The plan for technological developments

Nico Sneeuw
sneeuw@gis.uni-stuttgart.de
Institute of Geodesy
University of Stuttgart

Jakob Flury
flury@ife.uni-hannover.de
Institut für Erdmessung, QUEST
Leibniz Universität Hannover

Workshop
Towards a Roadmap for Future Satellite Gravity Missions
Graz
September 30 - October 2, 2009

priorities

- Short term
  - continuity
  - (or minimizing gap)
- Mid term
  - higher spatial resolution
  - higher temporal resolution
  - better accuracy
  - overcome undersampling
  - improve directional sensitivity
- Long term
  - investigation and implementation of novel technologies and concepts

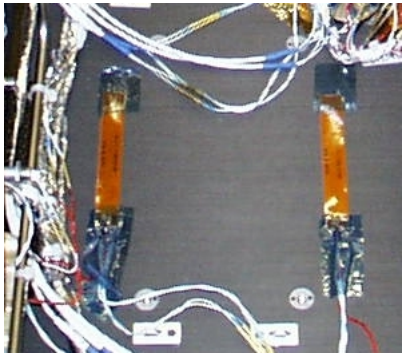
short term:
GRACE 2
a.k.a. GRACE Follow-On
a.k.a. gap-stop mission

GRACE 2: mission architecture

GRACE heritage, but lessons learnt:

(incremental improvements)

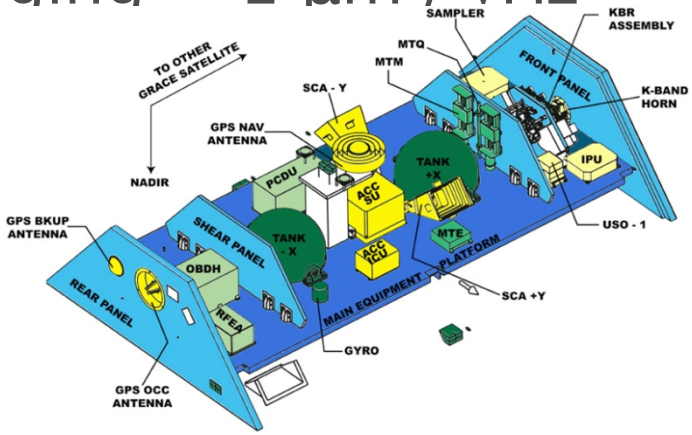
- GRACE-type formation
- height 350–400 km
- range 50–200 km (TBC)
- lifetime 5–10 yr
- orbit maintenance, repeat orbit (TBC)
- better ACC
- new/improved/smoother AOCS
- better thermal control



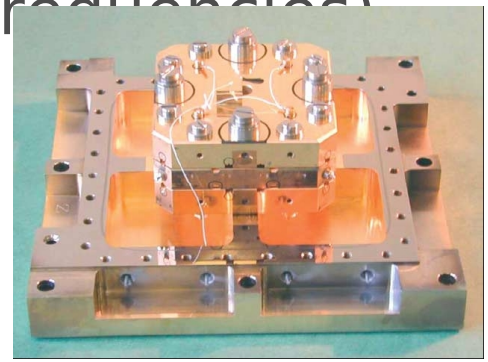
heaters

GRACE 2: payload

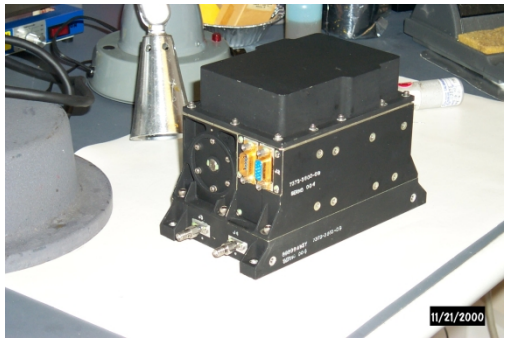
- Microwave inter-satellite ranging ~ 1 µm / √Hz
- GRACE lessons learnt
  - USO
  - SNR issues
  - phase center stability
  - thermal effects



