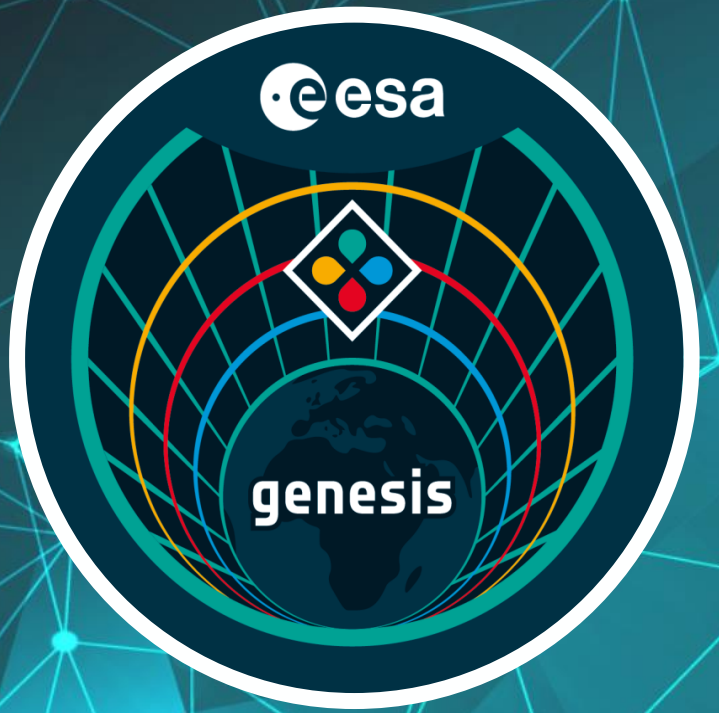
GENESIS: an ESA Mission for the benefit of Navigation and Science

P.Waller, S.Gidlund, G.Fusco, E.Honore-Livermore, E.Sakalauskaite: ESA ESTEC
E.Schoenemann, W.Enderle: ESA ESOC
V.Navarro: ESA ESAC



