International DORIS Service (IDS)

http://ids-doris.org/

Chairman of the Governing Board: Frank Lemoine (USA)

Overview

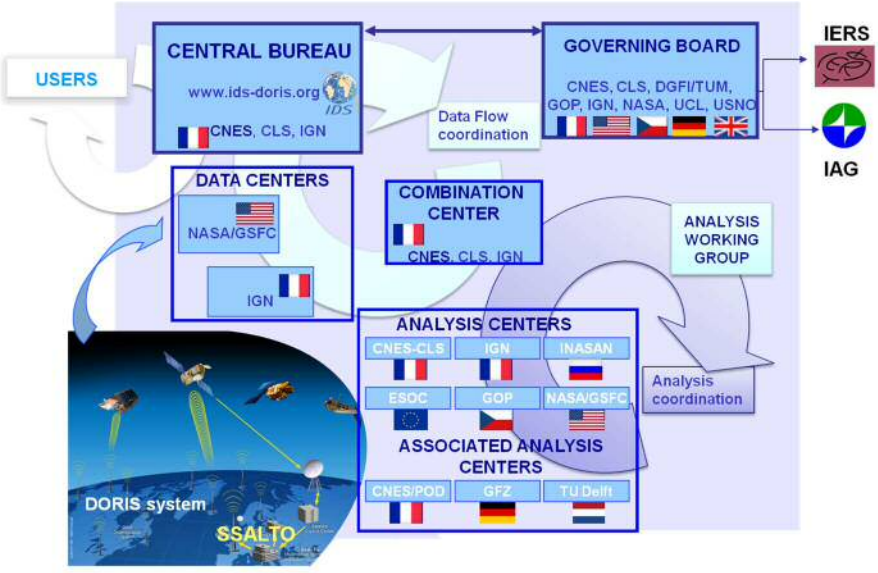
The leading achievement of the International DORIS Service (IDS) over the period 2015-2017 was the contribution to ITRF2014, the preparation of articles for the DORIS Special Issue in the journal "Advances in Space Research", and the initiation of a routine operational delivery of an IDS combination on a quarterly basis. Six IDS analysis centers (ACs) used five separate analysis packages to create IDS products as well as to reprocess all DORIS data since 1993 for inclusion in the DORIS combination for ITRF2014. The Combination Center in Toulouse creates the routine combinations in close collaboration with the Analysis Coordinators and the Analysis Centers. The components of the IDS meet regularly primarily during Analysis Working Group (AWG) meetings to discuss progress on current technical questions. The Governing Board of the IDS provides long-term direction while the Central Bureau manages the day-to-day activities brings its supports to the IDS components and operates the information system.

The current report presents the different activities held by all the components of the IDS for the period from the middle of 2015 to the middle of 2017.

Structure

The IDS organization is very similar to the other IAG Services. The service accomplishes its mission through the following components:

- Satellites carrying a DORIS receiver
- Network of tracking stations
- Data Centers
- Analysis Centers and Analysis Coordinator
- Combination Center
- Working Groups
- Central Bureau
- Governing Board



Activities

1. DORIS system

1.1 DORIS satellites

As described in Table 1.1, two new satellites were launched in early 2016: Jason3 and Sentinel3B, both using the new 7-channel DG-XXS DORIS receiver on-board the satellite. The DORIS constellation then steadily increased, including currently six satellites at altitudes of 720 and 1300 km, with near-polar or TOPEX-like inclination (66 deg).

Table 1.1: DORIS data available at IDS data centers, as of May 2017

Satellite	Start	End	Space Agency	Type
SPOT-2	31-MAR-1990 04-NOV-1992	04-JUL-1990 15-JUL-2009	CNES	Remote sensing
TOPEX/Poseidon	25-SEP-1992	01-NOV-2004	NASA/CNES	Altimetry
SPOT-3	01-FEB-1994	09-NOV-1996	CNES	Remote sensing
SPOT-4	01-MAY-1998	24-JUN-2013	CNES	Remote sensing
Jason-1	15-JAN-2002	21-JUN-2013	NASA/CNES	Altimetry
SPOT-5	11-JUN-2002	1-DEC-2015	CNES	Remote sensing
Envisat	13-JUN-2002	08-APR-2012	ESA	Altimetry, Environment
Jason-2	12-JUL-2008	PRESENT	NASA/CNES	Altimetry
Cryosat-2	30-MAY-2010	PRESENT	ESA	Altimetry, ice caps
HY-2A	1-OCT-2011	PRESENT	CNSA, NSOAS	Altimetry
SARAL/ALTIKA	14-MAR-2013	PRESENT	CNES/ISRO	Altimetry
JASON-3	17-JAN-2016	PRESENT	NASA/CNES/NOAA /Eumetsat	Altimetry
SENTINEL-3A	16-FEB-2016	PRESENT	GMES/ESA	Altimetry

In the next few years, more DORIS satellites are planned: Sentinel-3B, 3C, HY-2C, 2D, Jason-CS1/SENTINEL-6A Jason-CS2/SENTINEL-6B, SWOT (Surface Water Ocean Topography). Furthermore, other missions are under consideration. Of particular interest is an improved version of the E-GRASP/Eratosthenes proposal (ESA Earth Explorer-9 mission) which will be submitted to the new ESA/EE9 call, in June 2017. It will provide well-calibrated geodetic systems such as GNSS, DORIS, SLR, and VLBI, all on board the same spacecraft.

Figure 1.1 summarizes the evolution of the DORIS constellation since the launch of the SPOT-2 satellite in 1990, and includes satellites that are currently planned. It must be noted that in the past last years, four or more DORIS satellites have been available to IDS users, which is a key requirement for the precision of the geodetic products.

