THE DRAG-FREE CUBESAT

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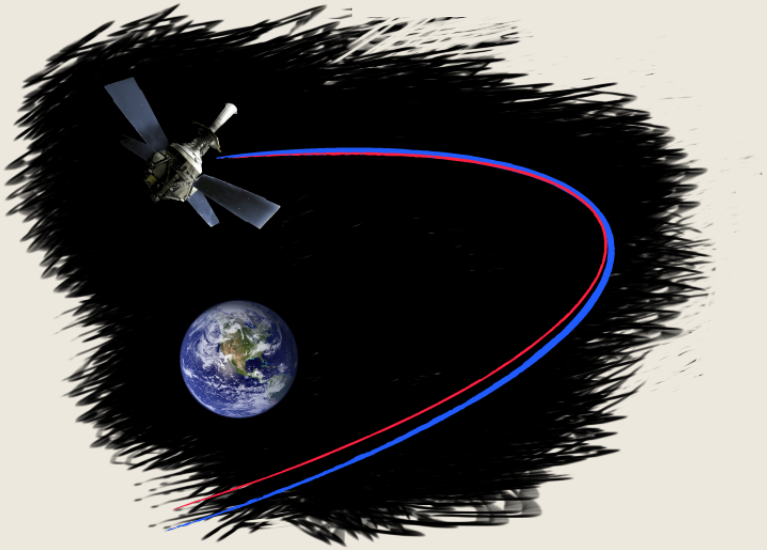
Drag-free Concept and Applications

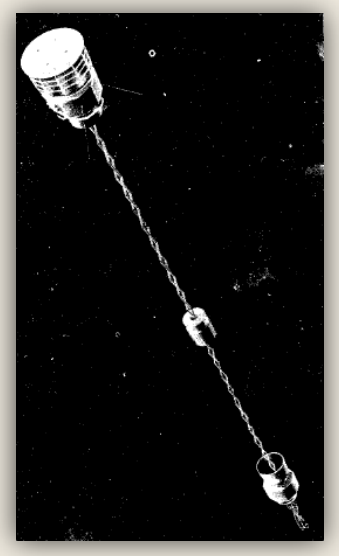
- Cancel deviation from geodetic orbit



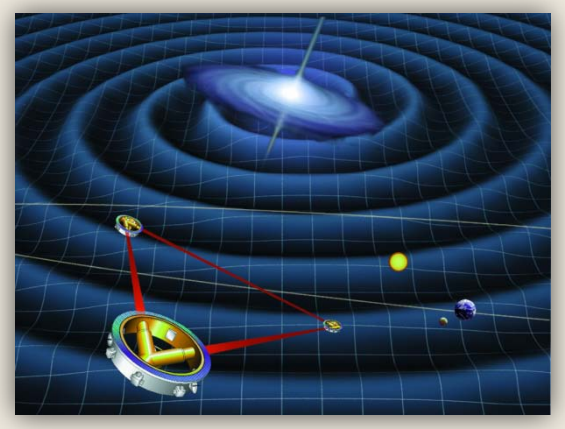
- Geodesy
- Aeronomy
- Autonomous orbit determination
- Fundamental Physics

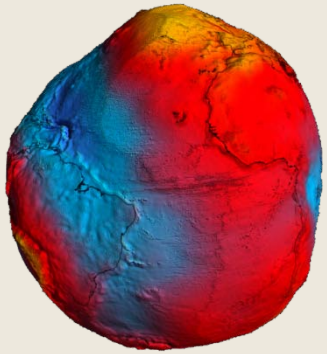
Drag-free History

- TRIAD I (1972)
- GRACE (2002)*
- Gravity Probe B (2004)
- GOCE (2009)



