Next Generation Fluxgate Magnetometers

2023 Technology Showcase for Future NASA Planetary Science Missions

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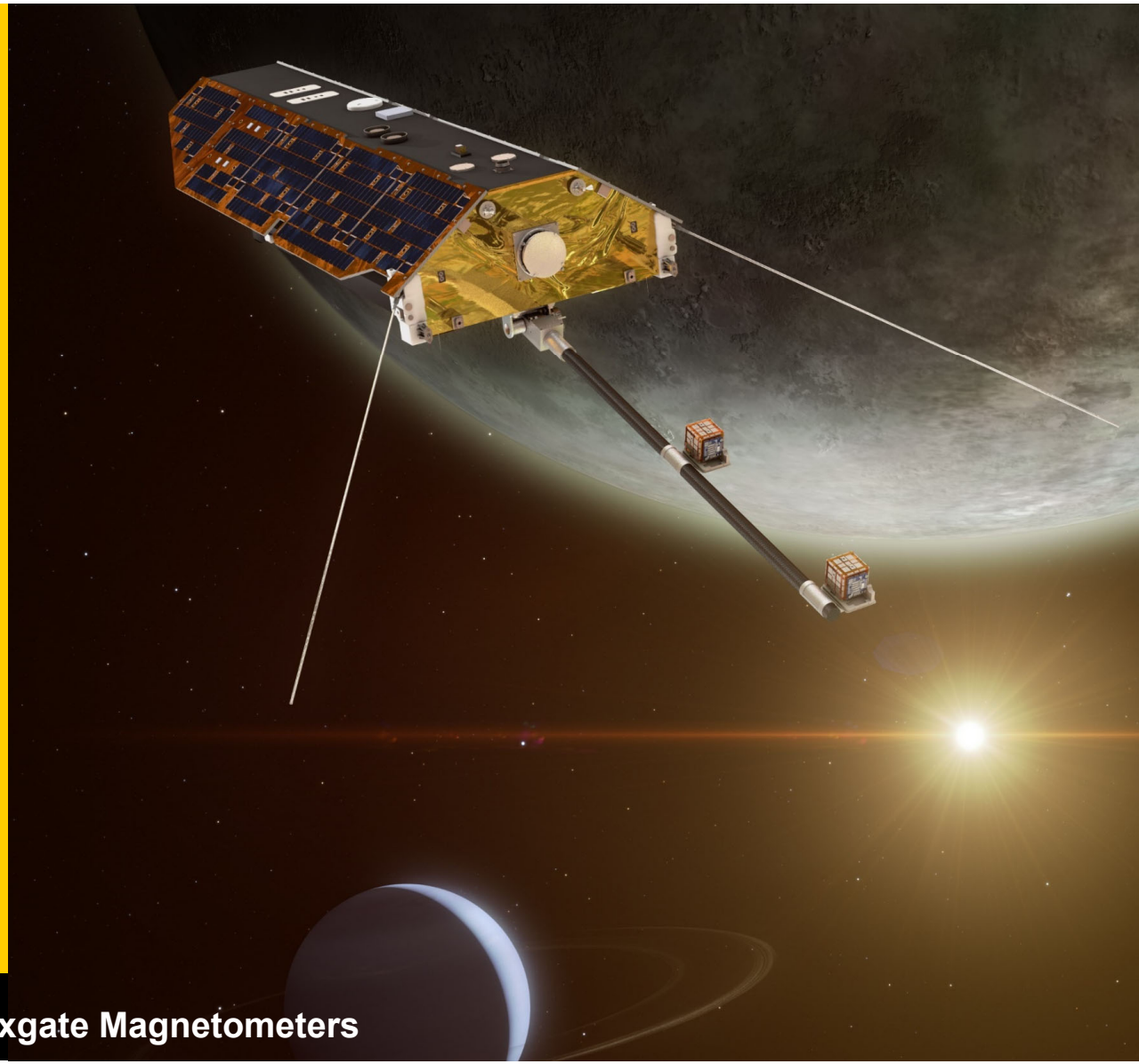
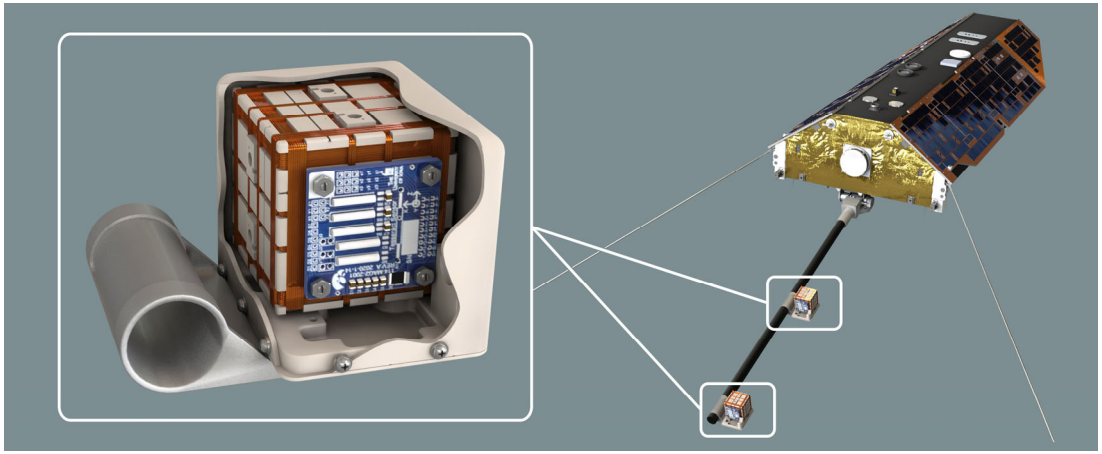
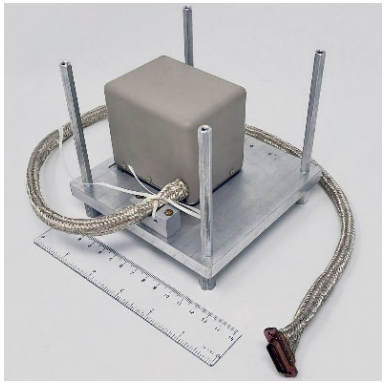
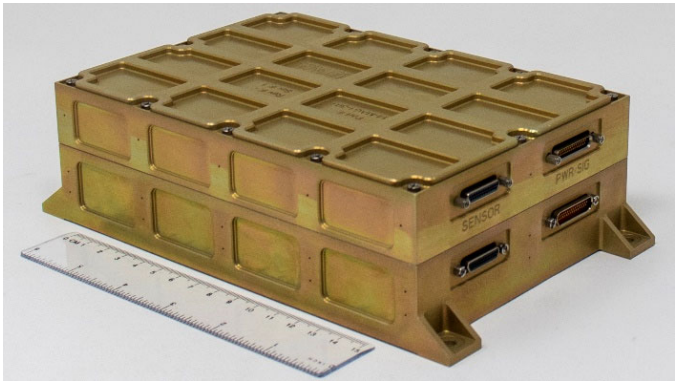


