esa

Europe's Access to Deep Space

The Deep Space Ground Station in Spain

New Radio Band Boosts Deep Space Satellite Communicat

Future deep space missions will transmit increasing amounts of data from hundreds of millions of kilometres and require higher frequencies to increase data return. Thus, ESA's new and highly accurate Cebreros ground station features Ka-band reception capability, significantly enhancing the European Space Agency's Tracking Network ESTRACK.

The ESA deep space antenna in Cebreros, Spain

Built in Spain on the site of a former NASA Apollo ground station, Cebreros features a 35m deep space antenna with a state-of-the-art Pointing Calibration System developed by SED Systems on behalf of ESA's European Space Operations Centre (ESOC), which limits the antenna pointing error to within 6.0 millidegrees, a factor of 10 better than for a 15m ESA standard antenna. This precise mechanical accuracy is required due to the higher frequencies of the Ka-band in comparison to X- or S-band, and is achieved by means of a very stiff mechanical structure and 250 temperature sensors mounted throughout the structure to automatically compensate for expansion and shrinkage due to temperature change.

Cebreros can receive Ka-band signals at 31.8 – 32.3 Gigahertz (GHz) and is equipped for future upgrade to transmit in Ka-band as well. The station also transmits and receives in X-band at 7.1 GHz and 8.5 GHz, respectively. These frequency capabilities are shown in Table 1.

The heart of Cebreros' antenna is the beam waveguide concept and the Ka-band reception capability featuring a dichroic mirror 1.2 x 1.1 metres in size (M6 in Figure 1). The mirror is 7.9 millimetres thick and has several thousand rectangular holes drilled to an accuracy of 10 micrometres (Figure 2). The dichroic mirror reflects radio signals in the X-band and transmits those in the Ka-band, thus channelling signals received from the main antenna dish into the correct receiver. A second dichroic mirror (M8) will be implemented in the future to enable transmission in the Ka-

ESA Missions supported by the Deep Space Ground Statio

Venus Express

Studying our nearest neighbour, Venus Express will be the first spacecraft to perform a global investigation of the Venusian atmosphere and clouds in detail and make global maps of the surface temperatures. As the closest planet to the Earth, it was a natural target for previous missions. However, Venus has been out of the limelight during the last decade, despite several scientific puzzles. For example, what are the characteristics of the atmosphere? How does it circulate? How does the composition of the atmosphere change with depth? How does the atmosphere interact with the surface? How does the upper atmosphere interact with the solar wind? Experts have designed Venus Express to be the first spacecraft to perform a global investigation of the Venusian atmosphere and of the plasma environment to answer these questions.

Venus Express

DEEP SPACE MISSIONS	LAUNCH DATE	DESTINATION
Mars-Express (2003-2007)	2 June 2003	Mars
Rosetta (2004-2015)	2 March 2004	Comet Churyumov Gerasimenko
Venus-Express (2005-2009)	October 2005	Venus
Herschel Planck (2007-2012)	August 2007	2nd Lagrange point
Lisa Pathfinder (2009-2010)	October 2009	1st Lagrange point
GAIA (2011-2016)	November 2011	2nd Lagrange point
BepiColombo (2012-2020)	April 2012	Mercury

tions for the European Space Agency

DSA 1 (NEW NORCIA)			DSA 2 (CEBREROS)		
Parameter	Mirror 6 (M6)	Mirror 4 (M4) optional Ka-Band Rx	Mirror 6 (M6)	Mirror 7 (M7) optional Ka-Band Tx	Unit
Transparent Bands	X-Band Tx: 7,145-7,235 Rx: 8,400-8,500	Ka-Band Rx: 31,800-32,300	Ka-Band Tx: 34,200-34,700 Rx: 31,800-32,300	Ka-Band Tx Tx: 34,200-34,700	MHz
Reflecting Bands	S-Band Tx: 2,025-2,120 Rx: 2,200-2,300	S-Band Tx: 2,025-2,120 Rx: 2,200-2,300	X-Band Tx: 7,145- 7,235 Rx: 8,400- 8,500	Ka-Band Rx Rx: 31,800-32,300	MHz
		X-Band Tx: 7,145-7,235 Rx: 8,400-8,500			

Table 1: New Norcia and Cebreros frequency capabilities

band. The current mirrors are shown as M6 and M7 in Figure 1.

Cebreros and its sister deep space ground station at New Norcia, Western Australia, are equipped with 35m full-motion pedestal-mounted antennas, making them among the world's largest used for satellite Telemetry, Tracking & Command.