- Planned:
  - LISA Pathfinder
  - LISA



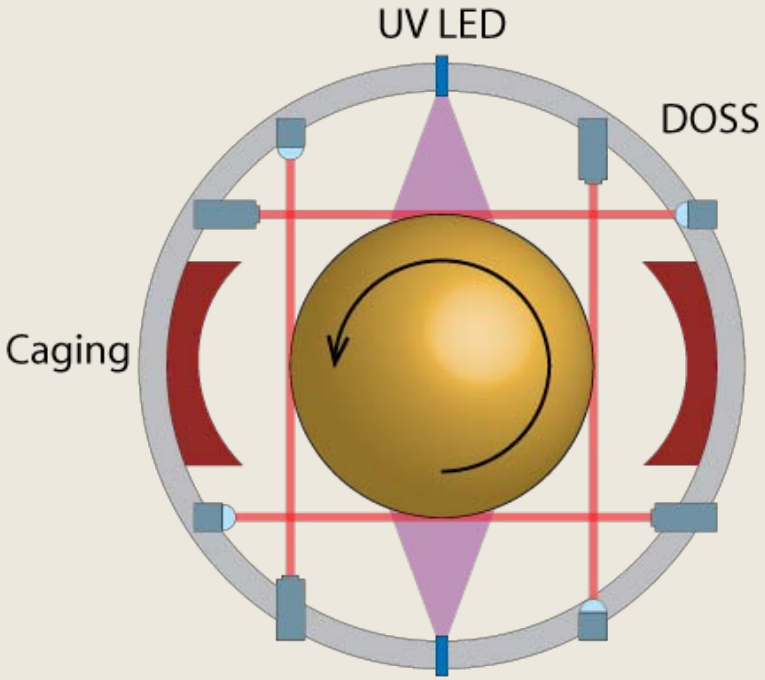


* Accelerometer only

Goal for Drag-free CubeSat

- Demonstrate inexpensive Drag-free mission
- Performance Goal derived from NASA Earth Science Goals for future Geodesy: $10^{-12} ms^2/\sqrt{Hz}$ from 10mHz to 1Hz
- Demonstrate integration of new technology

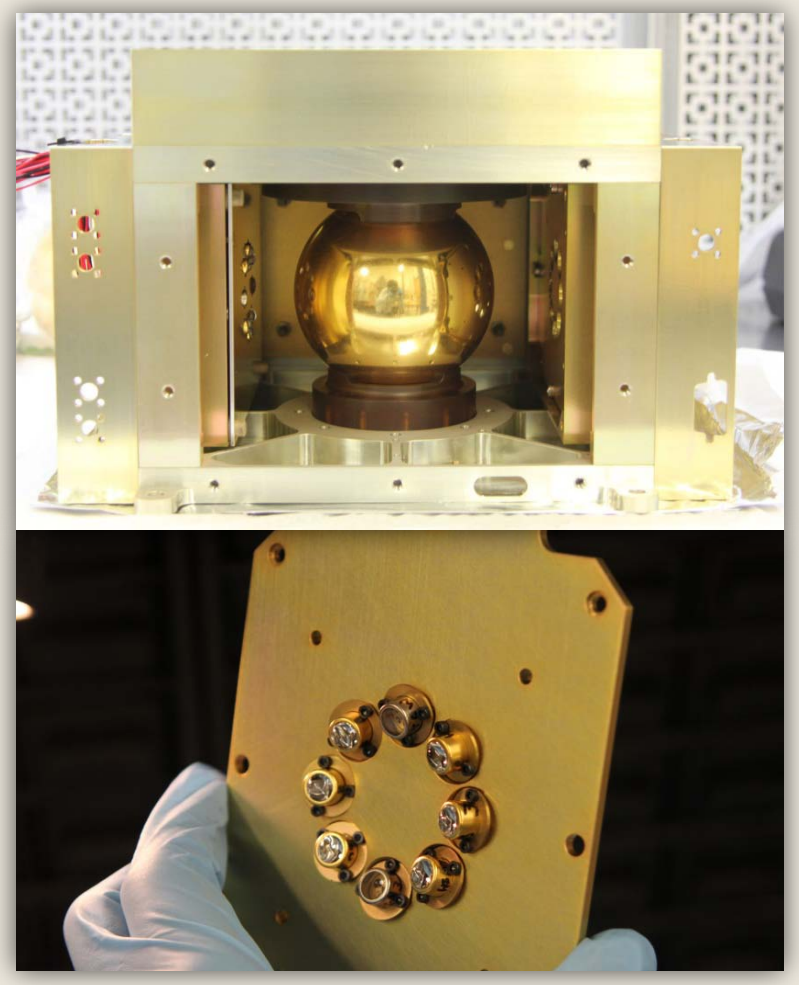
Modular Gravitational Reference Sensor (MGRS)



