INSTITUT NATIONAL
DE L'INFORMATION
GÉOGRAPHIQUE
ET FORESTIÈRE

MONUMENT STABILITY

DORIS NETWORK EXPERIENCE FEEDBACK

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IGN, service de géodésie et nivellement

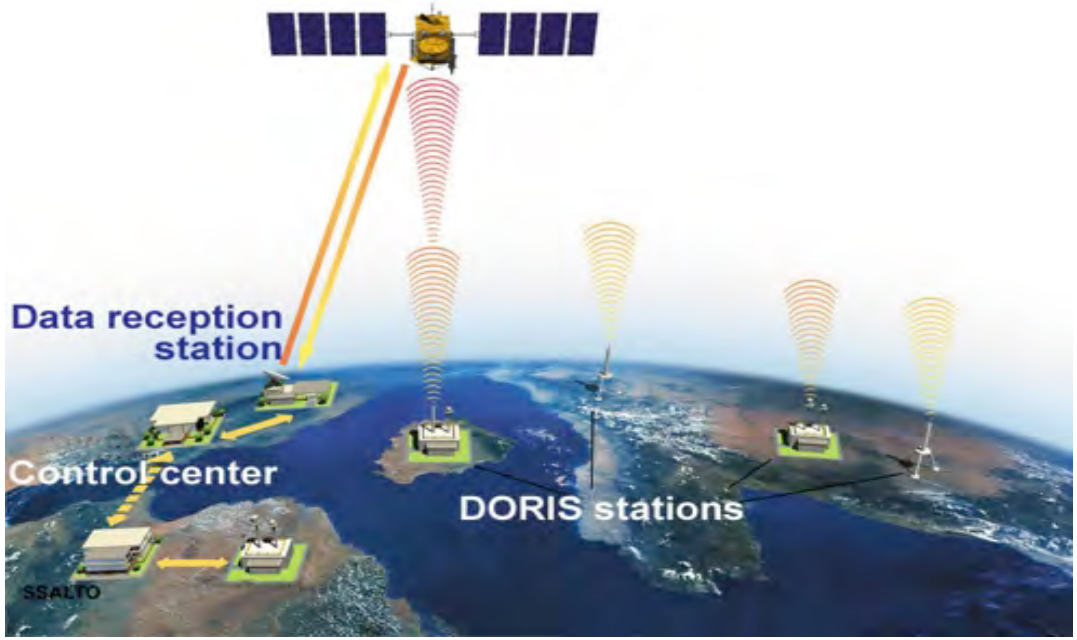
1. DORIS SPECIFICITIES

1. THE DORIS NETWORK

SPECIFICITIES OF THE SYSTEM

- ASCENDING SYSTEM : INTERNAL JAMMING
- DORIS NETWORK = HEART OF THE SYSTEM

=> CENTRALIZED CONTROL OF THE NETWORK DEPLOYMENT



1. EXCLUSIVELY MAINTAINED BY CNES AND IGN

- **FRENCH SYSTEM DEVELOPED BY CNES AND IGN**
- **NETWORK DEPLOYMENT BY IGN***
  - 1986-1990: Operational set-up (launch of Spot-2 = start of the system)
  - 1990-2000: Densification (32 > 54 stations)
  - 2000-nowadays: Renovation
    - System more exacting and effective
    - Instruments upgrade
    - Better stability and environment for the antenna
- **KEEPING TWO OBJECTIVES IN SIGHT:**
  - Homogeneous coverage
  - Co-location with other space geodetic techniques

* see Journal of Geodesy (2006), H. Fagard « Twenty years of evolution for the DORIS permanent network »

1. DORIS NETWORK MONUMENTS

- **MORE THAN TWENTY YEARS OF EXPERIENCE**
- **2005 : DORIS SYSTEM REQUIREMENTS**
  - Doc « System Requirements for management of the DORIS network station»
  - Requirements for station installation : 36 key points to observe
- **2009 : DRAWING UP THREE STANDARD MONUMENTS**
  - Compliant to all the DORIS system requirements
  - Dependent on the layout of the premises and the antenna environment
  - Fitting in all cases according to the site layout

1. SYSTEM REQUIREMENTS

- **REFERENCE POINT – ANTENNA VERTICALITY**
  - Antenna verticality adjusted with accuracy using leveling screws
- **ANTENNA HEIGHT**
  - > 1,85m to reduce signal power attenuation and multipath effect
  - Visibility : no obstruction above 5° elevation
- **RESISTANCE**
  - Corrosion: high quality stainless steel
  - Metals compatibility: antenna base / antenna support

