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CENTRE NATIONAL D'ÉTUDES SPATIALES

IGN
INSTITUT NATIONAL DE L'INFORMATION GÉOGRAPHIQUE ET FORESTIÈRE

CHANGER D'ÉCHELLE

DORIS NETWORK STATUS

IDS WORKSHOP 2024, MONTPELLIER

JÉRÔME SAUNIER (IGN)

OUTLINE

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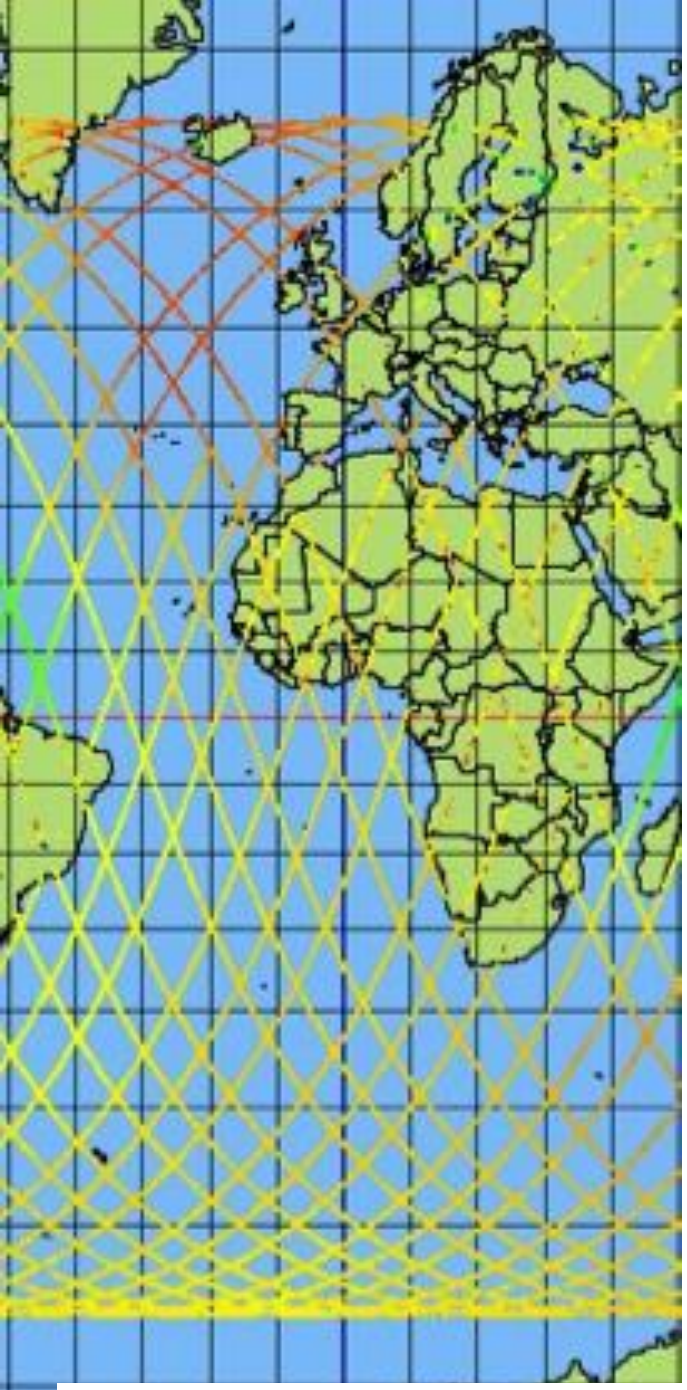
1. GENERAL OVERVIEW



