Jet Propulsion Laboratory
California Institute of Technology

GRACE-Continuity: Integration Status

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And many more, including JPL, GFZ, CSR, GSFC SDS teams, US/German LRI teams, and project engineering teams

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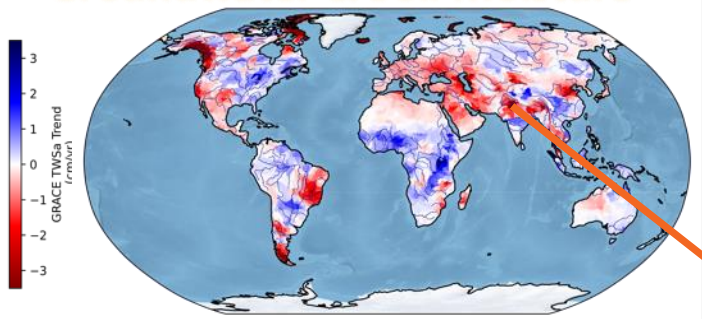
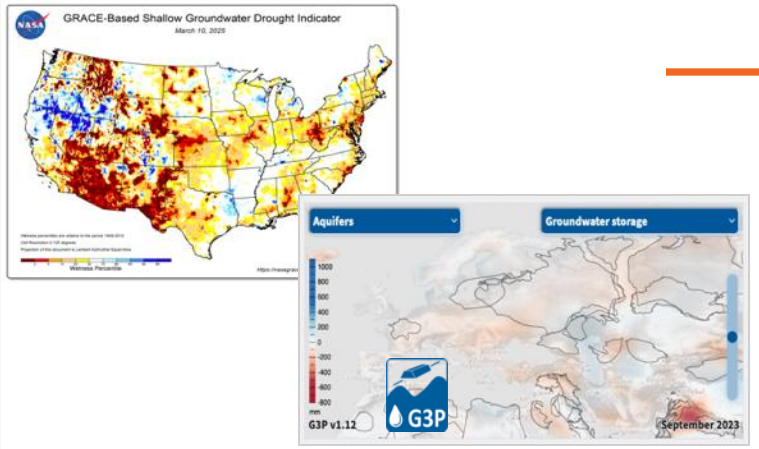
2: Germany Space Agency at DLR, Department Earth Observation, Germany
3: Helmholtz Centre Potsdam GFZ German Research Centre for Geosciences, Germany
4: University of Texas at Austin, Center for Space Research, United States

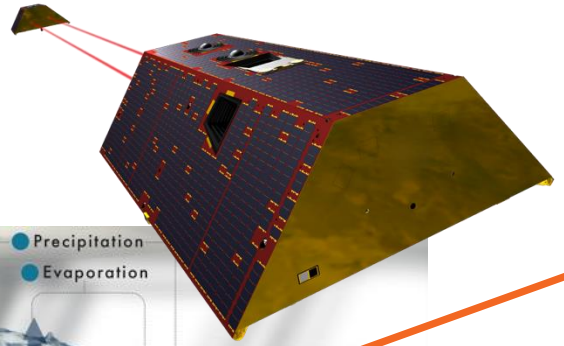
Smart Water Meters for Monitoring Drought & Flood Risks, and Groundwater, Sea Level and Glacier Changes

Groundwater & Soil Moisture

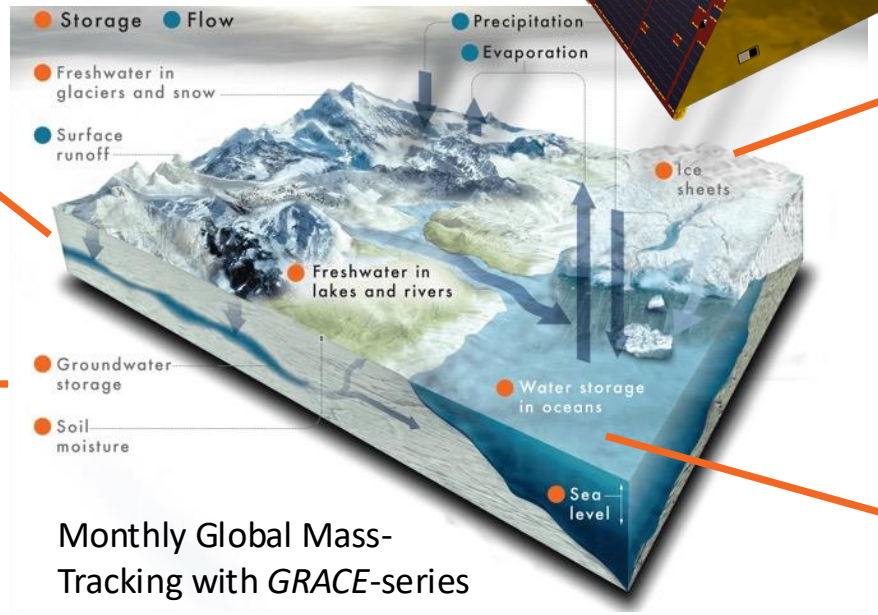


Drought Risk & Flood Potential



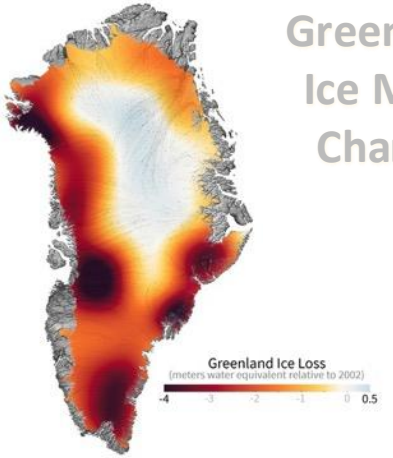


Earth's Water Cycle

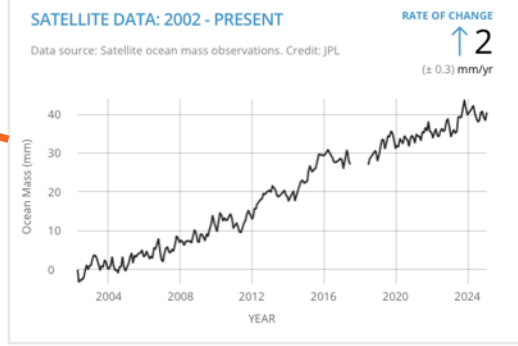


Monthly Global Mass-Tracking with *GRACE*-series

Greenland Ice Mass Change



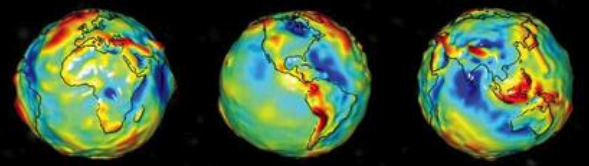
Sealevel Change



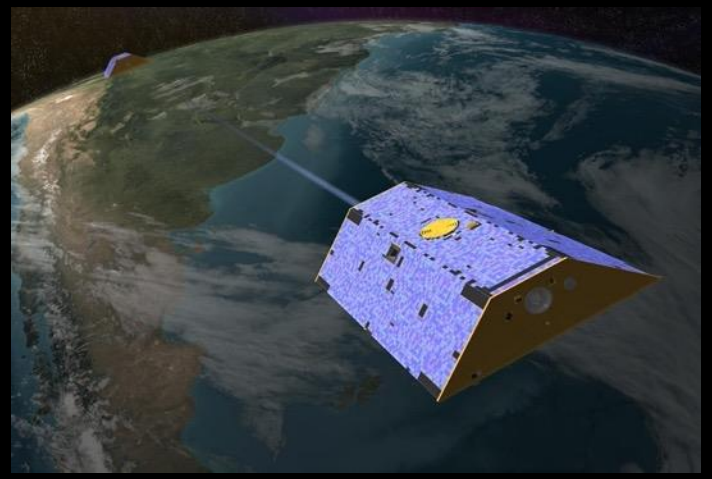
The GRACE-missions are vital for advancing scientific knowledge of Earth's evolving water cycle and systems.
They provide valuable information for water resources and hazards, supporting thriving economies & societies.

