

Status of the VGOS Infrastructure Rollout

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Abstract The legacy S/X system has been the production system of the IVS since the inception of the service. However, in 2020, after many years of development, the VGOS system was declared operational, and the fledgling VGOS network (of eight to ten stations) started contributing with operational sessions to the determination of IVS products. The VGOS observing program was expanded in 2021, and it is anticipated to grow further in 2022. In order to extend the observing program, aside from the growing observing network, other infrastructure components of the VLBI processing chain have been further developed. This includes the VGOS correlation and post-processing capabilities as well as VGOS data analysis. We provide a status overview of the infrastructure realization efforts of the VGOS station network and the correlation centers. Further, we outline the VGOS observing plan for 2022.

Keywords VGOS, infrastructure, correlator

1 Introduction

The member organizations of the International VLBI Service for Geodesy and Astrometry (IVS) operate an observational network of VLBI telescopes that currently consists of about 40 stations worldwide. This S/X VLBI network was developed mainly in the 1970s and 1980s. Due to the aging infrastructure but also because of demanding new scientific requirements, the

Table 1 Individual VGOS station projects with recent milestones and projected broadband readiness.

Station	Recent milestone	Broadband
GGAO	VGOS-O, VGOS-R&D	ready
Westford	VGOS-O, VGOS-R&D	ready
Wetzell (Ws)	VGOS-O, VGOS-R&D	ready
Yebes (Yj)	VGOS-O, VGOS-R&D	ready
Ishioka	VGOS-O, VGOS-R&D	ready
Kokee Park (K2)	VGOS-O, VGOS-R&D	ready
Onsala (Oe, Ow)	VGOS-O, VGOS-R&D	ready
McDonald	VGOS-O, VGOS-R&D	ready
Hobart	VGOS-O tagalong	imminent
Sheshan	VGOS-O tagalong	imminent
Santa Maria	S/X observing	mid-2022
Katherine	S/X observing	mid-2022
Yarragadee	S/X observing	end 2022
Ny-Ålesund (Nn)	signal chain work	mid-2022
Ny-Ålesund (Ns)	S/X observing	2022
HartRAO	signal chain work	2022
Metsähovi	signal chain work	2022
Gran Canaria	RT in warehouse, civil works	2023
Urumqi	S/X observing	2023
Chiang Mai	site selected	2024
Fortaleza	site selected	2024
Matera	contract bid	2024
Badary	fixed broadband system	[S/X/Ka]
Zelenchukskaya	fixed broadband system	[S/X/Ka]
Svetloe	fixed broadband system	[S/X/Ka]
Tahiti	site selected, RFI survey	2025
Flores	RFI surveys	2025
Songkhla	site selected	2025
Kanpur	proposal	2025

larger IVS community planned and started to roll out the next-generation VLBI system called VGOS (VLBI Global Observing System) at existing and new sites over the last several years.

In 2020, these efforts culminated in the VGOS system being declared operational. A fledgling network

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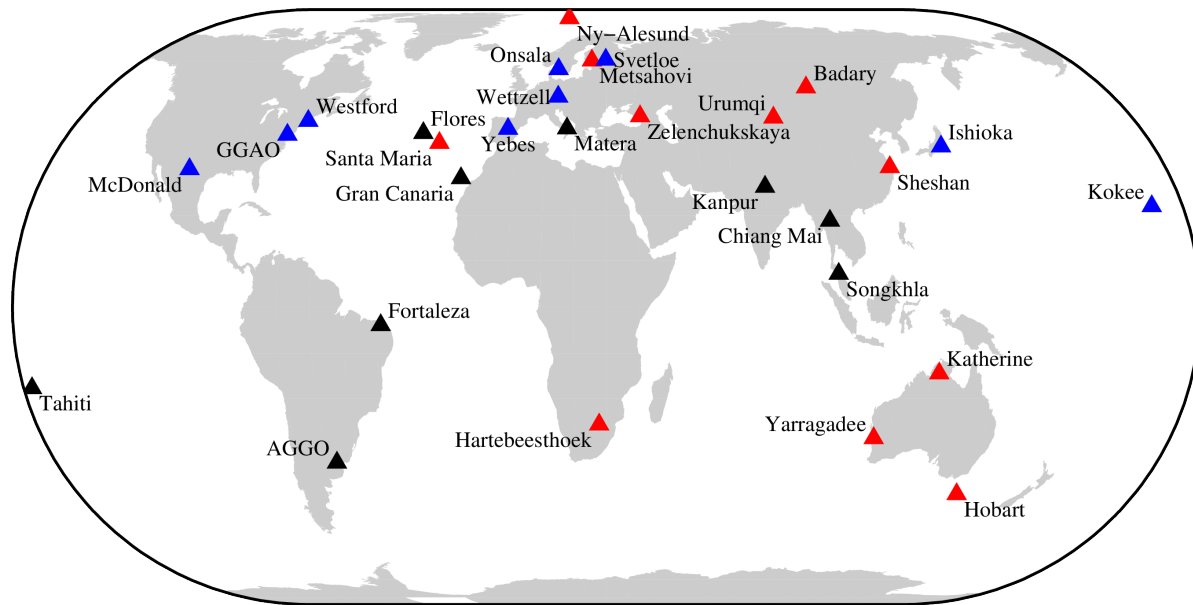