Magnetometers for Future Planetary Missions

- Next generation fluxgate magnetometers
- Built and tested in-house at the University of Iowa
- Recent heritage from MAGIC/TRACERS SMEX
- No dependency on legacy fluxgate cores
- Gradiometer available
- New algorithms for mitigating dynamic magnetic noise

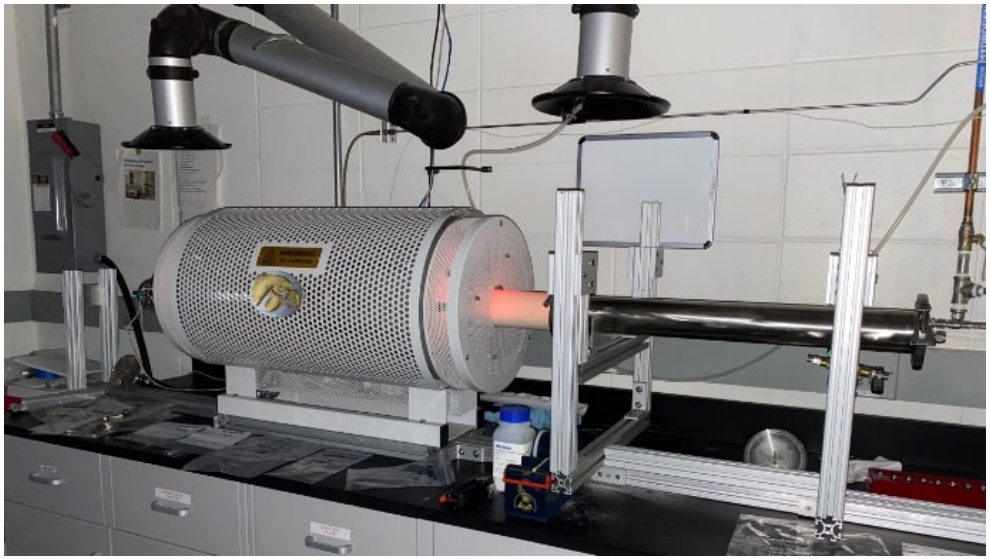


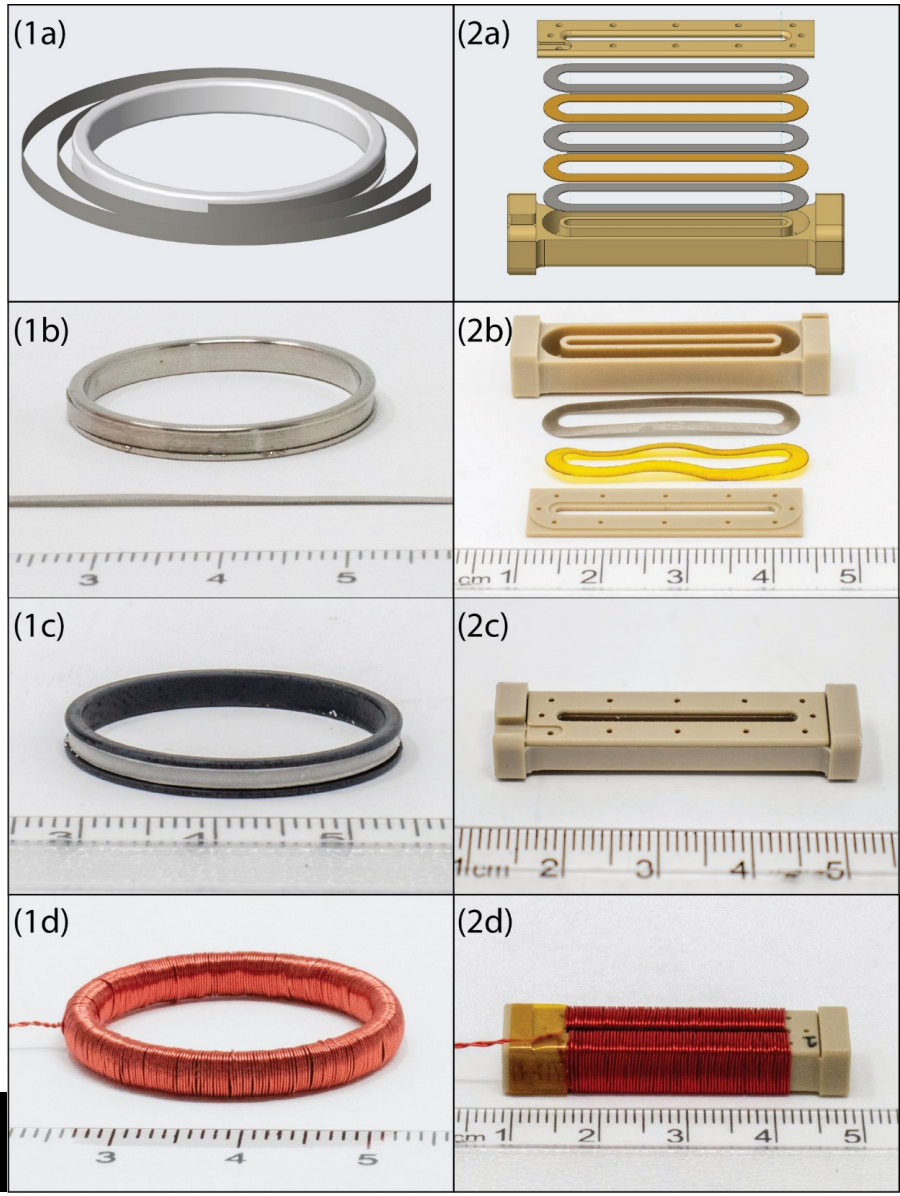




Bespoke Fluxgate Cores Require No Legacy Materials

- No dependency on legacy cores or materials!
- Fluxgate cores manufactured in-house from scratch.



