Warkworth Space Center

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Abstract During the 2023–2024 reporting period, several significant developments impacted the Warkworth Space Center operations and infrastructure. Notably for the 12-m antenna, attenuation issues in the S-band Right Circular Polarization Low-Noise Amplifier necessitated its replacement in 2023, and elevation drive problems led to the replacement of the jack-screw in 2024. This report provides an overview of these changes and summarizes the performance and technical characteristics of the VLBI station facilities.

1 General Information

The Warkworth Space Center, formerly known as the Warkworth Radio Astronomical Observatory, is located approximately 60 km north of Auckland, near the township of Warkworth, New Zealand. Until mid-2023, the observatory was operated by the Institute for Radio Astronomy and Space Research (IRASR) at Auckland University of Technology. Since then, operations have been managed by Space Operations New Zealand Ltd.

The Warkworth station contributes to the International VLBI Service (IVS) as a network station, supporting geodetic and astrometric VLBI observations. The site hosts two radio telescopes as shown in Figure 1), a 12-m dual-shaped Cassegrain antenna and a 30-m wheel-and-track beam-waveguide antenna. Both are equipped for VLBI operations and supported by modern backend systems and high-speed network connectivity.

Fig. 1 The Warkworth 12-m antenna in the foreground with the 30-m antenna in the background. Photo taken on 10 December 2024. Figure credit: Axl Rogers.

The station uses a Symmetricom Active Hydrogen Maser (MHM-2010) as its frequency standard. Data recording and streaming are handled by FlexBuff systems (Supermicro servers) running *jive5ab*, connected via fiber to the DBBCs. The observatory is linked to the Research and Education Advanced Net-

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Table 1 Specifications of the Warkworth 12-m and 30-m antennas. Note that the variation in the Warkworth 12-m antenna's S-band System Equivalent Flux Density (SEFD) values reflects the replacement of the Right-Hand Circular Polarization (RHCP) Low-Noise Amplifier (LNA) in October 2023.

Parameter	12-m Antenna	30-m Antenna
Antenna type	Dual-shaped Cassegrain	Wheel-and-track, Cassegrain Beam-waveguide
Manufacturer	Cobham/Patriot, USA	NEC, Japan
Main dish diameter	12.1 m	30.48 m
Secondary reflector diameter	1.8 m	2.715 m
Focal length	4.538 m	10.44 m
Surface accuracy	0.35 mm	1.2 mm
Mount type	Alt-azimuth	Alt-azimuth
Azimuth axis range	$90^\circ \pm 270^\circ$	-179° to $+354^\circ$
Elevation axis range	7.2° to 88°	6.0° to 90.1°
Azimuth max speed	5°/s	0.37°/s
Elevation max speed	1°/s	0.36°/s
Frequency range:		
S-band	2200–2300 MHz	2200–2300 MHz
C-band		6600–6700 MHz
X-band	8200–9000 MHz	8100–9000 MHz
SEFD (mid-band):		
S-band (01/2023-09/2023)	5800 Jy	2100 Jy
S-band (10/2023-04/2024)	8900 Jy	2100 Jy
C-band		700 Jy
X-band	5000 Jy	800 Jy

work New Zealand Ltd (REANNZ) national research network provided via a 10 Gbps fiber connection.

2 Component Description

The Warkworth VLBI station comprises two antennas with the specifications listed in Table 1. These facilities support a range of VLBI observations and have undergone several technical upgrades during the reporting period from January 2023 to December 2024.

The **12-m antenna** is equipped with an S/X dual-band, dual-circular polarization feed at the secondary focus. Backend digitization is performed using a DBBC2 system developed by HAT-Lab located in Catania, Italy.

The **30-m antenna** is also equipped with a DBBC2 for backend digitization. It is currently fitted with room temperature S-band, C-band, and X-band dual-circular polarization receivers. Additionally, a 4.8 GHz dual-circular polarization receiver was developed for participation in the RadioAstron mission.