1. GEODETIC REQUIREMENTS

- **GEODETIC PRINT**
  - Fiducial marker
  - Essential to measure antenna offset after replacing or moving
- **MARKER VISIBILITY**
  - Within sight of theodolites
- **STABILITY**
  - Anchored to the bedrock
  - Long-term stability: better than 3 mm over a ten-year period (apart from tectonics)

2. MONUMENT SPECIFICATIONS

2. CONCRETE BASE – GUIDING PRINCIPLES

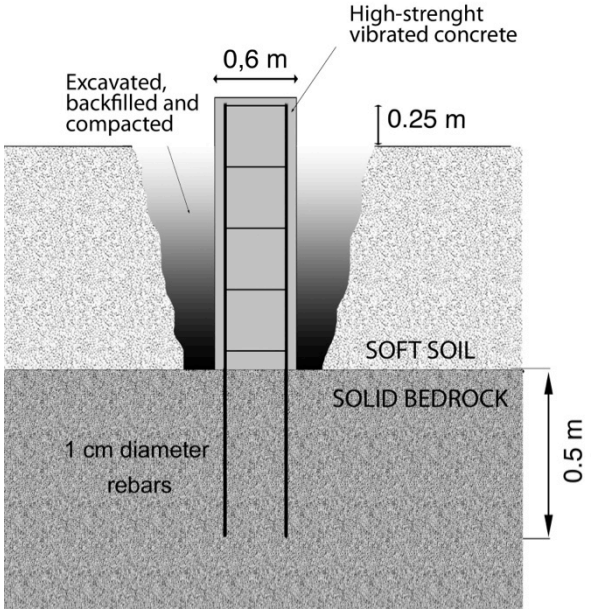
- **RECONNAISSANCE**
  - Geologic information
  - Search for rocky outcrop, exposed bedrock
  - Monument type selection (concrete block or pillar)
- **DIMENSIONS**
  - Design and depth: dependent on soil structure
  - Sizes (width and height above ground): dependent on the antenna environment
- **CONSTRUCTION**
  - High strength, reinforced and vibrated concrete is required.
  - Steel reinforcement rebars diameter 1cm are required.
  - After excavation and construction, soil is backfilled and compacted.
  - Curing time for concrete must be respected
  - Remote areas : make do with the existing local skills!

2. CONCRETE BASE CONSTRUCTION

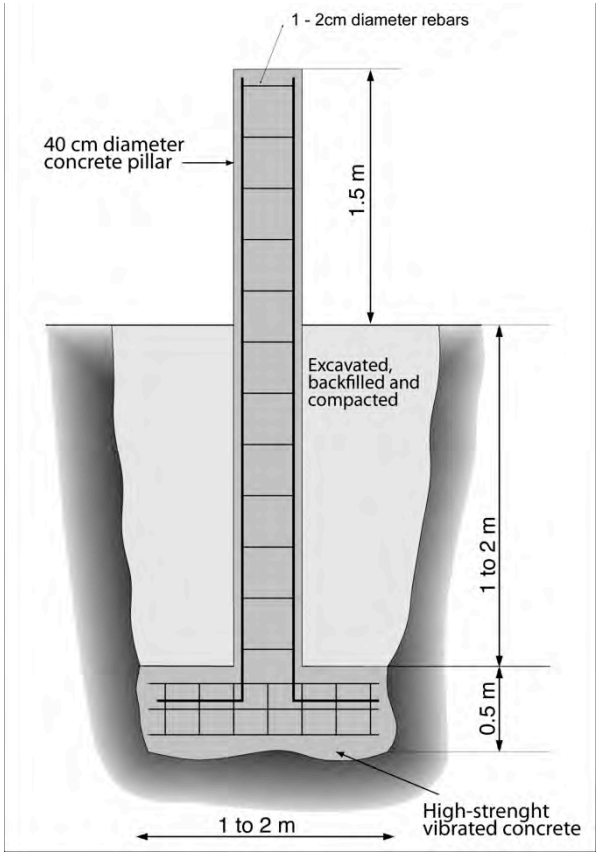
- **SOLID BEDROCK**
  - Drill down around 0,5m to embed 4 rods
  - Make a steel reinforcing cage
- **HARD SOIL**
  - Pour a large (1 m) reinforced concrete slab to make a stable foundation
  - Adjusted dimensions according to the hardness of the soil
- **SOFT SOIL**
  - Pour a very large (2m sided – half meter high) reinforced concrete slab
  - Optional : drive on the pillar axis a long pipe (15cm diameter – 10 m long)

