

UAV-based Vector Magnetic Surveying for Mineral Exploration: Technology Spin-Off Arising from Miniaturized CubeSat Fluxgate Magnetometer Development

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Outline

1. Instrument Development & CubeSat Heritage
2. Application in Mineral Exploration
3. Pathway to Commercialization

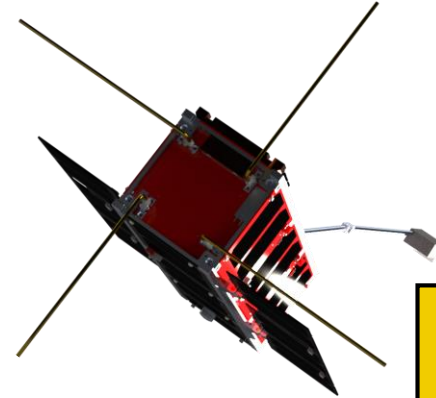
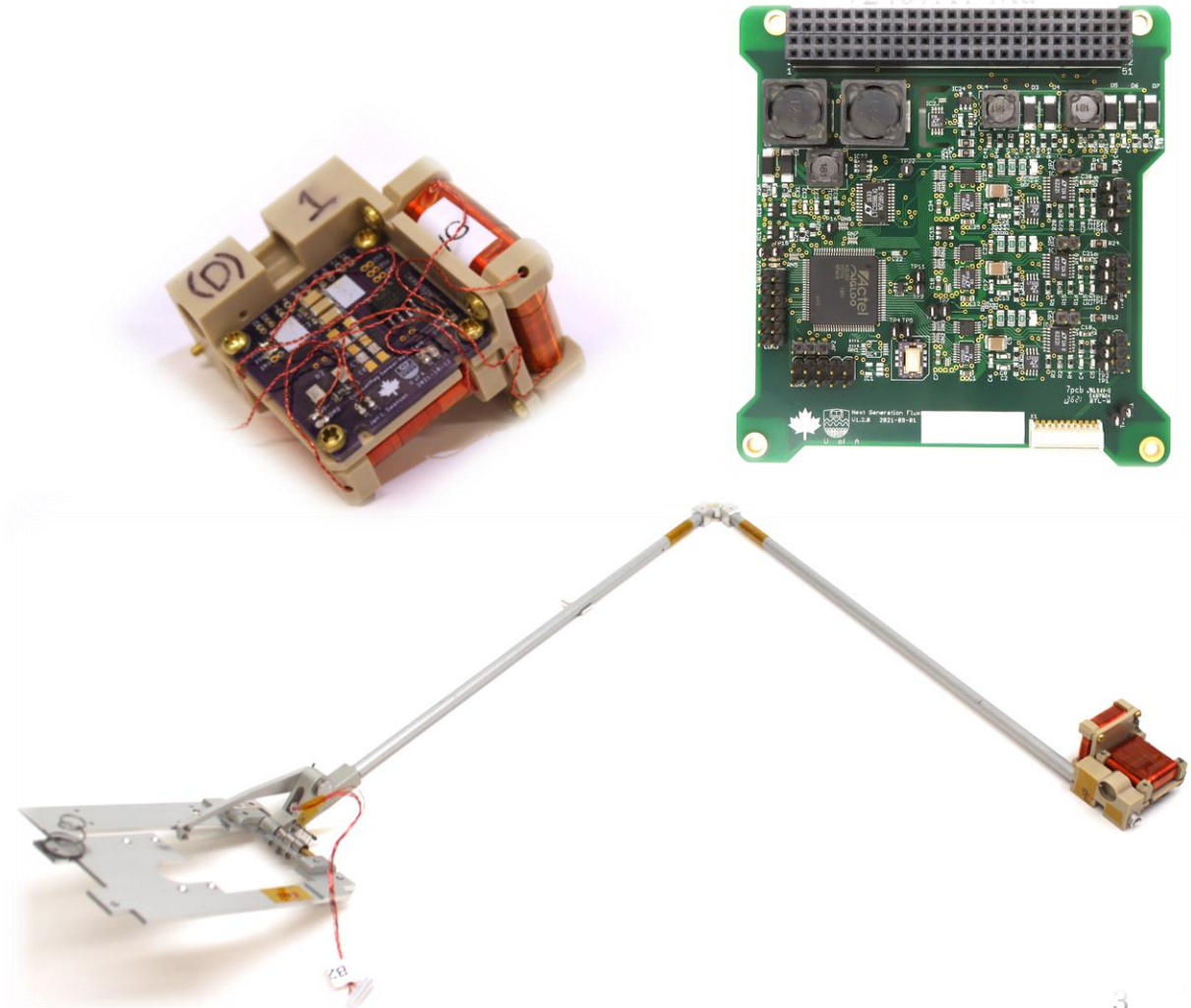