The height of Cebreros' antenna, 40 metres, and the weight of the reflector and equipment mounted on the

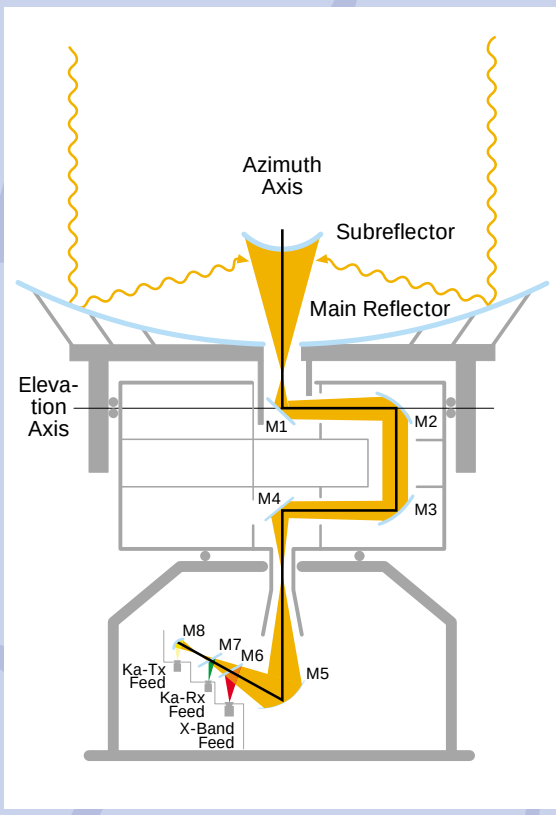


Figure 1: Cebreros antenna schematic

n in Cebreros, Spain

Herschel

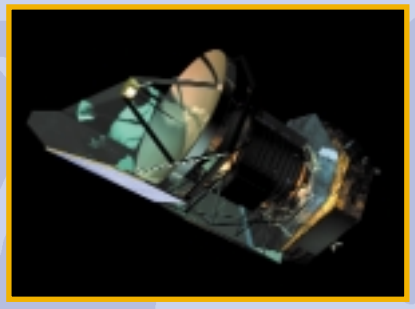
Herschel will be the largest space telescope of its kind when launched. Herschel's 3.5m mirror will collect long-wavelength infrared radiation from some of the coolest and most distant objects in the Universe. Herschel will be the only space observatory to cover the range from far-infrared to submillimetre wavelengths.

Planck

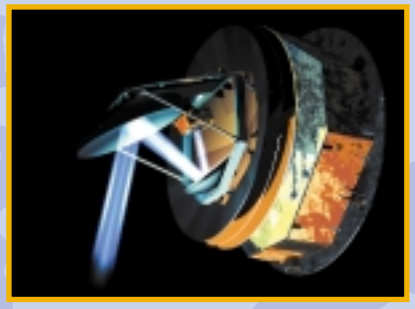
Planck will look back at the dawn of time, close to the Big Bang, and will observe the most ancient radiation in the Universe known as the "cosmic microwave background". Planck will analyse it for clues about how clusters of galaxies and even individual galaxies formed.

LISA Pathfinder

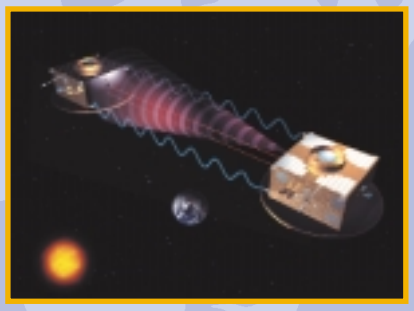
LISA Pathfinder is a mission that will



Herschel



Planck



LISA Pathfinder

movable pedestal, 620 tonnes, are similar to those of New Norcia, but Cebreros offers enhanced wind resistance, can operate in a wider temperature range and the antenna can rotate further in azimuth and at a higher speed. Cebreros' physical metrics are given in Table 2.

Like New Norcia, Cebreros relies on Low Noise Amplifiers cooled to 15 degrees Kelvin (-258 Celsius) to reduce the system noise temperature for reception of faint signals, and uses 20-kilowatt (kW) power amplifiers to transmit commands.

