Genesis Science Workshop

3rd -4th April 2025

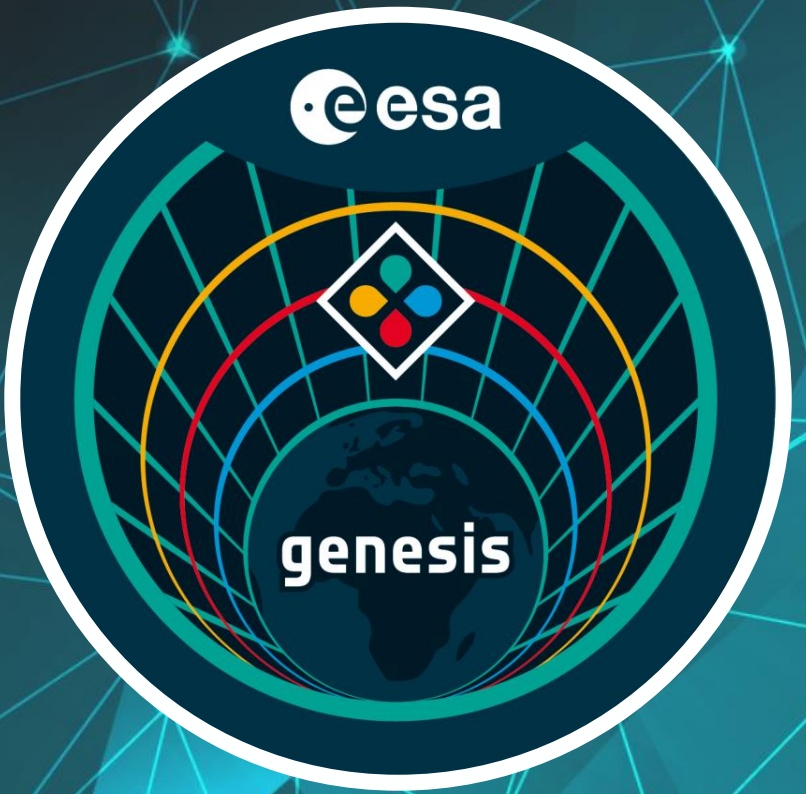
Matera, Italy

Genesis Science Exploitation Team

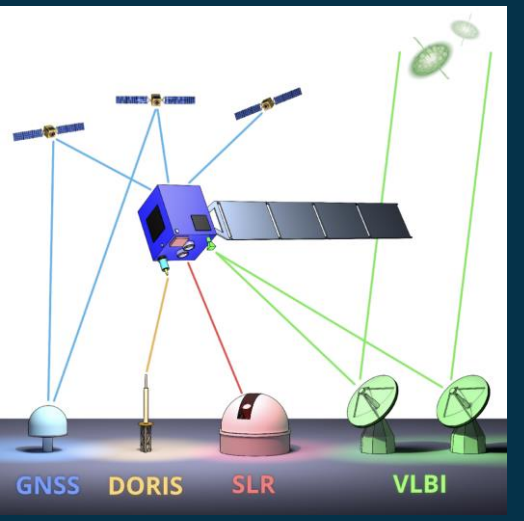
F. Vespe, O. Karatekin

Review of Genesis Science Objectives

On behalf of Genesis Science Exploitation Team (GSET)
Özgur Karatekin, Royal Observatory of Belgium
Francesco Vespe, ASI Direzione Ingegneria e Tecnologie



Genesis



A fully calibrated satellite platform:

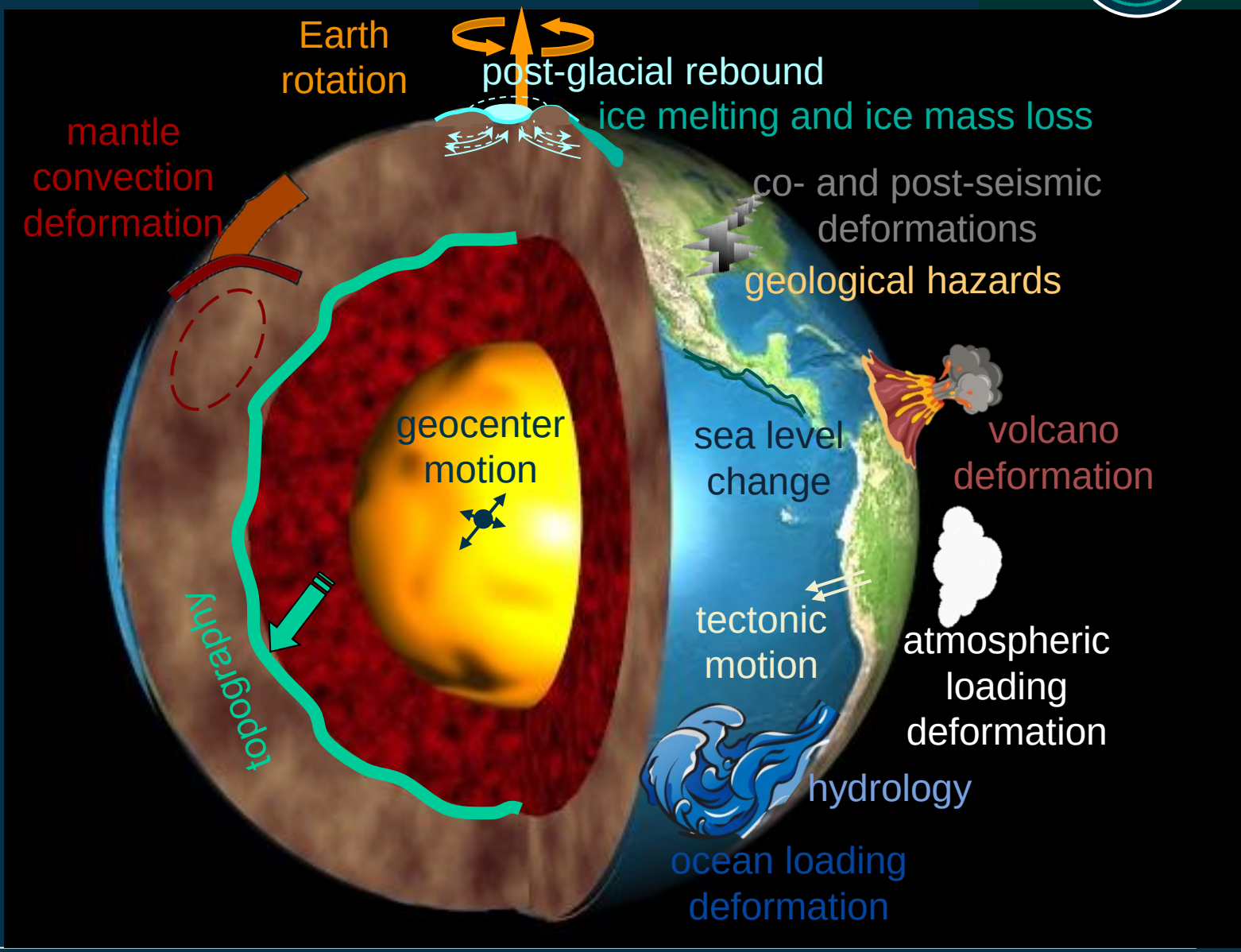
- co-locate the **4 main geodetic techniques**: SLR-GNSS-VLBI-DORIS
- **Identify and reduce the systematic errors**
- Determine if the error source are due to terrestrial ties or from the space geodetic estimates

Improve geocenter and scale for refinement of ITRF: Crucial for the Earth Sciences and Global Change studies