Fig. 1 Geographic distribution of the operational VGOS antennas (▲), built antennas with signal chain work in progress (▲), and VGOS projects in the planning stage (▲).

of up to eight to ten VGOS stations became part of the IVS observing program and, since then, has been contributing to the generation of IVS products. The nascent VGOS observing program has been expanded over the last two years. Prerequisites for this expansion, aside from the growing observing network, have been the further development of the VGOS correlation and post-processing capabilities as well as the VGOS data analysis, among other things. In the following, we summarize which VGOS station network is currently observing, which stations will be added soon, and which stations may be expected on a longer time horizon. In addition to the station infrastructure, we describe the network of operational VGOS correlators and its potential expansion. Finally, we describe the VGOS observing plan that the station and correlator resources in conjunction with data transport and storage capacities/limitations allow us to do in the observing year 2022.

2 Evolution of the VGOS Station Network

The network of VGOS stations currently observing in operational sessions consists of northern hemisphere sites only (Figure 1). This is anticipated to change in

the course of 2022 when the three Australian AuScope telescopes will successively be converted to the VGOS signal chain. First among them, the Hobart antenna is on the cusp of being used operationally. In South Africa, the new antenna at Hartebeesthoek is expected to be integrated in the second half of 2022.

The further evolution of the VGOS station network is depicted in the global distribution map (Figure 1). Recent milestones and the state of the individual VGOS projects are listed in Table 1.

Beyond the projects listed, there are also efforts underway in other parts of the world. This includes undertakings in India, Malaysia, and Indonesia. Please do let the authors know of any other projects that may be in the discussion stage.

3 VGOS Correlation Capabilities

Over the past few years, correlation has advanced from developing VGOS capabilities to operational state and has recently evolved from a single correlator to a network of globally distributed correlators that can process VGOS sessions operationally (Figure 2). Currently, the turnaround time for 24-hour VGOS sessions is one to two months and is improving

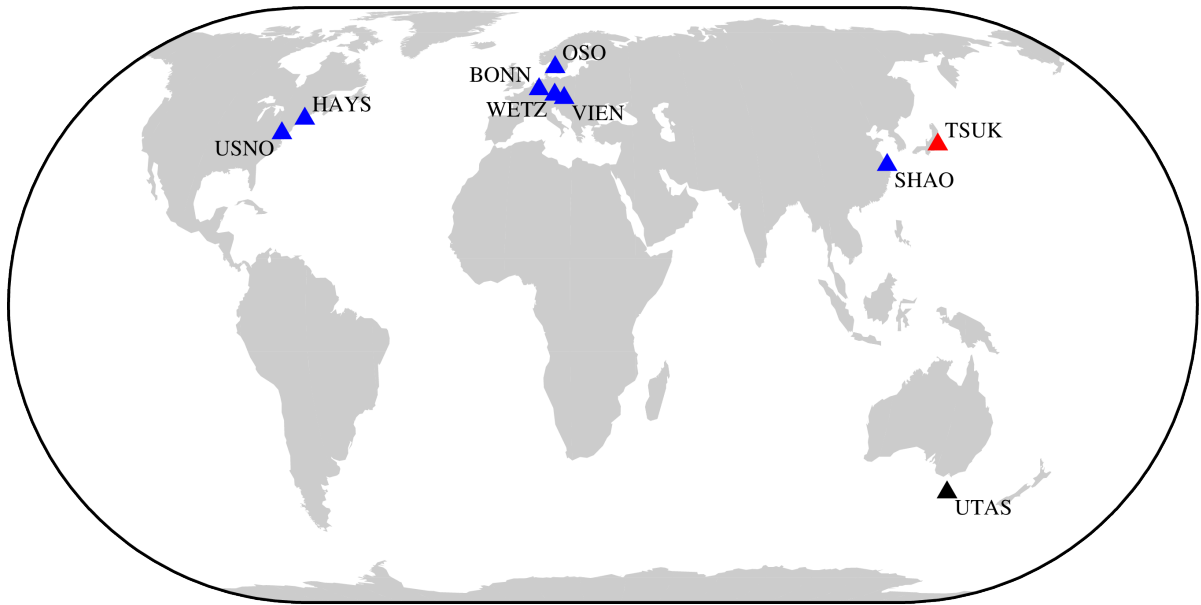


Fig. 2 Geographic distribution of the operational VGOS correlators (▲), correlators under verification (▲), and future correlation centers (▲).