European Navigation Conference 2024
ESA ESTEC, Noordwijk, NL
22 May 2024

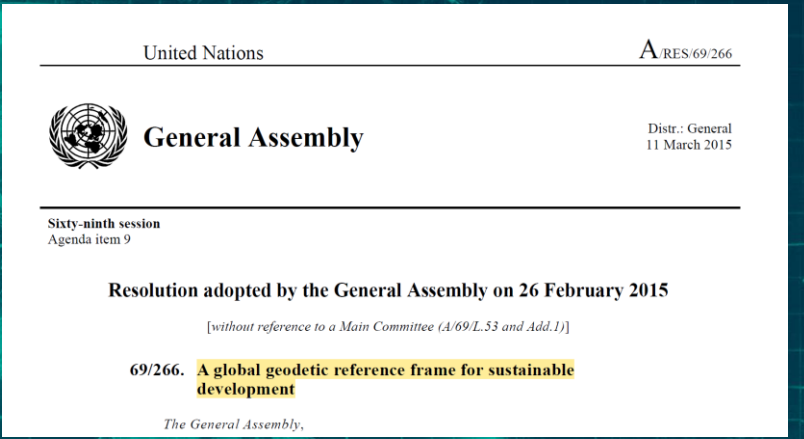
Index

GENESIS Primary Objectives

GEODESY and REFERENCE FRAMES

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

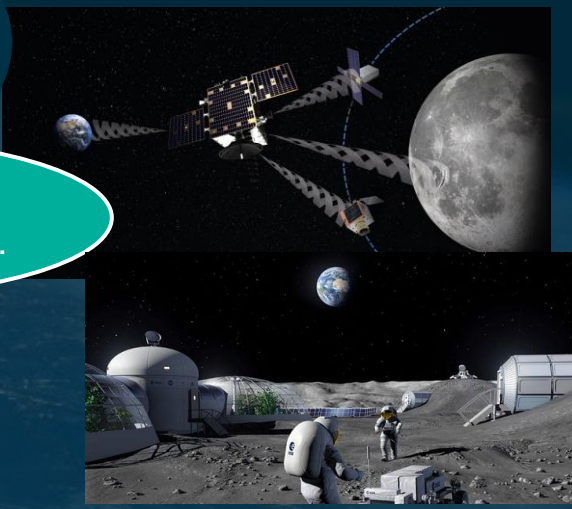
Geodesy, Reference Frames

Improved ITRF, EOPs, Unified Reference Frames

GNSS, Navigation

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

Navigation to the Moon, and beyond…

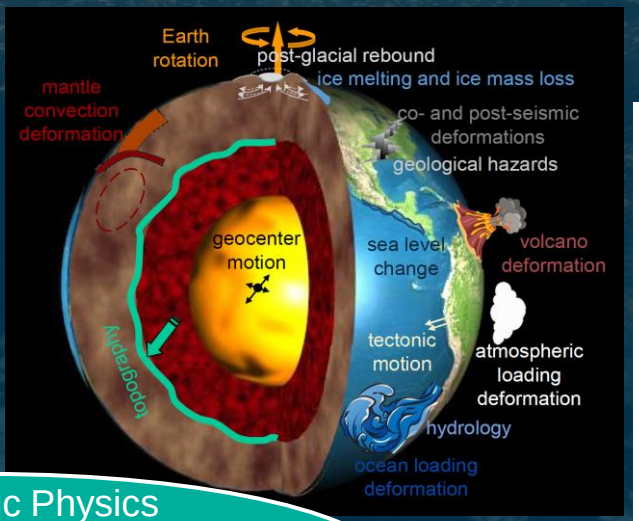


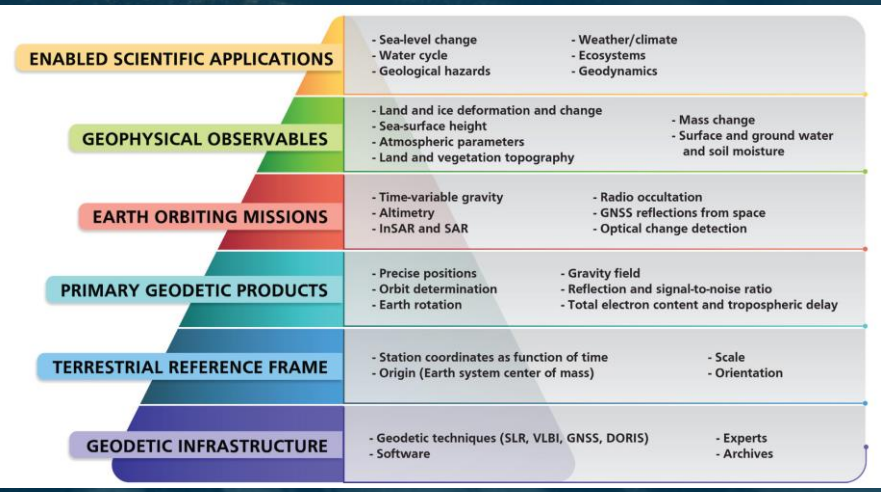
Earth Sciences

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)