Genesis : ITRF improvements

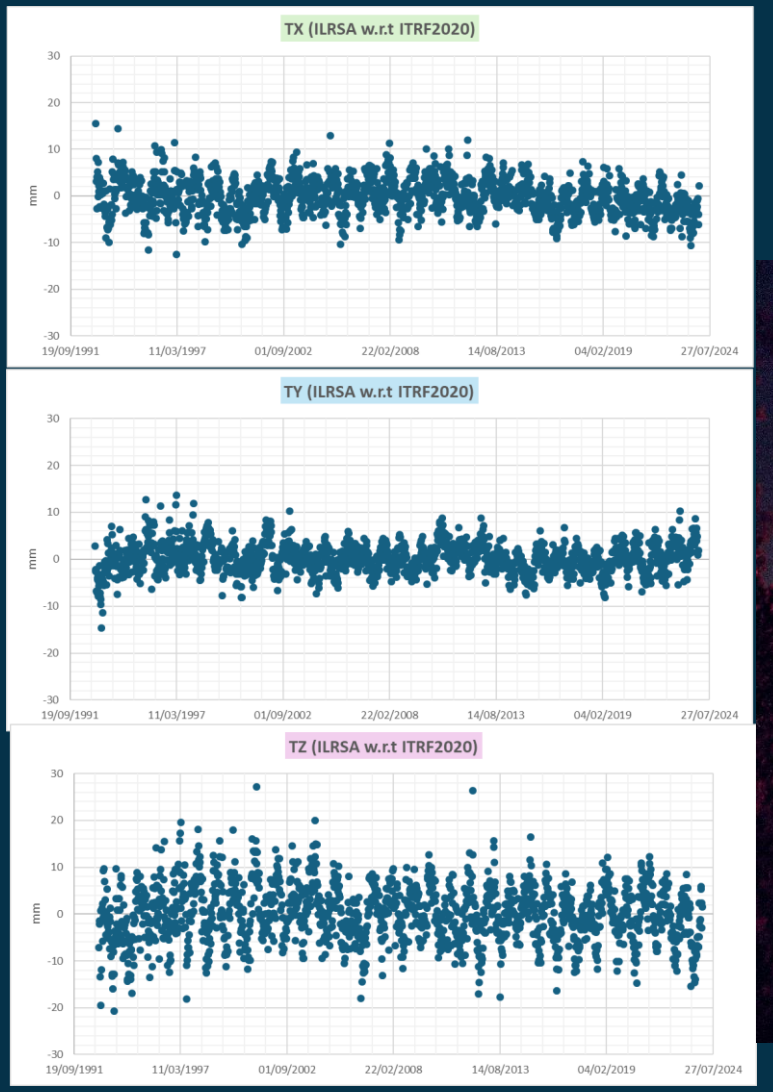
- **International Terrestrial Reference Frame (ITRF).** is the standard terrestrial reference frame for **positioning, satellite navigation and Earth science applications,** as well as for the definition and alignment of **national and regional reference frames** (see IAG Resolution No. 1, 2019).

- The ITRF is recognized to be the **metrological foundation** for all space- and ground-based observations in Earth Science



Genesis : improvement of Geocenter

- SLR and MEO satellites as LAGEOS & LARES are suitable to estimate the GC
- But there are bias. (range and network effects). They absorb modelling errors as well
- So it is important to estimate the GC with independent techniques
- GNSS and DORIS can estimate GC as well but with major trouble than SLR
- With GENESIS DORIS, GNSS and SLR can estimate in combination the GC
- VLBI purely geometric but was proven, observing GNSS as well as GENESIS, it can concur to estimate GC using VLBI



Genesis : Improvements on Scale of ITRF

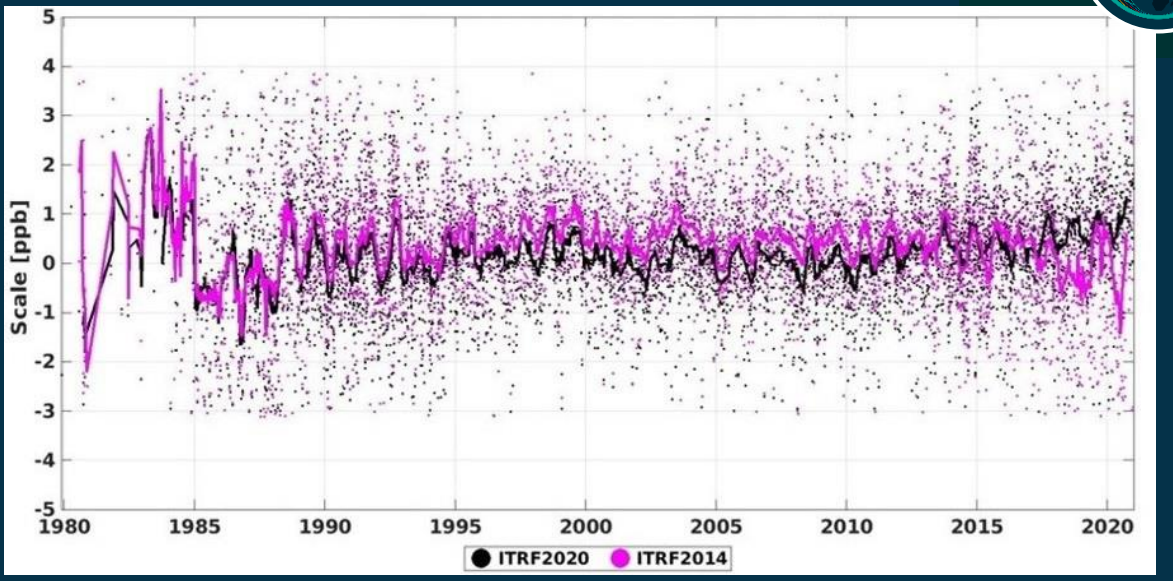
- VLBI and SLR can concur to set the scale of ITRF with the same trouble listed for the GC:
  - Unknown range bias of SLR
  - Unknow antenna deformations
  - Poor global distribution of the network

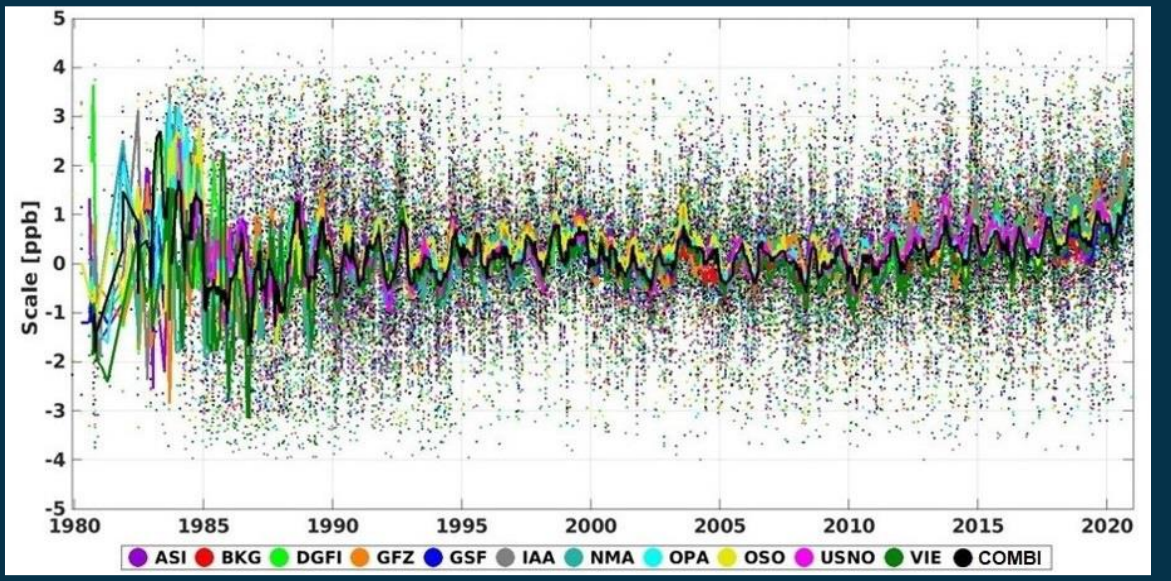
- GALILEO thanks to the rigorous phase center calibration of both ground and space antennas, concur in the scale determination;