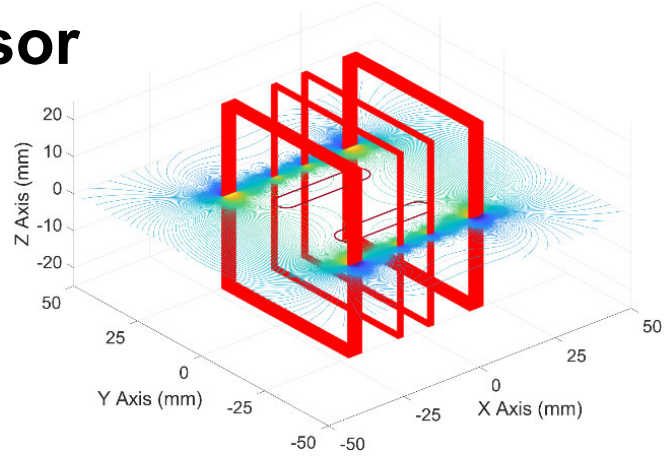


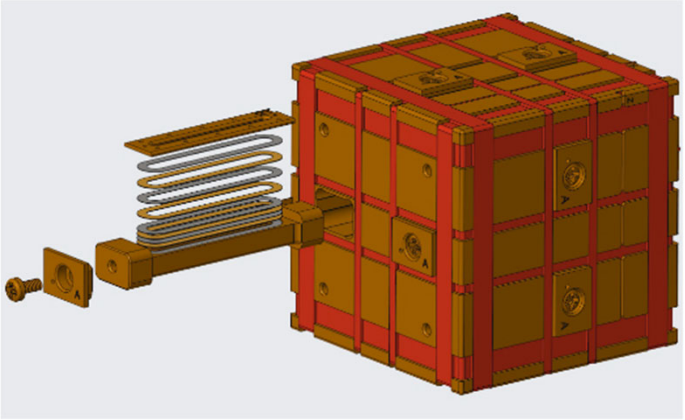
Radiation-Tolerant Electronics

- Scalable modern electronics
- Configurable FPGA-based design
- 1.5 W / 3-axis magnetometer
- 1200 g (two 3-axis magnetometers)
- 213 x 129 x 61 mm (two 3-axis)
- 28±6 Vdc isolated power input
- LVDS/RS-422 asynchronous serial for data/control
- 1 PPS timing input

High-Stability ‘Tesseract’ Fluxgate Sensor

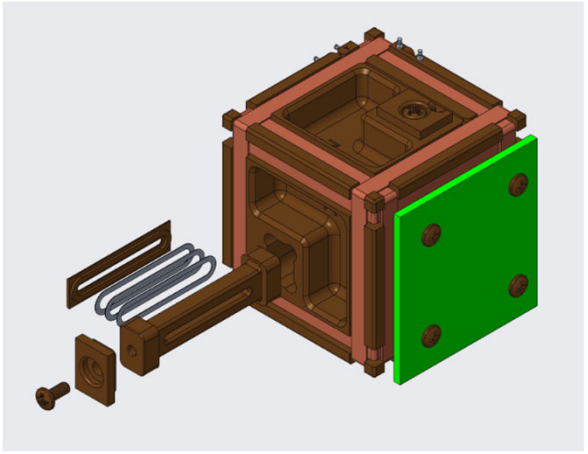
- Three-axis symmetric design is stable over extreme temperatures
- Uses new highly-repeatable racetrack core design
- Optimized magnetic nulling for repeatable core operation

