Liquid reaction wheel based on MHD effect in liquid Mercury

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Short Background

- First Georgian Satellite
  - Already assembled and functioning Ground Station
- Technology demonstration for MHD reaction wheel
- New technology development

Spherical Air Bearing

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  - Roundness $10 - 20\ \mu in$
  - Surface roughness $< 16\ \mu in$

Spherical Air Bearing

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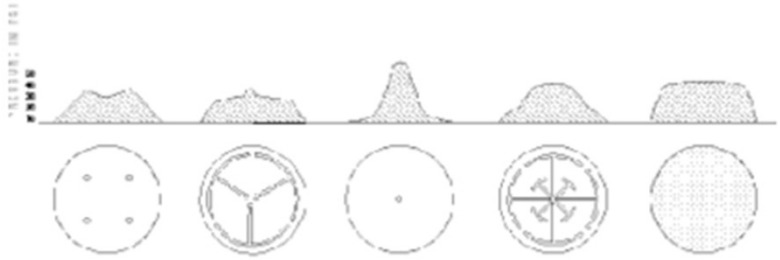
- Bowling Ball Standard Specification
  - Roundness < 0.010“
  - Surface Roughness < $50\ \mu in$

Spherical Air Bearing

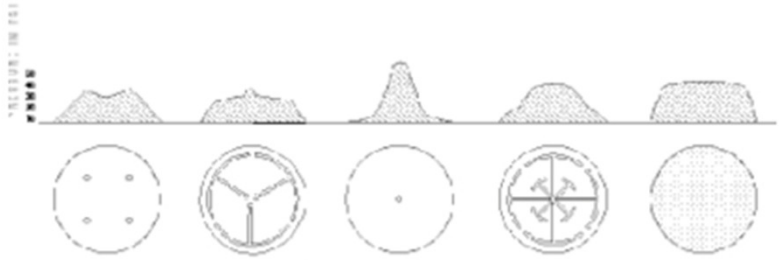
- Roundness
- Surface roughness
- Support
  - # 5) is Good



Pressure (psi) vs Lateral Position of various air bearings; From left to right: 1) Multiple orifices with no grooves, 2) Multiple orifices with distribution grooves, 3) Single orifice, no grooves, 4) Single non restrictive input port with depth and width of grooves providing restriction, 5) Full porous face with 10s of millions of sub-micron pores evenly spaced across the face

Spherical Air Bearing

- Roundness
- Surface roughness
- Support
  - # 5) is Good
  - Gypsum is the material to Go!
    - Easy to mold
    - Porous
    - Inexpensive



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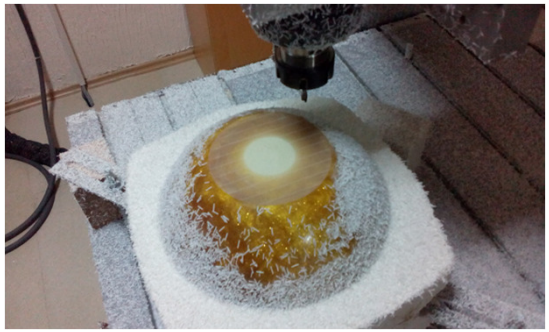
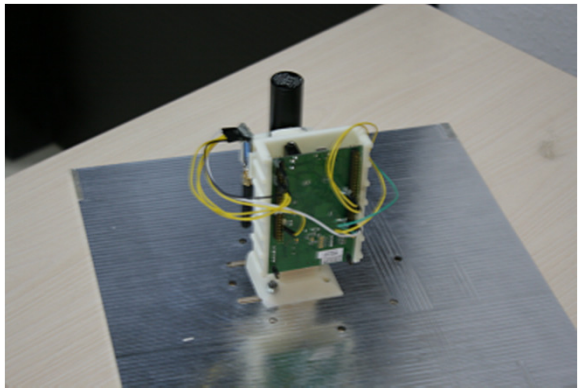
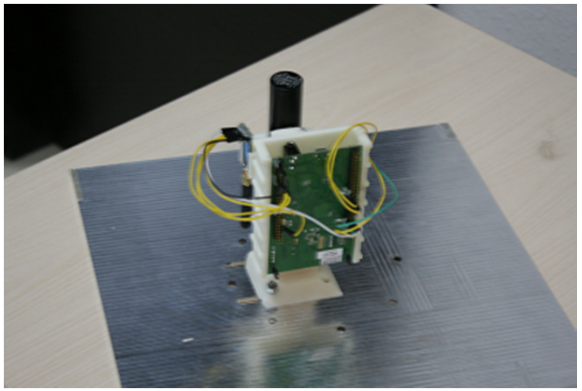
Spherical Air Bearing





