DORIS:

New DIODE navigator and beacon network developments

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Toulouse master beacon

DORIS was developed for precise orbit determination and precise positioning on Earth. Three satellites equipped with dual-channel second-generation receivers have been launched recently. Jason-1, EnviSat and SPOT 5 have a real autonomous capability thanks to DIODE real-time onboard orbit determination software. Today, the DORIS system has built up a global network of 56 stations. To achieve the new accuracy goals set for Jason-1 and EnviSat, it was decided to improve the long-term stability of antennas where necessary. Third-generation orbitography beacons deployed from the end of 2001 offer new features and greater reliability.

Diode navigator

Three satellites carrying second-generation DORIS receivers have been launched recently:

- Jason-1 on December 7, 2001. The DORIS receiver was switched on December 8 and started automatically. Orbit accuracy is already equivalent to that achieved with Topex/Poseidon and the goal of one centimeter on the radial component is already within reach.
- EnviSat on March 1, 2002
- SPOT 5 on May 4, 2002

Second-generation DORIS receivers have a dual-channel capability allowing multiple stations to be positioned in the same area, improved accuracy, phase measurements, and real autonomy thanks to the DIODE navigator.

Through instrument and DIODE self-initialization, these receivers go from switch-on to routine mode without any ground commands. DIODE self-programming directives control beacon signal acquisition, so the autonomous mode no longer requires daily uploads. Master beacons permanently broadcast "system uploads" to automatically update the onboard network status.

Radiation-hardened electronic components also increase the instrument's operational robustness.

Basic features

The core of the routine part of DIODE is a Kalman filter. It uses numerical integration with a Runge-Kutta algorithm to propagate the state vector every ten seconds and processes measurements from the DORIS receiver to correct its state vector.

All acquired DORIS measurements are stored on board and transmitted daily to the DORIS ground segment. We have used this large amount of data and several years of continuous Doppler measurements on SPOT 2, SPOT 3, Topex/Poseidon, and SPOT 4 to improve successive versions of DIODE.

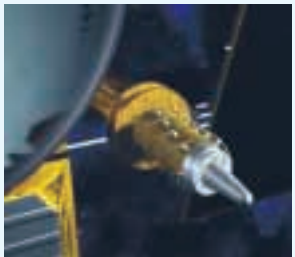
Second generation and second generation miniaturized

Basic features

The EnviSat version (second generation) is similar to the Jason-1 and SPOT 5 versions (miniaturized), and has been operating on EnviSat since March 2002. The accuracy on EnviSat is around one meter RMS (3-D), and 50 centimeters RMS on the radial component.

The last validated version of DIODE is used on Jason-1, and is also flying on SPOT 5.

Many enhancements have been made and accuracy has been further improved (through pole coordinate adjustment, Hill accelerations, drag adjustment and so on). The DIODE/Jason-1 algorithms are



described in detail in Rozo and Jayles [2001]. This version completed ground qualification in mid-2000.

The real-time orbit is used on the ground to produce Jason-1 Operational Sensor Data Records (OSDRs), which will be generated and distributed within three hours to operational oceanography centers throughout the world.

Real in-flight results

When comparing DIODE estimations with the ZOOM precise orbit ephemeris (POE, accuracy better than three centimeters RMS on altitude), the radial RMS difference oscillates between 8 and 25 centimeters (February to April 2002). The accuracy specified by altimetric users is 30 centimeters RMS on the radial component, and one meter RMS in 3-D.

be shifted with respect to the nominal frequencies: +/- 50 kHz (2 GHz) and +/- 10 kHz (400 MHz). It will thus be easier to avoid jamming by nearby stations.

Beacon modulation is now transmitted on the 2-GHz and 400-MHz frequencies (only on the 400-MHz frequency with previous beacons). This modulation is used to transmit beacon message and synchronization words. The current TAI date (with an LSB of 10 seconds) is broadcast and the observability of beacon operation status is improved. The beacon has an auto-initialization mode, and can be remote controlled, and upgraded to a master beacon.

Such beacons have already been installed in Toulouse (master beacon), Tristan Da Cunha, Mahe, Cibinong, St Helena, Adelie Land, Kauai, Thule and Cape Verde. Other upgrades

Doris network

up in Greenbelt, replacing Ottawa (antenna on a concrete pillar instead of a high building) and in Futuna (antenna on an iron tube + concrete), replacing Wallis. Several new local ties were established using other geodetic techniques and transmitted to the IERS Central Bureau. Eleven stations were upgraded in 2001: Rio Grande, Easter Island, Santiago, Amsterdam, Kerguelen, Kitab, Ponta Delgada, Yellowknife, Arequipa, Noumea, and Chatham. Four were upgraded in 2002: Tristan da Cunha, Adelie Land, Port Moresby and Kauai. Several other upgrades are underway. More than half of the stations (26 excellent, five good) meet the new stability requirement, compared to one out of six two years ago.

Conclusion

With DIODE, onboard orbit determination is today a reality and has been demonstrated in flight. The concept has been validated and is now entering an operational phase. Many satellite designers now factor a "navigation" function into their new bus designs.

From now on, constellations, automated Earth observation systems, and satellite designers in general can be confident that onboard orbit computation is an operational and reliable solution that provides pretty good accuracy. Cryosat, Jason-2, and Pleiades will be our next users. We are sure that, for those flights, DORIS and DIODE will once again be on board.

All the lessons learned with the first generation have been integrated in this version: on Jason-1, since February 2002, the observed availability is 100%.

Network

Third-generation beacons

CNES developed third-generation beacons to improve DORIS system accuracy and capacity. The emitted frequencies can now

are planned this year, such as in the French Southern Indian Ocean territories.

Network renovation

To reach the new accuracy goals set for Jason-1 and EnviSat, it was decided to improve the long-term stability of antennas where necessary.

Network upgrades started in 2000 with the stations in Cibinong, Djibouti, Hartebeesthoek and Metsahovi. Two new stations were set

References

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