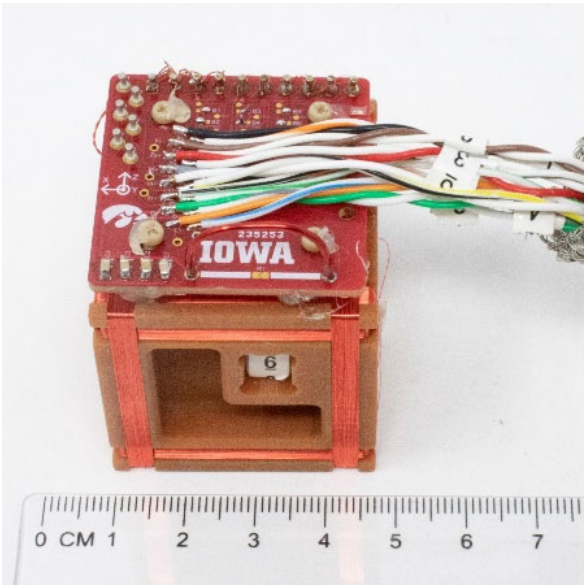




Nanosatellite Fluxgate Sensor

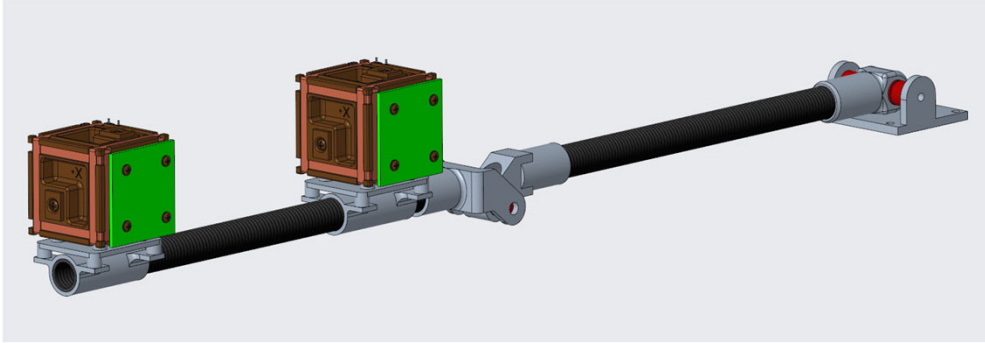
- DC – 50 Hz configurable bandwidth
- Low noise: ~10 pT / √Hz @ 1 Hz
- Low-mass: ~80 g sensor
- Compact: 40 x 40 x 45 mm sensor
- Optimized for low-cost volume production
- Qualification is ongoing

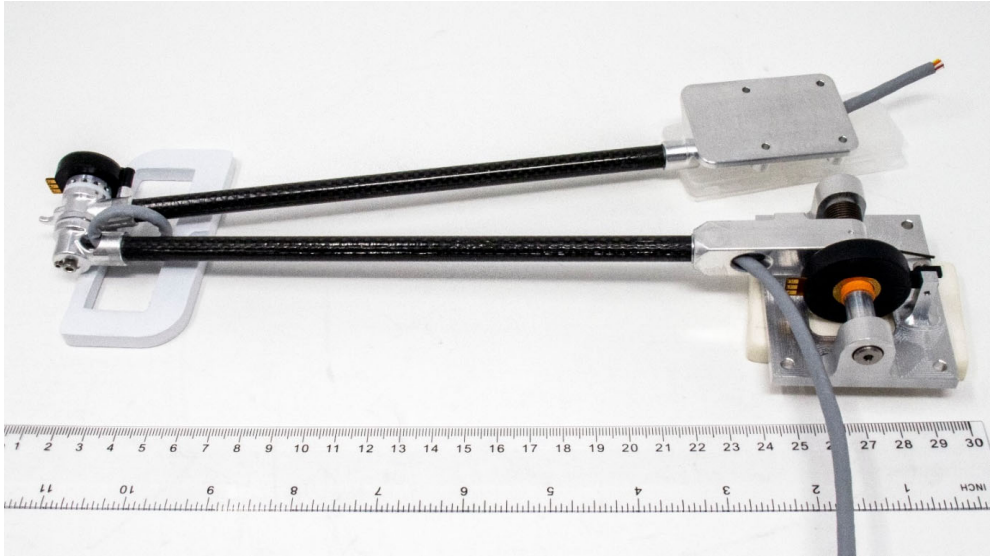




60 cm Nanosatellite Magnetometer Boom

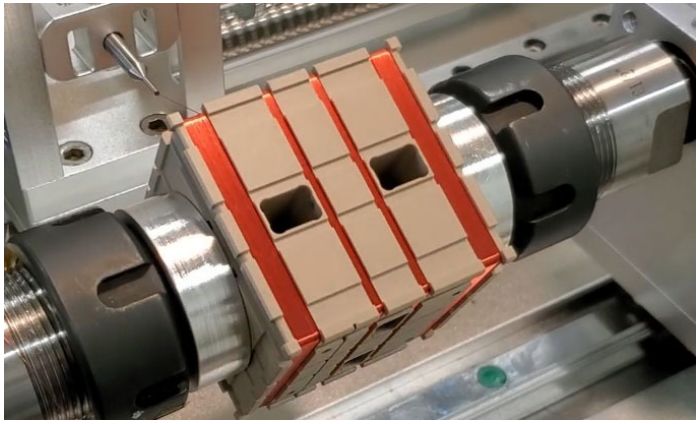
- Non-magnetic design
- Integrated wiring harnesses
- Parabolic flight testing in 2021 and 2022

