Status of the VGOS Infrastructure Rollout

Dirk Behrend[1], Chet Ruszczyk[2], Pedro Elosegui[2], Stuart Weston[3]

[1] NVI, Inc./NASA Goddard Space Flight Center, Greenbelt, MD, USA
[2] MIT Haystack Observatory, Westford, MA, USA
[3] Auckland University of Technology, Auckland, New Zealand

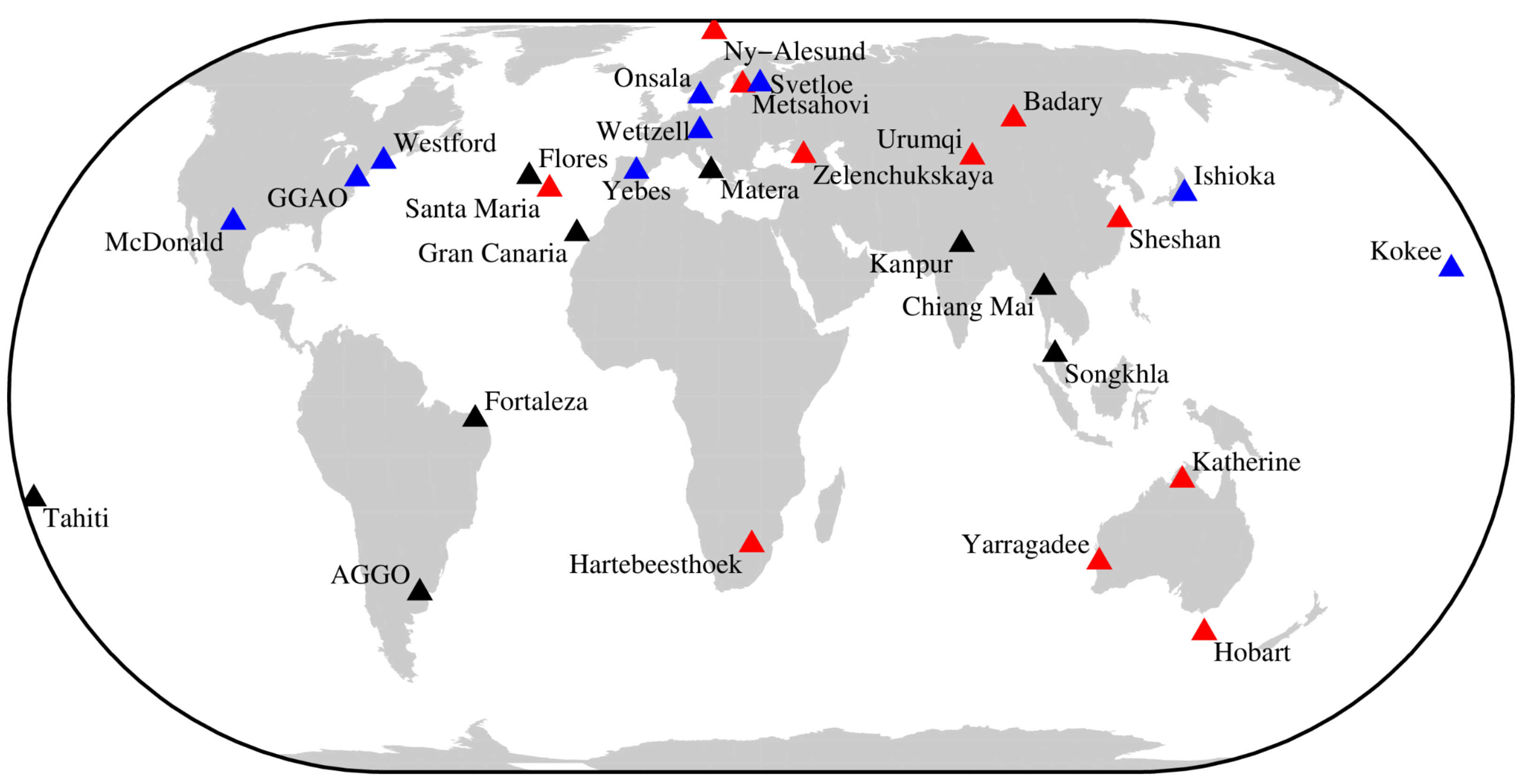
Introduction

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 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, following many years of development, the VGOS system was declared operational and the fledgling VGOS network (currently of 8–10 stations) started contributing with operational sessions to the generation of IVS products. The VGOS observing program was expanded in 2021 and it is growing 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. In the following, we give an overview of the current infrastructure realization of the VGOS station network as well as the correlation centers. Further, we outline the VGOS observing plan for 2022.