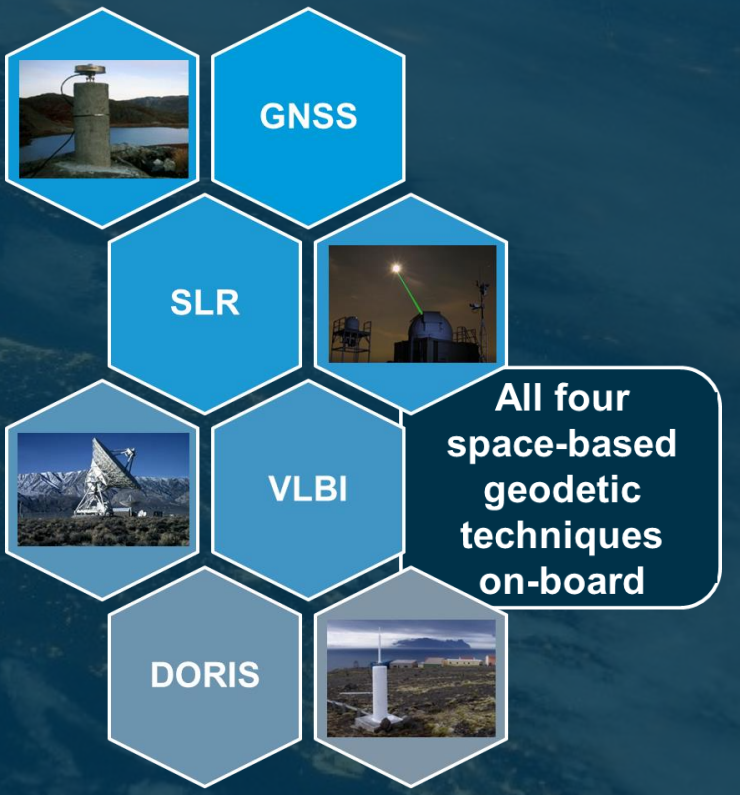
Overview of the GENESIS Mission

Overview

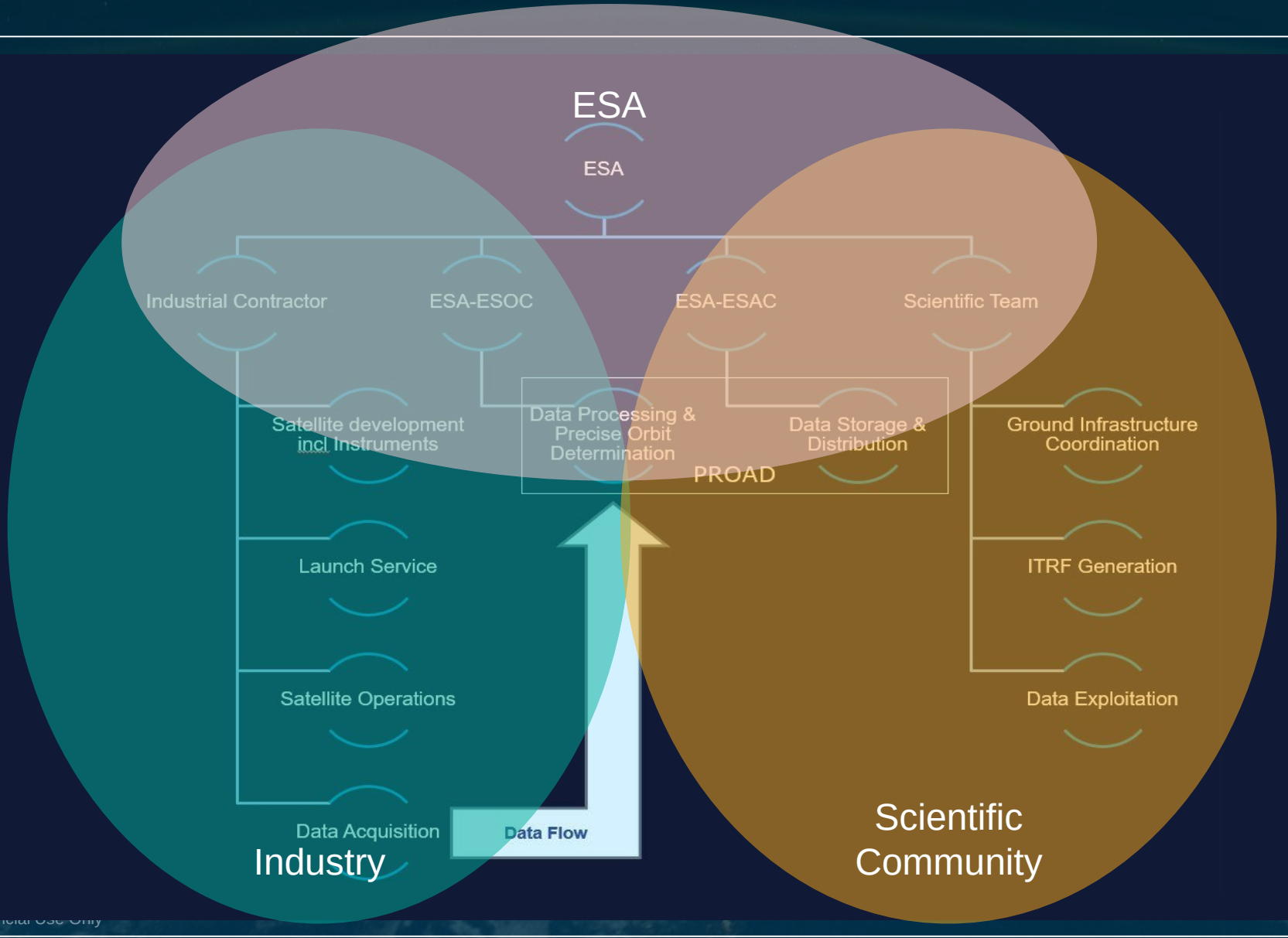
- GENESIS is managed by the ESA Navigation Directorate and part of its **FutureNAV Programme**

