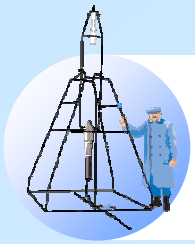
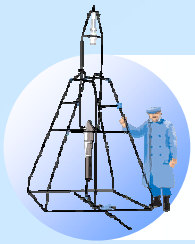


Status of LISA

Jordan Camp
LISA Deputy Project Scientist
NASA / Goddard Space Flight Center

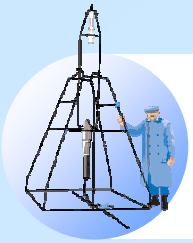
Jan. 19, 2005

LIGO-G050039-00-Z



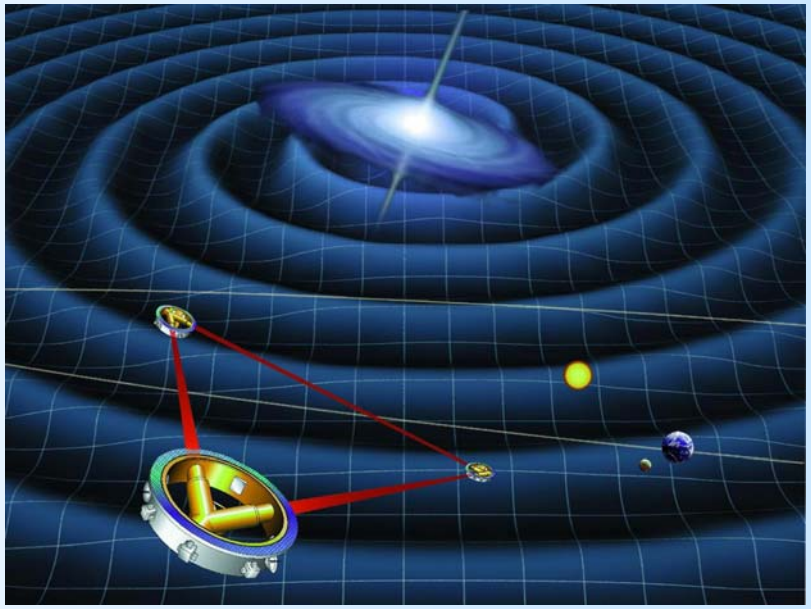
This Talk

- LISA
  - Budget and schedule
  - Technology
- LISA Pathfinder
  - Technology demonstration mission

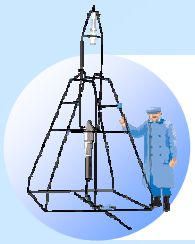


LISA – Search for Gravitational Waves

- A variety of astrophysical phenomena produce low-frequency gravitational waves
  - Massive BH binary coalescence
  - Massive BH capture of stellar mass BH
  - Galactic compact binaries

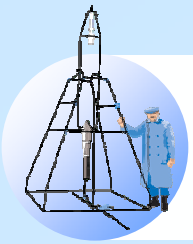


- LISA will measure strain from GW's of 10^{-21}
  - Measure position to 10^{-12} m, spacecraft separation of 5×10^{9} m
  - Need to isolate test masses from 10^{-16} N external forces



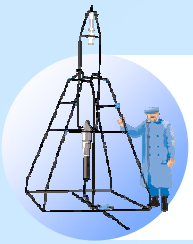
LISA Organization

- LISA is a partnership between NASA and ESA
  - Joint management agreement signed 8/04
  - ESA to provide optical bench, optics, other hardware
    - Provides launch vehicle for technology demonstrator
- Goddard and JPL participation within NASA
  - Goddard responsible for project management, provides spacecraft, final integration and test
  - JPL leads US science team, provides phase meter, other hardware
- *Lots* of politics for $2B!



