

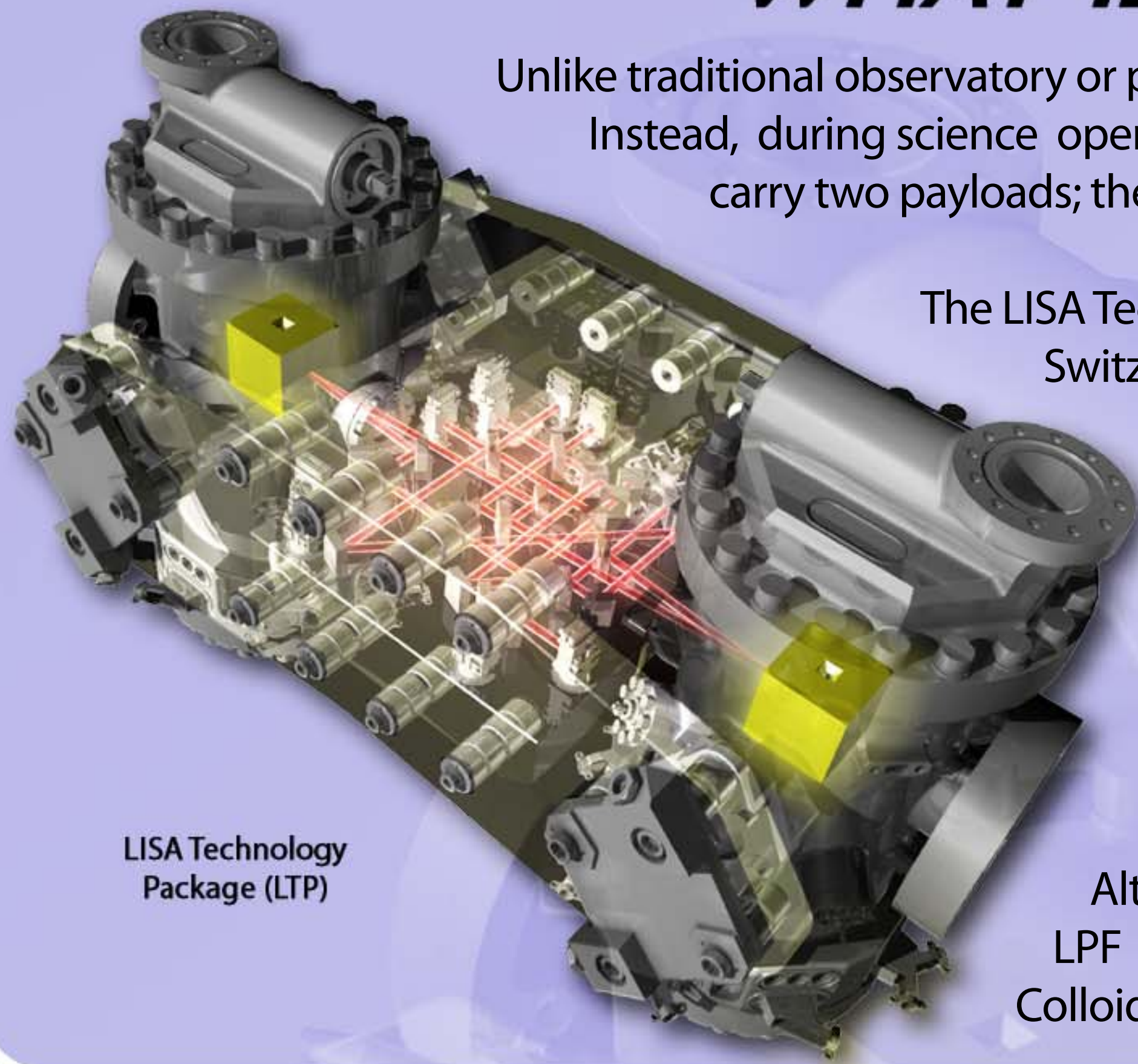
LISA TECHNOLOGY PACKAGE



Jeff Livas¹, Paul W. McNamara²
¹GSFC, National Aeronautics and Space Administration, Greenbelt, MD 20771, USA
²ESTEC, European Space Agency, Keplerlaan 1, 2200 AG Noordwijk, The Netherlands



WHAT IS THE LISA TECHNOLOGY PACKAGE?



