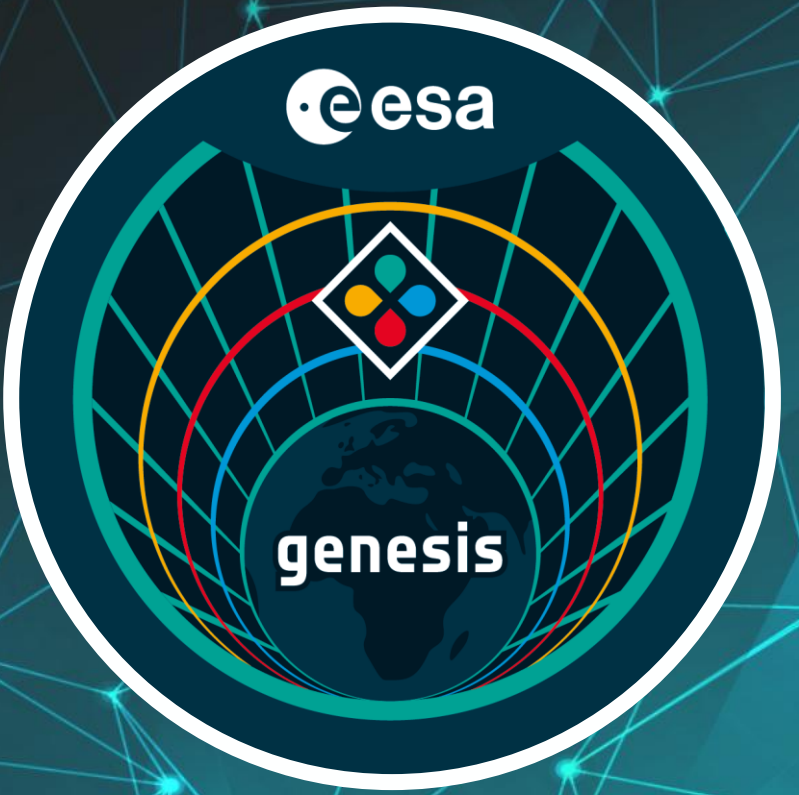
Genesis Science Workshop
12th – 13th March 2026
Brussels, Belgium

Genesis Mission Status & Key Topics

Gaia Fusco



FUTURE NAV esa.int/Applications/Navigation

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Overview of the Genesis Mission

Overview

- **Genesis** is a **satellite mission** managed by the ESA Navigation Directorate and part of its **FutureNAV Programme**

Mission scope

- Design, development, qualification and calibration 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 → input to the Scientific Community)
- Key involvement of the **Scientific Community** and **International Geodetic Services** → maximize benefits

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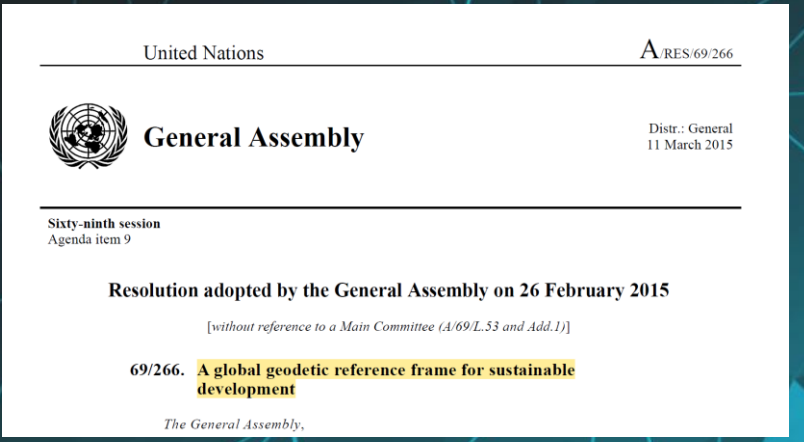
Genesis Primary Objectives

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

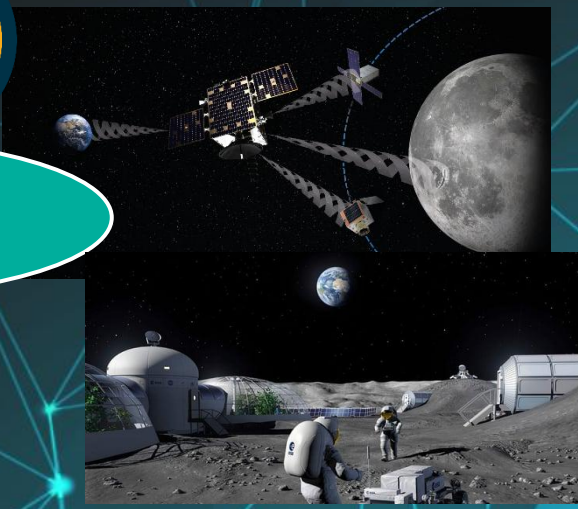
Geodesy, Reference Frames

Improved ITRF, EOPs, Unified Reference Frames

GNSS, Navigation

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

Navigation to the Moon, and beyond...

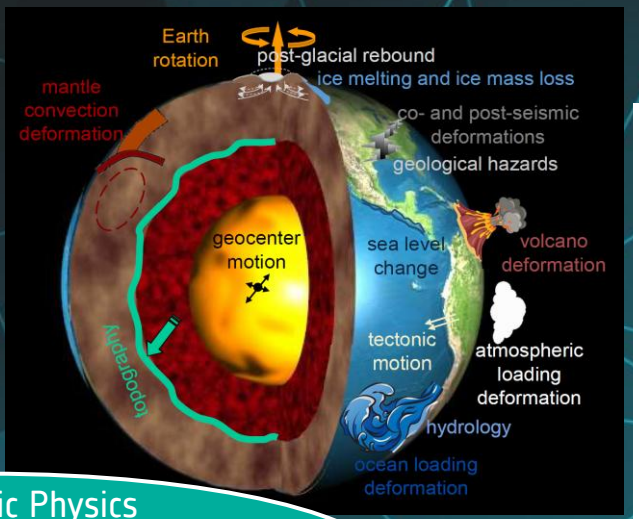


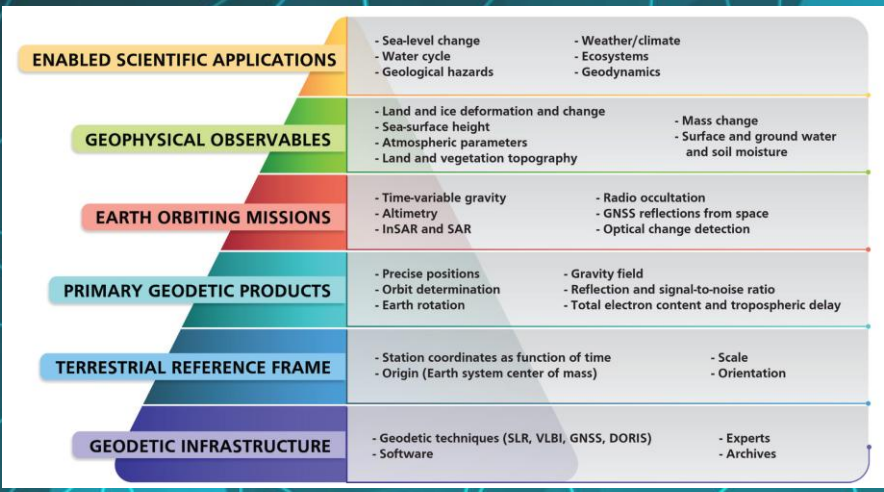
Earth Sciences

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)