GRACE, GRACE-FO, GRACE-C

A Successful International US-German Partnership Since 2002



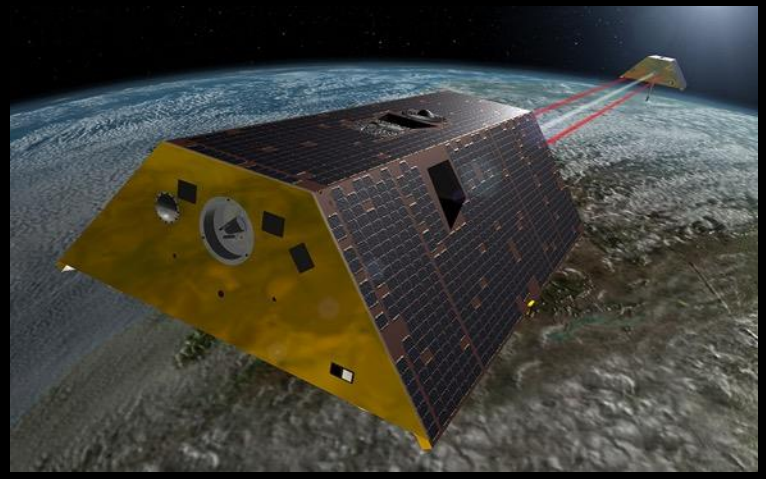
Fundamental geodetic measurements
of global mass changes



2002 - 2017

The ***GRACE*** mission was a collaboration with the German Aerospace Center to measure month-to-month gravity changes.

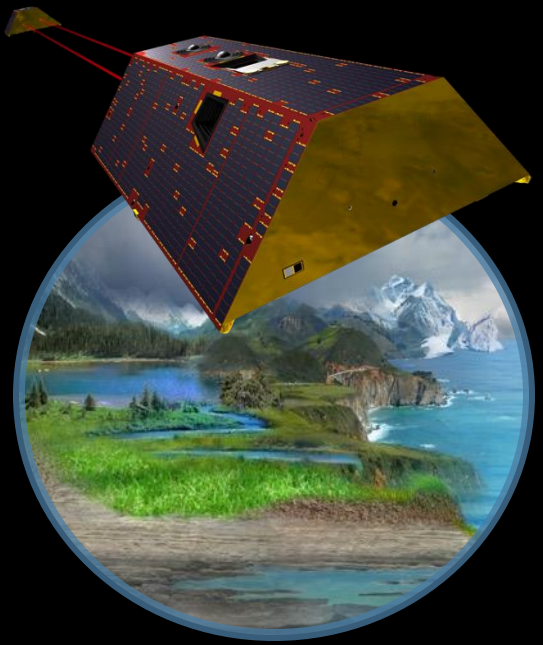
GRACE



2018 - ongoing

GRACE-FO continues the observations, while also demonstrating new laser-ranging interferometry (LRI), in collaboration with the GFZ German Research Center.

GRACE-FO



2028 (planned)

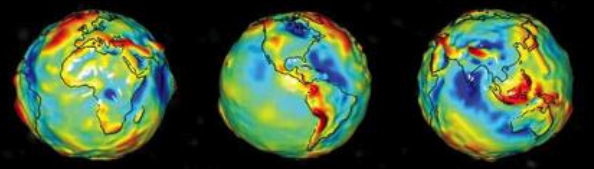
GRACE-Continuity will maintain and expand the foundational mass change measurements of Earth's changing water cycle.

GRACE-Continuity

Trillions of unique observations over the last two decades keep an eye on the ever-evolving planet.

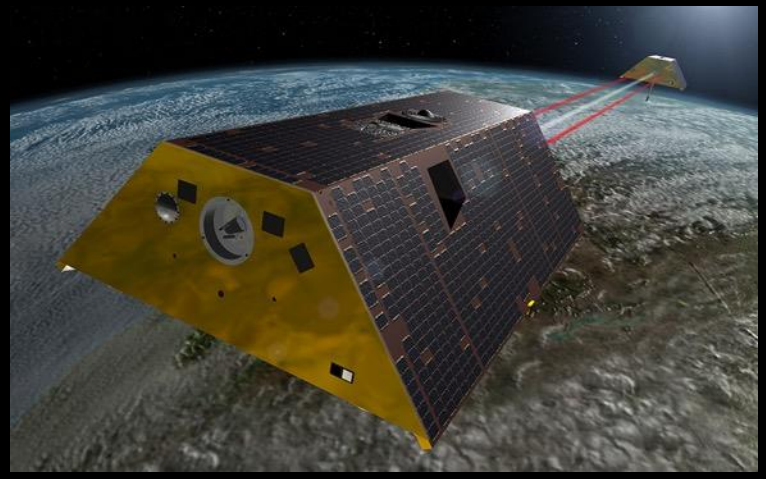
GRACE, GRACE-FO, GRACE-C

A Successful International US-German Partnership Since 2002



Fundamental geodetic measurements
of global mass changes

- Goal: 1 year overlap for Cal/Val activities
- Currently no lifetime issues on GRACE-FO (fuel budget, altitude projections and overall system health)
- GRACE-C on schedule for December 2028 launch
- GRACE-C Mission Operations after launch is funded by GFZ (for 5 years)
- Offer received from GSOC for GRACE-FO (till 12/2029) and GRACE-C (2029-2033)



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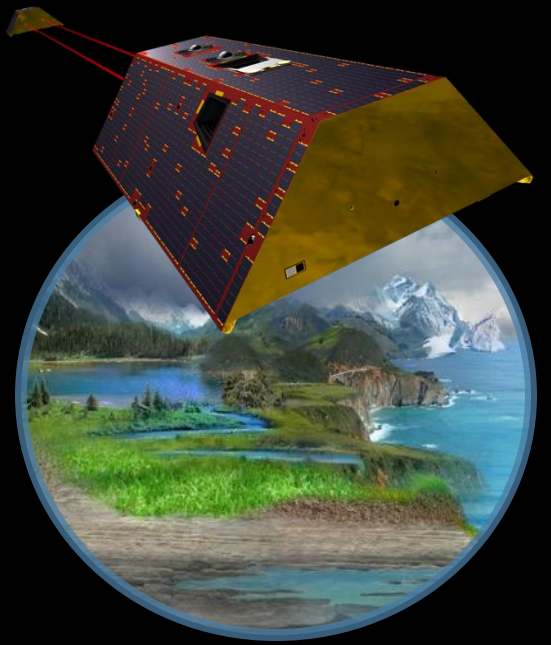
GRACE-FO NASA GFZ Helmholtz Centre for Geosciences



2028 (planned)

GRACE-Continuity will maintain and expand the foundational mass change measurements of Earth's changing water cycle.

