Concept and Capability of GOCE

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Outline

1. The GOCE Mission
   - Mission Concept & Goals
   - Performance
   - Instruments

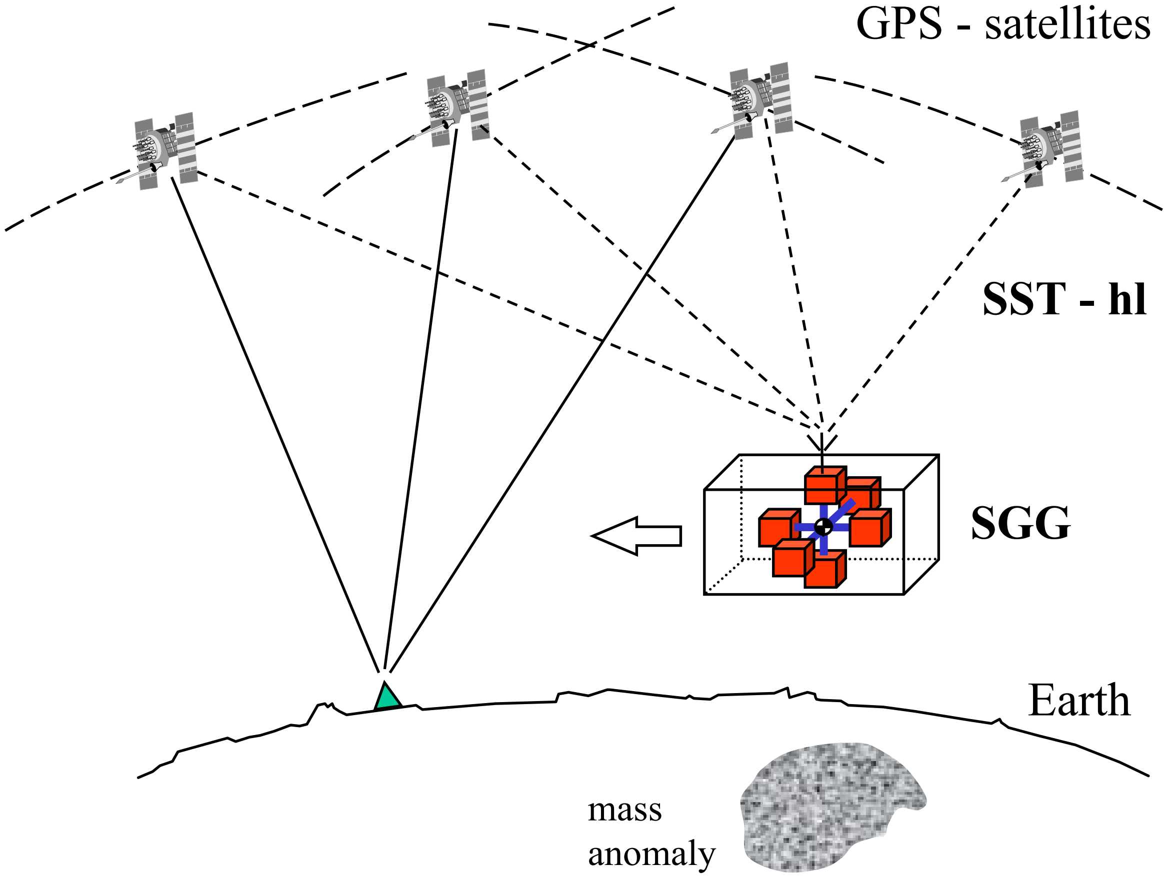
2. GOCE Data Processing
   - Gradiometry
   - Ground System Elements

GOCE Mission Concept

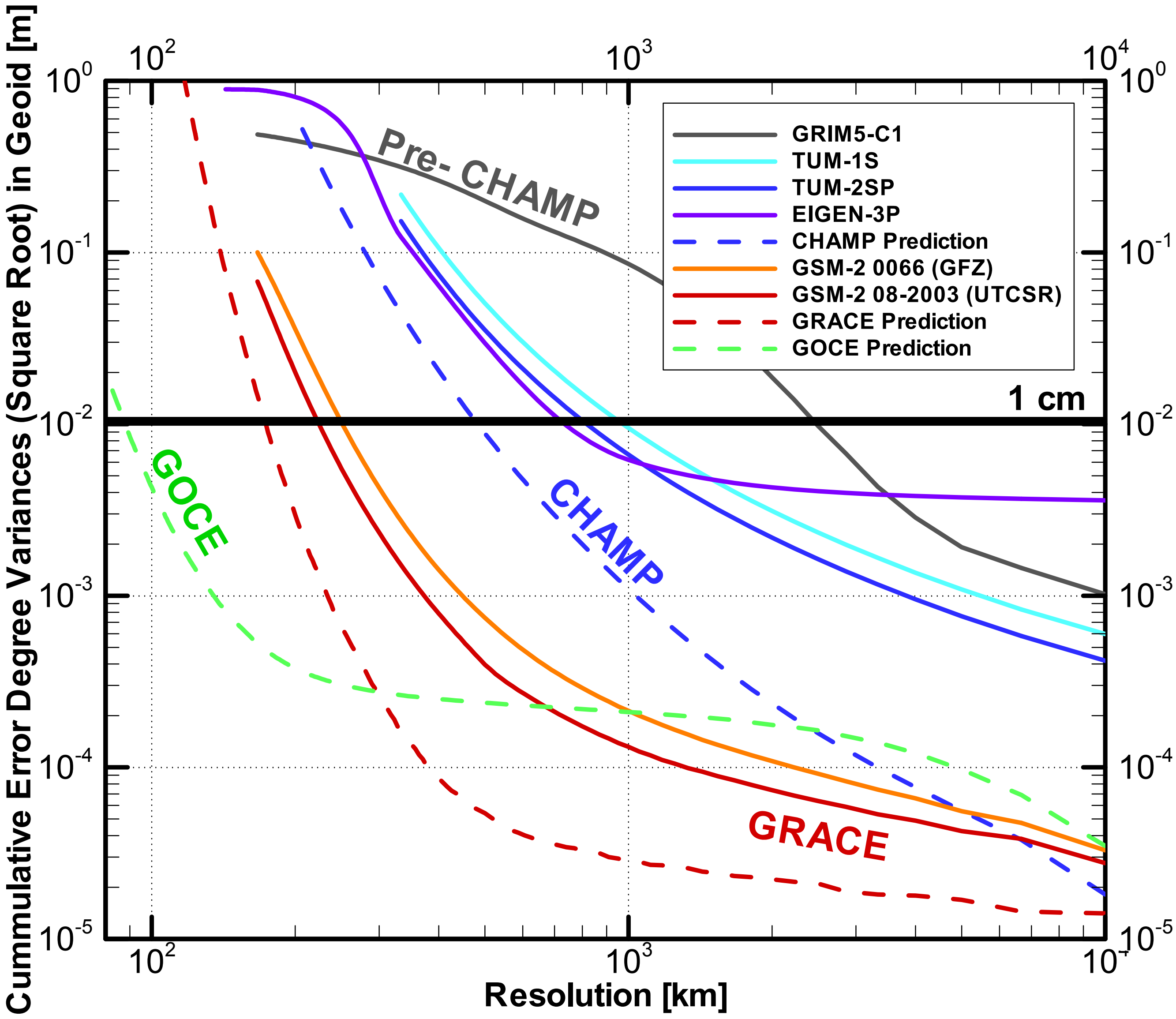
GOCE: Gravity and Steady-State **O**cean **C**irculation **E**xplorer

