

Fortaleza Station Report

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Abstract This report summarizes the activities carried out at the Fortaleza Geodetic Observatory (FGO), also known as the Rádio Observatório Espacial do Nordeste (ROEN), located in Eusébio, Ceará, Brazil, from January 2023 to December 2024.

1 General Information

The Fortaleza Geodetic Observatory (FGO), also known as Radio Observatório Espacial do Nordeste (ROEN), is situated within the INPE facilities in Eusébio, approximately 30 km east of downtown Fortaleza, Ceará, Brazil. The station began operations in 1993 and regularly performs geodetic VLBI and GNSS observations as part of international geodesy programs.

ROEN is part of Brazil's space geodesy initiative, originally implemented by CRAAE, a consortium comprising Universidade Presbiteriana Mackenzie (UPM), Instituto Nacional de Pesquisas Espaciais (INPE), USP, and UNICAMP. The initial structure was funded by NOAA (USA) and FINEP (Brazilian Ministry of Science and Technology).

Currently, FGO is coordinated by the Center of Radio Astronomy and Astrophysics Mackenzie (CRAAM), with support from INPE and the Universidade Federal do Semi-árido (UFERSA), which joined the technical cooperation within the last two

1. Universidade Presbiteriana Mackenzie, CRAAM, Rádio Observatório Espacial do Nordeste

years. Activities are carried out under an International Cooperation Agreement between NASA and the Brazilian Space Agency (AEB), extended through 2025. Operational support is partially funded through a contract between NASA and CRAAM/UPM, with additional infrastructure and staffing provided by INPE and Mackenzie.



Fig. 1 Installation of the 12-meter VGOS antenna at Fortaleza Geodetic Observatory (FGO/ROEN).



Fig. 2 Overview of the Fortaleza Geodetic Observatory (ROEN/FGO), showing the newly installed 12-meter VGOS antenna (foreground) and the legacy 14.2-meter antenna (background). Photo taken during the final phase of installation, early 2025.

2 Main Instruments

FGO operates a legacy 14.2-meter alt-azimuth radio telescope equipped with cryogenic radiometers for S- and X-band observations. It is supported by a Mark IV data acquisition system and a Mark 5A recording unit.

A new VGOS-compatible system is under installation. The 12-meter antenna was delivered and installed by the end of 2024, with full system completion scheduled for early 2025. Most VGOS components—including networking, timing and frequency equipment, auxiliary computing systems, and a new hydrogen maser atomic clock—have been partially delivered and installed.

Data transmission to the correlators is enabled through the Rede Nacional de Ensino e Pesquisa (RNP), a high-performance infrastructure dedicated to supporting education and scientific research in Brazil, offering both high availability and reliability. At the regional level, this connectivity is supported by GigaFor, which provides and maintains the local infrastructure required to ensure stable and efficient network performance.

A Sigma Tau hydrogen maser is operational, and a new Microchip MHM-2020 maser is expected by mid-2025.

GNSS monitoring continues in collaboration with NOAA (USA), with data submitted to NOAA/IGS and the Brazilian IBGE.

3 Staff

Dr. Jean-Pierre Raulin coordinates CRAAM at Mackenzie Presbyterian University, supported administratively by Valdomiro S. Pereira and Lucíola Russi. Engineer Silvia Fernandes joined the FGO team as the project manager for the VGOS installation.

On-site operations and management are led by Eng. Adeildo Sombra da Silva, supported by Eng. Renato de Abreu, Kelvin de Oliveira, and Eng. Antonio Lucivaldo.

4 Status and Activities

4.1 Azimuth Bearing Replacement

In early 2023, the 14.2-meter antenna's azimuth bearing was successfully replaced, allowing FGO to resume scheduled operations after nearly two years of downtime (see further details in Fortaleza Station Report for 2021 and 2022).

4.2 VGOS System Installation

NASA, through the Space Geodesy Project (SGP), funded and coordinated the installation of a full VGOS-compatible system, including a 12-meter

antenna, signal chain, support equipment, and site upgrades.