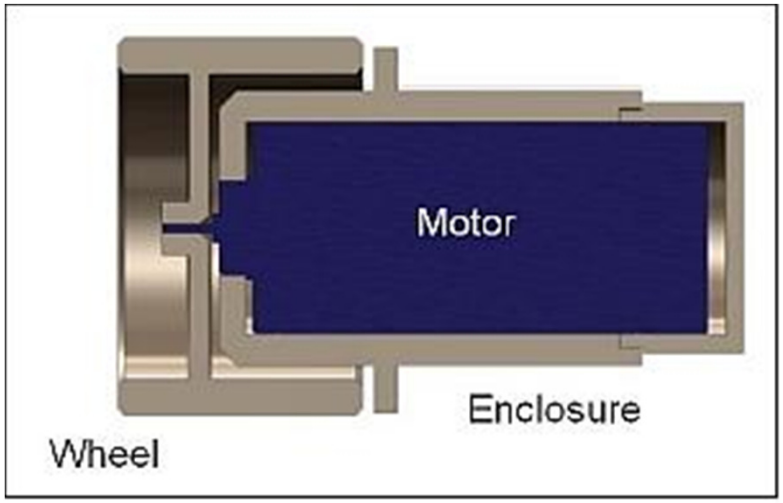
Kalman + RF

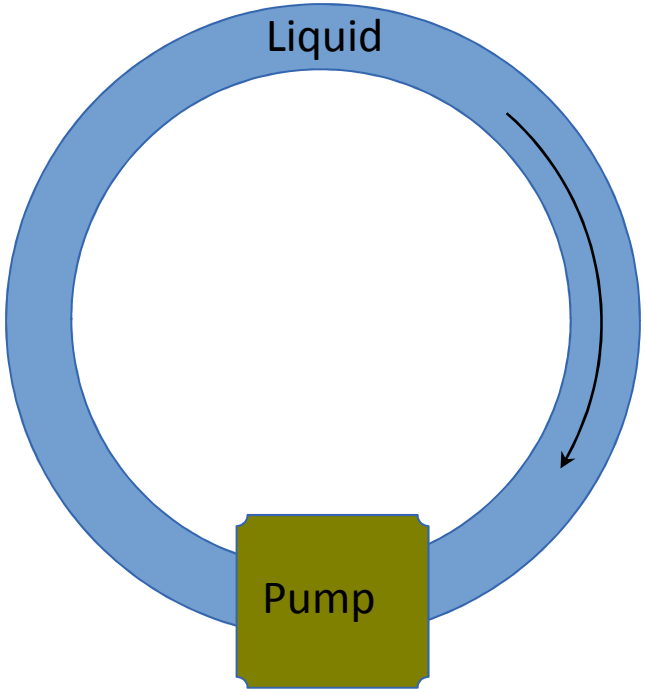


- STM32F407 Discovery Board
- CC1101 RF board
- Gyro + B Field + Accelerometer

- STM32F407 computes DCM matrix with implementation of Kalman filter for matrices, and Airs it to the desktop computer which is used for logging, and visualization

