Overview of the DORIS Network Monumentation

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DORIS system is dedicated to satellite altimetry. This main objective gave to the DORIS network a number of specificities: homogeneous distribution and centralized control of the deployment and maintenance.

Of the four space geodetic techniques contributing to the realization of the International Terrestrial Reference System, DORIS is the only global network managed by a unique entity. Such advantage allows to monitor the stations installation and to pay particular attention to the antennas monumentation.

IGN in charge of the network deployment since the beginning in 1986 has designed over the years – in consultation with CNES – standard monuments compliant to the DORIS system requirements. The progressive improvement in the quality of the positioning results has required more stringent monument specifications detailed below. After **15 years of effort on the DORIS stations configuration**, now is the time to assess again the network quality stability-wise.

Requirements

In order to control and qualify the network configuration, the working body "Groupe Mission DORIS" decided at the end of 2009 to reduce the number of monument types by specifying three standards.

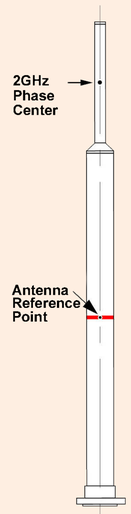
Besides being easy to assembly and easy to implement, these three standard monuments must meet some system and geodetic requirements and fit in all cases with the layout of the premises and the environment.

With regard to the system requirements, the monumentation must:

- enable a perfect adjustment of the antenna verticality;
- be higher than 1.85m to reduce signal power attenuation and multi-path effect;
- be resistant as much possible with regard to the solidity and the corrosion.

In addition, the installation must comply with general geodetic specifications:

- a lithospheric marker below the antenna embedded in concrete base is essential;
- markers must be within sight of theodolite; that is to say at head height;
- monuments must be very stable with foundations well anchored to the ground.



The DORIS Antenna

Components

A monument has two distinctive parts:

Concrete base
The concrete base is the connection element between the subsoil and the antenna support. We consider the following three types of concrete base:

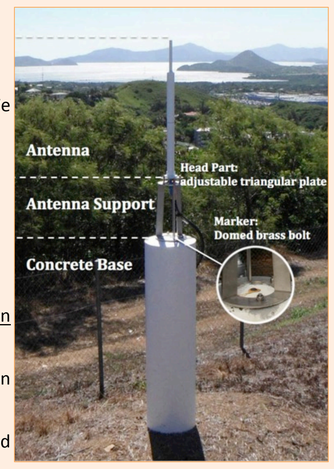
- Pedestal: concrete block or concrete slab close to the ground
- Pillar: concrete structure over 1m high
- Building: concrete construction according to the norms

The foundation sizes must be appropriate to the soil structure.

Antenna support
The antenna support is the metallic structure holding the DORIS antenna up in the space between the concrete base and the antenna bottom.

This metal part is fastened to the concrete base according to standard building rules with expansion anchors or threaded rods embedded with epoxy.

The antenna is fixed to the antenna support head made of submittal stainless steel plate equipped with leveling screws in order to adjust its verticality.



Nouméa

Adaptation to the terrain

After geological data studies (if available) and a field reconnaissance looking for possible exposed bedrock, the antenna location is determined to ensure a good level of stability. The design and the depth of the base construction are depending on the soil structure:

Solid bedrock: anchor with reinforcing rods the mount foundation in solid bedrock when accessible is the best option.
Hard soil: when this kind of soil not so easy to dig out is reached, a large reinforced concrete slab is poured in order to make a stable foundation.
***Soft soil*:** the solution consists of enlarging the concrete slab in order to behave as a stratum.

Sizes (height and width) of the pedestal or pillar are defined in accordance with the antenna support type. All construction must meet current physical building specifications; but, as DORIS network is set up in many remote areas, we have to work with the existing local expertise.

Opportunities for setting up antennas on existing construction are always considered in accordance with the requirements.

Terrace roofs are sometimes the only option to get a clear view of the sky with suitable obstructions. In that case, the antenna should be installed on bearing wall buildings or near support structures. Small footprint and one-storied buildings with solid foundations on bedrock are preferable to bigger and higher constructions.

Example: construction of a concrete pedestal on hard soil for a new DORIS station in New Zealand

Specifications

A document describing the standard configurations compliant with the system and geodetic requirements applicable to the management of the DORIS station network, named "DORIS Site Standard configurations" (J.Saunier, IGN) is available on IDS website as an appendix of the CNES document "System Requirements for Management of the Station Network".