Mission scope

- Design, development and qualification of the **satellite (incl payloads) and ground segment**
- **Launch and early operations** including commissioning and calibration
- **Operations** (2 years, option for extension)
- **Data exploitation** (Including processing, archiving and data distribution from ESA facilities)



Overview of the GENESIS Mission



Overview of the GENESIS Mission

Kick Off of activities
22 April 2024

System Requirements Review (SRR)

Preliminary Design Review (PDR)

Critical Design Review (CDR)

Qualification and Acceptance Review (QAR)

LAUNCH 2028
2 years of Operations
Option for extension

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

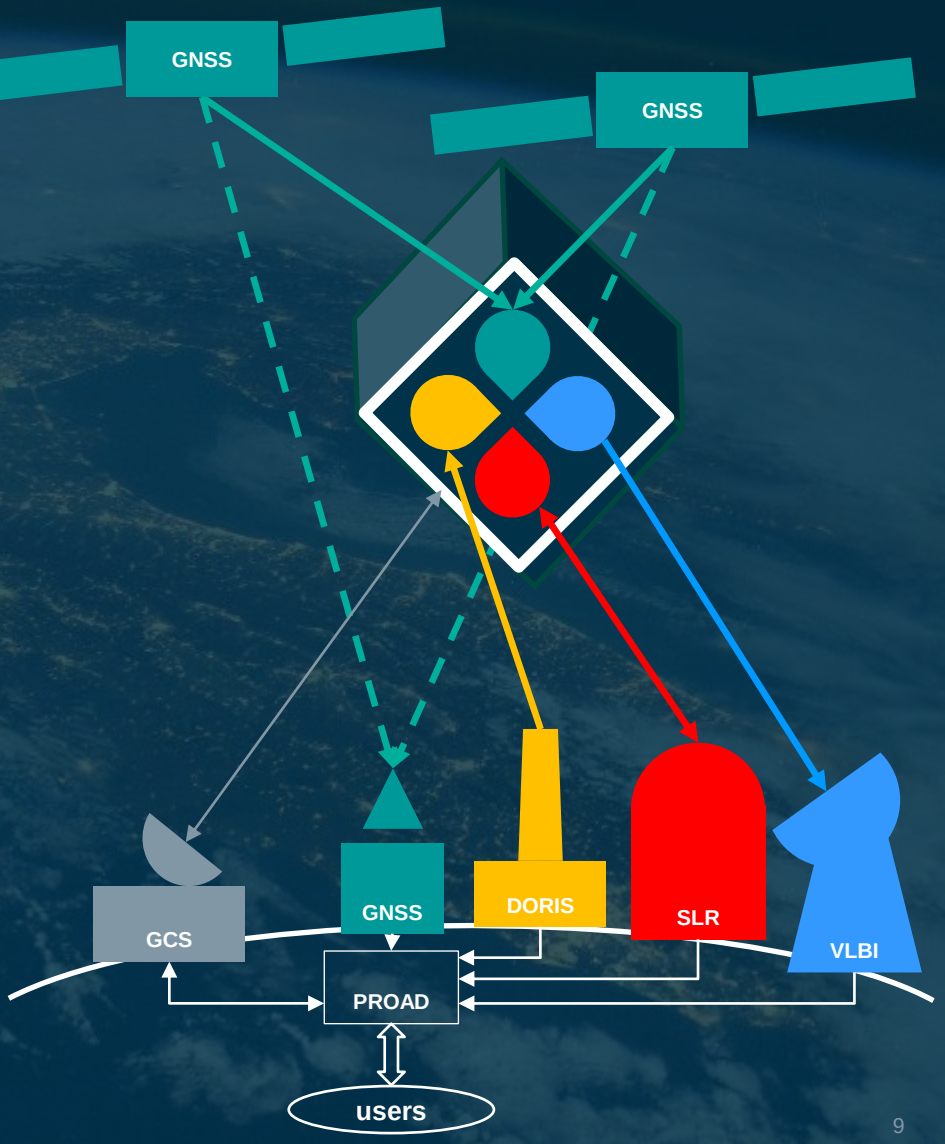
GENESIS Satellite and Payload Overview

Description

- Satellite ~250-300kg, ~6000km alt. (MEO), ~95º inclination
- Platform: maximum reuse of qualified equipment
- Payload: 4 co-located geodetic instruments (GNSS, DORIS, SLR, VLBI) and an ultra-stable oscillator for synchronisation

Key drivers:

- Radiation environment: total dose and single events effects
- Radiofrequency and electromagnetic compatibility
- Non-gravitational forces: mechanisms, geometry, materials...
- Spacecraft centre-of-mass and attitude law
- Synchronisation of active instruments to the on-board oscillator
- On-board instruments systematic biases and their calibrations: phase centres + group delays



