CENTRE FOR ENERGY RESEARCH HUNGARIAN ACADEMY OF SCIENCES

RadMag combined cosmic ray and magnetic field measuring space weather instrument development for CubeSat/SmallSat applications

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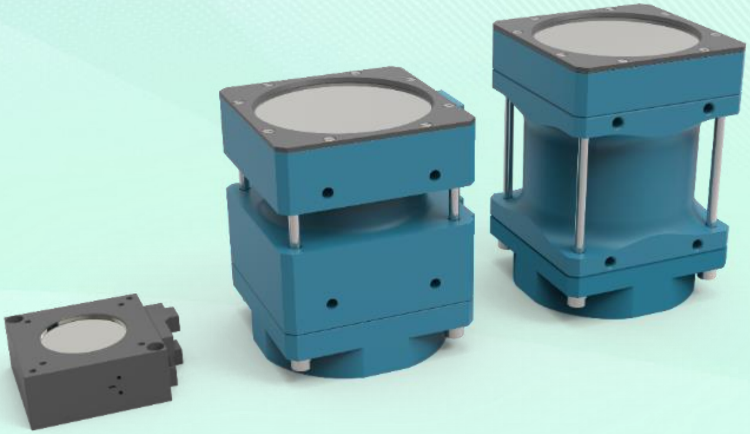

Instrument Concept & Development Team

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RadMag instrument concept

- ***RadMag = Cosmic Radiation and Magnetic Field Instrument Package***
- **Space weather monitoring by combination of cosmic ray and magnetic field measurements into one instrument**
- Specification is reflecting to ESA SSA SWE product requirements
- Cosmic ray measurements by silicon based telescopes: proton, electron, HZE spectra separately
- In-board and outboard 3-axis magnetoresistive sensor
- Built-in boom system to support the magnetic field measurements
- Built-in dose rate monitoring and Radiation Hardness Assurance (RHA) capabilities
- Small size to fit for CubeSat/SmallSat missions (fitting ~1.2U CubeSat standard)
- **Low-cost alternative in future space weather studies and forecast services and in general radiation damage monitoring for commercial use**
- Instrument development within ESA GSTP programme

RadMag Development Team

	Abbrv.	Team Member	Responsibility
	MTA EK	**Centre for Energy Research** **HUNGARY**	Instrument development coordinator Radiation sensor system development
Imperial College London	*ICL*	**Imperial College London** **UNITED KINGDOM**	Magnetometer development
Astronika space solutions here & now	*ASTRO*	**Astronika** **POLAND**	Boom system development
esa	*ESA*	**European Space Agency** **ESA ESTEC**	RHA development Instrument development reviewer

Instrument specifications

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Radiation Sensor System specification

Parameter	Values, ranges
Particle types	**electrons, protons, heavy ions**
Minimum electron energy	100 keV
Electron energy range	0.3 MeV – 8.0 MeV Channel number: 2-5 Contamination: <10 %
Minimum proton energy	1 MeV
Proton energy range	4 MeV – 1 GeV Channel number: 11-18 Contamination: <10 %
Heavy ion energy range (He&C&N&O&Fe)	100 MeV/n – 1 GeV/n Channel number: 4 Contamination: <10 %
Field of view for electron and proton measurement (half-angle)	31°
Field of view for heavy ion measurement (half-angle)	46°