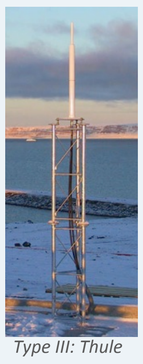
Monument type I	
Description	Half-meter high metal tower installed on load-bearing wall
Base type	Top of a load-bearing pillar or at the corner of two load-bearing walls of small building (one storied)
Base requirements	23cm width
Marker	Domed brass mark 12 mm diameter
Antenna support	Galvanized steel tower; triangular section of 21cm; 50cm high
Head part	Stainless steel triangular plate type I
Foot part	Steel triangular plate 20/10 with 3 holes
Manufacturer	Etablissement Normand, F-62110 HENIN BEAUMONT, France
Assets	Small footprint, easy shipping, easy setting
Disadvantage	Galvanized but not corrosion-resistant steel, low-rise support
Preferential use	Low-rise building with narrow walls, non-corrosive environment
Comment	For stability reasons, it is not recommended to add a 2nd element

Type I: Djibouti

Monument type II	
Description	Custom made stainless steel tripod installed on concrete pillar
Base type	Pillar 1,5 m high above ground
Base requirements	40 cm width
Marker	Domed brass mark 12 mm diameter
Antenna support	Custom made stainless steel tripod (min. height 40cm)
Head part	Stainless steel triangular plate type II
Foot part	Stainless steel disk with 3 holes
Manufacturer	IGN workshop
Assets	Custom made (adaptable on existing threaded rods), high corrosion resistance, stability, easy shipping, and easy setting.
Disadvantage	Maximum height 50 cm for stability reasons
Preferential use	Corrosive environment, clear sky view
Comment	This support type can also be used on load-bearing walls

Type II: Kerguelen

Monument type III	
Description	Very rigid steel tower installed on concrete block
Base type	Concrete block (25 cm minimum above ground) or concrete slab
Base requirements	60 cm sided minimum
Marker	Domed brass mark 12 mm diameter
Antenna support	ISO galvanized steel tower; triangular section of 32 cm; 2 m high
Head part	Stainless steel triangular plate type III
Foot part	Triangular tower base with 3 disks diam. 11cm with 4 holes
Manufacturer	Etablissement Leclerc, 3 rue des Crocs, 77873 Montereau, France
Assets	Higher monument, smaller pedestal
Disadvantage	Limited corrosion resistance, shipping, and setting
Preferential use	Poor visibility
Comment	This monument type can also be used on terrace roof of small building (one storied) and as an exception on wide and low concrete pillar.



Type III: Thule

History

In reviewing the history of the network evolution, three main phases can be identified:

1986-1992: the network set-up
- The Alcatel antenna era
- Initial objective: decimeter level accuracy orbits
- 32 stations deployed in 1990

1992-2000: the network densification
- The Starec antenna era
- Progressive evolution of the monumentation
- 54 stations deployed in 2000

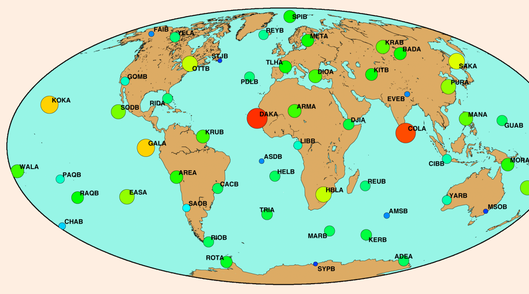
2000-nowadays: the network renovation
- Significant DORIS system performance improvement (centimeter level)
- More stringent stability requirements
- 62 renovation operations conducted by IGN through 15 years

The first era monuments no longer exist since the Alcatel antenna has been replaced by the Starec antenna.

During the densification phase, the monumentation has gradually evolved and some basic principles have been established.

In 2000, a first estimate of the stability taking into account the antenna type, the antenna support, the structure nature and the installation date was made by Fagard and Orsoni (IGN). This evaluation allowed the DORIS working group to decide on an action plan to renovate the network monumentation. It is during this renovation phase that standard monuments emerged.

In these last 15 years there has been significant improvement in the network monumentation and that action continues.



Stability evaluation before the start of the network renovation in 2000 (Fagard H. JoG 2006)

Stability assessment

The latest assessment of the monumentation stability was carried out by Fagard H. (Journal of Geodesy, 2006) "Twenty years of evolution for the DORIS permanent network". Of the different evaluation approaches, the option retained was to assess all elements in the monument that may contribute to the antenna instability in order to determine the "Instability Degree" (ID), based on 17 criteria.

Today, the resources at our disposal are identical. Specific field operations for the sole purpose to improve or to monitor the monumentation are impossible. We work for monumentation improvements only when we need to go on-site for another major reason. However, over time, we have collected a fair bit of information and little by little, the outcomes in terms of quality is measurable.

