UNIVERSITÉ CÔTE D'AZUR

Observatoire de la CÔTE d'AZUR

cnrs INSU Observer & comprendre

GENESIS

At the foundation of Navigation

WORKSHOP

APPLICATIONS DES TECHNOLOGIES TEMPS-FRÉQUENCE AUX DOMAINES DE LA DÉFENSE ET DU SPATIAL

OCTOBRE 2025

CLÉMENT COURDE

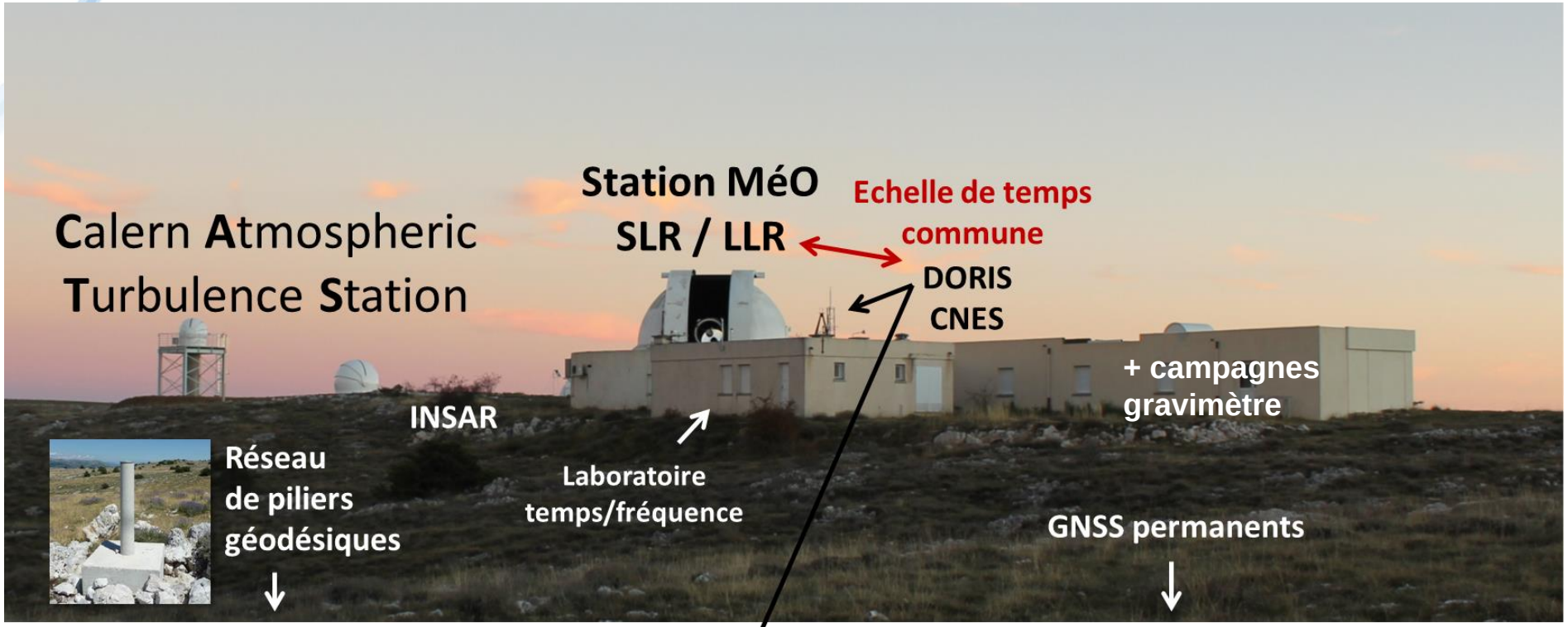
esa genesis

FUTURE NAV esa.int/Applications/Navigation

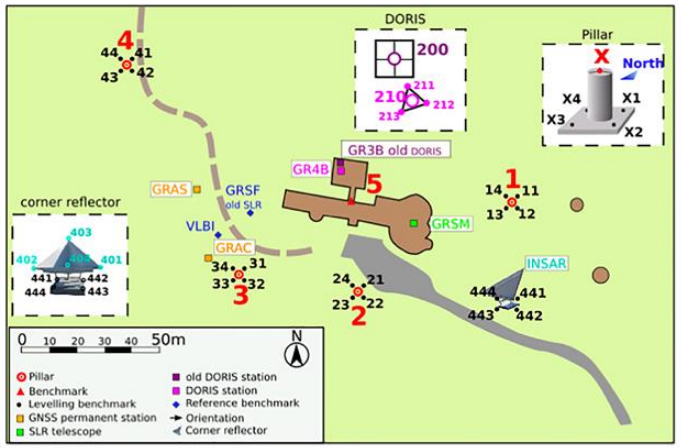
Summary

- Context
- Objectives of the project
- Time & Frequency opportunities

OBSERVATOIRE GÉODÉSIQUE MULTI-TECHNIQUES DE CALERN@OCA

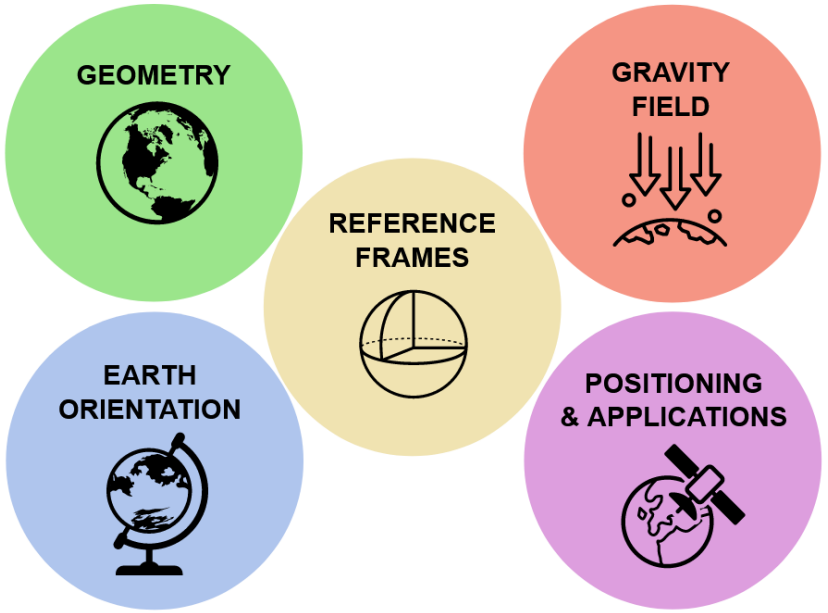


Rattachements topographiques – IGN



Réseau permanent 2020

A quoi sert un observatoire géodésique multi-techniques ?



