Experimental investigations of an inertial reference sensor with spherical test mass and optical read out

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Motivation

An alternative eLISA payload concept with In-Field Pointing (IFP) was proposed which aligns the line of sight of each telescope by an actuated mirror, the IFP-Mechanism, compensating for orbital driven geometrical changes of the satellite formation:

- In-Field Pointing replaces Telescope Pointing
- Single active test mass concept with reduced guiding
- Single optical bench without back-link fibers

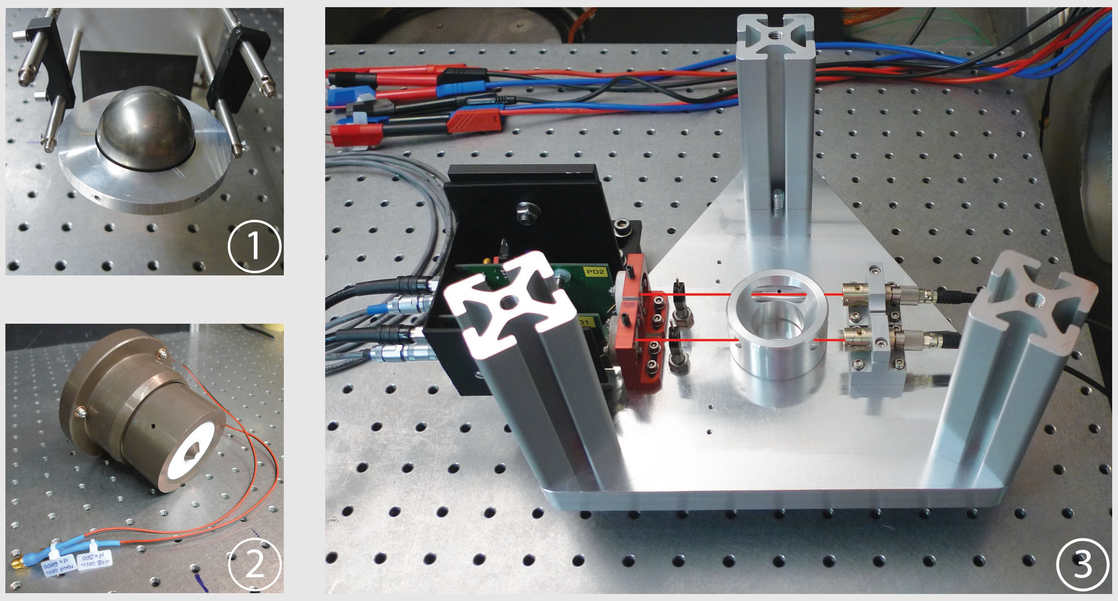
Potential performance improvements could be achieved by combining the IFP concept with a spherical test mass:

- No test mass guiding during science runs
- Larger gap between test mass and housing
- Enabling an all optical read out of test mass

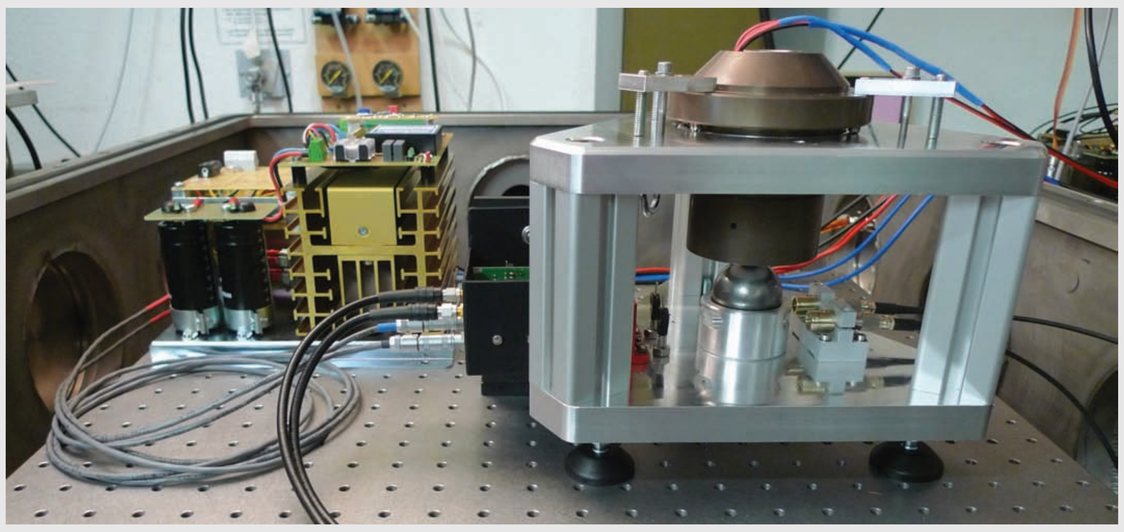
Levitation Test Bed

A levitation test bed is currently under construction to get some experience of levitating a spherical test mass. An electro-magnetic system is the chosen principle using a controlled electro-magnet and a magnetizable test mass. Starting point is a levitation system with 1 DoF guidance:

- Spherical test mass:
  - Diameter: ⌀40 mm
  - Surface quality (before coating): 60 nm (rms)
- Levitation of test mass via two level electro-magnet:
  - Dual-coil with 500 and 6000 windings for test mass height control
  - Controlling via FPGA based cascade control loop system
- Optical height sensing system by light barrier principle:
  - Two beam system for detection of lateral test mass movements



Spherical test mass (1), two level electro-magnet (2) and height sensing system (3).



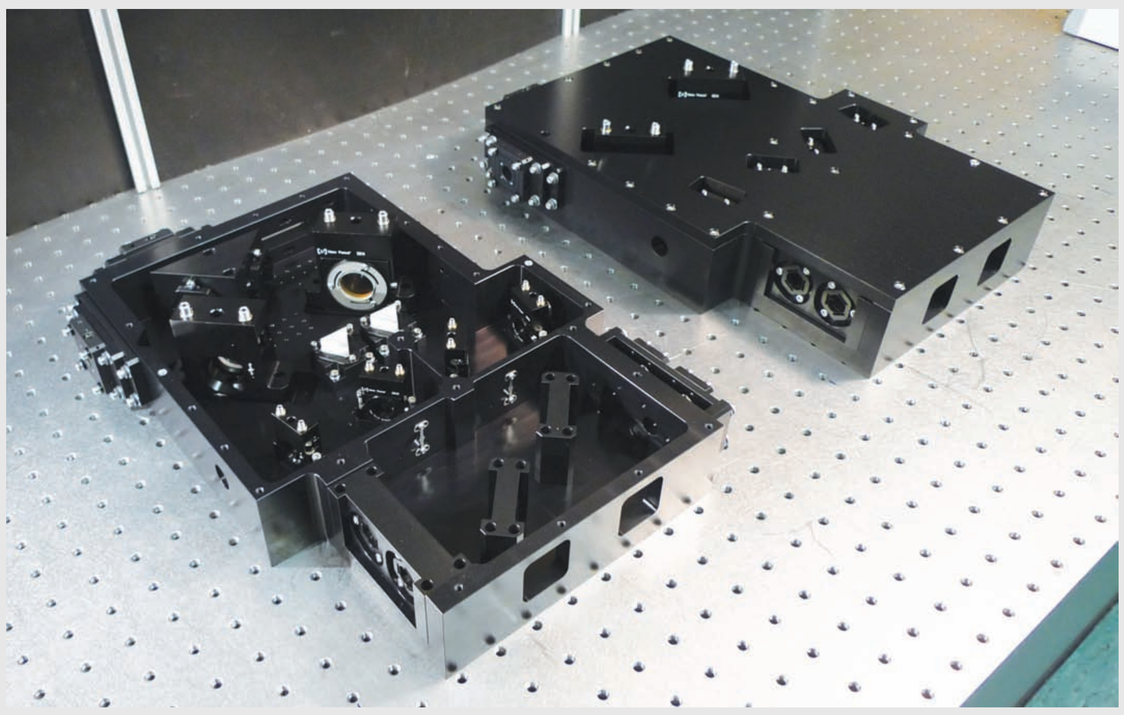
Levitation system test bed (currently under construction).