- Differential Optical Shadow Sensor (DOSS) to sense external disturbances
- UV LED for Charge Management to compensate internal disturbance
- Caging Mechanism designed for 1000 N holding force
- Spinning Sphere for spectral shift of disturbances

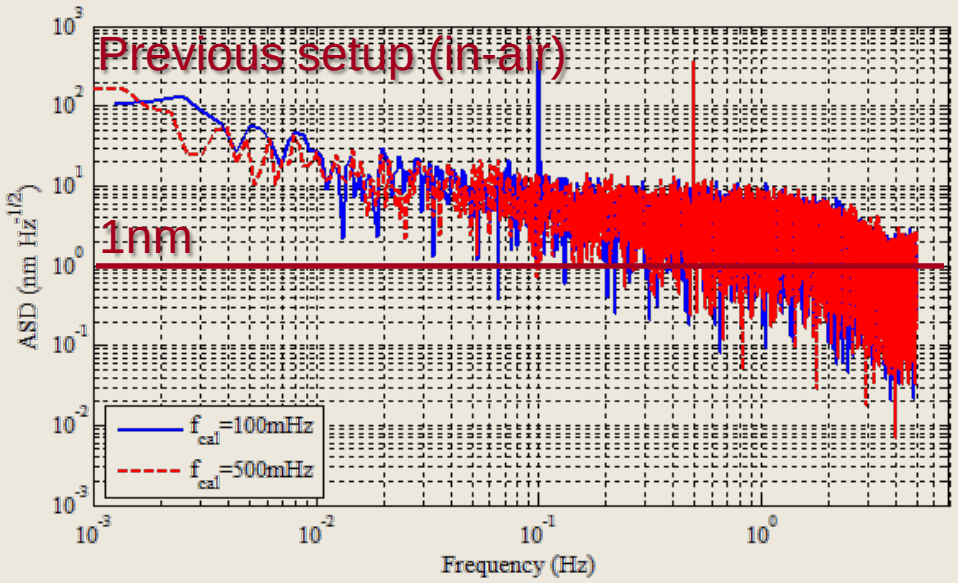
UV LED Satellite

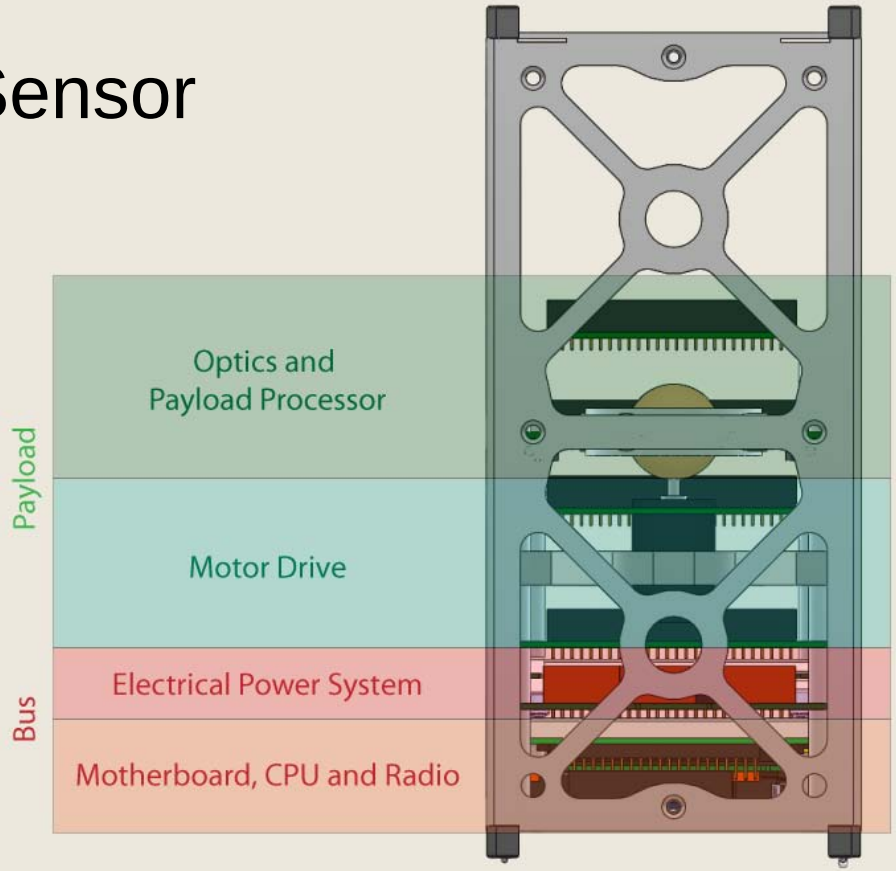
- Goal: Raise TRL up to 8/9 for Deep UV LEDs and AC charge control
- Collaboration with KACST and NASA Ames
- Spacecraft: Saudi Sat 3 (55kg)
- 16 UV LEDs & photodiodes