2. CONCRETE BASE CONSTRUCTION

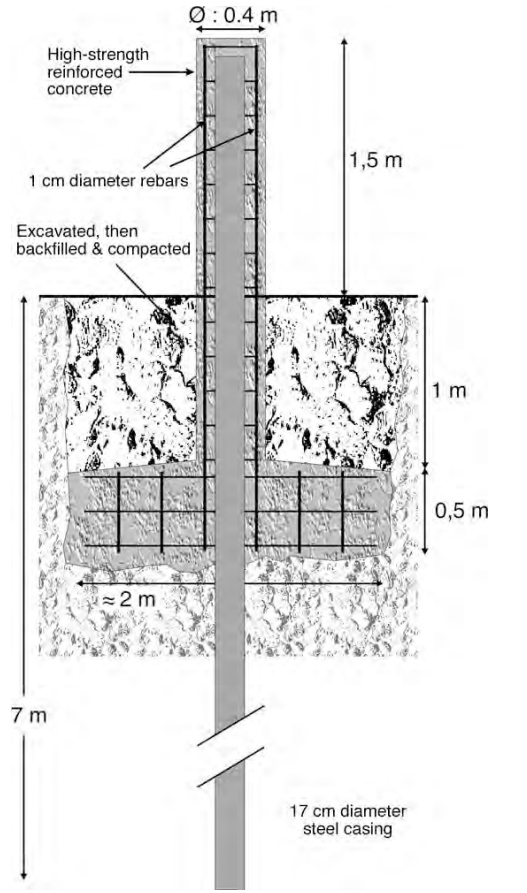
SOLID BEDROCK



HARD SOIL

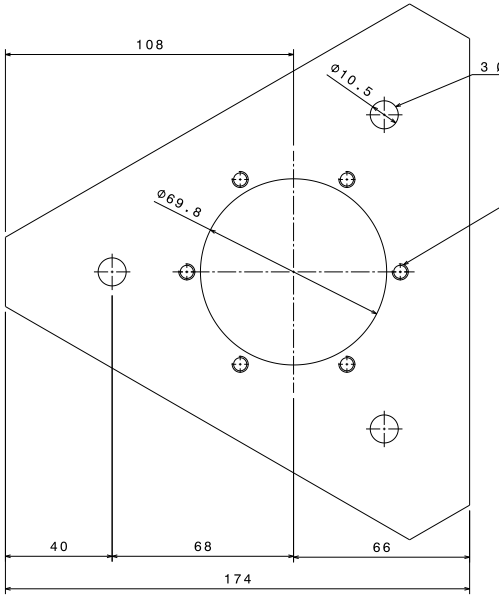


SOFT SOIL



2. ANTENNA SUPPORT

- = METALLIC STRUCTURE HOLDING THE DORIS ANTENNA
- ANTENNA SUPPORT PARTS: FOOT / BODY / HEAD
- HEAD : SUMMITAL TRIANGULAR PLATE EQUIPPED WITH LEVELING SCREWS TO ADJUST THE ANTENNA VERTICALITY



2. MONUMENT TYPE 1

Description	Mini-pylon (0,5m high) installed on load-bearing wall
Concrete base	Top of a load-bearing pillar or at the corner of two load-bearing walls of small building (one storied)
Antenna support	1 « Normand » pylon element topped by a stainless steel triangular plate type I
Benefits	Small footprint, easy shipping, easy setting
Drawbacks	Galvanized but not corrosion-resistant steel, low-rise support
Preferential Use	Low-rise building with narrow walls, non-corrosive environment

Djibouti

2. MONUMENT TYPE 2

Description	Custom made stainless steel tripod installed on concrete pillar
Concrete base	Pillar 1,5 m high above ground
Antenna support	Custom made stainless steel tripod topped by a stainless steel triangular plate type II
Benefits	Custom made (adaptable on existing threaded rods), high corrosion resistance, stability, easy shipping, easy setting.
Drawbacks	Maximum height 50 cm for stability reasons
Preferential Use	Corrosive environment, clear sky view

Port-Moresby

2. MONUMENT TYPE 3

Description	Very rigid steel tower installed on concrete block
Concrete base	Concrete block or concrete slab
Antenna support	2 « Leclerc » pylon element (2x1m) topped by a stainless steel triangular plate type III
Benefits	Higher monument, smaller pedestal.
Drawbacks	Limited corrosion resistance, shipping, setting.
Preferential Use	If surrounded by near obstructions