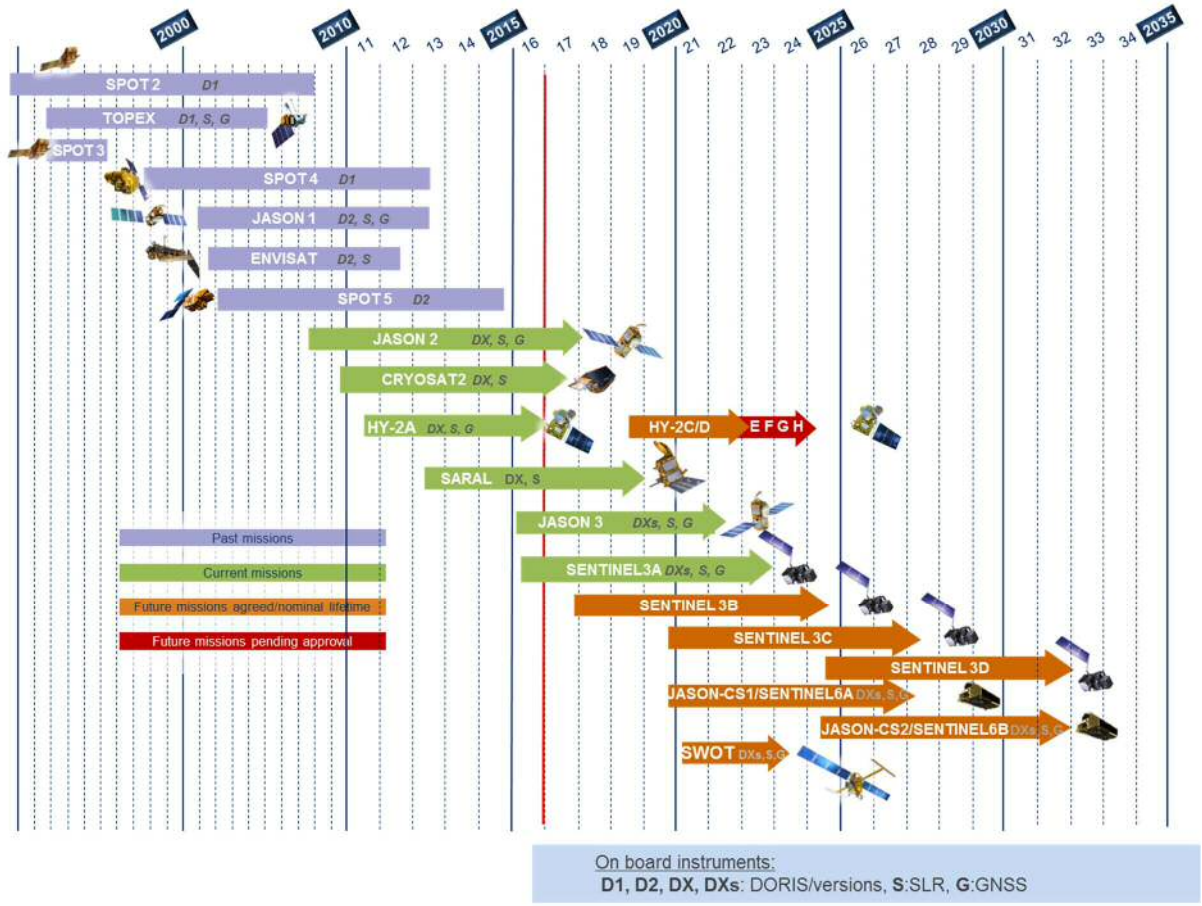


Figure 1.1: DORIS satellite constellation. As of March 2017.

1.2 DORIS network

DORIS has a globally distributed network of 56 permanent stations dedicated for precise orbit determination and altimetry with four master beacons and one time beacon. Two additional DORIS stations are used for other scientific purposes: Grasse (France) and Wettzell (Germany). See Figure 2.

The new DORIS station at the Geodetic Observatory Wettzell began operations in September 2016. With DORIS Wettzell becomes GGOS core site with all four of the space geodetic techniques.

We also note the newly installed DORIS stations at Goldstone, California (2015) and at Managua, Nicaragua (2016), both contributing to the robustness of the permanent network in North America. The installation of the station at Goldstone filled a gap in western North America, which appeared in 2010 after the closure of the Monument Peak DORIS station.

Overall, the DORIS network provided a very reliable service with the total number of operating stations approaching an annual average of 90% of active sites in 2015 and 2016, thanks to the responsiveness and the combined efforts of CNES, IGN and all agencies hosting the stations.

As regards the ground equipment, the 4th beacon generation is under development with a view to starting deployment from 2019. Designed with new electronic components and new architecture, this new beacon model aims at providing a better performance and reliability and will allow to install the antenna up to 50 m from the beacon (currently 10 m). This will improve options for placement of new stations, while still satisfying the station visibility constraint of minimizing obstructions at low elevation.

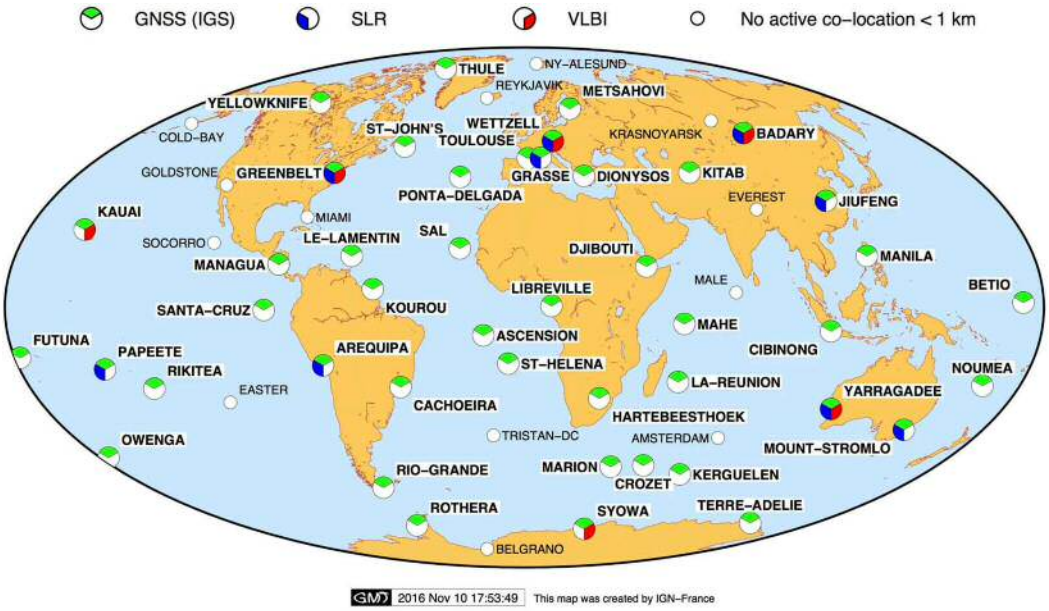


Figure 2: DORIS tracking network. Co-location with other IERS techniques as of Dec. 2016.