Antenna height	40 metres
Weight of reflector	125 tonnes
Movable part elevation	375 tonnes
Movable part El & Az	540 tonnes
Fixed part azimuth	80 tonnes
Total weight	620 tonnes

Table 2: Cebreros antenna physical metrics

Known as DSA1 and DSA2, respectively, the deep space ground stations in New Norcia and Cebreros accommodate the first two of ESA's three planned 35m deep space antennas; the third (DSA3) is likely to be built later in the decade and will be located at an American longitude. As an integral part of ESA's ESTRACK ground station network, these three deep space stations located 120 degrees apart from each other will provide continuous satellite coverage despite the Earth's rotation. All ground stations are remotely operated from ESOC in Darmstadt, Germany.

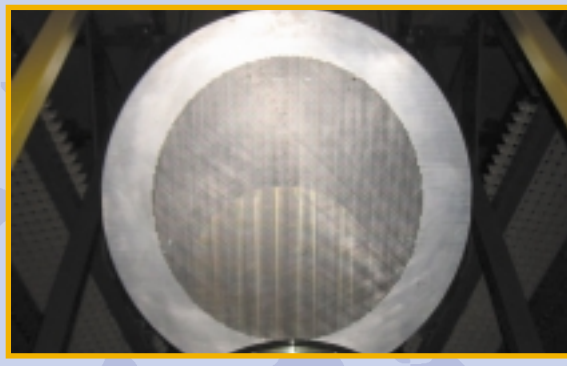


Figure 2: Dichroic mirror

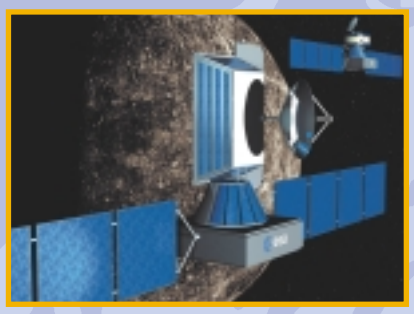
The Cebreros deep space ground station has been operationally ready since September 2005. It is the dedicated ground station for Venus Express and will provide back-up support to the Mars Express and Rosetta missions. The ESTRACK 35m deep space stations will also track Herschel Planck, Lisa Pathfinder, GAIA and BepiColombo, ESA's first mission to Mercury.

test the general concepts and technologies needed for highly accurate formation flying and precise measurement of the separation between two very distant spacecraft. This technology is essential for future ESA missions, such as LISA, which aim to detect subtle gravitational waves.

Gaia

Gaia

Gaia is a global space astrometry mission. Its goal is to make the largest, most precise map of our Galaxy by surveying an unprecedented number of stars – more than a thousand million. It is expected to discover hundreds of thousands of new celestial objects, such as extrasolar planets and failed stars called brown dwarfs.



BepiColombo

BepiColombo

Consisting of two orbiters, BepiColombo will provide the most complete exploration yet of Mercury, the innermost planet. This mission will help reveal information on the composition and history of Mercury, and the history and formation of the inner planets in general, including Earth. One component of BepiColombo will map the planet and another will investigate its magnetosphere.

International Cooperation for a World-class Antenna

The industrial consortium involved in the construction of the Cebreros deep space ground station included many industrial companies from ESA member states and associates: SED Systems (CA), Vertex Antennentechnik (DE), Alcatel (FR), Alpine (DE), Callisto (FR), ESTEYCO (ES), Iberdrola (ES), INSNEC (FR), LV Salamanca (ES), Mirad (CH), ND SatCom (DE), NECSO (ES), S&C (DE), Telefónica (ES), TimeTech (DE).

SED
a division of CALIAN Ltd.

SED Systems

As the prime contractor to ESA for this deep space antenna system, and for the one located in New Norcia, Australia, SED Systems was responsible for overall system design and assuring end-to-end technical performance. Program and subcontract management included site preparation and management of civil engineering, electrical, heating, ventilation and air conditioning activities.

Established in 1965, SED Systems is a world leader in developing and integrating satellite ground systems. Based in Saskatchewan, Canada, the company has systems operating on six continents and its customers include many of the world's top commercial satellite organizations as well as the Canadian and European Space Agencies. SED System's products include radio frequency systems and Earth stations, network management solutions, monitor and control and carrier monitoring systems, and custom test solutions.