Geometry

- Surface Deformation Models
- Ocean Topography Models
- Sea Level Change
- Digital Elevation Model
- Ice Sheets & Glaciers – Variations
- Station Positions & Variations
- Tide Gauge Records
- Sea Surface Heights

Gravity Field

- Global Gravity Field – Models
- Gravity Field – Temporal Variations
- Terrestrial Gravity Data
- Regional / Local Geoid Models
- Ice Sheets & Glaciers – Variations
- Height Systems

Earth Orientation

- Earth Orientation Parameters

Reference Frames

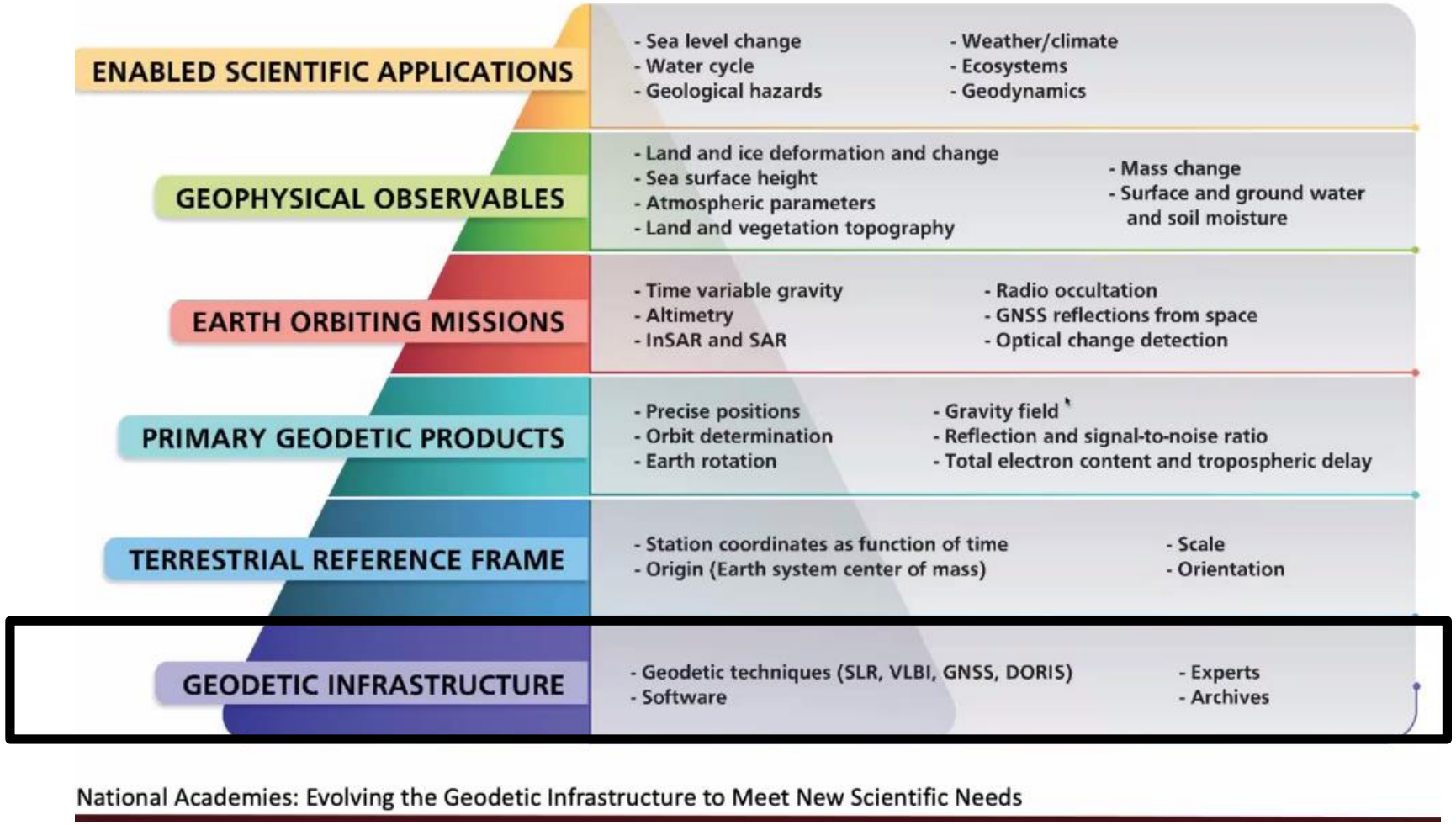
- Height Reference Frame
- Celestial Reference Frame
- Gravity Reference Frame
- Terrestrial Reference Frame