Efforts continue towards increasing the number of co-located sites, improving the monument stability at any new installation and carrying out high precision local tie surveys. There are currently several projects under way in Argentina, Guam, Spitsbergen (Ny Alesund), North Australia (Katherine), China and French Polynesia.

2. IDS organization

Like the other IAG Services, an IDS Governing Board (GB), helped by a Central Bureau (CB), organizes the activities done by the Analysis Centers (AC), the Data Centers (DC), and the Combination Center (CC).

2.1 Governing Board

In accordance with the Terms of Reference of the IDS, several positions within the Governing Board became vacant at the end of 2016. They concerned three members elected by IDS Associates (the representative of the Data centers, the representative of the analysis Center, one member at large) and four representatives appointed respectively by CNES (DORIS system), IGN (network), IAG and IERS. The CB coordinated the steps to update the GB membership for the next 4-year term (2017-2020). First, the CB contacted the relevant organizations to appoint their representatives; second, the CB organized the elections for the three vacant positions. In a final step for the GB elected its new chairman.

The members who were elected or appointed are:

- Frank Lemoine as Analysis Center Representative,
- Patrick Michael as Data Center Representative,
- Denise Dettmering as Member-at-Large,
- Pascale Ferrage, reappointed by CNES as the DORIS system representative,
- Jérôme Saunier, reappointed by IGN as the Network representative.
- Brian Luzum, reappointed by IERS as the IERS representative.
- Petr Štěpánek**,** nominated by IAG Executive Committee in February 2017 as the IAG representative to succeed Michiel Otten who served two terms.

The new Governing Board has designated Frank Lemoine as the new Chairperson of the IDS Governing Board for 2017-2020.

In addition, the CB carried out the selection of the Combination Center for 2017-2020. The call for proposals for the successor to the current Combination Center closed on October 15. Only one proposal was submitted, that of CNES/CLS who applies to continue the activities of the Combination Center. The GB accepts the application and selects it as the IDS Combination Center for a new period of four years, starting on January 1, 2017. Guilhem Moreaux (CLS) remains the representative of the Combination Center within the GB.

Table 2 IDS GB members since 2003, with members in office in 2017 indicated in bold.

Position	Term	Status	Name	Affiliation	Country
Analysis coordinator	**2015-2018**	Elected	**Hugues Capdeville**	CLS	France
			Jean-Michel Lemoine	CNES/GRGS	
	2013-2014	*Ext'd*	*Frank Lemoine*	*NASA/GSFC*	*USA*
	2009-2012	*E.b.GB*	*Frank Lemoine*	*NASA/GSFC*	*USA*
	2005-2008		*Frank Lemoine (subst.)*	*NASA/GSFC*	*USA*
	2003-2005		*Martine Feissel-Vernier*	*IGN/Paris Obs.*	*France*
Data Centers' representative	**2017-2020**	Elected	**Patrick Michael**	NASA/GSFC	USA
	2013-2016	*Elected*	***Carey Noll***	*NASA/GSFC*	*USA*
	2009-2012	*Elected*	*Carey Noll*	*NASA/GSFC*	*USA*
	2003-2008		*Carey Noll*	*NASA/GSFC*	*USA*
Analysis Centers' representative	**2017-2020**	Elected	**Frank Lemoine (chair)**	NASA/GSFC	USA
	2013-2016	*Elected*	***Pascal Willis (chair)***	*IGN+IPGP*	*France*
	2009-2012	*Elected*	*Pascal Willis (chair)*	*IGN+IPGP*	*France*
	2003-2008		*Pascal Willis*	*IGN+IPGP*	*France*
Member at large	**2015-2018**	Elected	**Marek Ziebart**	UCL	UK
	2013-2014	*Ext'd*	*John Ries*	*Univ. Texas/CSR*	*USA*
	2009-2012	*E.b.GB*	*John Ries*	*Univ. Texas/CSR*	*USA*
	2003-2008		*John Ries*	*Univ. Texas/CSR*	*USA*
Member at large	**2017-2020**	Elected	**Denise Dettmering**	DGFI/TUM	Germany
	2013-2016	*Elected*	***Richard Biancale***	*CNES/GRGS*	*France*
	2009-2012	*E.b.GB*	*Pascale Ferrage*	*CNES*	*France*
	2003-2008		*Gilles Tavernier (chair)*	*CNES*	*France*
Director of the Central Bureau	Since 2003	App.	**Laurent Soudarin**	CLS	France
Combination Center representative	Since 2013	App.	**Guilhem Moreaux**	CLS	France
Network representative	**2017-2020**	App.	**Jérôme Saunier**	IGN	France
	2013-2016	*App.*	***Jérôme Saunier***	*IGN*	*France*
	2010-2012		*Bruno Garayt (subst.)*	*IGN*	*France*
	2009	*E.b.GB*	*Hervé Fagard*	*IGN*	*France*
	2003-2008		*Hervé Fagard*	*IGN*	*France*
DORIS system representative	**2017-2020**	App.	**Pascale Ferrage**	CNES	France
	2013-2016	*App.*	***Pascale Ferrage***	*CNES*	*France*
IAG	**2017-2020**	App.	**Petr Štěpánek**	Geodetic Obs. Pecny	Czech Republic
representative	***2013-2016***	*App.*	***Michiel Otten***	*ESOC*	*Germany*
	2009-2012	*App.*	*Michiel Otten*	*ESOC*	*Germany*
	2003-2008		*Not designated*		
IERS representative	**2017-2020**	App.	**Brian Luzum**	USNO	USA
	2013-2016	*App.*	***Brian Luzum***	*USNO*	*USA*
	2009-2012	*App.*	*Chopo Ma*	*NASA/GSFC*	*USA*
	2003-2008		*Ron Noomen*	*TU Delft*	*Netherlands*

App. = Appointed ; Elected = Elected by IDS Associates ; E.b.GB = Elected by the previous Governing Board ; Ext'd = Extended term for two years linked to the set up of the partial renewal process

2.2 Central Bureau

The Central Bureau, funded by CNES and hosted at CLS, is the executive arm of the Governing Board and as such is responsible for the general management of the IDS consistent with the directives, policies and priorities set by the Governing Board. It brings its support to the IDS components and operates the information system.

