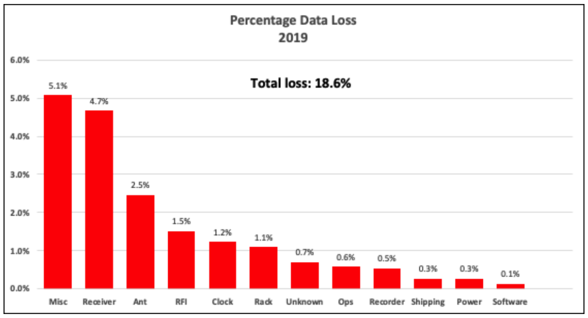

Fig. 3: Percentage of data loss for each sub-sytem in 2019.

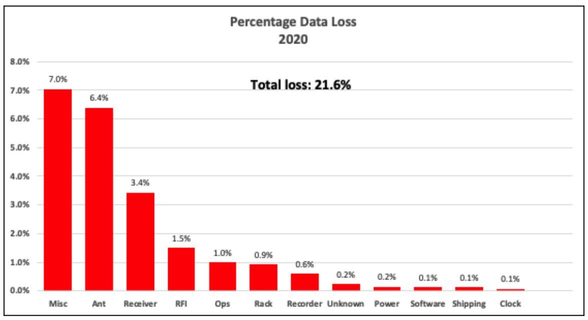

Fig. 4: Percentage of data loss for each sub-sytem in 2020.

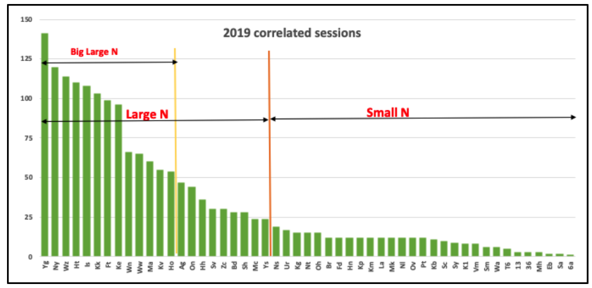

Fig. 5: The number of 24-hour sessions correlated in 2019.

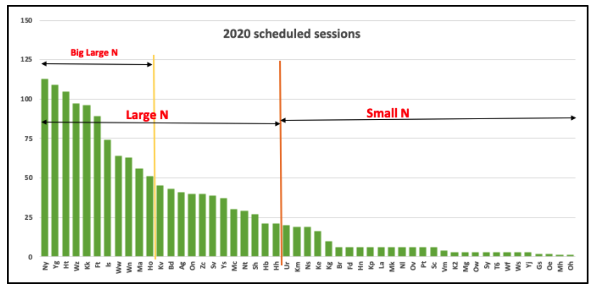

Fig. 6: The number of 24-hour sessions correlated in 2020.

In 2019 the network lost over 18.6% of its data as shown in Figure 3, a slight improvement over the previous period. But for 2020, shown in Figure 4, the loss was 21.6% and is a 3% increase in data loss. This appears to be a repeat of the prior 2017–2018 period. To analyze this global performance, the network has been analyzed by groups: Figure 5 shows 2019, and Figure 6 shows 2020. 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 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.

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 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

Table 2: Group analysis for 2019.

Category	Number stations	Station-days	Average	Median	>92%	<70%
Big Large N (>50)	14	1319	18.0%	19.8%	3	4
Large N (≥21)	23	1595	17.4%	17.0%	6	5
Small N (<21)	28	280	25.3%	19.9%	10	9
Full network	51	1875	18.6%	19.0%	16	14

Table 3: Group analysis for 2020.

Category	Number stations	Station-days	Average	Median	>92%	<70%
Big Large N (>50)	11	917	17.7%	14.4%	5	3
Large N (≥21)	23	1330	21.5%	16.6%	7	8
Small N (<21)	28	178	24.3%	4.1%	17	7
Full network	51	1508	21.8%	8.6%	24	15

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

Sub-System	**2020**	**2019**	**2018**	**2017**	**2016**	**2015**	**2014**	**2013**	**2012**	**2009**	**2008**	**2007**	**2006**	**2005**	**2004**	**2003**
Miscellaneous	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
Antenna	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
Receiver	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
RFI	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
Operations	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
Rack	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
Recorder	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
Unknown	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
Power	0.2	0.3	0.2	0.9	0.4	0.2	0.0	0.3								
Software	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
Shipping	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
Clock	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