Photo Credit: AlbertaSat



Instrument Development

- 1st generation miniature fluxgate flown on Ex–Alta 1 CubeSat in 2017
- 2nd generation miniature fluxgate flown on 3 Northern SPIRIT CubeSats in 2023
 - New sensor core geometry for improved noise floor
- 3 components enable vector magnetic measurements
- Details described at DASP 2022

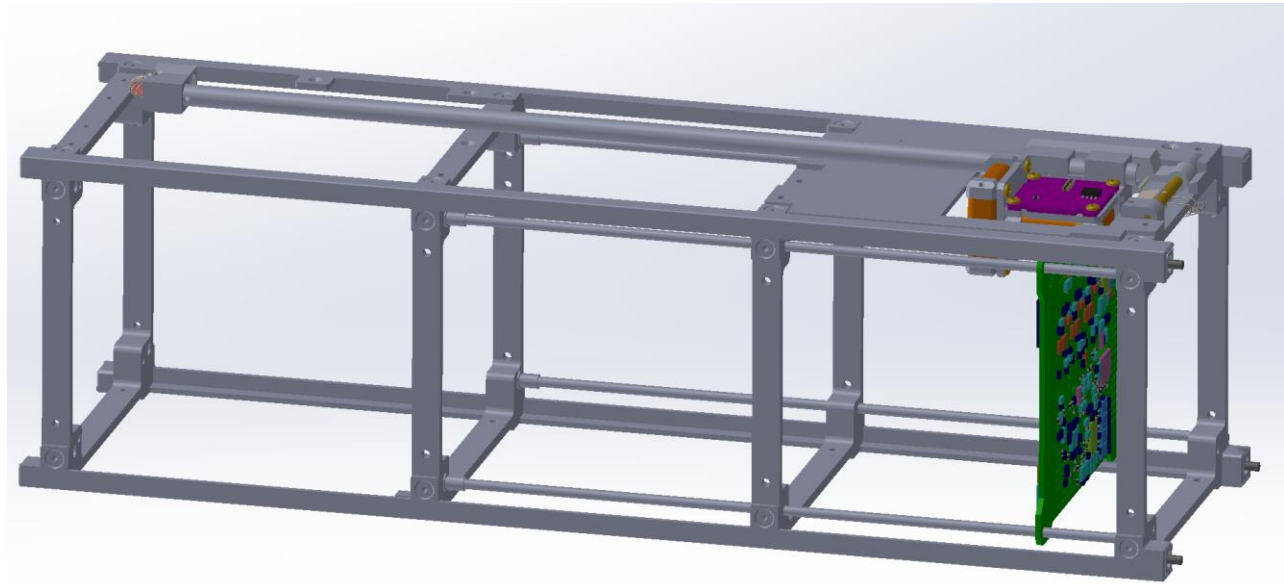


Instrument Development

- CubeSat platform drove reduction in size, weight & power

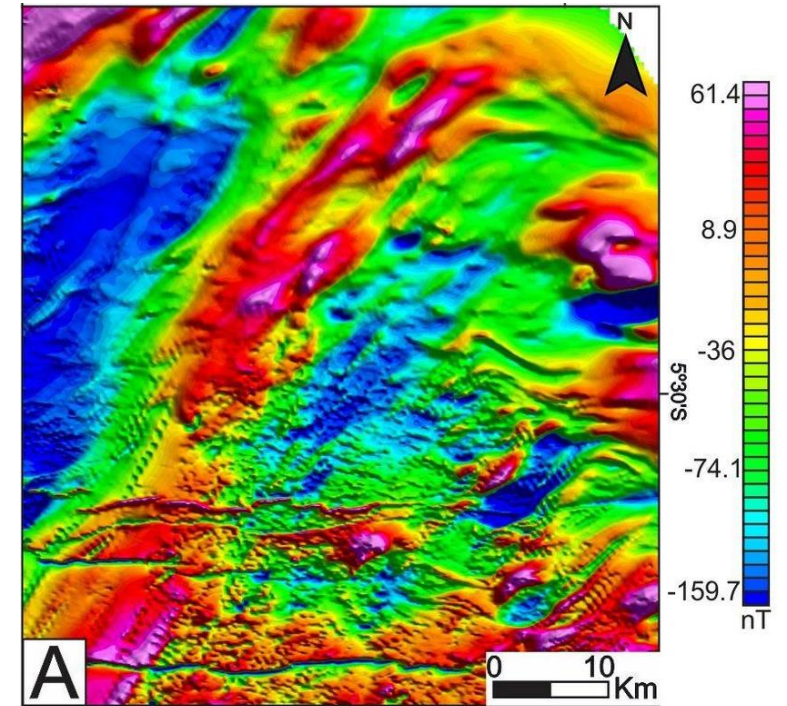
Total Mass	225 g
Sensor Dimensions	40 x 37.5 x 28.5 mm
Electronics Dimensions	96.0 x 91.0 x 12.5 mm
Power	500 mW
Cadence	100 sps
Magnetic Range	65,636 nT
Noise Floor	40 pT/Hz @ 1 Hz

