LISA Pathfinder is a space mission dedicated to demonstrating technology for the Laser Interferometer Space Antenna (LISA). LISA is a joint ESA/NASA mission to detect low-frequency gravitational waves in the 0.01 to 1 Hz frequency band. LISA is expected to observe 100+ of merging massive black hole binaries out to 20+ tens of thousands of coin compact binary systems in the Milky Way, merging intermediate-mass black hole binaries, tens of stellar-mass black holes falling into supermassive black holes in galactic centers, and possibly other exotic sources. Several critical LISA technologies have not been demonstrated at the requisite level of performance in spaceflight, and some flight hardware cannot be tested in a 1-g environment. Hence, the LISA Pathfinder mission is being implemented to demonstrate these critical LISA technologies in a relevant flight environment.

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 normally following their own geodesics, and thereby determines the relative residual acceleration between them near 1 mm, 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 separations with respect to the proof mass, and its propulsion system is commanded to keep the spacecraft centered about the test mass. Thus, the spacecraft obtains the test mass from external accelerations arising from the Earth's gravity field, and actuating on the test mass. LISA Pathfinder will compare the geodesic of one test mass against that of the other.

Only a metrology system based on interferometry can achieve the displacement sensitivity interferometers monitor the separation of both test masses with a sensitivity comparable to that required by LISA, and using the same technologies.

LISA Pathfinder is scheduled to be launched in the first half of 2010 to a Lissajous orbit around the first Sun-Earth Lagrange point, L1. In addition to a complete European technology package (the LISA Technology Package, or LTP), LISA Pathfinder will also carry thrusters and software, known as SIT, a part of NASA's New Millennium Program.

Top Level Requirements for the LISA Pathfinder Mission

The primary goal of LISA Pathfinder (LFP) mission is to verify that a LISA-like test mass can be free of disturbances within an order of magnitude of LISA's residual acceleration requirement. The order of magnitude rule applies also to frequency. Thus the top level requirement on the LTP is a residual acceleration noise (i.e., amplitude spectral density) of one test mass relative to the other of $S_{\alpha\alpha}(f) \leq 3 \times 10^{-13} \text{m}\text{s}^{-2} \text{~Hz}^{-1/2}$

Over the frequency range, $f$, of 1 to 30 mHz.

LISA Pathfinder Status

The LISA Technology Package successfully passed the Critical Design Review in November 2007. This review paved the way for the production and procurement of the LTP flight hardware. The Critical Design Review of the LISA Pathfinder Flight Hardware has been scheduled for mid-2008. However, spacecraft flight hardware has already been delivered or is awaiting delivery to the LFP prime contractor.