



# MagQuest Phase 4 Update

## Swarm 10<sup>th</sup> Anniversary Conference

April 2024

Jarret Baldwin

National Geospatial-Intelligence Agency (NGA)

Office of Geomatics

NATIONAL GEOSPATIAL **NGA** INTELLIGENCE AGENCY

# National Geospatial-Intelligence Agency

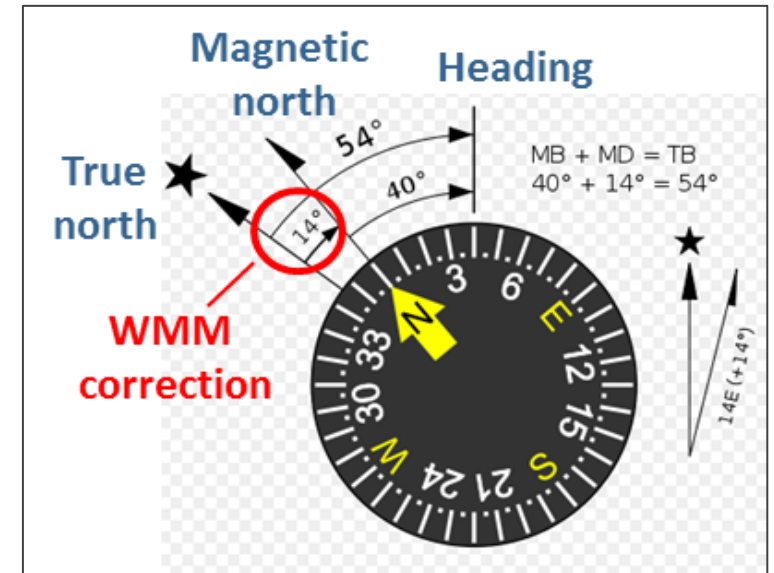
- The National Geospatial-Intelligence Agency (NGA) delivers world-class geospatial intelligence that provides a decisive advantage to policymakers, warfighters, intelligence professionals and first responders.
- NGA ensures safety of navigation in the air and on the seas by maintaining the most current information and highest quality services for U.S. military forces and global transport networks.
- NGA Office of Geomatics is the custodian of WGS 84, the best global geodetic reference system for the Earth available at this time for practical applications of mapping, charting, geopositioning, and navigation.
- WGS 84 includes the definition of the coordinate systems, the Earth Gravitational Model (EGM), the World Magnetic Model (WMM), and a current list of local datum transformations.
- NGA partners with USA's NOAA and UK's BGS to build and maintain the WMM.



N A T I O N A L   G E O S P A T I A L   **NGA**   I N T E L L I G E N C E   A G E N C Y

# WMM Users

- Federal Aviation Administration and other Aviation agencies around the globe
- All the Ships at Sea (International Hydrographic Organization)
- NATO / United States Department of Defense
- You! ... if you use a cell phone or any GPS device.



Ariel Cornejo

# MagQuest Overview

- NGA has used Swarm data to build/monitor the World Magnetic Model (WMM) since launch
- ESA Swarm is providing the data for upcoming WMM 2025 production
- NGA is sponsoring the MagQuest prize challenge to develop post-Swarm data source
- MagQuest is operated by NASA's Center of Excellence for Collaborative Innovation (CoECI)
- Phase 4 (final phase) underway since mid-2021 to build, test, and fly three different polar nano-sats
- Planned launches in 2025/2026 with data quality assessments through 2029
- NGA anticipating long-term data buy procurement with successful team(s), beginning ~2028

# Technology Demo: MagQuest Prize Challenge



NGA pursuing three independent nano-satellite prototype solutions under Phase 4

- ▶ *Phase 4a: Mini-magnetometer ground testing (completed)*
- ▶ **Phase 4b: Satellite development & testing, delivery for launch (current phase) (2024-2025)**
- ▶ Phase 4c: launch, data collection and analysis (2026-2029)


Successful results will lead to data procurement contract

- ▶ Potential data buy to support WMM 2030 production and beyond
- ▶ Tech demo data deemed acceptable may be used for WMM 2030 operational production


# MagQuest Phase 4a: July 2021 – September 2023

- Magnetometer data quality demonstration phase, with independent performance assessed by NASA Goddard Space Flight Center
- Several million dollars in prize money distributed amongst all three teams
- All three teams passed NASA testing and continued to Phase 4b