GENESIS Payload: GNSS Receiver

Description:

- Multi-channel/multi-GNSS receiver
- Nadir and Zenith antennas
- Externally synchronised to on-board reference frequency

Key drivers:

- Quality of observables (signal-to-noise ratio, Cycle Ambiguity Resolution, ...)
- GNSS visibility at 6000km
- Antenna Phase Center Offsets calibration (vs. azimuth/elevation, vs. temperature)
- Antenna location on platform
- Instrument and antenna group-delay stability
- On-board time tagging of observables

GENESIS Payload: VLBI Transmitter

Description:

- 4 frequency bands within [2GHz, 14GHz]
- PSFD: [0.5Jy, 10Jy]
- Single nadir antenna with full Earth Field of View
- Externally synchronised to on-board reference frequency

Key drivers:

- ITU regulations, RF Interferences and EMC
- Single multi-band antenna over wide bandwidth
- Compatibility with both legacy and VGOS stations
- Antenna PCOs calibration (vs. azimuth/elevation, vs. temperature)
- Instrument group-delay calibration

VLBI Transmitter breadboard for G2G
(https://h2020nav.esa.int/project/h2020-038-01)

VLBI Radio Telescope in Wettzell, Germany
(https://shorturl.at/ctwGP)

GENESIS Payload: Laser Retro-reflector

Description:

- Passive LRR on the nadir-side of the satellite
- Array of corner cube reflectors

Key drivers:

- Field of view and optical cross-section at 6000km
- Thermo-elastic effects, materials...
- Accommodation
- Compatibility with SLR stations
- PCO calibration