- Studies have proved that the SLR-based scale can be transferred to the GNSS network

- DORIS currently is unable to deliver reliable scale information for uncalibrated ground and space antennas

- With GENESIS each technique can concur to to the scale determination





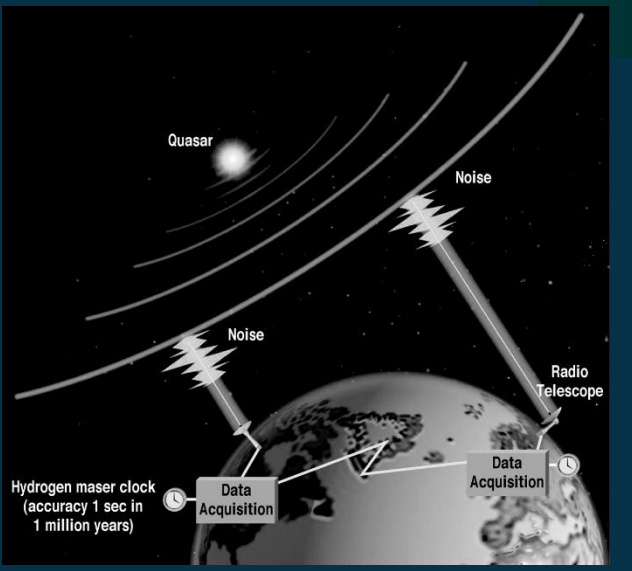
Genesis : Unifications of RF and Earth Rotation

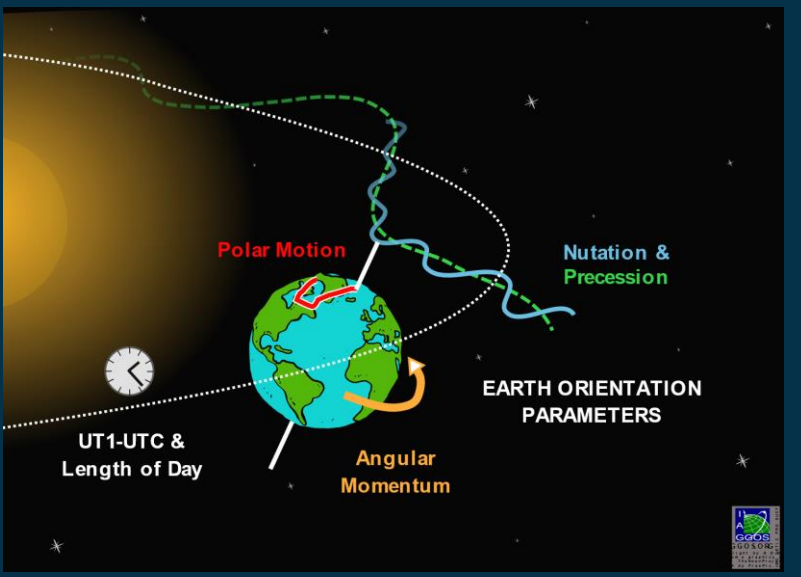
Geodetic VLBI, using the emission by extragalactic radio source (Quasar) concur to maintain the ICRF

Transmission of a quasar-like signal from a satellite platform can be understood biases between **celestial and dynamical realization by satellite orbits**

Earth Orientation Parameters (EOP): polar motion, UT1, allows to achieve the transformations between ITRF and ICRF

VLBI is the only technique able to determine the position of the celestial intermediate pole in the ICRF, expressed as celestial pole offsets to a conventional precession/nutation model, and the Earth's rotation angle, typically referred to as Universal Time or UT1–UTC.





Genesis benefits - In summary

GEODESY

- Improvements of ITRF
- Unification of reference frames
- Improvement of Earth rotation parameters

NAVIGATION

- Improvements of GNSS orbits and GNSS positionining
- GNSS antenna phase centre calibration
- Improvement on POD of LEO satellites
- Precursor of Lunar and extraterrestrial applications

EARTH SCIENCES

Improvements in the Climate

- Sea level
- ice mass losses
- Climatology
- ….

Monitoring solid Earth :

- Tectonic motion
- Tides and crustal deformation
- Predicting natural hazards

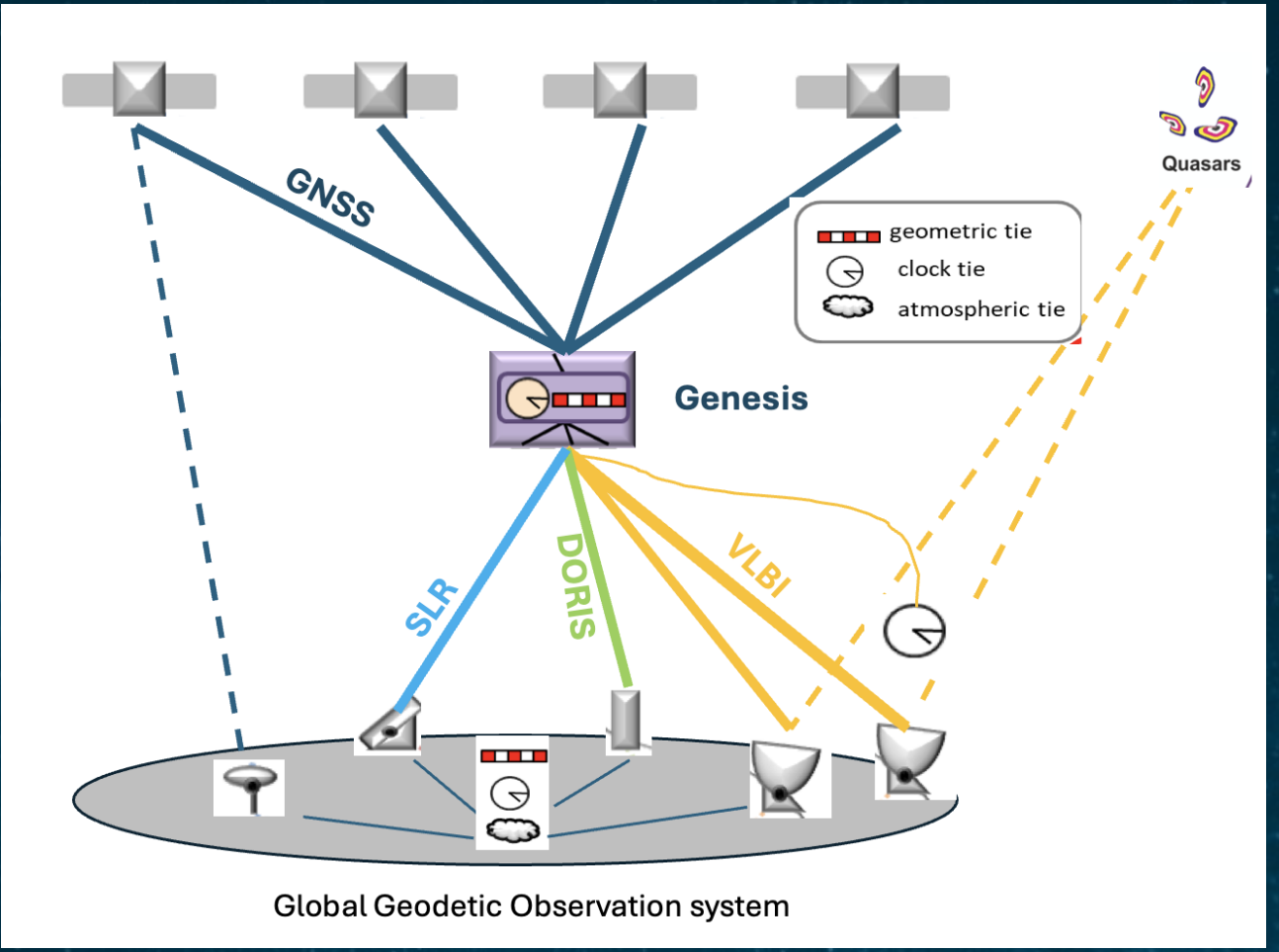
FUNDAMENTAL PHYSICS

Time
General Relativity

- Gravitational redshift
- Pericenter precession,
- Sagnac effect
- Lense-Thirring Gravitomagnetic effect
- Time Lense-Thirring
- …