MEETING THE NEEDS OF SATELLITE ALTIMETRY AND GEODESY

A UNIQUE NETWORK DESIGN

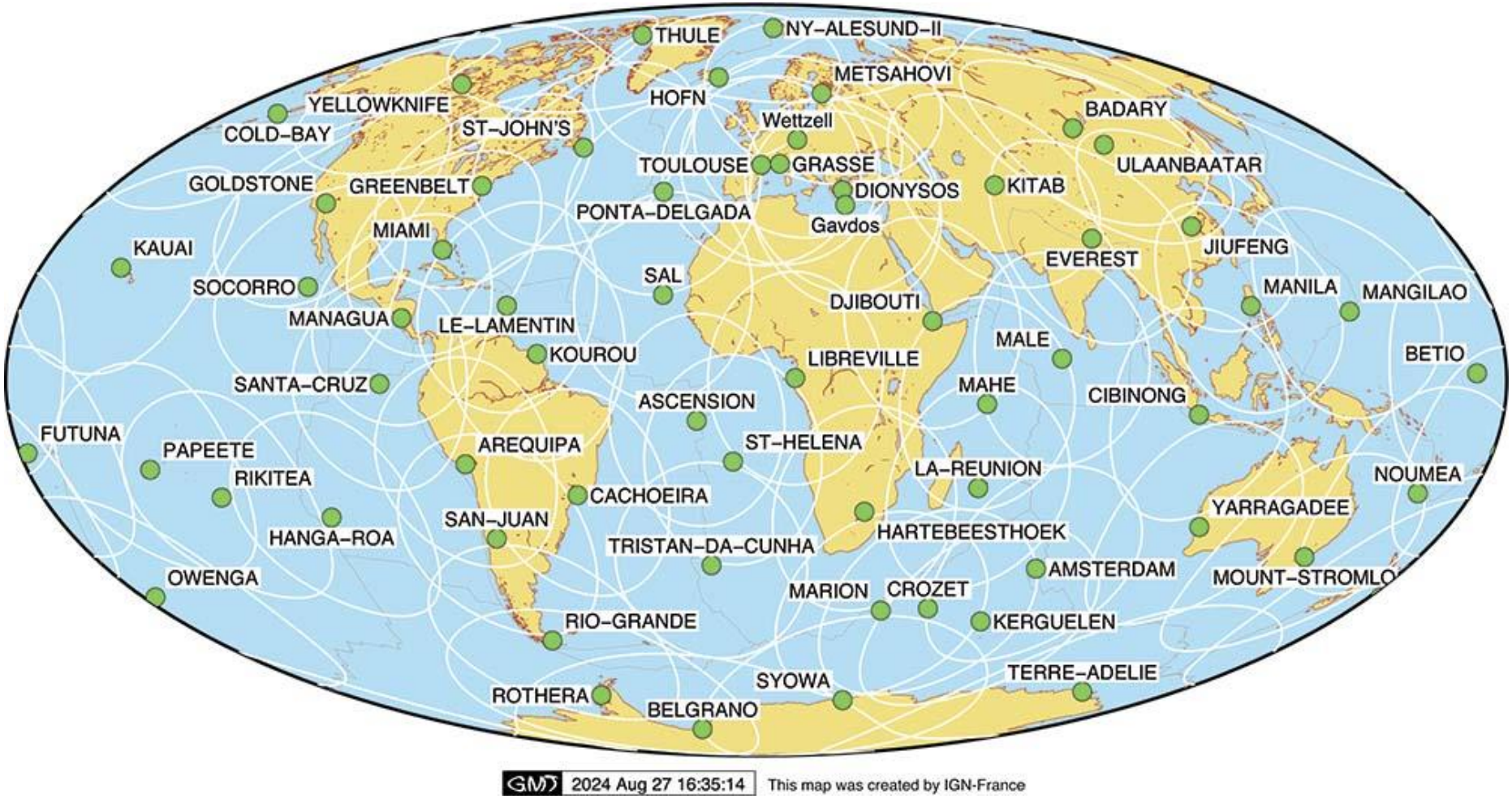
The DORIS Network was designed to serve satellite altimetry, giving it a number of specific features:

1. Even distribution of the stations
2. Reliable hosting conditions for good data availability
3. Suitable antenna environments for RF transmission
4. Monument stability
5. Rugged equipment
6. Long time series of station positions
7. Co-location with other techniques

1.1 EVEN DISTRIBUTION OF THE STATIONS

85% Low-Earth Orbit coverage (800km)

97% coverage at 1300km altitude



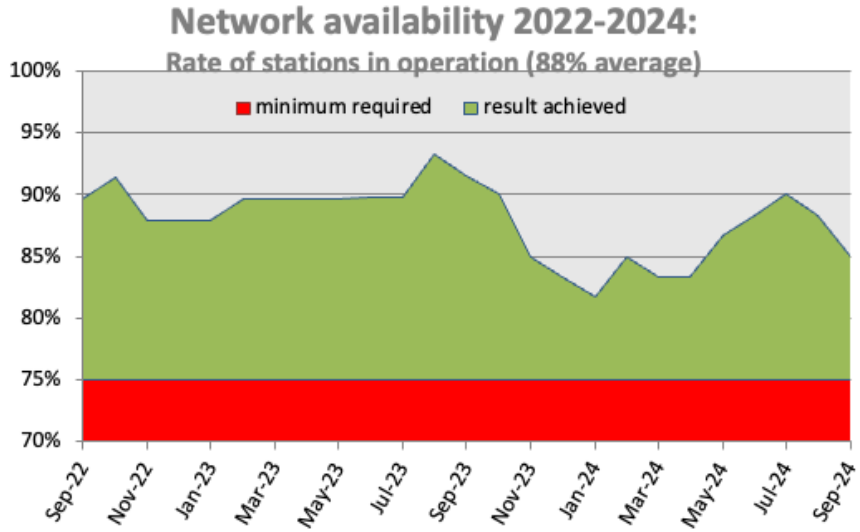
1.2 RELIABLE HOSTING CONDITIONS

HOST AGENCIES WITH AN INTEREST IN DORIS

- Mapping and Survey Agencies (25%)
- Space Agencies (15%)
- Polar Institutes (15%)
- Scientific Institutes (15%)
- Universities (15%)
- Weather Stations (15%)