Differential Optical Shadow Sensor (DOSS)

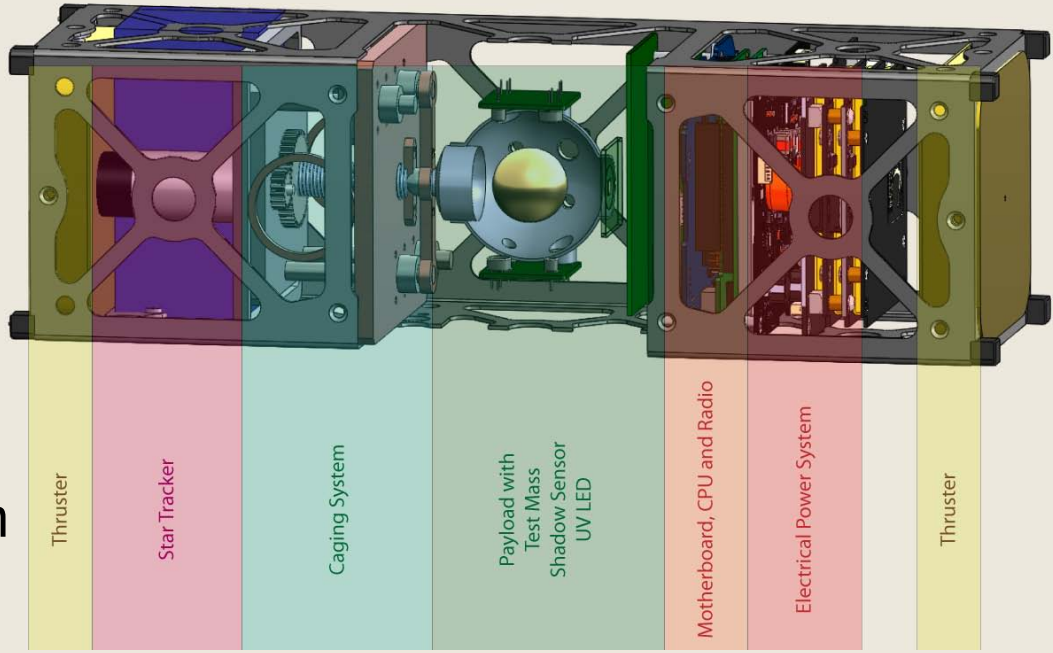
- 2U CubeSat
- Raise TRL for Shadow Sensor
- Completion: 2013