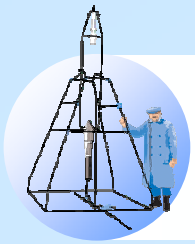
LISA Schedule

- LISA funding and schedule has been impacted by the transformation of NASA
  - Implementation of exploration vision has made science funding uncertain
  - LISA budget for 2005 is $13M, half of expected
- LISA formulation has begun
  - Products: project plan, staffing, WBS, etc….
- Launch date now 2013
  - Technology development 2005-2008
    - Little money for this so far
  - Phase C/D (implementation) 2009-2012



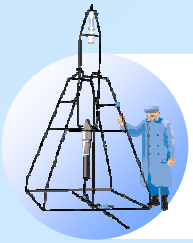
LISA Technology Drivers

- Picometer interferometry
  - 1 W laser (space qualified, 5 year lifetime)
  - Phase meter (10^{-6} radian over 1000 sec at 20 MHz)
  - Frequency stabilization of laser (10^{-14} over 1000 sec)
  - Time Delay Interferometry (10^{8} attenuation of f-noise)
    - Arm cavity locking (30 sec time delay)
- Drag-free spacecraft control
  - μ-Newton thrusters (5 year lifetime)
  - Torsion pendulum force studies (10^{-16} N over 1000 sec)
  - Test mass caging mechanism
- $60 M, 4 year program
  - Not yet underway



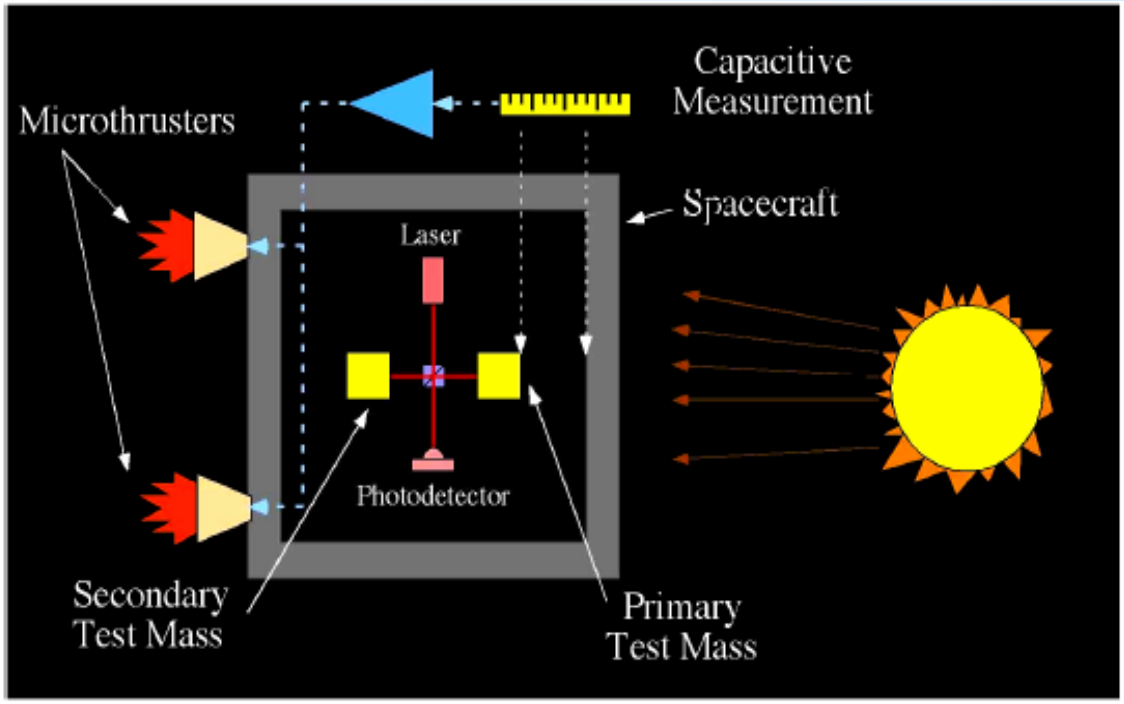
Technology Development Providers

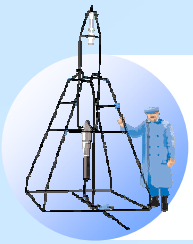
Product	NASA R&D	Industry	Test Flight
Laser		X	
Interferometer	X		X
TDI	X		
Microthrusters	X	X	X
Low force noise	X		X
Caging	X		X



LISA Pathfinder (Technology Demo)

- Test of drag-free control system and precision interferometry
- Interferometer reads out residual noise on out-of-loop mass
  - 10 pm, 3 x 10^{-15} N over 300 sec