Genesis : Unforeseen opportunity for Intercontinental Time transfer

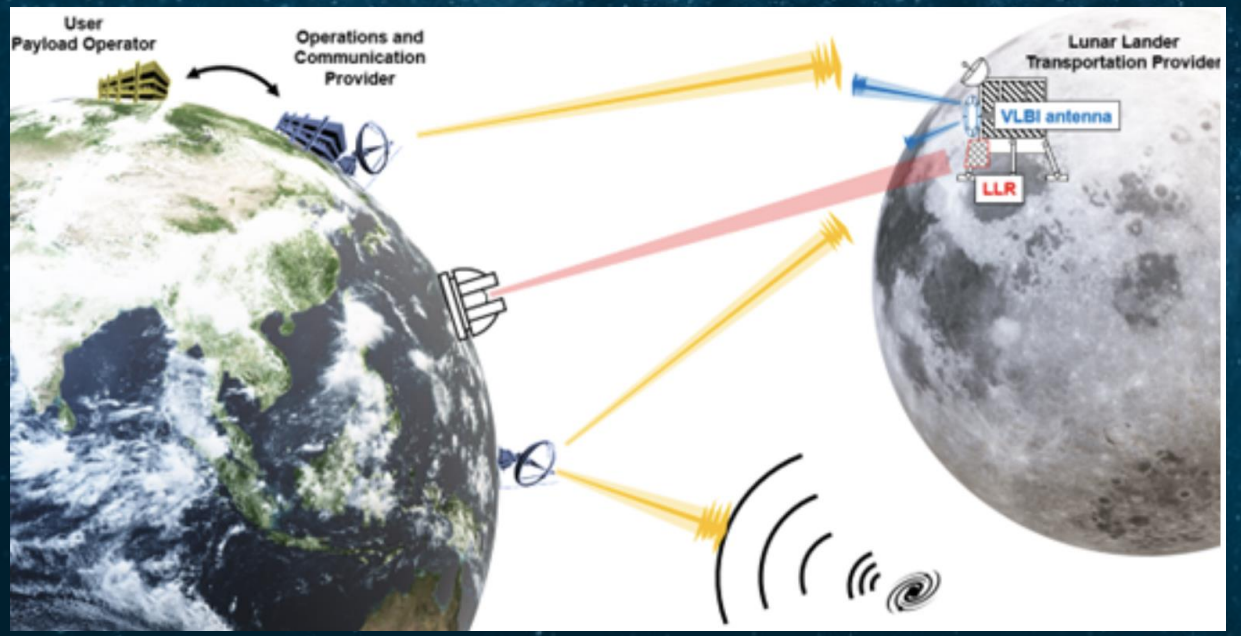
- With Genesis we will co-locate and combine for the **first time** ever the four space-geodetic techniques GNSS, SLR, VLBI, and DORIS aboard a single fully-calibrated satellite
- **New development - Genesis could allow for the first time, time transfer with VLBI technique**
- Traditionally the source for VLBI is Quasars, but in mimicking the quasar in the Genesis instrument there is an opportunity to build in a message in the signal, with broader frequency range than in GNSS
- Work ongoing in the Genesis Science Exploitation Team on this exciting new opportunity!

