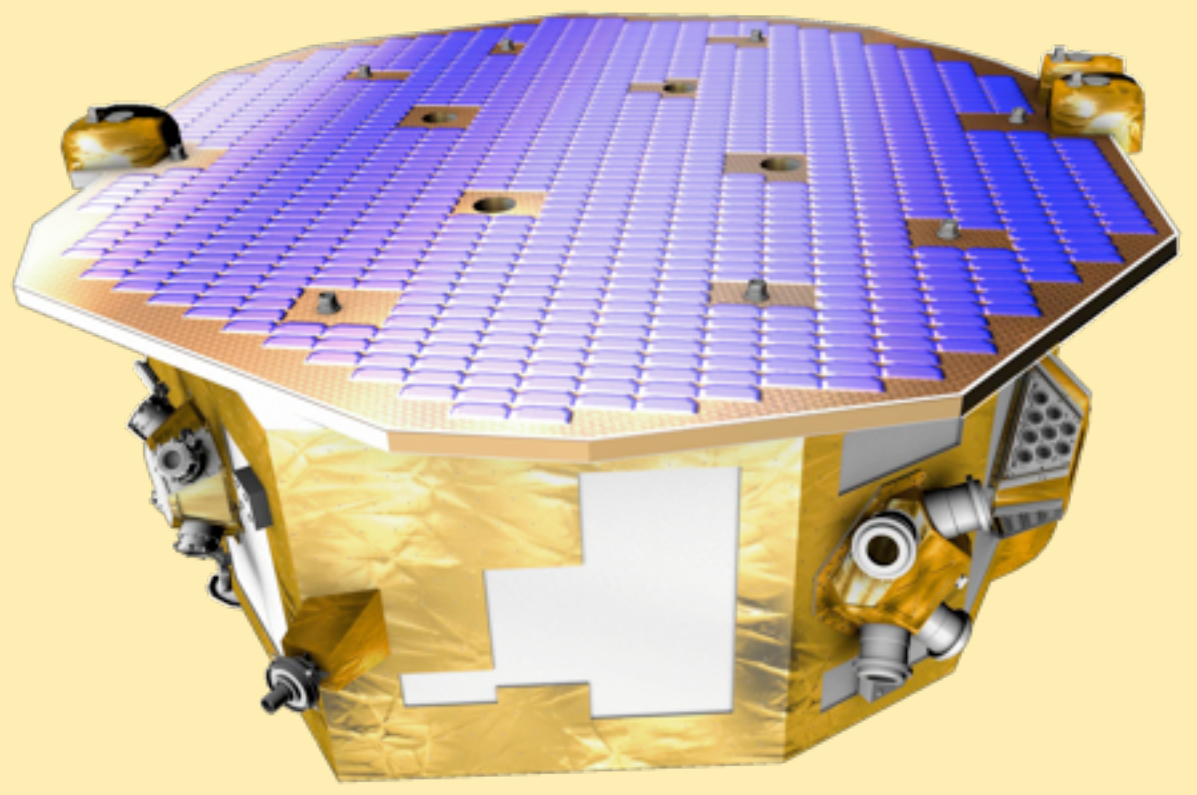
The LISAPathfinder Mission

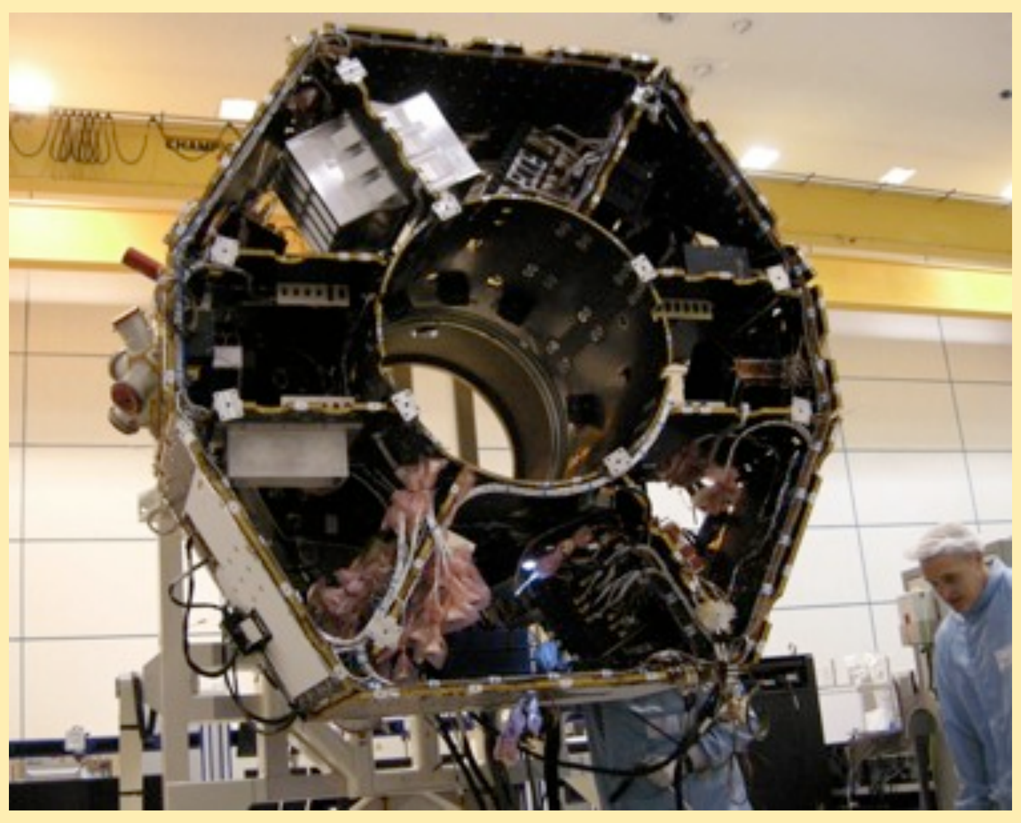
The **LISA** mission is based on 3 main technical challenges :

1. Maintaining on gravitational geodesics "test masses" (mirrors) protected from all external forces.
2. Measurements, to a precision of a few pico-meters, of the relative position of the test masses and with respect to the position of the spacecraft.
3. Attenuate by a factor greater than 10^8, the phase noise of the lasers used in the interferometric measurement of the test mass position.

