A proven system, made to measure

The DORIS system (Doppler Orbitography and Radiopositioning Integrated by Satellite) was designed and developed by CNES, the French space agency, in partnership with the space geodesy research institute GRGS and France's mapping and survey agency IGN, to determine the position of satellites on orbit and to locate ground stations with extreme accuracy.

Onboard the satellite:
An antenna pointed towards Earth receives radioelectric signals sent by stations as the satellite passes overhead.
An electronic receiver measures the Doppler shift. An ultrastable oscillator, which is the instrument's clock and the linchpin of the whole system, maintains measurement accuracy and timing.

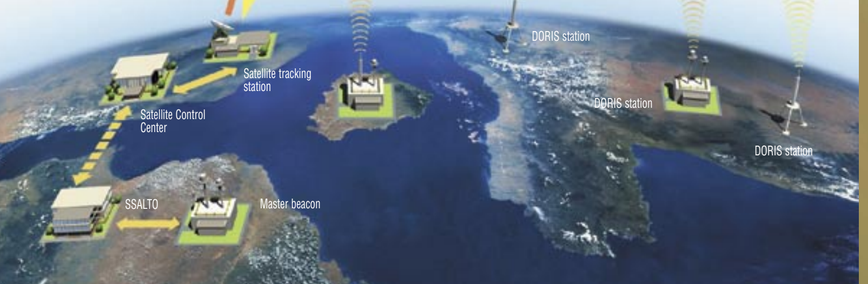
On the ground:
About sixty stations transmit radioelectric signals acquired by the satellite.

A global network of stations

In 1986, CNES and IGN began deploying autonomous ground stations worldwide. These stations are used as ground reference points to track satellite trajectories continuously.
Today, through close coope-ration with international partners, the DORIS system has built up a global network of 60 stations. Nearly half of these stations are on islands or in coastal areas.

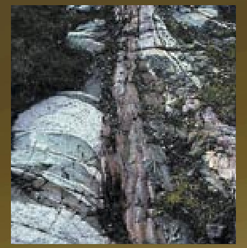
Millions of measurements

The satellites relay acquired and stored data at regular intervals to SSALTO, the multi-missions orbitography and altimetry center in Toulouse, France. This center keeps a check on station operations, processes measure-ments, calculates the orbit of the satellites carrying the DORIS instrument, and archives and distributes data. Since its maiden mission in 1990, DORIS has acquired over 50 million measu-rements for the international scientific community.



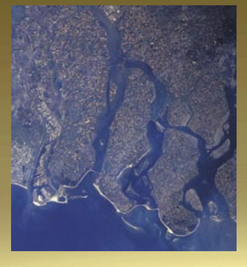
The shifting Earth

The level of performance DORIS has attained in its first ten years of operation has made it a benchmark system for precision orbit determination, vital for space oceanography altimeter missions. Its unique network of ground stations and its highly accurate positioning capability have also proven most valuable for geodesy and geophysics applications.



Measuring continental drift

The Earth's crust is made up of slowly-shifting tectonic plates. The motion of these plates is what causes earthquakes.
Precise measurements by DORIS over several years have made it possible to track imperceptible horizontal displacements.
DORIS data have also allowed us for the first time to measure the rotation of the Antarctic Plate and to show that the African and Eurasian plates are moving two centimeters closer to each other every year.

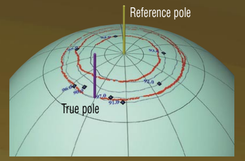


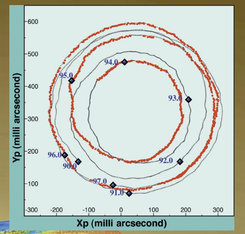
Monitoring sea level

A rise in sea level due to global warming would have disastrous consequences for populations in many regions of the world. That is why monitoring the oceans is now a key priority. Ocean data are derived using a broad range of techniques. DORIS data, combined with measurements acquired by the altimeter on the Jason-1 satellite and by tide gauges, yield essential information about this current topic of interest.