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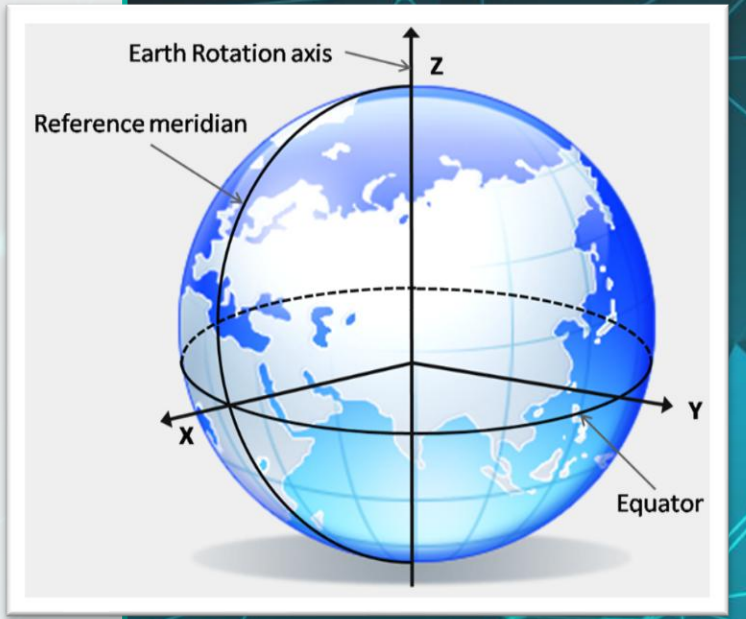
Genesis – Contributing to Resilient Navigation

Geodesy and Navigation

- GNSS have a **critical dependency on geodetic information** and ESA acknowledges the **importance of the Global Geodetic Supply chain**
- ESA acknowledges the **importance of a Global Geodetic Reference Frame** for Precise Navigation and Sustainable Development
- ESA significantly **contributes to the robustness of the Global Geodetic Supply chain and to the improvement of the Global Geodetic Reference Frame**



Genesis
A mission for the world

A **UNIQUE mission**, paving the way for **future ITRF related missions**

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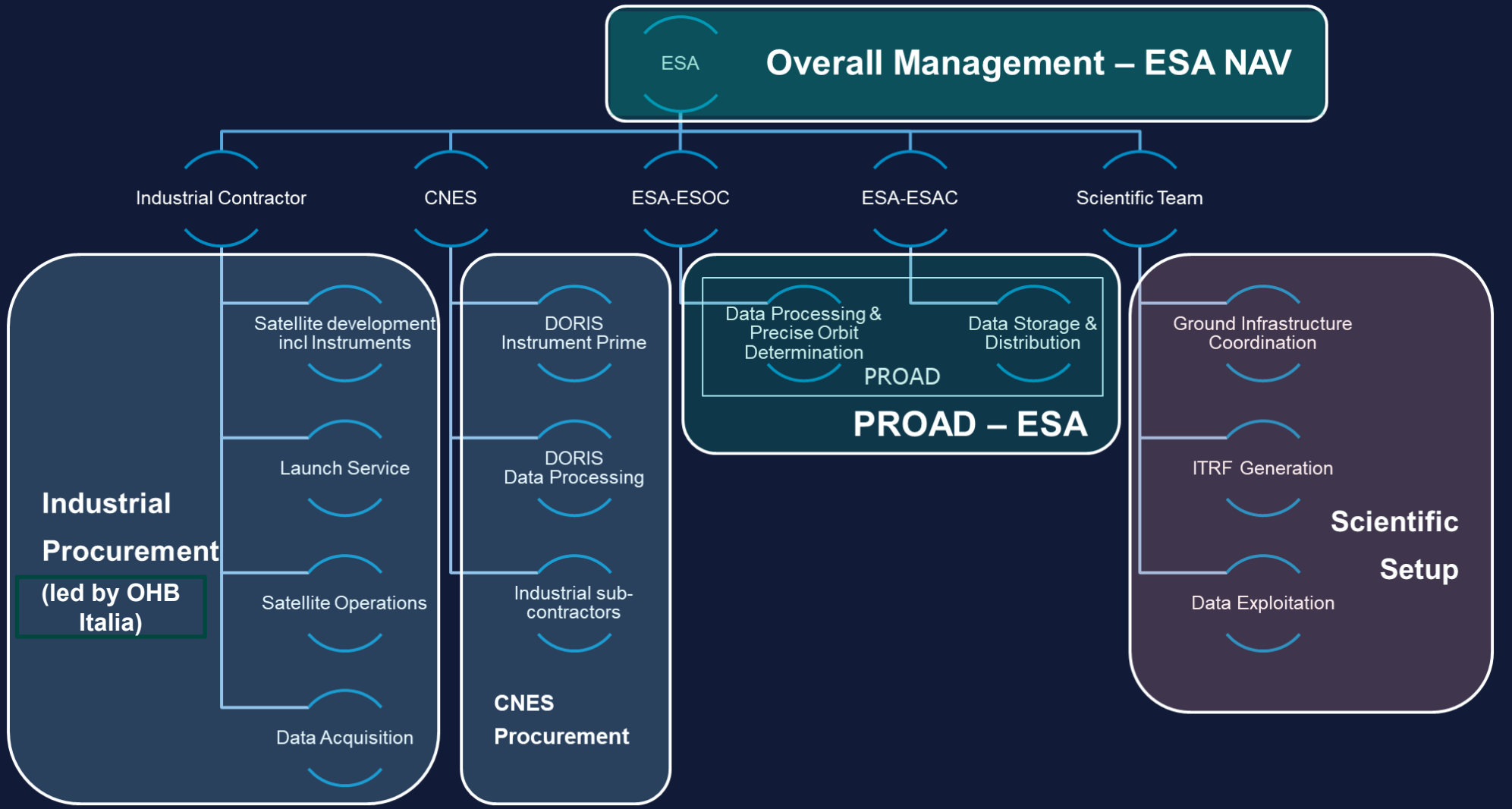
Overview of the Genesis Mission



