

## **The proposed International DORIS Service**

Pascal Willis (1,2), Gilles Tavernier (3), Martine Feissel-Vernier (1,4),

Frank Lemoine (5) Carey Noll (5), John Ries (6), Laurent Soudarin (7)

(1) Institut Geographique National, Direction Technique, 2, Avenue Pasteur, BP 68,  
94160 Saint-Mande, France

(2) Jet Propulsion Laboratory, MS 238-600, 4800 Oak Grove Dr., Pasadena, CA,  
91109, USA

(3) Centre National d'Etudes Spatiales, 18, Avenue E. Belin, 31055 Toulouse Cedex,  
France

(4) Observatoire de Paris, 61, Avenue de l'Observatoire, 75014 Paris, France

(5) NASA/GSFC, Greenbelt MD, USA.

(6) University of Texas, CSR, Austin TX, USA.

(7) CLS, Ramonville Saint-Agne, France.

Corresponding author: Pascal Willis

E-mail: [Pascal.R.Willis@jpl.nasa.gov](mailto:Pascal.R.Willis@jpl.nasa.gov)

Phone: 1-818-393-4748

FAX: 1-818-393-4965

## **The proposed International DORIS Service**

Pascal Willis (1,2), Gilles Tavernier (3), Martine Feissel-Vernier (1,4),  
Frank Lemoine (5) Carey Noll (5), John Ries (6), Laurent Soudarin (7)

- (1) Institut Geographique National, Direction Technique, 2, Avenue Pasteur, BP 68,  
94160 Saint-Mande, France
- (2) Jet Propulsion Laboratory, MS 238-600, 4800 Oak Grove Dr., Pasadena, CA,  
91109, USA
- (3) Centre National d'Etudes Spatiales, 18, Avenue E. Belin, 31055 Toulouse Cedex,  
France
- (4) Observatoire de Paris, 61, Avenue de l'Observatoire, 75014 Paris, France
- (5) NASA/GSFC, Greenbelt MD, USA.
- (6) University of Texas, CSR, Austin TX, USA.
- (7) CLS, Ramonville Saint-Agne, France.

### **Keywords**

DORIS, IDS, International DORIS Service, IGGOS

### **Abstract**

In 1999, an International DORIS Experiment has been initiated under the umbrella of the International Association of Geodesy. Since then, 3 new DORIS satellites have been launched carrying on-board improved Doppler receiver. On the other hand the DORIS

tracking network has also been improved regularly. In 2001, a DORIS analysis campaign has been launched. Several groups have participated using different software and providing time series of results available on Internet. The goal of this paper is to discuss the status of the DORIS Pilot experiment, to analyse the progress made during the past 2 years and to propose the official creation within the IAG of an International DORIS Service (IDS). Such a service would be with the already existing IGS, IVS and ILRS part of the proposed International Global Geodetic Observing System (IGGOS).

### **Introduction**

Since the launch of the first DORIS receiver on-board the SPOT-2 satellite in 1990, a lot has happened in terms in equipment technology as well as in software improvements. There is now a larger international community using DORIS data from different satellites for different types of scientific activities: precise orbit determination (Davis, 1997, Haines, 2003), geodesy, geodynamics (Cretaux, 1998, Soudarin, 1999),... In 1999, a DORIS Pilot Experiment has been initiated to prepare a possible additional Service of the International Association of Geodesy, based on the same principles or the IGS and aiming for similar scientific applications (Beutler, 1999) and chaired by G. Tavernier. These IAG services (IGS, IVS, ILRS and IDS) would be the backbone of a future International Geodetic Observing System, as proposed by Rummel (2002) and Beutler (2002). The goal of this paper is to present the recent developments in the DORIS technology, to summarize the results and the experience gained from the DORIS Pilot Experiment and to propose a new International DORIS Service.

### **DORIS satellites and receivers**

In the past 2 years, 3 more satellites have been launched : JASON (CNES/JPL for oceanography) on December 7, 2001, ENVISAT (ESA for oceanography) on March 1, 2002 and SPOT-5 (CNES for remote sensing) on May 4, 2002. There is today 6 available DORIS satellites. This doubling of the available DORIS satellites has enhanced the positioning performances of the DORIS system (Willis, 2003a). Furthermore these new DORIS receivers have a lower Signal-to-Noise Ratio and they are equipped with a dual channel capability allowing common observations of 2 DORIS beacons within the same region (Tavernier 2003). The improved on-board software DIODE (Jayles, 2002) allows precise real-time positioning of the satellites, currently at the sub-meter level in 3-D in real-time. Following the experience gained with the new satellites, some recent software updates will be made to all new DORIS satellites before the end the year, as already done for SPOT-4.

