CURRENT STATUS OF THE DORIS PILOT EXPERIMENT

Gilles TAVERNIER[1], Kristine LARSON[2], Carey NOLL[3], John RIES[4], Laurent SOUDARIN[5], Pascal WILLIS[6]

[1]Centre National d'Etudes Spatiales, Toulouse, France
[2]University of Colorado, Boulder, USA
[3]NASA Goddard Space Flight Center, Greenbelt, MD, USA
[4]Center for Space Research, The University of Texas at Austin, USA
[5]CLS, Ramonville Saint Agne, France
[6]IGN, LAREG, Marne-La-Vallée, France

ABSTRACT – DORIS was developed for precise orbit determination and precise positioning on earth. DORIS is on the way to establish an international service similar to the existing services related to the other techniques contributing to the International Earth Rotation Service (IERS). The purpose of such services is to provide the scientific community with data and products. As a preliminary step, following the CSTG Executive Committee and the IERS Directing Board recommendation, a Call for Participation in a DORIS Pilot Experiment was broadcasted in September 1999. By the end of 1999 many proposals were submitted. A Steering Committee has been instituted and is making up a Stations Selection Group and a Data and Products Formats Working Group. Planned activities for the coming year will also be discussed.

RESUME – Le système DORIS a été développé pour répondre au besoin de détermination précise de la position des satellites, et au besoin de localisation . DORIS est en train de mettre en place un service international similaire aux services existants pour les autres techniques contribuant au Service International de la Rotation Terrestre (IERS). L'objet de tels services est de fournir des données et des produits à la communauté scientifique. Dans un premier temps, suivant les recommandations du Comité Exécutif du CSTG et du Comité Directeur de l'IERS, un appel à participation à une Expérience Pilote DORIS a été diffusé en septembre 1999. A la fin 1999, de nombreuses propositions ont été soumises. Un Comité d'Organisation a été constitué et un Groupe de Sélection des Stations et un Groupe de Travail sur les Formats des Données et des Produits se mettent en place. Les activités envisagées pour l'année à venir sont également abordées.

1- INTRODUCTION

DORIS is one of the four techniques contributing to the International Earth Rotation Service. The other techniques have an international service providing the scientific community with data and products. There is an increasing demand among the international scientific community for a similar DORIS Service.

The CSTG Executive Committee and IERS Directing Board decided in July 1999 (IUGG - Birmingham) to initiate a DORIS Pilot Experiment.

A Call for Proposals was broadcasted in September 1999 to prompt qualified organizations to submit proposals for components of the future IDS. We received proposals for the Central Bureau, Data Centers, Analysis Centers, existing satellites and new stations.

The joint CSTG/IERS DORIS Pilot Experiment Terms of Reference were presented and discussed at the CSTG Executive Committee Meeting held during the AGU Fall Meeting (San Francisco-December 1999).

This paper recalls the objectives of the future IDS, points out its components and structure, describes the organization of the Experiment and draws up a report of the preliminary activities related to it.

2 – THE DORIS SYSTEM

2.1 – Backgroung

The DORIS system was designed and optimized to provide high precision orbit determination and ground station positioning. It was developed to support the TOPEX/POSEIDON oceanographic altimetry mission. It is an up-link radiometric system based upon precise Doppler measurements and using two frequencies, 2 GHz and 400 MHz, well suited to correct for ionospheric effects. In contrast to other navigation systems such as GPS or GLONASS, DORIS is a centralized system. Line-of-sight velocity measurements between the network transmitting stations and the space borne receivers are currently collected and pre-processed by one unique control center located in Toulouse (Mission center).

Analyses of the data from DORIS/SPOT2, SPOT3, TOPEX/POSEIDON and now SPOT4, have demonstrated the capabilities of the system for the precise monitoring of station positions and the determination of crustal motions. With high precision determination of the TOPEX/POSEIDON orbit, DORIS contributes also significantly to the success of this altimetric mission. The performance of the system led the IERS to accept DORIS as a fourth geodetic technique to be used in its analysis activities in 1994, i.e. only four years after the beginning of the first mission of DORIS on SPOT2.