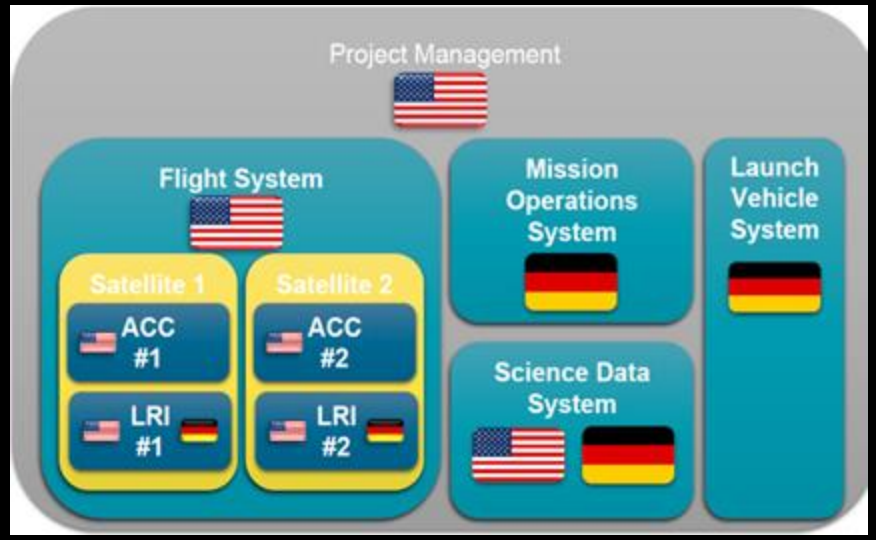
GRACE-Continuity NASA DLR

Trillions of unique observations over the last two decades keep an eye on the ever-evolving planet.

GRACE-Continuity Science Goals & Deliverables

Level-1 (instrument data)

- Similar to GRACE-FO
- Latency: 21 days



Level-2 (gravity fields)

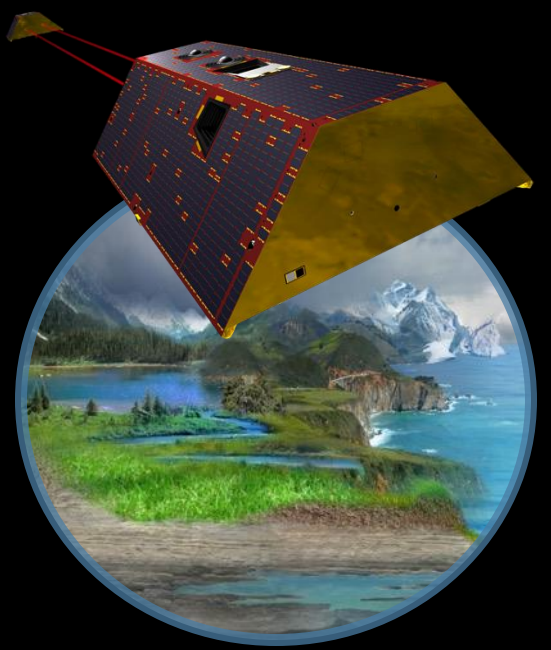
- Monthly fields, similar to GRACE-FO
- Nominal: 60-day latency
- Low-latency: <10-day

Level-3 (surface mass change)

- Gridded maps of surface mass changes derived from application of Level-3 processing to Level 2 data
- Also includes mascons, ancillary data products etc.

Level-4 (high) *NEW for GRACE-C!*

- Data-assimilation for drought / flood potential monitoring
- Climate Indicators (e.g., ice sheets, sea level, major currents)



2028 (planned)

GRACE-Continuity will maintain and expand the foundational mass change measurements of Earth's changing water cycle.

GRACE-Continuity

Gravity Recovery and Climate Experiment - Continuity

GRACE-Continuity Mission Overview

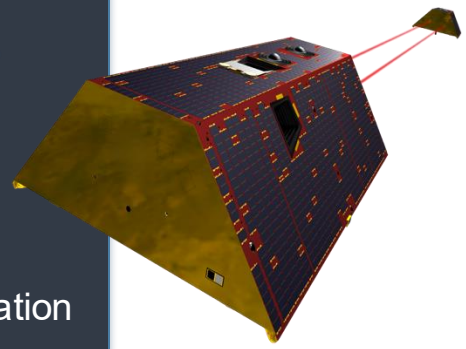
Technical Overview

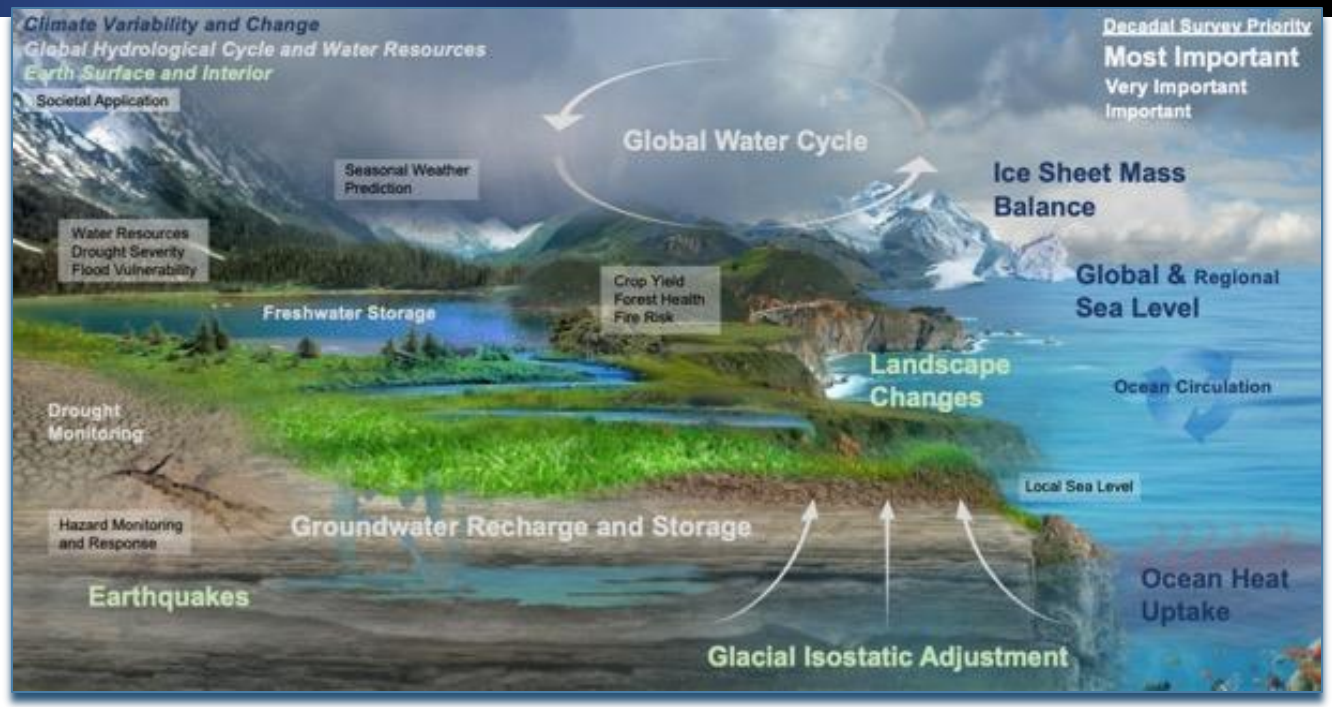
- Partnership between NASA & DLR
- Two identical Spacecraft separated by 100-300 km
- Launch Date: December 2028
- Launch Vehicle: Space-X Falcon 9
- Spacecraft Bus: Airbus; GRACE-FO Heritage
- Design life: 5 years (7 years consumables)
- Orbit: 500 km altitude, 89° Inclination
- Project: Cat II
- Risk Class: C