To demonstrate the feasibility of the first 2 challenges, the **LISAPathfinder** (**ESA**/**NASA**) mission is planned for launch in 2013. It will position, close to the Lagrange L1 point, two test masses whose distance of separation (40 cm) will be measured by laser heterodyne interferometry (Nd-YAG laser 1064 nm) to the picometer precision. A set of micro thrusters (ionic/molecular propulsion) will be used to correct the Spacecraft (S/C) position if displaced by external forces (solar winds) so as to maintain one of the test masses on its geodesic trajectory.



The Spacecraft after the release of the propulsion module

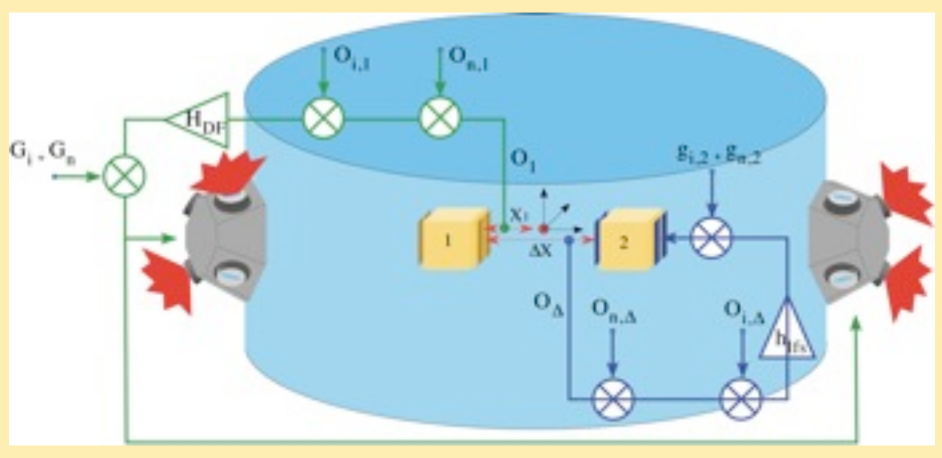


The LPF in 2010 at Astrium UK, waiting for the LTP.