2.2 – System evolutions and perspectives

Since the first flight on SPOT2 in 1990, several improvements have been implemented. On SPOT4, the orbit is also operationally computed on-board with a few meters accuracy using the DIODE navigator. This software will also be integrated in future DORIS receivers.

For ENVISAT, JASON-1 and later satellites, the second generation DORIS instrument will be able to perform simultaneous Doppler measurements from two ground stations, thus reducing the limitations for ground station positioning due to possible interference and increasing the system capacity. On JASON-1 and then SPOT-5, the DORIS instrument will perform a new type of DORIS measurement: an absolute phase measurement.

New beacon developments are being performed, such as using the shifted frequency technique that will allow the use of a larger number of stations in the same area. This will greatly increase the number of possible DORIS stations around the world. One can expect significant improvements in orbit determination, ground station localisation, and other application in the next few years.

It must also be noted that a significant source of error for DORIS-based positioning might presently come from the insufficient knowledge of the gravity field. Following the CHAMP and GRACE missions, DORIS may improve on its present performance.

2 - OBJECTIVES

The primary objective of the future IDS, an international collaboration of organizations which operate or support DORIS components, will be to provide a service to support, through DORIS data products, geodetic, geophysical, and other research and operational activities.

The aim of the DORIS Pilot Experiment is to assess the need and the feasibility of an International DORIS Service, attaching a particular care to its international character and the long-term involvement of contributing organizations.

3 - THE PRODUCTS

The future IDS will collect, archive and distribute DORIS observations data sets of sufficient accuracy to satisfy the objectives of a wide range of scientific and operational applications and experimentation. These data sets will be used by IDS to generate a variety of scientific products with differing applications, timeliness, detail, and temporal resolution, such as:

- High accuracy satellite ephemeris
- Three-dimensional coordinates and velocities of stations
- Time-varying geocenter coordinates
- Earth rotation parameters
- Static and time varying coefficients of the Earth's gravity field
- Surface meteorology, tropospheric and ionospheric information

4 - THE STRUCTURE

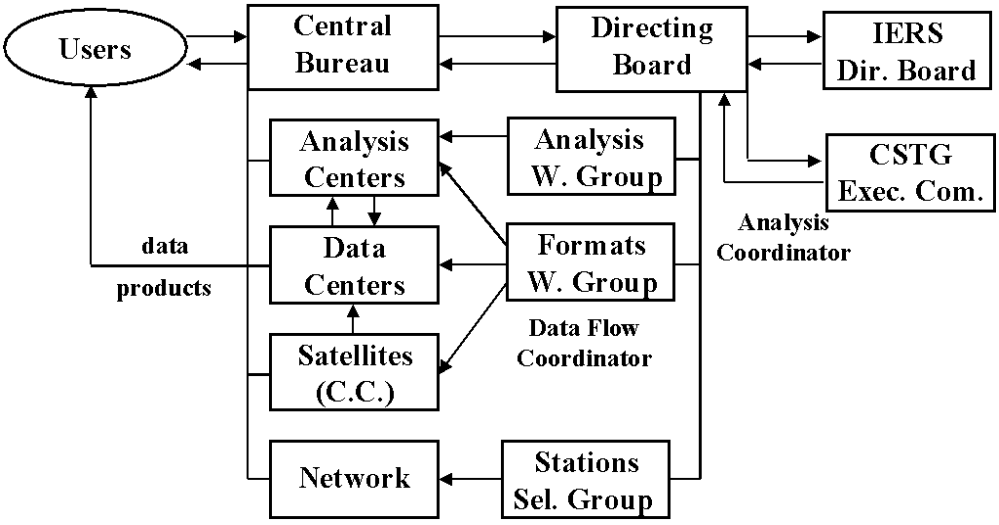

Fig. 1 : IDS Organization Chart

The future IDS will accomplish its mission through the following components:

- **Data Centers** – They archive and distribute the stations data and all required information needed by users. They archive and provide electronic access to the products from Analysis Centers.
- **Analysis Centers** – They produce at least one of the IDS scientific products, perform intercomparisons and quality checks of different solutions and generate the combined solutions of the IDS (for submission to the IERS…).