Measurement System

Satellite to Satellite Tracking:

- Laser Ranging Interferometer
- Accelerometer
- GNSS Receiver
- Star Camera Attitude determination





GRACE-C provides

- A global view of **underlying physical processes and interconnections** between Earth system components to distinguish between **trends, accelerations, and variability**.
- Quantitative measurements of **terrestrial water storage** that allow for a look beyond the surface, which helps **decision-making**.
- Constraints to the **water and energy budget**, which helps to bound trends and variability in other variables.
- Continuation of current **operational uses** and a potential for **expanding applications** for water resource management and coastal planning.

GRACE-C: high-level status (Oct-2025)

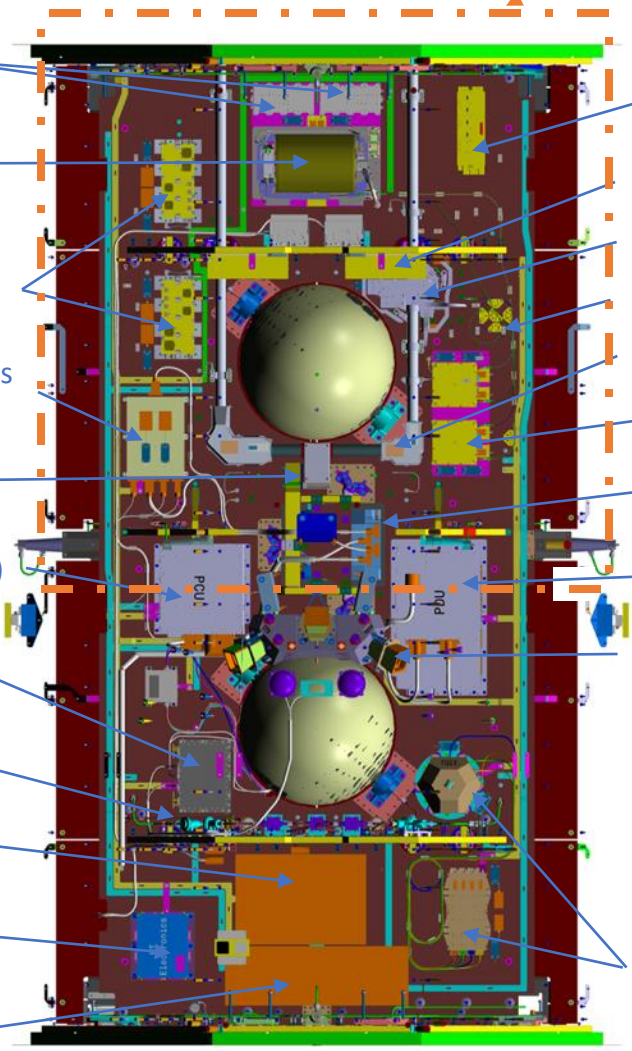
- Technical margins are solid, exceeding requirements.
- Project successfully passed the *Critical Design Review* (May 2025).
- Mission Operations System *CDR* at GSOC this week (Oct 2025).
- Primary spacecraft structure delivered for FM1 (FM2 on Oct-2025).
- LRI to be delivered to STI in Germany (Mar-2026).
- Accelerometers fully qualified and complete (Jun 2024).
- Thermal & distortion Analysis completed.
- Science Data System team is continuously verifying that requirements and performance are met during spacecraft integration & testing.

Next Major Milestones:

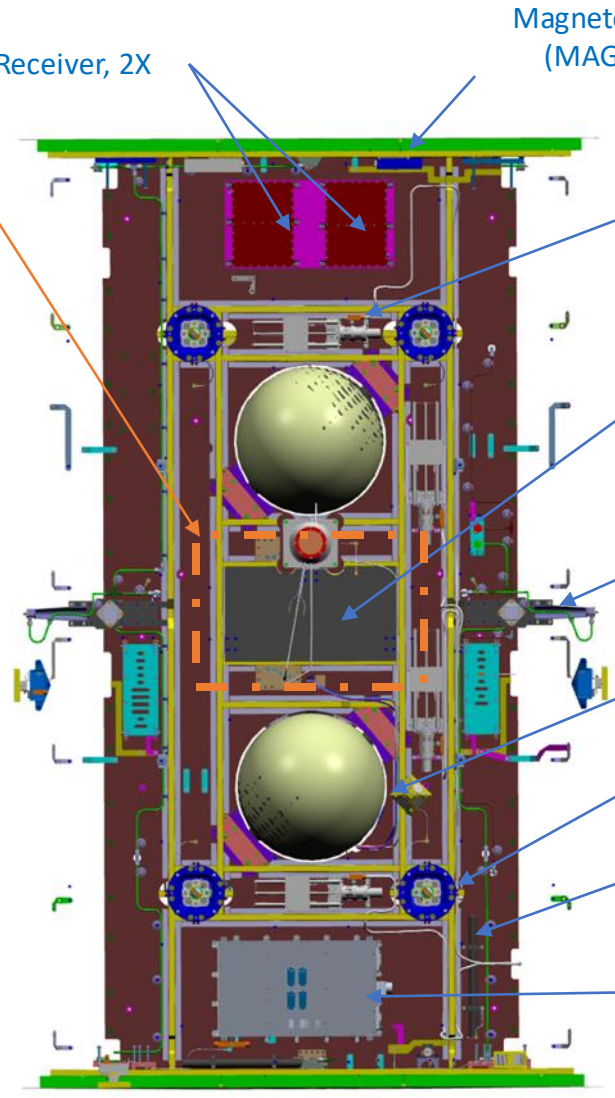
- Oct 2025: System Integration Review (SIR)
- Dec 2025: Key-Decision-Point D (KDP-D)
- Dec 2028: Launch (on track)