**Small Instrumentation for GeoMagnetic Analysis (SIGMA)**  
—  
Iota



**Compact Spaceborne Magnetic Observatory (COSMO) CubeSat**  
—  
University of Colorado Boulder



**Diamond powered Geomagnetic Data Collection from LEO**  
—  
Spire Global and SB Quantum



# Tech Demo Status – MagQuest Phase 4bc

- MagQuest Phase 4b launched late 2023
- Goal is to carry all three teams into orbit
- Earliest scheduled launch is Fall 2025
- Phase 4 completion September 2026
- Data delivery planned for 3 years after launch
- Independent performance assessment by NASA
- NOAA NCEI (National Oceanic and Atmospheric Administration’s National Centers for Environmental Information) to conduct data assessment
- Solver teams supported by team of technical magnetometer mission experts:
  - ▶ NASA GSFC satellite build, test and magnetometry experts
  - ▶ NOAA NCEI calibration and data quality experts
  - ▶ Academia experts for spacecraft development, magnetometer development and satellite operations

## ***NASA GSFC Magnetic Coil Facility***



*A view inside the magnetic coil facility at (Goddard Space Flight Center) GSFC. Coils are 42 ft in diameter with the ability to produce an 8-ft diameter region of homogeneous magnetic field that is stable and accurate to within  $\pm 0.25$  nT. Another set of coils cancels the Earth’s local magnetic field.*

# Io-1 (Iota Technology)

**Team:** Iota Technology, AAC Clyde Space, Oxford Space Systems, Twinleaf, RAL Space, Bartington Instruments, Arcsec

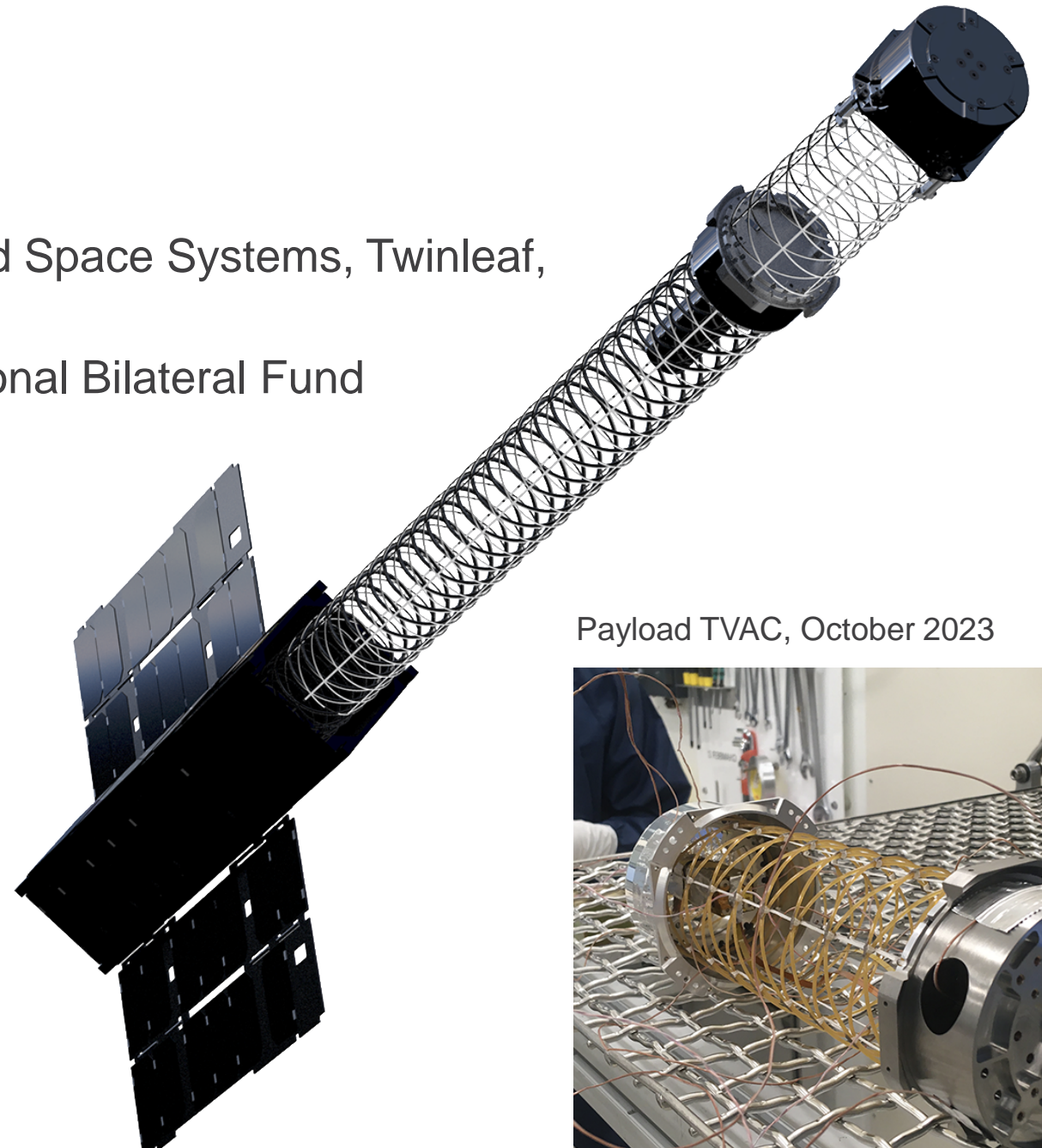
**Funding:** Magquest, UK Space Agency International Bilateral Fund