Liquid Reaction Wheel

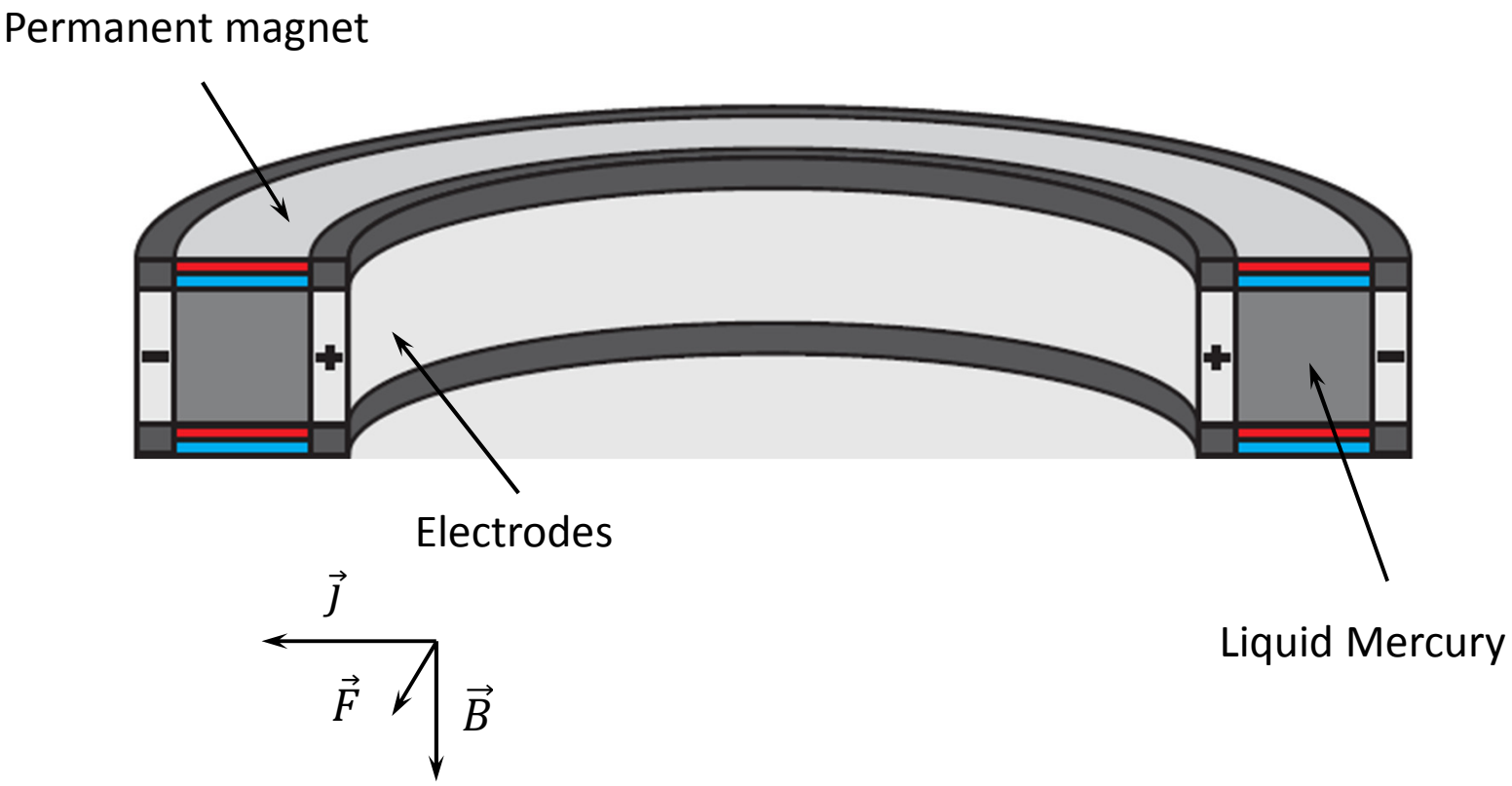




Mercury

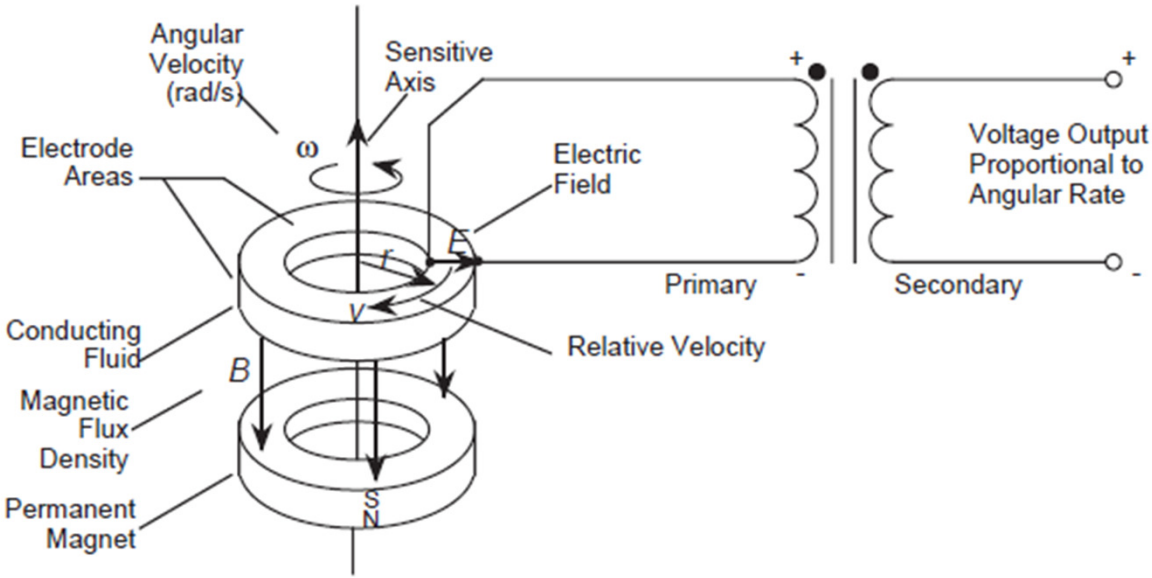
- Density = 13.546 g/cm^2
  - Lead = 11.35 g/cm^2
- Melting point = –38.8 °C
  - Boiling point = 356.7 °C
- Bonus future:
  - Electrical Resistivity = 961 $n\Omega \cdot m$

MHD


Permanent magnet
Electrodes
Liquid Mercury
$\vec{J}$
$\vec{F}$
$\vec{B}$

Other uses