LISA Technology Package (LTP)

Unlike traditional observatory or planetary missions, the payload in LISA Pathfinder cannot be considered as a discrete piece of hardware carried by the spacecraft. Instead, during science operations, the payload and the spacecraft act as a single unit: the attitude control of the spacecraft is driven by the payload. LPF will carry two payloads; the LISA Technology Package (LTP), and the Disturbance Reduction System (DRS).

The LISA Technology Package is provided by a consortium of European National Space Agencies (France, Germany, Italy, Netherlands, Spain, Switzerland, and the United Kingdom) and ESA.

The LTP consists of two main subsystems; the Inertial Sensor Subsystem (ISS) and the Optical Metrology Subsystem (OMS). The ISS contains the Gold:Platinum test masses, with their associated hardware (capacitive sensing housing, caging mechanism, vacuum enclosure, charge management system, and capacitive sensing and actuation electronics). This subsystem forms the gravitational reference sensor of the system. The OMS on the other hand forms the high precision displacement readout of the system, and consists of a Nd:YAG non-planar ring oscillator laser, an acousto-optic modulator unit, the optical bench interferometer, and a phase measurement system.

Although not part of the LTP, the other main technology to be demonstrated by LPF are the proportional micro-Newton thrusters. LPF will test two such thruster architectures: Field Emission Electric Propulsion (FEEP) thrusters being manufactured in Europe; and Colloidal Micro-Newton thrusters being delivered by NASA as part of the DRS.

LISA TECHNOLOGY PACKAGE PERFORMANCE

The performance and functional goals of LTP on LPF can be summarized as follows:

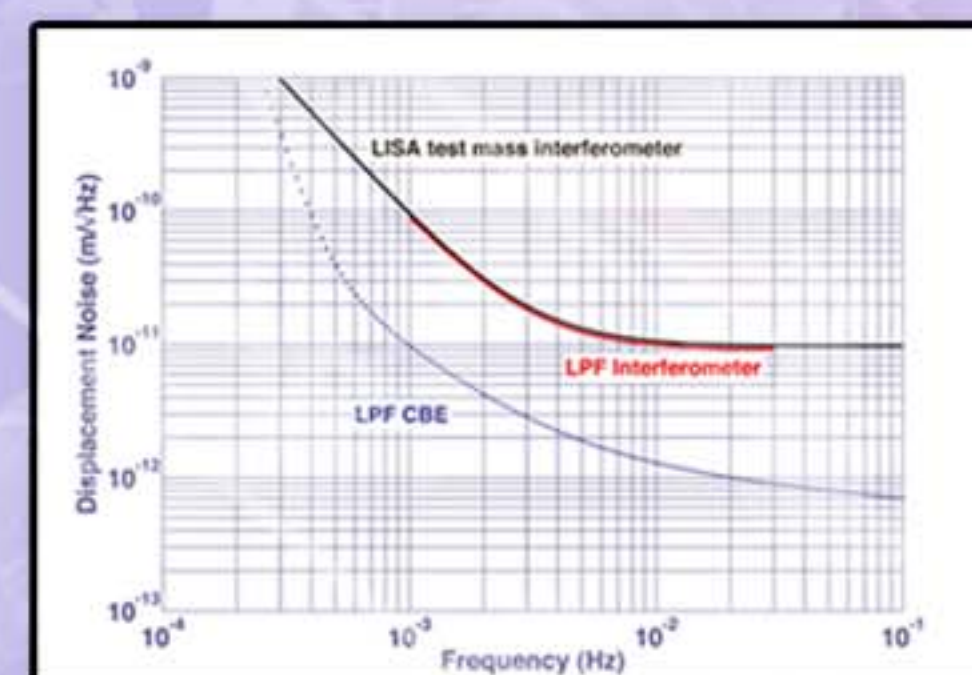
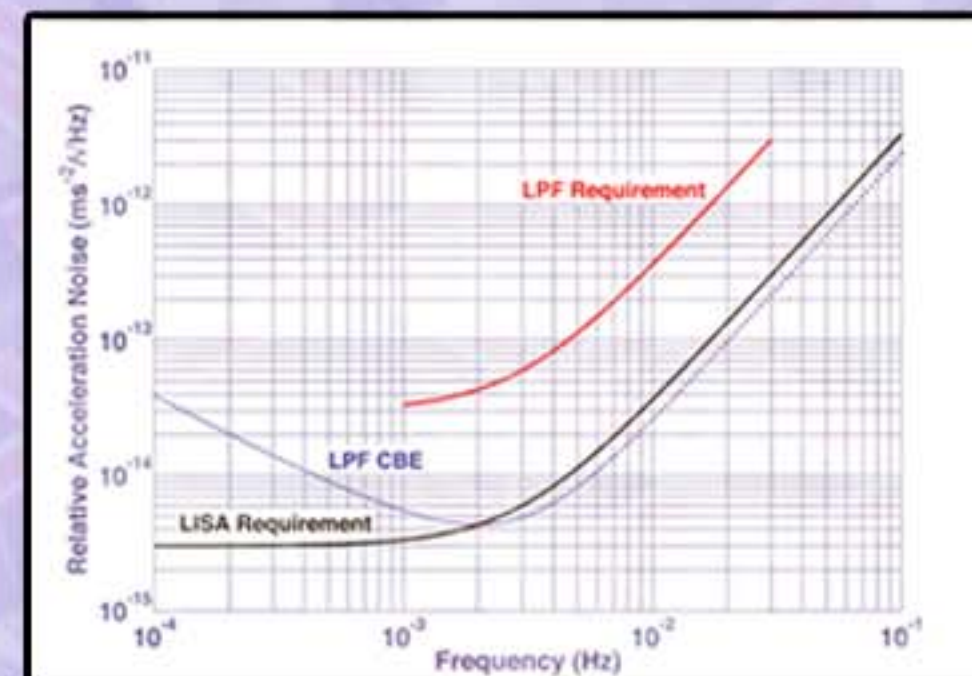
- Demonstrate that a test-mass can be put in pure gravitational free-fall within one order of magnitude of the req for LISA, i.e.: (over the LTP mbw of 1-30mHz)