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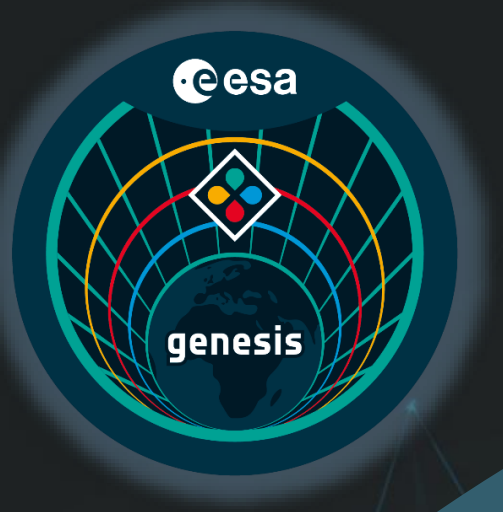
Genesis Mission Status



Contract Signature and Kick Off of activities
March-April 2024

System Requirements Review (SRR)
Q4 2024

Preliminary Design Review (PDR)
2025

Critical Design Review (CDR)
Start 2026

Qualification and Acceptance Review (QAR)
2028 (TBC)

LAUNCH 2028
2 years of Operations with option for extension to 5 years

Scientific exploitation

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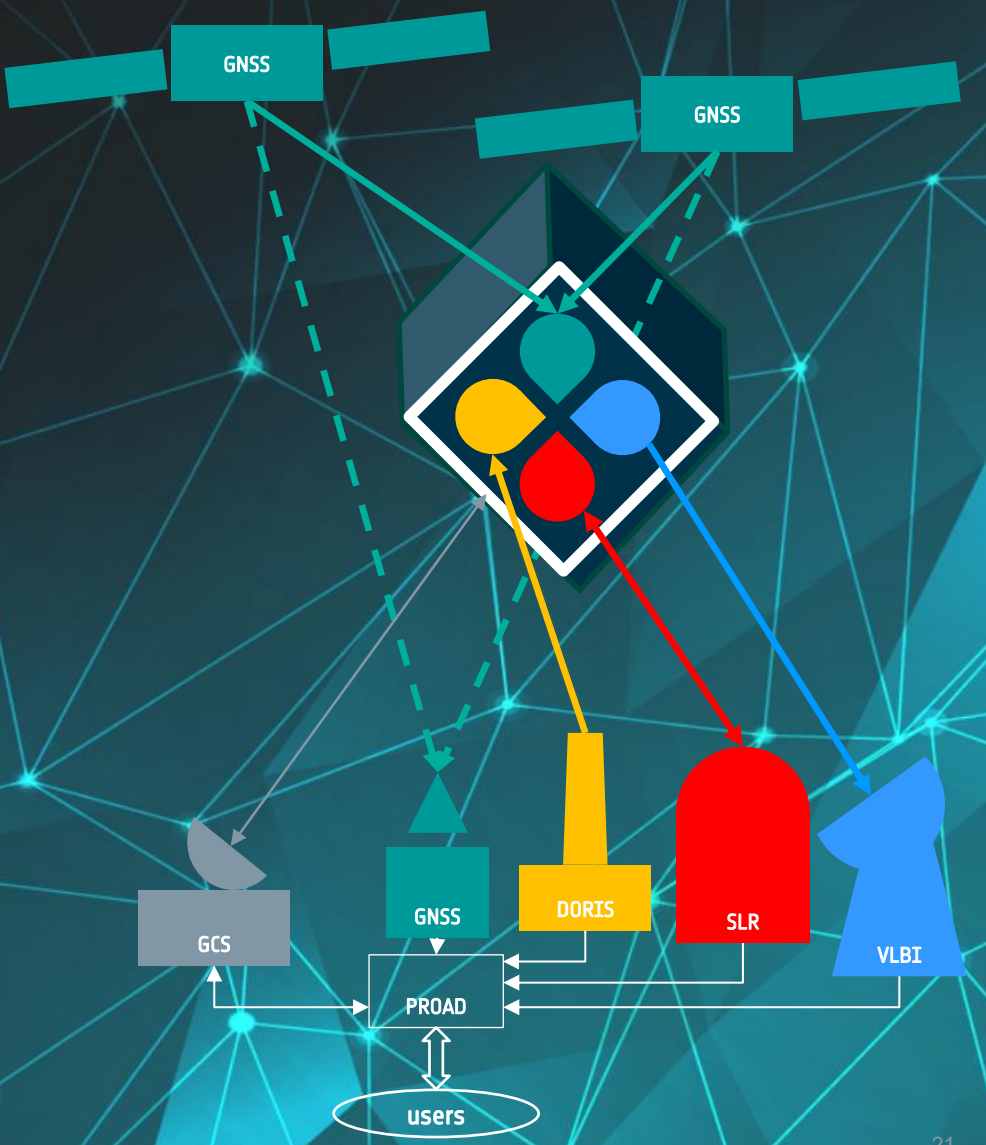
Genesis System PDR Overview

- Satellite
  - Mass: 406 kg
  - Power: 280 W (nominal)
  - Envelope: 1.85m X 1.33m X 3.39m
  - Attitude:
    - 3-axis stabilized, Nadir-pointing, yaw steering law
    - Pointing accuracy: < 1 degree (2 Sigma)
- Orbit:
  - 6000km altitude (low MEO)
  - 95.5º inclination
- Payload:
  - 4 co-located geodetic instruments
    - GNSS, DORIS, SLR, VLBI
  - Ultra-Stable Oscillator for synchronisation