Basic Sensors: 3 Axis Gravity-Gradiometer and GPS high-low tracking

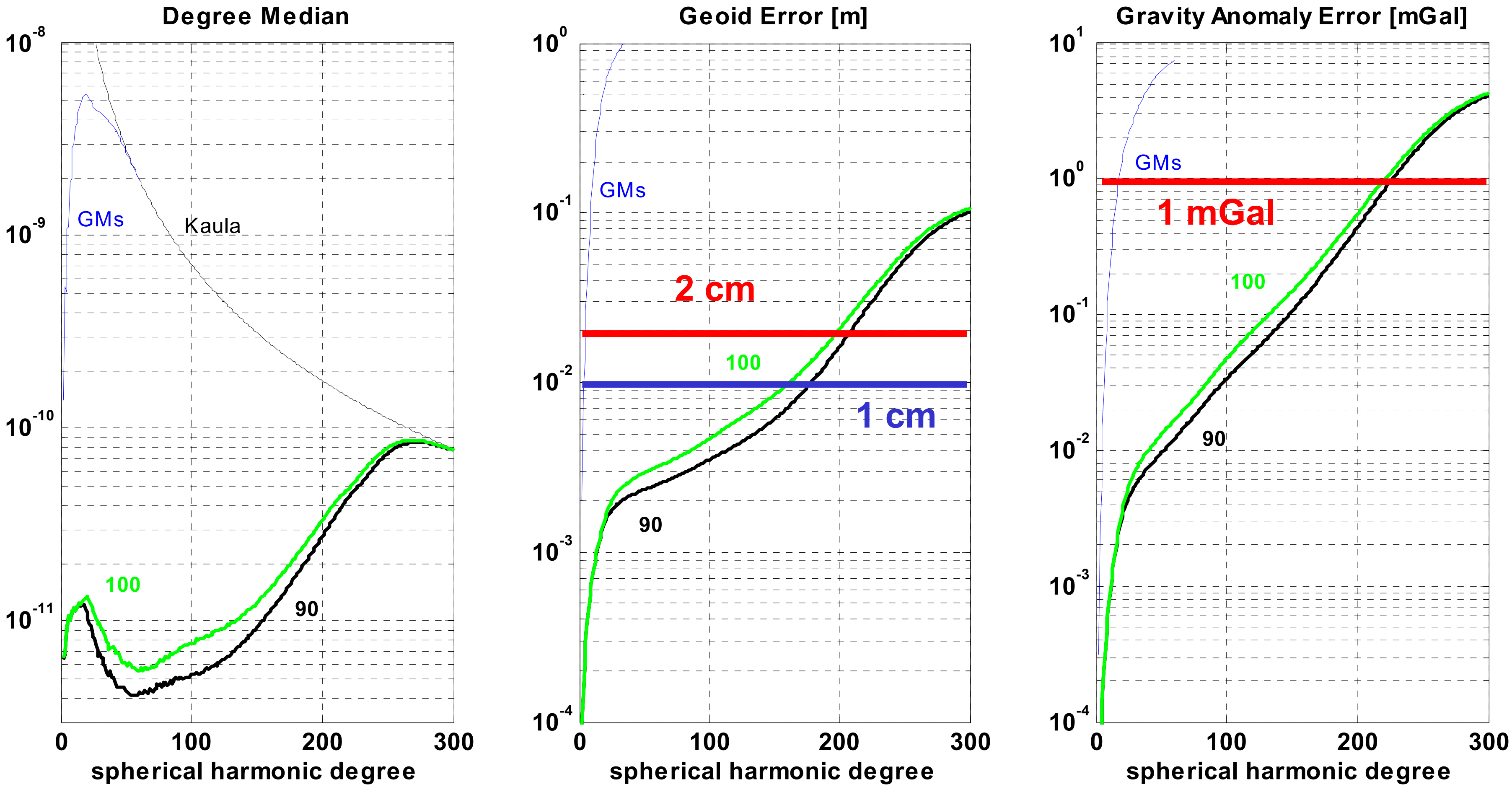
Launch: Second half of 2006



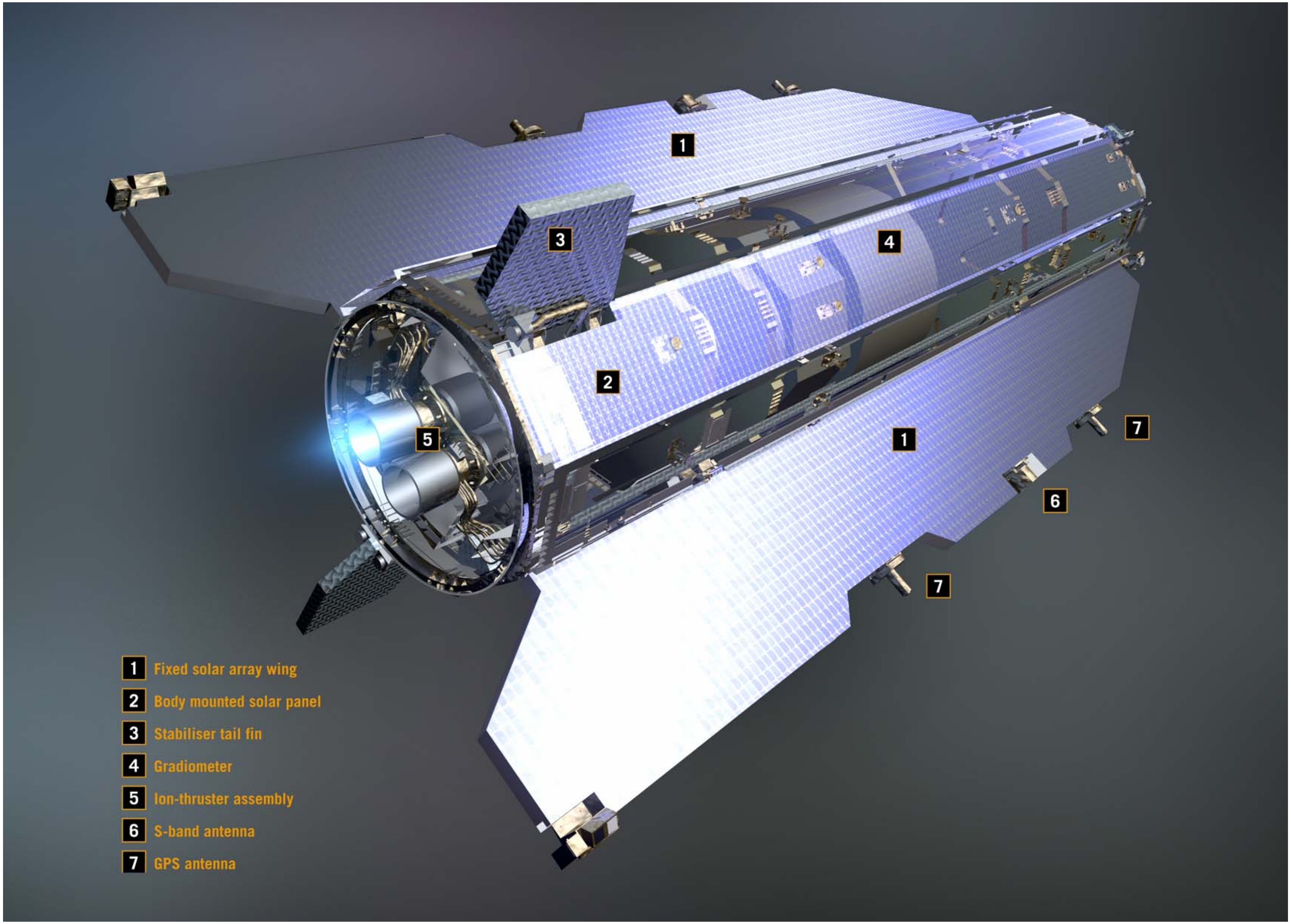
Goals of Gravity Field Missions



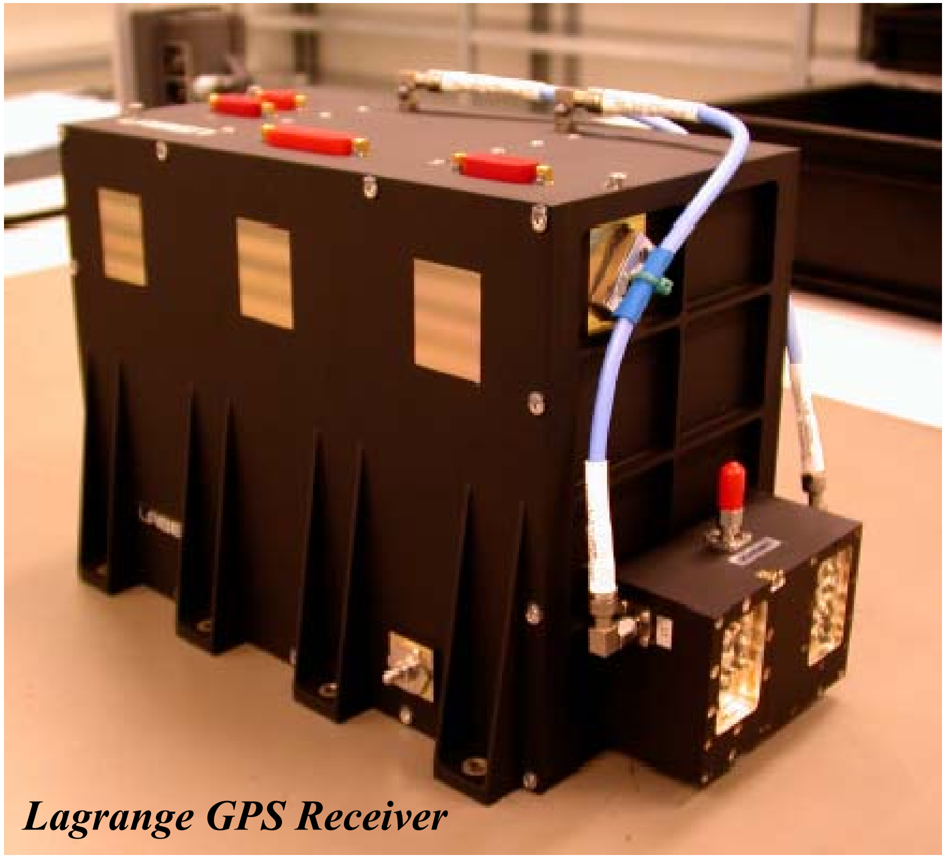
GOCE Performance Simulation



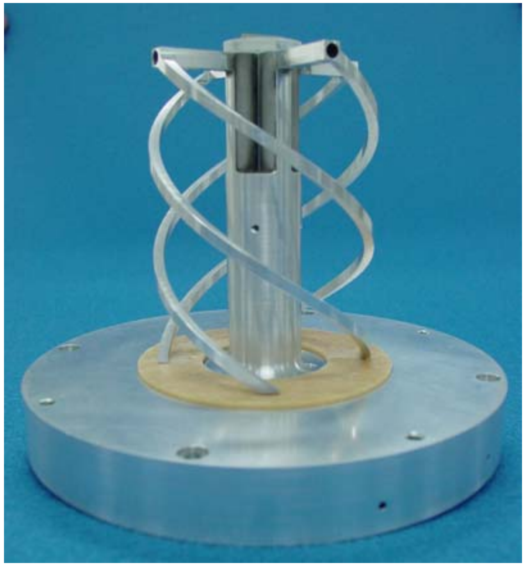
GOCE Satellite and Core Instruments