GOOD DATA AVAILABILITY

Thanks to the coordinated efforts of our network maintenance teams at CNES and IGN with the essential support of local teams



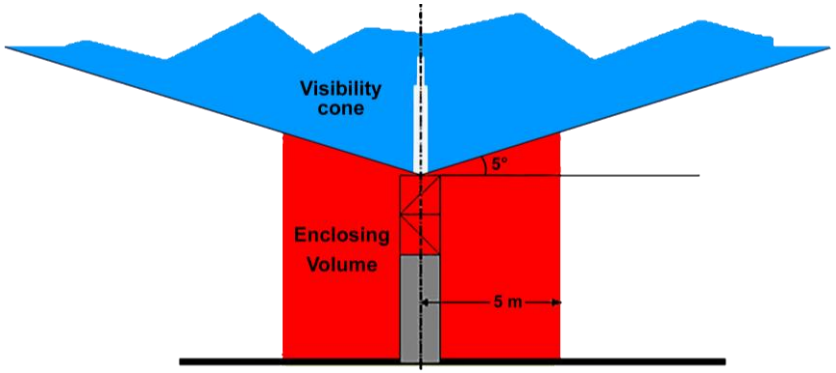
1.3 SUITABLE ANTENNA ENVIRONMENTS

SYSTEM REQUIREMENTS

- Clear sky view above 5° elevation
- No metal object (likely to cause multipath) in a 5m radius around the antenna
- No interferences with receiving / transmitting devices in the vicinity

MAXIMIZE THE NUMBER OF ON-BOARD MEASUREMENTS

The visibility of the antenna from the satellites is a key factor in the station performance and the contribution to Precise Orbit Determination



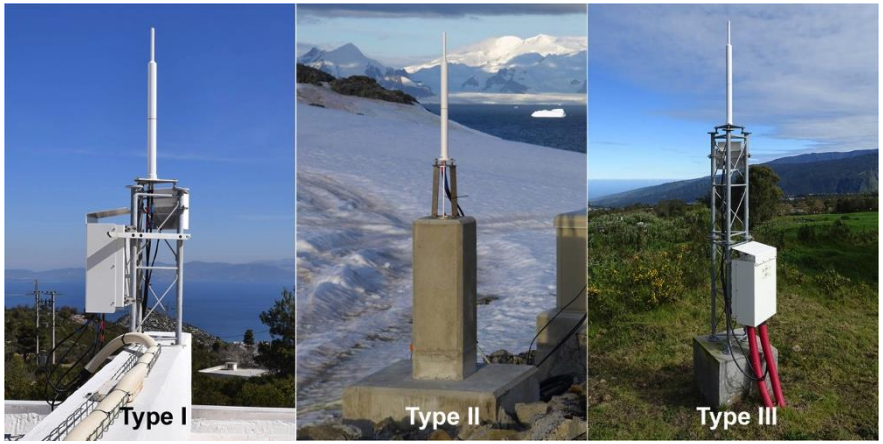
1.4 MONUMENT STABILITY

GEODETIC REQUIREMENTS

- **Minimize velocities uncertainty and noise in the position data**
- Monuments must be firmly coupled with the substrate
- Properly size monument foundations according to soil structure
- Minimizing thermal or elastic distortion due to weather conditions
- Stability assessment: field measurements during maintenance operations

THREE STANDARD MONUMENTS

Specifications applied to all new constructions since 2010



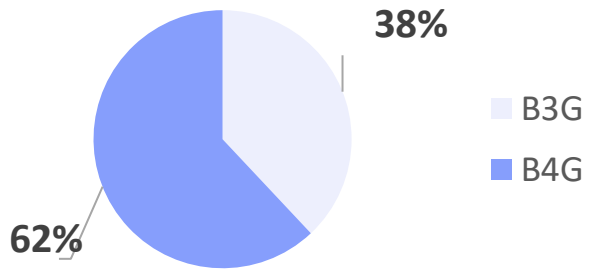
Current distribution:
Type I: 16 ; Type II: 17 ; Type III: 18 ; substandard: 9

1.5 RUGGED EQUIPMENT

BEACONS (SIGNAL TRANSMITTERS)

The network hardware has been continuously improved over 4 generations of beacons:

- Deployment of 4th generation beacons begins in mid-2019
- Manufactured using the latest electronic components, this beacon enhances the network robustness

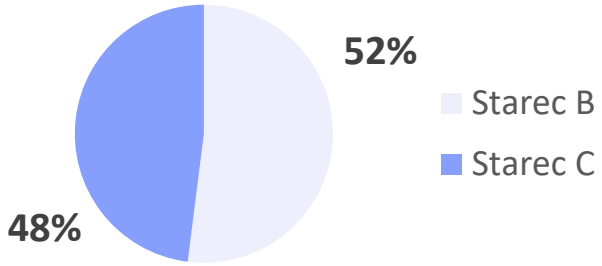


ANTENNAS

3 generations of antenna were developed and deployed over the years: Alcatel A, Starec B, Starec C

The manufacturing process of the Starec antenna was revised in 2013 to better characterize it and improve the repeatability.

