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MAGIC: a miniaturised magnetometer for space weather monitoring with cubesats

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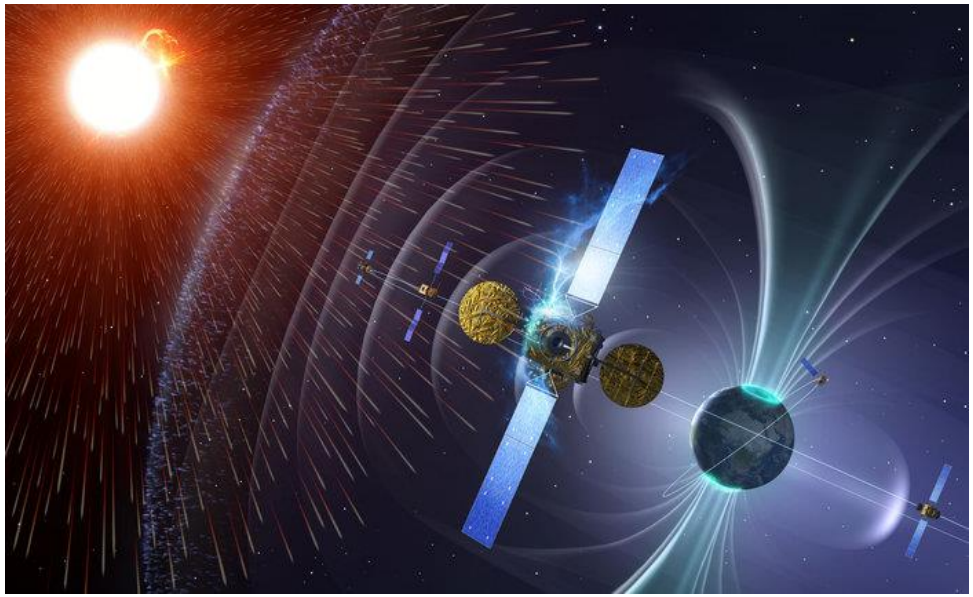
Contents

- ✓ Background
- ✓ MAGIC overview
- ✓ MAGIC on RadCube
- ✓ Conclusions

Background



SSA: Space Weather (Courtesy of ESA)

Space Weather

In situ measurements are currently sparse

Obstacle to improve our understanding of Sun-Earth interaction

- **Constellation** missions: enable comprehensive and broader set of magnetic field data at many points simultaneously
- Novel approach: exploit **CubeSat** platforms, however mass and power resources limited

MAGIC overview

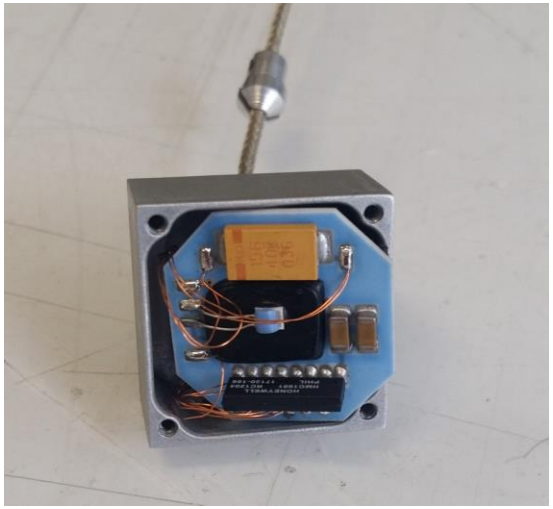
AMR magnetometer

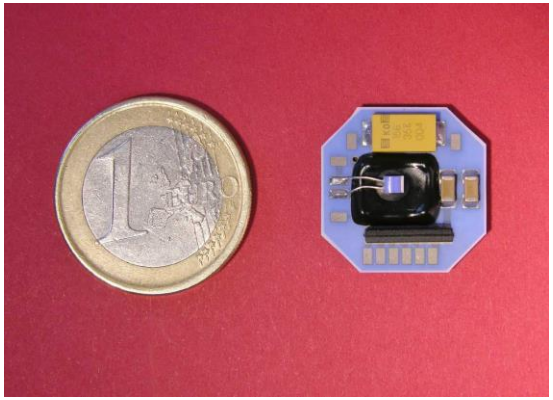
MAGnetometer from **I**mperial **C**ollege

