Atom Interferometer Gravity Gradiometer

GSFC and AOSense

Focus Area: Quantum Sensing

GSFC and AOSense are leading the development of a high sensitivity Atomic Interferometer Gravity Gradiometer flight instrument for a next generation gravity mission capable of an order of magnitude improvement in Earth time variable gravity observations from a single satellite.

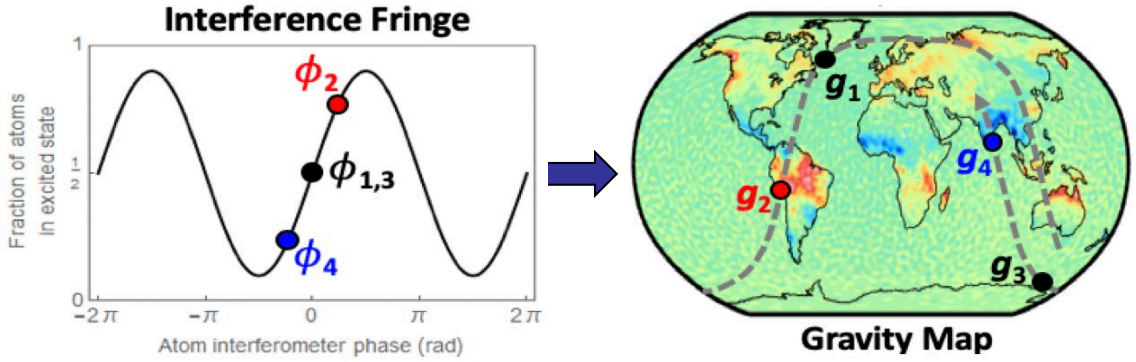
AOSense lab instrument in collaboration with NASA GSFC:

- **Currently TRL 4**
- **Expect measurement accuracy <1 $E\sqrt{Hz}$ early 2021**
- **Ground measurement of <1 $E\sqrt{Hz}$ corresponds to 10^{-5} $E\sqrt{Hz}$ in microgravity with longer interrogation time**
  - **Demonstrates order of magnitude improvement in time variable gravity observations**

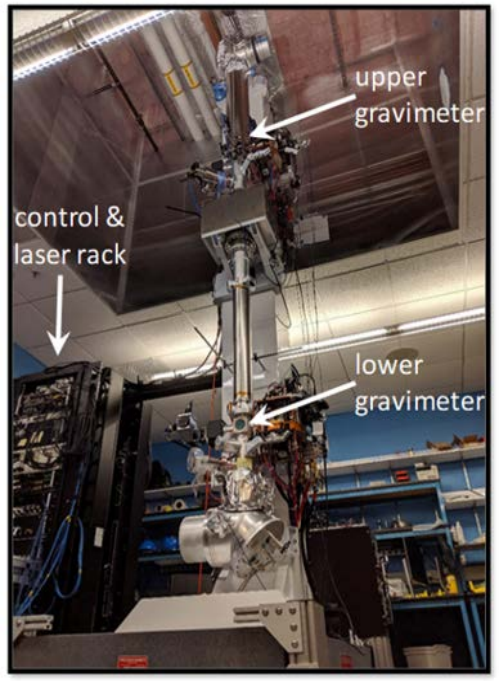
GSFC Instrument Design Lab (IDL) conducted June 1st – 5th

- **First AIGG flight instrument design**
- **Identified challenges and unique engineering solutions: Laser Reference System for precise orientation in inertial frame, mechanisms for rotational and translational compensation for high signal to noise radial observations**
- **Continue engineering design refinement**

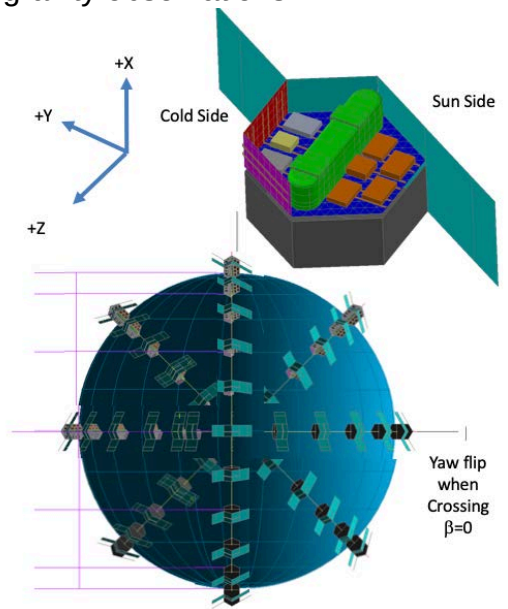
GSFC MDL to be conducted ~Jan. 2021



High sensitivity interferometer fringe measurements for time variable gravity observations



Atom interferometry gravity Gradiometer at AOSense



Flight Design

AIGG Performance Summary

- Performance summarized as monthly time variable gravity (TVG) geoid height error (mm) as function of gravity field spherical harmonic degree (~wavelength)
- Mass Change Designated Observable (MCDO) mission study team has evaluated performance of AIGG relative to all other architectures, and has noted the “high scientific value”
- MCDO study simulations consider instrument, attitude, orbit, and atmospheric and ocean high frequency variation aliasing errors
- The AIGG outperforms a future MCDO Satellite – Satellite Tracking (SST) (e.g. GRACE, GRACE-FO) pair employing Laser Ranging Interferometry (LRI).
- The single satellite AIGG out performs the SST two satellite architecture by over an order of magnitude nearly across the entire spectrum
- AIGG performs worse at only the lowest degrees (longest wavelengths) but this part of the spectrum is well observed by Satellite Laser Ranging (SLR)
- Largest error source for AIGG is attitude knowledge