Metsähovi

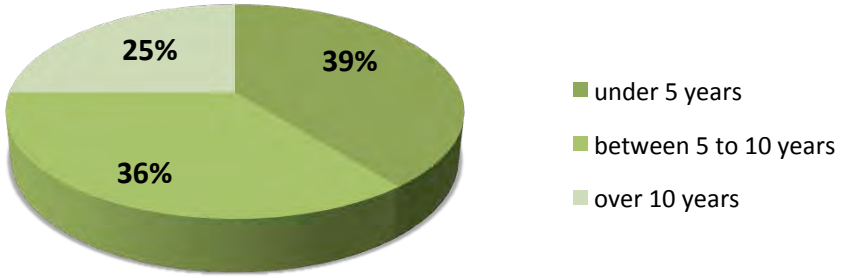
3. STABILITY ASSESSMENT

3. MONUMENTS IN THE DORIS NETWORK

MONUMENT AGE

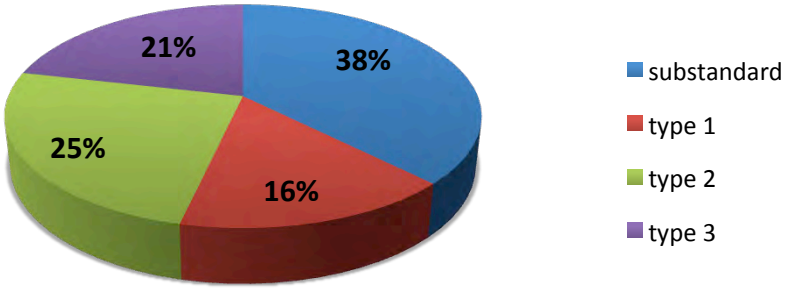
- About 5 on-site interventions per year – Network made up of **56 stations**

