ESA is Europe’s gateway to space. We guide the development of Europe’s space capability and carry out pioneering research in all areas of space.

For more than 40 years, ESA and its predecessors have been shaping and sharing space. We have been managing the research and development programmes needed to keep Europe at the forefront of space exploration and applications. We have been ensuring that investment in space delivers benefits to the citizens of Europe and the world: from jobs and economic growth, to public services, efficient communications and security. ESA is a prime example of what can be achieved by working together – a model for multicultural and international cooperation. By pooling resources, we are able to develop compelling projects that would not be possible by individual countries. The results of this cooperation are world-class industry, outstanding scientific discoveries and a stronger, richer European identity.

ESA’s headquarters in Paris are where policies and programmes are decided. ESA also has sites in a number of European countries, each with different responsibilities:

- EAC, the European Astronaut Centre in Cologne, Germany;
- ESAC, the European Space Astronomy Centre in Villanueva de la Cañada, Madrid, Spain;
- ESOC, the European Space Operations Centre in Darmstadt, Germany;
- ESRIN, the ESA Centre for Earth Observation in Frascati, near Rome, Italy;
- ESTEC, the European Space Research and Technology Centre in Noordwijk, the Netherlands.

The European Space Operations Centre is where ESA’s ground station systems are developed and operated and where the smooth working of spacecraft in orbit is ensured.

Since its establishment in 1967, ESOC has planned missions, operated more than 60 satellites and ensured that spacecraft meet their mission objectives. The mandate of ESOC is to conduct mission operations for ESA satellites and to establish, operate and maintain the ground infrastructure.

 Estrack is a worldwide network of ground stations providing links between satellites in orbit and the Operations Control Centre at ESOC. The core network comprises 9 stations in seven countries. There are four types of stations in the network:

- Parabolic antennas 15 m in diameter for tracking low-Earth orbit and near-Earth orbit satellites. These antennas are located at: Kourou (French Guiana), Maspalomas and Villafranca (Spain), Redu (Belgium) and Kiruna (Sweden).
- Parabolic antennas 35 m in diameter for tracking spacecraft in deep space. Estrack has stations at New Norcia (Australia), Cebreros (Spain) and Malargüe (Argentina).
- A dedicated station on Santa Maria Island (Azores, Portugal), together with the Perth station, supports the tracking of ESAs launch vehicles.
- A 4.5 m parabolic antenna co-located at New Norcia, Australia, to support newly launched satellites.

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estrack

→ ESA’S DEEP SPACE TRACKING NETWORK

DSA 1 New Norcia
Western Australia
2002

DSA 2 Cebreros
Ávila, Spain
2005

DSA 3 Malargüe
Mendoza, Argentina
2012
TRACKING EARTH-ORBITING SATELLITES

The core network has 9 stations: Kourou (French Guiana), Maspalomas, Villafranca and Cebreros (Spain), Redu (Belgium), Santa Maria (Portugal), Kiruna (Sweden), New Norcia (Australia) and Malargüe (Argentina).
Kiruna (Salmijärvi)
The Kiruna S- and X-band station primarily supports ESA’s Earth Explorers (such as GOCE and CryoSat) and GMES/Sentinel missions, and can also support highly inclined-orbit missions such as Integral. For Estrack, Kiruna hosts one 15 m and one 13 m antenna. The station is located at Salmijärvi, 38 km east of Kiruna, in northern Sweden.

Kourou
The Kourou S- and X-band station, also known as Kourou Diane, is 27 km from the town of Kourou and 90 km from Cayenne, the capital of French Guiana, in South America. The station site is 19 km from the Guiana Space Centre, Europe’s Spaceport. It is used mainly to communicate with XMM-Newton for routine operations, and for the Launch and Early Orbit Phase (LEOP) of other missions.

Maspalomas
The Maspalomas station hosts a 15 m antenna for S- and X-band reception, and S-band transmission. It is on the campus of the National Institute for Aerospace Technology (INTA), in the southern part of the Canary Islands’ Gran Canaria, at Montaña Blanca. The station provides routine support for ESAs Cluster mission and backup and LEOP support to other missions.

New Norcia 2
ESA’s long-time 15 m station at Perth, Australia, was closed in 2015, and its key tracking capacity was transferred to New Norcia.

Redu
The Redu station provides tracking capabilities in S- and Ka-band, and supports in-orbit testing of telecommunication satellites and Galileo. Redu supports ESA’s Artemis, Integral and Proba missions. The site hosts multiple tracking antennas operating in a variety of frequency bands, and is located in the Ardennes region of Belgium.

Santa Maria
The Santa Maria S-band station, also known as Montes das Flores (Hill of Flowers), is 5 km from the town of Vila do Porto on the Portuguese island of Santa Maria, in the Azores some 1500 km from Lisbon. Santa Maria is Estrack’s dedicated launcher tracking station and is used to receive realtime telemetry from vehicles ascending from ESA’s Spaceport in Kourou, French Guiana.