Positioning & Applications

- Thermosphere
- Ionosphere
- Lower Neutral Atmosphere
- Atmospheric Products
- GNSS Satellite Orbits and Clocks

From GGOS
https://geodesy.science/ggos/products/

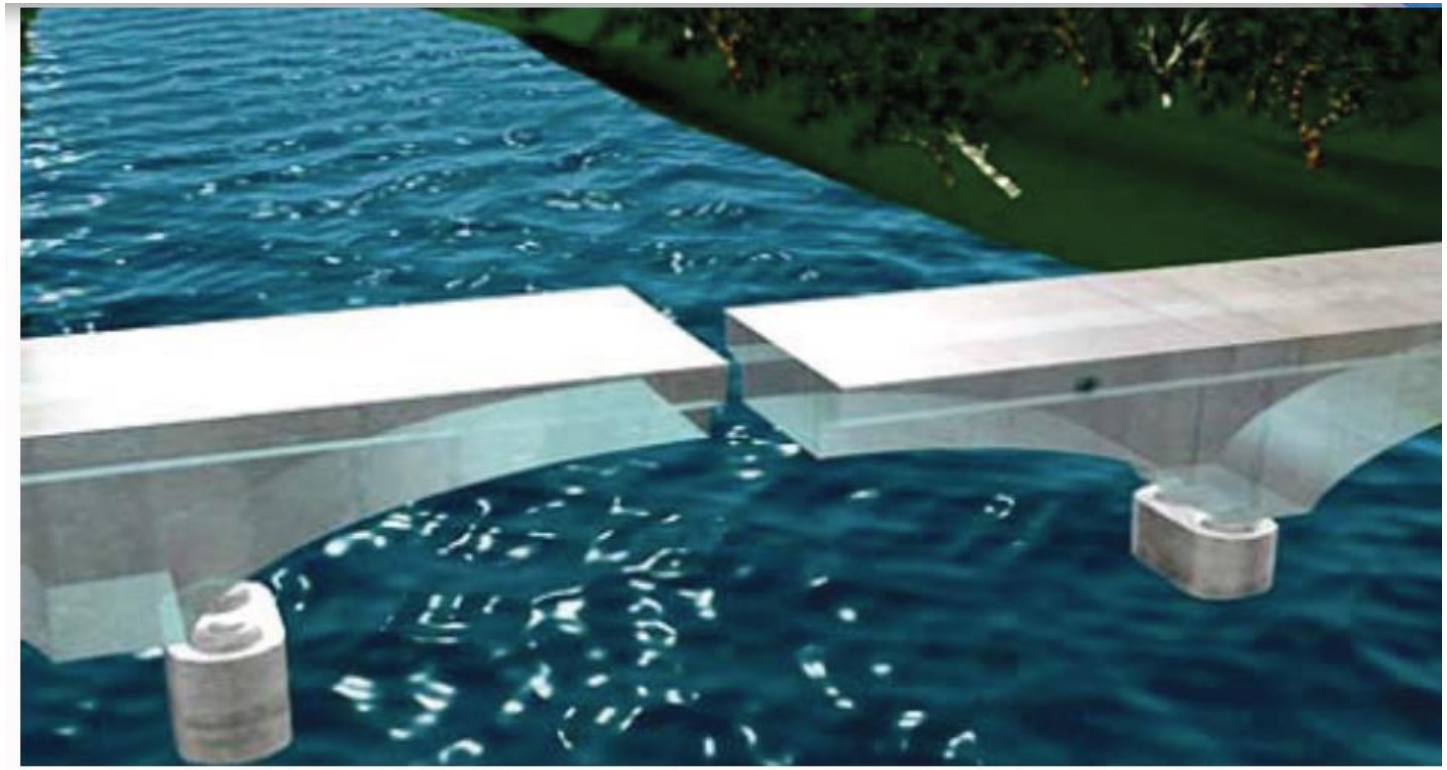
Ok, et dans tout cela, on se situe où ?