GRACE·C

Spacecraft Configuration: Main Equipment Panel & Instruments

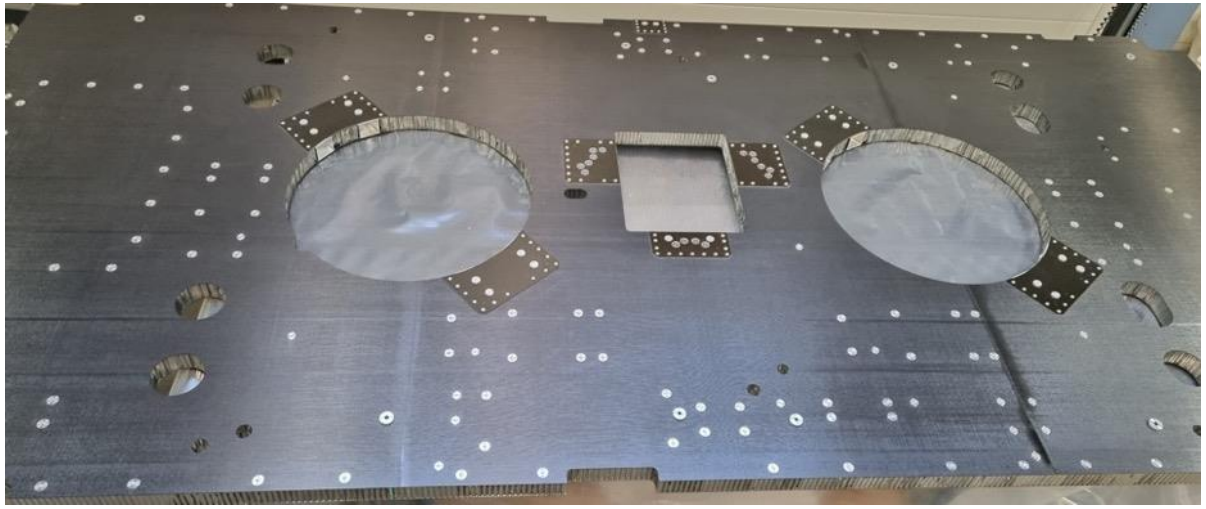


Main Equipment Panel (MEP) Top Side



Main Equipment Panel Bottom Side

GRACE-Continuity is taking shape. Satellite bus and instruments are being built and tested: Satellite Structure

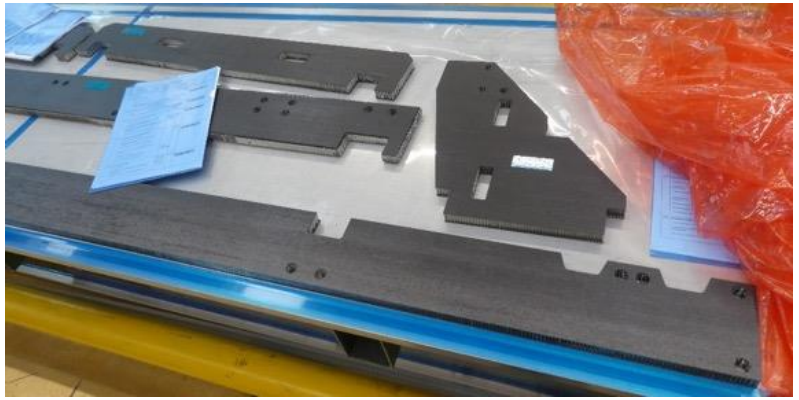


Main Equipment Panel

Zenith Panel

Front and Rear Panels

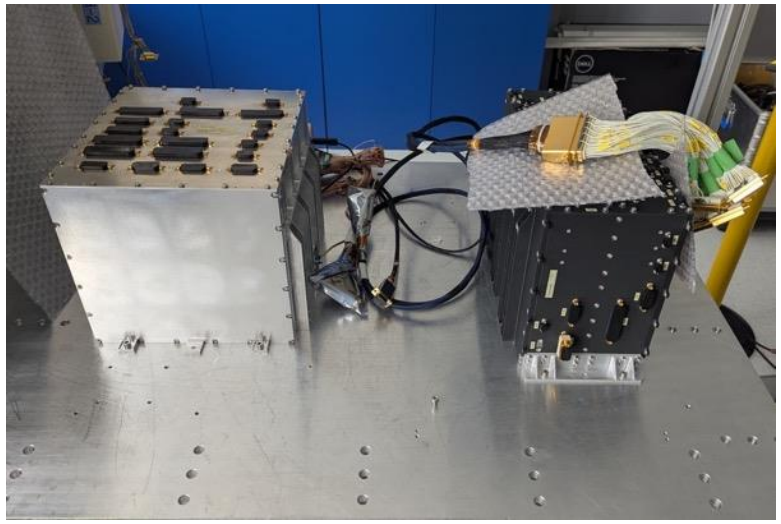
Shear Wall Panels



Rib Panels

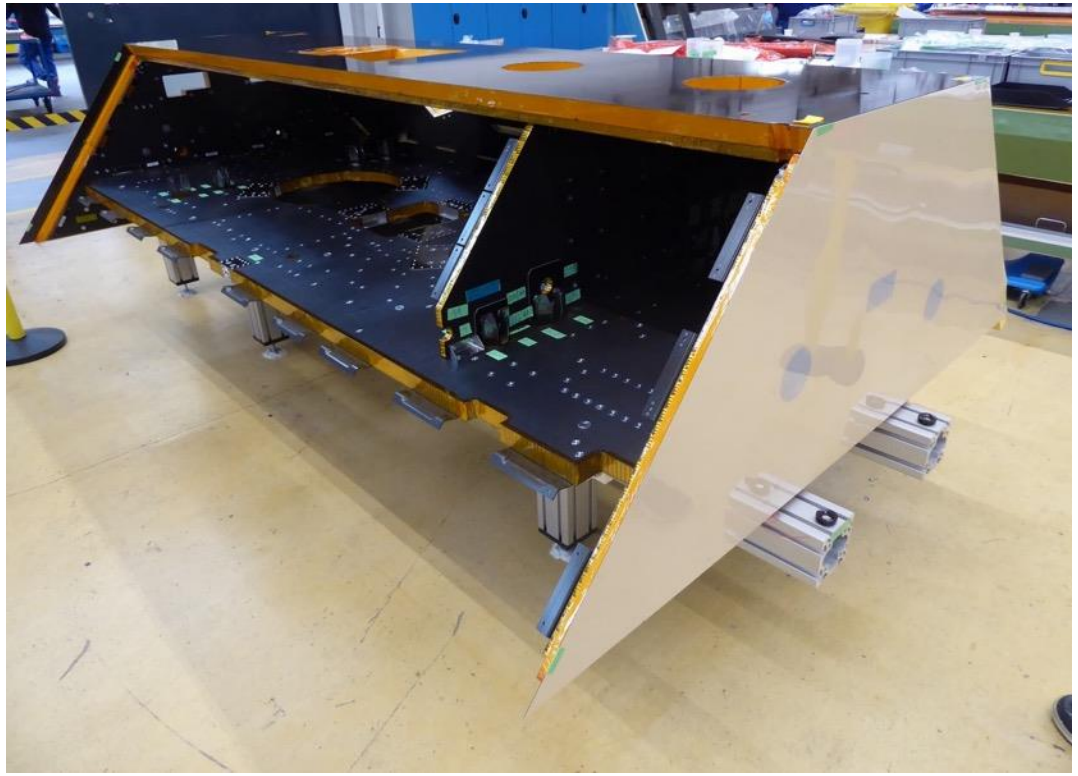
Photos courtesy Airbus DS, Germany.

GRACE-Continuity is taking shape: Testbed Computers & Solar Arrays.



Testbed Computers

- Elegant Breadboard (EBB)
- Engineering Model (EM)



FM1 Solar Array fit check

Photos courtesy Airbus DS, Germany.

GRACE-Continuity is taking shape: Propulsion Integration in the cleanroom.