Villafranca
ESA’s European Space Astronomy Centre lies in the Guadarrama Valley, 30 km west of Madrid, Spain. Villafranca hosts two 15 m antennas (VIL-1 and VIL-2), both for receiving and transmitting S-band. There is also the VIL-4 12 m antenna for receiving and transmitting in S-, X- and Ka-band, backing up ESA missions and supporting testing and educational activities.
In 1998, ESA decided to establish its own network for tracking deep-space craft to cope with the expected rapid rise in the number of interplanetary missions. The aim was to establish three terrestrial stations about 120° apart in longitude to provide continuous coverage as Earth rotated. All the stations are remotely controlled from ESOC.

These deep-space missions reach typically more than 2 million kilometres from Earth, where communications require highly accurate mechanical pointing and calibration.

ESA’s first station, Deep Space Antenna 1 (DSA 1), was completed in 2002 in Australia. DSA 2, in Spain, was completed in 2005 and DSA 3, in Argentina, in 2012. These three stations make up ESA’s Deep Space Network. They are equipped with 35 m-diameter parabolic dishes that provide the increased range and data transmission speed required for current and future exploration missions, such as Mars Express, ExoMars, Rosetta, Gaia, BepiColombo, LISA Pathfinder, Solar Orbiter, Euclid and JUICE.

They also have facilities for radio science experiments, allowing scientists to study the characteristics of matter through which the spacecraft–ground communication signals travel.

With its new network, ESA became independent of NASA’s Deep Space Network for controlling its deep-space missions. However, both agencies recognised the value of tracking and controlling NASA satellites by ESA stations and vice versa, in addition to having more reliable control of their own satellites. Separate but interoperable networks are also an advantage in the event of satellite emergencies or station malfunction.
**NEW NORCIA, WESTERN AUSTRALIA**

A site was found some 120 km from Perth in the Shire of Victoria Plains, a location that had the support of its neighbours and of the Benedictine monks at the monastery in New Norcia. A small historical town, with the only monastery in Australia, New Norcia is some 90 minutes' drive from Perth. The ESA station thus links 150 years of Benedictine tradition with cutting-edge spaceflight technology.

In October 1999, ESA approved the new location for the 35 m antenna on the Dalmeny Downs farm, just south of New Norcia. The ceremony to lay the first stone was held on 2 March 2000. Antenna operations were confirmed in June 2002 upon receipt of signals from the Stardust comet probe, then about 315 million kilometres from Earth. DSA 1 was completed at a cost of €28 million, and inaugurated on 4 March 2003.

In 2015, a 4.5 m antenna was built at New Norcia to provide acquisition support to newly launched satellites.

**CEBREROS, ÁVILA, SPAIN**

To extend the coverage of satellites by New Norcia, a second station had to be positioned 120° to the east or west. The ESA station already in Spain, at ESAC near Villanueva de la Cañada (Madrid), would have been perfect. However, authorities from the Secretary of State for Telecommunications and the Information Society, which manages Spain’s radio spectrum, indicated that the antenna would be too near to the city and could interfere with the mobile phone networks. As a result, the decision was made to locate the station at Cebreros, some 90 km northwest of Madrid, in the province of Ávila.

In April 2002, negotiations began for an agreement between ESA and Spain for the station; this was signed in May 2003. In March 2004, INTA formally delivered the site and buildings to ESA, which began modernising the infrastructure and installing a new power plant. Installation of the antenna was completed in November 2004 and the station was officially opened on 28 September 2005.

**MALARGÜE, MENDOZA, ARGENTINA**

In 2007, ESA began searching for a location for the third deep-space station, which had to be in the western hemisphere in order to be some 120° in longitude from the other two. Both North and South America were suitable. The southern hemisphere was chosen so that, between the ESA and NASA networks, there would be three stations in the northern and three in the southern hemisphere.

Numerous locations in Chile and Argentina were studied. On 22 June 2009, ESA informed the Argentinian authorities that an area some 40 km from the city of Malargüe in the province of Mendoza was the best site for the third antenna, also measuring 35 m in diameter.

On 11 and 16 November 2009, respectively, ESA and the government of the Republic of Argentina, represented by the National Space Activities Commission (CONAE), signed an agreement to install the station at Malargüe. Installation of the antenna reflector and subreflector was completed on 8 December 2011. The Malargüe station was officially opened on 18 December 2012.
Future deep-space missions will generate increasing quantities of data from hundreds of millions of kilometres, requiring much higher frequencies to increase data transmission capacity. For this reason, ESA has added Ka-band signal reception capacity at both Cebreros (DSA 2) and Malargüe (DSA 3), significantly improving the capabilities of the Agency’s network.

DSA 2 and DSA 3 will be upgraded in the next four years to receive K-band (25.5–27 GHz) for future missions requiring the high data rates available in that band thanks to the larger bandwidth, e.g. Euclid.