National Academies: Evolving the Geodetic Infrastructure to Meet New Scientific Needs

Les observations réalisées à Calern par l'Observatoire Géodésique multi-techniques participent au socle des produits scientifiques en géodésie et geophysique

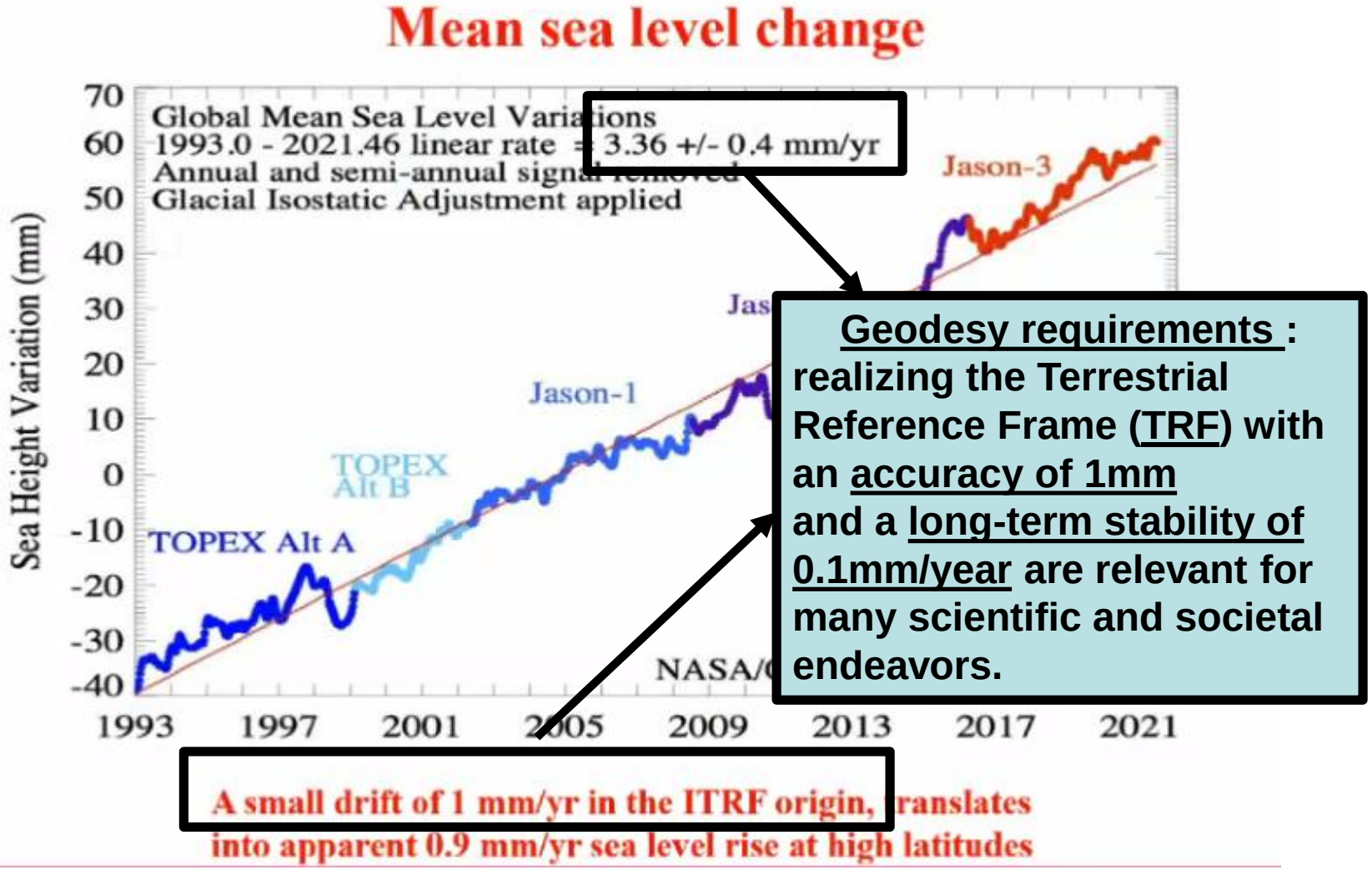
Concrètement, à quoi ça sert ?