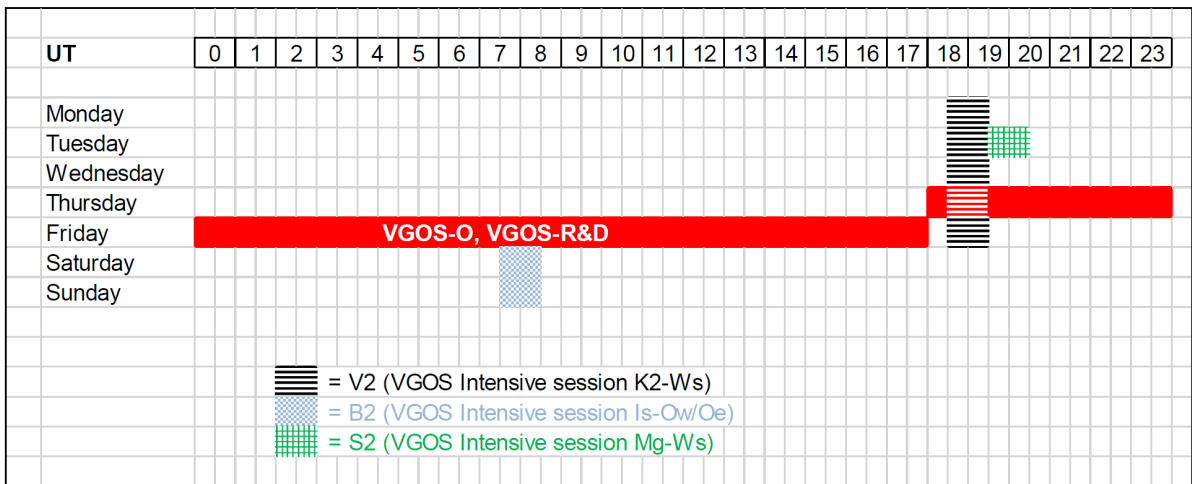


Fig. 3 Overview of the weekly VGOS observing plan for 2022.

as new Correlation Centers gain experience and as data transfer connections from stations to correlators increase capacity.

Other considerations include the need at correlator centers to match the storage capacity for the electronically transferred data of the entire observing network. A subset of the correlators can handle physically shipped Mark-6 modules, while some only support e-transfers. This entails that some data transports need an intermediary.

4 VGOS Observing Plan in 2022

The amount of VGOS observing in 2022 is governed by data transfer and storage limitations as well as correlation limits. The core observing program consists of one 24-hour session and five VGOS Intensives (V2) per week (Figure 3). There are six VGOS-R&D experiments (VR) planned with a cadence of two months replacing the regular VGOS-O sessions (VO).

In addition to the V2, there are two other Intensive series in the planning: B2 on the baseline Is-Ow/Oe (Ishioka–Onsala) to be processed at OSO/TSUK (Onsala/Tsukuba); and S2 on the baseline Mg-Ws (McDonald–Wetzell) to be processed at WETZ (Wetzell). Each VGOS-R&D session (VR) is paired with a one-hour VGOS Test session (VT) to prepare the subsequent R&D session. The VR/VT session pairs are run every other month with increasingly aggressive strategies to test the limits of VGOS (e.g., lower scan lengths in steps down to 3–8 s, reduced accumulation period (AP) times at the correlator from 1 to 0.25 s). Also, an improved frequency sequence that matches protected Radio Astronomy Service (RAS) frequencies of the International Telecommunication Union (ITU) will be employed (RAS matching). The pairing of the VR/VT may require the prioritization of the processing order and correlation time frame.

In short, there are well over 300 VGOS observing sessions planned for 2022, of which about 50 and 265 will be 24-hour and one-hour sessions, respectively.

5 Conclusions and Outlook

The rollout of the VGOS infrastructure is advancing steadily. Indeed, the VGOS network is expected to almost double from its fledgling state of nine northern

hemisphere sites to up to sixteen global sites by the end of 2022. Importantly, several of those new sites are located in the southern hemisphere. The number of correlators capable of processing VGOS data has grown to seven centers—a most remarkable increase compared to only one a few years back.

The number of VGOS observing sessions planned for 2022 thrives relative to past years. However, data transport and storage as well as correlator time are the main resources that limit the current program. It is expected that processing efficiencies at the correlators will be improved over time resulting in an increased cadence of observing sessions. Nonetheless, this has to go hand in hand with enhancements of storage capacity and data transfer rates.

There is still work to be done to be able to transition from the legacy S/X system to the VGOS system as the production workhorse of the IVS. Having two systems in parallel, of course, also means that they compete for resources. It is however essential that the nascent VGOS time series are rigorously integrated with the existing S/X time series so that the long-lasting S/X series can be carried forward by VGOS without real lapse. The tie of the S/X and VGOS systems can be accomplished by mixed-mode sessions as well as local tie sessions at sites with co-located legacy S/X and VGOS stations.