- 3-axis anisotropic magnetoresistive (AMR) sensor
- Hybrid design
- Ultra-lightweight harness (<10 g per m)
- Optimise noise performance, minimising power
- ✓ Suitable for **CubeSats**

Main elements:

- Triad MR sensors
- Gate driver for flipping pulses
- Non-magnetic capacitor
- Temperature sensor

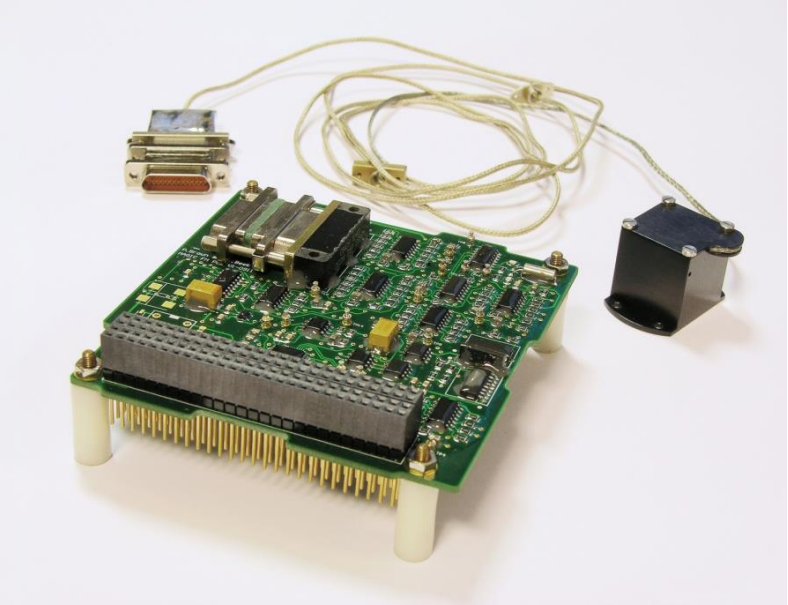




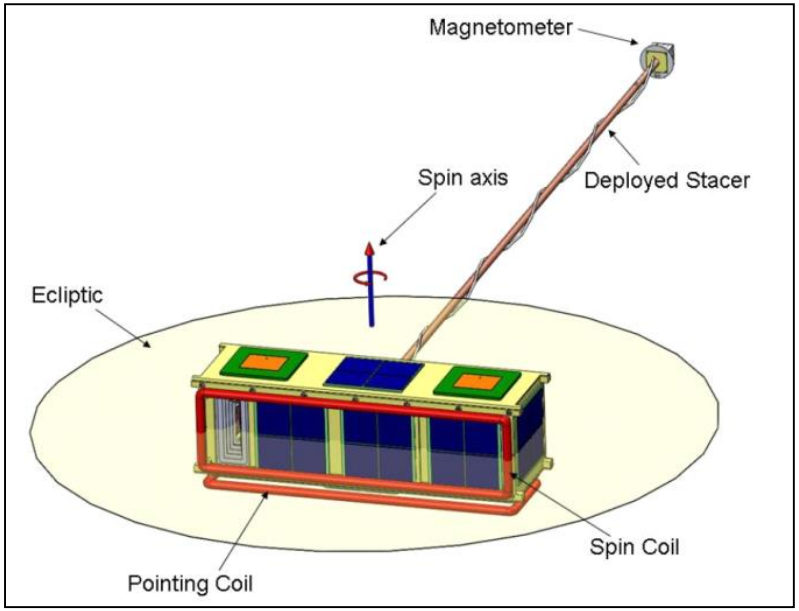
MAGIC overview

In-flight heritage

- ✓ Flown on 3 CubeSats: **TRIO-CINEMA** (2012, 2013)
- ✓ Improved design developed for Sunjammer microsatellite