The Central Bureau participated in the organization of the AWG meetings held at CLS in Toulouse (May 28 and 29, 2015), at NASA/Goddard Space Flight Center in Greenbelt, Maryland, (October 15 and 16, 2015), at the Faculty of Aerospace Engineering in Delft, Netherlands, (May 26 and 27, 2016), and of the IDS Workshop in La Rochelle, (October 31 to November 1st, 2016). It documented the Governing Board meetings held on these occasions.

Besides the regular updates of pages and additions of documents, the website was upgraded and enriched with new pages. The IDS video channel was created on YouTube (https://www.youtube.com/channel/UCiz6QkabRioCP6uEjkKtMKg) to host a set of existing videos for outreach, and new videos showing the DORIS-equipped satellites in orbit. These videos were produced with the Visualization Tool for Space Data (VTS) free software from CNES. The IDS web service (http://ids-doris.org/webservice) has been upgraded with a new plot tool to visualize the time series of Earth Orientation Parameters from the IDS Combination Center analysis.

At its meeting in Washington in October 2015, the Governing Board asked the Central Bureau to consider the publication of a newsletter. The intention is to improve the flow of information within the community of providers and users of DORIS data and products, to highlight the activities of the groups participating in the IDS, and to bring the DORIS and IDS news to a wider audience, from the host agencies to the other sister services. In March 2016, the Central Bureau proposed a draft to the Governing Board who approved the concept. So, the IDS Newsletter was created. Three issues were published in 2016, #1 in April 2016, #2 in July, and #3 in December. The issues are distributed via email to the subscribers to the DORISmail and a number of identified managers and decision-makers. They are also available from the IDS website (https://ids-doris.org/ids/reports-mails/newsletter.html).

The Central Bureau works with the SSALTO multi-mission ground segment and the Data centers to coordinate the data and products archiving and the dissemination of the related information. Data, meta-data and documentation of the two missions Jason-3 and Sentinel 3A launched in early 2016, were put online the IDS data and information sites as they become available.

During the change to the new file upload system at the CDDIS, the Central Bureau also interacted with the CDDIS staff, SSALTO, and the IDS components in order to ease the transition.

2.3 Data Centers

Two data centers currently support the archiving and distribution of data for the IDS:

- Crustal Dynamics Data Information System (CDDIS), funded by NASA and located in Greenbelt, Maryland USA
- l'Institut National de l'Information Géographique et Forestière (IGN) in Marne la Vallée France

Both of these institutions have archived DORIS data since the launch of TOPEX/Poseidon in 1992. The CDDIS (ftp://cddis.nasa.gov) runs fully redundant systems with both primary and secondary systems at different physical locations with access transparent to the end user. IGN in France uses two sites (ftp://doris.ign.fr) and (ftp://doris.ensg.ign.fr) which are exact mirrors of each other offering continued operational basis even if one of them is inaccessible due to a temporary failure. The data holdings between CDDIS and IGN are not mirrored between the sites but rely on data providers to upload data and products to both to ensure full coverage at each center.

On 1 December 2016, CDDIS moved its entire operations to new facilities associated with its parent organization the Earth Observing System Data and Information System (EOSDIS). At the same time, it moved away from the old ftp protocol to a https-based upload procedure for data uploads; this new procedure offers both web and command line interfaces. The move to https was necessitated by security and operational concerns. Before the transition all DORIS data and products were supplied by seven individuals/groups. On 1 December 2016, five (5) of the suppliers (GSFC, ESA, SSALTO, INA, IDS ACC) had made the transition to the new procedure with the remaining two groups (GOP, IGN) transitioning to the new procedure in March 2017.

2.4 Analysis Centers and Analysis Coordination

The activities of all the DORIS analysts of the years 2015 and 2016 were dominated by the IDS contribution to ITRF2014 and its evaluation, and the implementation of the data processing of DORIS RINEX. In 2016, the IDS Analysis Centers processed the data from the most recent DORIS satellites, Jason-3 and Sentinel-3A. The ACs analyzed the sensitivity to the South Atlantic Anomaly (SAA) of the respective satellite Ultra Stable Oscillators (USO).

Analysis working group meetings were held in Toulouse (France), May 28-29, 2015 (*hosted by Collecte Localisation Satellites*), in Greenbelt, Maryland (USA), October 15-16, 2015 (*hosted by NASA Goddard Space Flight Center in Greenbelt, Maryland, USA*) and in Delft (The Netherlands), May 26-27, 2016 (hosted by Technical University of Delft). An IDS Workshop was held in La Rochelle (France), October 31 to November 01, 2016, in conjunction with the Ocean Surface Topography Science Team (OSTST) meeting.

For ITRF2014, the six active analysis centers agreed to submit new SINEX solutions. In addition, the CNES POD center is a lead DORIS analysis center. They do not submit SINEX solutions for the IDS combination, but since they have prime POD responsibility for many of the DORIS satellites, they are the source for much of the spacecraft information needed for processing. In addition, they prepare the DORIS format 2.2 data (the range-rate format) that is used by the IDS ACs. We have also the participation by three other institutions: GFZ, TU/Delft, The University College/London. The GeoForschung Zentrum (GFZ) has participated in several of the IDS meetings, and focused on the POD analysis for altimeter satellites. TU/Delft is analyzing data from Cryosat-2, and has made available the spacecraft quaternions for use by other team members. UCL is interested in working with individual DORIS ACs on the refinement of non-conservative force modeling for DORIS satellites. GFZ was recognized by the Governing Board as an Associated Analysis Center (AAC) in October 2015. CNES POD and TU/Delft became AAC in May 2017.

So to summarize, the IDS includes six Analysis Centers and three Associated Analysis Centers who use seven different software packages, as summarized in Table 3. We also note which analysis centers on a routine basis perform POD analyses of DORIS satellites using other geodetic techniques (c.f. Satellite Laser Ranging (SLR), or GNSS). The multitechnique analyses are useful since they can provide an independent assessment of DORIS system performance, and allow us to validate more easily model changes and the implementation of attitude laws for the different spacecraft, in the event spacecraft external attitude information (in the form of spacecraft quaternions) is not available. We note that a representative of the Norwegian Mapping Authority (NMA) expressed in an interest in analysis of DORIS data, and also in multi-technique analyses. The participation of the NMA (Geir Arne Hjelle) and other potential IDS ACs continues to be encouraged.