## Baseline CubeSat Highlights\*

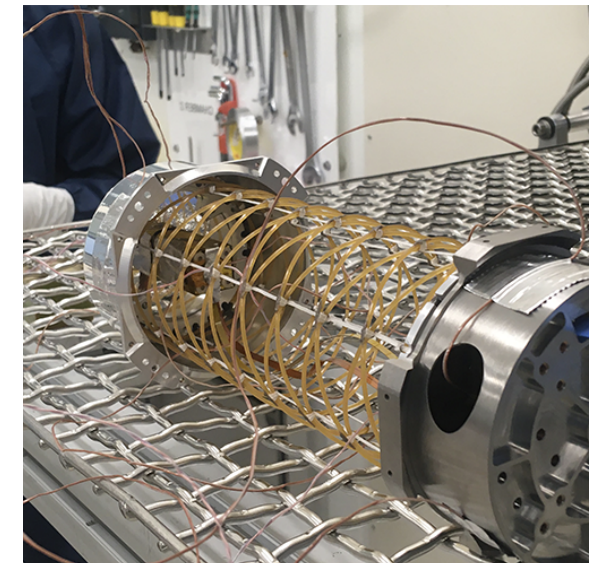
- 4U bus, 80 cm deployed boom
- 500 - 600 km sun-synchronous orbit
- Attitude measurement: Dual star trackers

## Magnetometer Description

- Vector: Rod-core fluxgate
- Scalar: Cesium vapor (vectorized)



Payload TVAC, October 2023



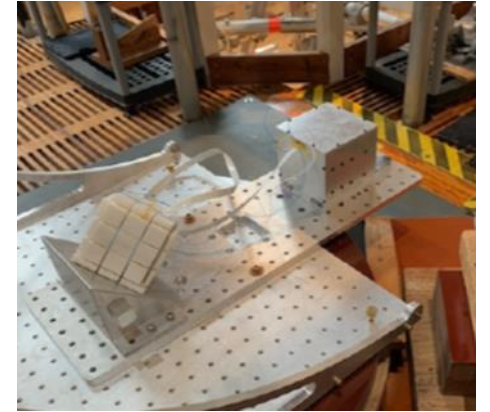
Approved for public release, NGA-U-2024-00579



# COSMO – University of Colorado Boulder

**Team:** CU (University of Colorado) Boulder (Aerospace / Mechanical); LASP (Laboratory for Atmospheric and Space Physics); FieldLine Inc.; USGS (United States Geological Survey) Boulder Magnetic Observatory

*Instrument under test*



## Baseline Cubesat Highlights\*

- 6U CubeSat at 500 km, near-polar orbit
- Continuous scalar-vector mag data collection
- 3-year mission life



## Magnetometer Description

- Vectorized scalar rubidium optical magnetometer
- 0.05 nT magnitude precision
- 3 nT vector precision at 1 Hz

\*Final design subject to change

# LEMUR2-MQ: Spire & SB Quantum

**Team:** Spire Global, Inc; SB Quantum;

**Collaborators:** Ottawa Geomagnetic Observatory (NRCan); Institut quantique, Université de Sherbrooke

## Baseline Nanosatellite Highlights\*

- 8U spacecraft with 1.5m deployable boom
- Mag and star trackers located on deployed instrument bench
- 3-year mission lifetime

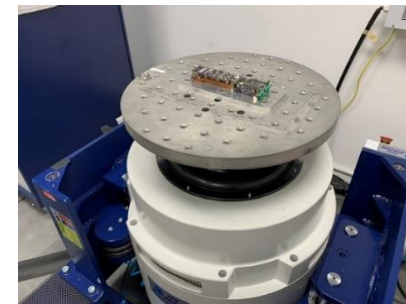
\*Final design subject to change



*Instrument under test*

## Magnetometer Description

- Diamond based Quantum Vector Mag based on Nitrogen-Vacancy (NV) Optically Detected Magnetic Resonance (ODMR)



# MagQuest Future Efforts

- Phase 4b: Complete construction of demo satellites, with each assessed by NASA GSFC (2023-2024)
- Phase 4c: Launch of all nano-sats with data quality assessed by NOAA NCEI(2025-2026)
- Data Delivery 3 years post launch
- Beyond: Long term Magnetic data procurement contract(s)
- NGA hopes to make MagQuest Demo data available after data procurement contract is signed (est. 2028-2029)
- Public access to Operational procured data is TBD, NGA's objective is that it will be freely available.



For more information  
about the challenge, visit  
[MagQuest.com](https://MagQuest.com)



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