

Westford Antenna Report

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Abstract Technical information is provided about the geodetic Very Long Baseline Interferometry (VLBI) antenna and equipment located at the Westford site of the Haystack Observatory, the off-campus location of the Massachusetts Institute of Technology (MIT) in Westford, Massachusetts (MA). Updated information is also provided about changes to the VLBI system as well as to the global navigation satellite system (GNSS) at the Westford site since the last International VLBI Service (IVS) Biennial Report in 2023.

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 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.

MIT Haystack Observatory

Westford Antenna

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Table 1 Geographical location (in the WGS84 reference ellipsoid) and shipping addresses of the Westford antenna.

Longitude	71.4937971° W
Latitude	42.6129489° N
Height	86.77 m
MIT Haystack Observatory 99 Millstone Rd Westford, MA 01886-1299 U.S.A. https://www.haystack.mit.edu	

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; Merkwitz 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 online around the world.

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, RF power distributor, four Up/Down converters (v2.1), four R2DBEs, and a Mark 6 recorder with expansion chassis. The VGOS signal chain is controlled by the personal computer field system (PCFS) running



Fig. 1 Aerial view of the radome and facilities of the Westford antenna. (For scale the diameter of the radome is 28 m.)

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 2 Technical parameters of the Westford antenna for geodetic VLBI.

<i>Parameter</i>	<i>Westford</i>
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
<i>Frequency range 2 – 14 GHz</i>	
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 VeraChoke 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 GNSS at Westford

The Westford site also continues to host WES2, a permanent Global Navigation Satellite System (GNSS) site of the International GNSS Service (IGS) network in continuous operations since 1992. The GNSS antenna is located on top of a tower about 60 meters from the VLBI antenna. Westford installed a new Tallysman VeraChoke VC6150 antenna in 2023, which together with the Trimble Alloy receiver and LMR-600 cabling, make up the WES2 station. The GNSS receiver clock is fed off the same hydrogen maser that runs the VLBI system.

4 Standard Operations

From January 1, 2023 through December 31, 2024, Westford participated in 62 VGOS sessions under IVS auspices, including 53 VGOS operational sessions (known as VO series) and nine VGOS R&D-type sessions (known as VR series). Westford also supported many short fringe tests with other worldwide stations, thus assisting in their VGOS system configuration and operational checkout.

5 Research and Development

Presently, Westford is running approximately weekly 24-hour sessions supporting the core VGOS network. These sessions cover a wide range of foci from engineering testing to the standardizing of operational configurations, thereby supporting the expansion and consolidation of the VGOS network.

6 Outlook

Westford expects to continue to support the VGOS operational series that are coordinated by the IVS, along



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

with supporting new development, testing, and integration of VGOS operational systems around the world.

Furthermore, there is the prospect of expanding the Westford contribution to the IGS by hosting a new GNSS monument, WES3, in the coming year. The plan is for the new antenna to be mounted on a deep drilled braced monument (DDBM), which will provide a more stable base than the current location for WES2.

We expect to continue to upgrade our operational systems over the next two years 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.

7 Westford Staff

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

- Tony Bettencourt: Technician, Observer
- Alex Burns: Site Manager
- Chris Eckert: Mechanical Engineer
- Pedro Elosegui: Principal Investigator
- Phil Erickson: Haystack Director
- Abiel Mendez: Technician, Observer
- Arthur Niell: VLBI Science Support
- Michael Poirier: Site Manager (retired)
- Ganesh Rajagopalan: RF Engineer
- Chet Rusczyk: Co-Principal Investigator

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References

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