www.sedsystems.ca

VERTEX ANTENNENTECHNIK

Vertex Antennentechnik

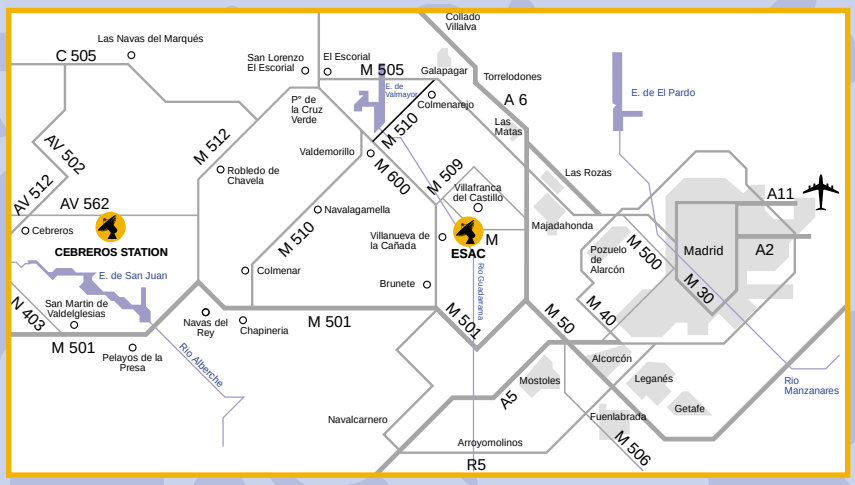
A major subcontractor to SED Systems for both of ESA's deep space antennas, Vertex Antennentechnik (VA) of Duisburg, Germany, was responsible for the mechanical, servo and radio frequency subsystems.

VA is the successor of the KRUPP Antenna Division and was founded in 1992 as a German entity. Today, the company is part of General Dynamics C4 Systems SATCOM Division and combines more than 40 years of high-tech know-how and experience under a responsive and modern organization. VA's products comprise precision tracking antennas including large aperture radio/optical telescopes, drive & control systems, uplink stations and communications antennas. Standard VertexRSI and Prodelin SATCOM products are also distributed to European customers.

www.vertexant.de

How to Find Us

The Cebreros deep space ground station is situated about two hours west of Madrid and about one hour west of ESA's European Astronomy Centre (ESAC).

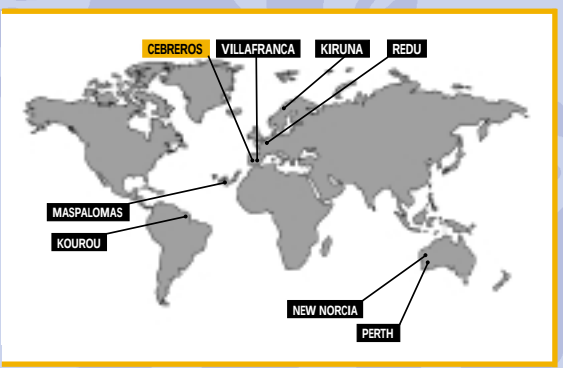


Years of Experience in Mission Operations

ESA – The European Space Agency

The European Space Agency is Europe's gateway to space. Its mission is to shape the development of Europe's space capability and ensure that investment in space continues to deliver benefits to the citizens of Europe. By coordinating the financial and intellectual resources of its 17 member states, it can undertake programmes and activities far beyond the scope of any single European country.

The Agency's projects are designed to discover more about the Earth, its immediate space environment, the solar system and the Universe, as well as to develop satellite-based technologies and services, and to promote European industries. ESA also works closely with space organisations outside Europe to share the benefits of space with the whole of mankind.



ESOC – The European Space Operations Centre

Located in Darmstadt, Germany, ESOC is the mission control centre of the European Space Agency. It is responsible for all spacecraft operations, the establishment and running of the necessary ground infrastructure as well as communication networks. Since its creation in 1967, ESOC has planned missions, operated more than 50 satellites and ensured that spacecraft meet their mission objectives.

ESOC can support many spacecraft for different types of missions at the same time. To be able to communicate with satellites in a variety of orbit and conditions, ESOC engineers develop and maintain a global network of ground stations known as ESTRACK, where the antennas and systems are located. These stations are distributed around the world – some of them in Europe, up to the polar circle in Kiruna (Sweden), others as far away as Kourou (French Guiana) and Australia.

ESAC – The European Space Astronomy Centre

Space telescopes are humankind's eyes in the sky: from their advantageous viewpoint above the Earth's atmosphere they obtain for us the best views of the Universe. At ESAC, the European Space Astronomy Centre, in Guadarrama Valley near Madrid, those views are first studied. Data from black holes and distant galaxies, from neighbour planets and even from planets outside the solar system, are delivered from the European Space Operations Centre (ESOC) to ESAC. It is the "home" of ESA space telescopes and planetary missions' science operations and one of ESA's centres for space science.

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