GENESIS Payload: DORIS receiver

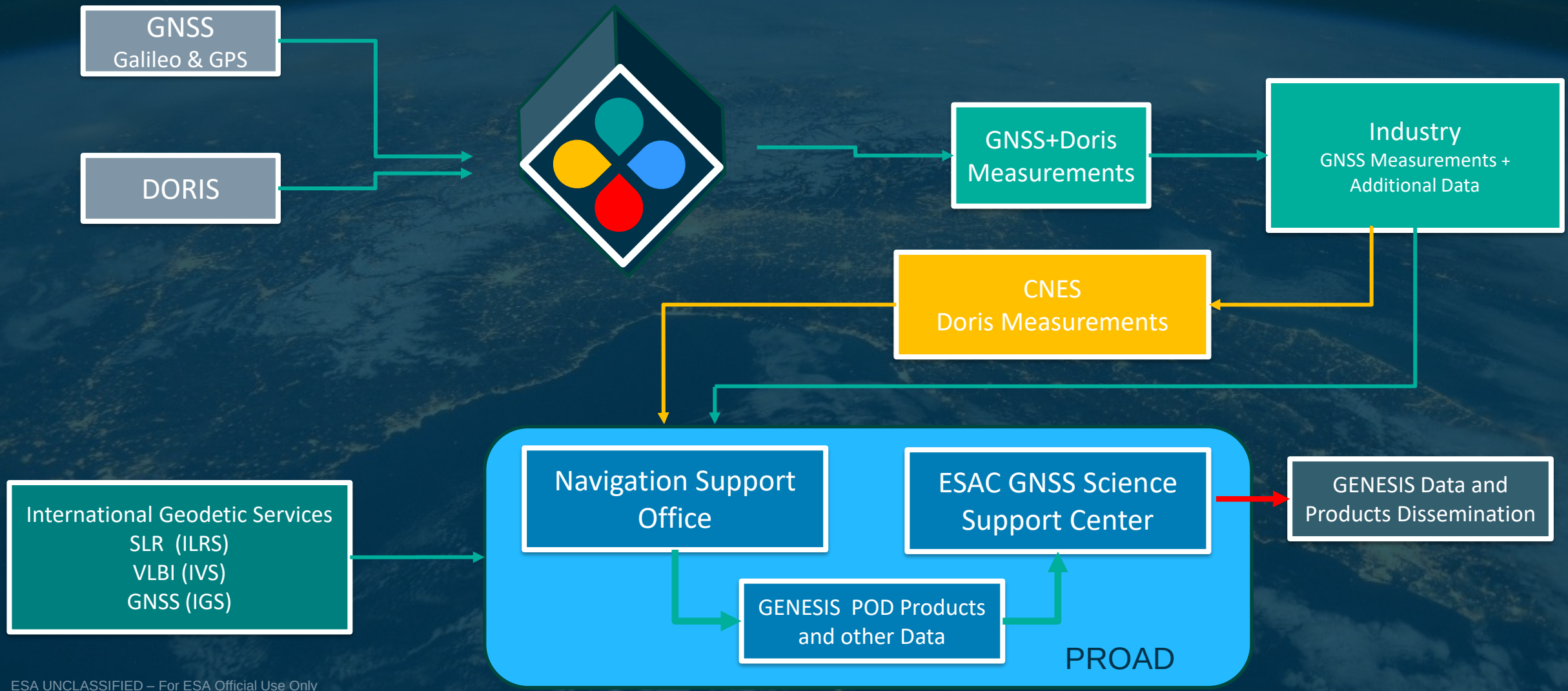
Description:

- Doppler tracking of UHF and S-band ground beacons
- Dual-frequency nadir antenna
- Externally synchronised to on-board reference frequency

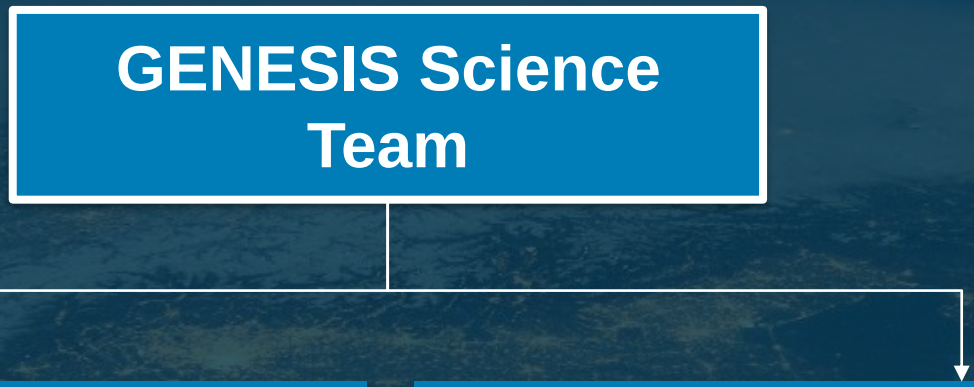
Key drivers:

- Ground Beacon visibility at 6000km
- Quality of observables and on-board processing
- Antenna PCOs calibration (vs. azimuth/elevation, vs. temperature)
- Instrument group-delay calibration
- MEO radiation environment

GENESIS Data PROcessing, Archiving and Delivery



GENESIS Science Team



GENESIS Science Management Board

- ESA GENESIS Scientific Representative
- GENESIS Mission Lead Scientific Coordinator
- GENESIS Mission Lead Scientific Co-Coordinator
- Working Groups Chairs

GENESIS Science Exploitation Team (GSET)

- GENESIS Mission Lead Scientific Coordinator and Co-Coordinator
- GENESIS Working Groups (WGs)
  - WG1: ITRF and Combination of Techniques
  - WG2: GNSS
  - WG3: VLBI
  - WG4: DORIS
  - WG5: Laser Ranging

GENESIS Science Workshop

29th February @ ESOC

- **Attendance from all relevant International Geodetical Services** (Chairs or deputies):
  - **IAG, IERS, IGS, IVS, ILRS, IDS**
- **Strong commitment and engagement** from the community
- Over 100 people onsite and online

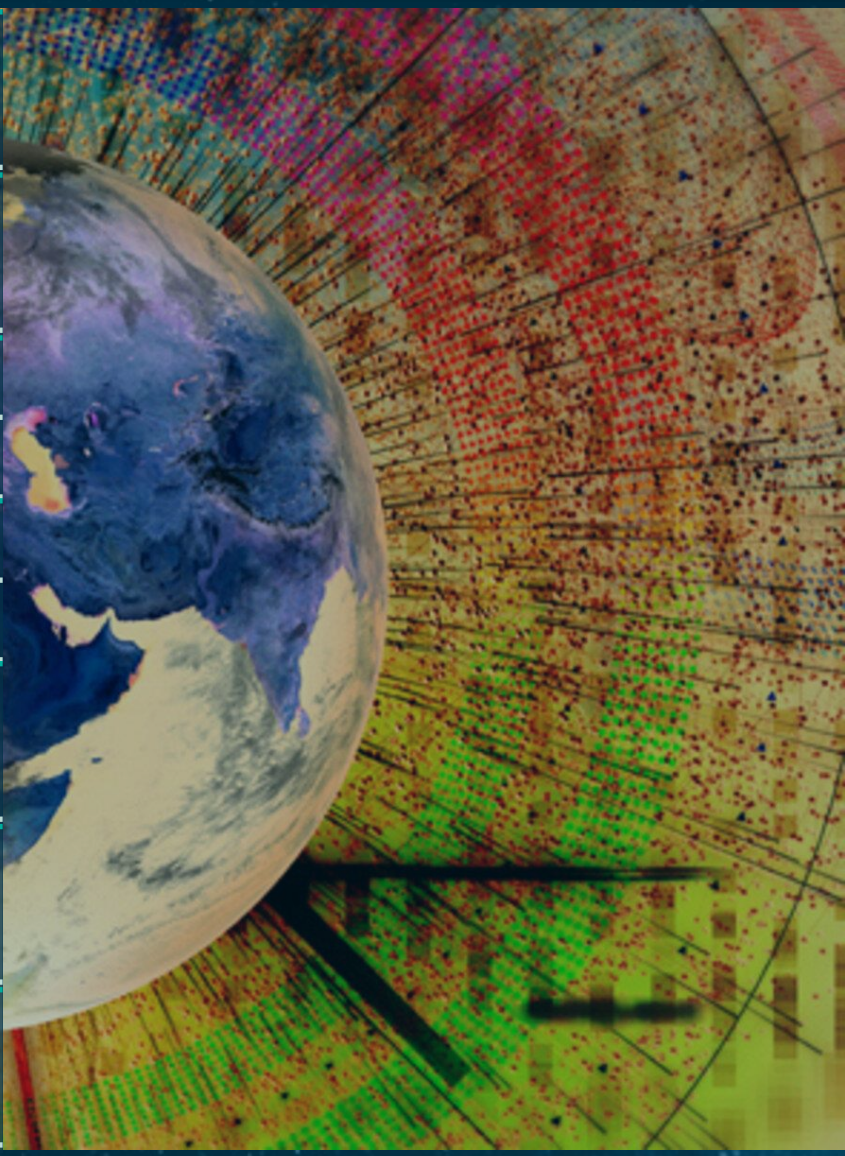
