

# Propulsion Options for the LISA Mission

Eric H. Cardiff\* and Gregory C. Marr†  
NASA Goddard Space Flight Center, Greenbelt, MD 20771

The LISA mission is a constellation of three spacecraft operating at 1 AU from the Sun in a position trailing the Earth. After launch, a propulsion module provides the  $\Delta V$  necessary to reach this operational orbit, and separates from the spacecraft. A second propulsion system integrated with the spacecraft maintains the operational orbit and reduces non-gravitational disturbances on the instruments. Both chemical and electrical propulsion systems were considered for the propulsion module, and this trade is presented to show the possible benefits of an EP system. Several options for the orbit maintenance and disturbance reduction system are also briefly discussed, along with several important requirements that suggest the use of a FEEP thruster system.

## Nomenclature and Acronyms

ACS	=	Attitude Control System
AU	=	astronomical unit
$C_3$	=	excess launch energy
DISCOS	=	Disturbance Compensation System
DRS	=	Disturbance Reduction System
EP	=	electric propulsion
FEEP	=	field emission electric propulsion
FTR	=	Final Technical Report
FY	=	fiscal year
GEM	=	graphite epoxy motor
GSFC	=	Goddard Space Flight Center
Hz	=	hertz
kg	=	kilograms
kW	=	kilowatts
LISA	=	Laser Interferometer Space Antenna
$m_p$	=	propellant mass
$m_{s/c}$	=	mass of the spacecraft
O/F	=	oxidizer/fuel ratio
TR	=	Technology Readiness (Level)
TRIP	=	Technology Report and Implementation Plan

## I. Introduction

The primary goal of the LISA mission will be to detect gravity waves from galactic and extra-galactic sources in a frequency range from  $10^{-4}$  to  $10^{-1}$  Hz. These detections will enable the following science goals to be met:

- Determination of the role of massive black holes in galaxy evolution,
- Precision testing of the theory of general relativity,
- Determination of the population of ultra-compact binaries within our galaxy, and
- Detection of gravitational waves from the early Universe.

The gravity waves will be detected by measuring the change in distance between proof masses in three satellites as a function of time by means of a laser interferometer. The three satellites are launched from Earth on the same Delta IV launch vehicle, and transfer via onboard propulsion to a final orbit located at 1 AU from the Sun at an angle of  $20^\circ$  behind the Earth. The inclination of the operational orbits of each satellite is offset to one another by

---

\* Propulsion Engineer, Senior Member, AIAA.

† Flight Dynamics Specialist, AIAA Member.