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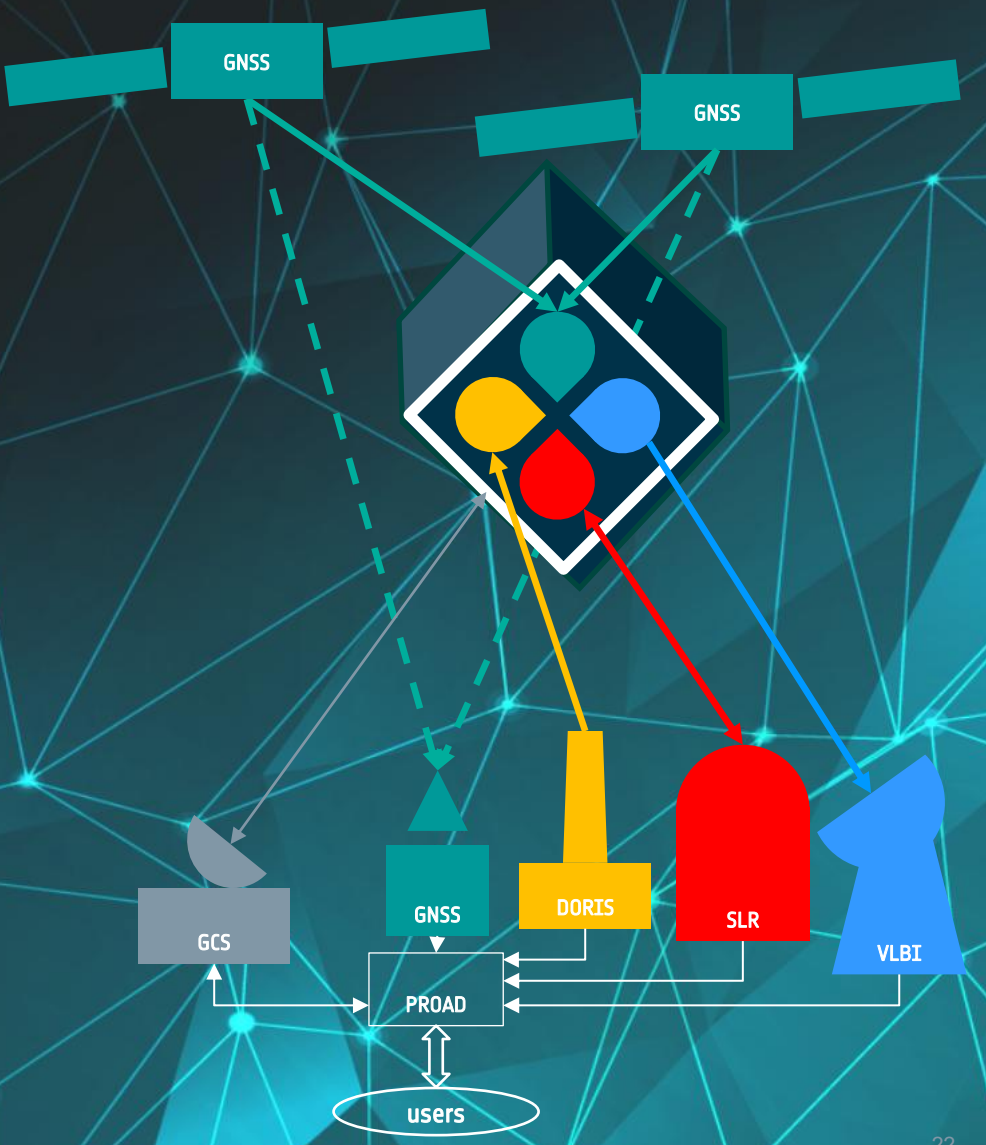
Genesis System Design Drivers

Key drivers confirmed at PDR:

- Radiation environment (total dose and single events effects)
  - Need for radiation shielding
- Precise knowledge of the centre of mass position and variation during the lifetime
  - No propulsion, no mechanisms
  - Verification and calibration
- Timing
  - Synchronisation of active instruments to USO
- Radiofrequency and electromagnetic compatibility
- Non-gravitational forces (accurate modelling, knowledge)
  - Geometry, materials...
- On-board instruments systematic biases
  - Calibrations: phase centres + group delays



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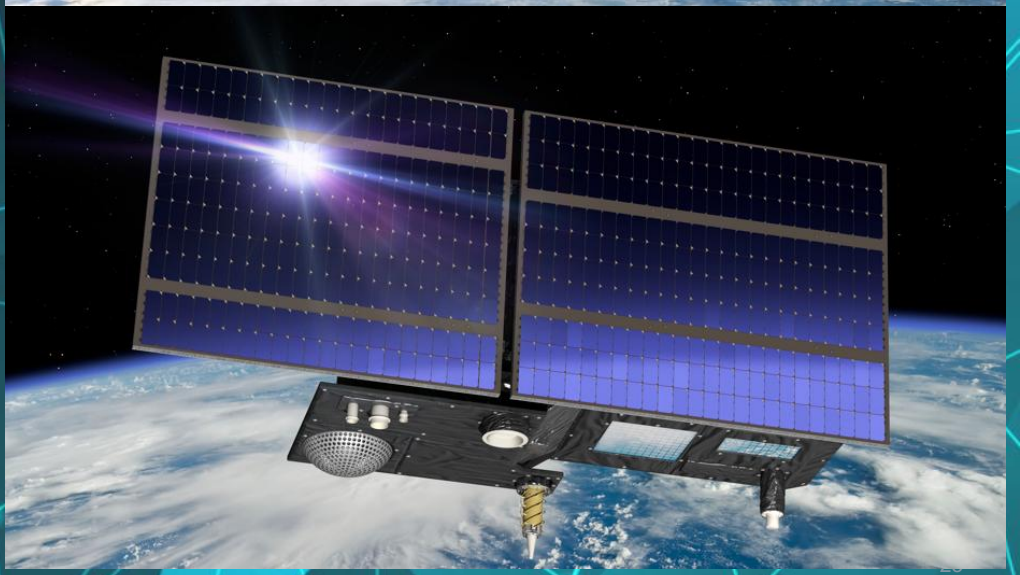
Genesis System PDR Overview

Satellite composed of two modules

- Platform module in Aluminium sandwich panels
  - It houses all platform units and payload electronic boxes
  - Box shape providing radiation shielding
  - S-band antennas elevated on brackets
  - Launcher Interface Ring (LIR) on the bottom
- Payload module in CFRP sandwich panels
  - It hosts the payload antennas, the SLR, and two star-trackers
  - Sandwich panels with skins in CFRP
  - Connected to the platform module through four Titanium bipods
- Solar panels
  - Two-body mounted, fixed Solar Panels
  - One integrated on the Platform module and one on the Payload module