A major milestone was the FGO Element Design Review (EDR) held in August 2023, which included participation from Fortaleza, ISI-Calian, Haystack, Peraton, and NASA teams. The review addressed design improvements and modifications.

The 12-meter antenna, designed and manufactured by Calian Inc. (Canada), underwent controller enhancements to incorporate satellite tracking capabilities. It successfully passed factory acceptance tests in September 2023 and was shipped in late 2024. Installation commenced in early 2025.

Peraton was responsible for procuring and integrating meteorological sensors, networking infrastructure, monitoring equipment, and time and frequency systems, which were delivered and integrated in February 2025. A new hydrogen maser from Microchip Inc. is expected for mid-2025 delivery.

MIT Haystack designed the signal chain, which will be installed in 2025. It includes R2DBE (ROACH-2 Digital Back End) systems that digitize and timestamp the signals before recording. The system includes new features such as GRITSS satellite signal reception and the Cable Delay Measurement System (CDMS) for monitoring cable delays. It also includes the Vibration Monitoring System (VMS), which enables remote diagnostics of the antenna's mechanical performance.

NVI, Inc. delivered an upgraded Field System to enhance scheduling, automation, and control. Earthscope provided and installed three GNSS antennas and receivers.

First light is expected in August 2025, before commissioning, and full operational readiness is expected by the end of 2025.

4.3 Site Modifications for VGOS Antenna

Site planning began in 2021. KBR Inc. developed the initial design, later adapted by Inova Engenharia to meet Brazilian construction standards.

All necessary licenses for construction and operations were obtained in a timely and proper manner, with guidance from the HL assessment team. Upon completion, the local Fire Department issued the re-

quired permit, certifying compliance with fire safety regulations.

Construction, carried out by Comtexsa, began in August 2024. The antenna foundation was completed in November 2024, requiring approximately 336 tons (4,300 cubic feet) of concrete.

Infrastructure upgrades included a new power station with increased capacity, updated distribution panels, a diesel generator, and a UPS system capable of supporting all equipment. Environmental surveys ensured compliance with Brazilian and U.S. regulations. The maser and operations rooms received HVAC upgrades with redundancy, in accordance with atomic clock humidity and temperature specifications.

4.4 VLBI Observations

FGO participated in 142 VLBI sessions between 2023 and 2024. The reduced number of sessions resulted from maintenance activities and RFI issues in the S-band.

Table 1 Number of sessions observed per type.

Session	Count
IVS-R1	54
IVS-R4	60
IVS-T2	7
IVS-RD	12
IVS-OHIG	8
TRF-TIE	1

4.5 Operational and Maintenance Activities

Key activities conducted include:

1. Identification, evaluation, and procurement of contractors for conducting topographic and geotechnical surveys, environmental assessments, design adaptation to comply with Brazilian codes, construction management, and the construction itself.
2. Technical and logistical support provided to KBR and Inova engineering and design teams.

3. Procurement assistance for critical equipment including generators, UPS systems, transformers, power station infrastructure, and a tower for meteorological sensors.
4. Facilitation of rental arrangements for essential antenna installation equipment such as cranes and lifting platforms.
5. On-site supervision and oversight during construction activities.
6. Maintenance management of the 14.2-meter legacy antenna, including its cryogenic systems, motors, and gearboxes, and supervision of the main reflector repainting process.
7. Operational support for the Earthscope installation team.
8. Continuous operation of GNSS systems in collaboration with NOAA.

5 Future plans

Plans for 2025 include significant upgrades to station infrastructure, such as renovating bathrooms, common areas, accommodations, and general facilities, to enhance comfort and usability for employees, visitors, and students.

Additionally, there will be an expansion of network bandwidth and optimization of VLBI data quality, aiming to achieve full operational capability for VGOS by the end of the year.

6 Acknowledgments

The FGO team extends its sincere gratitude to NASA, through the Space Geodesy Project (SGP), for funding and coordinating the installation of the VGOS system and to Mackenzie Presbyterian University for its continued institutional support, which has been essential to the observatory's operation.