Precisely calculating Earth's rotation

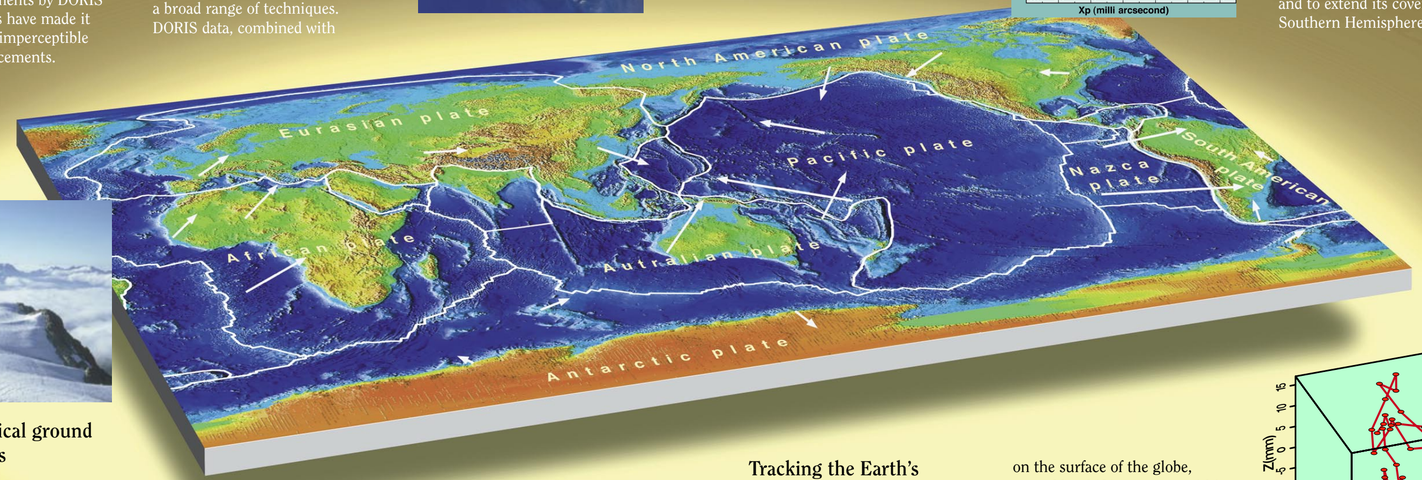
The Earth's rotational motion is irregular. Its speed of rotation varies and its rotation axis wobbles slightly. Thanks to DORIS, we can now keep track of this polar motion - confined within an area of approximately 20 meters by 20 meters - on a daily basis. As more satellites carrying DORIS instruments are launched in the years ahead, we will be able to measure these movements more accurately than ever before.





Contributing to the International Reference System

The world's nations have been deploying grids of geodetic control points since the 18th century. In France, surveyors at the national mapping and survey agency IGN recently upgraded the country's geodetic network. The emergence of space geodesy techniques has helped to build a highly accurate global land network called the International Terrestrial Reference Frame (ITRF).
Since 1994, the network of DORIS stations has been helping to maintain and densify the ITRF and to extend its coverage of the Southern Hemisphere.

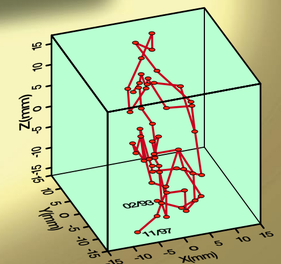


Gauging vertical ground displacements

In winter, in the northernmost regions of the globe, snow cover weighs so heavily that the ground sinks. This movement is detected by measuring minute vertical displacements of DORIS stations, which rise and fall as snow cover forms and melts.
Until now, these tiny deformations in the Earth's crust - no more than a few millimeters a year - were very difficult to measure.
Climatologists are keen to observe these deformations, which can also be caused by varying soil moisture and atmospheric pressure.