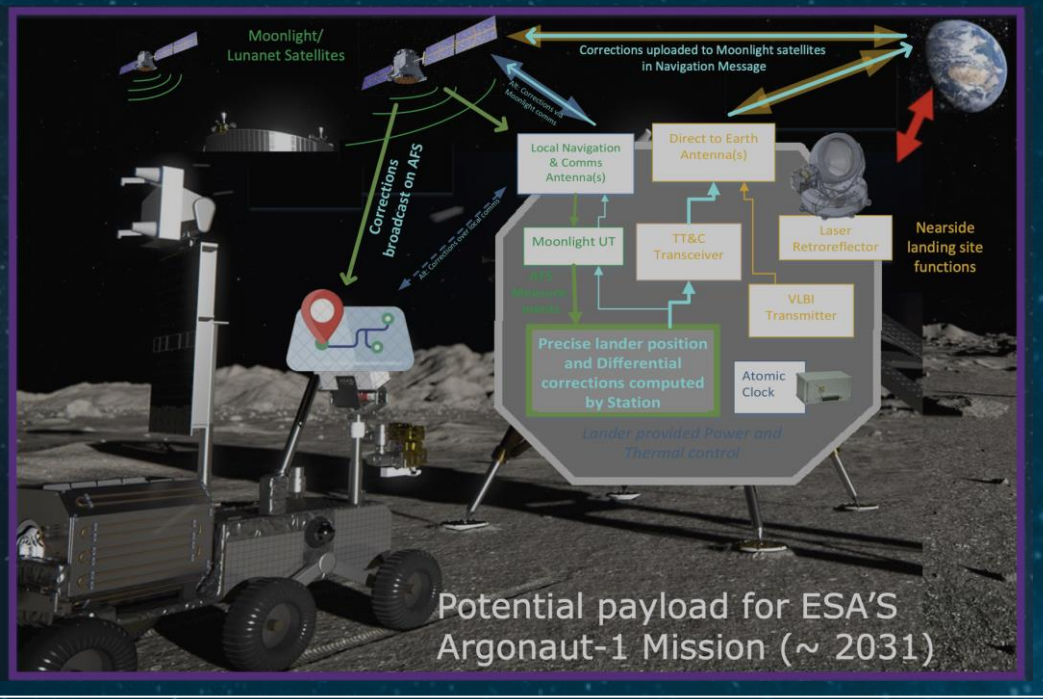


Global Geodetic Observation system

Genesis : Opens the way to future NAV & Science

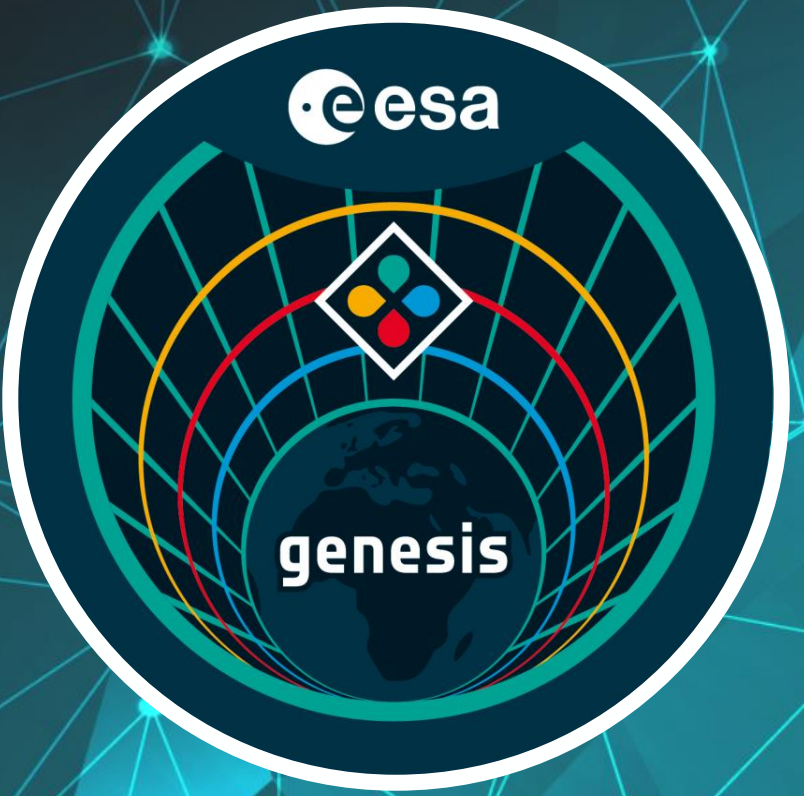
- Reference frames provide the fundamental basis to the geodetic observations of the Earth & solar system objects
- Installing a geodetic reference station on the Moon, co-locating geodetic techniques, will effectively transform it into an Earth's object observable by the ground geodesy network, like the Genesis mission
- NovaMoon can set the international standard station for Lunar refence frame realisation, support the continued improvement of the fundamental lunar reference frame, with the objectives to monitor changes in the Moon's orientation, to understand its interior structure, as well fundamental physics and general relativity.



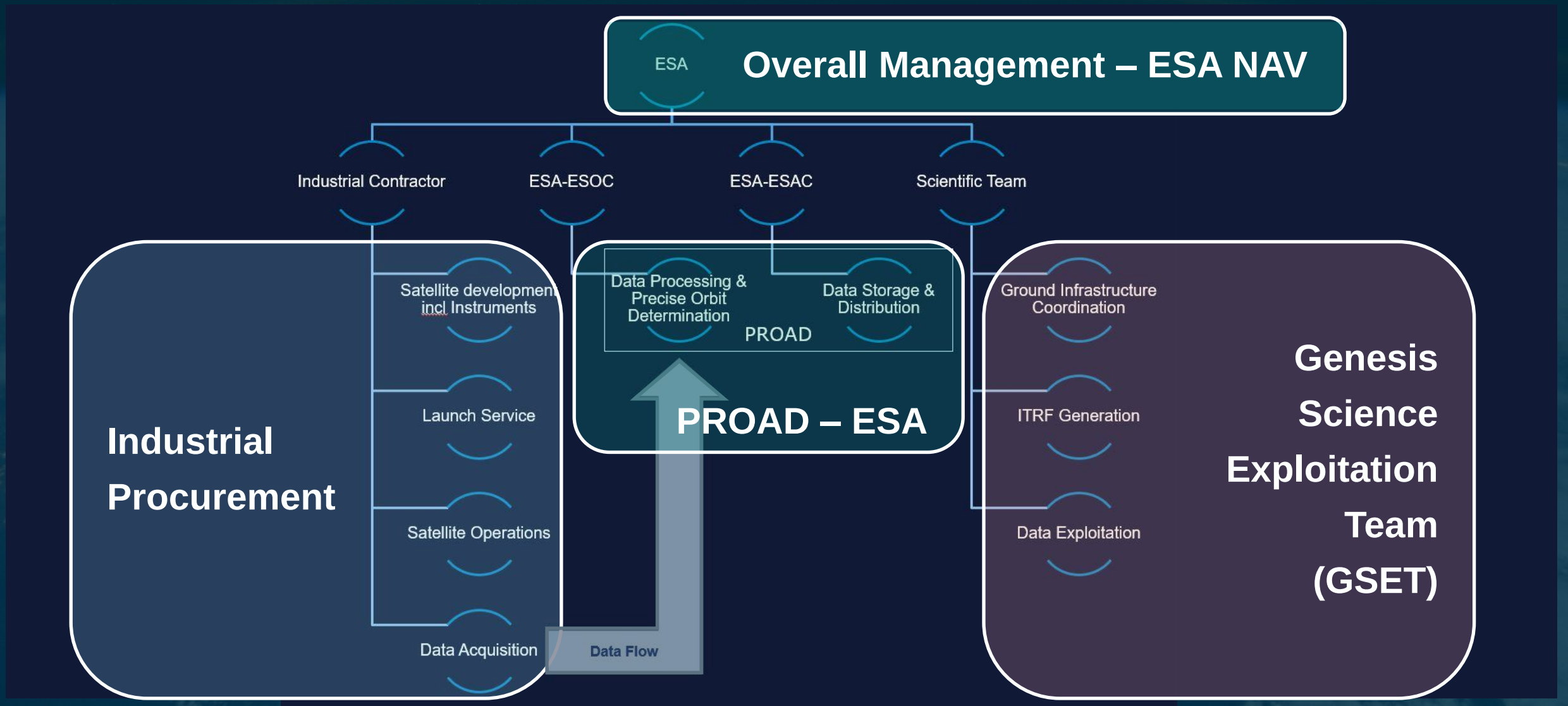


GSET Setup

On behalf of Genesis Science Exploitation Team (GSET)
Özgur Karatekin, Royal Observatory of Belgium
Francesco Vespe, ASI Direzione Ingegneria e Tecnologie



Overview of the GENESIS Mission



Genesis Science Exploitation Team

Scientific Community

- **Scientists & Experts**
- **All Relevant International Geodetical Services:**
  - **IAG, IERS, IGS, IVS, ILRS, IDS**

Working Groups

- 5 WGs

Management Board

- WG chairs, Lead & co-Lead Science Coordinators, ESA

“GENESIS – A Mission for the World”

Scientific Involvement in 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 Science Exploitation Working Groups

All Working Groups have the responsibility to exchange and interact with one another

WG1: ITRF & Combinations of Techniques

- **Focal point for ITRF and Combinations of Techniques** related topics
- **System Aspects**
- **Accuracy analysis** of the ITRF and the associated improvements, based on Genesis generated data
- **Quantify the impact of the mission performance** on the ITRF accuracy and stability
- **Interact** with the International Earth Rotation and Reference Service (IERS)

WG2: GNSS

- **Focal point for GNSS** related topics
- Investigate what new or improved Position Navigation and Timing (PNT) products can be obtained with the improved knowledge of the ITRF and all the data products that will stem from the Genesis mission

WG3: VLBI

- **Focal point for VLBI** related topics
- **Analyse & quantify the impact** of mission performance on the **Earth Orientation Parameters** (EOP) and **ties between ITRF and International Celestial Reference Frame** (ICRF)
- Coordinate, prepare and realise the required **VLBI campaigns**, including any required upgrades to infrastructure, data processing etc