3 Staff

The following personnel contributed to IVS-related activities at the Warkworth Space Center during the 2023–2024 reporting period:

- **Dr. Stuart Weston** (Station Manager) – Responsible for overall station operations, coordination of IVS sessions, and technical oversight of antenna maintenance and upgrades. Dr. Weston also leads collaboration efforts with international partners and contributes to system diagnostics and performance analysis.
- **Axl Rogers** (Engineer, Ground Segment) – Provides hands-on support for antenna maintenance and equipment calibration. Axl also contributes to observation scheduling, participates in all IVS observing sessions, and ensures data integrity and timely delivery to correlators following each session.

4 Current Status and Activities

During the 2023–2024 reporting period, the Warkworth 12-m antenna continued to support IVS operations, although its availability was significantly impacted by technical issues and weather-related downtime. A breakdown of scheduled and observed IVS sessions by experiment type is presented in Table 2.

Table 2 Warkworth 12-m IVS 2023 and 2024 session participation.

Experiment	2023		2024	
Type	Scheduled	Observed	Scheduled	Observed
AOV	12	10	4	0
AUA	11	11	11	3
AUM	16	14	0	0
CRD	6	6	5	0
OHG	6	4	6	1
R1	4	4	22	6
R4	31	27	42	7
TRF	0	0	1	1
Total	86	76	91	18

In 2023, the station experienced moderate disruption, with 10 sessions (12%) lost due to weather and mechanical issues, particularly with the elevation motor. The MET4 meteorological sensor also failed during this period, resulting in a loss of weather data. Additionally, the S-band RHCP LNA failed and was replaced.

In 2024, the station faced more severe operational challenges. Only 18 of 91 scheduled sessions (20%) were observed. The elevation motor issues from 2023 recurred early in the year, leading to extended downtime. A series of mechanical repairs were undertaken, including replacement of the lower hard limit switch, bevel gear bushes, and trunnions. The failure was ultimately traced to degradation of the jack-screw's case hardening—a known issue with Patriot antennas. The six-month lead time for a replacement accounted for most of the downtime. These repairs restored full functionality to the 12-m antenna by the end of 2024.

Both the 12-m and 30-m antennas continue to support Australian Long Baseline Array (LBA) sessions, with antenna selection based on frequency requirements. The station also maintains ongoing collaborations with space agencies and commercial partners for spacecraft tracking using both antennas.

5 Future Status

Following the sale of the Auckland University of Technology facilities to Space Operations New Zealand Ltd in July 2023 and the successful replacement of the elevation jack-screw in December 2024, the Warkworth Space Center is now fully operational under its new management, with a focus on maintaining its contributions to IVS and other international collaborations.

Regular participation in IVS sessions is planned for 2025, with a focus on R1, R4, and AUA sessions. To help reduce session losses, priority is being given to the implementation of Zabbix, an open-source monitoring system designed to actively track and assess component performance.

To improve system sensitivity, temporary Kuhne (KULNA 200250A-SMA) LNAs have been installed for S-band on the Warkworth 12-m antenna. This has resulted in a reduced SEFD of approximately 4800 Jy. While this is an interim solution, it represents a significant improvement as more permanent upgrades are evaluated. We look forward to reporting on the improved performance and outcomes in the next biennial report for 2025–2026.

Planned activities and developments for 2025 include:

- Re-engagement with a full IVS observing schedule, with a focus on improving session completion rates
- Continued support for Australian LBA observations and spacecraft tracking operations
- Evaluation of potential backend system upgrades (e.g., installation of a DBBC3)
- Replacement of aging infrastructure, including RF cabling, legacy servers, and related components
- Review of as-built documentation
- Comprehensive review of all operational software for completeness and serviceability
- Configuration of the 12-m antenna to support space operations. This includes the installation of very low-loss waveguide switches to toggle between VLBI and space operation modes without compromising sensitivity. These enhancements aim to ensure sustainable funding and maintain the commercial viability of VLBI observations.

The station remains committed to supporting the global geodetic and astrometric VLBI community and is actively seeking opportunities to expand its role in

international scientific and commercial space operations.

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