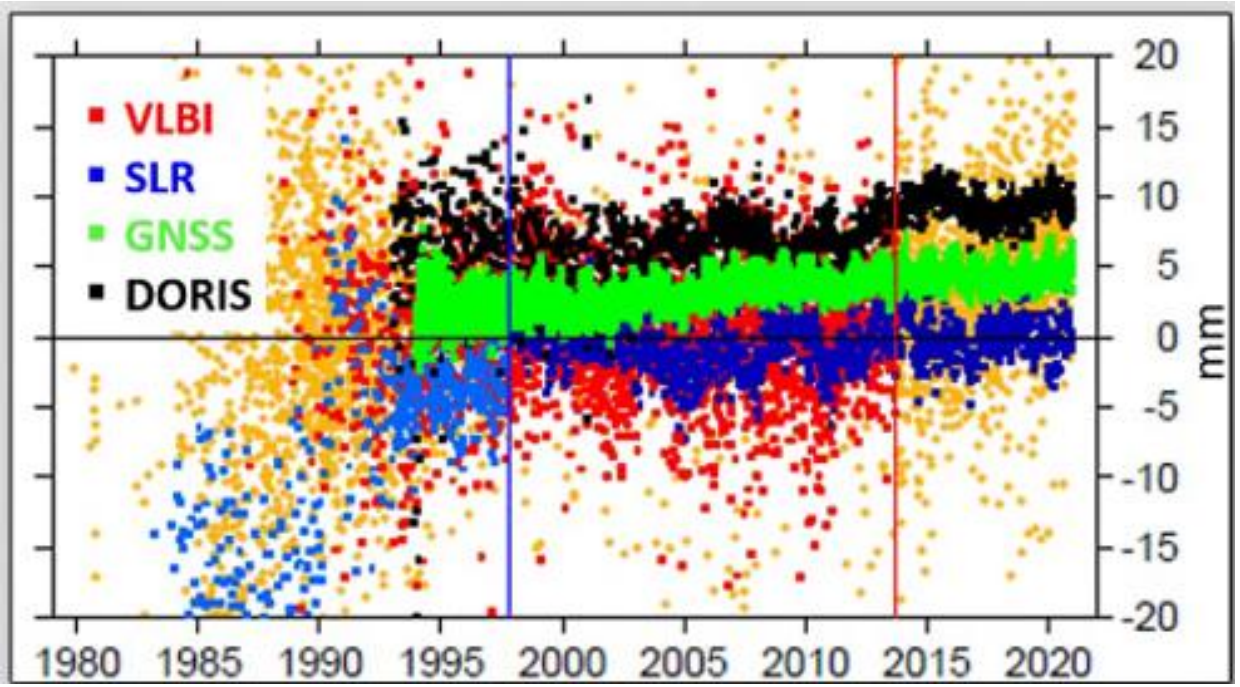
Design error at bridge construction in Laufenburg (2003): During the construction of the bridge across the Rhine river in Laufenburg, a control showed that a height difference of 54 centimeters exists between the bridge built from the Swiss side and the roadway of the German side. Reason of the error is the fact that the horizons of the German and Swiss side are based on different reference frames. Germany refers to the sea level of the North Sea, Switzerland to the Mediterranean.

Courtesy of Hermann Drewes / DGFI

Pourquoi rechercher l'exactitude millimétrique du TRF ?



Situation actuelle



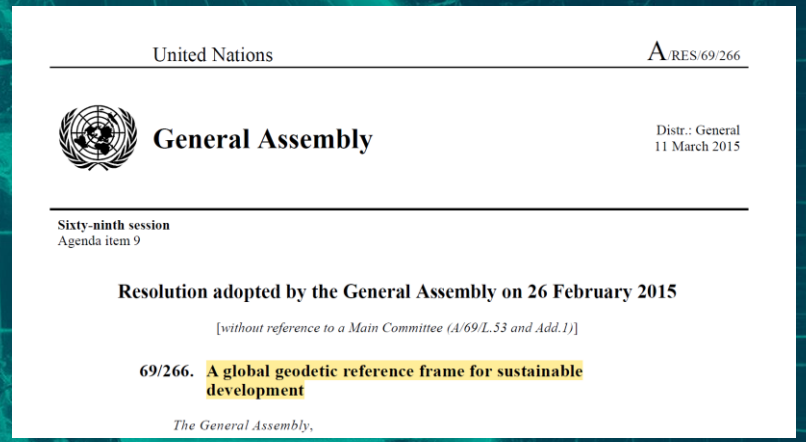
Facteur d'échelle relatif estimé par technique
(Altamimi et al., 2023)

- ITRF 2020 : 5 mm en positionnement et 0.5 mm/an en vitesse
- Erreurs systématiques VLBI, SLR, DORIS, GNSS
- Nombreux processus pas ou mal modélisés

Genesis Primary Objectives

Contribute to improve ITRF accuracy and stability by providing in-orbit colocation and necessary combined processing for the four space-based geodetic techniques that contribute to its realization. The goal is to contribute to the achievement of the Geodetic Global Observing System (GGOS) objectives for the ITRF realisation, aiming for a parameter **accuracy of 1 mm and a stability of 0.1 mm/year**, in order to provide significant scientific benefits in Earth modelling, and to support a wide range of societal applications (as endorsed by the United Nation resolution A/RES/69/266).