$$S_a^{1/2}(f) \leq 3 \times 10^{-14} \left[1 + \left(\frac{f}{3 \text{ mHz}} \right)^2 \right] \text{ ms}^{-2} / \sqrt{\text{Hz}}$$

- Demonstrate laser interferometry with free-falling mirrors (test masses of LTP) with displacement sensitivity meeting the LISA requirement over the LTP measurement bandwidth, i.e.:

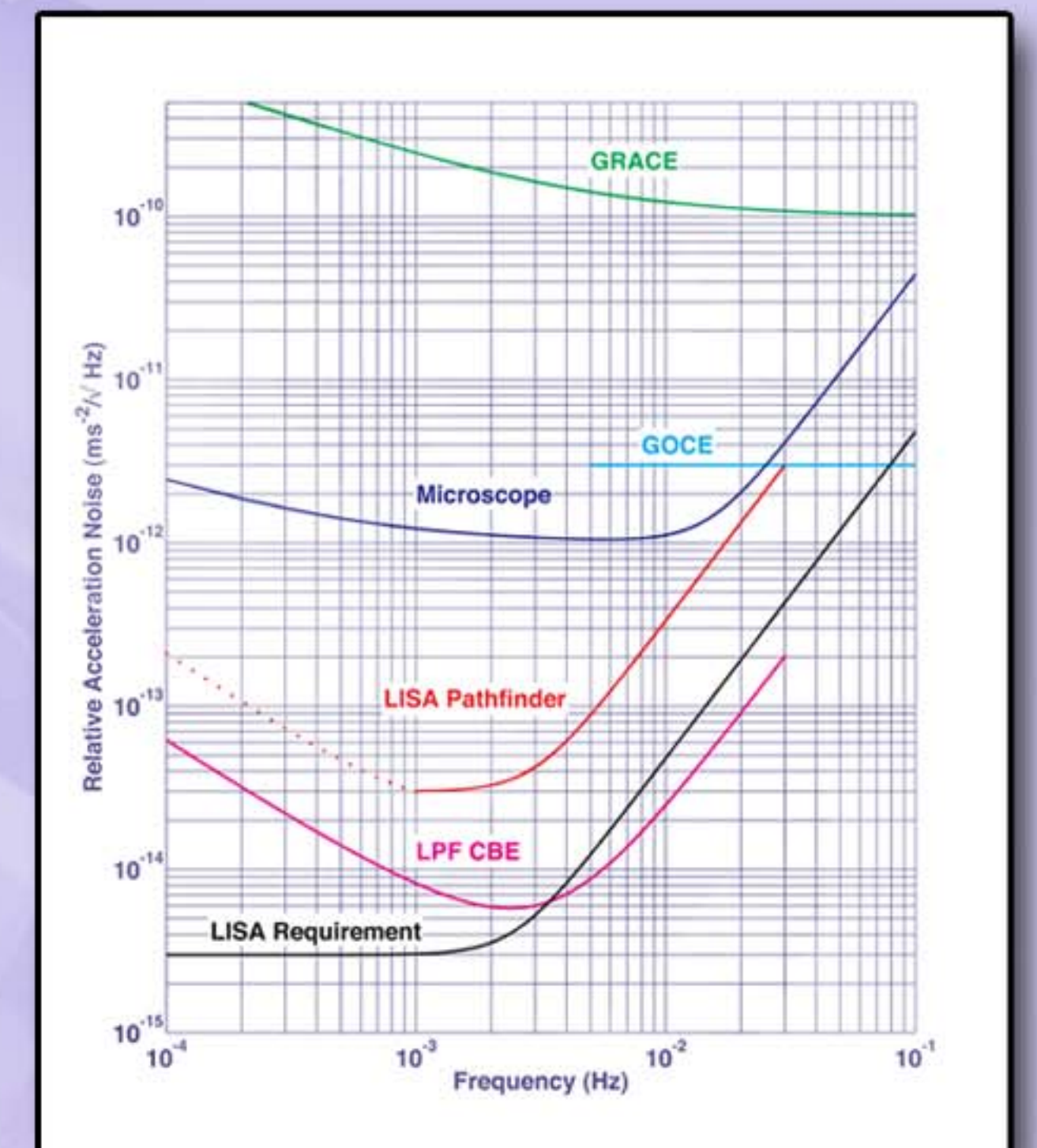
$$S_{\Delta v}^{1/2}(f) = 9.1 \times 10^{-12} \left[1 + \left(\frac{f}{3 \text{ mHz}} \right)^{-2} \right] \text{ m} / \sqrt{\text{Hz}}$$

- Assess the lifetime and reliability of the micro-Newton thrusters, lasers and optics in a space environment.



Several other missions have been flown, or are under development, which will use tracking of the relative motion of nearly free-falling artificial bodies. A comparison of expected performances of these missions versus LISA Pathfinder is shown on the right. It is important to stress that LISA Pathfinder is not a mission mainly aimed at demonstrating drag free control. Drag-free control is just one of the many tools used to achieve geodesic motion.

The main difference is that geodesic motion is the lack of relative acceleration between free test-masses other than due to space-time curvature, while drag free motion is the lack of acceleration of the spacecraft relative to a local inertial frame.