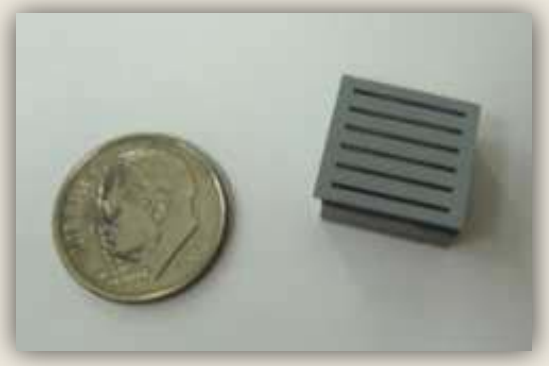
The Drag-free CubeSat

- 3U CubeSat
- Demonstrate fully integrated MGRS
- 2y development time
- Areas of Research:
  - Drag-free control algorithm
  - In-orbit performance evaluation
  - Environmental modeling and optimization (thermal, electro-magnetic)



Thruster comparison

SRI International



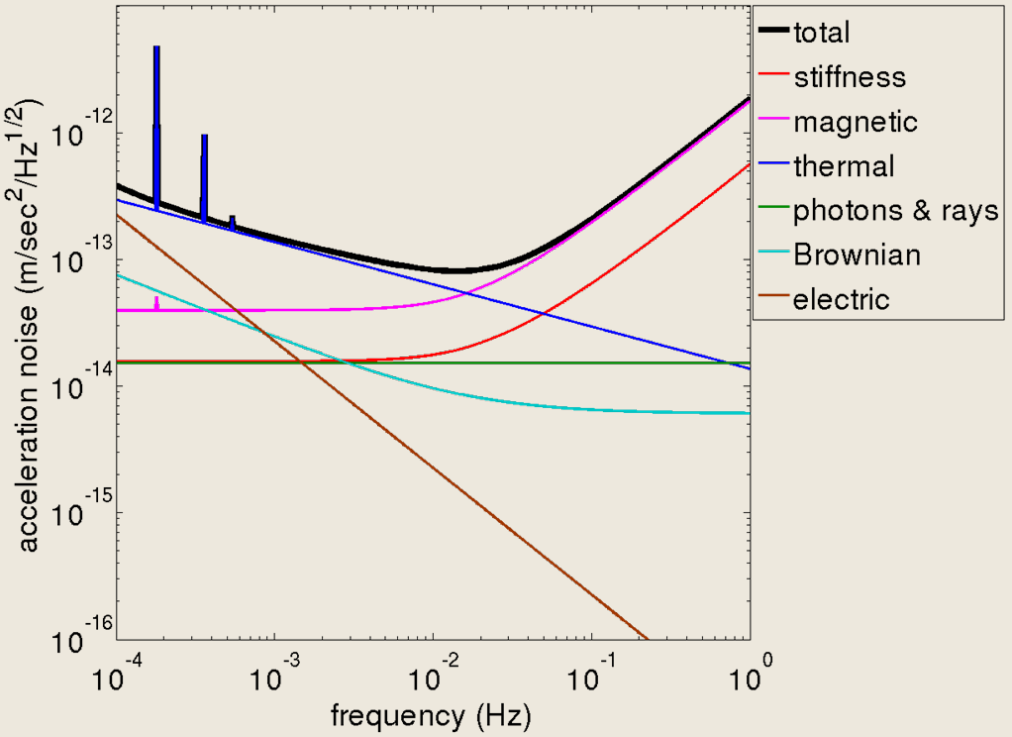
- TRL 4
- Thrust: 1 nN to 5 μN
- ISP: up to 10,000 sec
- Advantages:
  - Single unit produces forces + torques
  - High dynamic range
  - Low noise
  - Higher lifetime

VACCO Industries

- TRL 6
- Thrust: 25 to 55 mN
- ISP: 65 sec
- Advantages:
  - Higher TRL

Error Budget

- Follows LISA error budget
- Assumptions:
  - 25mm AuPt Sphere
  - Temperature stability:
    ±20K at orbit rate
    1K at other frequencies
- Thermal noise limited below 10mHz
- Magnetic noise limited above 10mHz



Conclusion

- State of the art drag-free performance can be demonstrated on CubeSat

- Prospects for funding include:
  - Edison (Invited to submit full proposal)
  - Earth Science Technology Office (ESTO)
  - NSF CubeSat Program

BACKUP SLIDES

Error Budget