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

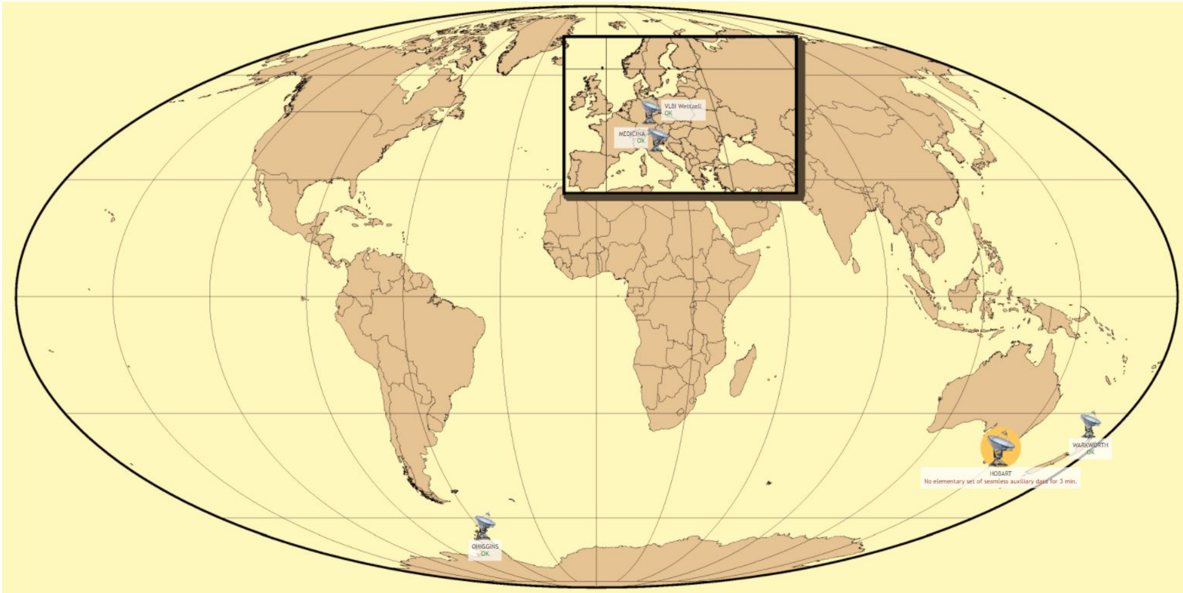

Fig. 7: IVS Auxiliary Data Archive world map with current participating stations.

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 this year's data loss are given below.

- The two largest sources of data loss for 2019–2020 are Miscellaneous and Antenna. 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, 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 a few stations observing a total of 122 station days with warm receivers while waiting for replacement parts.
- Operator performance is very good with less than 0.8% 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 1.5% 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.

4 New Initiatives

In IVS Newsletter 58 [3] Alexander Neidhardt and Stuart Weston introduced the initiative “Data Unlimited – The IVS Seamless Auxiliary Data Archive.” As of early 2021, there are five stations shown in Figure 7 sending data to this archive; these are Wettzell, Medicina, O’Higgins, Hobart, and Warkworth. Currently the following data points are archived: meteorological values, clock offsets, and cable calibrations. We would like to encourage more stations to adopt this; Alexander and Stuart are very happy to assist stations in setting this up. At the March 2021 IVS Directing Board meeting this was adopted as a resolution for stations to try to adopt and contribute to the service.

In addition, there is an initiative from Eskil Varenius (Onsala Space Observatory) in cooperation with and supported by the Network Coordinator for stations to log and record their SEFD/T_{sys}. Eskil Varenius kindly presented a seminar on Station Amplitude Calibration, which he recorded; the slides and video from the seminar are available on the Web [4]. This will help with scheduling for the future, as IVS will have accurate and up-to-date SEFD/T_{sys} measurements for stations. In addition this will assist with investigating source structure in more detail, again leading to improved scheduling. We also envisage a spin-off benefit in that IVS will build a catalog and archive of time monitored source flux density for the sources; this may provide other astronomical discoveries.

Metrics need to be designed and monitored to track and report on the performance of the VGOS network. These metrics also need to allow for possible mixed-mode S/X and VGOS sessions as the two systems run in parallel.

5 Summary

Estimating station data losses could be subjective and some times approximative, but this is a useful tool for evaluating the health of the S/X 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 2019–2020. In addition it is hoped that the new initiatives will be generally adopted by stations and help to improve further the IVS scheduling and service. The VGOS network is not the production system of the IVS yet and has not been included in this report but will be included in future reports.

References

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