In the near future, additional satellites could carry these new types of DORIS receivers: Cryosat (ice sheet altimetry mission, 2004), JASON-2 (oceanography mission, 2005) and potentially several satellites of the Pleiades constellation (SPOT follow-on remote sensing mission, 2007).

### **DORIS network and data centers**

In the past 10 years, the DORIS permanent tracking network has been extremely stable making this system attractive for long-term geodetic and geophysical studies such as reference frame monitoring (Altamimi, 2002). The network is presently composed of 56 stations geographically well distributed over 333 countries. Some new stations were

added to improve the already good geographical distribution of the tracking network (Sal Island). More recently, a very important rejuvenation of the network has been undergone by the Institut Geographique National since 2000 : recent local ties campaigns, improved monumentation, local investigations on long-term antenna stability (Fagard, 2003). Presently, 26 out of the 56 DORIS stations are considered as excellent for all of these criteria. The new installed DORIS stations can now slightly shift their transmitting frequency by +/- 50 kHz on the 2 Ghz frequency and +/- 10kHz on the 400 MHz frequency in order to avoid jamming. This is already the case for 6 stations : Toulouse, Tristan Da Cunha, Mahe, Cibinong, Sainte-Helena, Thule. Following some problems related to the DORIS/JASON oscillator (Willis, 2003a), a third DORIS Master Beacon (reference for time and frequency) will be soon installed in Hartebeestoech (South Africa).

With the new dual-channel capability, CNES has proposed to extend this network and send out a call for participation. A group has been formed under the chairmanship of F. Lemoine (Goddard Space Flight Center). For example a first DORIS beacon has been installed at Wetzell in Germany in order to prepare a collocation with the TIGO project in South America (Schluter, 2002). A specific campaign (Lambert campaign) has been also conducted on the Sorsdal glacier from December 12, 2001 to February 5, 2002, led by Geoscience Australia. Another campaign has been organized in Corsica by the CERGA for the JASON/TOPEX calibration activities. These type of DORIS data as densification of the permanent tracking network could also be soon distributed for further investigation.

The DORIS data distribution has been improved in the past year. The CNES data center SSALTO has been able to cope with the recent doubling in the DORIS data stream. The IGN data center is now operational as a back of the CDDIS data center that has been performing constantly well since 1993. Those two data center provide preprocessed DORIS data from all satellites on a daily basis, as well as necessary information files (satellites maneuvers, satellites attitude files, satellites physical models,...). More recently, DORIS results from different analysis centers (stations weekly and monthly positions, stations positions and velocities, geocenter variations, ionospheric contents) can also be obtained at these data center. A specific study has been conducted by the DORIS Analysis Coordinator (M. Feissel-Vernier) in conjunction with the DORIS Data delivery Coordinator (C. Noll) to better define the format, content and delivery specifications

### **From the DORIS Pilot experiment to the IDS**

The DORIS Pilot Committee is steered by an international committee, chaired by G. Tavernier. The day-to-day activities, such as the Web site maintenance (<http://ids.cls.fr>) are conducted by a Central Bureau (CLS, CNES, IGN). A DORISMail facility has been created and is presently distributed to 158 individuals. A total of 246 emails were distributed in total and are still archived at <http://list.ensg.ign.fr/wws/arc/dorismail>. Anybody can subscribe easily at anytime or have access to the previous messages.

Several international meetings have been organized recently and all presentations can be found on Internet (<http://ids.cls.fr/html/report.html>): IDS Workshop, Biarritz, June 13-14,

2002 (90 participants), IDS Analysis workshop, Marne-la-Vallee, February 20-21, 2003 (30 participants).

As the DORIS results are now available regularly on Internet, several groups have used them in conjunction with results from other technique (Nothnagel, 2002). Of course additional steps are needed to increase the accuracy of the results as well as their integrity, for example by unifying first all DORIS solutions, but it must be noted that a somehow important activity has been conducted in the past two years by the DORIS Analysis groups. Furthermore, some major improvements could be obtained when new gravity field model, based on recent gravity field mission, such as GRACE (Dunn, 2002) could be available to all participants. This could enhance the accuracy of the DORIS results as Low Earth Orbit satellites are used (SPOT at 830 km altitude and more recently ENVISAT at 750 km altitude)

### **Status of the IDS Analysis campaign**

On November 2001, an international call for participation was issued by the DORIS analysis coordinator (M. Feissel-Vernier) to process the DORIS measurement for precise point positioning (time series of coordinates). Six out of the eleven DORIS analysis centers answered positively and proposed to process the data. Results were presented at the IDS Analysis workshop using different software. Experiences were compared during the meetings and a preliminary combination of all available series was obtained for weekly and monthly solutions. Several problems inherent to the DORIS techniques and to some specific DORIS stations were raised. Data formats and distributions were discussed. All these necessary should help us provide a regular unified DORIS solutions

obtained by rigorous combinations of all available DORIS individual time series solutions.