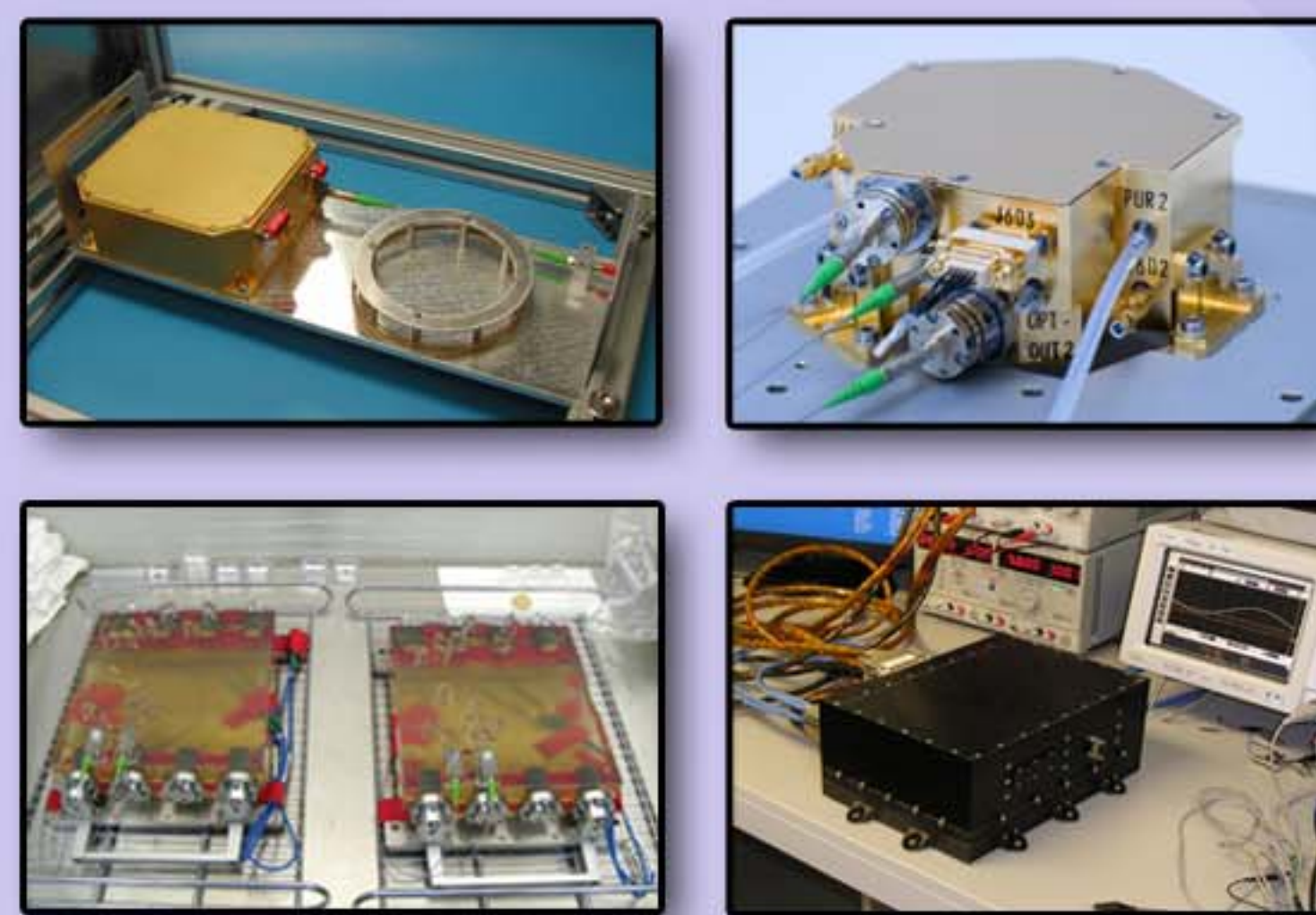


Comparison of relative acceleration noise. LPF CBE is the current best estimate of the expected mission performance

OPTICAL METROLOGY SUBSYSTEM

The Optical Metrology Subsystem (OMS) is the high resolution laser interferometric readout of the test masses' positions. The OMS comprises several subsystems, namely; the reference laser unit, the laser modulator, optical bench interferometer and the phase meter.