WG4: DORIS

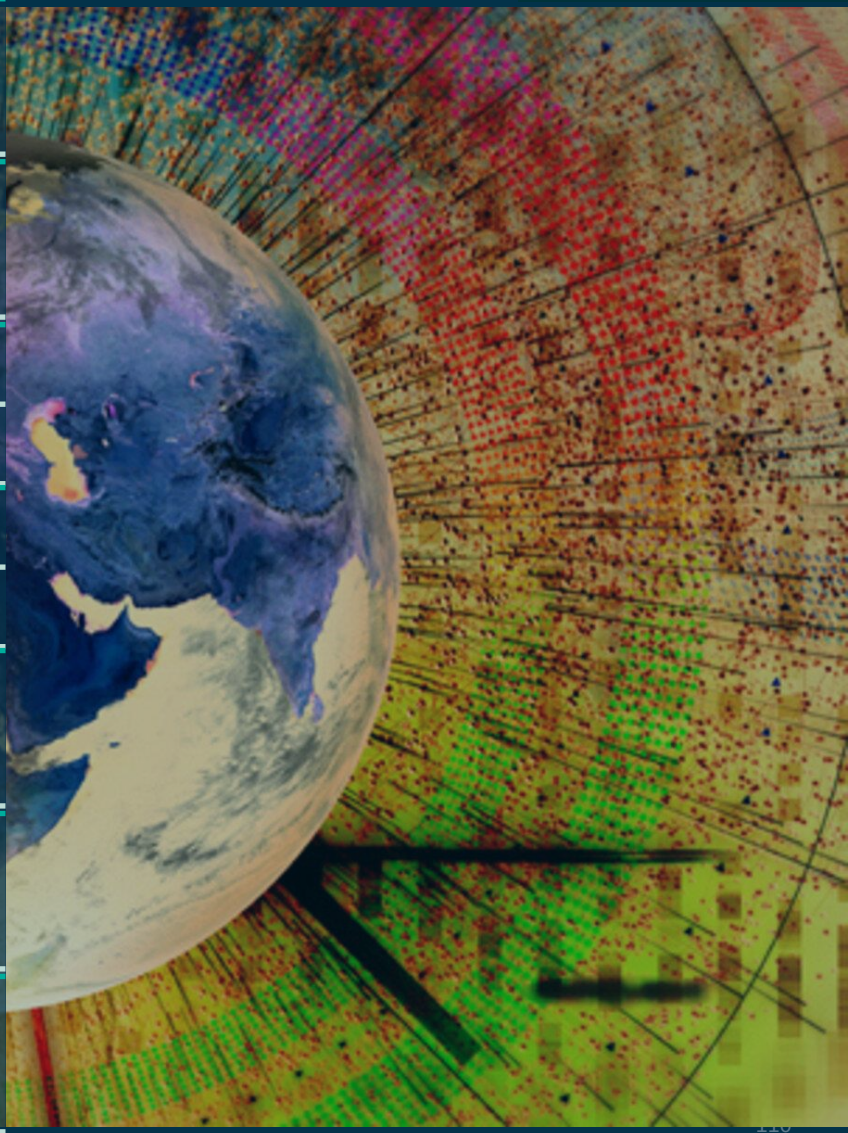
- **Focal point for DORIS** related topics
- **Improve the current measurements** of the ties between DORIS and the other geodetic technics

WG5: SLR

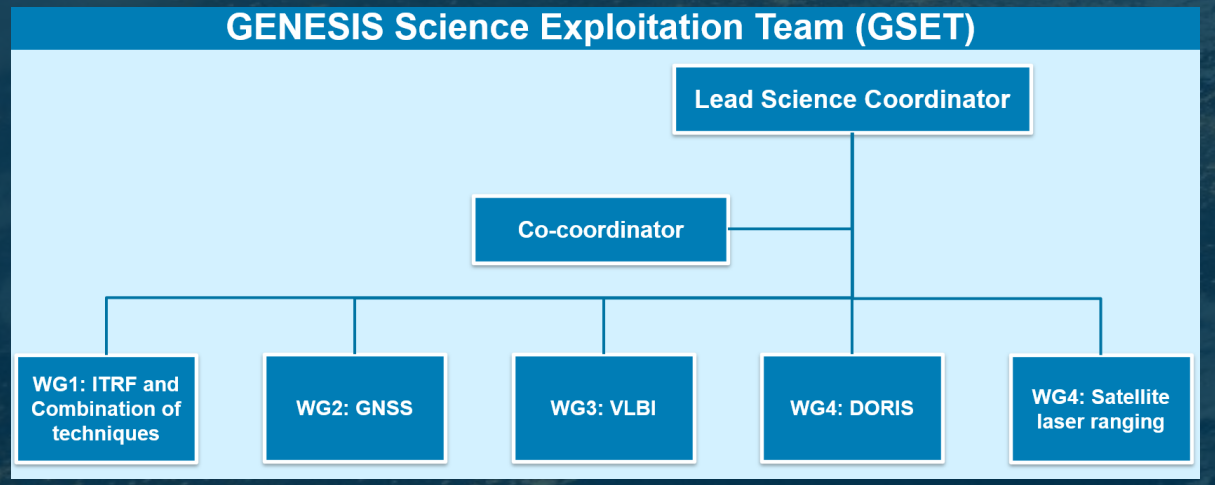
- **Focal point for SLR** related topics
- Coordinate, prepare and realise the required **SLR campaigns**, including any required upgrades to infrastructure, data processing etc.

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



GENESIS Science Exploitation Team (GSET)

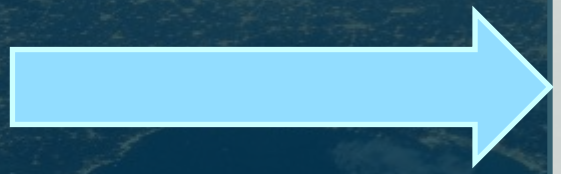


TASKS

- Acting as advisory group to the ESA GENESIS project team for all aspects related to performance requirements and assessing the compliance to the mission objectives
- Advising on requirements changes
- Supporting the ESA GENESIS project team in the follow up of the developments, qualification and operations planning and execution
- Ensuring an extensive data exploitation of the GENESIS
- Assisting in the calibration, processing and validation of the GENESIS mission data

Working Group Chairs (WG Chairs)

Working Group Chairs



- Support the mission development, operations, data analysis and exploitation
- Determine and appoint WG Members
- Coordinate and assign work packages to WG Members
- Support the GENESIS operations planning and instrument calibration
- Provide relevant information or demands to the international services and technique-related analysis centres
- Regularly inform the GSET and WG Members on the progress of ongoing activities.

TASKS

GENESIS Lead Science Coordinator and Co-Coordinator

GENESIS Mission Lead Scientific Coordinator

GENESIS Mission Lead Scientific Co-Coordinator

TASKS

- is the primary interface to ESA
- is supported by the Working Group Chairs

- helps the Coordinator in their tasks
- acts as deputy in the absence of the Lead Science Coordinator