MAGIC suite for CINEMA

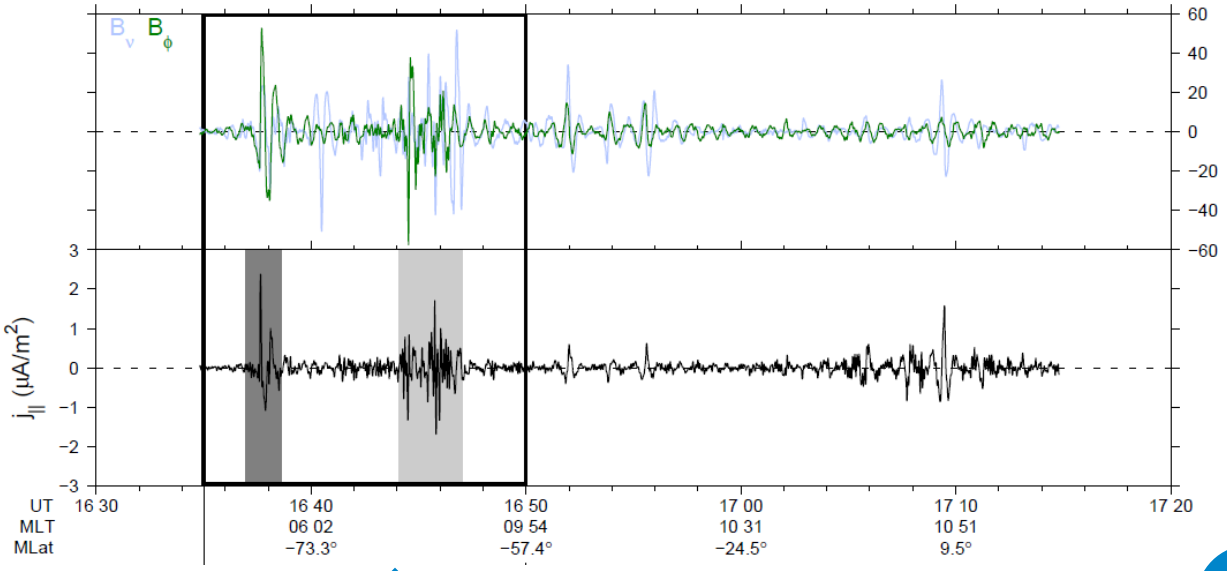


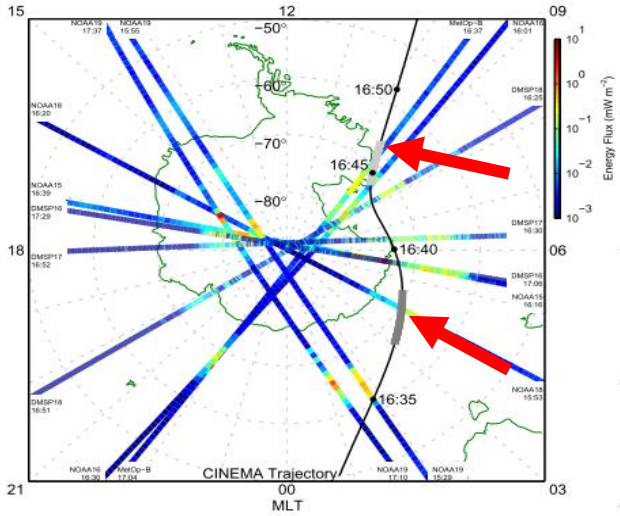
The CINEMA CubeSat

MAGIC overview

In-flight heritage

Archer et al., Ann. Geophys. 2015





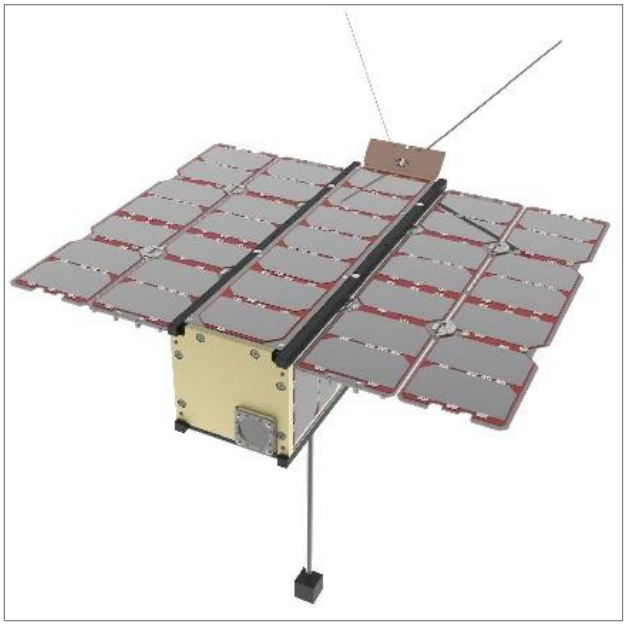
On **CINEMA**, MAGIC detected magnetic field fluctuations associated with field aligned currents (FAC) over northern auroral oval

- Transients of ~20-60 nT
- Correspond to current densities of a few μAm^{-2}
- Consistent with POES and DMSP data

MAGIC on RadCube

Mission overview

- 3U CubeSat
- esa funded, under IOD GSTP
- MAGIC part of the **RadMag** payload
- Launch planned in 2020