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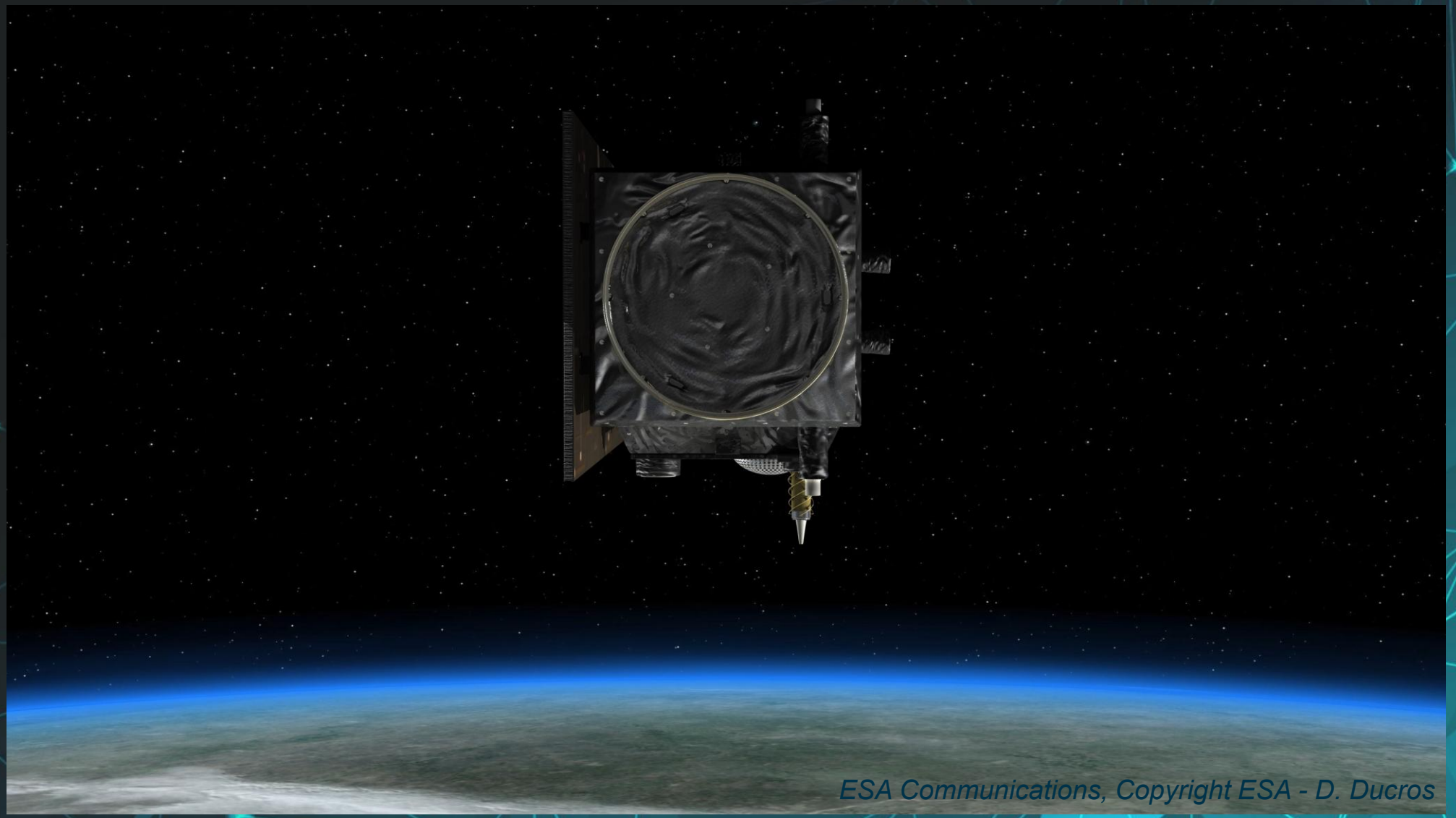
PDR Satellite Configuration



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PDR Satellite Configuration (ESA render)

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Genesis Science

Scientific Involvement in Genesis mission

- Participation already from requirements consolidation in Phase A
- Support ESA in the follow up of the industrial activities, with emphasis on instruments and calibration
- 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)

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Genesis Science: GSET and IAG/IERS JWG 1.1.1

Genesis Science Exploitation Team (GSET) Composition

- Scientists & Experts organised in 5 Working Groups
- All Relevant International Geodetical Services:
  - IAG, IERS, IGS, IVS, ILRS, IDS

Genesis Science Exploitation Team (GSET) Management Board

- WG chairs, Lead & co-Lead Science Coordinators, ESA
- For coordination of GSET activities

IAG/IERS JWG 1.1.1 (Chair: J. Boehm)

- Complementary working group under IAG
- Focused on science preparation and execution

GSET Workshop Matera 2025

GSET Workshop ESA 2024

“Genesis – A Mission for the World”

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Genesis Science Exploitation Team (GSET)

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

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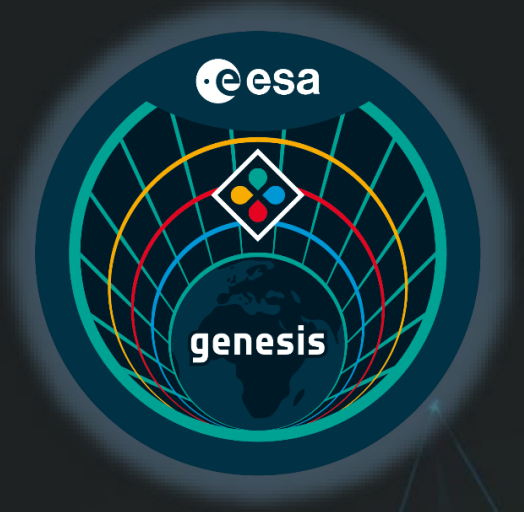
Genesis Mission: next steps after PDR



Phase C (up to the CDR - Critical Design Review):

- Consolidate the design for the Satellite and Ground Segment
- Complete the detailed design definition of the system at all levels
- Complete units and equipment procurements
- Detailed Analyses
- Consolidate System budgets and Interfaces (ICDs)
- Complete Tests on Development Models
- Start Manufacturing of Flight Hardware
- Consolidate and finalize Calibration approach
- Consolidate Mission and Instruments Operations Concepts
- Consolidate PFM and in-flight verification approach

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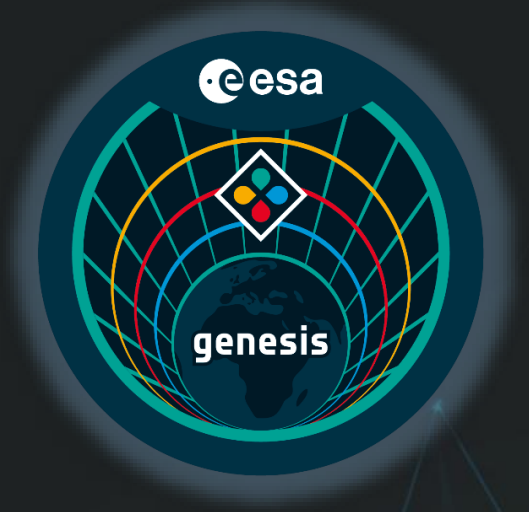
Genesis Mission: next steps after PDR



Support of the Genesis Science Team during Phase C:

- Support detailed satellite & instrument design consolidation
- Support testing, verification and calibration strategy
- Support data type, volume and interface definition
- Contribute to end-to-end performance assessments
- Consolidate Genesis data processing concepts
- Contribute to system, instrument and technique operational concept
- Contribute to preliminary observation campaign definition and planning
- Consolidate service-specific interfaces for IGS, IDS, IVS, ILRS
- Prepare readiness of the services ground support infrastructure
- ➢ Manage and execute GSET activities