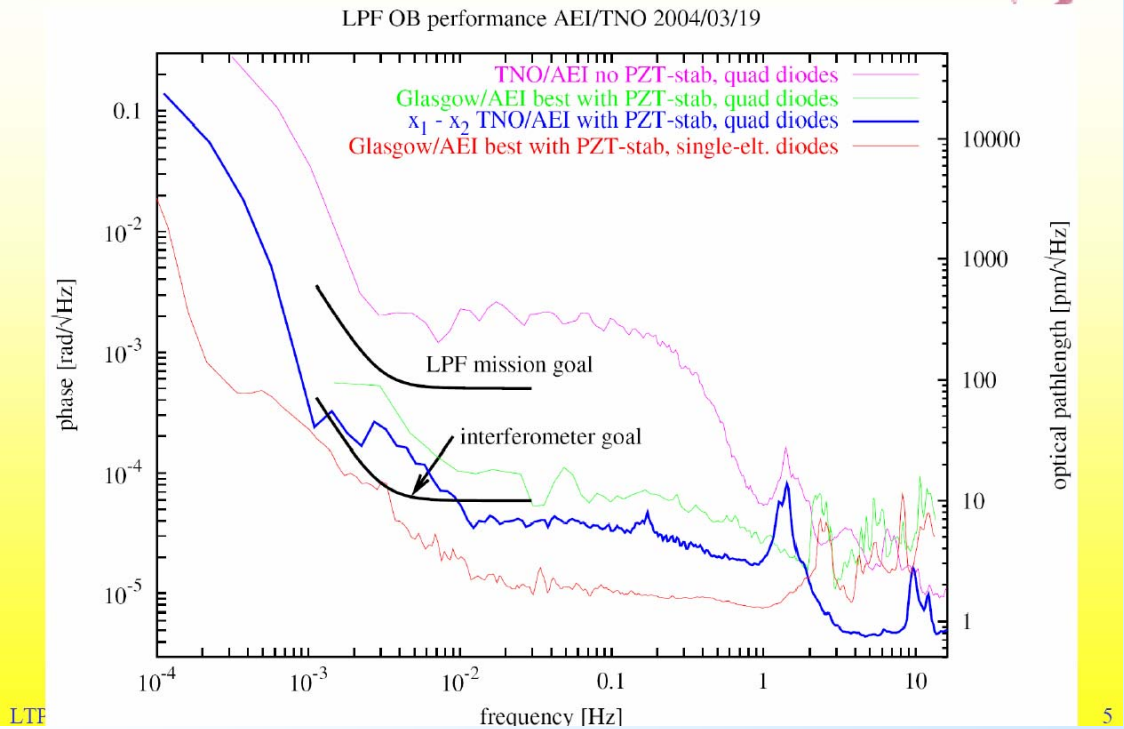


LISA Pathfinder

- Experiments flown by both NASA and ESA on the same (ESA) spacecraft
  - $300 M (technology development) mission
- Goals
  - Measurement of acceleration noise
    - Understand components of noise: magnetic, thermal, charging, patch effect, etc.
    - Measure coupling of test mass to spacecraft
  - Precision interferometry on free-falling masses
  - Flight test of caging mechanism
  - Thruster performance
- Schedule
  - Delivery of both instruments to ESA by 6/06
  - Launch 6/08