Table 3: Summary of IDS Analysis Centers

Name	AC	AAC	Location	Contact	Software	Multi-technique
ESA	X		Germany	Michiel Otten	NAPEOS	SLR, GNSS
GOP	X		Czech Republic	Petr Stepanek	Bernese	
GRG	X		France	Hugues Capdeville	GINS	SLR, GNSS
GSC¶	X		USA	Frank Lemoine	GEODYN	SLR
IGN	X		France	Pascal Willis	GIPSY	
INA	X		Russia	Sergei Kuzin	GIPSY	
CNES		X	France	Alexandre Couhert	Zoom	SLR, GNSS
GFZ		X	Germany	Sergei Rudenko/Rolf Koenig	EPOS-OC	SLR, GNSS
TU Delft		X	The Netherlands	Ernst Schrama	GEODYN	SLR

Following the DORIS processing for the realization of the ITRF2014, there were still many substantive issues that remained to be addressed. Some issues, such as the jump in the DORIS scale (2012 and later) have been analyzed. The IDS scale jump in 2012 is now fully explained by a variation in the number of low-elevation measurements included in the processing. Indeed, the increase of the scale factor for Jason-2 and Cryosat-2 is linked to the change of tropospheric model used by CNES in its POD processing (GDR standards): from CNET (GDR-C) to GPT/GMF (GRD-D). It caused a reduction of the amount of data marked as "rejected" in the doris2.2 file (input DORIS data file) and then, an increase of the data used considered to be good in CNES pre-processing. The larger amount of data, especially at low elevation, could thus be the cause of the change observed in the scale factor. The date of change is mission dependent. The scale increase of the multi-satellite solutions is due to the jump of the scale of the Jason-2 and Cryosat-2 solutions as well as to the high scale of HY-2A, whose DORIS data became available starting in November 2011. So, IDS ACs need to do their own pre-processing, while the high scale observed on HY-2A remains an unelucidated issue.

Since 2008, starting with Jason-2, the satellites equipped with a DORIS receiver carry the new generation of receivers called DGXX which provides phase and pseudo-range measurements. They are distributed in a dedicated format, called RINEX/DORIS 3.0 derived from the RINEX/GPS format. One major advantage of these new measurements is that they are available with a very short latency. They also allow analysis centers to be less dependent on the CNES since the new data format provides the raw information that is necessary for computing the ionosphere delays and the precise time-tagging of the measurements. This was not the case for the former data format where this information was only given in a pre-processed form, following a pre-processing done by the CNES. While CNES supplies data files in doris2.2 and RINEX/DORIS 3.0 formats for the missions equipped with DGXX (Jason-2, Cryosat-2, HY-2A and Saral), only the latter format is available for the missions from Sentinel-3A and Jason-3 and following. To help ACs to implement the RINEX data processing in their software a dedicated web page about DORIS RINEX data was created on the IDS website: http://ids-doris.org/about-doris-rinex-format.html

IDS completed an assessment of the three realizations of the Terrestrial Reference Frame which are the outcome of the "ITRF2014 effort": the ITRF2014 (IGN), DTRF2014 (DGFI) and JTRF2014 (JPL). While ITRF2014 and DTRF2014 are qualitatively similar, differing mainly by the Post Seismic Deformation model (PSD), which was introduced into the IGN solution, the JPL solution was quite different, being a time series of weekly solutions obtained through a Kalman filter process. Due to editing criteria the JPL solution contains less stations at a given time than the two other realizations, particularly at the beginning of the DORIS data period, in 1993. The three TRF realizations were evaluated in terms of DORIS observation residuals, orbit overlaps and transformation parameters of the DORIS network. All TRF realizations show a

clear improvement over the previous realization, ITRF2008. Based on the different criteria used for evaluation, analysis by IDS components showed that the ITRF2014(IGN) realization provides the best overall performance. It is this realization that will serve as a basis for the operational processing of future DORIS data. For that purpose the ITRF2014 needs to be augmented (e.g. with new DORIS stations not present in the ITRF2014 solutions, or if necessary, correction of the position and velocity for the stations which had a short observation interval in the ITRF2014). This extension of ITRF2014 for the DORIS network is called DPOD2014: an update of the position/velocity of all stations is performed and aligned on the ITRF2014, leading to possible minor adjustment of older stations. A version of the DPOD2014 (DORIS extension of the ITRF for Precise Orbit Determination) was submitted by IDS Combination Center to the evaluation of the users at the beginning of 2017 and is described in more detail in the next section. More information about DPOD2014 is available from the URL: https://ids-doris.org/analysis-coordination/combination/dpod.html

The behavior of the various DORIS on-board oscillators in the vicinity of the high radiation area "South Atlantic Anomaly" (SAA) was also studied. DORIS ACs showed that all DORIS receivers are sensitive to the crossing of the SAA, though to different degrees. Thanks to the extremely precise time-tagging provided by the T2L2 experiment on-board Jason-2, A. Belli and the GEOAZUR team showed that the Jason-2 DORIS Ultra Stable Oscillator (USO) is approximately 10 times less sensitive to the SAA than that of Jason-1. The IGN AC has shown, thanks to the "DORIS PPP method" on uncorrected Jason-2 DORIS data, that the positioning error due to the SAA can reach up to 10 cm for some stations with this satellite. The GRG AC and C. Jayles from CNES both showed that Jason-3 is also sensitive to the SAA, at a level that is lower than that of Jason-1, but still 4 to 5 times higher than that of Jason-2. The CNES POD team showed that Sentinel-3A is also sensitive to the SAA. Using a novel method based on the clock determination of the GNSS receiver on-board Sentinel-3A, the CNES POD team showed that it is possible to obtain an accurate and continuous observation of the satellite's USO frequency excursions. One of the conclusions of these studies was that, while no noticeable effect of the SAA influence was shown on POD or reference frame transformation parameters, there is an important impact on the station position estimation for some stations in the vicinity of the SAA area. Building accurate models of frequency variations in response to the temperature and to the SAA radiation effects for each DORIS USO is therefore a task that is encouraged by the IDS community for the accurate position estimation of all DORIS stations.

ACs must complete the implementation of the DORIS/RINEX data processing in order to be able to process the data from Jason-3 and Sentinel-3A (available first quarter of 2016). The IDS will switch to ITRF2014 for operational products when the DPOD2014 becomes available. The next IDS Analysis working group meeting will be held in London (U.K.), May 22-24, 2017 (*hosted by University College London*).

