esa LISA PATHFINDER

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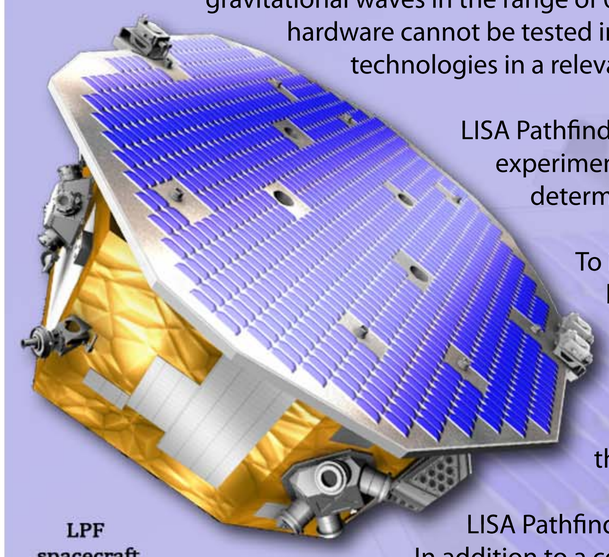
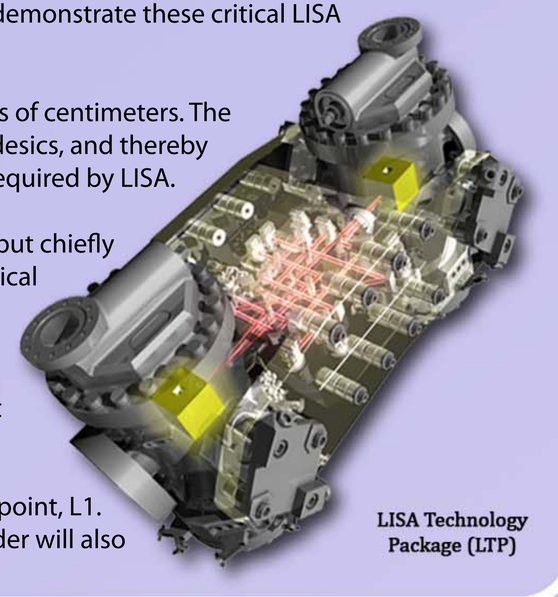
INTRODUCTION

LISA Pathfinder is a dedicated technology demonstration space mission for the Laser Interferometer Space Antenna (LISA). LISA is a joint ESA/NASA mission designed to detect low frequency gravitational waves in the range of 0.1mHz to 0.1Hz. Several critical LISA technologies have not been demonstrated at the requsite level of performance in spaceflight, and some flight hardware cannot be tested in a 1-g environment. Hence, the LISA Pathfinder mission was implemented by the European Space Agency to demonstrate these critical LISA technologies in a relevant flight environment.


LPF spacecraft

LISA Pathfinder mimics one arm of the LISA constellation by shrinking the 5-million-kilometer armlength down to a few tens of centimeters. The experimental concept is to measure the relative separation between two test masses nominally following their own geodesics, and thereby determine the relative residual acceleration between them near 1 mHz, about a decade above the lowest frequency required by LISA.

To implement such a concept, disturbances on the test-masses must be kept very small by many design features, but chiefly by "drag-free" flight. A drag-free spacecraft follows a free-falling test mass which it encloses, but has no mechanical connection to. The spacecraft senses its orientation and separation with respect to the proof mass, and its propulsion system is commanded to keep the spacecraft centered about the test mass. Thus, the spacecraft shields the test mass from most external influences, and minimizes the effects of force gradients arising from the spacecraft, and acting on the test mass. LISA Pathfinder will compare the geodesic of one test mass against that of the other.


LISA Technology Package (LTP)

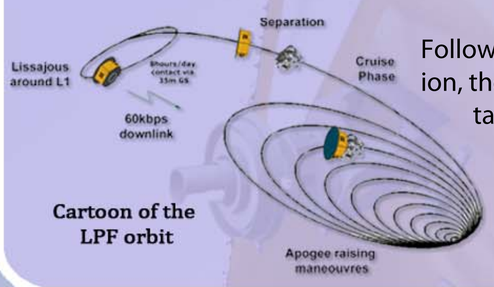
LISA Pathfinder is scheduled to be launched in the first half of 2012 to a Lissajous orbit around the first Sun-Earth Lagrange point, L1. In addition to a complete European technology package (the LISA Technology Package - see LTP poster for details), LISA Pathfinder will also carry thrusters and software, known as ST-7, a part of NASA's New Millennium Program.