- Ideally suited for flight on UAVs



Magnetic Surveys in Mineral Exploration

- One of the first investigation methods used in mineral exploration
- Magnetic surveys are inexpensive
- Susceptibility: magnetization induced by the background field
- Remanence: permanent magnetization of rock
- Both susceptibility and remanence can be associated with mineralization



Example total magnetic intensity survey.
Adapted from Ramos *et al.*, 2017

Current State of the Art in Magnetic Surveys

- Crewed aircraft-based surveys
- Ground based surveys (on foot)
- UAV-based surveys
 - Less expensive
 - Safe to fly close to the ground
 - Tight line spacing
 - Scalar magnetics only
- Vector magnetics only available on helicopters
 - Instruments are >100 kg

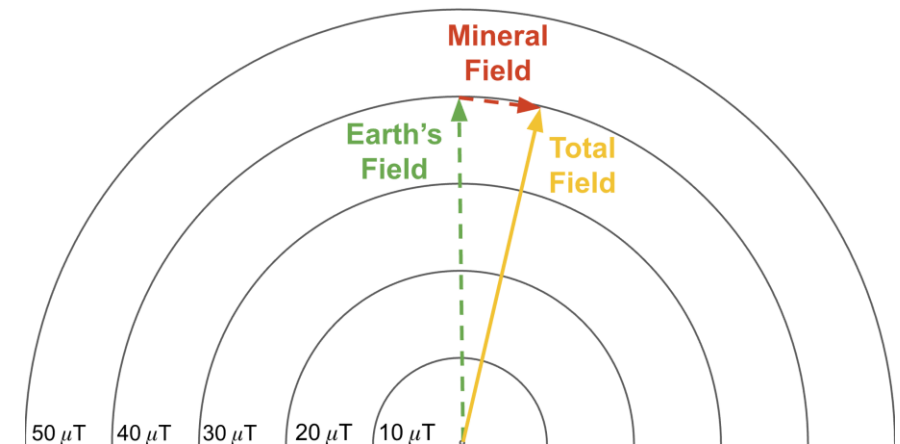
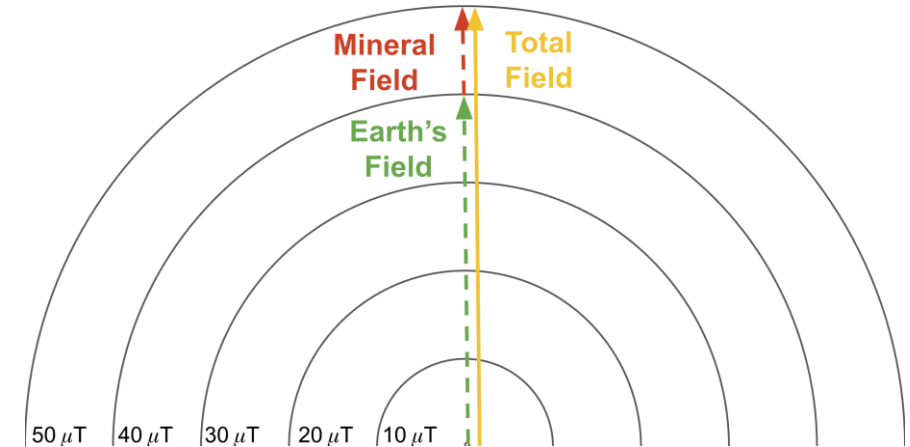


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Vector Magnetic Surveying

- Remanently magnetized targets can introduce a field component perpendicular to the background field
- In some cases, remanence causes no difference in magnitude
 - Angular difference can be as low as 2 arcseconds
- Vector magnetic surveying is a major advantage
- UAV-based vector magnetic surveying would fill a market gap
 - Cubesat-sized 3-component fluxgates are ideally suited!



Barriers to Realization & Path Forward

- Precise Attitude Measurement
 - On satellites, star-trackers can provide arcsecond precision in attitude measurement
 - Inertial measurement required for airborne platforms
- Mitigation of UAV-generated magnetic interference
 - Multi-sensor approaches on satellites have been used for the same reason and could be adapted
 - In airborne surveying, long booms and towed birds are used
- Currently exploring advanced signal processing to address these challenges
 - Minimize the development of new hardware
 - Enable the use of inexpensive and commercially available inertial sensors

Commercialization Opportunity

- Awarded an NSERC Idea2Innovation Market Assessment Grant in 2022
 - Participated in the Lab2Market Validate program
- 140 stakeholder interviews completed throughout 2022-23
- Received strong interest from survey providers
- Attitude measurement and magnetic interference challenges are the main barrier to successful commercialization

Thank you!

Please feel free to reach out:

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