GOCE Instruments - GPS



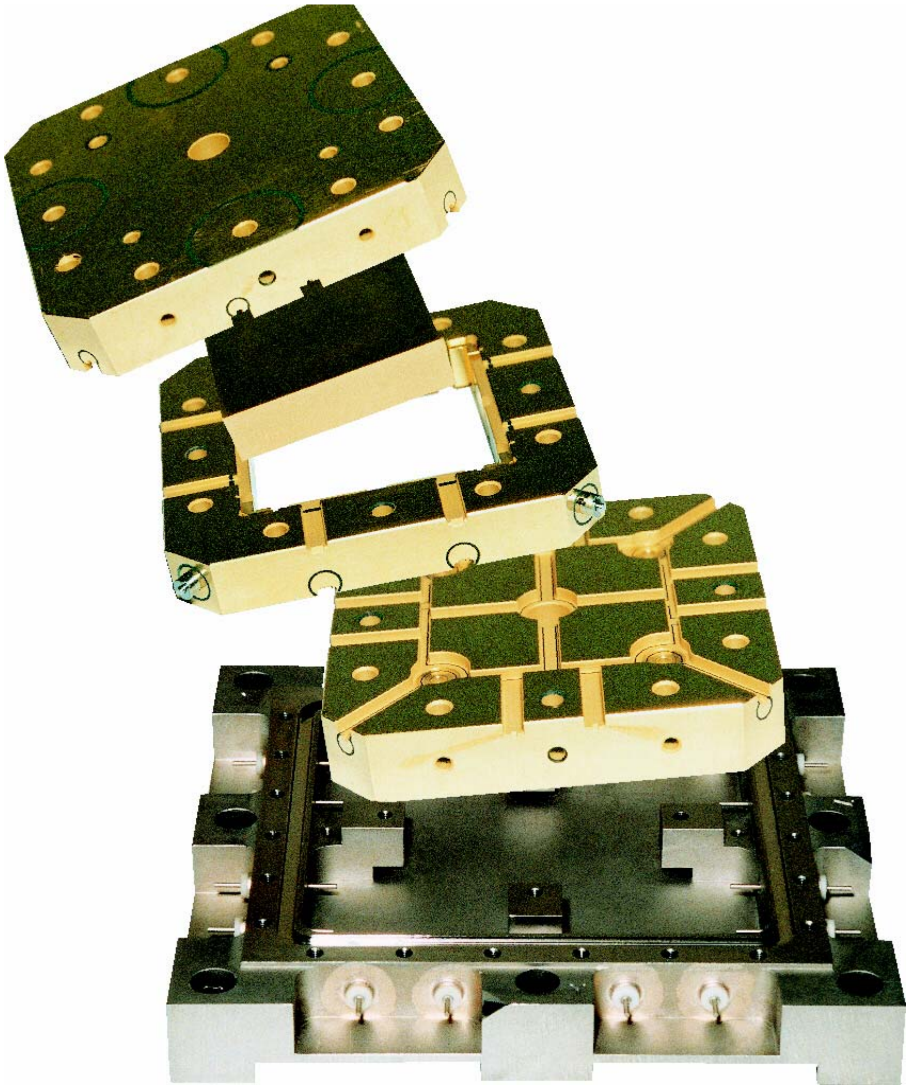
Lagrange GPS Receiver



GPS Antenna

- ❑ **Dual receiver units (LABEN)**
  - ✓ **12 dual-frequency channels**
  - ✓ **L1 C/A code**
  - ✓ **L1, L2 P(Y) code**
  - ✓ **L1 (LA), L2 carrier phase**
  - ✓ **L1 integrated Doppler**
  - ✓ **On-board measurement of C/No ratio**

