

New Zealand 12-m VLBI Station

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Abstract

This report provides geographical and technical details of a new 12-m geodetic VLBI antenna operated by the Institute for Radio Astronomy and Space Research at Auckland University of Technology. Details of the VLBI system installed in the station are outlined. A co-located GNSS station and specialized surveying equipment are also described.

1. Introduction

The IVS VLBI2010 Progress Report [1] outlines a number of strategies to improve the long-term accuracy of geodetic VLBI with an eye to achieving 1 mm long-term accuracy on baselines. Among these strategies are: “to increase the number of antennas and improve their geographic distribution” and “to increase the number of observations per unit of time”. These IVS strategies can best be addressed through construction of new small (~ 12 m), fast-slewing automated antennas in areas that are under-represented (Southern Hemisphere) or lack geodetic VLBI stations (e.g. New Zealand).

Developing this approach, AUT University has invested US\$1m in a geodetic VLBI system, consisting of a fast-slewing automated 12-m antenna, hydrogen maser clock, digital receiving and digital backend systems, and a 1 Gbps network connectivity.

The 12-m antenna installed in August–September 2008 and officially launched on 8 October 2008 (Figure 1) is scheduled to start participating in regular IVS VLBI sessions from the middle of 2010.

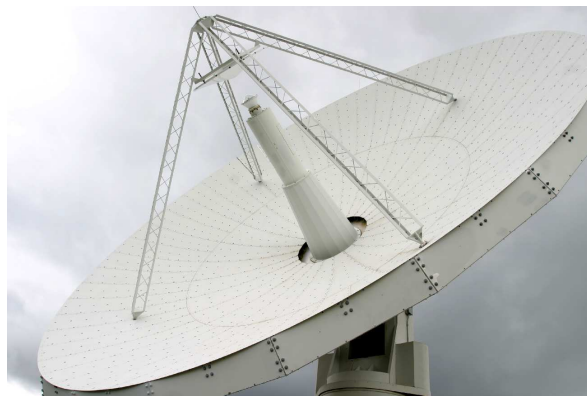


Figure 1. New Zealand 12-m VLBI antenna

2. Geographical Information

The New Zealand VLBI Station is located at Satellite Station Valley some 5 km south of the township of Warkworth, which is about 60 km north of the city of Auckland (Figure 2).

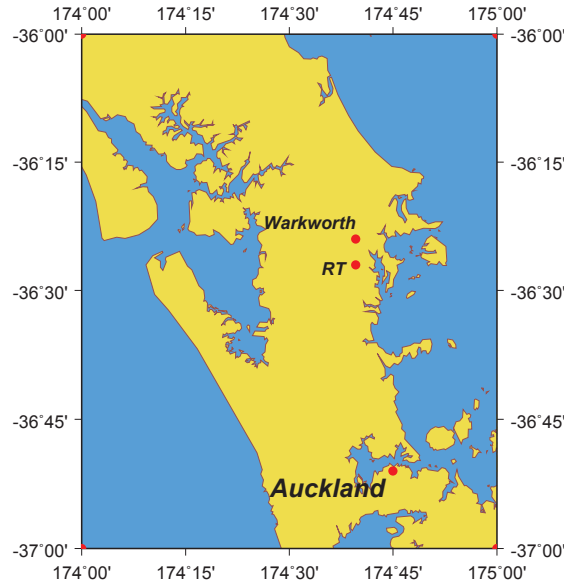


Figure 2. Map of New Zealand’s North Island. Location of the VLBI station and Warkworth are indicated. (Projection: Mercator)

The valley is owned by Telecom New Zealand with several satellite dishes installed (of which a 30-m is the biggest one) and operated to provide communication between New Zealand and Pacific Islands (Fiji, Cook Islands, Samoa) and Antarctica (Scott Base). The dishes are directed towards geostationary satellites to the north of the site and operate in C-band (4 and 6 GHz). The location is reasonably radio quiet in both S and X bands, and it is protected by local by-law from potential RFI sources.

The location of the antenna’s rotational axes intersection was surveyed to a decimeter accuracy with the use of the real-time kinematic GPS (see [2]).

The approximate location of the antenna axes intersection is

Latitude: $36^{\circ}26'05.338''$ S

Longitude: $174^{\circ}39'47.699''$ E

X = -5115327.28 m

Y = 477844.04 m

Z = -3767196.04 m

3. Technical Information

The 12-m Radio Telescope (RT) was manufactured by Patriot Antennas Inc. in Albion, Michigan, USA.