Tracking the Earth's center of gravity

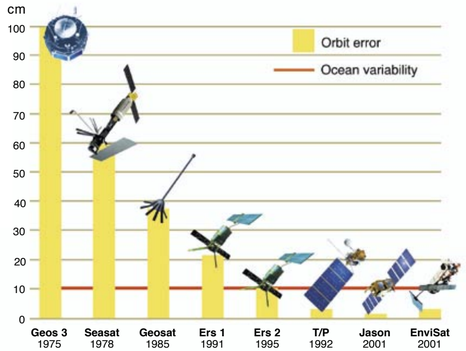
The Earth's center of gravity is constantly changing its position within a one-centimeter cube in response to mass redistributions on the surface of the globe, caused by shifting masses within the ocean and by soil moisture, snow cover and groundwater.
DORIS measures these seasonal millimetric variations, which impact orbit calculations.



Tracking trajectories with ever-increasing accuracy

Spectacular results

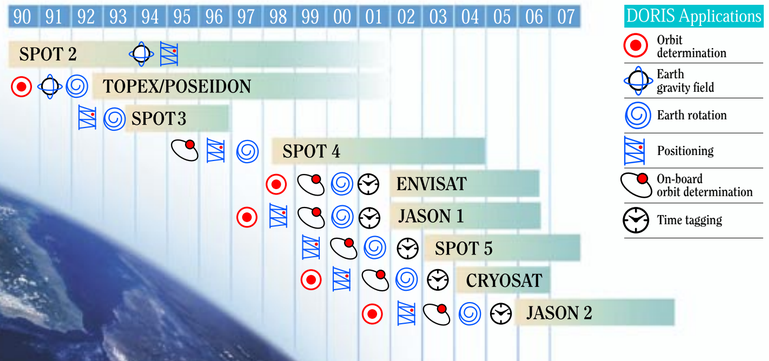
Since embarking on its initial proof-of-concept mission on the SPOT 2 satellite, the DORIS system has taken every new challenge in its stride. The goal the TOPEX/POSEIDON mission set itself was to measure the satellite's altitude to within 13 centimeters. An ambitious goal indeed, since the best systems at the time could achieve no better than one-meter accuracy. For space oceanography applications, that was not nearly accurate enough.
DORIS soon began calculating orbits to within 10 centimeters, then 2.5 centimeters. This superb feat laid the foundations for the success of the TOPEX/POSEIDON mission. Over the years, performance demands on the DORIS system have continued to increase. Now, the overall accuracy specifications for the Jason-1 satellite altimetry system require DORIS to calculate orbits to within just one centimeter.



DORIS – a ten-year success story

The DORIS system has been a great technical, operational and scientific success. The DORIS instrument, which is already flying on a number of satellites and is being considered for several new missions, guarantees users a high-quality operational service providing precise orbit determination over the long term.
In the decade ahead, new partners will be contributing to the system's continued success through the International DORIS Service (IDS), bringing the international scientific community more measurements and derived products.

New satellites carrying the DORIS instrument will make the system even more accurate than before. Its enhanced performance will be a great boost for many fields of Earth Science.



DORIS Applications
- Orbit determination
- Earth gravity field
- Earth rotation
- Positioning
- On-board orbit determination
- Time tagging

Looking ahead to new products and applications

The DORIS system is constantly improving, with more onboard processing capability, more accurate orbit determination, more reliable and more compact components, and more features being developed all the time. Today, we find ourselves at the beginning of a new decade poised to spawn a wealth of new applications dedicated to the study of our planet.

Even better performance...

Third-generation DORIS stations operated from the end of 2001 offer greater reliability. These new stations feature a number of enhancements, including the ability to shift transmission frequencies to avert the risk of interference with nearby stations. Stations installed at new sites are being added to the existing network. Some are near tide gauges to make the most of complementarity with sea level observations.
Satellite receivers are also now more compact. Second-generation receivers have a second channel for simultaneous reception of signals from two stations. Other upgrades under study are seeking to further improve performance and increase receiving capacity to meet the needs of new applications.