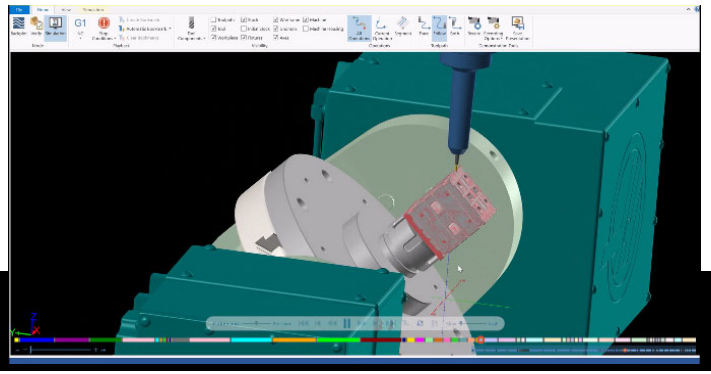




In-House Manufacturing and AI&T

- 5-axis CNC
- CNC Coil Winding
- PWB Pick-and-Place
- Vapor Phase Reflow
- Thermal Vacuum
- Polymerics
- Vibration
- EMI/EMC



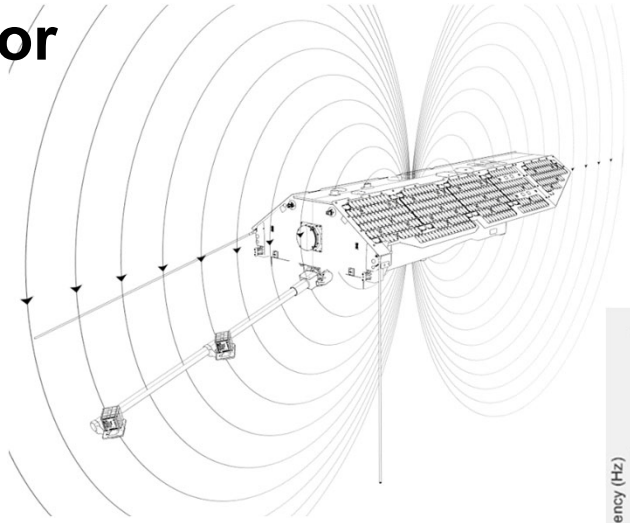


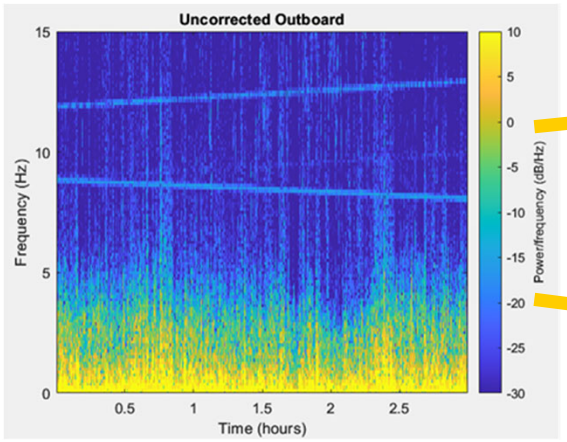
Pre-Flight and In-situ Calibration

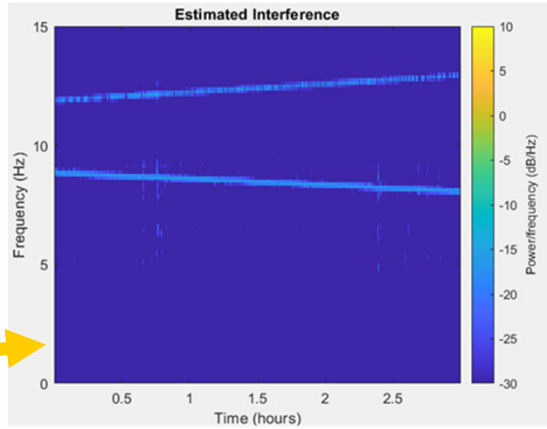
- Pre-flight calibration performed at U. Iowa
  - Sensitivity
  - Orthogonality
  - Zeroes
  - Thermal Stability
  - Thermal Gain
- In-situ calibration when a model field is available using robust vector-vector residual minimization

