Westford Antenna 2021+2022 Report

Mike Poirier, Alex Burns

Abstract Technical information is provided about the VLBI antenna and equipment located at the Westford site of the Haystack Observatory, which is the off-campus location of the Massachusetts Institute of Technology (MIT) in Westford, Massachusetts. Updated information is also provided about changes introduced to the VLBI systems since the last IVS Biennial Report in 2021.

1 Westford Antenna at Haystack Observatory

Since 1981, the Westford antenna has been one of the primary geodetic VLBI sites in the world. Located about 70 km northwest of Boston, Massachusetts, the antenna is part of the MIT Haystack Observatory complex (Table 1). The Westford antenna was constructed in 1961 as part of the West Ford Project by Lincoln Laboratory. The project demonstrated the feasibility of long-distance communications by bouncing radio signals off a spacecraft-deployed belt of copper dipoles flying at an altitude of about 3,600 km above the Earth's surface. The antenna was converted to geodetic use in 1981, becoming one of the first two VLBI stations of the POLARIS Project by the National Geodetic Survey (NGS). Westford has continued to perform geodetic VLBI observations on a regular basis since 1981. In recent years, Westford has been focused on, and has supported, the technology development and operational integration of the next-generation VLBI Geodetic Observing System (also known as VGOS; e.g., Niell et al., 2018; Merkowitz et al., 2019). As the first "prototype" VGOS station, Westford continues to provide this valuable knowledge base to all of the new VGOS operational stations as they come on line around the world.

MIT Haystack Observatory

Westford Antenna

IVS 2021+2022 Biennial Report

Fig. 1 Aerial view of the radome and facilities of the Westford antenna at MIT Haystack Observatory. (For scale, the diameter of the radome, which veils the 18.3-m diameter antenna, is 28 m.)

2 Technical Parameters of the Westford Antenna and Equipment

The Westford antenna is enclosed in a 28-meter air-inflated radome constructed of a 1.2-mm thick teflon fabric (Raydel R-60) (Figure 1 and Table 2). The major components of the VLBI data acquisition system at Westford include a VGOS broadband cryogenically-cooled receiver, RF-over-Fiber (RFoF) transmission links, an RF power distributor, four Up/Down converters (v2.1), four R2DBEs, and a Mark 6 recorder with an expansion chassis. The VGOS signal chain is controlled by the personal computer field system (PCFS) running version 10.0.0. Westford is also equipped with an MCI system, which monitors and logs parameters for key components in the system. The primary frequency standard on site is the NR-4 hydrogen maser.

Table 1 Approximate geographical location, altitude above mean sea level (m.s.l.), and shipping addresses of the Westford antenna.

Longitude	71.49° W
Latitude	42.61° N
Height above m.s.l.	116 m
MIT Haystack Observatory 99 Millstone Rd Westford, MA 01886-1299 U.S.A.	
https://www.haystack.mit.edu	

Table 2 Technical parameters of the Westford antenna for geodetic VLBI.

Parameter	*Westford*
primary reflector shape	symmetric paraboloid
primary reflector diameter	18.3 meters
primary reflector material	aluminum honeycomb
feed location	primary focus
focal length	5.5 meters
antenna mount	elevation over azimuth
antenna drives	electric (DC) motors
azimuth range	90° – 470°
elevation range	4° – 87°
azimuth slew speed	3° s^{-1}
elevation slew speed	2° s^{-1}
	Frequency range 2–14 GHz
T_{sys} at zenith	40–70 K
aperture efficiency	0.25–0.60
SEFD at zenith	1800–4500 Jy

Westford also continues to host WES2, the permanent Global Navigation Satellite System (GNSS) site of the International GNSS Service (IGS) network. The WES2 system currently consists of a Tallysman Vera-Choke GNSS antenna and a Trimble Alloy receiver. The antenna is located on top of a tower about 60 meters from the VLBI antenna, and the receiver is housed within the Westford premises. This new receiver, as well as LMR-600 cable and an additional lightning protector, were installed in March of 2021, and the new antenna in October 2021.

3 Westford Staff

The personnel associated with the geodetic VLBI program at Westford, and their primary responsibilities, are:

- Tony Bettencourt: Technician, Observer
- Alex Burns: Technician, Observer
- Chris Eckert: Mechanical Engineer
- Pedro Elosegui: Principal Investigator
- Colin Lonsdale: Site Director
- Glenn Millson: Observer
- Arthur Niell: VLBI Science Support
- Michael Poirier: Site Manager
- Ganesh Rajagopalan: RF Engineer
- Chet Ruszczyk: Associate Principal Investigator

4 Standard Operations

From January 1, 2021 through December 31, 2022, Westford participated in 77 VGOS sessions, including three VGOS Tests (VT), 65 VGOS operational sessions (VO), and seven S/X legacy—VGOS R&D-type 24-hour sessions. Westford also supported two so-called VGOS Intensive sessions (VI and/or V2), along with many short fringe tests with other worldwide stations, thus assisting in their VGOS system configuration and operational checkout.

5 Research and Development

Presently, we are running bi-weekly 24-hour sessions supporting the core VGOS network. These sessions cover a wide range of focus from engineering testing to the standardizing of operational configuration formats supporting the expanding VGOS network.

Fig. 2 View of the Westford antenna inside the radome. The VGOS broadband receiver is located at the prime focus.

6 Outlook

Westford presently expects to continue to support the VGOS operational series of 24-hour sessions, along with supporting new development, testing, and integration of VGOS operational systems around the world.

We expect that over the next two years we will continue to upgrade our operational systems to help Westford in breaking new ground in VLBI technical development and support for the operational network of stations, along with locally running stable and consistent operations.

Acknowledgements

Funding for geodetic VLBI research and development (R&D) as well as operations at Westford is provided by the NASA Space Geodesy Program (SGP).

References

1. Niell A., J. Barrett, A. Burns, R. Cappallo, B. Corey, M. Derome, C. Eckert, et al. 2018. Demonstration of a Broadband Very Long Baseline Interferometer System: A New Instrument for High-Precision Space Geodesy.*Radio Science*, 53:1–23. doi.org/10.1029/2018RS006617.
2. Merkowitz, S. M., S. Bolotin, P. Elosegui, J. Esper, J. Gipson, L. Hilliard, E. Himwich, et al. 2019. Modernizing and Expanding the NASA Space Geodesy Network to Meet Future Geodetic Requirements. *Journal of Geodesy* 93 (11): 2263–2273. doi.org/10.1007/s00190-018-1204-5.