Magnetometer specification

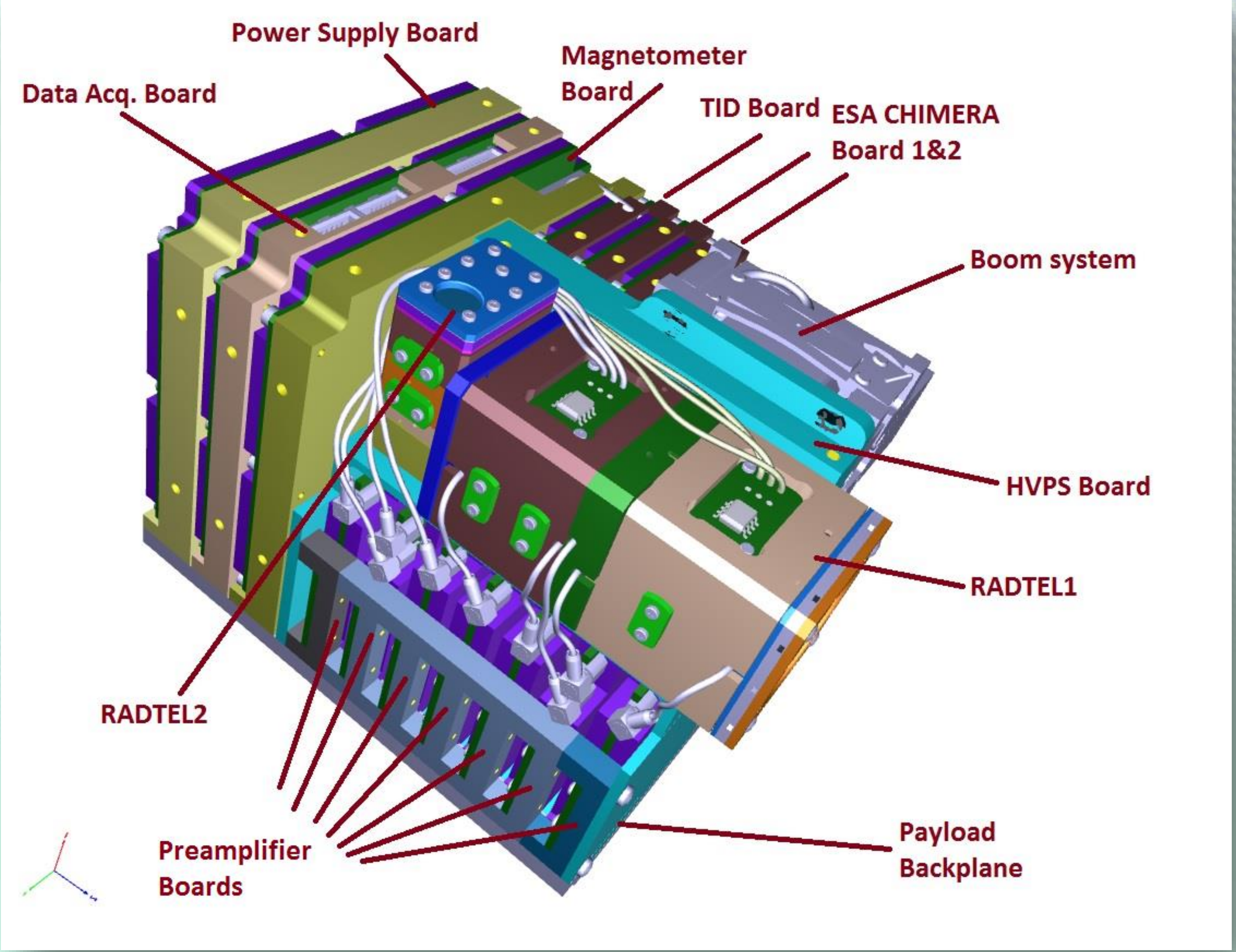
Parameters	Mode	
	Nominal	High resolution
Range	± 60,000 nT	
Sampling rate	1.0 Hz	10 Hz
Orthogonal directions	3	
Orthogonality error	≤0.1°	
Noise limit	≤500pTrms/√Hz (at 1Hz at 25°C)	
Temperature coefficient	≤±1 nT/°C	
No. of sensors	2 (1: inboard, 1: outboard)	

Boom System Specification

Parameters	Values
Maximum deployed length	80 cm
Retraction capability	No
Carried mass (with harness)	30 g
Carried volume	2.0x2.0x1.2 cm^3
Deployed position accuracy	≤ ±3 cm
Deployed angular accuracy	≤ ±1.5deg/m
Deployment encoder	Yes
Available volume for the boom system (with harnessing)	4x4x10 cm^3
Maximum deployment velocity	20 mm/s
Peak power consumption	4 W