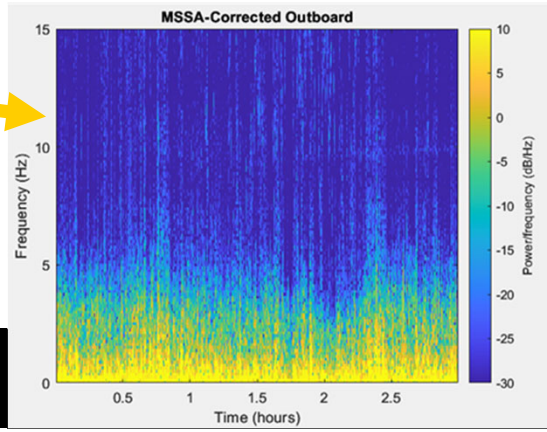
Robust Signal Processing for Magnetic Noise Removal

- New techniques beyond Ness for removing AC magnetic noise
- Statistical technique for simultaneous decomposition of multiple inputs into physically meaningful components
- Noise vs Signal automatically labelled by statistical analysis against gradients
- Used on e-POP/Swarm-Echo
- Validated on Parker Solar Probe



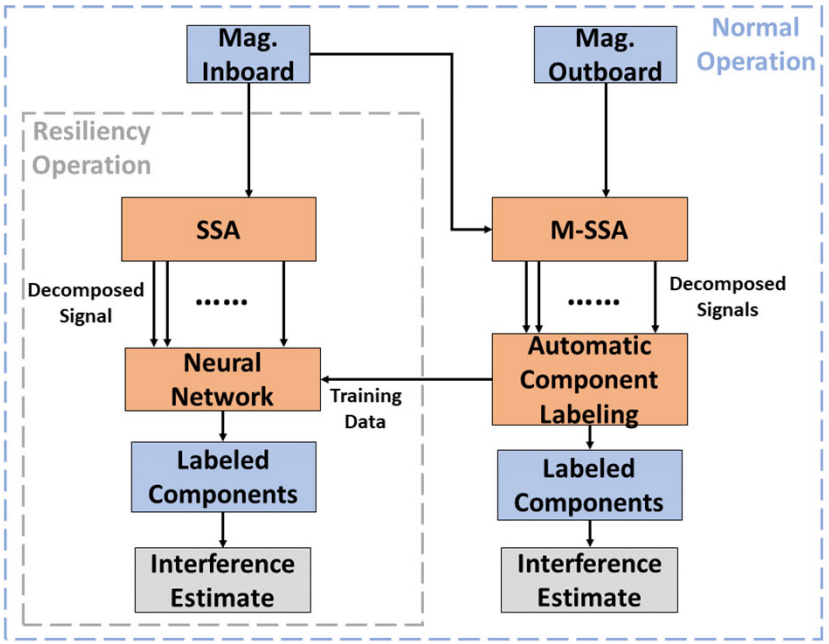


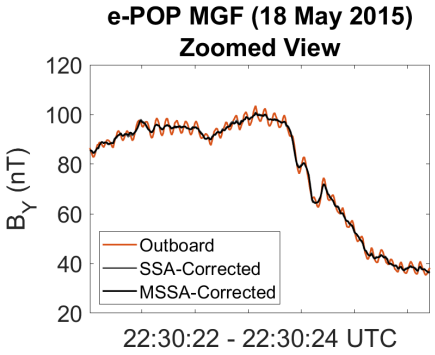


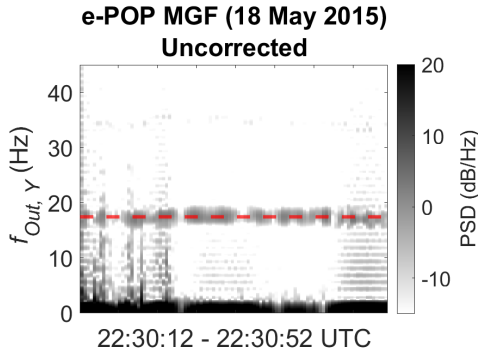


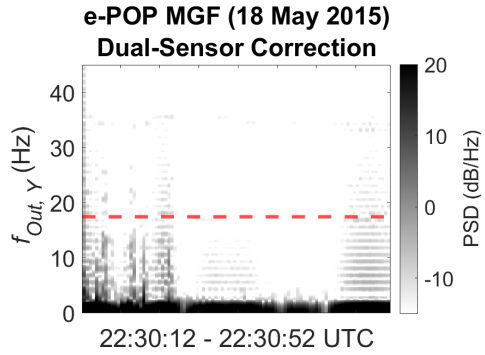
Deployable Denoising Software

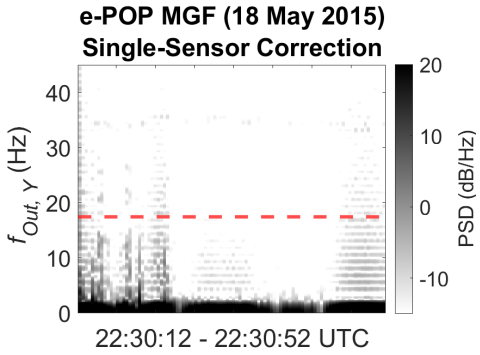
- Gradiometer capability not always practical in-situ