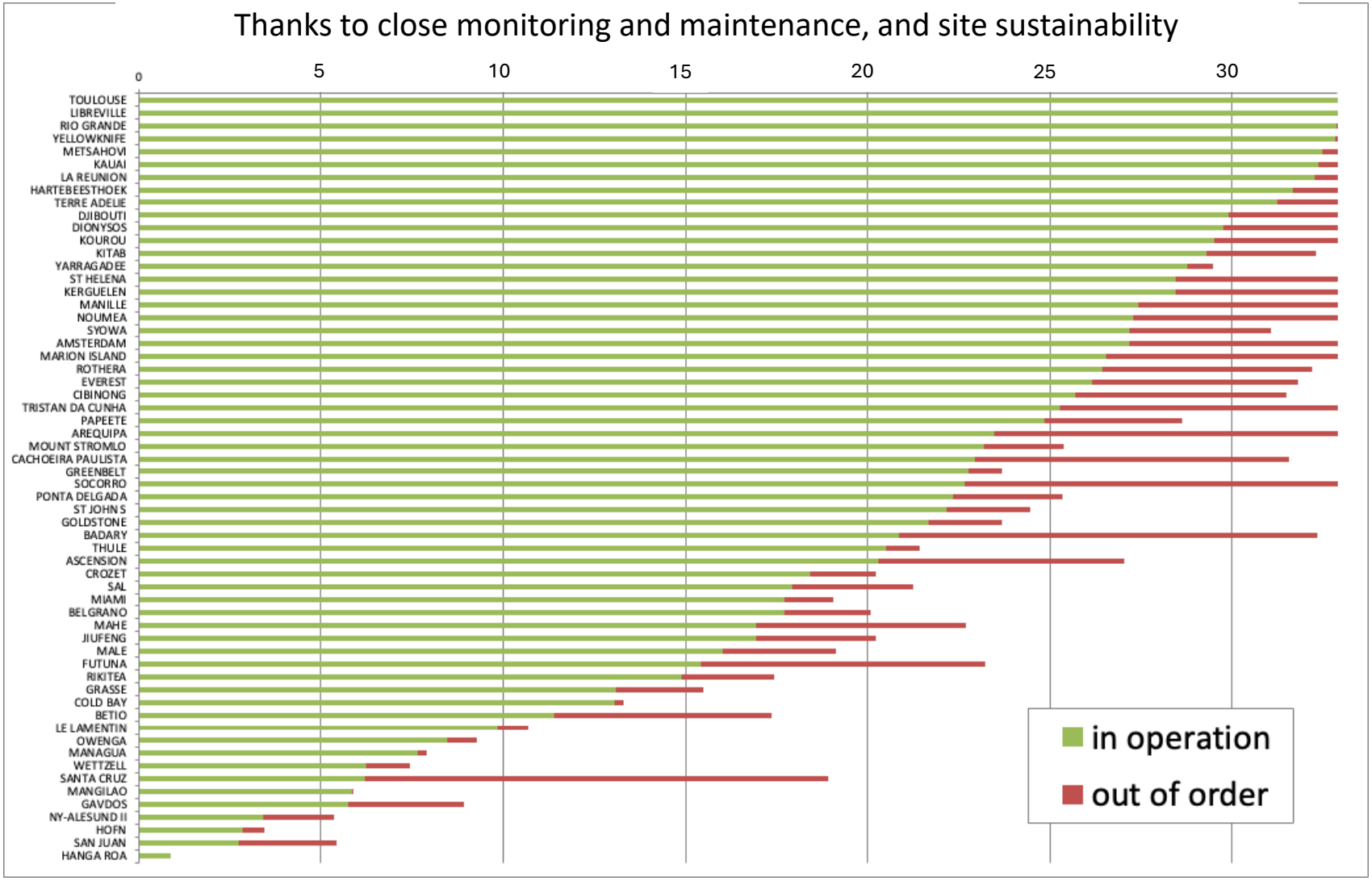
- Starec C deployment from 2014



1.6 LONG TIME SERIES

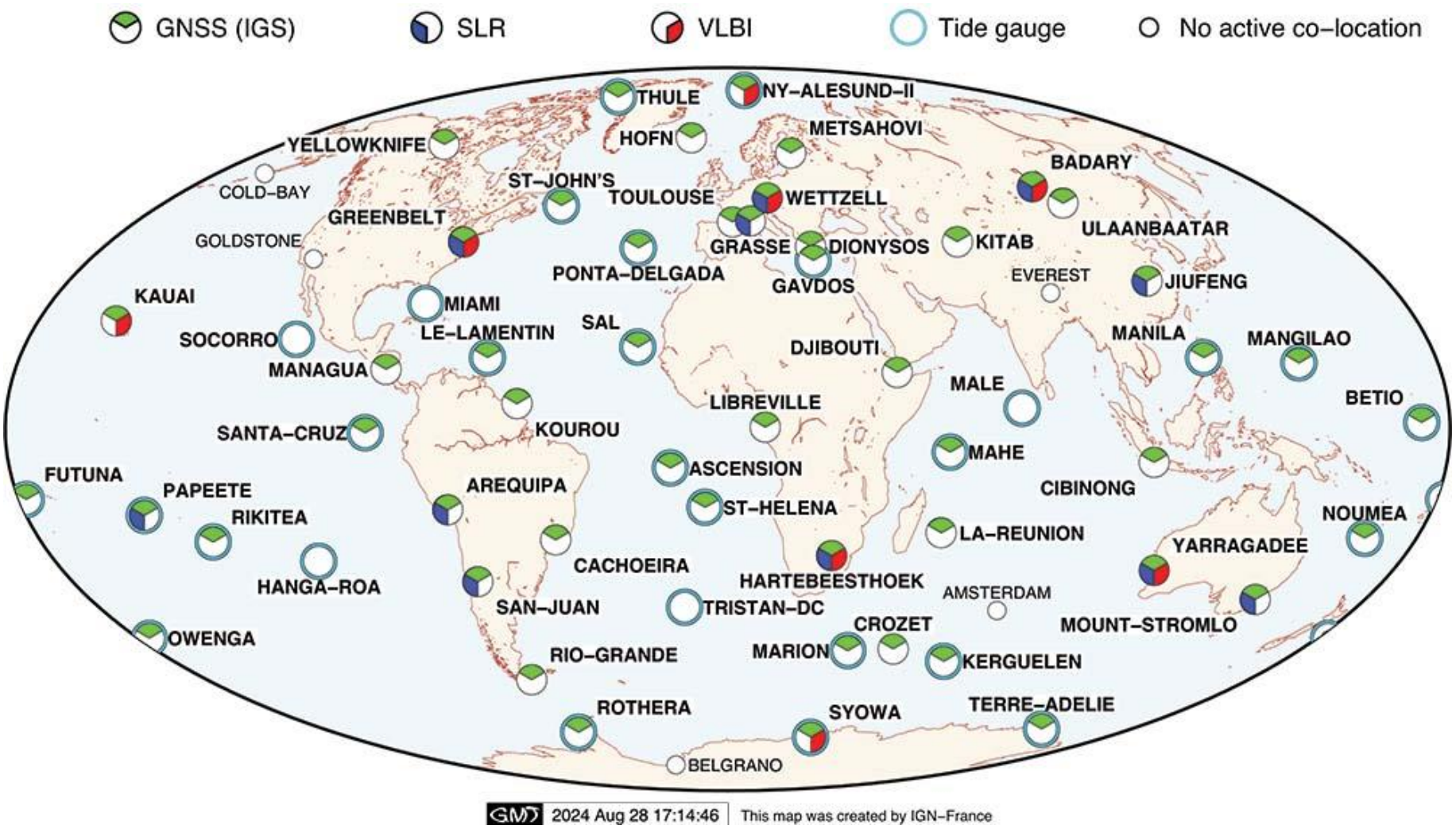
Half of the current network stations has 23y data availability

Thanks to close monitoring and maintenance, and site sustainability



1.7 CO-LOCATION WITH OTHER TECHNIQUES

On-going efforts to co-locate DORIS with other IERS techniques and tide gauges



2. RECENT EVENTS AND CURRENT STATUS

2023 NETWORK EVENTS

2023	Station		Event
Jan.	CIDB	Cibinong	*Beacon replacement: 3G > 4G*
Apr.	KOLB	Kauai	*Beacon replacement: 3G > 4G*
	HROC	**Hanga Roa**	**DORIS station installation (new site)**
	MAVC	Marion	*Antenna and Beacon replacement 3G > 4G*
Jun.	**SCSC**	Santa Cruz	**Antenna and Beacon replacement 3G > 4G; restarting after 2y-outage**
Jul.		**Ulaanbaatar**	**Site reconnaissance for a new DORIS site**
Sep.	**GAVC**	**Gavdos**	**DORIS station installation**
	CADB	Cachoeira	*Beacon replacement: 3G > 3G*
Oct.	YEMB	Yellownife	*Beacon replacement: 3G > 4G*
Nov.	**DJIB**	Djibouti	*Beacon replacement: 3G > 4G*
	TLSB	Toulouse	*External clock replacement*
Dec.		**Kanpur**	**Site reconnaissance for a new DORIS site**
	RIMC	Rikitea	**Major renovation** (moved 21m south + equipment upgrade)