2.5 Combination Center

In addition to its operational activities of evaluation and combination of all the individual ACs weekly solutions, the IDS Combination Center has been involved in several studies proposed by the AWG and the Analysis Coordinator such as the scale jump in 2012 and the evaluation of the three 2014 TRF realizations from DGFI, IGN and JPL.

DORIS position and velocity cumulative solution

In line with the successful IDS contribution to the ITRF2014, the IDS CC initiated the elaboration of a DORIS position and velocity cumulative solution. To validate the stacking procedure and the DORIS mean velocities, the IDS CC compared the DORIS velocities with global tectonic models as well as with GNSS velocities at co-located sites. The analysis of the velocity differences (Moreaux et al., 2016, Geophysical Journal Intl.) validated the new stacking procedure. Then, early in 2017, the IDS CC started to regularly (on a quarterly basis)

process and deliver (via the IDS Data Centers) a DORIS position and velocity cumulative solution from the latest IDS combined series. So far, this solution does not include Post-Seismic Deformation corrections; a piecewise linear (position+velocity) model is used to describe the station motions. A dedicated webpage (https://ids-doris.org/analysis-coordination/combination/cumulative-solution.html) was also added to the IDS website to give further information on the IDS cumulative solution (ex: residual time series, DORIS-to-DORIS tie vector residuals, DORIS-to-GNSS tie vector comparisons, position and velocity differences with ITRF2014…).

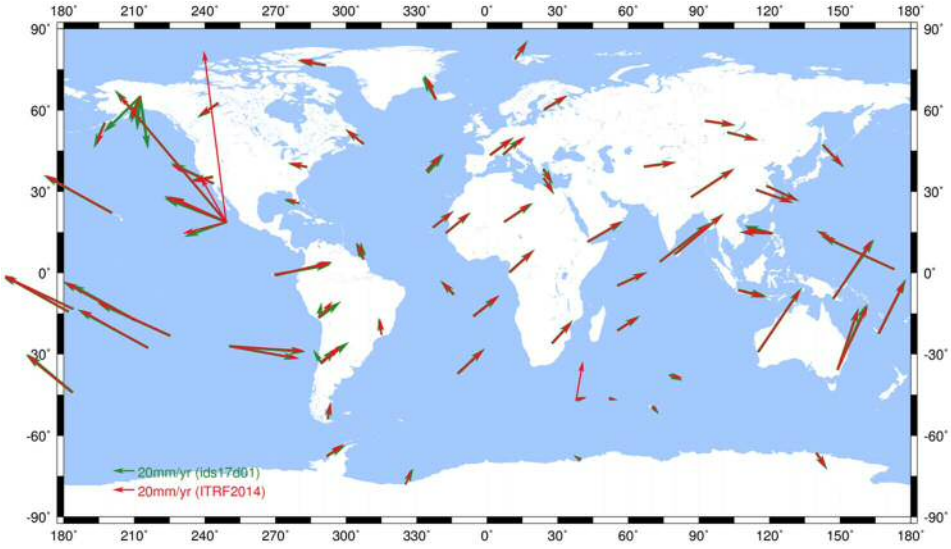


Figure 3 - Horizontal velocities of the DORIS sites from ITRF2014 (red) and the first DORIS cumulative solution

DPOD2014

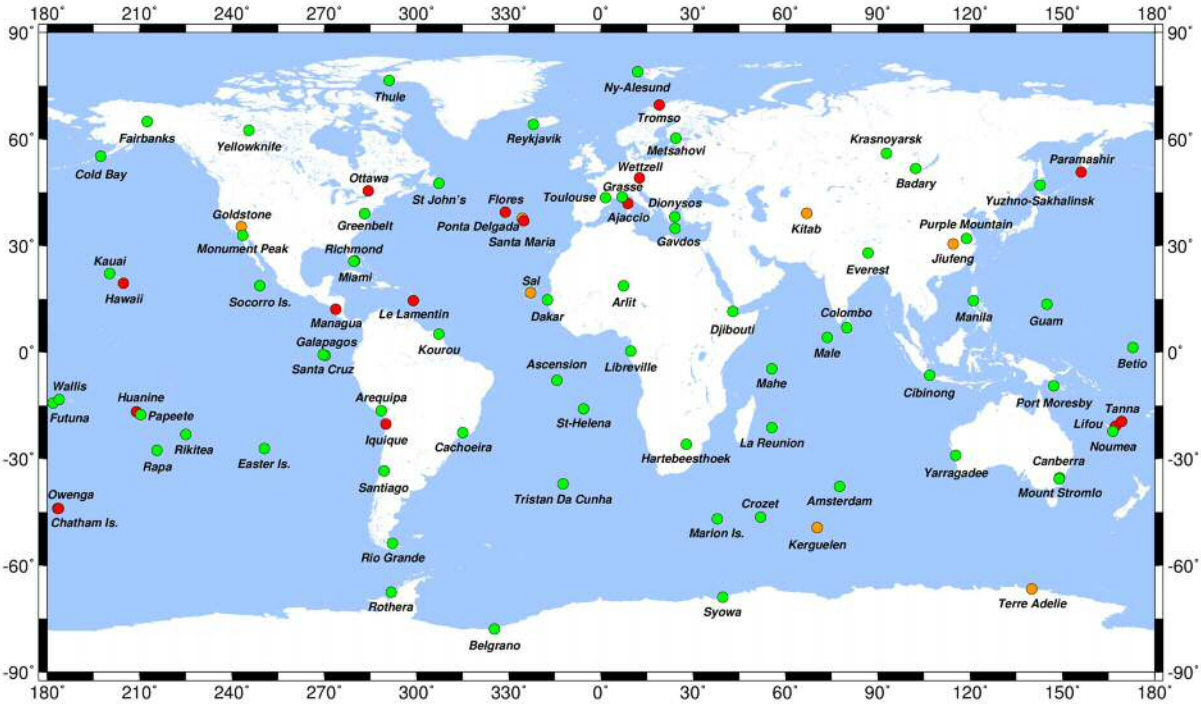


Figure 4 - DORIS sites in DPOD2014_v01 produced by the IDS Combination Center; green indicates sites in ITRF2014 and DPOD2014_v01; orange indicates sites in both coordinate sets but updated in DPOD2014_v01; red indicates sites **not** in ITRF2014, but included in DPOD2014_v01.