- Resilience mode enables denoising even with limited telemetry for gradiometer
- Comparable results to dual-sensor normal operating mode (>99% improvement)





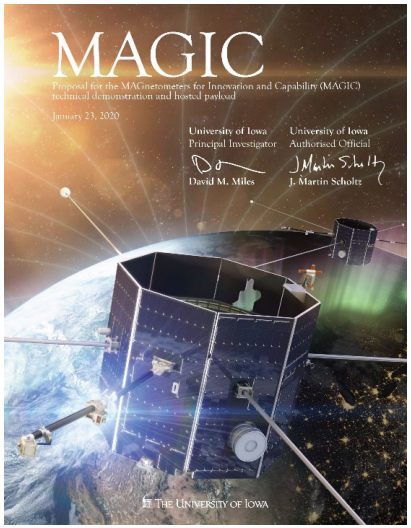






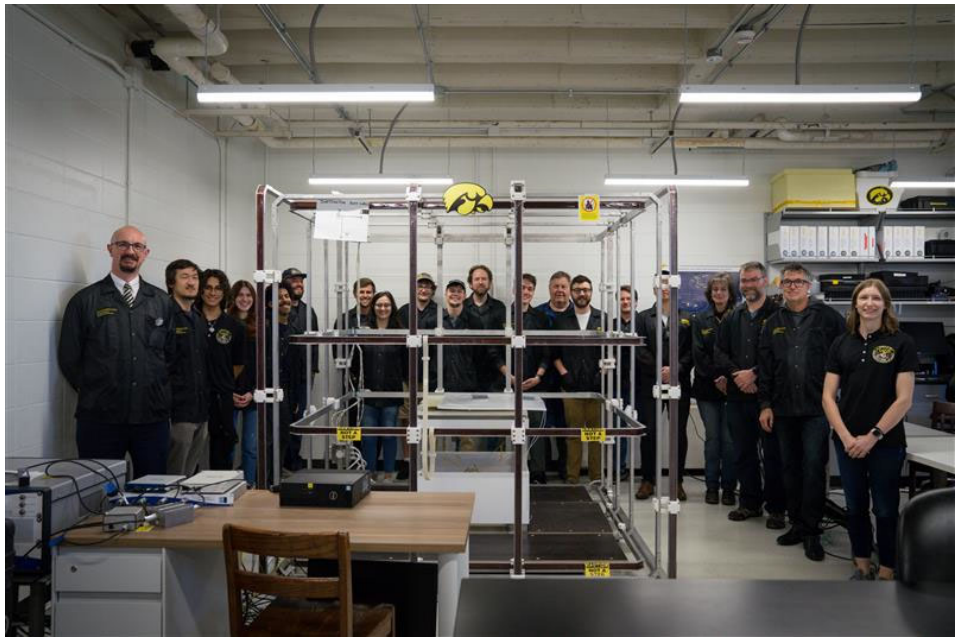
Flight History and Heritage

- e-POP/Swarm-Echo (2013)
- ICI-4/ICI-5 Rockets (2014/2019)
- Ex-Alta 1 CubeSat (2017)
- ACES-II Rockets (2022)
- TRACERS/MAGIC SMEX (2024)



Summary

1. Next generation magnetic field instruments
2. Nanosatellite sensors available
3. Pre-flight and in-situ calibration
4. Modern signal processing for noise removal



Thank-you!

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