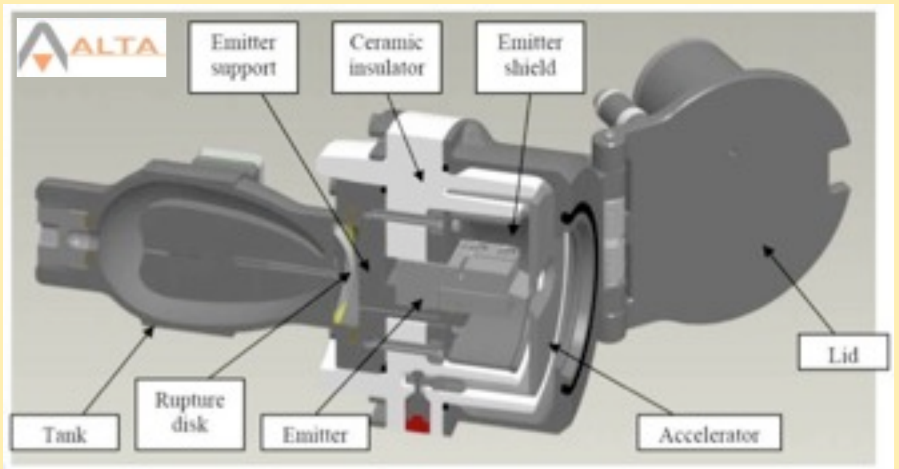
The FEEPS and the DFACS System

The Drag Free system is based on 3 groups of 4 FEEPS whose thrust are calculated by a control loop based on the position of one of the test masses w/o to its enclosure. The position of each TM is measured to a precision of a few picometers by the optical bench.