- Angular Displacement Sensor on Advanced Land Observing Satellite (ALOS)



AIAA Guidance, Navigation, and Control Conference
10 - 13 August 2009, Chicago, Illinois

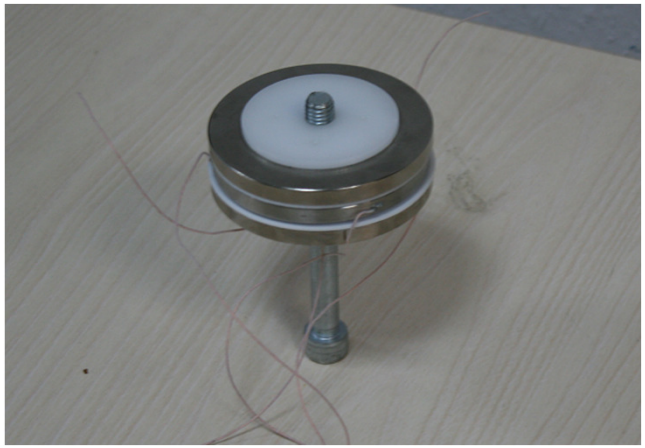
Pros and Cons

- Minimal number of moving parts
- Simple driving electronics
- High efficiency
- High reliability
- Inexpensive

- Hg is hard to work with (Health Hazard)
- Corrodes Aluminum
- Magnetic field containment
- Increased friction