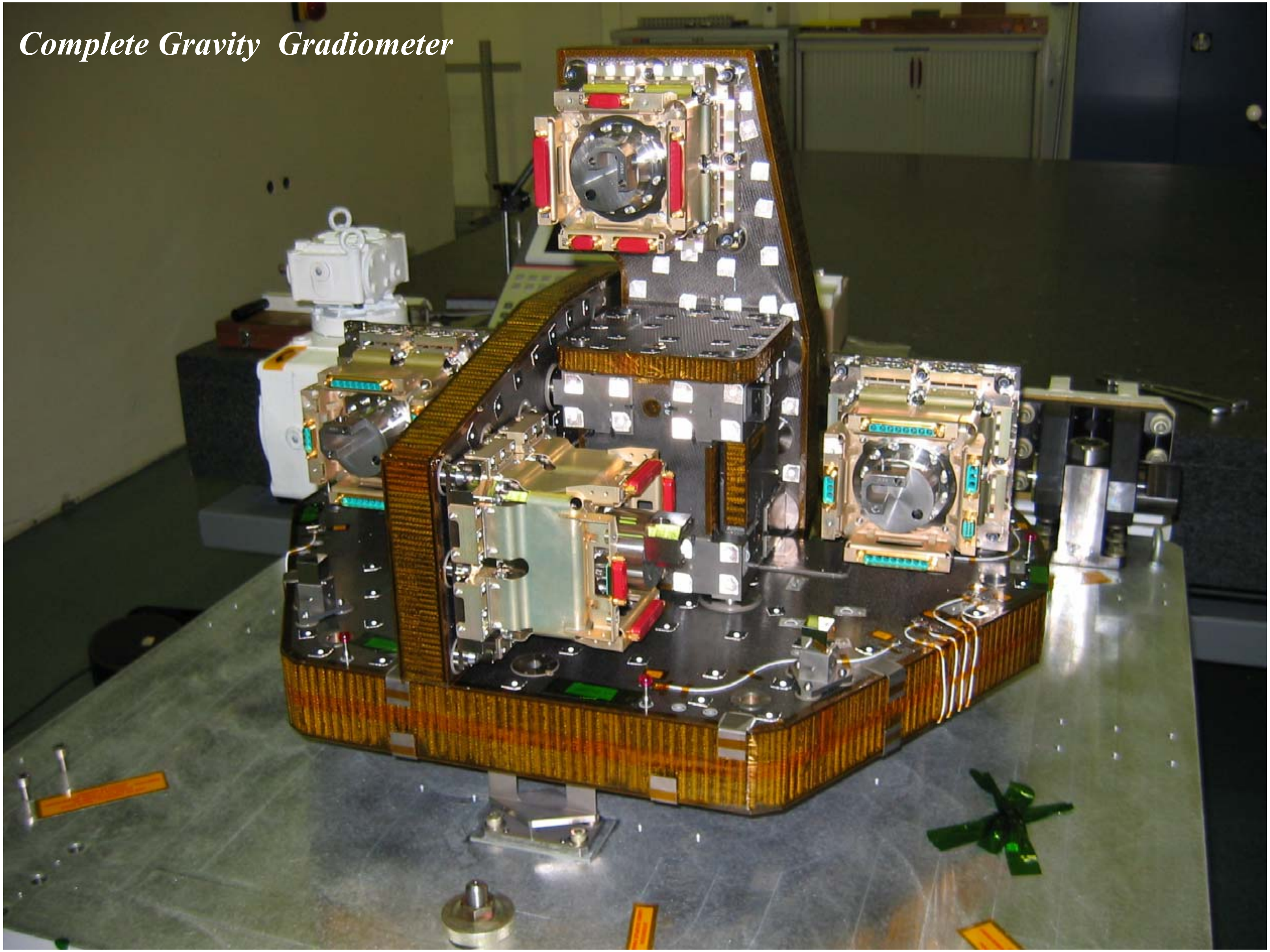
GOCE Instruments - Gradiometer



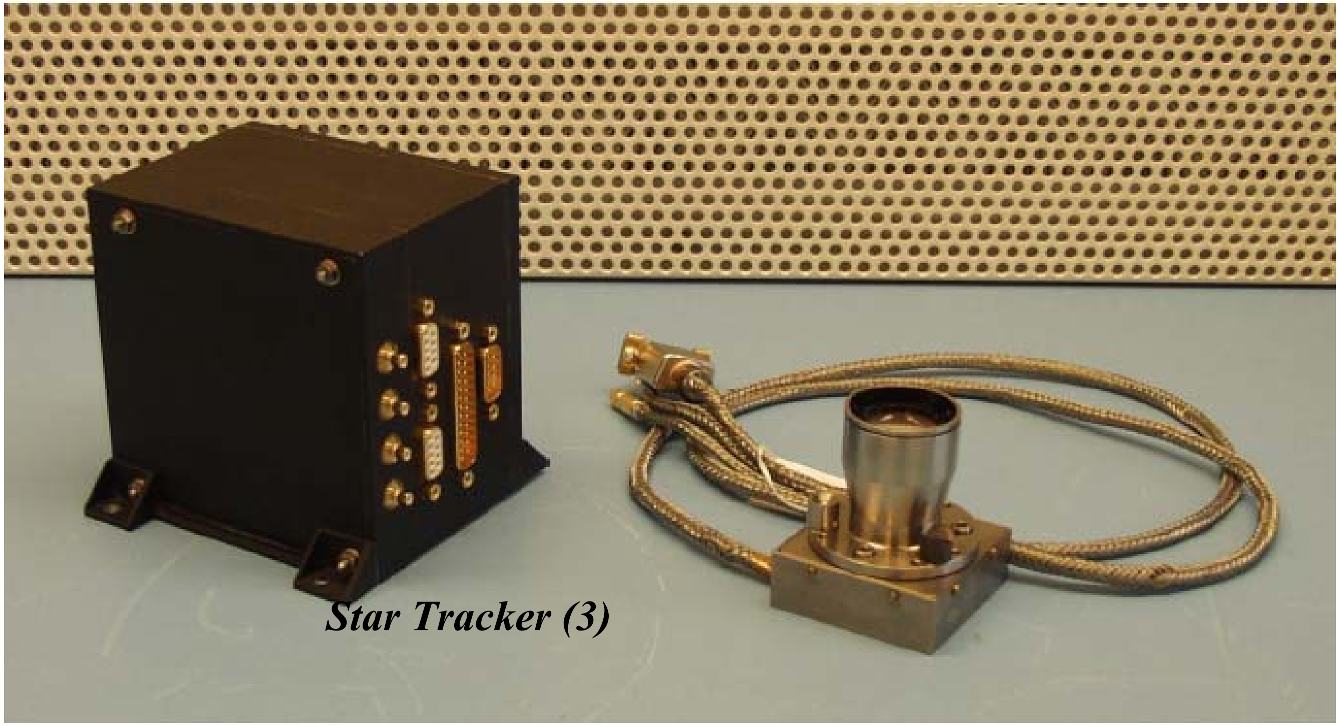
Accelerometer Sensor Heads

- Pt-Rh proof mass of 4x4x1 cm and 320 g mass
- Accelerometer cage made of ULE ceramics with gold electrodes for 6 DOF control
- Sole plate in INVAR
- 8 electrode pairs per sensitive element (for redundancy reasons)
- Proof mass grounded by a 25 mm long and 5 micron “thick” gold wire