FM1 structure moving to cleanroom for propulsion integration

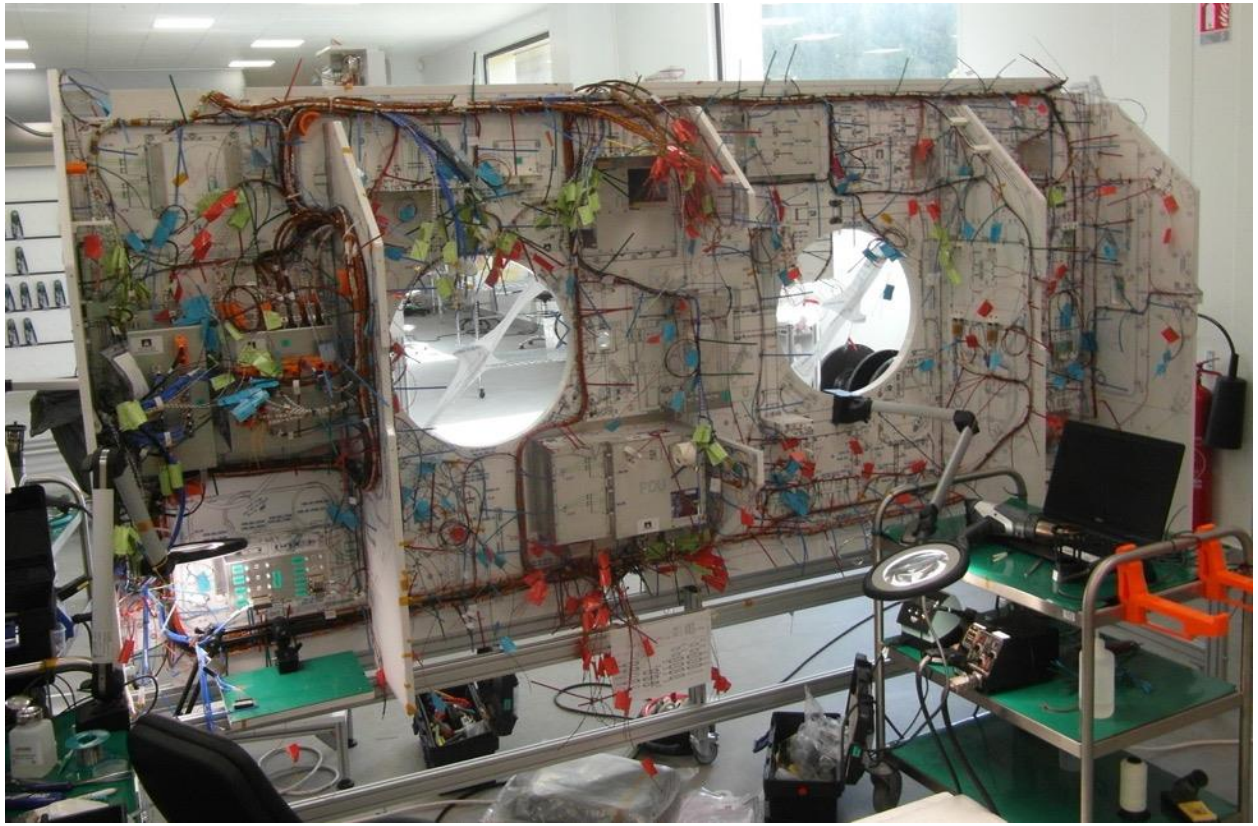
Photos courtesy Airbus DS, Germany.

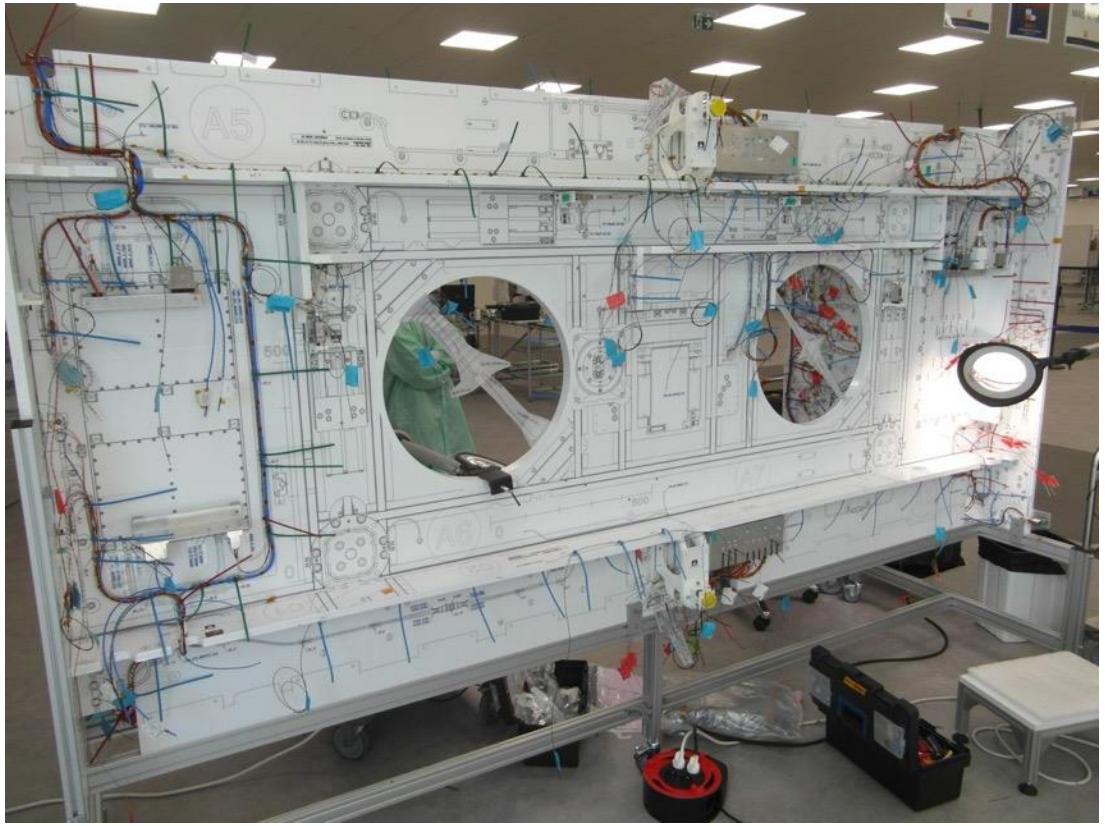
GRACE-Continuity is taking shape.
Satellite FM-1 Cold Gas Feed Module (AOCS).

- Cold Gas Feed Module and the associated pipework.
- The Feed Modules are currently in final assembly, with delivery projected for Q4 2025.

Photos courtesy Airbus DS, Germany.

GRACE-Continuity is taking shape.
Satellite FM-1 Flight Harness.





FM1 Flight Harness

Photos courtesy Airbus DS, Germany.