- accelerometer, at least 3x better sensitivity
- GNSS receiver (GPS, Galileo?, #channels, #frequencies)



accelerometer sensor head
ONERA



black-jack GPS receiver

GRACE 2: add-on

- technology demonstrator
  - Active transponder laser interferometer instrument
  - ~10 nm / √ Hz
  - frequency stabilization
  - pointing stability
  - lifetime?
  - ...
- GNSS reflectometry
- if allowed by schedule & cost

GRACE 2: technology roadmap

- Critical developments: none
- Components: platform, KBR, ACC, AOCS development
- Laser demonstrator
  - phase meter
  - AOCS/additional pointing actuator
  - launcher
- Not included due to time restrictions/risk/cost
  - drag-free
  - multiple pairs
  - pendulum formation
  - more accelerometers per satellite
- Timeline: 2 years

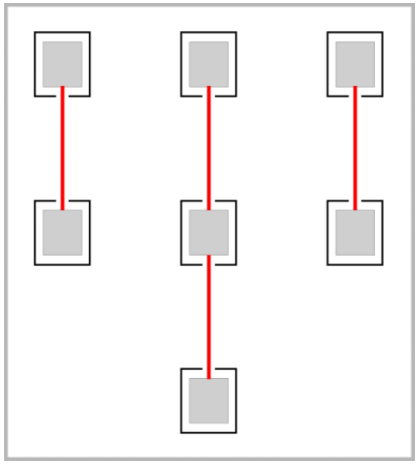
mid term

next generation mission: architecture

- 2 or more satellite pairs
- laser satellite-to-satellite tracking
- at least one polar orbit for ice processes
- perhaps 2nd pair on lower inclination (>1 launch?)
- Formation
  - pendulum
  - cartwheel: feasibility TBC
  - TRL: GRACE > pendulum > cartwheel> Lisa-type
- Lifetime goal 7-10 y
- Altitude: 300–400 km

next generation mission: technology

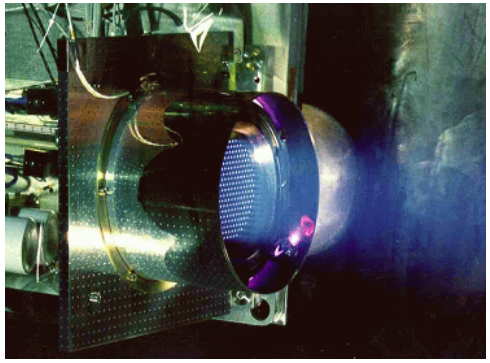
- Inter-satellite ranging
  - active laser interferometer (5 nm / √ Hz, frequency stabilization, fine pointing, ...)
  - passive retroreflector laser interferometer (10 nm ?)
  - frequency comb laser (absolute range)
- ACC, accelerometer pair?
- AOCS & DFC: ion propulsion (mini-RIT), FEEPs, GOCE/LPF heritage, for non-sun-synchronous orbit? Lifetime? Degrees of freedom?
- platform stability improvement
- explore complementary payload (GNSS reflectometry, ...)
- laser gravity gradiometer (TBC)



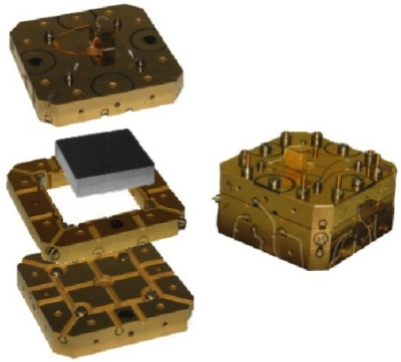
laser gradiometer concept

next generation mission: roadmap

- major effort for progress in de-aliasing
- studies of mission architectures and sensitivity (ESA, BMBF, CNES, …)
- laser systems development ongoing (frequency stabilization)
- low-thrust thrusters (mini-RITs, others)
- accelerometer (smaller, more stable)



ion thruster



ACC, ONERA

long term

spaceborne gravimetry 2020?

- modularity
  - multi-satellite-pair scalable concept
  - later launches (e.g. China?) can always join and improve spatio-temporal resolution
- Future technology
  - GOCE is not the endpoint for solid test masses
  - atomic interferometry → AI-based gradiometry?
  - optical clocks in space → differental potential meter?

long term technology roadmap

- what is the geodetic observable?
- technological readiness
- space qualification
- cost reduction & miniaturization → sensor webs

Spaceborne gravimetry

- science and engineering coupled