The RadioAstron Green Bank Earth Station

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The RadioAstron satellite consists of a 10-meter space radio telescope operating from ∼300 MHz to 25 GHz. It has a highly elliptical orbit extending to 350000 km at apogee and observes simultaneously with several ground telescopes, forming the world's longest radio interferometer. Data downlinks must be collected via large stations on Earth to provide sufficient gain for the reception of the signals, particularly when the satellite is at apogee. Because the initial Earth station at the Pushchino Radio Astronomical Observatory (PRAO), Russia, is limited to observing the satellite when it is above their horizon, it is essential to have stations in other parts of the world to maximise available downlink time. To meet this need, a new Earth station for data downlink has been commissioned at the National Radio Astronomy Observatory (NRAO) in Green Bank, West Virginia.

Components of the Green Bank Earth Station (GBES) include an antenna, the electronics to receive, process, and record signals, and system control and management software. The GBES uses the modernised and refurbished NRAO 140–ft telescope. Antenna optics were refurbished with new motors and drives fitted to the secondary mirror positioning system, and the deformable subreflector was refurbished with a new digital controller and new actuators.

A new observing system was developed for the 140–ft and is based on the Green Bank Telescope (GBT) monitor and control system and the ASTRID observation management system, allowing telescope operators to track the RadioAstron satellite using a simple scheduling block. Tools were also developed to read and log the received power, which provides a means to check and adjust the antenna pointing automatically during tracking, allowing reduced manual attention to antenna positioning. Data from the antenna control systems and logs are saved and sent with the science data for processing at the Astro Space Center (ASC) of the Lebedev Physical Institute (LPI) of the Russian Academy of Science.

NRAO provides infrastructure at the antenna's Cassegrain focus cabin for the use of the guest electronics systems, including reference signals (1 pulse per second, 10 MHz, and 5 MHz signals), Ethernet connectivity, and single-mode fibers connected to the Jansky Lab. An uncooled Ku-band receiver is also available for testing, independent of the guest electronics. Additional NRAO equipment is supplied in the Jansky Lab for monitoring and controlling observations: a wideband detector module allowing monitoring of the signals from both the 8.4 and 15 GHz receivers and remotely accessible spectrum analysers.

The LPI supplied a complete electronics suite to the GBES to collect and store transmitted data, consisting of systems installed in both the 140–ft Cassegrain focus cabin and the Janksy Lab. In the focus cabin, this includes a dual-frequency feed designed specifically for the 140–ft, dual-frequency receiver, LO system, upconverter/transmitter for transmitting a reference tone to the satellite, and control computers. At the other end of the optical fiber transmission system, the Jansky Lab houses the LPI supplied demodulator, decoders, and data recorders. A second digital decoder module, based on the VLBA ROACH Digital Backend, was developed by NRAO's Socorro Electronics Division to decode data from the satellite and format it into standard VLBI packets, which are written to a standard Mark 5C VLBI data recorder. The duplicate system increases overall reliability and provides native formats to different correlators working with RadioAstron.

We will discuss the implementation of the Green Bank Earth Station, including its design and commissioning, as well as results from the first several months of operation.