A set of 4 Feeps



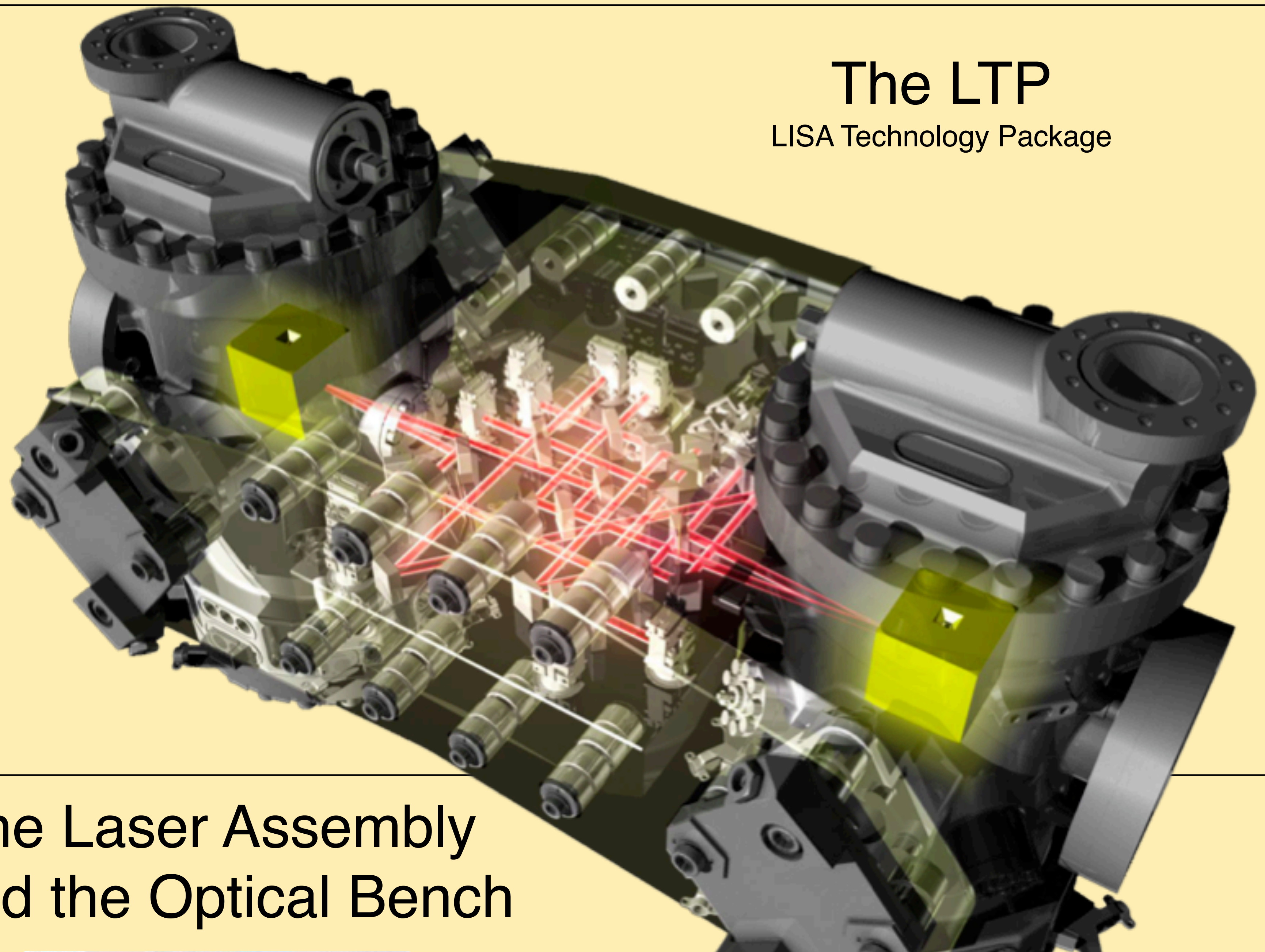
The logic of the DFCAS control loop
DFCAS : Drag Free Attitude Control System