2024 NETWORK EVENTS

2024	Station		Event
Jan.	SYQB	**Syowa**	***Station relocation*** *(moved to 400m) but restart failure*
	ROBC	Rothera	*Antenna replacement*
Feb.	**CRRC**	Crozet	*Antenna replacement*
	ARFB	Arequipa	*Beacon replacement: 3G > 3G*
Apr.	**HOGC**	Höfn	Antenna replacement
Jul.	**MAMC**	Malé	Antenna replacement
Aug.	**ULAC**	**Ulaanbaatar**	**DORIS station installation (new site)**

HANGA ROA NEW SITE

NEW STATION IN EASTER ISLAND

Acronym: HROC

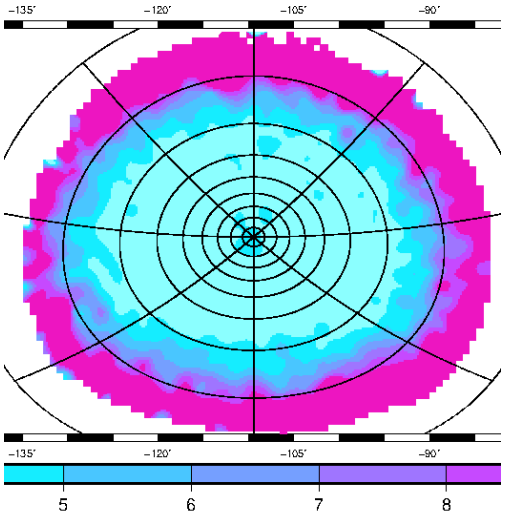
Commissioning April 2023

Excellent cooperation with Universidad de Chile

ESSENTIAL STATION FOR PACIFIC COVERAGE

Strategic site for the DORIS network

Filling an important gap in South Pacific Ocean



1.5x1.5 Doppler residual RMS (mm)

POE RMS Mapping; Courtesy P. Yaya, CLS

EXCELLENT INITIAL RESULTS

Very good compliance with system requirements

Good POE RMS (mean of 7mm)

ULAANBAATAR NEW SITE

NEW STATION IN MONGOLIA

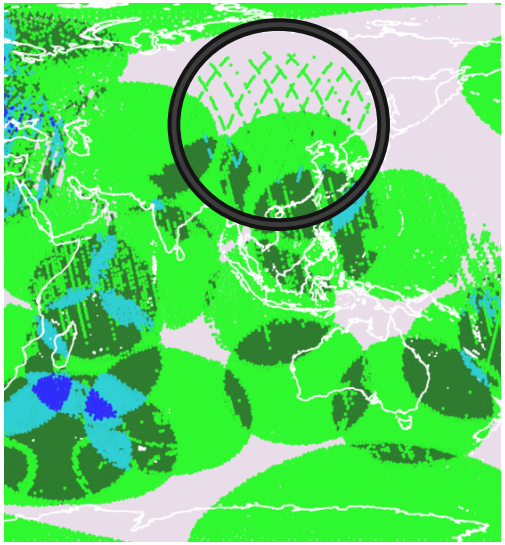
Acronym: ULAC

Commissioning last week!

Co-location with IGS station “ULAB”

PROJECT COMPLETED IN 2 YEARS!