Contribute to improve the link between the ITRF and the ICRF, thanks to the increased consistency of the Earth Orientation Parameters (EOP). In particular, this mission shall allow for the first time a link between the orbit reference frame, ITRF and ICRF.



United Nations A/RES/69/266

General Assembly

Distr.: General
11 March 2015

Sixty-ninth session
Agenda item 9

Resolution adopted by the General Assembly on 26 February 2015

[*without reference to a Main Committee (A/69/L.53 and Add.1)*]

69/266. A global geodetic reference frame for sustainable development

The General Assembly,

Targets:

Accuracy: 1 mm

Stability: 0.1 mm per year

Genesis-enabled Science and Applications

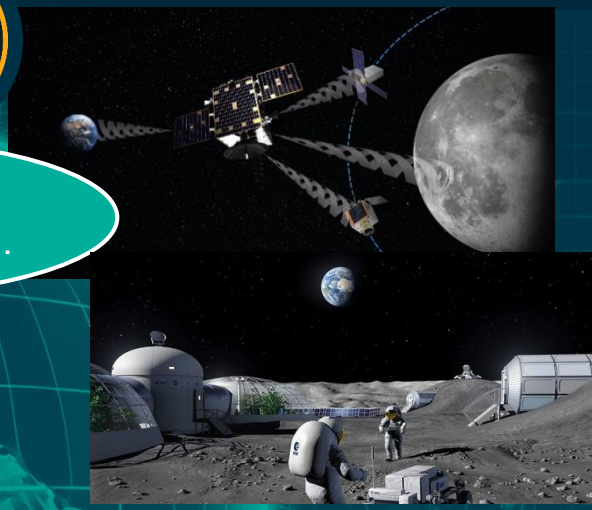
Geodesy, Reference Frames

Improved ITRF, EOPs, Unified Reference Frames

GNSS, Navigation

Improved GNSS POD (LEO, MEO, GEO), calibrations…

Navigation to the Moon, and beyond…

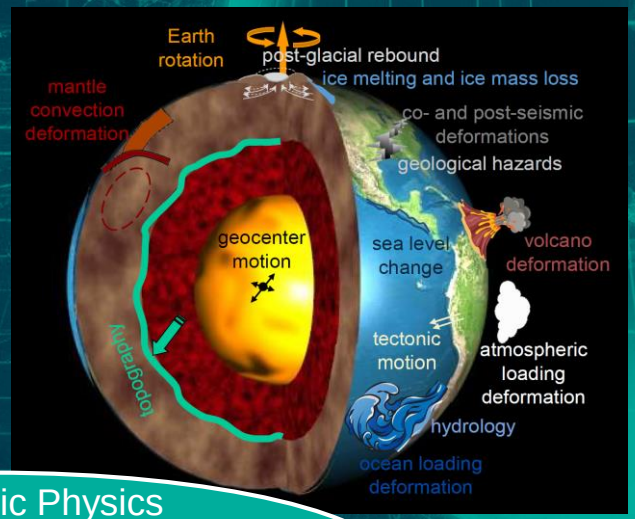


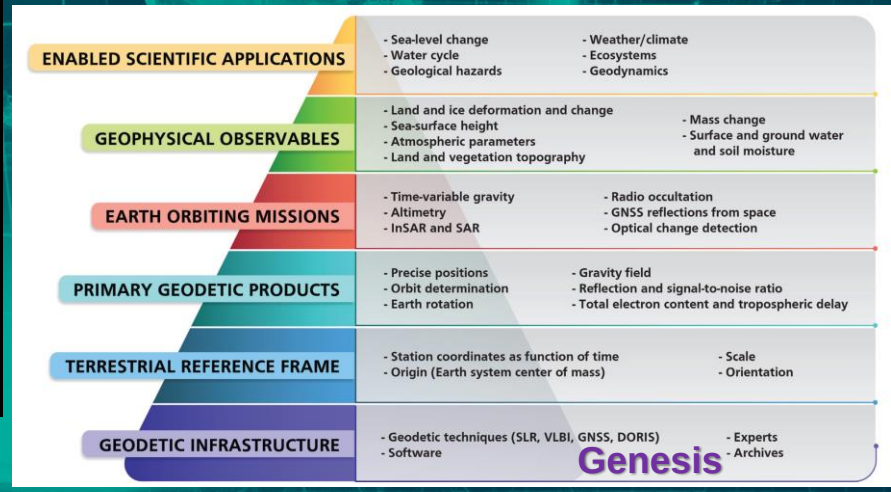
Earth Sciences

Geophysics: Deep Interior
- Geo-centre motion
- Core flows
- Magnetic field…

Geophysics: Mantle, Oceans
- Tectonic motions
- Post-glacial rebound
- Ice melting, Ice mass loss
- Sea level change…