LAUNCH AND ORBIT

LISA Pathfinder is due to be launched in 2012 on-board a dedicated small launch vehicle. The launcher selected is the new Arianespace VEGA launcher, which will launch LPF from the European spaceport of Kourou in French Guyana into a parking orbit with perigee at 200 km, apogee at 1620 km, and an inclination to the equator of 5.3°.


Artists impression of the VEGA launcher

After a series of nine apogee raising manoeuvres using an expendable propulsion module, LISA Pathfinder will enter a transfer orbit towards the first Sun-Earth Lagrange point (L1). After separation from the propulsion module, the LPF spacecraft will be stabilised using the micro-Newton thrusters, entering a 500,000km by 800,000km Lissajous orbit around L1 (see figure below).



Cartoon of the LPF orbit

Following the initial on-orbit check-out and instrument calibration, the in-flight demonstration of the LISA technology will then take place. The nominal lifetime of the science operations is 180 days; this includes the LTP and DRS operations, and a period of operations when the LTP will control the DRS thrusters.

SCIENCE OPERATIONS


35m Cebreros ground station

During science operations, the spacecraft is commanded via Payload Operatons Requests (POR) stored in the mission timeline, Each POR contains exactly 24 hours of telecommands, and up to 6 PORs are stored on board at any time.

The ground segment of LPF is composed of two operational centres, both provided by ESA:

- The **Mission Operations Centre (MOC)** is responsible for the launch and early orbit phase, the transfer phase, and the execution of the in-orbit operations. The MOC is in contact with the spacecraft for a max. of 8 hours per day through the 35 m Cebreros ground station. It is located at the European Space Operations Centre (ESOC) in Darmstadt, Germany

- The **Science and Technology Operations Centre (STOC)** is the point of interface to the scientific community, and is responsible for the payload scheduling (both long and short-term), quick-look data analysis, data processing and archiving. The STOC will also take a leading role in the analysis of the mission data. Development of the STOC is run from the European Space Astronomy Centre (ESAC) in Villafranca, Spain.


European Space Astronomy Centre (ESAC)

PROJECT STATUS


Top: S/C with thermal blankets
Bottom: Propulsion module

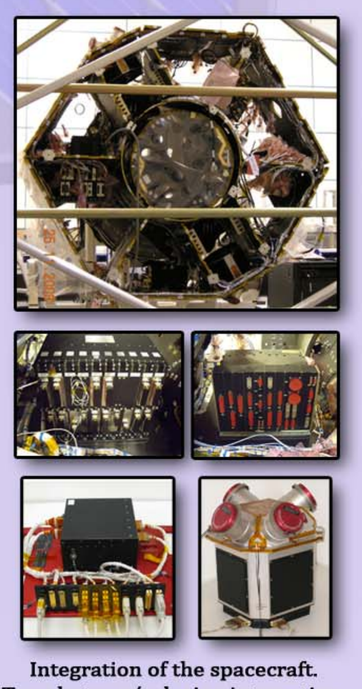
Following the successful closure of several reviews including the LTP Critical Design Review (CDR), the System CDR, and the Science and Technology Operations Centre (STOC) CDR, LISA Pathfinder has entered the next phase of the mission development, namely the Assembly, Integration and Test Phase (AIT). The AIT phase centres around system testing and integration of the spacecraft and payload.

All spacecraft flight units have been delivered with the exception of the Field Emission Electric Propulsion (FEEP) micro-Newton thrusters. The FEEP subsystem consists of two main components; the power control units, and the thruster clusters (three of each). The former are scheduled for delivery in the first half of 2010, while the latter are scheduled for delivery in late 2010 (first cluster), and early 2011 (clusters 2 and 3). The FEEP clusters are not scheduled to be integrated before early 2012.

AIT is well underway at the LISA Pathfinder Prime Contractor's (Astrium UK) facility, with most of the system flight units already integrated to the spacecraft (see photographs on right). The first spacecraft integrated system test (magnetic test) will take place in January 2010.

In addition, the NASA provided ST-7 (Disturbance Reduction System) flight units have been delivered to ESA. The DRS consists of an Integrated Avionicd Unit, and two clusters of 4 Colloidal thrusters (see photos on right). The DRS is now integrated to the spacecraft structure.

LISA Pathfinder is on track for a launch in the first half of 2012. Approximately two months after launch, LISA Pathfinder will enter orbit around the 1st Sun-Earth Lagrange point, After a period of hardware commissioning, LPF will begin the science demonstration phase. Initial results on the performance of the mission will be available immediately, with full results being available approximately three months thereafter.


Integration of the spacecraft.
Top photo: s/c during integration.
Bottom photos (clockwise):
on-board computer, power distribution unit, DRS computer, DRS colloidal thrusters.

More information on LISA Pathfinder can be found at
http://sci.esa.int/lisapf
http://www.rssd.esa.int/index.php?project=LISAPTHFINDER&page=index