Instrument Design Status Overview

Instrument overall design

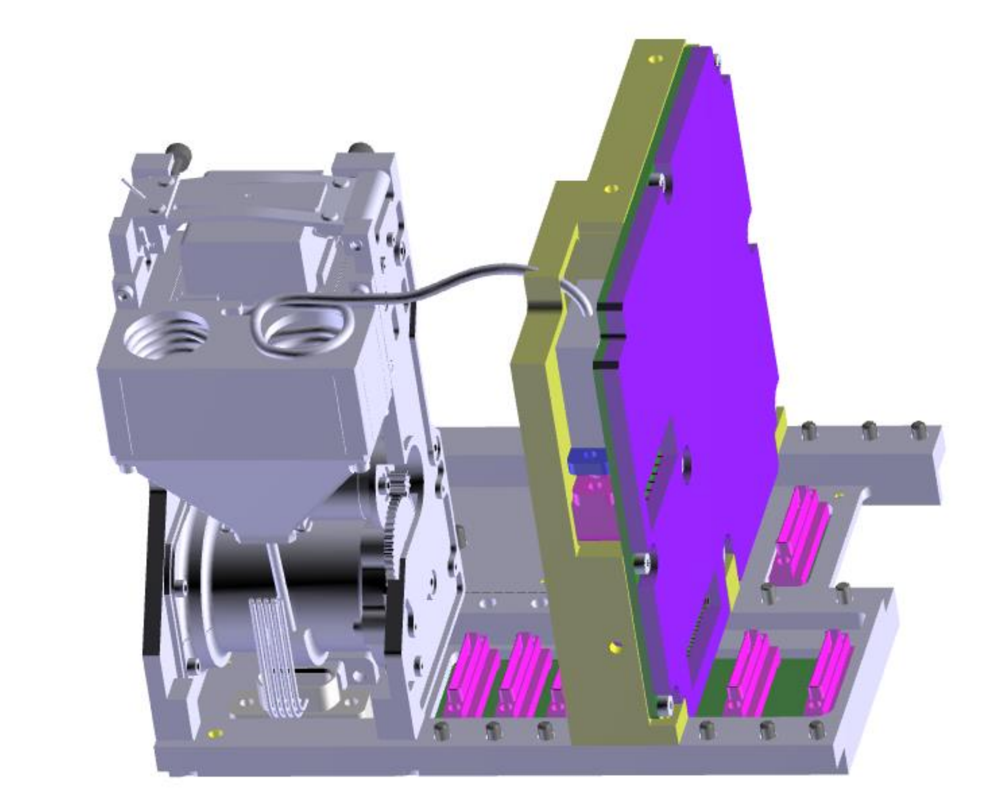


Radiation telescopes

- Two different telescopes
  - different sensitive area
- Perpendicular arrangement
  - directionality assessment
- Utilising Micron silicon detectors
- 10-µm thick titanium entrance windows

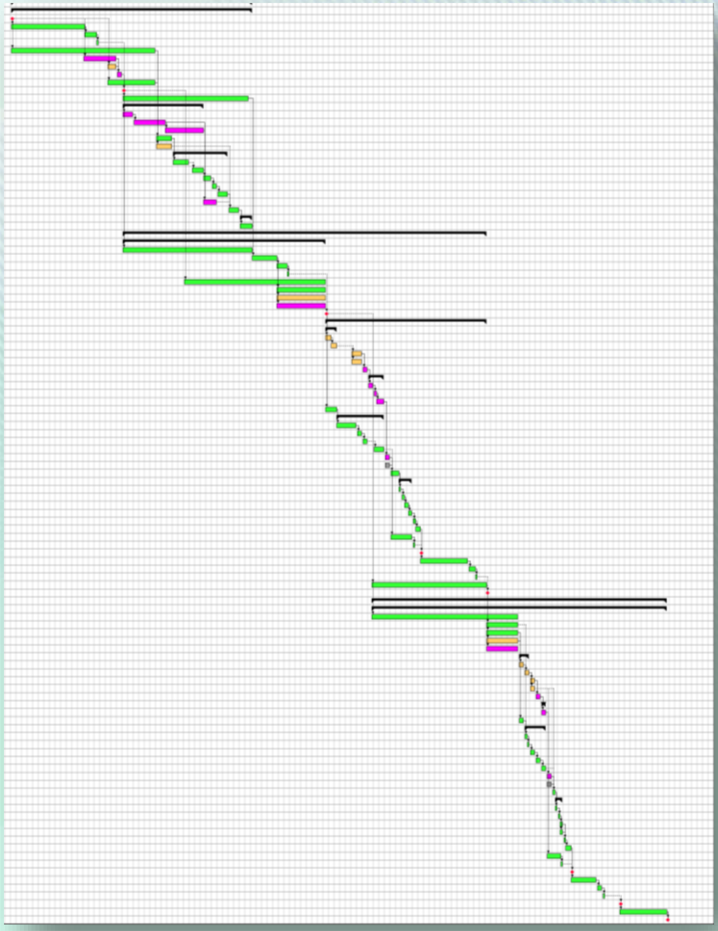
Magnetometer and boom system

- Magnetoresistive sensors
  - 3-axis sensors
  - inboard and outboard
- Tape spring based boom
  - up to 80cm long
  - opening in definitive steps



Development status

- Kick-Off Meeting – June 2016
- IRR – December 2016
- *PDR – December 2017*
- CDR – August 2018
- QR – February 2019
- FAR – August 2019
- 1st flight – Q3 2019