- Status: approaching CDR



The RadCube CubeSat

Aim & Objectives

- Demonstrate miniaturised instrument technologies in LEO for space weather monitoring
- MAGIC goal: improve understanding of field aligned currents and ring current during geomagnetically disturbed conditions

C3S

mta

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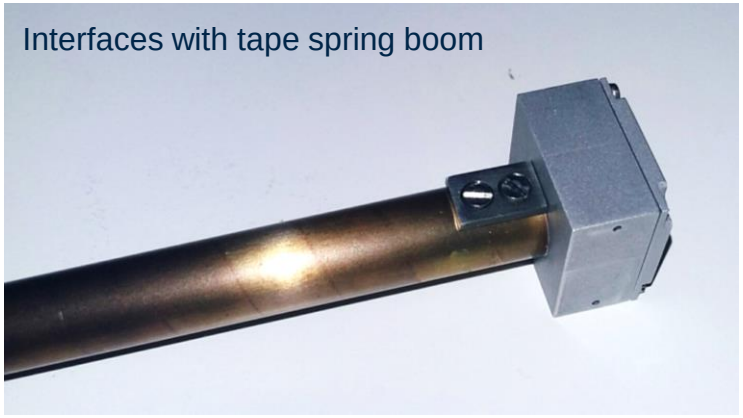
Astronika

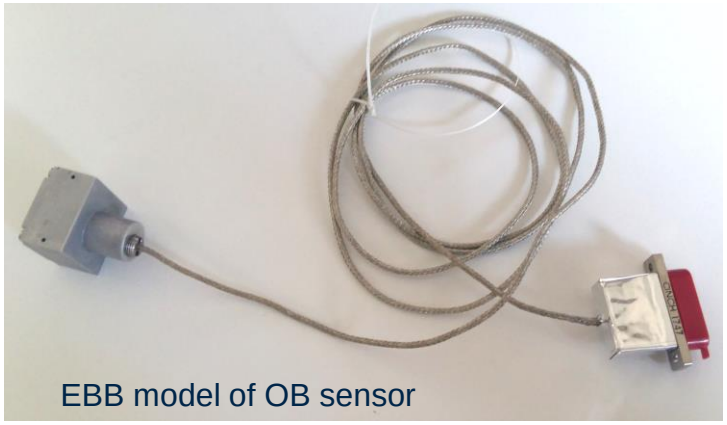
MAGIC on RadCube

Design

- 2x AMR three axes DC sensors:
  - in-board (IB)
  - out-board (OB), 50% volume reduction, deployed by tape spring boom
- Main sensor and control loop at TRL 9
- **Technical developments**