During the first 2015 IDS AWG held in Toulouse, the IDS CC agreed to take over from P. Willis the routine production of the DPOD: "the DORIS extension of the ITRF for Precise Orbit Determination". The DPOD solutions were initiated to overcome some intrinsic drawbacks of using the latest ITRF: i) some stations are added to the tracking network after the completion of the ITRF; ii) some stations might be affected by coordinate and/or velocity discontinuities that could occur after the realization of the ITRF; iii) the precision of the position and velocities of the stations with few observations at the time of the ITRF can be increased with a longer data span and; iv) some problems in geodetic technique data processing may be found after the computation of the ITRF (e.g. USO sensibility to the SAA). Based on the latest IDS position and velocity cumulative solution, the IDS CC constructs the DPOD2014 solutions aligned to the ITRF2014. After some IDS CC internal validation tests (including coordinate and velocity differences with the previous DPOD solution and ITRF realization), the IDS POD validation group lead by P. Willis performs some POD tests with many of the DORIS satellites. After approval by the POD validation group, the new version of DPOD2014 solution is released. DPOD2014 is available from the two IDS Data Centers and is added to the dedicated IDS website page (https://ids-doris.org/analysis-coordination/combination/dpod.html). The DPOD2014 will be updated twice a year.

IDS products

Table 4 presents the current IDS products available through the two IDS data centers. All Analysis Centers provided at a least a long-term weekly solution of SINEX files.

Table 4 Summary of IDS Products.

Type of Products	**Contributing Analysis Centers ¶**							
	ESA	**GOP**	**GRG§**	**GSC**	**IGN**	**INA**	**IDS✚**	**SSA**
Time series of SINEX solutions (***sinex_series***)	X	X	X	X	X	X	X	X
Global SINEX solutions (***sinex_global***)			X		X		X	
Geocenter time series (***geoc***)			X	X				X
Satellite Orbits (*orbits*)			X	X				X
Ionosphere products/sat. (***iono***)								X
Time series of EOP (***eop***)					X	X		
Time series of station coordinates (***stcd***)	X		X	X	X	X	X	X
Time series of SINEX solutions (***2010campaign***)		X	X	X	X	X		
	✚ Combination Center of the IDS. **§ The GRG analysis center was renamed from the "LCA" analysis center in 2015.** **¶ Previous analysis centers who have contributed products include GAU (Geoscience Australia) and CNES POD team under the ID "SOD"**							

3. IDS meetings and publications

3.1 Meetings

IDS organizes two types of meetings:

- IDS Workshops (every two years), opened to a large public and related to scientific aspects or applications of the DORIS systems
- Analysis Working Group Meetings (AWG) (when needed), more focused on technical issues, and usually attended by representatives of Analysis Centers.

Table 5 IDS Meetings (2015-2017)

Meeting	Location	Country	Dates
DORIS AWG Meeting	Toulouse	France	28-29 May 2015
DORIS AWG Meeting	Greenbelt	Maryland, USA	15-16 October 2015
DORIS AWG Meeting	Delft	Netherlands	26-27 May 2016
IDS Workshop	La Rochelle	France	31 ctober – 1 November 2016

3.2 Publications

During the last two years, IDS published several activity reports:

Willis, P., International DORIS Service (IDS), Report of the International Association of Geodesy 2011-2015, Travaux de l'Association Internationale de Géodésie, 2015.
http://ids-doris.org/documents/report/IDS_Report_mid2011_mid2015_for_IAG.pdfhttp://ids-doris.org/documents/report/IDS_Report_2007_2011_for_IAG.pdf

Capdeville, H., Couhert, A., Ferrage, P., Kuzin, S., Lemoine, F., Moreaux, G., Noll, C., Otten, M., Rudenko, S., Saunier, J., Schrama, E., Soudarin, L., Stepanek, P., Willis, P. International DORIS Service Activity report 2014, 122 pages, 2015. http://ids-doris.org/documents/report/IDS_Report_2014.pdf

Capdeville, H., Couhert, A., Ferrage, P., Kuzin, S., Lemoine, F., Moreaux, G., Noll, C., Otten, M., Rudenko, S., Saunier, J., Soudarin, L., Stepanek, P., Willis, P. International DORIS Service Activity report 2015, 99 pages, 2016. http://ids-doris.org/documents/report/IDS_Report_2015.pdf

3.2 Peer-reviewed publications related to DORIS

Following two DORIS Special Issues published in Journal of Geodesy in 2006-2007, and Advances in Space Research in 2010, a third DORIS Special was launched in 2014. A total of 18 manuscripts passed the peer-reviewed process and were published in Advances in Space Research on December 15, 2016, in Volume 58, Number 12. This special issue is entitled "The scientific applications of DORIS in Space Geodesy" and is edited by Frank G. Lemoine and Ernst J.O. Schrama. The papers cover five themes: ITRF2014; DORIS Ultra Stable Oscillator (Jason-2); Precise orbit determination; DORIS System and Network; Intertechnique comparisons of DORIS products. The direct link to the special issue index is available at the following URL: http://www.sciencedirect.com/science/journal/02731177/58/12

IDS also maintains on its Web site a complete list of DORIS-related peer-reviewed articles published in international Journals (http://ids-doris.org/report/publications/peer-reviewed-journals.html). In the last two years, the following articles were published (by year):

In press

Kong, Q.; Guo, J.; Sun, Y., 2017. Centimeter-level precise orbit determination for the HY-2A satellite using DORIS and SLR tracking data, ACTA GEOPHYSICA, DOI: 10.1007/s11600-016-0001-x http://link.springer.com/article/10.1007/s11600-016-0001-x

Rudenko, S.; Neumayer, K.-H.; Dettmering, D.; Esselborn, S.; Schöne, T.; Raimondo, J.-C.; 2017. Improvements in precise orbits of altimetry satellites and their impact on mean sea level monitoring, IEEE Transactions on Geoscience and Remote Sensing, DOI: 10.1109/TGRS.2017.2670061

2017

Chen, P.; Yao, Y.; Yao, W., 2016. Global ionosphere maps based on GNSS, satellite altimetry, radio occultation and DORIS, GPS SOLUTIONS, 21(2), 639-650, DOI: 10.1007/s10291-016-0554-9

Gu, Y.; Yuan, L.; Fan, D.; You, W.; Su Y., 2017. Seasonal crustal vertical deformation induced by environmental mass loading in mainland China derived from GPS, GRACE and surface loading models, ADVANCES IN SPACE RESEARCH, 59(1), 88-102, DOI: 10.1016/j.asr.2016.09.008