- **Central Bureau** – It provides overall coordination; maintains documentation and electronic databases (*e.g.*, satellite anomalies, site changes, DOMES identification numbers); organizes meetings and workshops.
- **Directing Board** – It is responsible for the general directions in which the IDS is providing its services. It defines the official IDS products, adopts standards, (approves the scientific and operational goals for IDS), and ensures, through its chairperson, the contact to other services and organisations.
- **New temporary or permanent DORIS transmitting stations** – In addition to the current permanent network which will form the primary network used by the IDS, new stations installed temporarily or permanently could be included in the IDS network. Their data would be provided to the Data Centers and would thus be available to the community of users.
    - A few second-generation beacons should be available in the next few months.
    - Third-generation beacons are currently being developed. Their shifted frequency capability combined with future dual-frequency receivers flying on board JASON-1 and ENVISAT will increase the system capacity. They will be used to upgrade the permanent network and will also be available for other IDS purposes.
- **Additional DORIS on-board packages** – Space Agencies or Research Centers can decide to take DORIS instruments, acquiring data from the station network, on-board satellites and to contribute to IDS.
    - Data will be available to the other IDS components and to the community of users.
    - Organizations could develop their own Control Center, or benefit from the support of the CNES DORIS multi-mission ground segment (SSALTO).

5 - ORGANIZATION OF THE DORIS PILOT EXPERIMENT

5.1 – Steering Committee

The DORIS Pilot Experiment is initiated by a Steering Committee in charge of:

- preparing and broadcasting a Joint CSTG/IERS Call for Participation
- setting up the review and selection of proposals for IDS components. For Stations: a Selection Group will be appointed.

To start the Experiment, the Steering Committee has appointed or will appoint:

- a Data and Product Formats Working Group to propose exchange formats
- a Data Flow Coordinator to define the methods of data exchange between:
    - Control Centers and Data Centers for measurements and ancillary information (spacecraft maneuvers, receiver status, meteorological data …)
    - Analysis Centers and Data Centers for products and data
- an Analysis Coordinator chairing an Analysis Working Group in charge of:
    - helping newcomers in DORIS data processing
    - defining an intercomparison plan to assess the quality and performance of the products of the various centers
    - proposing ways to improve data processing

  The Analysis Coordinator will coordinate the activities of the Analysis Centers.

According to the submitted proposals and to the outcome of the activity of the selected components, the Steering Committee will:

- Check that there are at least two global data centers in two different countries
- Establish the products to be initially considered as IDS products
- Examine the operational nature of the Central Bureau
- Assess the opportunities to set up new stations and to fly additional receivers

Paying particular care to:

- The international character of the DORIS Pilot Experiment
- Long term involvement of contributing organizations

to be ready to appeal to CSTG and IERS for the adoption of the IDS.

The chairperson is in charge of drawing up a DORIS Pilot Experiment Annual Report.

The current Steering Committee is composed by the following individuals:

- Gilles TAVERNIER Gilles.Tavernier@cnes.fr CNES
  chairperson
- Kristine LARSON kristine.larson@colorado.edu University of Colorado
  Stations Selection Group chairperson
- Carey NOLL noll@cddis.gsfc.nasa.gov NASA GSFC
  Data Flow coordinator
- John RIES ries@csr.utexas.edu University of Texas CSR
  Data and Products formats Working Group chairperson, DORIS representative to IERS
- Laurent SOUDARIN Laurent.Soudarin@cls.fr CLS
- Pascal WILLIS pascal.willis@ensg.ign.fr IGN LAREG
  DORIS representative and Coordinating Center to IERS

to be completed soon by an Analysis Coordinator

5.2 - Data and Products Formats Working Group

The Data and Products Formats Working Group is composed by the following individuals:

- John RIES (chairperson) University of Texas at Austin CSR USA
- Jean-Paul BERTHIAS CNES, Toulouse France
- Werner GURTNER Astronomical Institute, University of Bern Switzerland
- Carey NOLL NASA GSFC USA
- Pascal WILLIS IGN LAREG France
- Jean-Jacques VALETTE CLS, Toulouse France

The mandate of the group is to:

- Analyze the existing DORIS measurements format used by IERS Data Centers and check whether it needs some accommodation to be able to handle the measurements of the second generation receivers (JASON1, ENVISAT, SPOT5…).
- The above-mentioned format is used to exchange preprocessed data. The group will prepare a proposal for a "raw measurements" format. It could be a RINEX format extension for the DORIS data. A limited "raw data" set could be prepared, available for Analysis Centers willing to develop an expertise on DORIS data processing.
- Propose a format for ancillary information necessary to process DORIS data
- Propose formats for the products to be delivered to the Data Centers

5.3 – Station Selection Group

The Station Selection Group is chaired by Kristine LARSON.

The Group should include a representative of the DORIS Stations Installation and Maintenance Service (IGN SIMB) and scientists involved in various applications such as geodesy, geophysics, altimeter calibration, tide gauges, ITRF collocation …

The mandate of the group is to:

- Define Sites Criteria (International Space Geodetic and Gravimetric Network - ISGN, DORIS Stations Installation and Maintenance Service…), taking into account the DORIS system specificity (jamming, interference…).
- Analyze the proposals with respect to these Criteria.
- Propose a list of stations according to the number of beacons available for the Experiment, as stated by the Steering Committee.

The DORIS Stations Installation and Maintenance Service together with the selected candidate will then manage the installation in the same way as for the existing permanent network.

6 - PROPOSALS

A Call for Proposals was broadcasted in September 1999 to prompt qualified organizations to submit proposals for components of the future IDS using:

- DORIS, IGS, ILRS and IVS Mails
- IERS Gazette
- a CDDIS web page : http://cddisa.gsfc.nasa.gov/dpe_cfp.html

We received proposals for the Central Bureau, Data Centers, Analysis Centers, existing satellites and new stations.

5.1 - Central Bureau: 1 proposal

CNES / CLS / IGN	France	Gilles Tavernier

5.2 - Data Centers: 2 proposals

NASA GSFC CDDIS	USA	Carey Noll
IGN LAREG	France	Pascal Willis

5.3 - Analysis Centers: 10 proposals

AUSLIG	Australia	Ramesh Govind
CNES	France	Jean-Paul Berthias
CSR The Univ. of Texas at Austin	USA	John Ries
ESA ESOC Darmstadt	Germany	John Dow
Geodetic Observatory Pecny	Czech Republic	Jan Kostelecky
IAA St Petersbourg	Russia	George Krasinsky
IGN LAREG	France	Pascal Willis
INASAN Moscow	Russia	Suriya Tatevian
LEGOS-GRGS / CLS Toulouse	France	Jean-François Crétaux
Royal Observatory of Belgium	Belgium	René Warnant

5.4 - Satellites: 4 until now + 3 to be launched

Until now, 4 satellites were flown fitted out with a DORIS receiver : SPOT-2 (launched in 1990), TOPEX/POSEIDON (launched in 1992), SPOT-3 (1993-1996) and SPOT-4 (launched in 1998).

3 more satellites carrying a second generation DORIS receiver will fly soon : JASON-1, ENVISAT and SPOT-5.