GRACE-Continuity is taking shape. Satellite bus and instruments are being built and tested: LRI Status

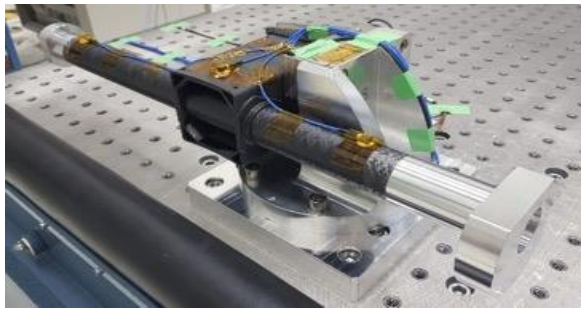
Flight Modules (FMs):

- LRP (Laser Ranging Processor) and Lasers have been delivered to JPL, integration and testing is underway
- SFU (Scale Factor Unit) to provide precise observations of any LRI frequency drifts are built and undergoing testing at JPL

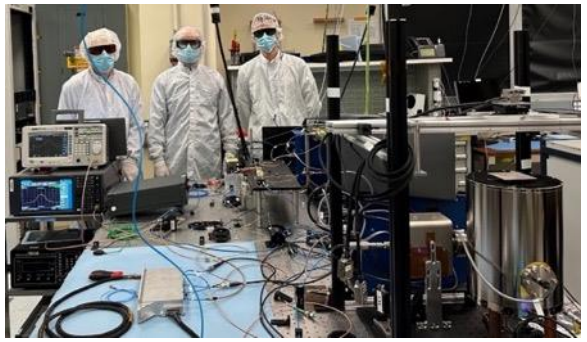
- LRI deliveries to Airbus starting in 2026
- Integration & Testing on the spacecraft throughout ’26 & ’27

LRP EM001 stack

EM cavity arrival and unpack



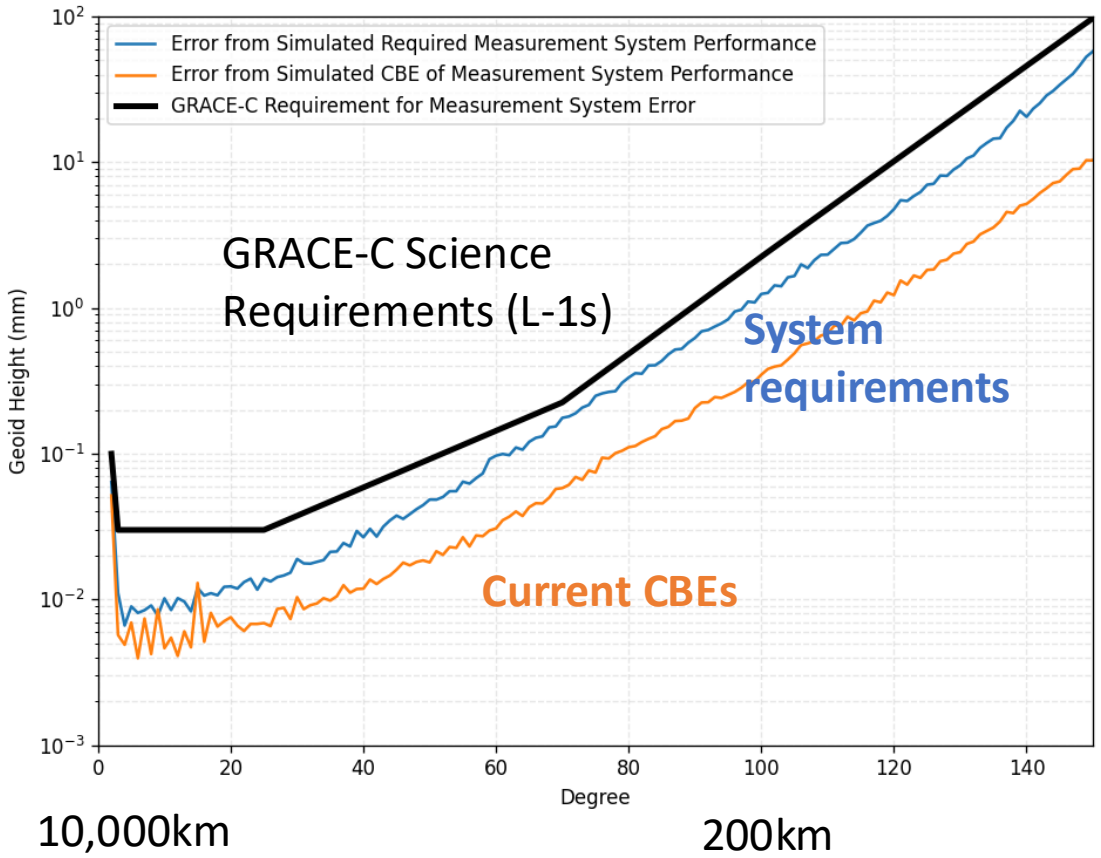
Structural TMA model in random vibe test



LRI Testbed SFU prototype testing

Summary

- **GRACE-C** implementation & testing phase is underway on schedule for a Dec-2028 launch
  - Will maintain and expand the foundational mass change measurements of Earth's changing water cycle
  - Based on (more redundant) LRI (no KBR, new SFU), spare GRACE-FO accelerometers and Podrix GNSS (GPS, Galileo) receivers
  - One year overlap with GRACE-FO (2029) planned for Cal/Val activities
- GRACE-C will constitute the polar orbit element of Mass-Change and Geosciences International Constellation (**MAGIC**) in 2032 with ESA´s Next Generation Gravity Mission (NGGM)

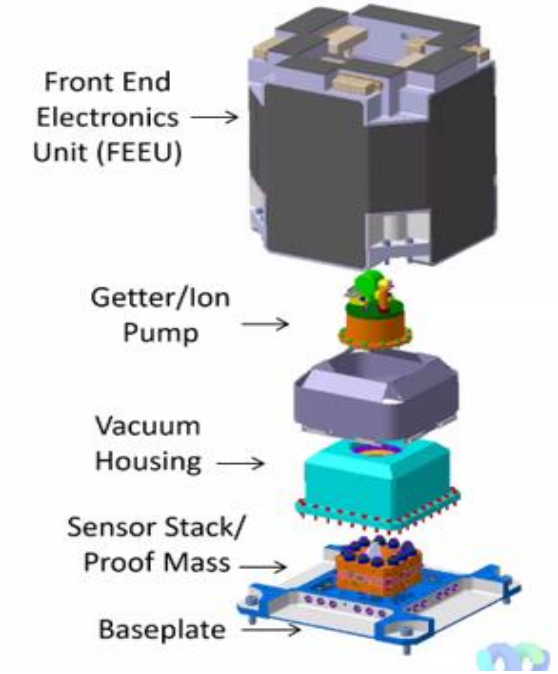


Status: Level-1 requirements are met.

Backup / Appendix

GRACE-Continuity is taking shape. Satellite bus and instruments are being built and tested: Instruments

Core Science Instruments:

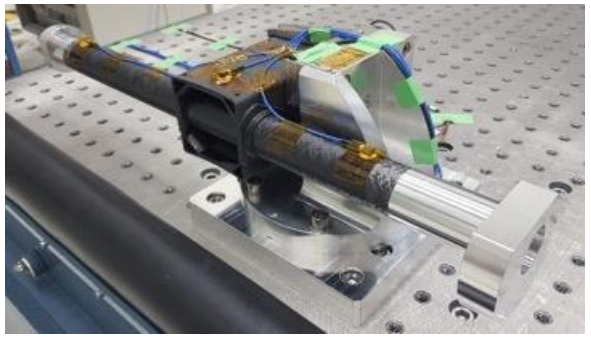


Accelerometer

- GRACE-FO spare units have been recertified for flight (delivery review held in June 2024) by repeating functional and performance tests
- ACC hardware is flight-proven, built, and will be delivered to spacecraft in mid-2026 for integration

GNSS Receiver

- PODRIX GNSS receiver from Beyond Gravity (replaces JPL furnished GPS within MWI)
- Block redundant
- Triple frequency (L1, L2, L5) (GPS/Galileo)
- Already flown on Sentinel-2 and 6