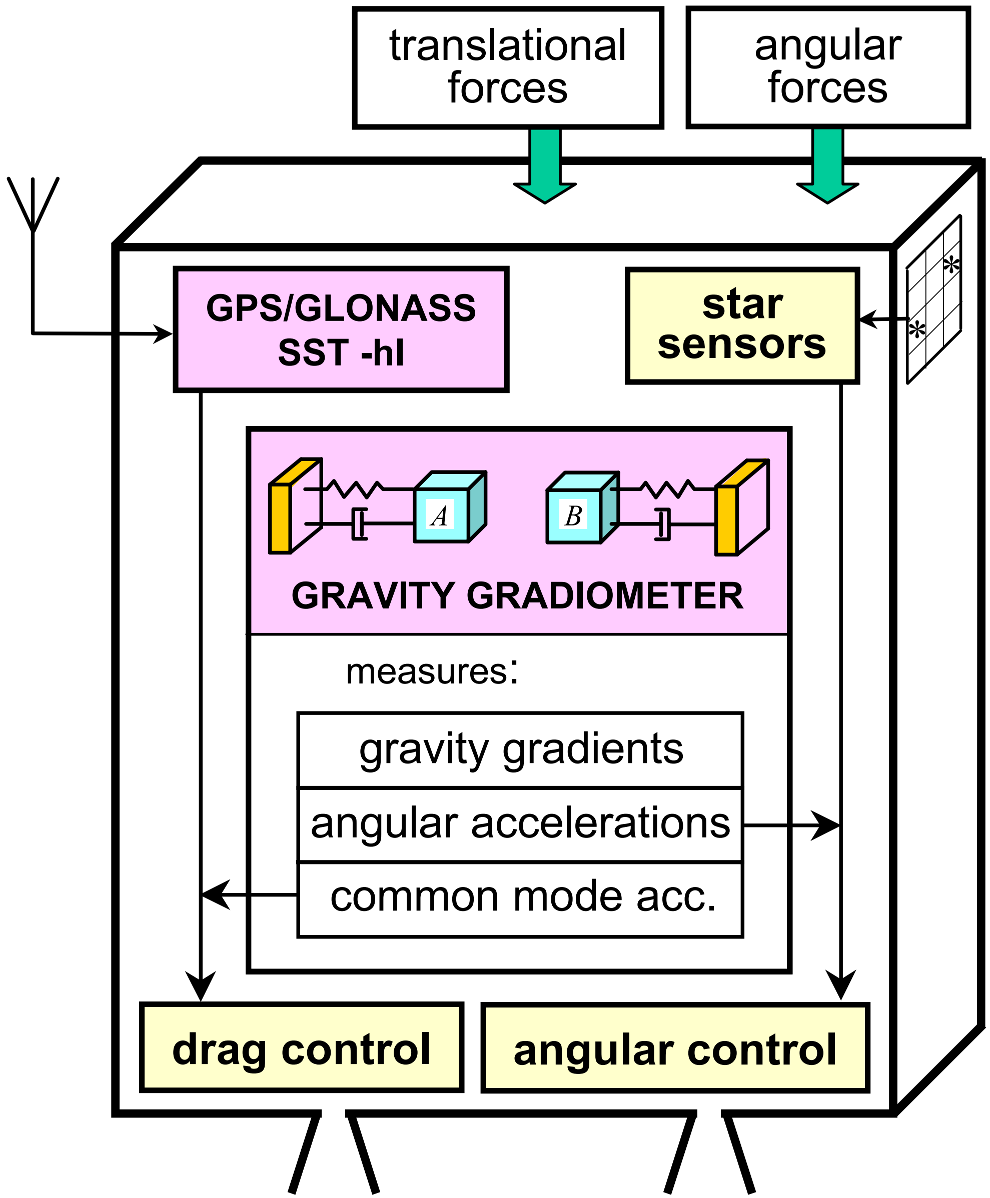
GOCE Instruments - Gradiometer



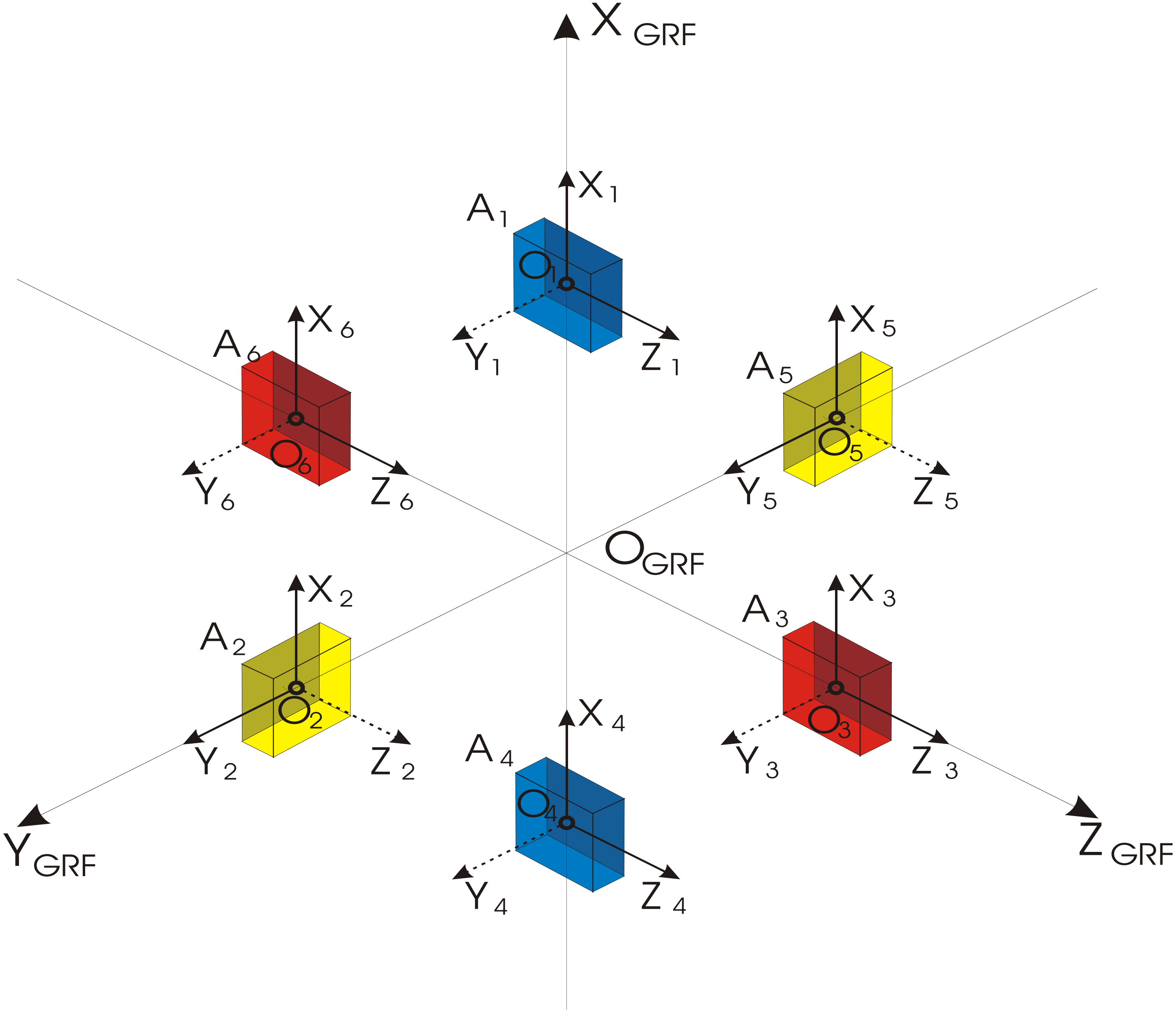
GOCE Instruments – Attitude Control



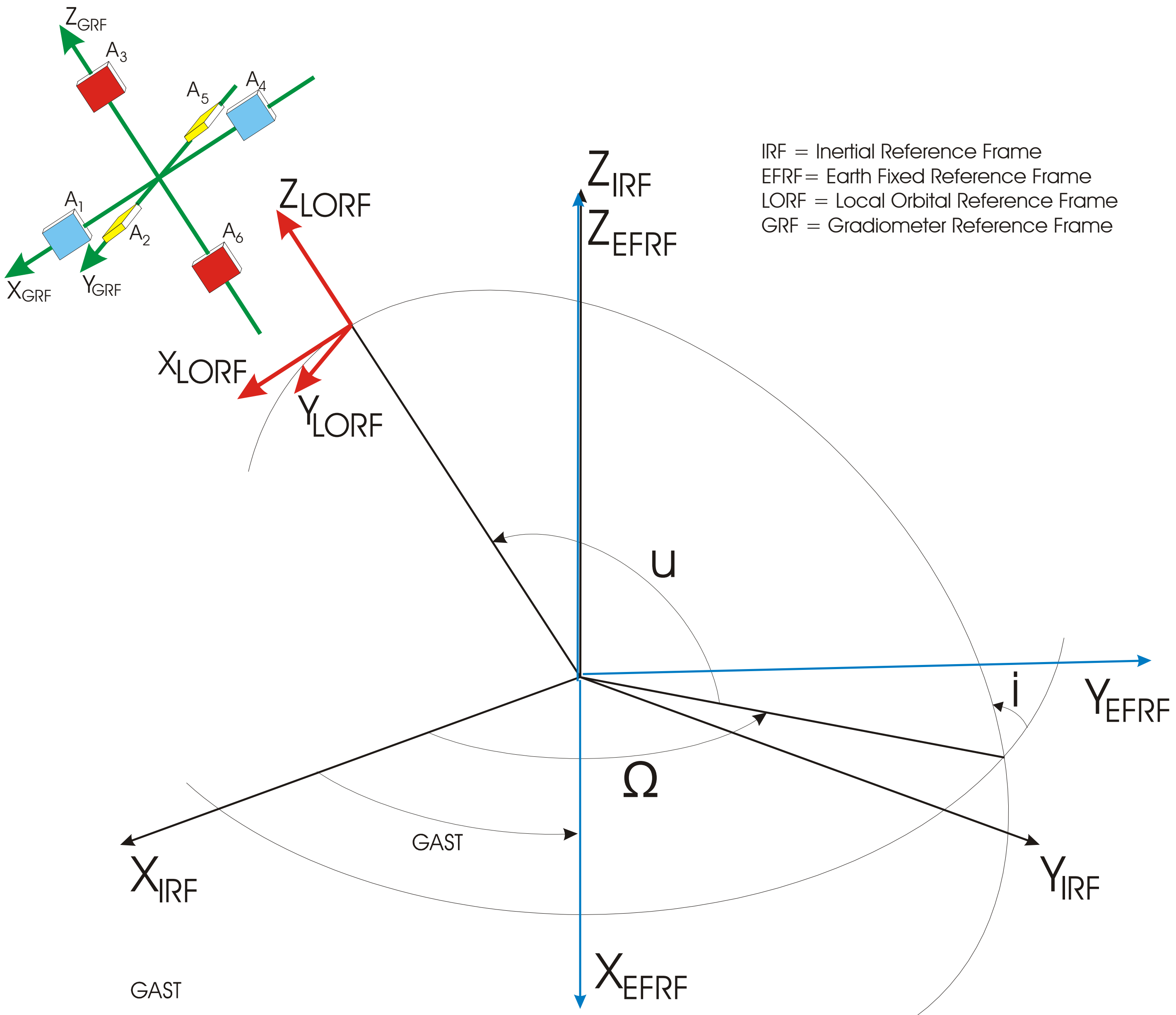
GOCE Instrument System



Gradiometry – Gradiometer Reference Frame



Gradiometry – Gradiometer in Orbit



Gradiometry – Simplified Observation Equation

$$\underline{a} = -\underline{V} \cdot \underline{r} + \underline{\dot{\omega}} \times \underline{r} + \underline{\omega} \times (\underline{\omega} \times \underline{r})$$