1^{st} IOD Mission: RADCUBE

Future Concept: CROSS Network

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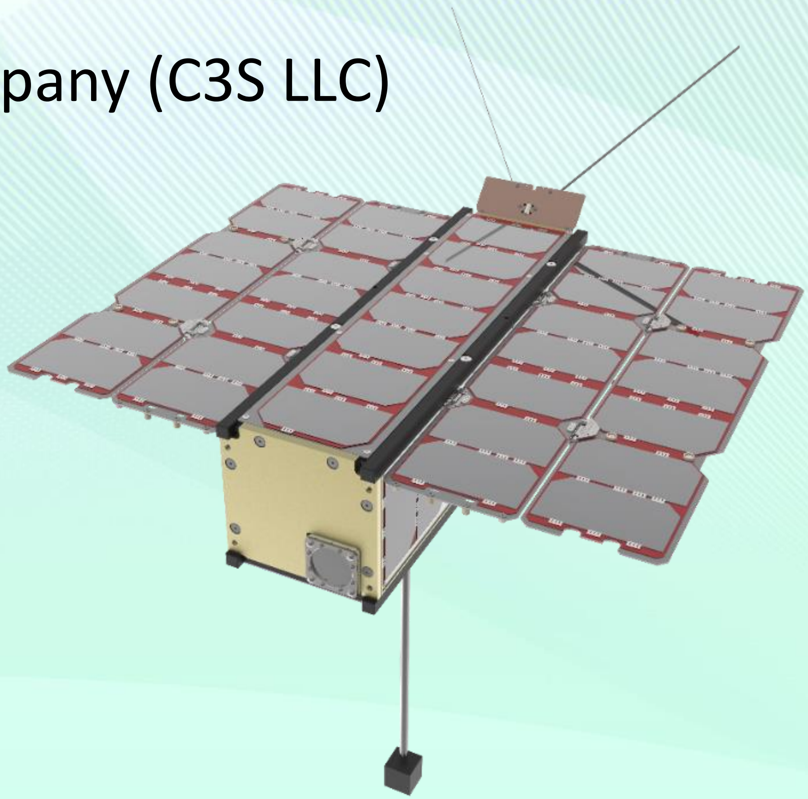
RADCUBE Mission

- In-orbit demonstration 3U CubeSat mission within ESA GSTP 6.3 programme
- Lead by a Hungarian CubeSat Company (C3S LLC)
- Project is just now passed the PDR
- Expected launch: Q3 of 2019



COMPLEX SYSTEMS & SMALL SATELLITES

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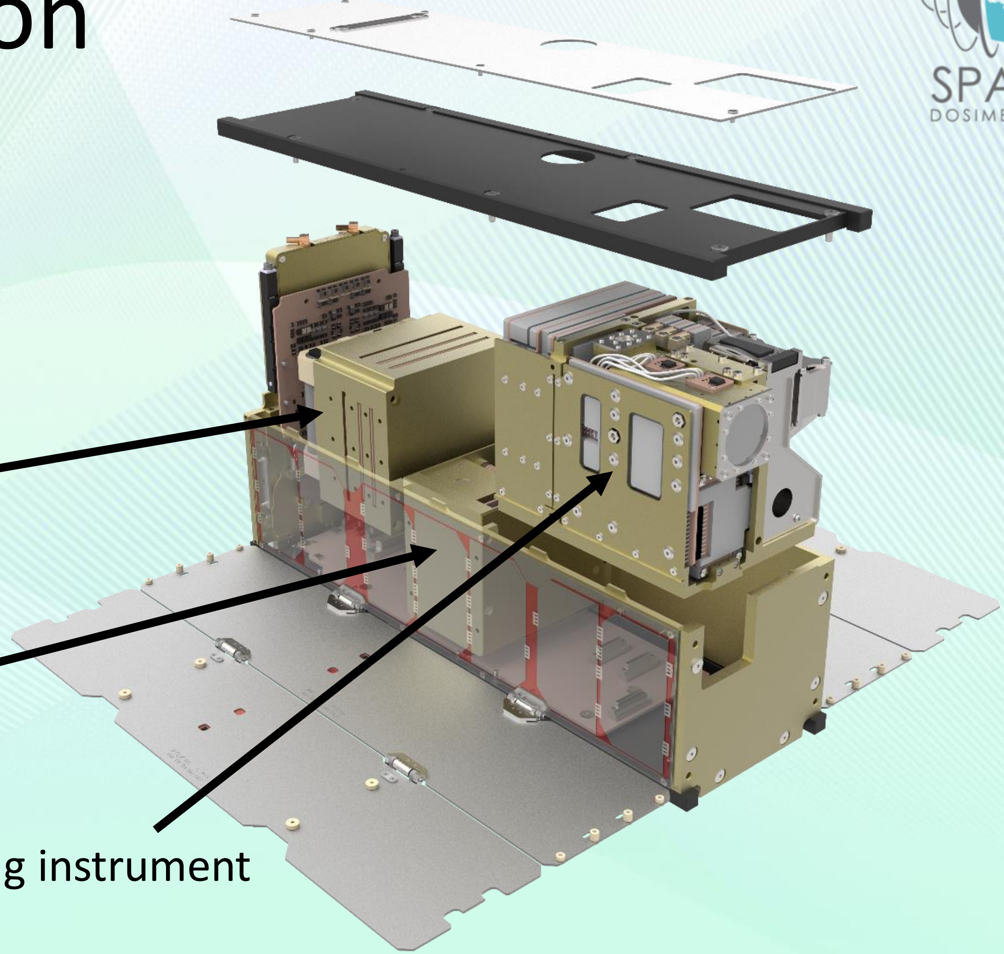
RADCUBE Mission