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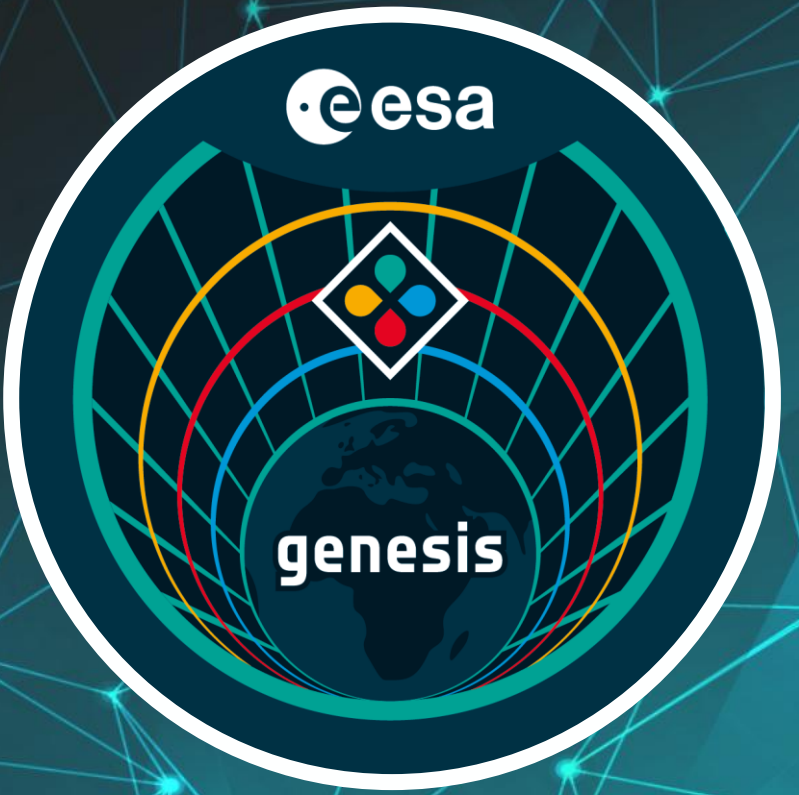
Genesis Payload Overview and Calibration Status

Pierre Waller



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→ THE EUROPEAN SPACE AGENCY

Genesis Payload - Pierre

Four Instruments, tightly tied:

GNSS

- Galileo E1/E5a, GPS L1/L2/L5
- Nadir + Zenith Antennae
- Tracking optimised for Genesis orbit
- High quality code and phase observables
- *SpacePNT (Rx) and Beyond Gravity (Ant)*

Laser Retro-Reflector

- Compatible with ILRS stations (532nm)
- Nadir panel
- CCR & geometry optimised for Genesis orbit
- Increased optical cross-section (6Mm2)
- *INFN*

Master USO
+ Distribution Amplifier
Safran Timing Technologies

VLBI

- Wideband signals in S, C and X-bands
- Compatible with VGOS stations
- 3 New ~~multiband~~ Tx antennas
- One-way ranging capability
- *AntwerpSpace (Tx) and UCLouvain (Ant)*

DORIS

- Legacy DGXX-S instrument, UHF/S-band
- Legacy LEO Antenna
- On-board processing tuned for Genesis orbit
- Use of external USO signal
- *CNES/Thales*

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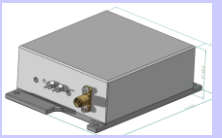
Genesis Payload - Pierre

Four Instruments, tightly tied:

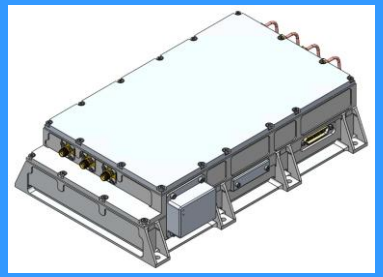
GNSS

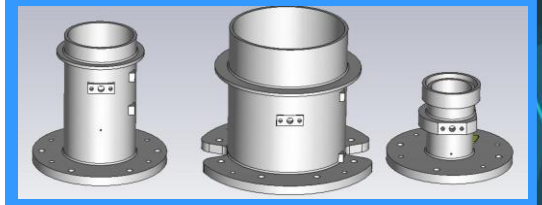
Laser Retro-Reflector

Master USO



VLBI





DORIS

Calibration

Calibration is a **key driver** to achieve **Genesis scientific objectives**

The specified Genesis **calibration requirements** are recognised to be **very challenging to verify** (no test facility have been able to confirm yet their ability to achieve this level)

In the frame of Genesis System PDR, the Genesis Satellite and Payload contractors (OHBI and AWS) have defined a **preliminary approach** for the verification of these requirements, together with a **preliminary uncertainty budget**

It is essential that the proposed calibration approach meets the **expectations of the scientific community** and is properly reflected in an **agreed Calibration Plan**

Calibration

Calibration activities are split in two parts

Satellite Calibration

- Cover the “geometrical” Reference points
  - CoM coordinates in Satellite Reference Frame
  - Instrument Reference Point coordinates in Satellite Reference Frame
  - and their variations over environment, lifetime...

Instrument Calibration

- Cover the “measurement” Reference points
  - Instrument Centre of Phase coordinates in Instrument Reference Frame
  - and their variations over frequency, azimuth/elevation, environment, lifetime…

Calibration Splinter Meeting

Held yesterday at the Royal Observatory of Belgium

Goals:

1) To share and exchange the proposed preliminary calibration plan with industry and scientific experts
2) To define the next steps for the consolidation of the calibration plan

~50 participants, ~10 presentations, many exchanges..

Next steps:

Calibration plan will be updated and further iterated with the support of the relevant experts

Calibration Plan Consolidation Plan

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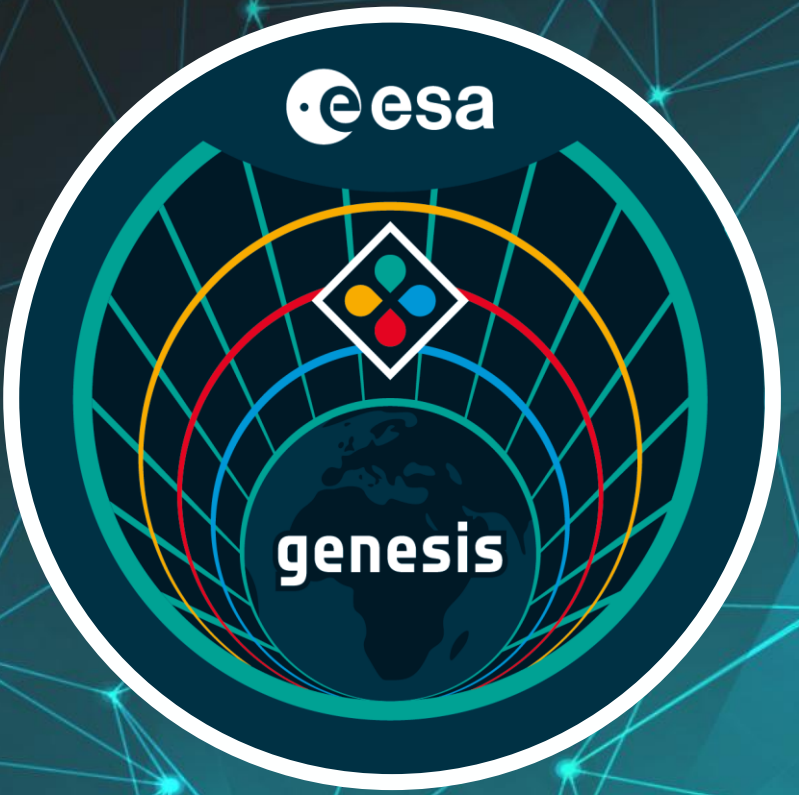
Genesis PROcessing Archiving and Distribution