Since the criteria used by Fagard H. (2006) are now obsolete, new indicators has been defined:

Monumentation type
0: Standard (I, II, or III)
1: Good quality (ex: pillar)
2: Medium quality (ex: mast attached to the ground)
3: Poor quality (ex: guyed tower)
4: Dubious (ex: building)

Monumentation date
0: < 5 years
1: 5 < D < 10 years
2: D > 10 years

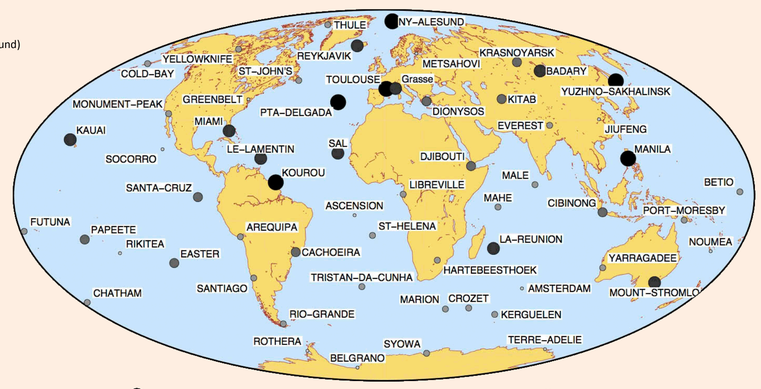
Height above ground
0: < 2,5m
1: 2,5 < H < 3m
2: 3 < H < 4m
3: 4 < H < 5m
4: 5 < H < 10m
5: H > 10m

Geological stability
1: High stability
2: Normal
3: Dubious

Ground hardness
1: Rock
2: Hard soil
3: Soft soil

Base construction type
1: Meets IGN specifications
2: Doesn't meet specifications
3: Dubious or unknown

Location on the terrace roof
0: Not applicable
1: On Load-bearing pillar or wall
2: On a beam or a slab above a load-bearing pillar or wall
3: Away from a load-bearing pillar or wall

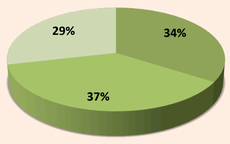


Stability assessment of the current DORIS Network (October 2014)
=> see "Instability Degree" values in the table below

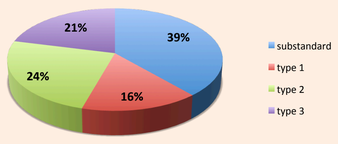
Station	AMVB	ARFB	ASEB	BADB	BEMB	BETB	CADB	CHAB	CIDB	COBB	CRQB	DIOB	DJIB	EASB	EVEB	FUUB	GR4B	GRFB	HBMB	HEMB	JIVB	KOLB	KETB	KIUB	KRWB	KRBB	LAOB	LICB	MAIB	MALB	MANB	MAUB	MEUB	MIAB	MOOB	MOSB	MSPB	NOXB	PAUB	PDMB	REUB	REZB	RIMB	RIRB	ROVB	SALB	SCRB	SAKB	SANB	SOEB	SPJB	STKB	SYQB	ADGB	THUB	TLSB	TRJB	YASB	YEMB
ID	5	8	5	15	5	7	11	8	11	6	6	10	10	9	7	6	15	5	8	8	5	13	6	9	18	10	13	6	6	7	19	7	5	12	6	8	13	5	11	17	13	13	5	7	3	15	9	20	8	4	16	6	6	5	7	18	7	8	6

Status

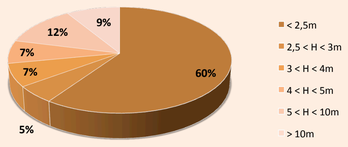
Today, we can say that the overall stability of the network monumentation is quite good but there is still room for improvement.



Monuments age



Monuments type



Monuments height above ground

These "Instability Degree" values served as input into a table of estimated uncertainties in the position of the antenna reference points for co-located sites (contribution to ITRF2013).

In order to gather meaningful information from the DORIS station position time series, we must continue this effort on the monumentation stability. **Several actions are already in progress** aiming at providing better assessment of the network monumentation:

- Systematic control of antenna verticality before equipment replacement
- Equipping sites with geodetic control points and targets on the monument in order to carry out stability monitoring surveys (2013: Grasse)
- Mechanical laboratory study of the 3 antenna supports (metal part): resistance, distortion, expansion

Another action is to conduct a study on the time series of the co-located sites (about 40) in order to measure and analyze the remaining noise after elimination of the tectonic plates movement.