GSET Organisation

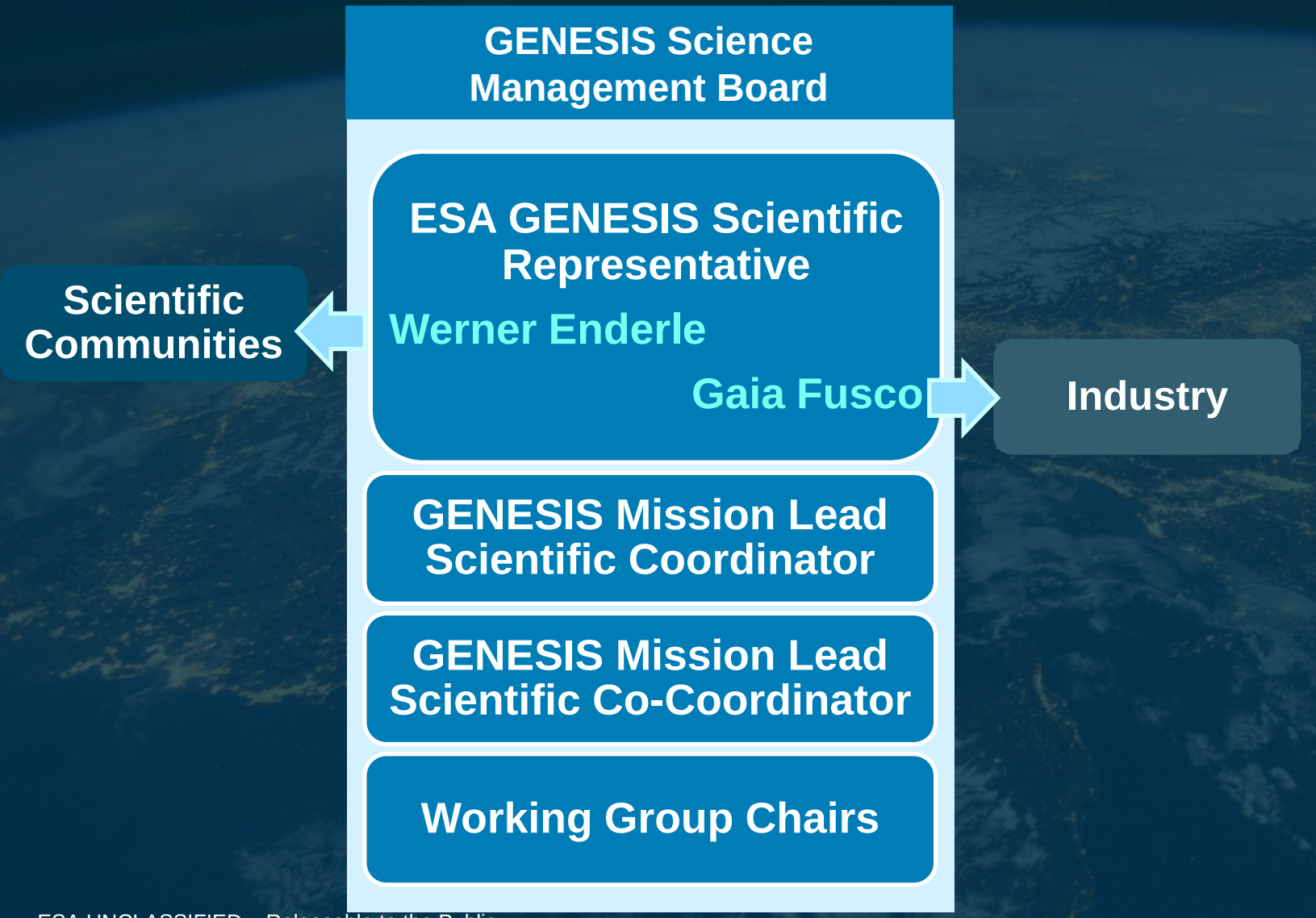
On a yearly basis, the Lead Science Coordinator shall convene a workshop inviting all members of the GSET, the ESA GENESIS Scientific Representative and ESA GENESIS project team

Each WG Chair will be responsible for the organisation of regular WG meetings to coordinate the work of each Working Group Member, share results and discuss future steps.

The frequency and schedule of meetings shall be established by each Working Group.

The Working Group Chairs shall invite the Lead Science Coordinator and the ESA GENESIS Scientific Representative to such meetings and provide a summary status report to the ESA GENESIS project manager every six months.

GENESIS Science Management Board



TASKS

- Advising ESA GENESIS project team on all aspects related to the mission objectives and the satellite and ground segment development implementation, qualification and operations
- Ensuring that the WG activities cover the needs of the Mission

TERMS OF REFERENCES

Charter: Description of the Working Group's purpose and alignment to the overall project goals

Objectives: Definition of Working Group goals

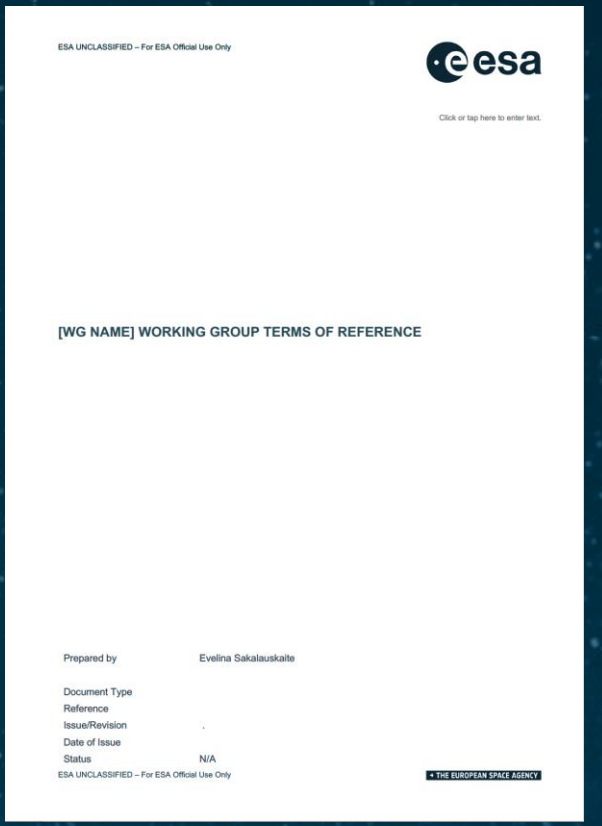
Term :When activities of the Working Group are effective from and continues until when

WORKING GROUP GOVERNANCE

- Structure: structure of the working group (e.g., roles, groups etc.)
- Scope of Work: Detailed definition of tasks and activities
- Roles and Responsibilities
- Membership : Specification of criteria for participation in the working group/nomination process
- Meetings Specification of meeting frequency, communication protocols,

WORKING GROUP INTERFACES

- Collaboration with ESA GENESIS Team: Definition of reporting, communication lines and deliverables
- International Services
- Other GSET Working Groups
- Other Organisations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[WG NAME] WORKING GROUP TERMS OF REFERENCE

Prepared by Evelina Sakalauskaite

Document Type
Reference
Issue/Revision .
Date of Issue
Status N/A

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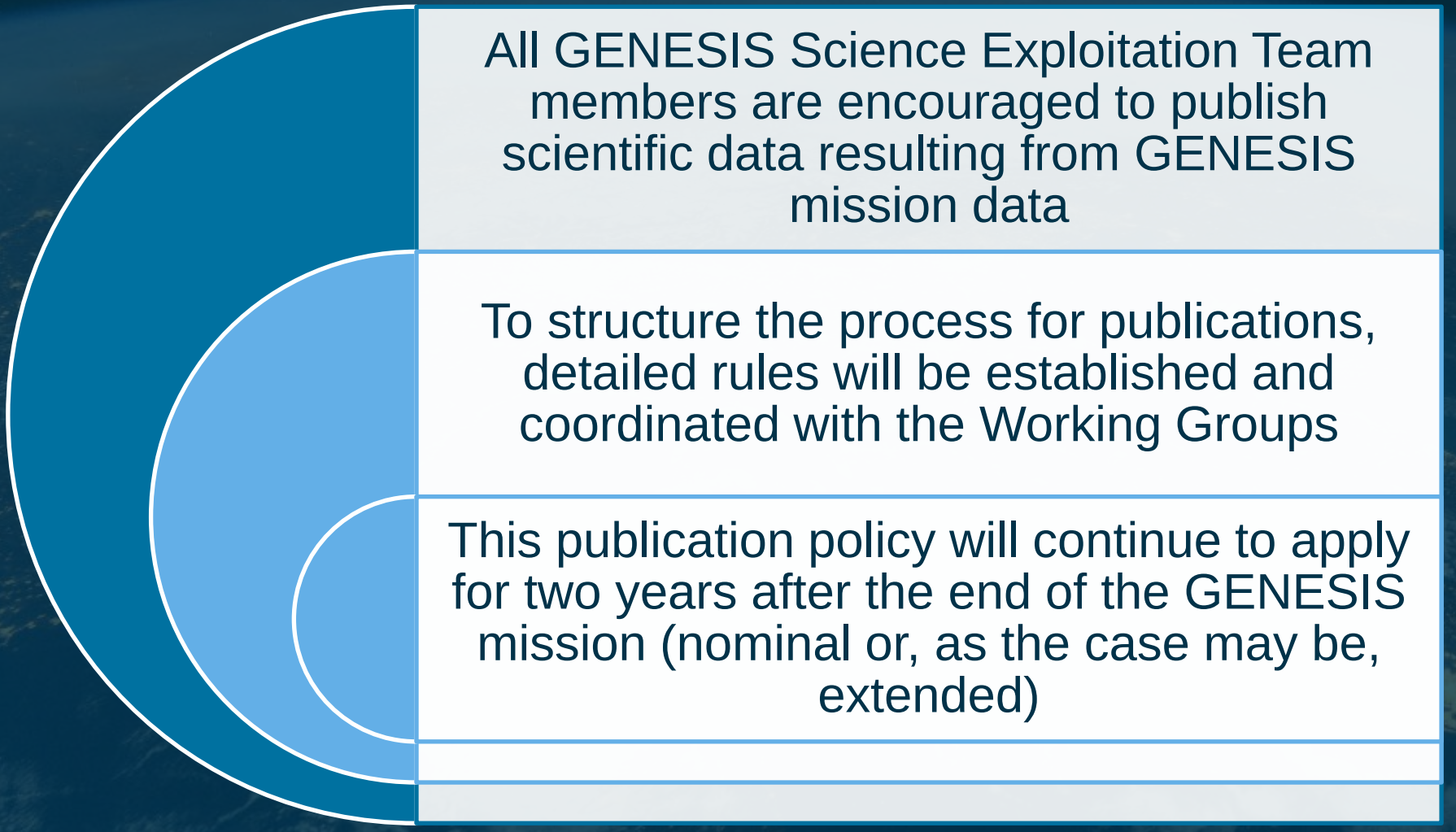
THE EUROPEAN SPACE AGENCY