The list below provides technical specifications for the high-frequency RTNF antenna:

- Diameter: 12.1 m
- Surface Accuracy 0.36 mm (0.014 inches) rms.

- Frequency range: 1.6 - 32 GHz.
- Dual shaped Cassegrain, $F/D = 0.375$ (primary surface)
- Directive efficiency: 85%
- Pointing Accuracy: 0.005 degree
- Operational temperature range: -15 to +55 deg C
- Specs apply in winds of 30 mph (50 km/h)
- 100 mph (160 km/h) survival in stow
- + 4.5 to 88 deg elevation travel
- +/- 270 degree azimuth travel
- Slew and scan rates
 - Up to 5 deg/s in Azimuth
 - Up to 1 deg/s in Elevation

Installation of the 12-m radio telescope was finished in October 2008 with the first light in August 2009. The radio telescope is equipped with the coaxial dual band (S and X) dual polarization (circular left/right) feed horn, which was specifically developed by Patriot Antennas. Four MITEQ's high-gain low-noise amplifiers (LNAs) are installed for both S and X bands and both polarizations. Symmetricom Active Hydrogen Maser MHM-2010 (75001-114) has three outputs @ 5 MHz, one output @ 10 MHz, one output @ 100 MHz, two outputs @ 1 pps (pulse per second), and a 1 pps sync. A separate distribution amplifier unit allows up to 15 outputs of the 10 MHz signal to be obtained. A digital base band converter (DBBC) developed at the Italian Institute of Radio Astronomy is expected to be installed in May 2010. The AUT VLBI receiving system uses the Mark 5B+ data recorder developed at MIT Haystack Observatory.

Both S and X receivers have been installed, and preliminary figures for SEFD are around 4000 Jy, a figure that is higher than expected. Investigations in collaboration with the manufacturer are underway, and several areas in which improvements can be made have been identified.

4. Co-located Facilities

New Zealand's traditional role in contributing to global reference frame determination is through its GNSS PositionNZ network operated by Land Information New Zealand in a partnership with the Geological and Nuclear Sciences Research Institute (GNS Science). The PositionNZ network consists of 33 GNSS continuously operating reference stations (CORS) in mainland New Zealand, 1 on the Chatham Island (400 km east of Christchurch) and 3 in Antarctica [5]. Data from several of these sites are forwarded to the International GNSS Service (IGS) where they are incorporated into solutions used to determine GNSS satellite orbit and global reference frame determinations.

In November 2008 a new PositionNZ station (WARK) was built at the AUT radio telescope site, and an accurate tie has been established between the radio telescope antenna and the GNSS

antenna. With this purpose, four geodetic monuments were built in the vicinity of the antenna (15-20 m from its pedestal).

5. Network Connectivity

With wide spread development of e-VLBI, the issue of broadband network connectivity becomes essential for both existing and emerging radio astronomical facilities.

Internationally, New Zealand's major broadband supplier is Southern Cross Cables Ltd—a commercial organization, which owns and operates the cable connecting New Zealand with Australia in the West and with the US in the South-North direction. This is a multi-wavelength cable with the capacity of 1 Tbps.

Locally, the regional advanced network operating in New Zealand is KAREN (Kiwi Advanced Research and Education Network), which provides a 10 Gbps connectivity between New Zealand's educational and research institutions. KAREN is planning to establish a GigaPoP in Warkworth near the location of the 12-m radio telescope.

6. Education

The radio telescope is operated by the Institute for Radio Astronomy and Space Research (IRASR). Being a research tool for astronomy and geodesy, the antenna is also used in a new educational program in astronomy started in 2009 at AUT's School of Computing and Mathematical Sciences—an Astronomy Major in the framework of the Bachelor of Mathematical Sciences degree. It is envisaged that both undergraduate and postgraduate students will use the radio telescope in their research projects and as a teaching resource in the courses taught at AUT such as Astrophysics, Radio Astronomy, Practical Astrophysics, Space Geodesy and others.

References

- [1] Petrachenko, B. et al., Design Aspects of the VLBI2010 System. Progress Report of the IVS VLBI2010 Committee. NASA/TM-2009-214180, June 2009.
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