the linear acceleration of accelerometer proof mass induced by the gravity potential	the linear acceleration of accelerometer proof mass induced by satellite angular accelerations	the centrifugal acceleration of accelerometer proof mass induced by satellite angular rotation

Not taking into account accelerometer bias and scale factors, misalignments, centre of mass displacements, etc.

Gradiometry – Common Mode Accelerations for Drag Control

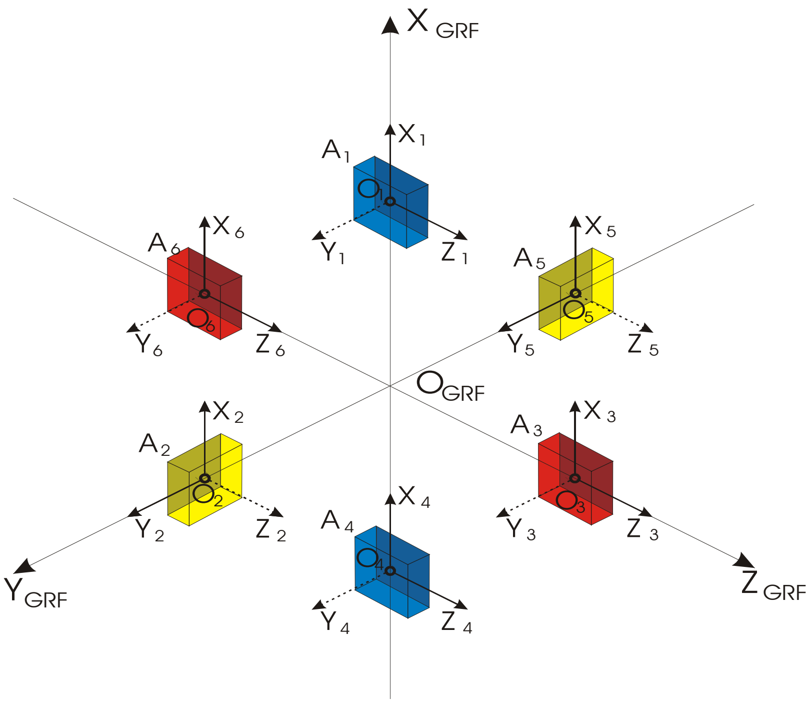
Example: Accelerometer Pair 1-4

$$a_{c,1,4,x} = \frac{1}{2}\left(a_{1,x} + a_{4,x}\right) = \frac{1}{2}\left(-V_{xx} - \omega_y^2 - \omega_z^2\right)\frac{L_x}{2} + \frac{1}{2}\left(-V_{xx} - \omega_y^2 - \omega_z^2\right)\left(-\frac{L_x}{2}\right) =$$

$$= \frac{L_x}{4}\left(-V_{xx} - \omega_y^2 - \omega_z^2 + V_{xx} + \omega_y^2 + \omega_z^2\right) = 0$$

$$a_{c,1,4,y} = \frac{1}{2}\left(a_{1,y} + a_{4,y}\right) = 0$$

$$a_{c,1,4,z} = \frac{1}{2}\left(a_{1,z} + a_{4,z}\right) = 0$$



In analogy for accelerometer pairs 2-5 and 3-6:

$a_{c,2,5,x}$, $a_{c,2,5,y}$, $a_{c,3,6,x}$, $a_{c,3,6,z}$, $a_{c,2,5,z}$, $a_{c,3,6,y}$

green	highly sensitive axis
red	less sensitive axis
magenta	combination of two less sensitive axes

Gradiometry – Differential Mode Accelerations for Angular Control and Gravity Gradients