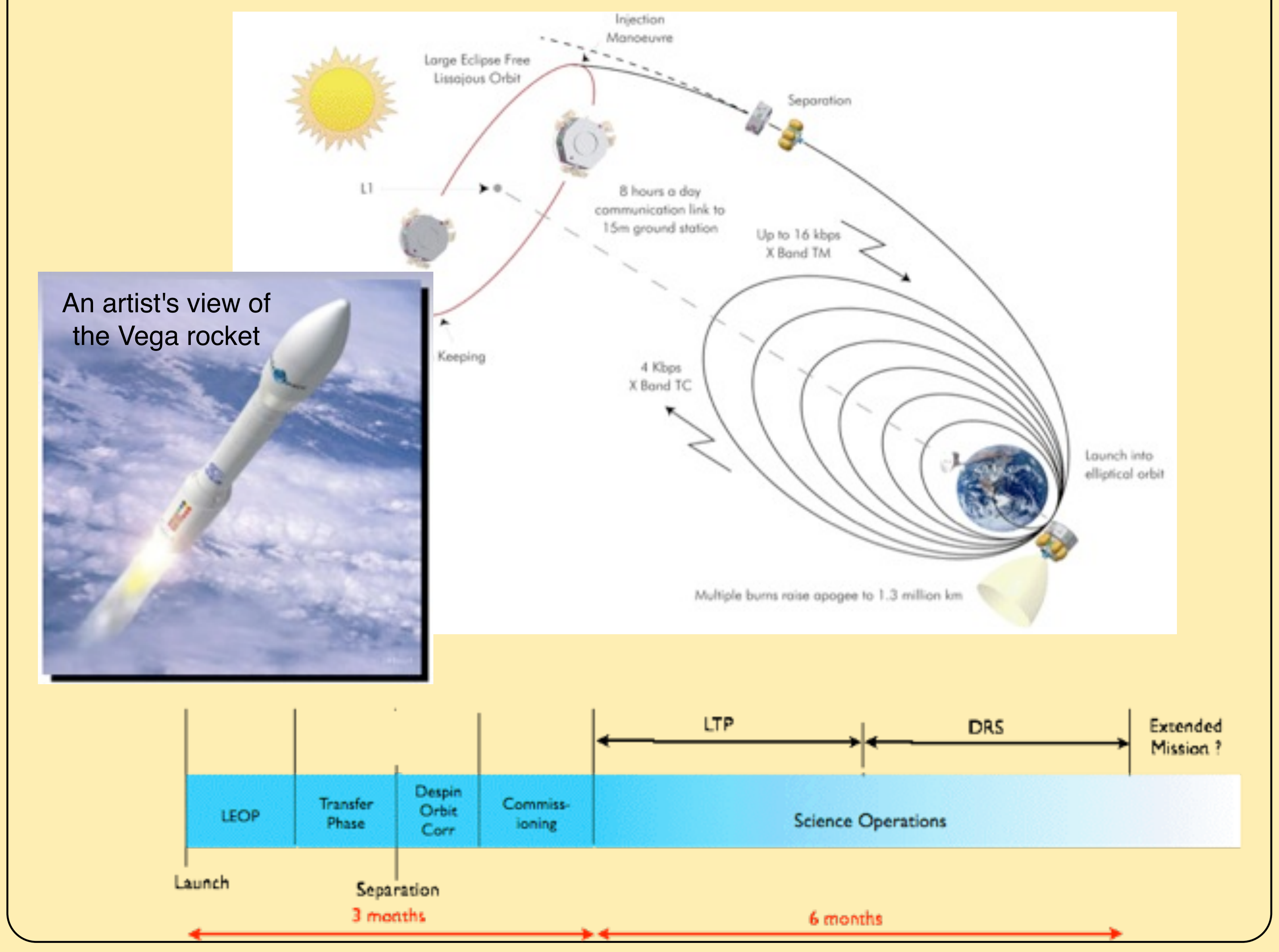
The anatomy of a FEEP : Field Emission Electric Propulsion