Agenda

- **Morning**
  - Presentations from the ESA GENESIS project team
- **Afternoon**
  - Interactive working group discussions
  - Wrap up and Conclusions

“GENESIS – A Mission for the World”

GENESIS Science Exploitation Team - 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



To conclude…

Thanks to combined efforts from Scientific Community, ESA Member States, Industry and ESA, the **GENESIS Mission has become a reality!**

This challenging mission will be a stepping stone towards **improved GNSS and navigation**, together with addressing **major scientific and societal goals**

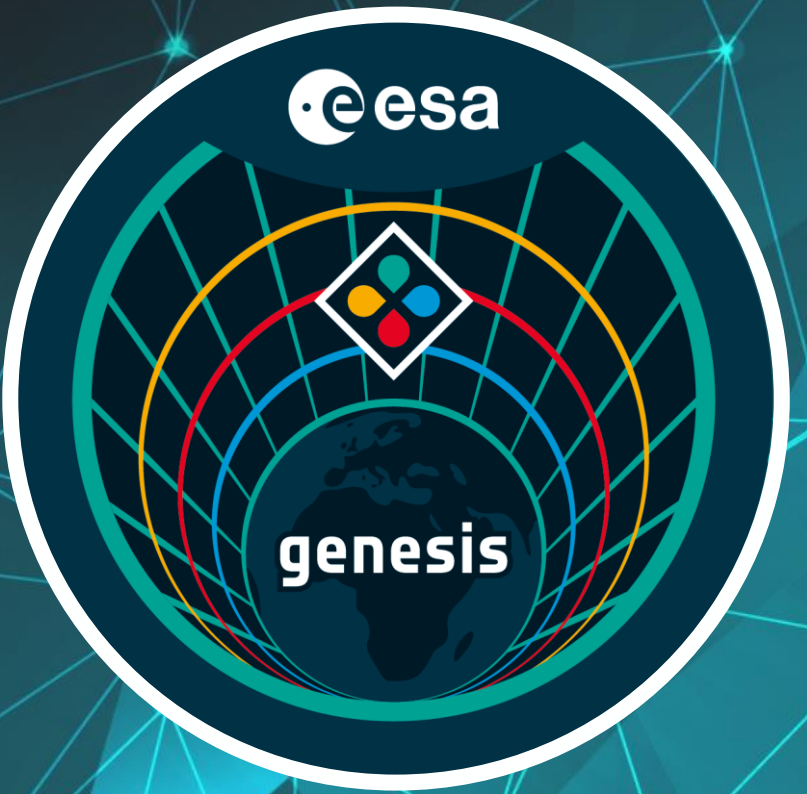
Despite a challenging schedule, ESA, Industry and the Scientific community are fully committed to the **success of the Mission**, starting with a System Requirement Review in fall 2024

We are looking forward to updating the community on the progress of the mission

GENESIS – AT THE FOUNDATION OF NAVIGATION

Thank you for your attention

ENC 2024



Back-up Slides

ENC 2024