- Next steps:
  - Extension of height sensing by tilt signal (DWS) of the optical read out
  - Implementing additional electro-magnets for 3 DoF guidance
  - Implementing a system to apply a defined torque onto test mass

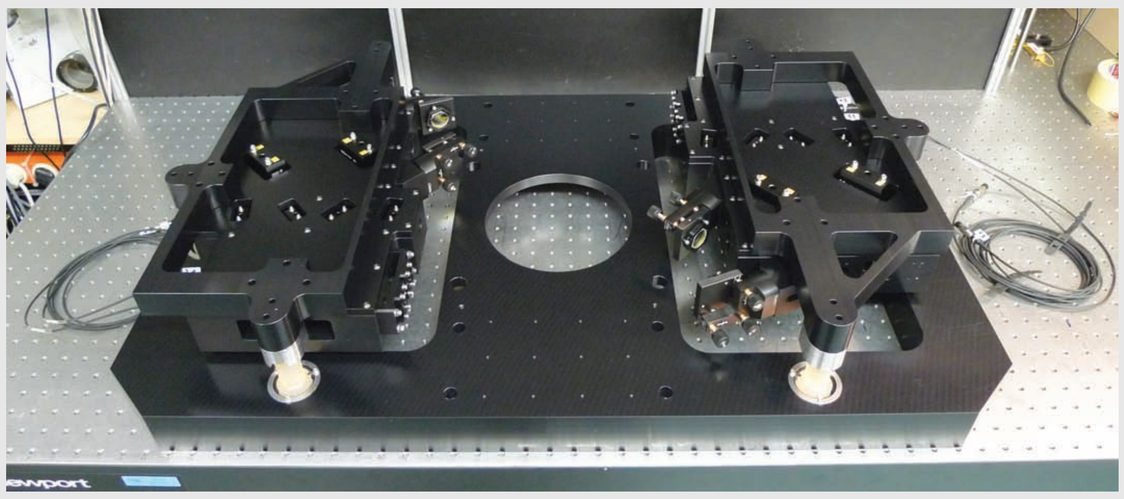
Inertial Sensor Setup

As a first step Airbus is developing a setup to characterize the surface of the spherical test mass and to gain experience with the optical read out. Therefore the test mass will be mounted on a rotation table while its surface is measured interferometrically.

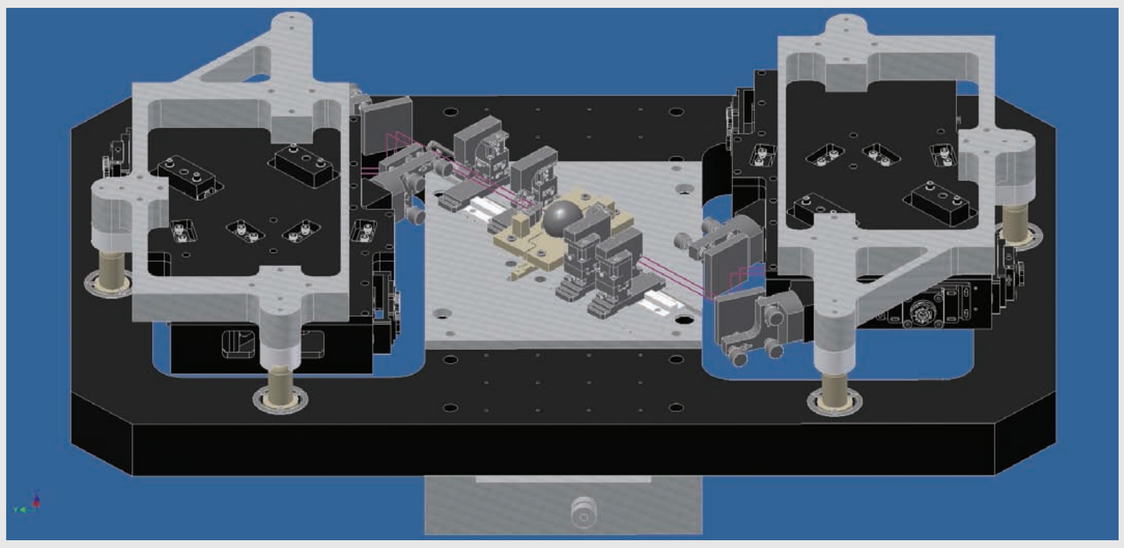
- Principal tests with non levitated test mass
  - Test mass mounted on a highly precise rotation table
  - Optical read out using two heterodyne interferometers
  - Mode match of output laser beams onto test mass



Heterodyne interferometers for the optical read out (currently under construction).



Setup for characterizing test mass surface (currently under construction).



CAD rendering of the final setup for characterizing test mass surface.

- Next steps: Tests with levitated test mass
  - Setup shown above is also designed for future measurements with a levitation system
  - Implementation of levitation system into setup
  - Measurement of the test mass's center of mass
    - Compensation of surface error by calibration
    - Compensation of surface error by spin of test mass
  - Implementation of two additional interferometers