The LTP

LISA Technology Package

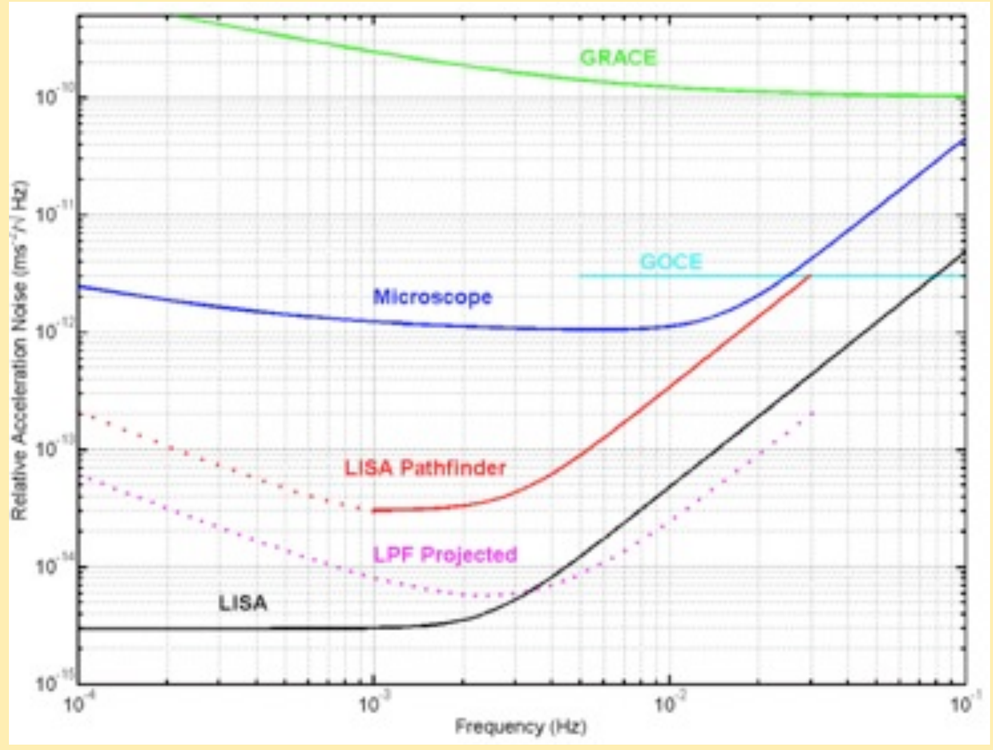


The Launch, L1 and the mission



The success criterium of LISAPathfinder

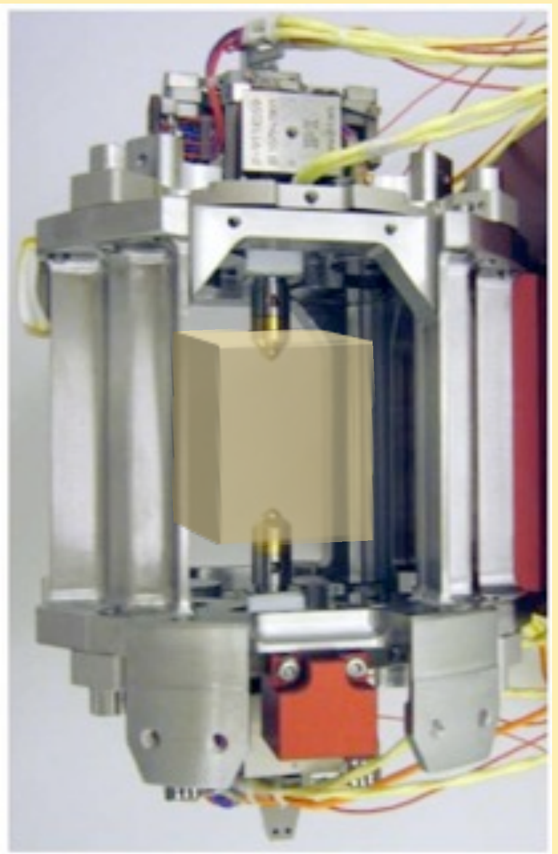
One of the success criteria of LISAPathfinder will be its ability to maintain, over several thousand seconds, its two test masses with a very small relative acceleration ($3\ 10^{-14}$ m sec^{-2} $Hz^{-1/2}$)



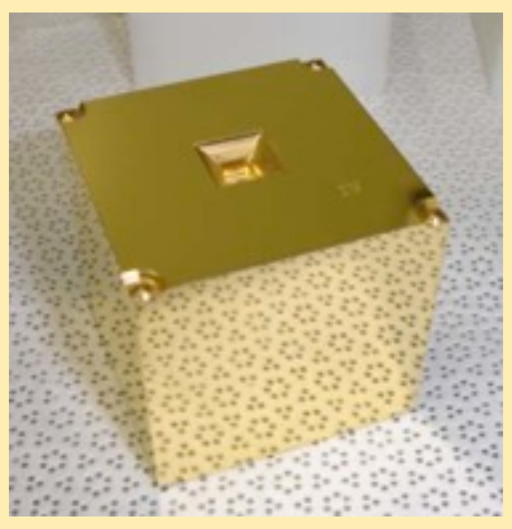
The Test Masses and the Caging Mechanism

The 2 test masses are located in vacuum enclosures positioned on both sides of the optical bench. In order to sustain the launch environment, a caging system made of 8+2 hydraulic "fingers" will hold each TM and release them with quasi-zero velocities on reaching L1.

