



National Aeronautics and
Space Administration
Jet Propulsion Laboratory
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Pasadena, California



Deep Space Network — Communications





Capturing a Whisper from a Billion Kilometers

The National Aeronautics and Space Administration (NASA) Deep Space Network (DSN) provides the means of communicating with robotic spacecraft exploring the solar system and beyond.

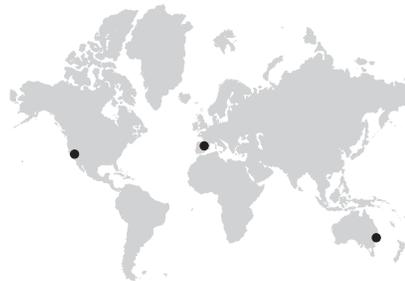
Deep space communications are far more challenging than communications with Earth-orbiting satellites because the distances are so staggering. Signals must travel millions or billions of kilometers between Earth and the spacecraft. Yet, in order to carry as much scientific payload as possible, instruments on the spacecraft are designed to take up little space and be lightweight. The spacecraft's small, light communications equipment consequently transmits at very low power, typically limited to 20 watts, about the same as a refrigerator light bulb. Signal power arriving at the antenna can be as weak as one 100-millionth of one 100-billionth of a watt — 20 billion times less than the power required for a digital wristwatch.

To “hear” the whisper of a signal from a spacecraft at planetary distances, receiving antennas on Earth must be very large and be equipped with highly sensitive receivers. Imagine a person with a loud voice shouting to a companion a block away. If the street is quiet — late at night, for instance — the person could be heard and understood. But what if the two companions were separated by 700 kilometers, with one in Los Angeles and the other in San Francisco? No one's voice is loud enough to be heard. Yet this analogy accurately describes the increased sensitivity required to achieve communication with spacecraft in deep space compared with Earth-orbiting satellites.

To hear the low-power spacecraft signal, large collectors (antenna dishes) with precisely shaped surfaces are crucial,

On the front: One of the three Deep Space Network's 70-meter antennas. The close-up of the structure housing the electronics — with an engineer working at the top of a ladder — gives an idea of the sheer size of the antenna. (Photos: JPL 9015dc; JPL 9015bc)

and they must accurately point towards the source (the spacecraft). Extremely sensitive receivers use amplifiers cooled to within a few degrees above absolute zero to reduce the background noise generated by the electronic equipment. DSN antennas incorporate the most modern technology, while research into new methods continually improves the capability of receiving and transmitting commands and data. Very high-power transmitters (of nearly half a million watts) send commands to the spacecraft to turn on computers, activate instruments, and make course corrections.



DSN Communications Complexes around the world

The Global Network Imagine that you are standing on the surface of Callisto, one of Jupiter's moons, looking out towards Earth. First, the United States faces you. A few hours later, as Earth rotates on its axis, Australia, and still later, Europe, come into view. To compensate for Earth's rotation, the DSN operates clusters of antennas at three locations around the globe — in California; near Canberra, Australia; and near Madrid, Spain. The spacecraft signals are received at one site; as Earth turns, the spacecraft “sets” at that site — like the Sun setting each night — and the next site picks up the signal, then the third site, and on to the first again. Think of a runner in a relay race handing off the baton to the next runner, who hands it off to a third. With this configuration, a distant spacecraft is in view of one of the DSN Communications Complexes 24 hours a day, every day.

Acquiring Data While on its mission, the spacecraft sends more than one kind of data back to Earth. One type reports on spacecraft “health,” advising mission operators about

power levels, instrument functioning, and course maintenance. Another data set is science information — the primary reason for the mission. The spacecraft sends data gathered by its instruments, which measure atmospheric chemical composition, surface temperature, humidity, wind speed, and other characteristics. The most exciting and best-known mission results are the pictures of planets and their moons. Images are taken by a special onboard camera, transformed into electrical signals by an encoder, then transmitted to Earth in the form of 0's and 1's, called binary arithmetic symbols. When these digital signals are received on Earth, computers reconstruct them into the images originally “seen” by the spacecraft camera, and photographs are produced.

By using information derived from the spacecraft's signal, mathematicians are able to determine the precise location and motion of the spacecraft — vital data needed for navigation. Commands are sent back, or uplinked, to correct the spacecraft's course or set it in orbit around a planet at the precise time for “orbit insertion.”



The DSN Complex near Canberra, Australia

The Jet Propulsion Laboratory, California Institute of Technology, manages the DSN for NASA. To learn more, check our Web site at <http://deepspace.jpl.nasa.gov/dsn>, or write to DSN, Mail Stop 303-401, Jet Propulsion Laboratory, 4800 Oak Grove Drive, Pasadena, CA 91109-8099.