DIODE – a big step towards greater satellite autonomy

The DIODE navigator (Détermination Immédiate d'Orbite par Doris Embarqué) on SPOT 4 marked a milestone advance towards providing satellites with a real autonomous navigation capability. DIODE software processes DORIS receiver measurements onboard the satellite to calculate the satellite's trajectory in real time. Flown initially as a proof-of-concept payload, DIODE has proven a truly operational system, delivering over 99.5% availability and accuracy of a few meters, far exceeding its designers' expectations. SPOT 4 sends this precious information to stations receiving SPOT imagery, thus allowing scenes to be located precisely and automatically.
DIODE is now preparing to fly on all new DORIS missions, thus paving the way for full satellite autonomy.

1990, 18 kilograms and 20 litres... ...2001, 5 kilograms and 5 litres

To find out more:
International DORIS Service (IDS): http://ids.cls.fr
CNES scientific missions - DORIS: http://doris@www-projet.cst.cnes.fr:8086

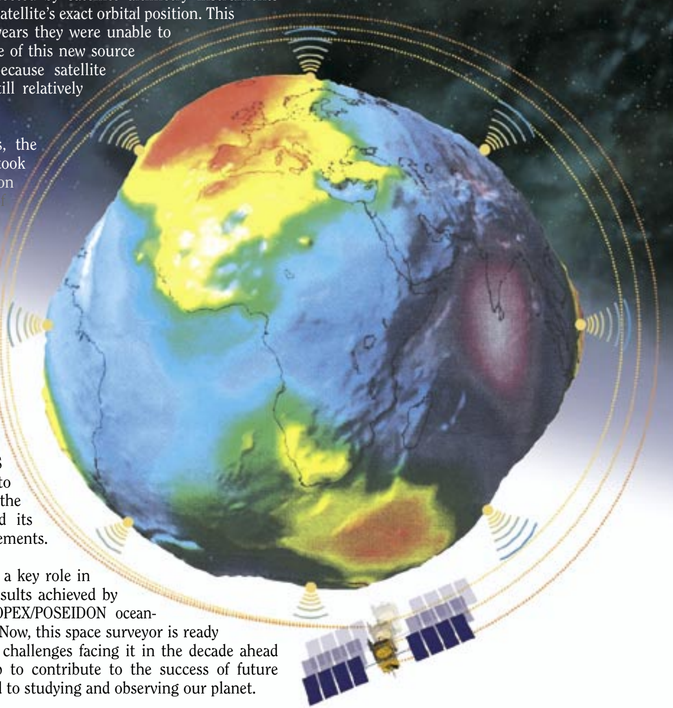
DORIS, the space surveyor

Rising to the one-centimeter challenge

Space is a unique vantage point for observing and studying Earth's ever-changing oceans. Scientists working with the precious data collected by satellite altimetry instruments need to know the satellite's exact orbital position. This is why for many years they were unable to take full advantage of this new source of information, because satellite orbit data were still relatively inaccurate.

During the 1990s, the DORIS system took orbit determination to new levels of accuracy. For the first time, precise orbit calculations to within one centimeter became possible. DORIS is also a highly accurate location system that has brought major advances in geodesy and geophysics. DORIS data are vital to scientists studying the Earth's shape and its most minute movements.

DORIS has played a key role in the remarkable results achieved by the French-US TOPEX/POSEIDON ocean-observing mission. Now, this space surveyor is ready to meet the fresh challenges facing it in the decade ahead and is gearing up to contribute to the success of future missions dedicated to studying and observing our planet.



IGN INSTITUT GEOGRAPHIQUE NATIONAL
GRGS Groupe de Recherche de Géodésie Spatiale
cnes CENTRE NATIONAL D'ETUDES SPATIALES