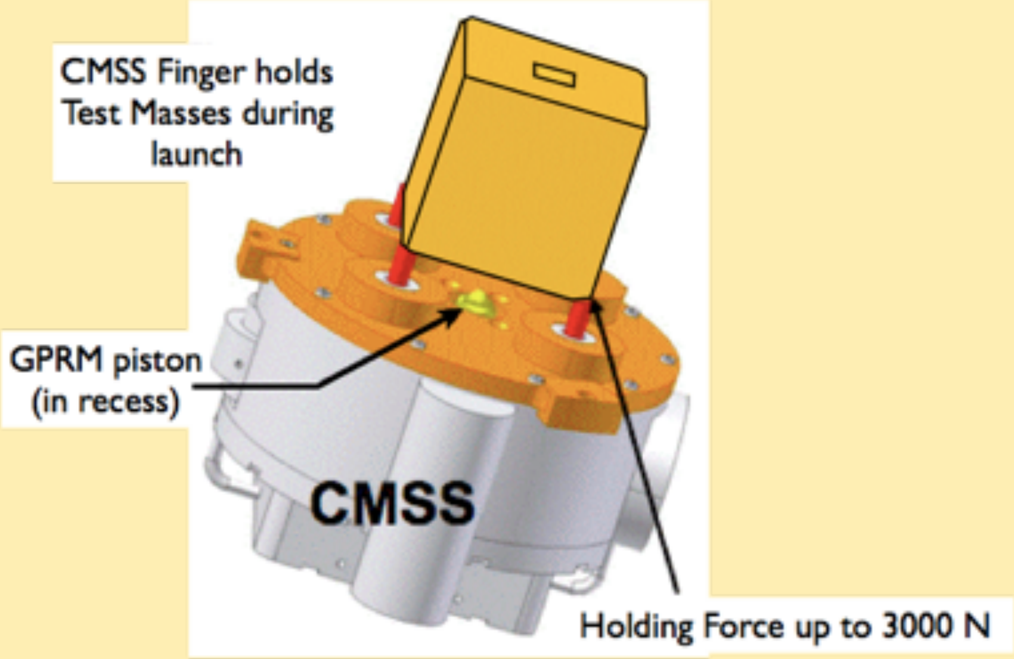
A vacuum enclosure



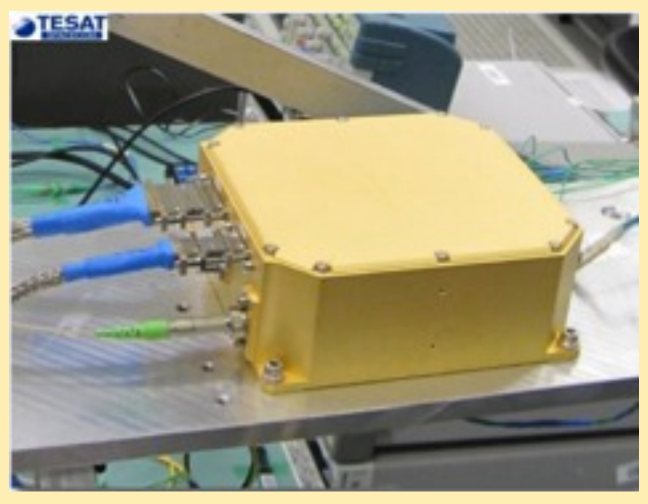
The central GPRM fingers



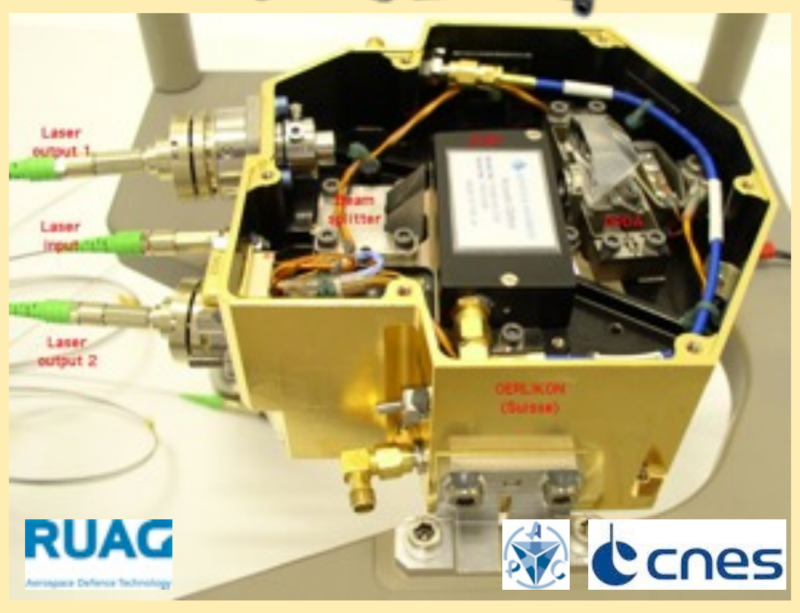
A Test Mass



The Laser Assembly and the Optical Bench



The Laser

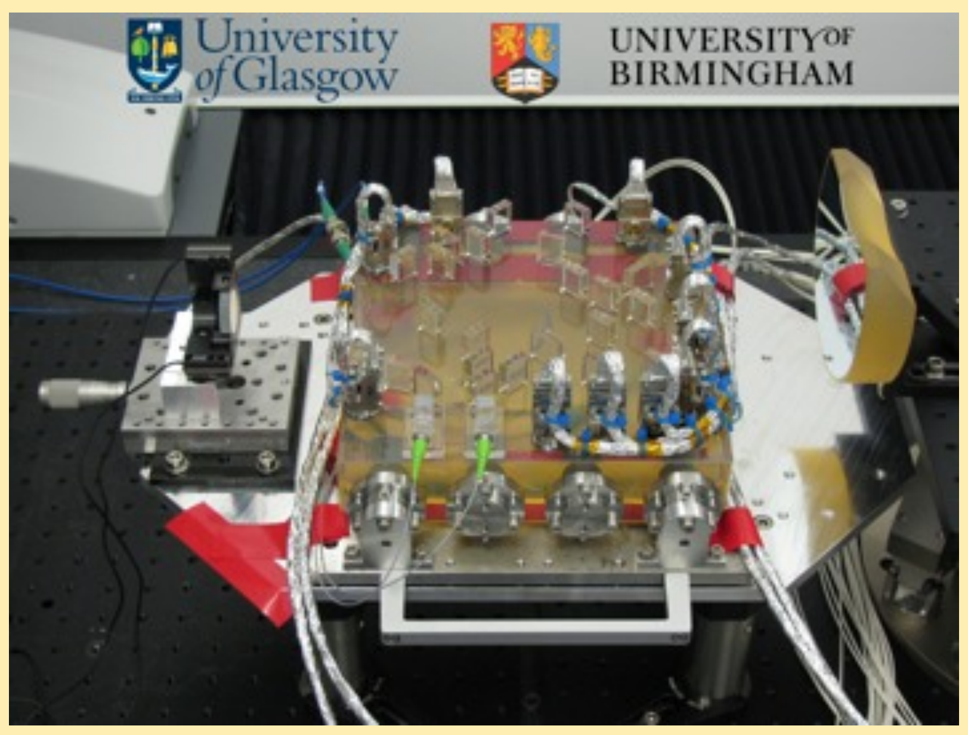


The Laser Modulator

In LISAPathfinder, the inter distance measurements (between TMs and TMs and the OBI) are obtained through the use of an ultra-stable interferometry optical bench. It is based on the heterodyne Mach-Zender method.

The laser beam is split into two components which are shifted in frequency by a system of AOM (Acousto-Optic Modulator). One of the beams is shifted by 80 MHz and the other by 80 MHz + 0.5< f_{het}< 5 kHz (f_{het} is called the heterodyne frequency). The interference of the two beams provides a beat frequency at f_{het} with a constant phase difference as long as their relative flight path does not change: A change of the position of the TMs will translate into a modification of the phase. The **Laser Modulator** is the sub-system in charge of the laser splitting, frequency shifting, optical power control and optical path length adjustment. It is made up of two elements: the **LMU** (the optical system) and the **LME** (the electrical counterpart).

This system is made by RUAG (Germany/Switzerland) under the supervision of APC and financed by CNES.



The Optical Bench Interferometer (OBI)

Located between the test masses is the optical bench, on which the optical components are mounted. It is made of Zerodur ceramic glass, which barely expands or contracts when subjected to temperature changes.