Erik Schoenemann
(Jean-Christophe Berton)



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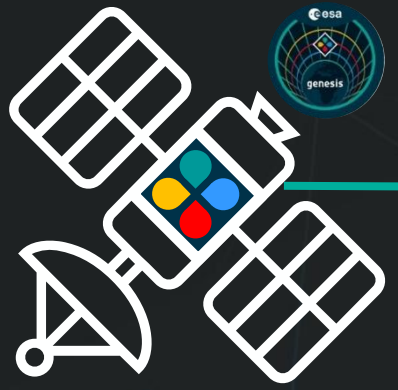
Genesis – Overall Data Flow



GNSS
Galileo & GPS

DORIS

GNSS+Doris
Measurements

Industry
(OHB Italia S.p.A)
GNSS/DORIS Measurements
Additional Data (Aux/Meta)

CNES
Doris Products and
Measurements

DORIS Ground
Segment (IDS)

PROAD

Navigation Support
Office

GNSS Science
Support Centre

esa ESOC

esa ESAC

Genesis
POD Product
and other Data

International Geodetic Services
SLR (ILRS)
VLBI (IVS)
GNSS (IGS)
DORIS (IDS)

Genesis
Data and Products
Dessimination

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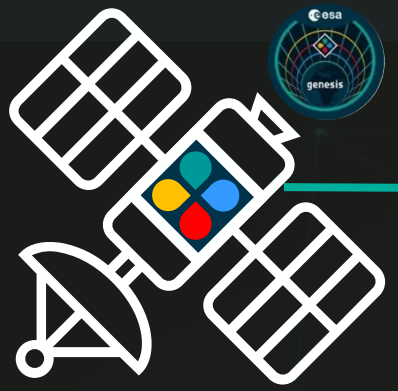
Genesis – ICD Overview



GNSS
Galileo & GPS

DORIS

GNSS+Doris
Measurements

Industry
(OHB Italia S.p.A)
GNSS/DORIS Measurements
Additional Data (Aux/Meta)

ICD

CNES
Doris Products and
Measurements

DORIS Ground
Segment (IDS)

ICD

VLBI
SiS
ICD

PROAD

Navigation Support
Office

esa
ESOC

GNSS Science
Support Centre

esa
ESAC

ICD

International Geodetic Services
SLR (ILRS)
VLBI (IVS)
GNSS (IGS)
DORIS (IDS)

ICD

Genesis
POD Product
and other Data

Genesis
Data and Products
Dessimination

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Genesis Data ICD Status – Industry to ESA

- **Ground Control Segment to PROAD Interface**
  - Preliminary IRD delivered at S-PDR
  - On going actions:
    - Mapping of SRD requirements into IRD
    - Elaboration of the IRD/ICD details ongoing
    - Further iterations until S-CDR
  - Subsequent evolution along the mission lifecycle

- **VLBI Signal in Space**
  - Under consolidation
  - Will be published by ESA

4.6.4 L0/L1 PROCESSORS TO PROAD INTERFACE DESCRIPTION
4.6.5 EXTERNAL ENTITIES TO MOC INTERFACE DESCRIPTION
5. TIME SCHEDULES
6. ROLES AND RESPONSIBILITIES
7. PRODUCTS SUMMARY
7.1 RAW TM FORMAT
7.2 GNSS OBSERVATIONS
7.3 [illegible]99
7.4 [illegible]99
7.5 [illegible]99
8. HOUSEKEEPING PRODUCTS PRESENTATION
8.1 PLATFORM HK FORMAT
8.1.1 ANCILLARY
8.1.2 AUXILIARY
8.2 PAYLOAD DATA FORMAT POST OBSW PROCESSING
8.3 CALIBRATIONS
8.3.1 ON-GROUND CALIBRATION
8.3.2 IN FLIGHT CALIBRATION
8.4 METADATA
8.4.1 HK
8.4.2 INSTRUMENTS
9. PAYLOAD PRODUCT PRESENTATION
10. FILES FORMAT
11. OPERATIONAL INTERFACES
11.1 DAILY OPERATIONS
11.2 ANOMALY REPORTING AND HANDLING
11.3 INTERFACE MAINTENANCE PROCEDURES
11.4 SCHEDULED OUTAGES AND NOTIFICATIONS
11.5 CHANGE MANAGEMENT PROCESS
12. SECURITY
13. PERFORMANCE REQUIREMENTS
14. INTERFACE VERIFICATION AND VALIDATION