5.5 - Existing Stations: 54

Orbitography Network CNES/IGN	France	Hervé Fagard
Yarragadee, Mount Stromlo AUSLIG	Australia	Ramesh Govind
Badary, IAA	Russia	Zinovy Malkin
Kauai, Fairbanks NASA GSFC	USA	John Bosworth
Metsahovi, Finnish Geodetic Institute	Finland	Matti Paunonen
Syowa, National Institute of Polar Research	Japan	Kazuo Shibuya

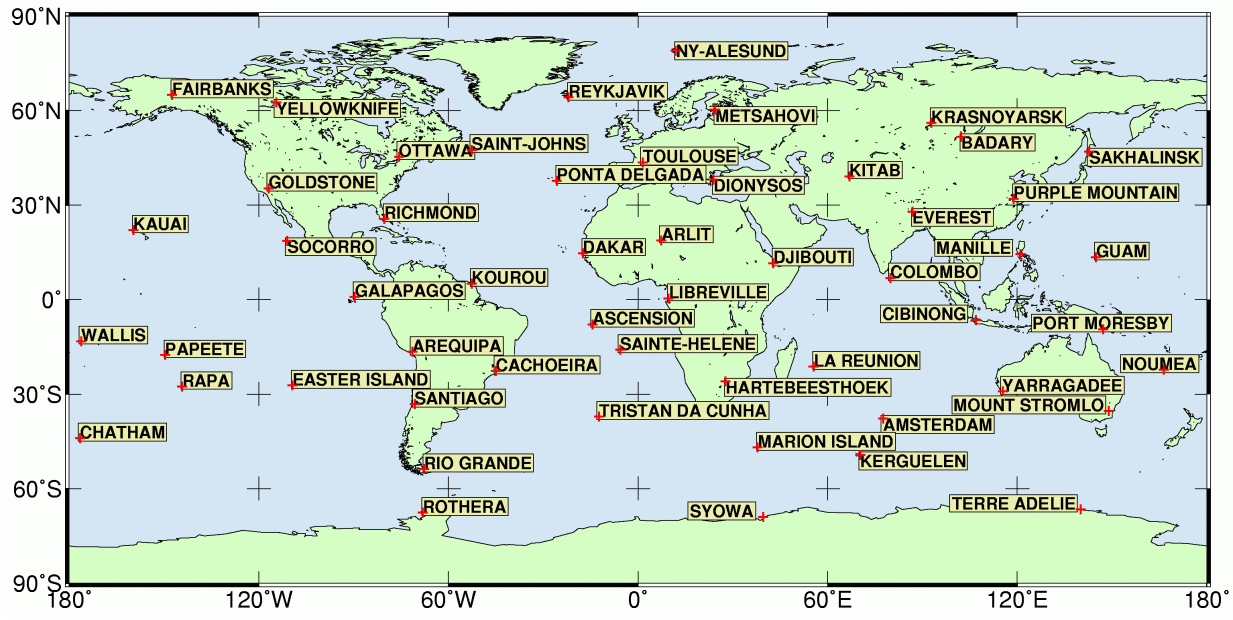

Fig. 2 : DORIS Orbitography Network

5.6 - New Stations

We also received many proposals for new DORIS stations:

Australia, Antarctica AUSLIG	Australia	Ramesh Govind
Brussels, Royal Observatory of Belgium	Belgium	René Warnant
Dome C	Antartica	Christian Vincent
Grasse, Ajaccio	France	Pierre Exertier
Gavdos TU Crete	Greece	Stelios Mertikas
Greenbelt NASA GSFC	USA	John Bosworth
Herstmonceux	UK	Phil Moore
Iran	Iran	Faramarz Nilforoushan
Irkutsk VS NIIFTRI	Russia	Vjacheslav Zalutsky
Geodetic Observatory Pecny	Czech Republic	Jan Kostelecky
San Fernando	Spain	Jose Martin Davila
Svetloe, Zelenchukskaya , IAA	Russia	Zinovy Malkin
Terra Nova Bay	Italy/Antartica	Alessandro Capra
Warsaw University of Technology	Poland	Janusz Sledzinski
Wetzel, TIGO	Germany	Wolfgang Schlueter
Wousi	New Hebrides	Stéphane Calmant