DEADLINE: End of May…2025

Publication Policy



Publication Policy

- All Science Team members are encouraged to publish scientific data resulting.
- Topics of papers are to be proposed by GSET Members.
- The papers on mission will be coordinated by the Science Management Board
- When information about the performance of the spacecraft/mission is included in the publication, the ESA mission shall be asked to review the related content of the paper and its prior approval must be obtained.
- Annual workshops are organised to share results of the respective analysis across the various domains
- The working group chairs will have responsibility for coordinating data analysis related to each group's objectives under the coordination of the science coordinators, ESA and Science Management Board.
- Publication policy will be published in Rules of the Road and implemented by Science Management Board

Decision making: Rules of the Road

Workshop: On a yearly basis, with invitation to all members of the GSET to facilitate collaboration;

- Issue recommendations to all members of the GSET and the ESA on new topics or tasks to be covered
- Agree on the processes and WGs' responsibilities in tackling interdisciplinary analyses
- Identify any opportunity to increase the mission scientific return;
- Promote the mission among the scientific community by discussion, publications and scientific conferences;
- Coordinate the organisation of public events to promote the Genesis mission among the general public.

WGs :

- Regular WG meetings to coordinate the work of each WG member, share results and discuss future steps.

Science Management Board:

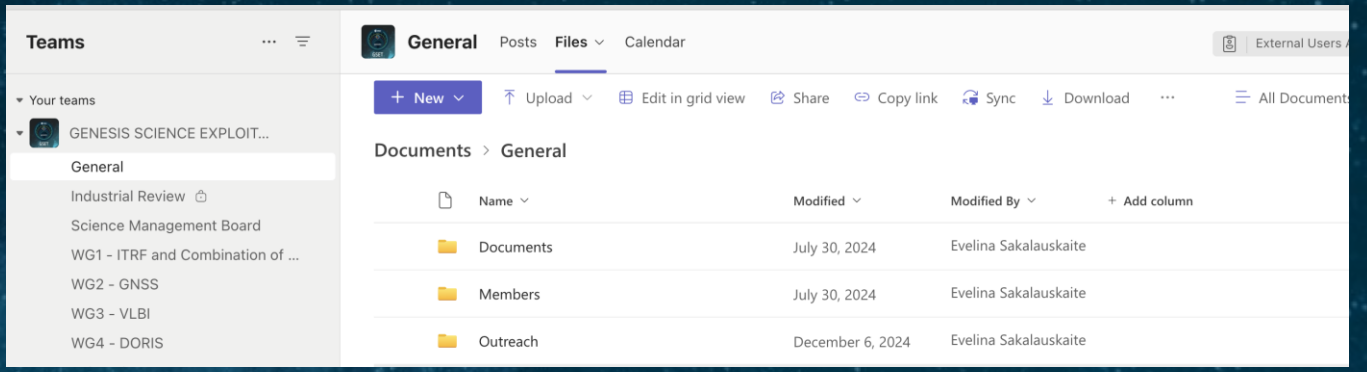
- Advising the ESA mission project team on all aspects related to the mission objectives;
- Ensuring that the WGs activities cover the needs of the mission;
- Implementing the Publication Policy

Coordination Communications

- Monthly meetings of GSET Management board
- Regular WG Meetings & communications via emails, Teams platform
  - WG1 Kick-off meeting January 2025
  - WG2 Kick-off meeting July 2024
  - WG3 Kick-off meeting July 2024
  - WG4 Kick-ff meeting November 2024
  - WG5 Started in summer 2024, last meeting, on January 2025
- Yearly Genesis Workshops
- Also, Meetings in other international meetings
  - IAG WG 1.1.1 on Genesis

Coordination Communications

- Genesis Science Exploitation Team has been created on Teams
- All members should have received notification from Microsoft Teams
- We have created this shared environment for collaboration within the science community.
- Platform allows to share
  - Documents
  - Announcements,
  - Science team meetings, participants list, agenda
- Any comments or suggestions for its structure, are welcome



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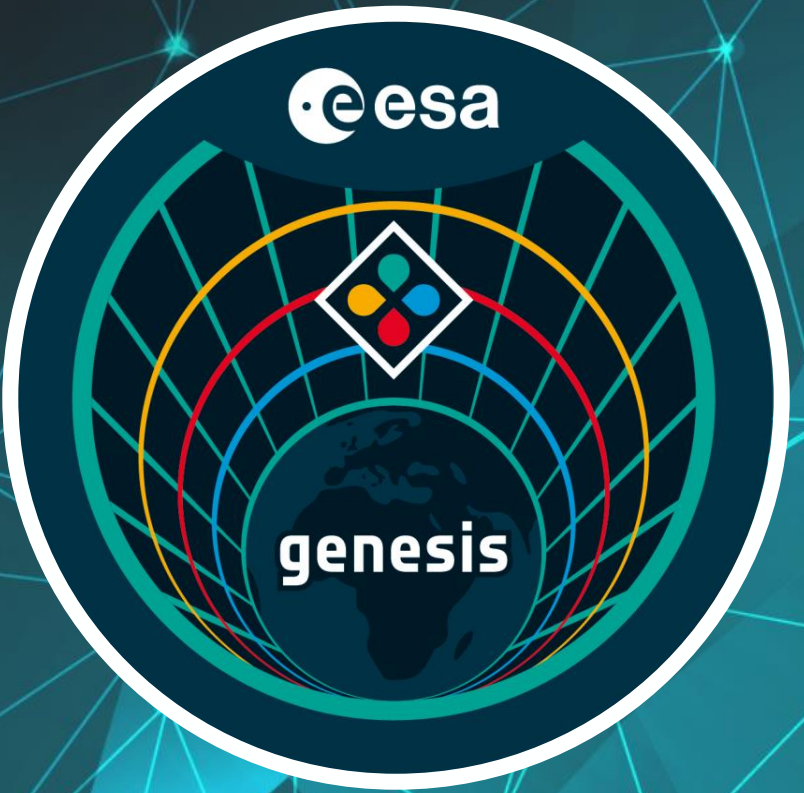

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