Atmospheric Physics
- Iono, Plasmaspheric density
- Radiation budgets, Earth Energy imbalance…





"Evolving the Geodetic Infrastructure to Meet New Scientific Needs", National Academies of Sciences, Engineering and Medicine (2020)

Genesis System Overview

System:

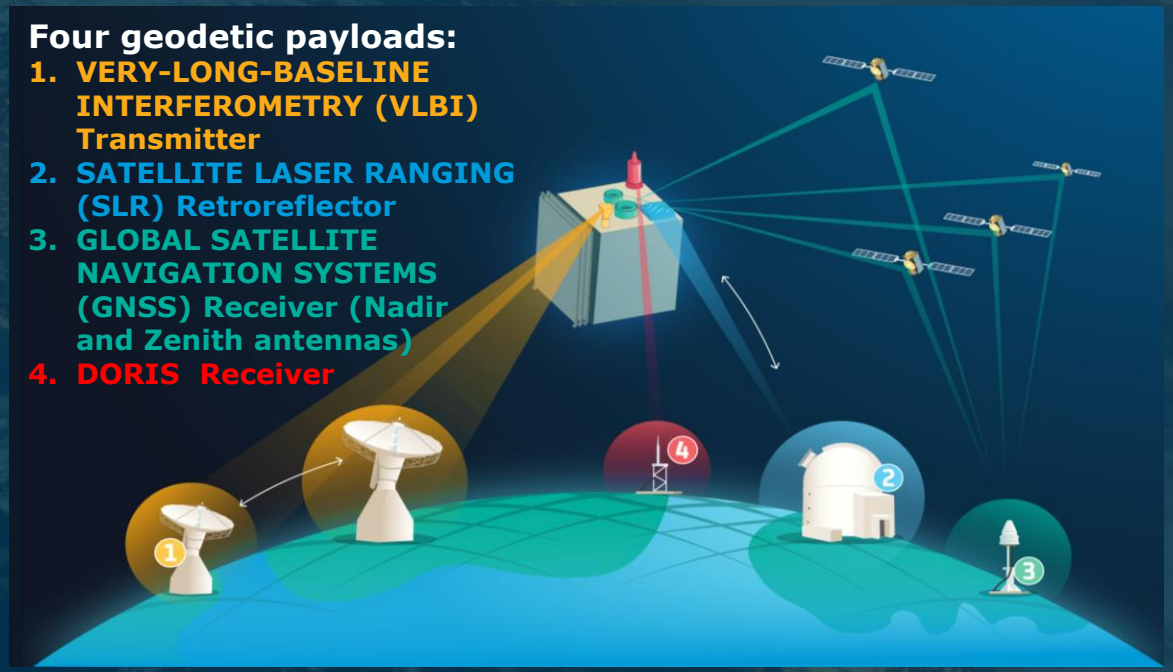
- Satellite
- GCS (Ground Control Segment)
- ESA PROAD (PROcessing, Archiving & Distribution)
- Existing infrastructure (GNSS, SLR, VLBI, DORIS)

Four on-board geodetic Instruments:

- SLR: passive reflector
- DORIS, GNSS: on-board receivers
- VLBI: on-board transmitter in existing VLBI frequency bands

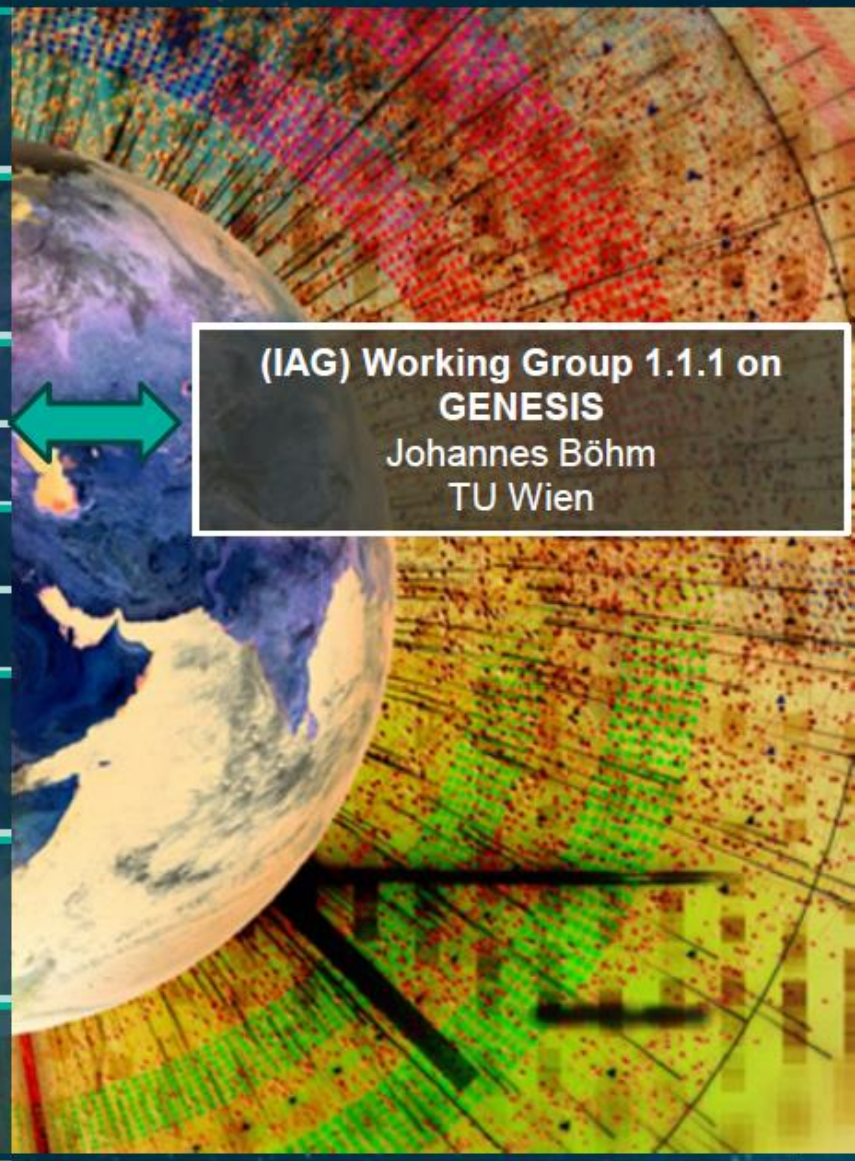
Mission Phases:

- Launch and commissioning
- In-orbit test and calibration
- Operations
- End of mission



GENESIS Science Management Board - Nominations

Coordinator	**Özgur Karatekin** Royal Observatory of Belgium – RoB
Co-Coordinator	**Francesco Vespe** ASI Space Geodesy Centre at Matera
WG1: ITRF & Combination of Techniques	**Zuheir Altamimi** Institut national de l'information géographique et forestière – IGN
	Florian Seitz Deutsches Geodätisches Forschungsinstitut-Technischen Universität München – DGFI
WG2: GNSS	**Rolf Dach** Universität Bern
	Benjamin Männel Deutsches GeoForschungsZentrum – GFZ
WG3: VLBI	**Rüdiger Haas** Chalmers Tekniska Högskola
WG4: DORIS	**Guilhem Moreaux** CLS-Collecte Localisation Satellites
WG5: Laser Ranging	**Clément Courde** Centre national de la recherche scientifique – Géoazur



(IAG) Working Group 1.1.1 on GENESIS
Johannes Böhm
TU Wien

Overview of the GENESIS Mission

Scientific Involvement in GENESIS mission

- Participation to requirements consolidation in Phase A
- Support ESA in the follow up of the industrial activities, with emphasis on instrument and platform developments
- Analysis of mission performance and the mission contribution towards target ITRF improvement
- Preparation of the scientific data exploitation, covering any gaps in algorithms, tools or ground infrastructure required
- Preparation and execution of required ground-based campaigns (in particular VLBI, SLR)

Genesis Mission Status

Contract Signature and Kick Off of activities
March-April 2024

System Requirements Review (SRR)
Q4 2024

Preliminary Design Review (PDR)
Q4 2025

Critical Design Review (CDR)
2026

Qualification and Acceptance Review (QAR)
2028

LAUNCH 2028
2 years of Operations with option for extension

Scientific exploitation

Genesis is not a T&F Mission, but:

4 geodetic instruments tightly tied (mm-level) and synced to master USO:

- Multi-technique (GNSS, DORIS, VLBI) T&F transfer
- Inter-techniques bias characterizations, calibrations… etc…

First well-calibrated wideband VLBI Transmitter in-orbit:

- 4 frequency bands in [3GHz, 10GHz], with up to 500MHz bandwidth!
- Well-distributed Ground Station Network
  - All equipped with Masers
  - Some co-located with optical clocks and ACES GT (e.g. Wetzell)
  - Some connected to optical clocks via optical fibre
- Two operation modes:
  - AWGN for classical interferometric VLBI, can also be used for frequency transfer
  - PRN for one-way ranging, can also be used for time transfer → concept to be consolidated!

Similar Instrument Suite considered to be flown on the Moon Surface (NovaMoon)

Thanks to Pierre Waller (ESA) for the slides

GENESIS-F : coordination de l'implication française

- Objectifs :
  - coordonner la communauté FR pour optimiser les études et initiatives,
  - valoriser l'expertise FR transverse dans tous les WG,
  - partager au niveau FR les activités de tous les WG,
  - assurer la visibilité de la contribution FR à la mission et à l'ESA,
  - consolider le financement

- Coordinateur : Felix Perosanz (CNES)

- Mail communauté : genesis-f@services.cnrs.fr

- Programmation d'une réunion mensuelle le 2ème jeudi de 14 à 16h avec rédaction d'un CR

Thanks for your attention