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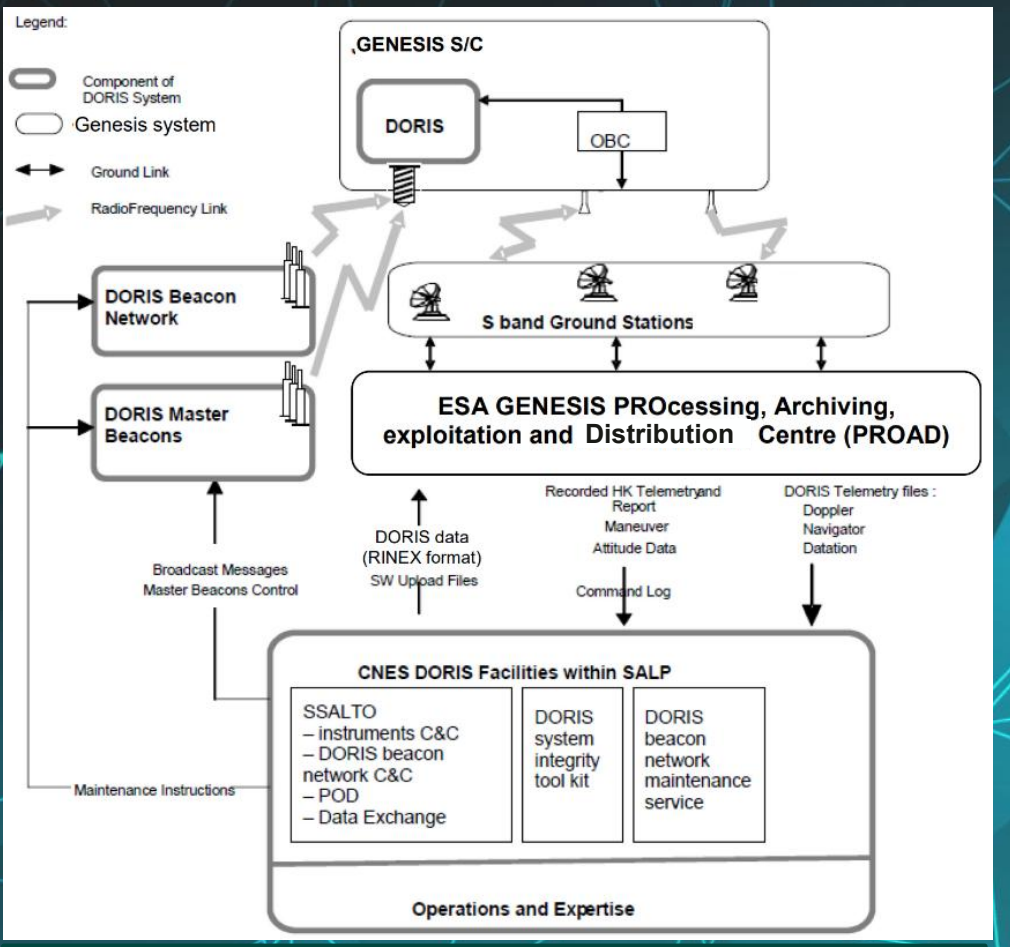
Genesis Data ICD Status – CNES to ESA (DORIS)

- L0 DORIS data content being defined
- TC description
- L1 products (RINEX) to delivered to IDS/PROAD
- Assessment of test, validation and calibration

- Further iterations until S-CDR
- Subsequent evolution along the mission lifecycle



Principle: all like Sentinel 3/6A, but for Genesis

Interface to Science Community

ICD with Scientific Community

- ICD to scientists under elaboration
  - Current baseline identical to Sentinel 3 and 6A:
    - > GNSS: RINEX 3.04 at least
    - > Quaternions: ASCII
    - > PVT: SP3 ECEF ITRF2020
    - > DORIS: RINEX 3.0
    - > PCO/PCV: ANTEX 1.4
    - > ARP, CoM: CSV file, one epoch per line (UTC)
  - Metadata under definition
- Draft ICD will be shared on Teams for comment before summer

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Interface to IAG Services

ICD with IAG Services

- ICD PROAD to IAG Services under elaboration, e.g.
  - VLBI (tracking details, sessions scheduling, format…)
  - SLR (tracking details, sessions scheduling, format…)
  - IGS and IDS as needed

- Draft ICDs will be shared on Teams for comment before summer

Genesis Data PROcessing

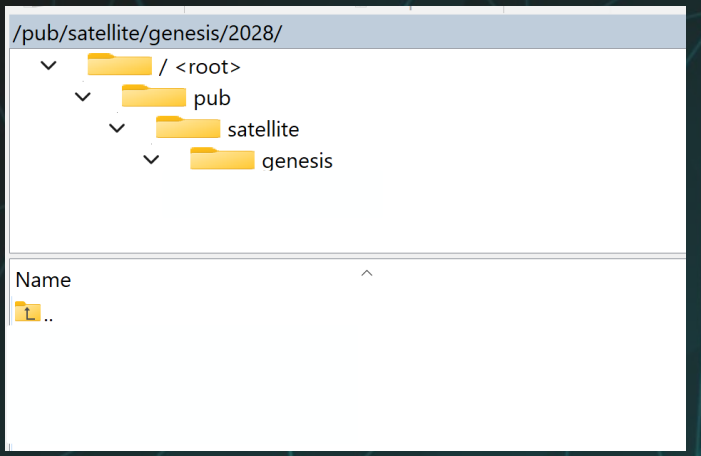
The ESA Navigation Support Office will:

- Check data completeness (gap analysis), correctness (file format) and validity
- Generate solutions for all four geodetic techniques, based on its AC tools/experience
- Generate POD for Genesis, Galileo and GPS
- Generate ESA Earth Orientation Parameter (EOP) data
- Validate the pre-launch calibrated space ties between the different payloads
- Apply its COmbination at Observation Level (COOL) to detect/treat technique-specific systematics
- Package and validate the processed data before provisioning to GSSC

Scientists are strongly invited to provide feedback on their needs to Navigation-Office@esa.int

Genesis Data Archiving and Distribution

- The Genesis data will be archived and made accessible worldwide in https://gssc.esa.int/webftp/main.html
- The Genesis related PROAD files will be released
  - on gssc.esa.int (S)FTP server
  - in **/satellite/genesis/**
  - Reference orbit files will be shared on GSSC (shortly)
  - GSSC ICD available to GSET in Teams PROAD ICD to IAG



- GSSC will issue regular project related Newsletters

- GSSC will release/host worldwide authorised documents
  - Reference documents
  - Future scientific publications - please use this as a reference point !!!

- Documents limited to GSET are made available on Teams (PDR Overview comes shortly)

How far are you GSSC aware?

The GNSS Science Support Centre (GSSC):

- is a global IGS Data Centre
- offers registered users specific features
- is accessible via FTP/SFTP/HTTPS/Caster/API
- issues Newsletters and News to keep users updated
- mirrors IGS, ILRS, IVS and IDS Data Centres
- largely complies with the IGS DC Charter
- keeps evolving/consolidating its infrastructure

- needs you to prepare your data push/pull pipelines
- needs you to register, try it and pass on the message

To Recall: Genesis is an End-To-End Procurement

GENESIS Mission – End-To-End Procurement Approach

Impact of the End-To-End Procurement Approach

- ESA provides high-level requirements for
  - Performance
  - Functionality
  - Interfaces

No **detailed** requirements from ESA for systems, subsystems , payloads, testing, operations etc.

- **Industry is responsible** for break down of high-level requirements into detailed requirements

S-PDR completed!

- ESA needs support from Genesis WGs throughout the different phases of the project to analyze specific aspects so ESA can provide feedback to Industry and mitigate any potential impacts on the Genesis mission.

Valuable feedback already received

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Scientists are strongly invited to continue providing feedback on their needs to GSET!

Scientific and Fundamental Aspects of GNSS

10th International Colloquium

7 - 9 October 2026

École de technologie supérieure (ETS) of Quebec, Montreal, Canada

Chaired by:

European Space Agency (ESA)

École de technologie supérieure (ETS)

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