Laser Ranging Frequency Stabilization for GRACE II

Completed Technology Project (2008 - 2011)

Project Introduction

Objective:

- Enable measurement of time-variable gravity at smaller spatial scales than current GRACE capability
- Develop frequency reference for inter-satellite laser range measurements with accuracy 10x better than GRACE microwave ranging system
    - Frequency stability of ~$10^{-14}Hz^2$ will be 30x better than the microwave stability.
- Verify suitability for flight through appropriate vibration and thermal testing.

The GRACE mission has provided accurate monthly maps of the Earth gravity field, which have proven a valuable tool for monitoring changes in the distribution of water on the surface of the Earth. The GRACE flight system includes two spacecraft in low polar orbits (450 km altitude) separated by 200 km. Each spacecraft includes a GPS receiver, a microwave instrument, and an Accelerometer. The microwave instrument measures changes in the separation between spacecraft which are due to the Earth¿s gravity field and also due to atmospheric drag and other non-gravitational forces, which are measured by the Accelerometer.

It has long been recognized that a successor to the GRACE mission could make more accurate measurements of changes in the Earth gravity field using lasers for the inter-satellite ranging measurement. A laser ranging instrument can easily improve on the measurement precision of the microwave instrument by using a shorter wavelength for measurement of the distance between spacecraft. The accuracy of a laser ranging instrument is expected to be limited by the stability of the frequency (and wavelength) of the laser used.

The work described here focused on the development of a thermally-stabilized optical cavity for use as a stable reference for the inter-satellite laser signal, and electronics for locking a laser to the cavity. Previous laboratory work had demonstrated stability of optical cavities sufficient to enable more than a factor of 10 improvement in ranging accuracy over the GRACE microwave instrument when used with a suitable overall instrument architecture.

The laser frequency stabilization prototypes were designed with the constraints of available mass, power, and volume of the GRACE-FO mission. The GRAC-FO project entered phase A in January 2012 and includes the laser frequency stabilization subsystem developed here are part of an inter-satellite laser ranging instrument as a technology demonstration.

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Organizational Responsibility

Responsible Mission Directorate:

Science Mission Directorate (SMD)

Lead Center / Facility:

NASA Headquarters (HQ)

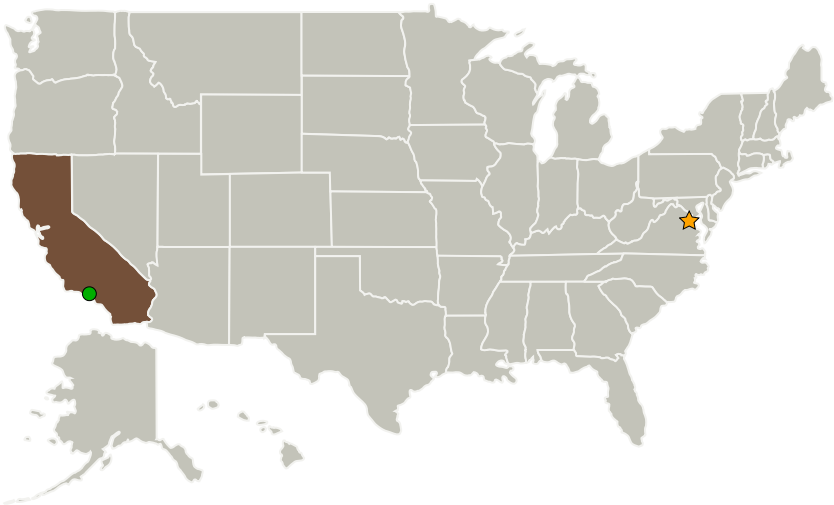
Responsible Program:

Earth Science

Anticipated Benefits

GRACE FO

Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
★NASA Headquarters(HQ)	Lead Organization	NASA Center	Washington, District of Columbia
●Jet Propulsion Laboratory(JPL)	Supporting Organization	NASA Center	Pasadena, California

Primary U.S. Work Locations
California

Stories

Technology Infusion: Laser Frequency Stabilization Subsystem for GRACE Follow-On Mission
(https://techport.nasa.gov/file/22154)

Project Management

Program Director:

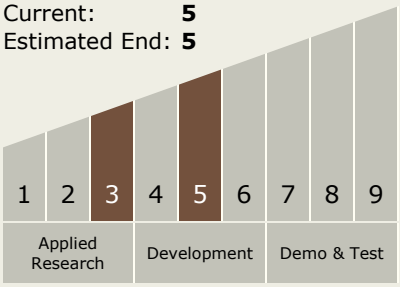
George J Komar

Principal Investigator:

William M Folkner

Technology Maturity (TRL)

Start: **3**
Current: **5**
Estimated End: **5**



Technology Areas

Primary:

- TX08 Sensors and Instruments
  └ TX08.1 Remote Sensing Instruments/Sensors
    └ TX08.1.4 Microwave, Millimeter-, and Submillimeter-Waves

Target Destination

Earth