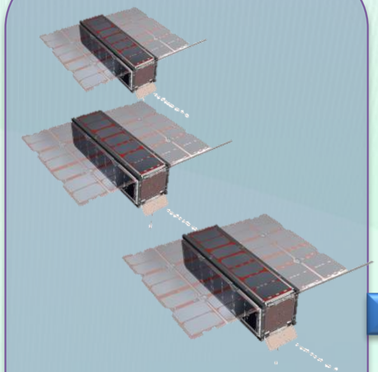
COMPLEX SYSTEMS & SMALL SATELLITES



- **Future vision: CROSS Network = Cosmic Ray Observatory Satellite System**

Future vision

- ***CROSS Network = Cosmic Ray Observatory Satellite System***



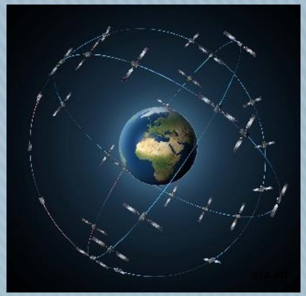
Fleet of CubeSats and Ground Stations

Cosmic ray environment information system

Space weather/ radiation damage related database

Space weather/ radiation damage forecast services

Users:



Conclusions

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Conclusions

- ***New space weather monitoring instrument development: RadMag***
- **Unique combination of cosmic ray and magnetic field measurements into one instrument**
  - Very small size to fit for CubeSat/SmallSat missions (fitting ~1.2U CubeSat standard)
  - Built-in boom system to support the magnetic field measurements
  - Relatively low-cost alternative for future space weather studies and in general radiation damage monitoring for commercial use
- Instrument development just now passed PDR and moving into phase C
- 1st IOD Mission: **RADCUBE 3U CubeSat**
  - Expected launch is Q3 2019
- **Future vision (CROSS Network): CubeSat/SmallSat constellation for space weather and radiation damage monitoring services**

mta EK

esa
European Space Agency

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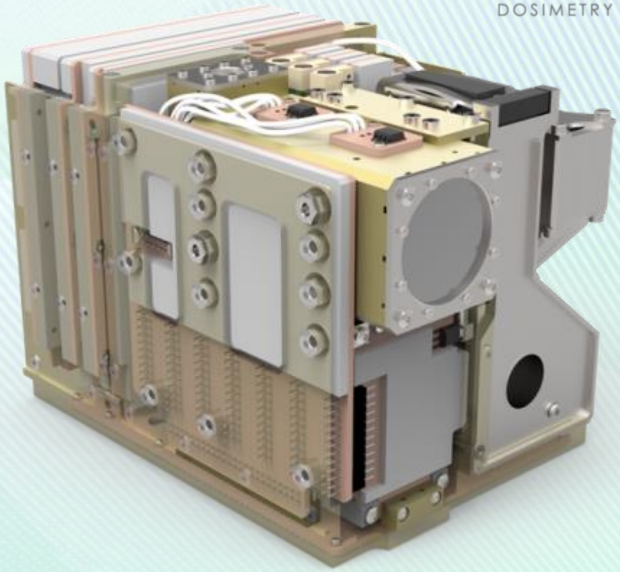
Imperial College London

Hungarian Space Office



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COMPLEX SYSTEMS & SMALL SATELLITES

Thank you for your attention!

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