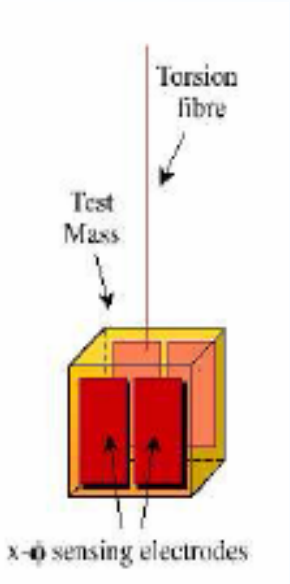
Lisa Pathfinder Interferometry

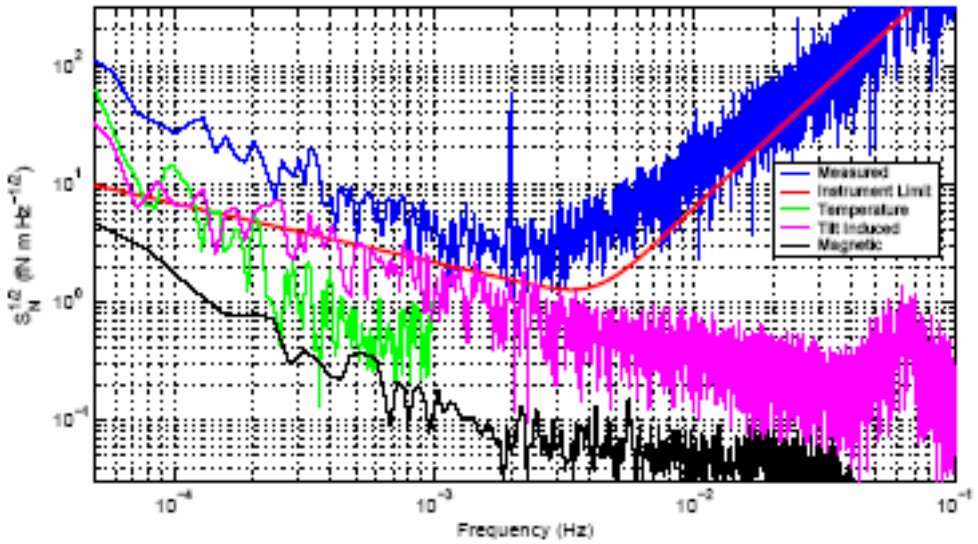
Optical Bench EM Performance



- **Investigation of many LISA interferometry issues**
  - **Stability, alignment-length coupling, etc.**

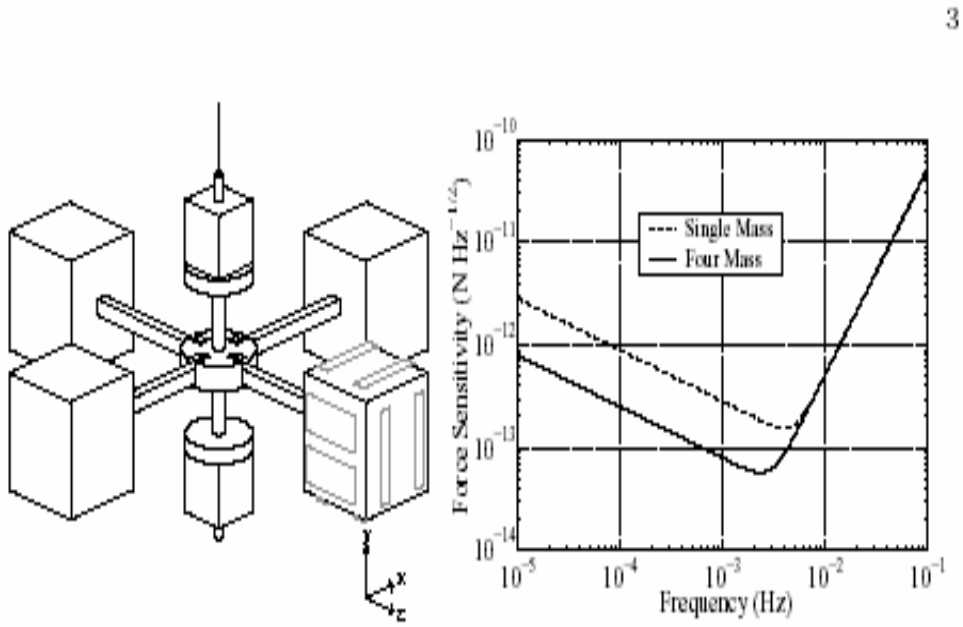
Torsion Pendulum Force Noise Study



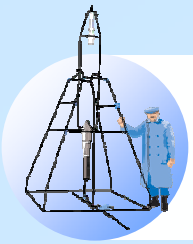


- Thermal noise limit of pendulum within 1/10 of test flight goal
- Fluctuating surface potentials (1 mV at 10^{-4} Hz) presents noise
  - Independently measured with Kelvin probe

Advanced Torsion Pendulum



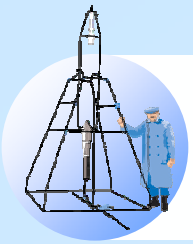
- 4 mass design directly sensitive to force
  - 10 cm arms increase force sensitivity



Two experiments on Pathfinder

- NASA and ESA will fly separate experiments
  - Use of different technologies
  - Higher probability of success

Technology	NASA	ESA
Interferometer	homodyne	heterodyne
Thruster	ion	colloidal
System Engineering	in-house	industry



Summary

- LISA has suffered some "slings and arrows" of the new NASA exploration vision
  - 2 year delay in full mission ramp-up
  - Ground-based technology development also delayed
- LISA Technology Demonstration Mission is fully funded
  - Interferometry, drag-free control meeting goals
    - ~1/10 LISA requirements
  - Launch date of 6/08