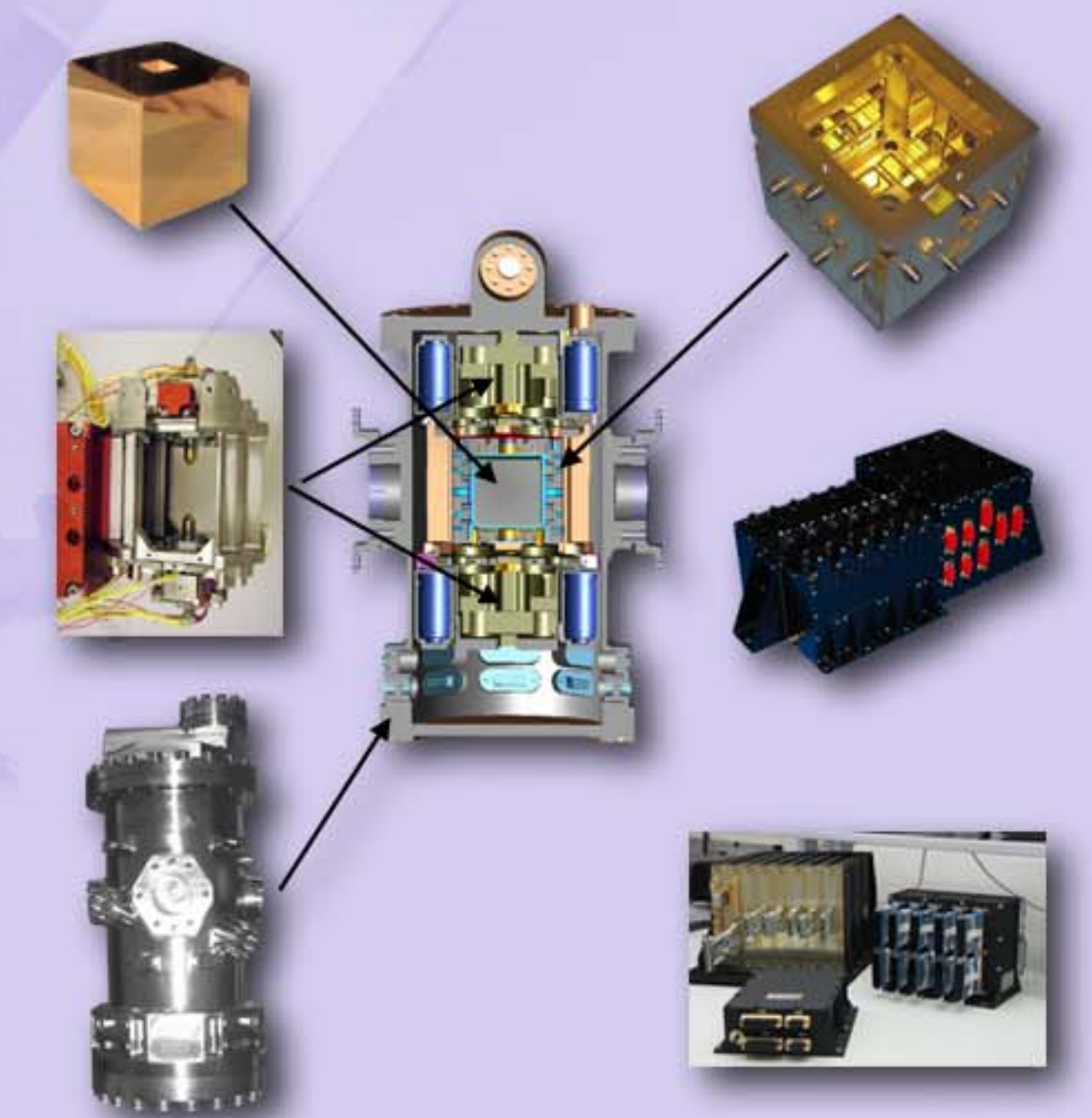
All flight units have either been delivered to the payload integrator, or are in final testing at the supplier. Hardware in the loop testing of the OMS Engineering Units has recently finished, with the Flight Unit system testing due to begin in early 2010



Photographs of the Flight Models of the Optical Metrology Subsystem. From top left (clockwise): Reference Laser Unit, Acousto-Optic Modulator Unit, Optical Bench Interferometer, and Phase Measurement Unit.

INERTIAL SENSOR SUBSYSTEM

The Inertial Sensor Subsystem (ISS) is the heart of the LISA Pathfinder mission. The ISS consists of six main components: the Au:Pt test mass; the electrode housing to allow capacitive sensing of the test mass position; a caging mechanism to hold the test mass during launch and to position and release the mass when on orbit; and a Ti vacuum enclosure with getter pumps housing the above (titanium is used as it is non-magnetic). In addition, the ISS also contains a non-contacting UV discharge system consisting of six Mercury vapour lamps, and a set of ultra-low noise capacitive sensing electronics.



Photographs of the Inertial Sensor Subsystem units. From top left (clockwise): Au:Pt test mass, electrode housing, UV lamp unit, front-end electronics, Ti vacuum chamber, caging mechanism

More information on LISA Pathfinder can be found at
<http://sci.esa.int/lisapf>

<http://www.rssd.esa.int/index.php?project=LISAPATHFINDER&page=index>