=> on average each site is visited every 10 years



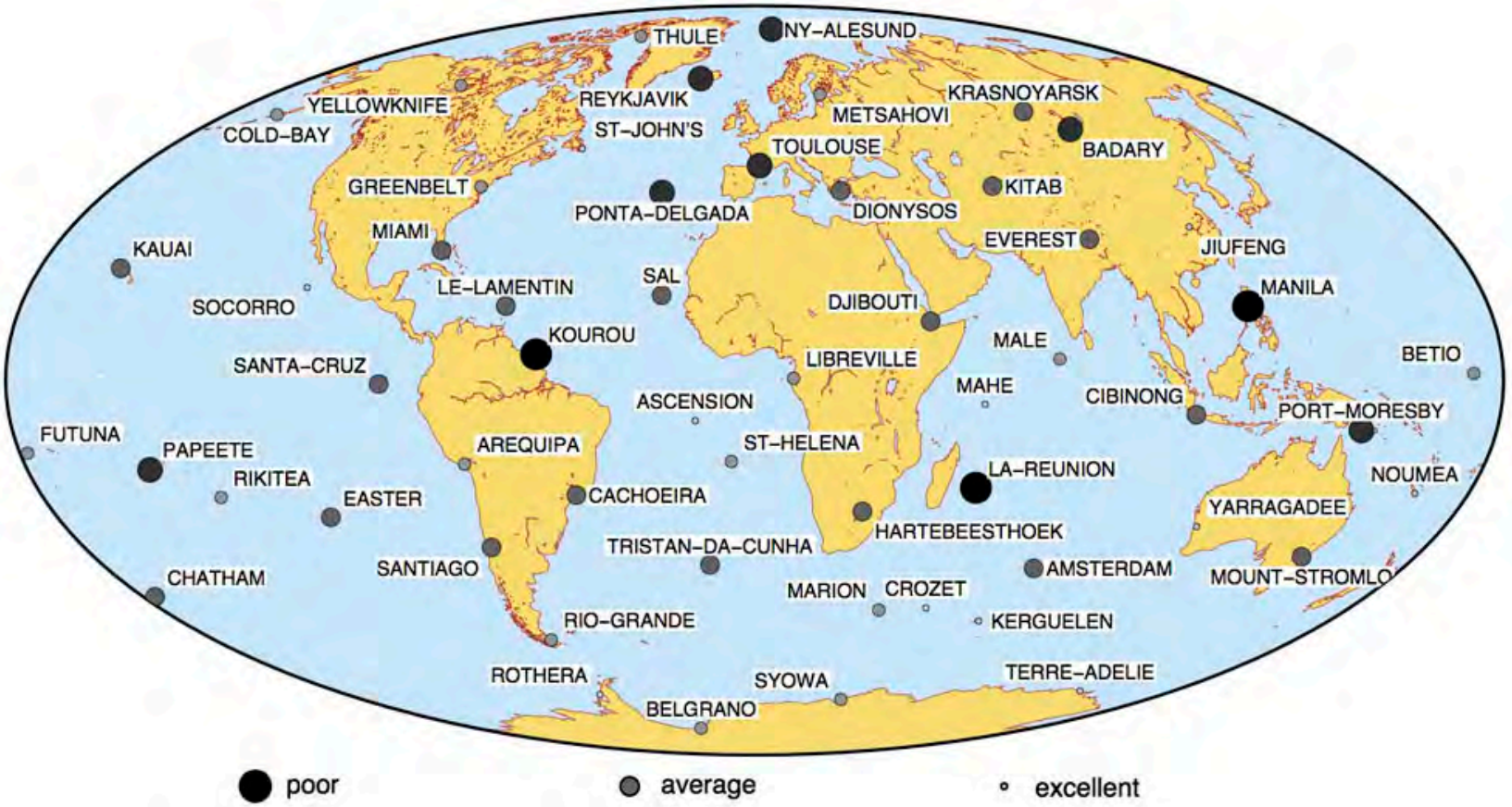
MONUMENT TYPES

- Progressive renovation



3. NETWORK REVIEW: COMPARATIVE ASSESSMENT

- STABILITY IMPROVEMENT: AN ONGOING EFFORT SINCE 15 YEARS
- CURRENT STABILITY OF THE MONUMENTS RATHER GOOD ON THE WHOLE



Reykjavik – Iceland (REZB)

Distance to GPS (REYK) = (-1856.22 m, -1334.64 m, 595.235 m)
Distance to Tide Gauge : ~1.57 km (GLOSS gauge 229)

Hartebeesthoek - South Africa (HDMB)

Monument type:

2 meter tubular mast; 4 m deep (3 m in soil, 1 m in rock).

Distance to GPS (HARB) = (4.188 m, -22.29 m, -10.254 m)
Distance to SLR (7501) = (747.659 m, -2017.167 m, -217.841 m)

Greenbelt – U.S.A. (GRFB)

Monument type:

1.8 m concrete pillar.

Distance to GPS (GODE) = (62.159 m, 138.602 m, 139.019 m)
Distance to SLR = (8.288 m,41.594 m, 45.159 m)
Distance to new VLBI = (18.876 m, 146.212 m, 166.658 m)

3. STABILITY ISSUE

- **TIME SERIES: MONUMENT MOTION CAN BE CONFOUNDED WITH GEODETIC SIGNALS**
- **CONCRETE BASE MOVEMENT**
  - Bedrock anchoring or not
  - Height of the structure (building)
- **METALLIC SUPPORT MOVEMENT**
  - Thermal expansion/distortion effects: seasonal or diurnal
  - Prevailing winds
  - Storms

⇒ **LIMITING THE MONUMENT MOVEMENT**

⇒ **MONITORING THE MONUMENT STABILITY**

3. ACTIONS IN PROGRESS

- **EQUIPPING SITES WITH GEODETIC CONTROL POINTS IN ORDER TO MONITOR THE MONUMENT STABILITY**
  - Fiducial pillars distributed around the monument
  - Regular observations campaigns
- **GRASSE (SOUTHERN FRANCE) CHOSEN AS EXPERIMENTAL SITE**
  - August 2013: first observations campaign

  ⇒specification, method assessment, cost evaluation

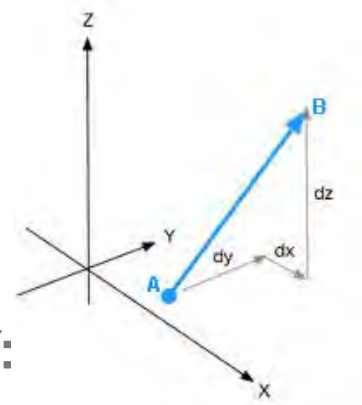
  before extending to the whole network
- **ENSURING THAT EACH ANTENNA MEETS ITS SPECIFICATION**
  - Perpendicularity antenna base / antenna axis
  - Alignment of the 2GHz connector on the antenna axis
  - => new instrument optical access point

- **STUDY OF THE MECHANICAL RESISTANCE OF THE 3 METALLIC SUPPORTS**

3. ARP COORDINATES DETERMINATION

- **CASE 1 "RENOVATION (ANTENNA MOVE)":**

TIE VECTOR WITH THE FORMER REFERENCE POINT



- **CASE 2 "NEW STATION":**

TIE VECTORS WITH AVAILABLE POINTS IN THE VICINITY:

  - Co-location with other IERS techniques: terrestrial method
  - IGS network: GPS method

- **HIGH PRECISION LOCAL TIE SURVEY**
  - Combining terrestrial measurements of angles, distances and height differences
  - Objective : submillimetric tie vectors precision
  - Contribution to ITRF
  - 21 sites done in the last 3 years