ESA’s deep-space stations are dominated by a parabolic antenna 35 m in diameter. The design is based on waves guided by multiple mirrors (M1 to M7), reflecting all frequency bands. The M6 and M7 ‘dichroic’ mirrors pass specific ranges of frequencies while reflecting others (see diagram). These dichroic mirrors have different thicknesses and layers, with thousands of rectangular holes drilled with a precision of 5–15 microns. The diagram shows the positions of the various mirrors, while the table indicates the frequency bands in which the various mirrors are either reflective or transparent. In the future, the Cebreros M6 mirror will be changed to a dichroic mirror reflecting the X/K-bands (25.5–27 GHz). Alternatively, rotating the M5 mirror 180° will provide X/K-band without affecting the X/Ka-bands. Malargüe has both. Only the New Norcia station has the capacity to transmit and receive in S-band.

The pointing accuracy has been increased to 0.0055° (20 times better than 15 m antennas) by increasing the mechanical rigidity and by calibrating most of the systematic pointing errors of the antenna by using a Pointing Calibration System and radio star measurements.
Characteristics

The physical characteristics of the antennas are illustrated in the accompanying table. There are some differences between the three antennas, in wind resistance, rotation speed and resistance to seismic movement, depending on local conditions.

To reduce system electrical noise and improve reception of very weak signals from satellites, all of the stations are equipped with low-noise receivers cooled to –258°C and use S-band (DSA 1) and X-band (DSA 1, DSA 2 and DSA 3) transmitters of up to 20 kW for sending telecommands to space.
International cooperation for a first-class antenna

ESA has worked with an international and local national industrial consortium for each station, permitting construction to be adapted to local conditions in the three countries.

In each case, construction of the antenna and related equipment was contracted to SED Systems (Canada) and Vertex Antennetechnik (Germany).

The consortium constructing the buildings, infrastructure and equipment in the various stations was:

**New Norcia (DSA 1)**
Anite (DE), BAE Systems (GB), Callisto (FR), CSELT (IT), In-SneC (now Zodiac, FR), NDSatcom (DE), Observatoire de Neuchâtel (CH), SED Systems (CN), Telefonica Sistemas (now Ixion, ES), Timetech (DE), Vertex (DE), TIW, ETM and PTI (all US), Bovis Land Lease, Telstra and Western Power (all AU) and others.

**Cebreros (DSA 2)**
Alcatel (FR), Apine (DE), ARDISAN (ES), ESTEYCO (ES), Iberdrola (ES), INSA (ES), INSNEC (FR), LV Salamanca (ES), MIRAD (CH), ND Satcom (DE), NESCO (ES), S&C (DE), Telefónica (ES), Timetech (DE), URAN (ES), VEGA (DE) and others.

**Malargüe (DSA 3)**
Actia Sodielec (FR), Callisto (FR), Esteyco (ES), Femto (FR), Mirad (CH), NDSatcom (DE), SED Systems (CN), Timetech (DE), T4Science (CH), Vertex (DE), Weiss Klimatechnik (DE), Carlucci, Pascual Casetta, Alcatraz, Desarrolladora Monteverdi, Distrocuyo, Telespazio Argentina (all AR) and others.

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Gaia is an astrometry mission designed to measure the precise positions of a billion stars in our Galaxy. It is expected that hundreds of thousands of celestial objects will be discovered, such as extrasolar planets and failed stars called brown dwarfs. Gaia was launched in December 2013.

Solar Orbiter will be the first spacecraft to provide close-up views of the Sun's polar regions, and it will be the first to almost match the Sun's rotation to study regions from the same viewpoint for several days. Launch is expected in 2018.

LISA Pathfinder will pave the way for another major ESA/NASA mission planned for the near future: LISA (Laser Interferometer Space Antenna), aimed at detecting gravitational waves generated by very massive objects such as black holes. Detecting gravitational waves will tell us more about the way space and time are interconnected. Lisa Pathfinder was launched in December 2015.

Euclid, scheduled for launch in 2020, is a cosmology mission to study the hidden side of the Universe – dark matter and dark energy – by looking some 10 billion years back in time. It will fly to the Sun-Earth Lagrangian Point L2. It will scan approximately one-third of the sky during its 6-year mission to map around 2 billion galaxies with very great accuracy.

BepiColombo, conducted in cooperation with Japan's JAXA space agency, will be launched to Mercury in 2018. It consists of two probes, ESA's Mercury Planetary Orbiter, which will map the planet, and Japan's Mercury Magnetospheric Orbiter, which will investigate the planet's magnetosphere.

In order to establish if life ever existed on Mars, ExoMars will investigate the martian environment and demonstrate new technologies to pave the way for a future Mars sample-return mission in the 2020s. Two missions are planned: an orbiter plus an entry, descent and landing demonstrator module will be launched in 2016, and a rover will be launched in 2018. The rover will drill to a depth of several metres to extract and analyse samples.

The Jupiter Icy moons Explorer will explore the emergence of potentially habitable worlds around gas giants like Jupiter. Planned for launch in 2022, it will travel 8 years before entering the Jupiter system. After flybys of the icy moons Europa and Callisto, it will enter orbit around Ganymede, the largest moon in the Solar System, to observe its water-ice surface and environment.