ESA's New Cebreros Station Ready to Support Venus Express

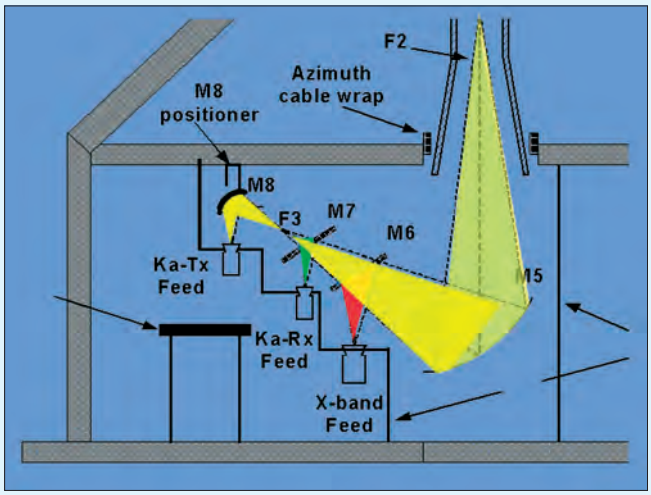
Manfred Warhaut, Rolf Martin & Valeriano Claros
ESA Directorate of Operations and Infrastructure, ESOC, Darmstadt, Germany

ESA's new deep-space radio antenna at Cebreros (near Avila) in Spain was officially inaugurated on 28 September. The new 35 metre antenna is the Agency's second facility devoted to communications with spacecraft on interplanetary missions or in very distant orbits; the first is at New Norcia in Western Australia. Cebreros's first task is the tracking of ESA's Venus Express spacecraft, launched on 9 November.

Introduction

The construction of ESA's deep-space antenna at Cebreros was completed in record time. The site-selection process began in April 2002, the procurement activities began in February 2003, and the building work began in Spring 2004 on the site of a former NASA ground station. After successful assembly of the antenna structure in November 2004 and the almost flawless acceptance testing of the various infrastructure elements and the radio-frequency components, the new antenna was completed in August 2005, which provided just sufficient time for final testing before being used for the first time to support Venus Express.

Technical Specifications of the Cebreros Antenna



The novel Cebreros antenna feed concept

REFLECTOR DISH

Diameter:	35 metres
Depth:	8 metres
Surface contour:	shaped parabola
Number of panels:	304 on 7 rings
Surface accuracy:	0.3 mm rms
Weight:	100 tons

ANTENNA PEDESTAL

Height:	40 metres
Weight movable part:	500 tons
Total weight:	620 tons

OPERATING ENVIRONMENT

Temperature:	-20°C to + 50°C
Relative humidity:	0 – 100% including condensation
Wind:	up to 50 km/h constant, gusting to 70 km/h
Rain:	up to 35 mm/h
Solar heat:	up to 1200 W/m^2

MECHANICAL PERFORMANCE

Slew range:	
Azimuth	0 to 540 deg
Elevation	0 to 90 deg
Slew rate:	
Both axes	1.0 deg/s max.
Acceleration:	
Both axes	0.4 deg/s^2 max.
Pointing error:	0.006 deg

RF PERFORMANCE

- X-band (8 GHz) transmission/reception with right- and left-hand polarisations
- Ka-band reception
- Beam-waveguide concept
- G/T at 10 deg elevation ≥ 50.8 dB/K at X-band
- G/T at 10 deg elevation ≥ 55.8.0 dB/K at Ka-band
- Transmit EIRP >107 dBW at X-band

SPECIAL FEATURES

- Temperature-measuring system incorporating 230 sensors on antenna structure
- Compensation of pointing errors
- Steerable sub-reflector
- Helium-cooled amplifiers (LNAs) with very low noise temperature
- 20 kW de-ionised water-cooled primary high-power amplifier
- 2 kW air-cooled secondary low-power amplifier
- Fully digitised receive system with ranging function
- Hydrogen-maser timing system with very high accuracy
- Designed for unmanned and full remote-controlled operation
- Completely power self-contained with back-up power diesel generators.