Evolution of the VGOS Station Network

The network of VGOS stations currently observing in operational sessions consists of northern hemisphere sites only. 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.



▲ operational ▲ antenna built, signal chain work
▲ in planning stage

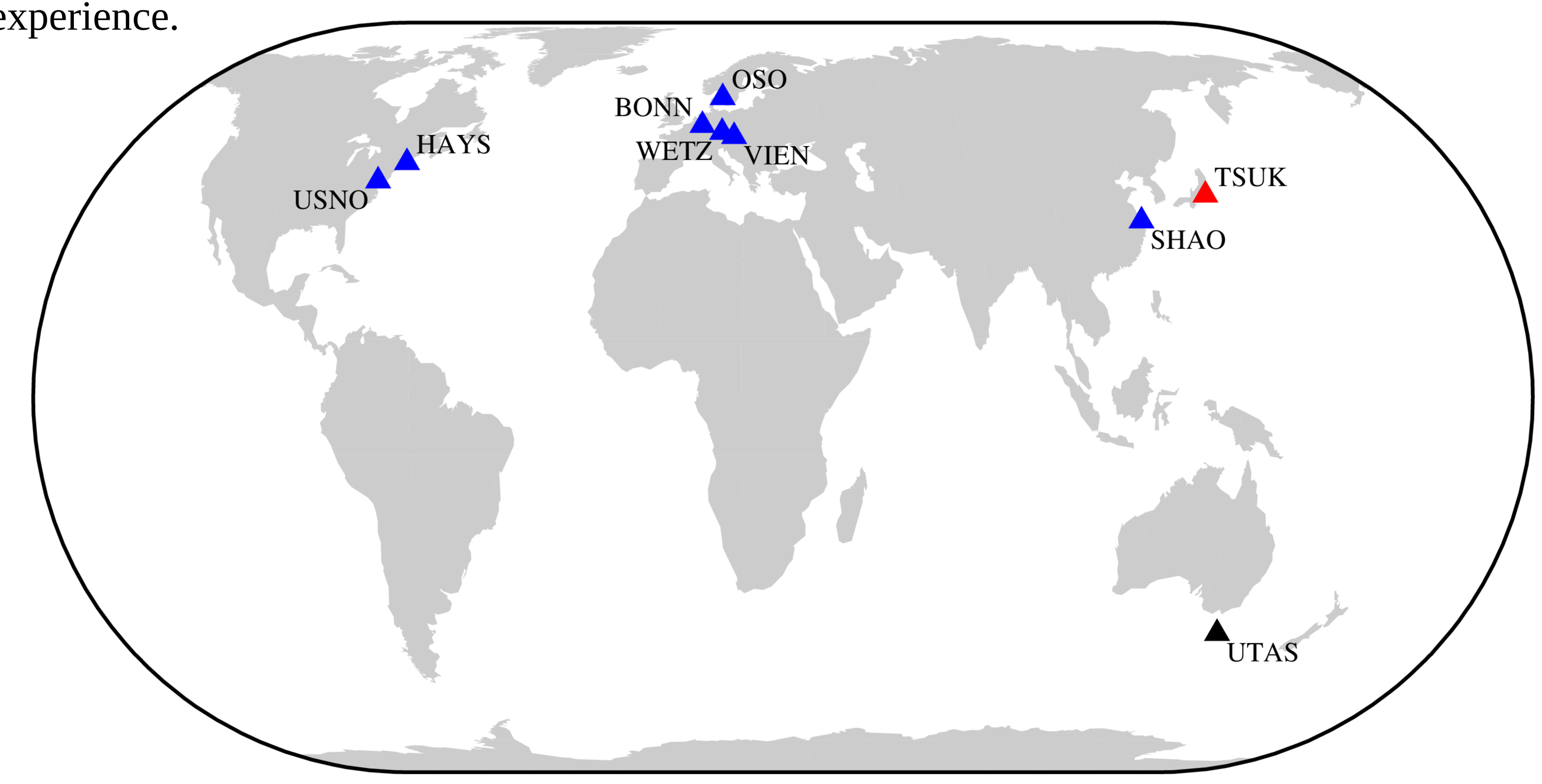
The further evolution of the VGOS station network is depicted in the global distribution map. Recent milestones and the state of the individual VGOS projects are listed in the table.