Main Features	
Volume	Electronics 90x90x1.8 mm^3 Sensor 21x21x11 mm^3
Mass	20 g (Sensor) ~70 g (Electronics)
Power	<1 W (12V DC)
Range	60 000 nT
Sensitivity	2 nT (calibrated)
Cadence	1 vector/s 10 vectors/s


Interfaces with tape spring boom


EBB model of OB sensor

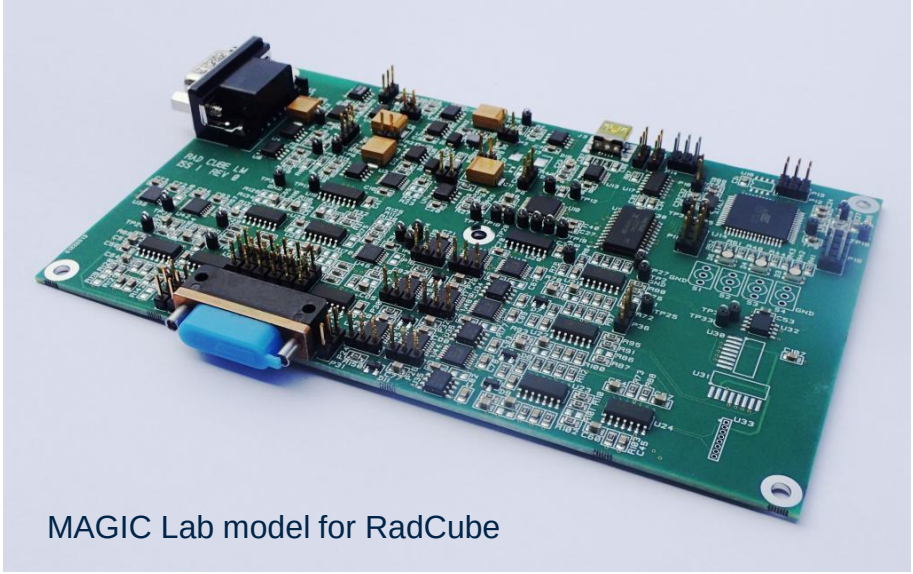
MAGIC on RadCube

Design

- ✓ Inclusion of intelligence via Atmel microcontroller: enabling use of standard communications protocol to bus, flexibility in instrument management
- ✓ Instrument to be implemented on PCB compliant with CubeSat form factor
- ✓ Components optimized for longer lifetime mission than CINEMA.

MAGIC PCB:

- Power electronics
- Microcontroller & digital circuitry
- ADC
- IB magnetometer
- IB signal chains (3 axes)
- OB signal chains (3 axes)
- *Digital potentiometers*
- *V & I monitoring*



MAGIC Lab model for RadCube

MAGIC on RadCube

Science data

How to exploit the instrument science mode in the best way?

Scientific target of interest (e.g. geomagnetic storms)

Conjunctions with other missions

Guest investigator campaign

Opportunity to openly share MAGIC data with the scientific community

Could improve our capabilities to predict space weather phenomena such as geomagnetic storm, but also understanding of substorms

Conclusions

- Flight heritage + MAGIC **improved design =** optimized, more resilient and flexible magnetometer instrument
- Future implementation as "**plug and play**" sensor on CubeSats, to be used either in a constellation configuration or as single hosted payload
- Payload for **space weather monitoring** in the context of ESA SSA's D3S monitoring concept.

For more information:

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SPACE MAGNETOMETER LABORATORY

Thanks for your attention!