2016

Altamimi, Z.; Rebischung, P.; Métivier, L.; Collilieux, X., 2016. ITRF2014: A new release of the International Terrestrial Reference Frame modeling nonlinear station motions, JOURNAL OF GEOPHYSICAL RESEARCH: Solid Earth, 121(8), 6109-6131, DOI: 10.1002/2016JB013098 OPEN ACCESS

Belli, A.; Exertier, P.; Samain, E.; Courde, C.; Vernotte, F.; Jayles, C.; Auriol, A., 2016. Temperature, radiation and aging analysis of the DORIS Ultra Stable Oscillator by means of the Time Transfer by Laser Link experiment on Jason-2, in DORIS Special Issue: Scientific Applications of DORIS in Space Geodesy, F. Lemoine and E.J.O. Schrama (Eds.), ADVANCES IN SPACE RESEARCH, 58(12):2589-2600, DOI: 10.1016/ j.asr.2015.11.025

Bloßfeld, M.; Seitz, M.; Angermann, D.; Moreaux, G., 2016. Quality assessment of IDS contribution to ITRF2014 performed by DGFI-TUM, in DORIS Special Issue: Scientific Applications of DORIS in Space Geodesy, F. Lemoine and E.J.O. Schrama (Eds.), ADVANCES IN SPACE RESEARCH, 58(12):2505-2519, DOI: 10.1016/j.asr.2015.12.016

Capdeville, H.; Štěpánek, P.; Hecker, L.; Lemoine, J.M., 2016. Update of the corrective model for Jason-1 DORIS data in relation to the South Atlantic Anomaly and a corrective model for SPOT-5, in DORIS Special Issue: Scientific Applications of DORIS in Space Geodesy, F. Lemoine and E.J.O. Schrama (Eds.), ADVANCES IN SPACE RESEARCH, 58(12):2628-2650, DOI: 10.1016/j.asr.2016.02.009

Jayles, C.; Chauveau, J.P.; Didelot, F.; Auriol, A.; Tourain, C., 2016. Doris system and integrity survey, in DORIS Special Issue: Scientific Applications of DORIS in Space Geodesy, F. Lemoine and E.J.O. Schrama (Eds.), ADVANCES IN SPACE RESEARCH, 58(12):2691-2706, DOI: 10.1016/j.asr.2016.05.032

Jayles, C.; Exertier, P.; Martin, N.; Chauveau J.P.; Samain E.; Tourain C.; Auriol A.; Guillemot P., 2016. Comparison of the frequency estimation of the DORIS/Jason2 oscillator thanks to the onboard DIODE and Time Transfer by Laser Link experiment, in DORIS Special Issue: Scientific Applications of DORIS in Space Geodesy, F. Lemoine and E.J.O. Schrama (Eds.), ADVANCES IN SPACE RESEARCH, 58(12):2601-2616, DOI: 10.1016/j.asr.2015.08.033

Khelifa, S., 2016. Noise in DORIS station position time series provided by IGN-JPL, INASAN and CNES-CLS Analysis Centres for the ITRF2014 realization, in DORIS Special Issue: Scientific Applications of DORIS in Space Geodesy, F. Lemoine and E.J.O. Schrama (Eds.), ADVANCES IN SPACE RESEARCH, 58(12):2572-2588, DOI: 10.1016/j.asr.2016.06.004

King, M. A.; Santamaría-Gómez, A., 2016. Ongoing deformation of Antarctica following recent Great Earthquakes, GEOPHYSICAL RESEARCH LETTERS, 43, 1918–1927, DOI: 10.1002/2016GL067773

Kuzin, S.; Tatevian, S., 2016. DORIS data processing in the INASAN Analysis Center and the contribution to ITRF2014, in DORIS Special Issue: Scientific Applications of DORIS in Space Geodesy, F. Lemoine and E.J.O. Schrama (Eds.), ADVANCES IN SPACE RESEARCH, 58(12):2561-2571, DOI: 10.1016/j.asr.2016.07.010

Heinkelmann, R.; Willis, P.; Deng, Z.; Dick, G.; Nilsson, T.; Soja, B.; Zus, F.; Wickert, J.; Schuh, H., 2016. Multi-technique comparison of atmospheric parameters at the DORIS co-location sites during CONT14, in DORIS Special Issue: Scientific Applications of DORIS in Space Geodesy, F. Lemoine and E.J.O. Schrama (Eds.), ADVANCES IN SPACE RESEARCH, 58(12):2758-2773, DOI: 10.1016/j.asr.2016.09.023

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Lemoine, J.M.; Capdeville, H.; Soudarin, L., 2016. Precise orbit determination and station position estimation using DORIS RINEXdata, in DORIS Special Issue: Scientific Applications of DORIS in Space Geodesy, F. Lemoine and E.J.O. Schrama (Eds.), ADVANCES IN SPACE RESEARCH, 58(12):2677-2690, DOI: 10.1016/j.asr.2016.06.024

Moreaux, G.; Lemoine, F.G.; Argus, D.F.; Santamaría-Gómez, A.; Willis, P.; Soudarin, L.; Gravelle, M.; Ferrage, P., 2016. Horizontal and vertical velocities derived from the IDS contribution to ITRF2014, and comparisons with geophysical models, GEOPHYSICAL JOURNAL INTERNATIONAL, 207(1), 209-227, DOI: 10.1093/gji/ggw265

Moreaux, G.; Lemoine, F.G.; Capdeville, H.; Kuzin, S.; Otten, M.; Štěpánek, P.; Willis, P.; Ferrage, P., 2016. The International DORIS Service contribution to the 2014 realization of the International Terrestrial Reference Frame, in DORIS Special Issue: Scientific Applications of DORIS in Space Geodesy, F. Lemoine and E.J.O. Schrama (Eds.), ADVANCES IN SPACE RESEARCH, 58(12):2479-2504, DOI: 10.1016/j.asr.2015.12.021

Rudenko, S.; Dettmering, D.; Esselborn, S.; Fagiolini, E.; Schöne, T., 2016. Impact of Atmospheric and Oceanic De-aliasing Level-1B (AOD1B) products on precise orbits of altimetry satellites and altimetry results, GEOPHYSICAL JOURNAL INTERNATIONAL, 204(3), 1695-1702, DOI: 10.1093/gji/ggv545

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