### **Conclusions**

In conclusion, the DORIS technique has benefited in the past two years from significant improvement in the receiver technology as well as from a large increase in the number of available satellites. These facts have attracted new group to process the DORIS data mainly for geodetic or geophysical purposes. This community has joined its forces within the scope of the IAG established DORIS Pilot Experiment in 1999. Since then, several international meetings have been organized and regular results from different analysis groups are regularly available on Internet. We think that the time has now come to create a new IAG Service, called International DORIS Service, that would be naturally a part of the near-to-come Integrated Global Geodetic Observing System (IGGOS).

### **Acknowledgements**

This research was carried out at the Jet Propulsion Laboratory, California Institute of Technology, under a contract with the National Aeronautics and Space Administration.

### **References**

Altamimi Z, Sillard P, Boucher C (2002) ITRF2000, a new release of the International Earth Rotation System. *J. Geophys. Res. Solid Earth* 107: B10 2214

Beutler G, Rothacher M, Schaer S, Springer TA, Kouba J, Neilan RE (1999) The International GPS Service (IGS, An interdisciplinary service in support of Earth Sciences). *Adv. Space Res.* 23: 4 631-653

Beutler G, Brunner F, Dickey J, Feissel M, Forsberg R, Mueller II, Rummel R, Sanso F, Schwartz KP (2002) The IAG review 2000-2001: Executive Summary. *International Association of Geodesy Symposia, Springer-Verlag* 125: 603-608

Crétau JF, Soudarin L, Cazenave A, Bouille F (1998) Present day tectonic plate motions and crustal deformations from the DORIS space system. *J. Geophys. Res.* 103: 30167-30181

Davis GW, Ries JC, Tapley BD (1997) The accuracy of precise orbits computed from Doppler tracking data. *J. Astr. Sci.* 45 : 4 451-469

Dunn C, Bertiger W, Franklin G, Harris I, Kruizinga G, Meehan T, Nandi S, Nguyen D, Rogstad T, Brooks Thomas J, Tien J (2002) *Proc. ION GPS 2002, Portland, USA, September 2002* 724-730

Fagard H (2003) The DORIS network, status report on renovation and collocations. *IDS Analysis Workshop, IGN, Marne-la-Vallee, France, February 2003.*

Haines BJ, Bertiger W, Desai S, Kuang D, Munson T, Young L, Willis P (2003) Initial Orbit Determination Results for Jason-1: Towards a 1-cm Orbit *J. Navigation*, in press

Jayles C, Berthias JP, Laurichesse D, Nordine S, Cauquil P, Tavernier G (2002) DORIS-DIODE: Two-years results of the first European Navigator. *Adv Space Res* 30: 2 301-306

Nothnagel A, Dill R, Feissel-Vernier M, Ferland R, Noomen R, Willis P, (2002) EOP Alignment Campaign, *IDS/IGS/ILRS/IVS EOP combinations and systematic errors, IERS Workshop, Munich, Novembre 2002*

- Rummel R, Drewes H, Beutler G (2002) Integrated Global Geodetic Observing System (IGGOS): A candidate IAG project. International Association of Geodesy Symposia, Springer-Verlag 125: 609-614
- Schlüter, W, Hase H, Böer A, Riepl S, Cecioni A (2002) TIGO starts its operation in Concepcion in 2002, CSTG Bulletin 17: 92-93
- Soudarin L, Crétaux JF, Cazenave A (1999) Vertical crustal motions from the DORIS space geodesy system. Geophys. Res. Lett. 26: 1207-1210
- Tavernier G, Soudarin L, Larson K, Noll C, Ries J, Willis P (2002) Current status of the DORIS Pilot Experiment. Adv. Space Res. 30: 2 151-156
- Tavernier G, Granier JP, Jayles C, Sengenés P, Rozo F (2003) The Current Evolutions of the DORIS System. Adv. Space Res. (in press)
- Willis P, Haines B, Bar-Sever Y, Bertiger W, Muellerschoen R, Kuang D, Desai S (2003) Topex/Jason combined GPS/DORIS orbit determination in the tandem phase. Adv. Space Res. (in press)
- Willis P, Bar-Sever Y, Tavernier G (2003a) DORIS as a potential part of a Global Observing System. Springer-Verlag, Proc. IUGG General Assembly, Sapporo, July 2003.