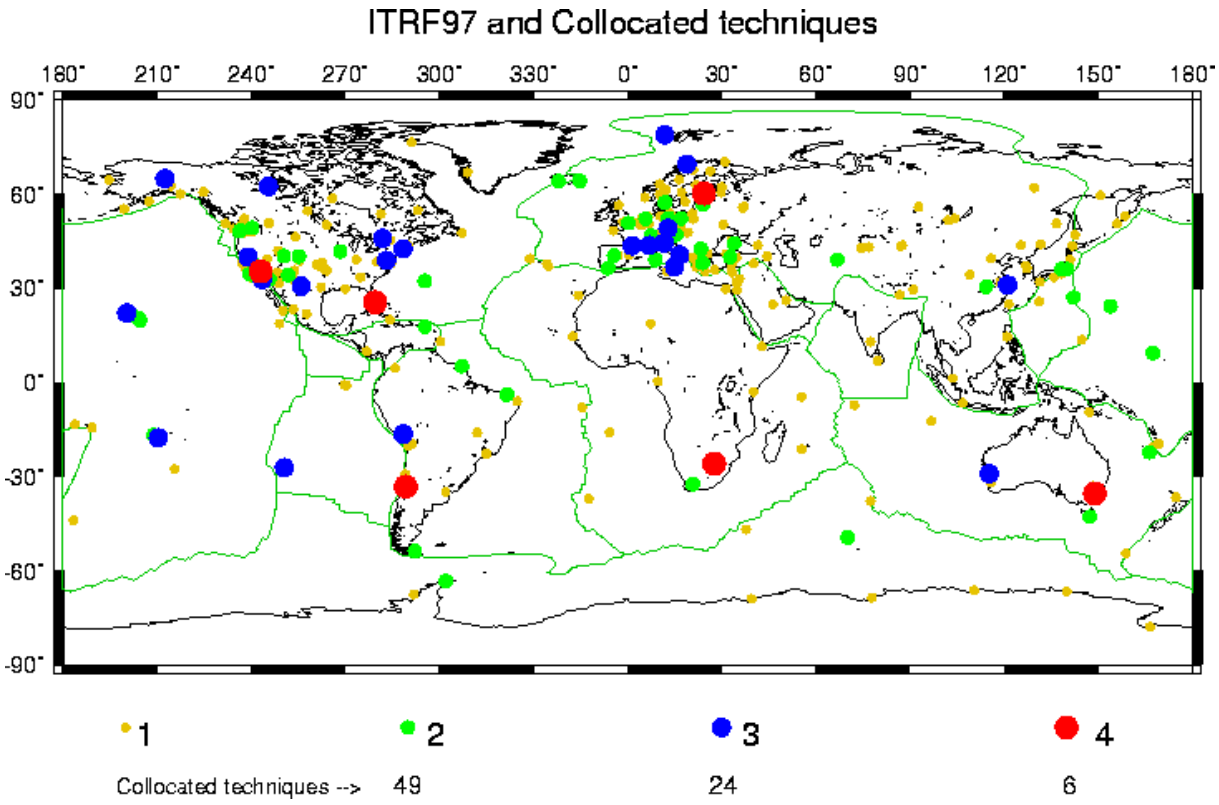

Fig. 3 : ITRF 97 and collocated techniques

6 – PLANNED ACTIVITIES FOR THE COMING YEAR

DORIS Days are held in Toulouse, with the purpose to promote exchanges between different designers, operators and users of the DORIS system by presenting the results obtained since the system was placed in orbit.

This second version of these DORIS Days is in particular devoted to a review of the start-up of the Doris Pilot Experiment and of presenting the technological changes which have been made to the system (Jason, ENVISAT and SPOT5 missions, 3rd generation beacons). Two workshops will give the opportunity to discuss on:

- the organization of the Experiment and the interaction between scientific research & services
- the DORIS system and performances evolutions as planned as well as needed by the users

The Central Bureau will implement a DORIS Pilot Experiment Website: http://ids.cls.fr

Data Centers will compare available measurements, add ancillary information and Exchange formats should be adopted to allow Analysis Centers to start to process data and compare their products.

The Stations Selection Group will propose a list of stations according to the number of beacons available for the Experiment.

The Steering Committee will propose the statutes of the future Directing Board (membership, nomination and election of members, election and role of Chairperson, frequency of meetings…) and Associate Members.