Station	Recent milestone	VGOS broadband
GGAO	VGOS-O, VGOS-R&D	ready
Westford	VGOS-O, VGOS-R&D	ready
Wettzell (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
Badary	Fixed broadband system	2017 (S/X/Ka)
Zelenchukskaya	Fixed broadband system	2017 (S/X/Ka)
Svetloe	VGOS fringe test with Oe/Ow	2019 (S/X/Ka)
Gran Canaria	RT in warehouse, civil works	2023
Chiang Mai	Site selected	2024
Fortaleza	Proposal	2024
Matera	Contract bid	2024
Tahiti	Site selected, RFI survey	2025
Flores	RFI surveys	2025
Songkhla	Site selected	2025
Kanpur	Proposal	2025

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.

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. Currently, the turnaround time for 24-hr VGOS sessions is 1–2 months and improving as new correlation centers gain experience.

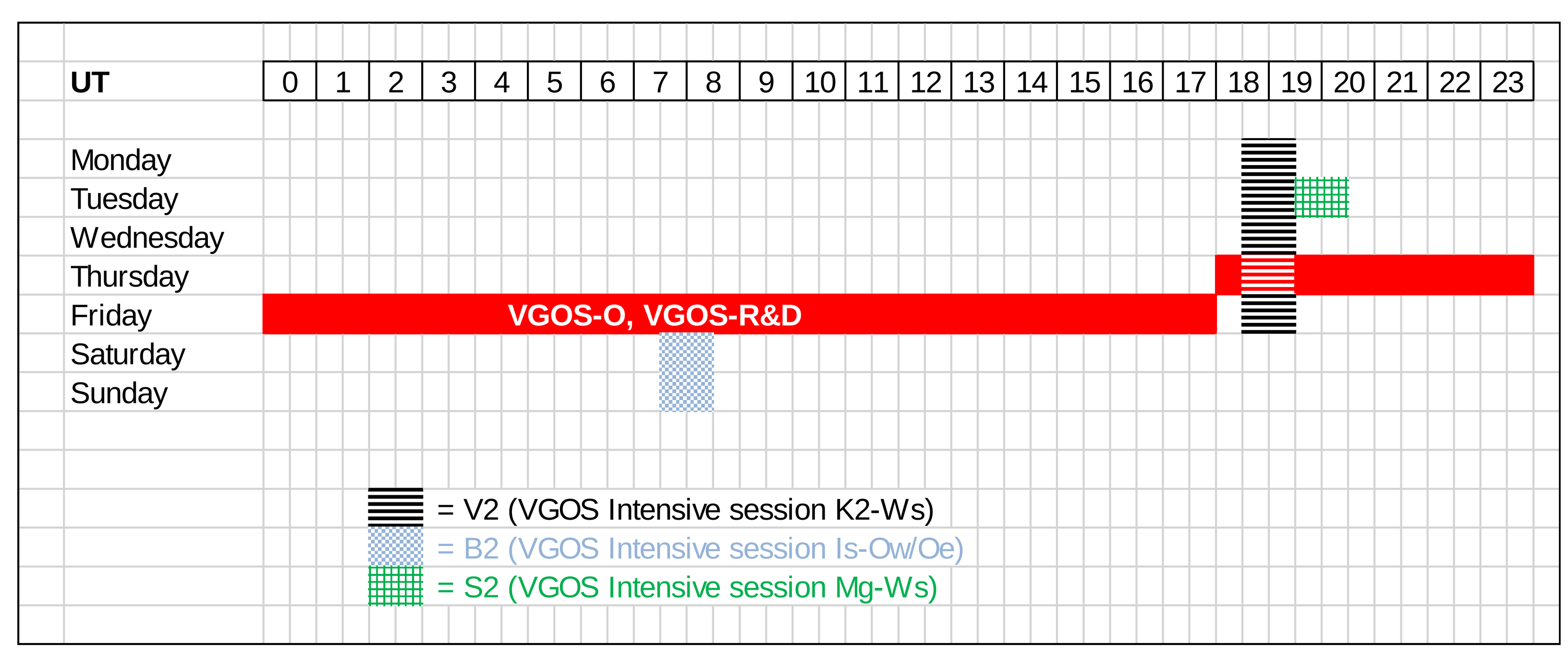


▲ operational ▲ under verification
▲ future correlation center

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 Mark6 modules, while some only support e-transfers. This entails that some data transports need an intermediary.

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. There are six VGOS-R&D experiments (VR) planned with a two-monthly cadence 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 Ishioka–Onsala to be processed at Onsala/Tsukuba; and S2 on the baseline McDonald – Wettzell to be processed at Wettzell. Each VGOS-R&D session (VR) is paired with a 1-hr 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 AP times at the correlator from 1 to 0.25 s). Also, an improved frequency sequence (RAS matching) will be employed. 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-hr and 1-hr sessions, respectively.

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.

E-mail: dirk.behrend@nasa.gov