Excellent collaboration with the Institute of Astronomy and Geophysics of MAS

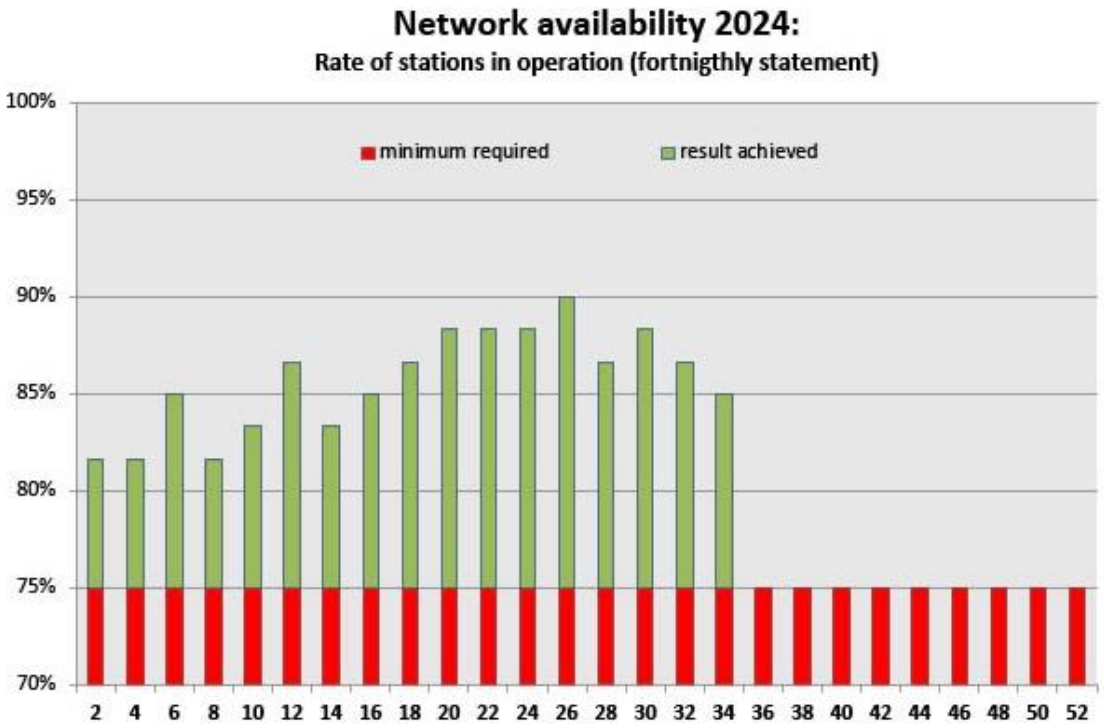


Sentinel 3A Network coverage; CNES

FILLING COVERAGE GAP OVER RUSSIA

Following Russian stations shutdown in 2022, ULAC fills a large coverage gap in this area

CURRENT NETWORK OPERATING CONDITIONS



STATIONS OUT OF ORDER (SINCE):

- BETIO (10/06/2022)
- SYOWA (07/02/2023)
- CACHOEIRA-PAULISTA (03/11/2023)
- AREQUIPA (27/09/2023)
- KERGUELEN (13/06/2024)
- OWENGA (20/06/2024)
- PAPEETE (26/07/2024)
- DIONYSOS (22/08/2024)

Good rate of stations in operation: 85%

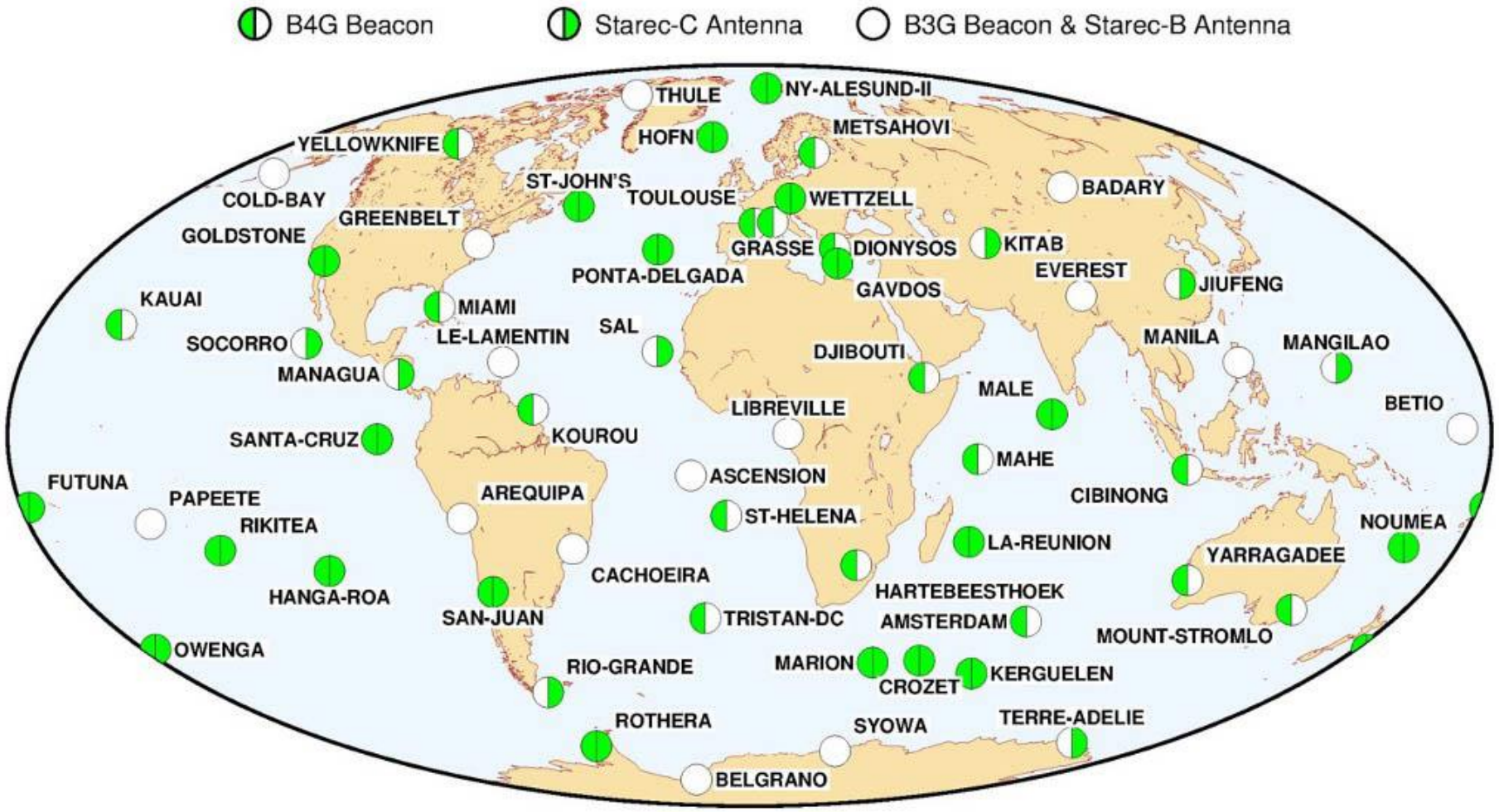
Current main difficulties:

1. **Russian stations shutdown in April 2022:**
   - Alternative sites underway
2. **Ageing beacons in remote areas:**
   - Ongoing 4th generation beacon deployment
3. **Local red tape:**
   - Pending agreement renewal

EQUIPMENT UPGRADING

Good distribution

Remaining upgrading in remote areas



CURRENT NETWORK STATUS

61

Active DORIS stations

38

Stations equipped with 4th generation beacon

29

Stations equipped with 3rd generation antenna

51

Stations collocated with IGS stations

29

Stations collocated with Tide gauges

3. FUTURE PROSPECTS

NETWORK ONGOING DEVELOPMENTS

GRADUAL REPLACEMENT OF THE EQUIPMENT WITH NEW GENERATION

- 4th generation beacon deployment
  - Starec C* antenna deployment

DENSIFICATION: 10 ADDITIONAL STATIONS => 70-STATIONS

- Make the network more robust by adding stations in critical areas
- Enhance the network contribution to various applications

SITE RENOVATION

- Better meet the system requirements to improve the station performance

CONNECTION TO EXTERNAL CLOCKS

- Connection to atomic clocks where possible
- Connection between DORIS beacons and GNSS receivers

*: uncertainty of the vertical location of the 2GHz phase center is reduced from 5 (Starec B) to 2 mm (Starec C)

DENSIFICATION TO IMPROVE COVERAGE

KATHERINE BY THE END OF 2024

- Handled by Geoscience Australia
- Co-location with GNSS + VLBI

ALTERNATIVE SITES TO REPLACE RUSSIAN STATIONS

- Ongoing negotiations with Kazakhstan and South Korea (KASI)

OTHER PROJECTS TO IMPROVE PACIFIC COVERAGE

- Midway Islands, US Navy : with NOAA-NGS help
- Pohnpei Island, Micronesia : with GA help

TWO FUTURE 4 TECHNIQUES SITES

KANPUR, INDIA

- Site selected following call for proposals in 2022 for hosting a station dedicated to IDS for scientific purposes
- Site reconnaissance in late 2023
- Agreement with the Indian Institute of Technology Kanpur (NCG-IITK)
- DORIS station installation planned by the end of 2024

=> see poster by Ropesh Goyal et al.

PAPENOO, FRENCH POLYNESIA

- Observatoire Géodésique et Géophysique de Polynésie (OG2P)
- French Steering Committee: BdL, CNES, CNRS, IGN, IRD, OCA, UPF...
- Instruments: VLBI (NASA), SLR (OCA), DORIS (CNES/IGN), GNSS (CNES/IGN)
- Reconnaissance and RF compatibilty tests planned in late September 2024 in order to determine the best relative geometry between VLBI and DORIS instruments to minimize interference.

SITE RENOVATION WITH ANTENNA RELOCATION

THE 4TH GENERATION BEACON ALLOWS TO MOVE THE ANTENNA FURTHER AWAY THANKS TO THE ADDITION OF A SIGNAL AMPLIFIER => LONGER CABLES

Several stations renovations are planned in order to improve the antenna environment thanks to cables 50m long instead of 15m:

- **Everest**, Nepal (October 2024): approx. 30 m antenna relocation
- **Cachoeira**, Brazil (end of 2024): 35 m antenna relocation: roof terrace => ground
- **Syowa**, Antarctic (early 2025): station relocation about 400m away
- **Le Lamentin**, Martinique (early 2025): station relocation: roof terrace => ground
- **Sal**, Cape Verde (2025): 40 m antenna relocation: roof terrace > ground level


Le Lamentin, Martinique

CONCLUSION

- Continuous effort to improve the network is essential to ensure its day-to-day reliability.
- The network must meet the ever-increasing demands of satellite altimetry and geodesy.
- Network densification is a long process and a real challenge, but we are well on our way!


MERCI POUR VOTRE ATTENTION