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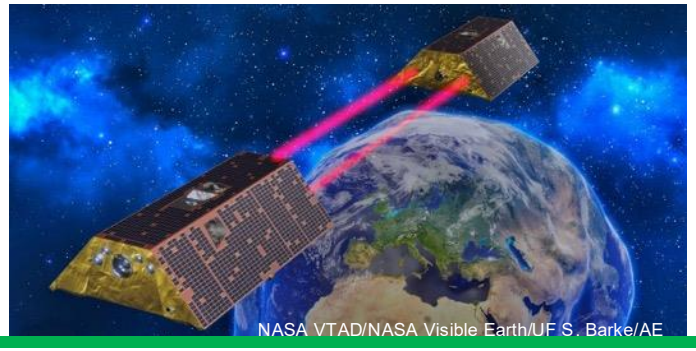
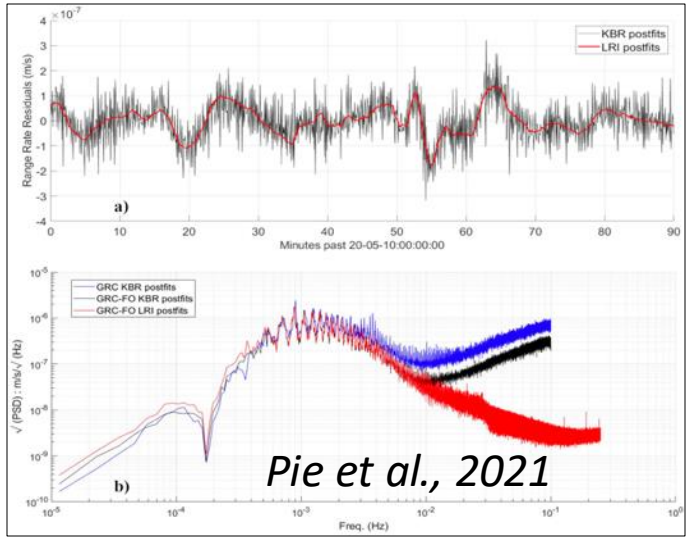


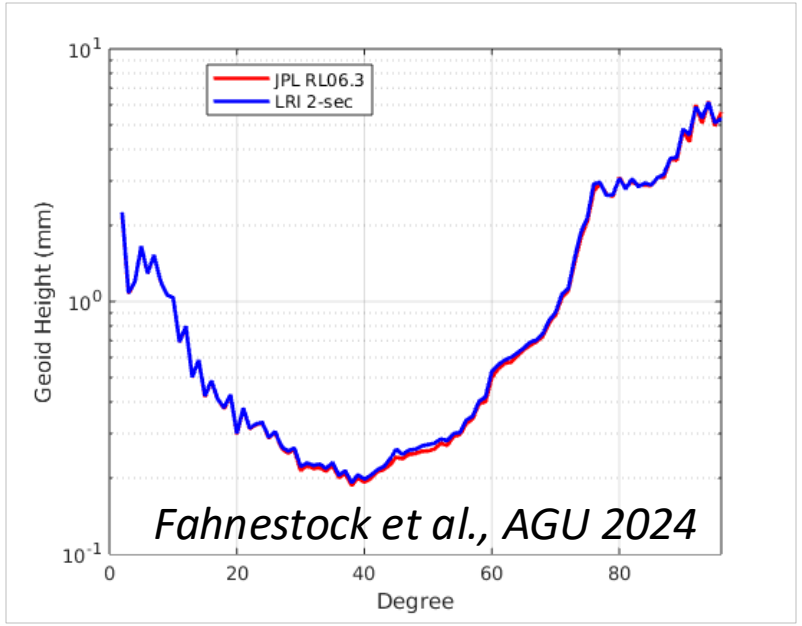
Laser Ranging Interferometer

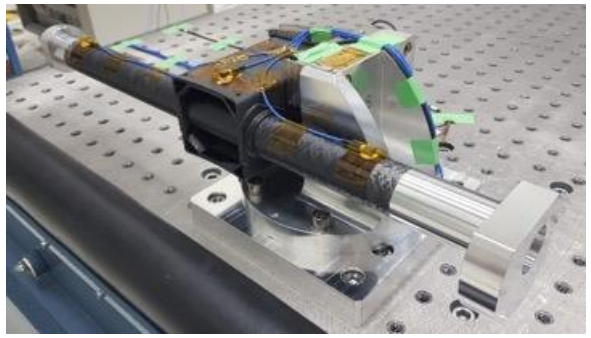
- GRACE-C will feature the LRI as the only ranging instrument (incl. more redundancy and a new Scale Factor Unit)
- GRACE-FO LRI experience 2018-2023: very stable, very low operational overhead
- Consistent GRACE-FO gravity fields derived from MWI and LRI data

GRACE-Continuity is taking shape. Satellite bus and instruments are being built and tested: LRI Heritage

Laser Ranging Interferometer was successfully demonstrated on GRACE-FO:







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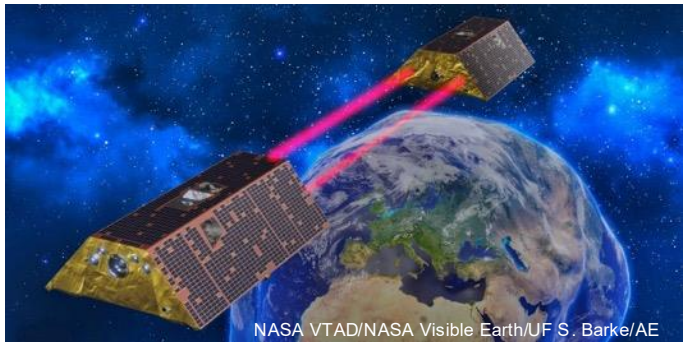

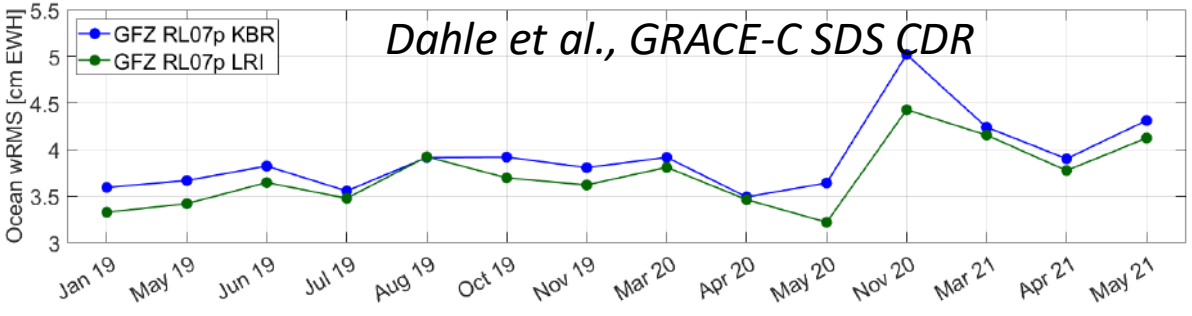

Ocean RMS (relative to climatology, 300 km smoothing) for comparison between GFZ KBR (blue) and LRI (green) solutions, both processed using preliminary GFZ RL07 processing standards

Laser Ranging Interferometer

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- GRACE-FO LRI experience 2018-2023: very stable, very low operational overhead
- **Consistent GRACE-FO gravity fields have been derived from MWI and LRI data**