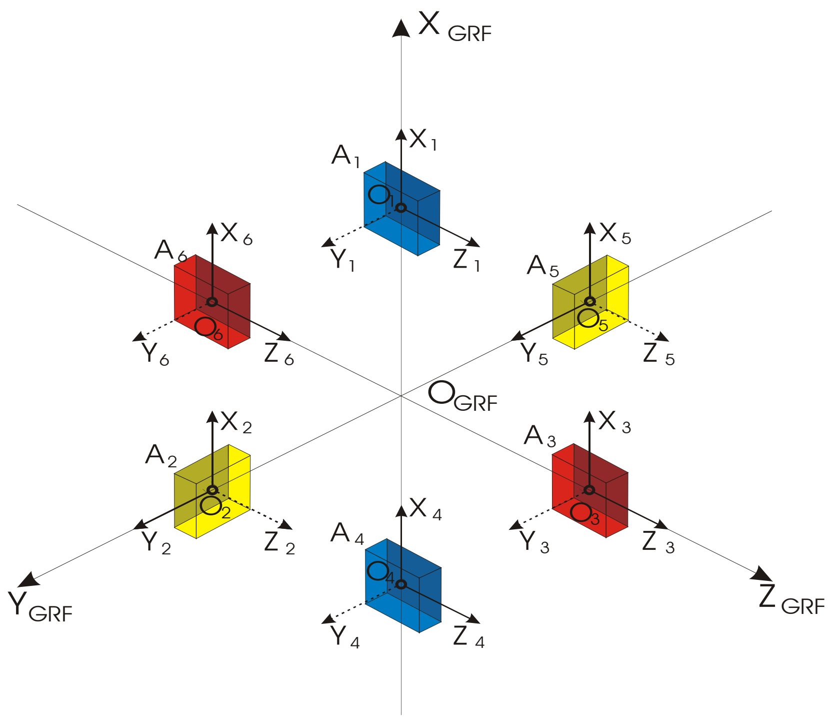
Example: Accelerometer Pair 1-4

$$a_{d,1,4,x} = \frac{1}{2}\left(a_{1,x} - a_{4,x}\right) = \frac{1}{2}\left(-V_{xx} - \omega_y^2 - \omega_z^2\right)\frac{L_x}{2} - \frac{1}{2}\left(-V_{xx} - \omega_y^2 - \omega_z^2\right)\left(-\frac{L_x}{2}\right) =$$

$$= \frac{L_x}{4}\left(-2V_{xx} - 2\omega_y^2 - 2\omega_z^2\right) = \frac{L_x}{2}\left(-V_{xx} - \omega_y^2 - \omega_z^2\right)$$

$$a_{d,1,4,y} = \frac{1}{2}\left(a_{1,y} - a_{4,y}\right) = \frac{L_x}{2}\left(-V_{yx} + \dot{\omega}_z + \omega_x\omega_y\right)$$

$$a_{d,1,4,z} = \frac{1}{2}\left(a_{1,z} - a_{4,z}\right) = \frac{L_x}{2}\left(-V_{zx} - \dot{\omega}_y + \omega_x\omega_z\right)$$



In analogy for accelerometer pairs 2-5 and 3-6:

$a_{d,2,5,x}$, $a_{d,2,5,y}$, $a_{d,3,6,x}$, $a_{d,3,6,z}$, $a_{d,2,5,z}$, $a_{d,3,6,y}$

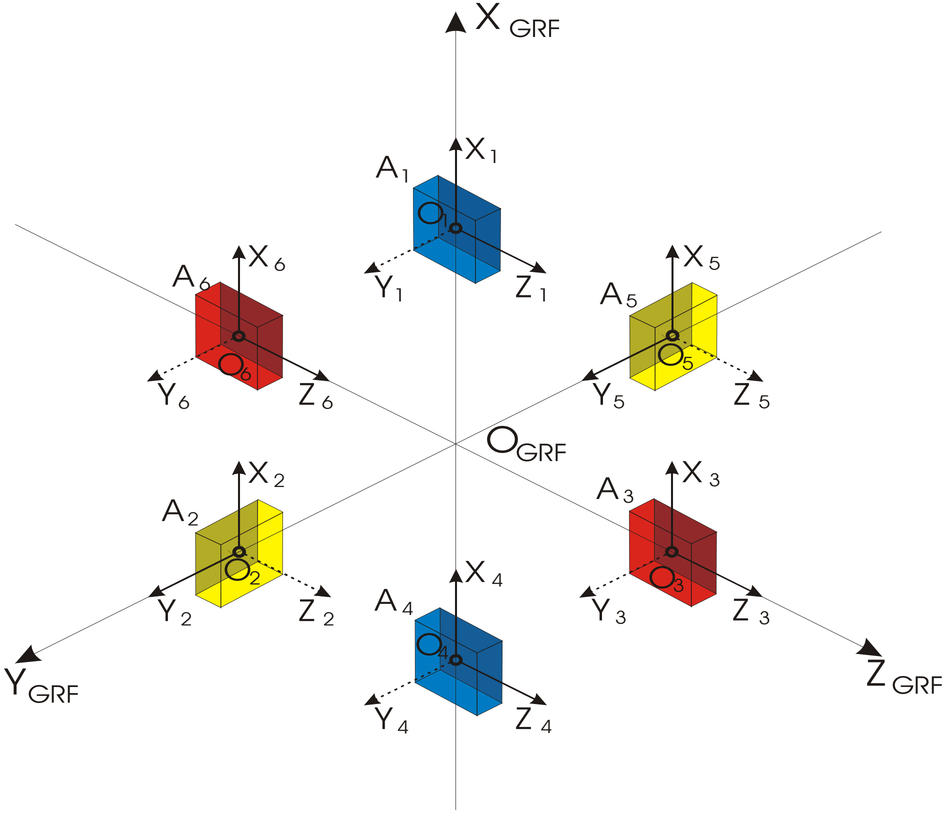
green	highly sensitive axis
red	less sensitive axis
magenta	combination of two less sensitive axes

Gradiometry – Angular Accelerations

$$2\dot{\omega}_x = -\frac{2a_{d,3,6,y}}{L_z} - V_{yz} + \omega_y\omega_z + \frac{2a_{d,2,5,z}}{L_y} + V_{zy} - \omega_y\omega_z \quad ; \quad \dot{\omega}_x = -\frac{a_{d,3,6,y}}{L_z} + \frac{a_{d,2,5,z}}{L_y}$$

$$\dot{\omega}_y = -\frac{a_{d,1,4,z}}{L_x} + \frac{a_{d,3,6,x}}{L_z}$$

$$\dot{\omega}_z = \frac{a_{d,1,4,y}}{L_x} - \frac{a_{d,2,5,x}}{L_y}$$



green	highly sensitive axis
red	less sensitive axis
magenta	combination of two less sensitive axes

Gradiometry – Gravity Gradients

$V_{xx} = -\frac{2a_{d,1,4,x}}{L_x} - \omega_y^2 - \omega_z^2$		
$V_{xy} = -\frac{a_{d,1,4,y}}{L_x} - \frac{a_{d,2,5,x}}{L_y} + \omega_x\omega_y$	$V_{yy} = -\frac{2a_{d,2,5,y}}{L_y} - \omega_x^2 - \omega_z^2$	
$V_{xz} = -\frac{a_{d,1,4,z}}{L_x} - \frac{a_{d,3,6,x}}{L_z} + \omega_x\omega_z$	$V_{zy} = -\frac{a_{d,2,5,z}}{L_y} - \frac{a_{d,3,6,y}}{L_z} + \omega_y\omega_z$	$V_{zz} = -\frac{2a_{d,3,6,z}}{L_z} - \omega_x^2 - \omega_y^2$

green	highly sensitive axis
red	less sensitive axis
magenta	combination of two less sensitive axes