Our Implementation

- NdFeB Grade N42
- 13200 gauss
- 3” OD x 2” ID x 0.25”
- ≈0.3 RPS/A



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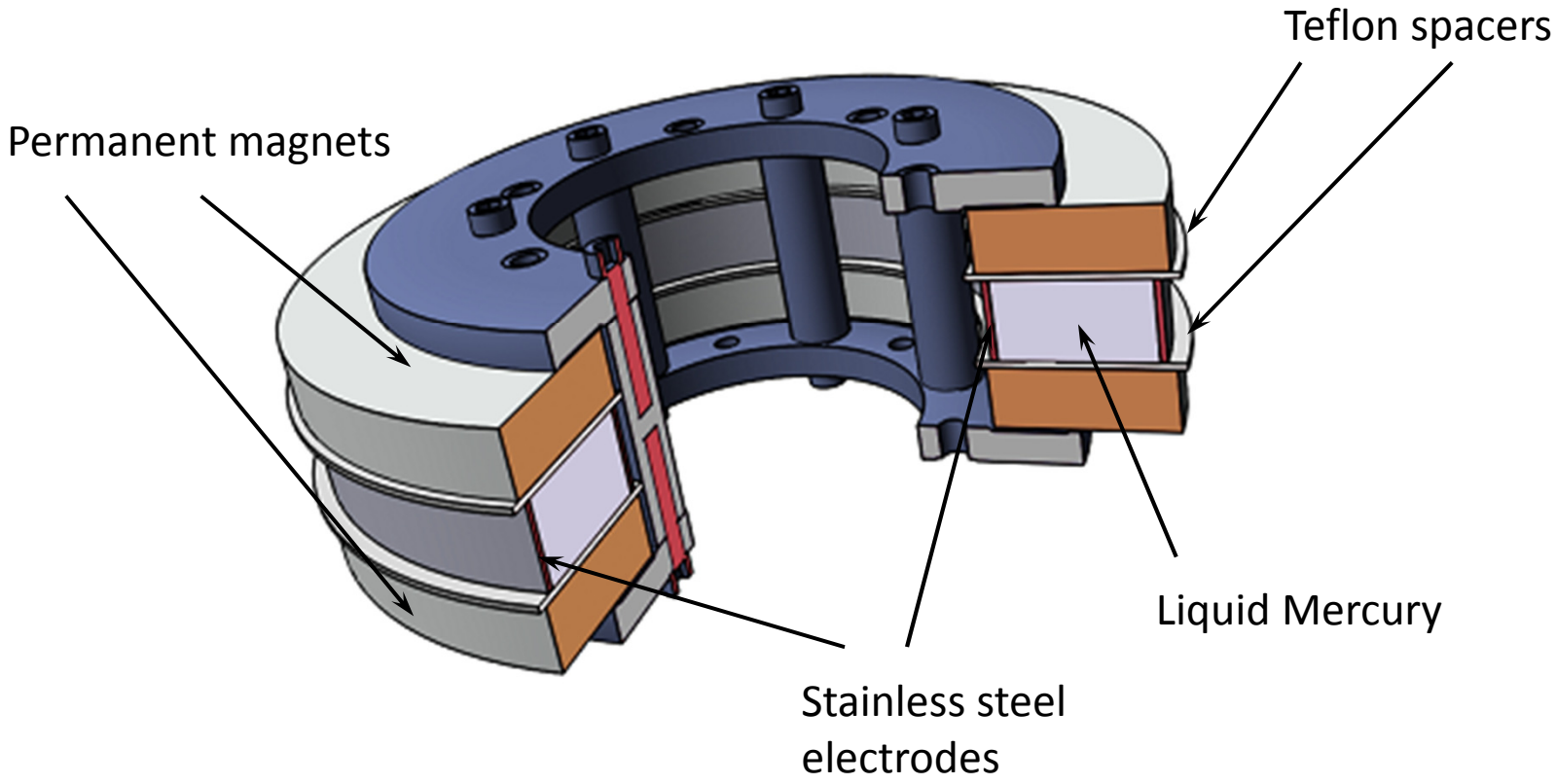

Things to Improve on

- Material and Geometry optimization
- Accurate measurement of parameters

Team

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The END