The supporting structure of the Cebreros antenna

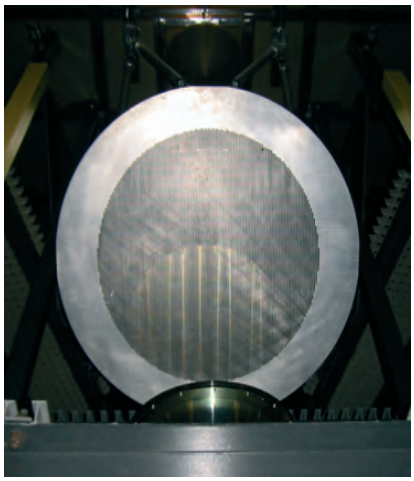
Cebreros was chosen as the site on which to build ESA's second deep-space antenna for several reasons. To achieve the required coverage, this antenna had to be positioned 120 degrees East or West of the antenna in Australia and an ideal location would have been ESA's European Space Astronomy Centre (ESAC) at Villafranca near Madrid. However, active urban development in the surroundings of ESAC could be a source of interference. The Cebreros location is equally good from a technical point of view and is also well away from densely-populated areas, but still sufficiently close to ESAC for purposes of operating efficiency. Like all other ground stations within ESA's ESTRACK network, Cebreros will be remotely operated from ESOC in Darmstadt, Germany, and will only be manned during especially critical mission phases, such as launches.

The entire antenna-carrying structure is 40 metres high and weighs about 630 tons, making it one of the World's largest TT&C antennas. It has been built by an industrial consortium led by the Canadian company SED Systems. The Spanish firms Esteyco and Necso built the antenna-tower infrastructure, and LV Salamanca was responsible for the building refurbishment.

Novel Features of Cebreros

Future deep-space missions will transmit increasing amounts of data from positions hundreds of millions of kilometres from Earth and require higher frequencies to increase data return. ESA's new Cebreros ground station therefore features a Ka-band reception capability, significantly enhancing the performance of the ESA Station Tracking Network (ESTRACK).

The Cebreros antenna incorporates the latest technology, which provides some advantages compared to the New Norcia facility. For instance, the Cebreros data acquisition capacity is higher, due to the fact that it will receive signals in the Ka-band (31.8 – 32.3 GHz). Cebreros also has a higher pointing accuracy, with a state-of-the-art pointing/calibration system with a maximum error of 6 milli-degrees, which is ten times better than a standard ESA 15 metre antenna. This exceptional mechanical accuracy is required due to the higher frequencies of the Ka-band compared to X- or S-band. It is achieved through the combination of a very stiff mechanical structure and 250 temperature sensors mounted throughout the antenna structure to automatically compensate for expansion and contraction due to temperature changes. Cebreros offers enhanced wind resistance compared with the New Norcia dish, can operate over a wider temperature range, and can rotate further in azimuth and at a higher speed.



The novel dichroic mirror used in the Cebreros antenna

The heart of Cebreros' antenna is the beam waveguide concept and the Ka-band reception capability featuring a 1.2 m x 1.1 m dichroic mirror. This mirror is just 7.9 mm thick but contains several thousand rectangular holes drilled to an accuracy of 10 microns. It therefore reflects radio signals in the X-band (7.1 and 8.5 GHz) and allows those in the Ka-band to pass through its surface, thereby channelling the signals of different wavelength received by the main antenna dish to the correct receivers. Like New Norcia, Cebreros relies on Low-Noise Amplifiers cooled to 15K (-258°C) to reduce the system noise temperature to facilitate the reception of faint signals, and 20 kW amplifiers are used to transmit instructions and commands.

Conclusion

Cebreros and New Norcia are the first two of ESA's three planned 35 metre deep-space antennas. The third is likely to be built later in the decade and will be sited at an American longitude. As an integral part of a nine-station ESTRACK ground-station network, these three ground stations located 120° apart will be able to provide continuous coverage for any ESA mission despite the Earth's rotation.

In addition to being the dedicated ground station for Venus Express, Cebreros is also providing back-up support for the Mars Express and Rosetta missions. In the coming years, it will also be involved in tracking the Herschel/Planck, Lisa Pathfinder and Gaia spacecraft, as well as BepiColombo, ESA's first mission to Mercury.