

D3S-RADMAG COMBINED INSTRUMENT DEVELOPMENT

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- 2) 3) REMRED Space Technologies Ltd.
- JULIUS-GLOBE Ltd.
- 4 European Space Agency, SSA-SWE
- European Space Agency, TEC-EPS 5)







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Introduction and Motivation

D3S-EK-MAN-HO-403_i1.0 @ EK SPACELAB 2019.

Centre for Energy Research Space Research Laboratory

Centre for Energy Research (EK)

- Main research fields: general nuclear research, renewable energy sources, material research, space research
- > EK is the coordinator of the National Nuclear Research Program launched in 2014
- > The Centre operates the Budapest Research Reactor

Space Research Laboratory (SPACELAB)

- 50 years space research experience
- Main fields of interest: space electronics and system development and testing, space dosimetry, cosmic ray and space weather monitoring
- > ~70% of the Hungarian space hardware ever made





Centre for Energy Research Space Research Laboratory

Service instrumentation portfolio (in used)

- > Pille
 - > TL based space dosimetry service monitor for manned missions
 - Specifically used for spacewalks
 - Used from 1980 until nowadays
 - > Several generation has been introduced
 - Currently is part of ISS Zvezda service system
 - > >10 years proven service lifetime

> TRITEL SYSTEM

- > Silicon detector-based space dosimetry service monitor for manned missions
- > 3D silicon detector telescope array in one instrument
- Used from 2012 until nowadays
- > Currently is operated on-board ISS Zvezda
- >3 years proven service lifetime

> TRITEL

- > Silicon detector-based radiation monitor for satellite missions
- > 3D silicon detector telescope array in one instrument
- Used from 2018 until nowadays
- > IOD demonstration missions in progress
- REM-RED
 - > GM based radiation monitor for sounding rocket measurements
 - Demonstrated on-board REXUS rocket
 - Proven experimental system

> TECHDOSE

- > Silicon detector and GM based radiation monitor for stratospheric balloon measurements
- Demonstrated on-board BEXUS balloons
- Proven experimental system



SWE Service Instrument Development Key Points

- Space weather product requirements compliance
- Service oriented design approach (not science oriented)
- Instrument combination for simplicity
- Cost and development time reduction
- SmallSat and CubeSat application possibility
- Featuring on-board and in-flight services for possible hosting platform providers



D3S-RADMAG Instrument Concept

Hungarian Task Force Activity



Title: Combined cosmic ray and magnetic field measuring instrument package (D3S-RADMAG) development for space weather service within ESA's D3S hosted payload concept

> Activities (WPs):

- Management and Quality Assurance (WP111)
- Instrument Concept and Requirements Definition (WP121)
- Measurement Techniques Definition (WP122)
- Instrument EBBs Design Definition (WP123, WP124)
- Instrument EBBs Manuf. & Testing (WP131, WP132, WP133)
- Development RoadMap Definition (WP141)
- Instrument Performance Analysis (WP000)
- Contract No.: 4000124572/18/NL/Cbi
- Prime Contractor: Centre for Energy Research (EK), Hungary
- Duration: 28 months (August 2018 November 2020)
- > Value: 195 kEUR
- TRL at the end: 4 / 5
- Supervision by: ESA SSA-SWE, ESA TEC-EPS

ongoing WP finished WP (@Instrument IRR) finished WP (@Instrument IRR) ongoing WP (@EBB CDR @Feb-2020) future WP future WP ongoing WP (supporting activity)



D3S-RADMAG (RM) Instrument Overview

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D3S-RADMAG (RM) Instrument Concept

- Space weather service instrument combining
 - Radiation Monitor (RM-RAD)
 - Magnetometer (RM-MAG)
 - Built-in Boom System (RM-BOOM)
 - Central Electronics Box (RM-CEB)
- Design approach
 - Modularity & cost effectiveness by combining different instrumentation in package
 - Easy adaptation capability for hosting missions realized through configuration management
 - Featuring in-flight services for hosting platform providers
 - Parallel development possibility to reduce development time
 - Capability for future instrument package extension
 - Compliance with space weather product requirements and D3S hosted mission requirements (ESA SSA PSD, D3S AORD, Radiation Monitoring HP TRS)
 - Built-in boom system to support magnetic field measurements
 - Miniaturization (size, mass, data rate, power needs)









Targeted measurement products as per ESA SSA PSD

#	ESA SSA product identifier	Description	Data to be provided	Possible derived products
1	MR-006-M	High energy >10MeV protons – Measurement	Proton flux (m ⁻² s ⁻¹ sr ⁻¹ MeV ⁻¹)	MR-006-P MR-006-N
2	MR-008-M	Low energy 1-10MeV protons – Measurement	Proton flux (m ⁻² s ⁻¹ sr ⁻¹ MeV ⁻¹)	MR-008-P MR-008-N
3	MR-011-M	High energy 30 keV-8 MeV electrons – Measurement	Electron flux (m ⁻² s ⁻¹ sr ⁻¹ keV ⁻¹)	MR-011-P MR-011-N
4	MR-007-M	High energy >10MeV/n ions – Measurement	Ion flux (cm ⁻² s ⁻¹ sr ⁻¹ (MeV/nuc) ⁻¹)	MR-007-P MR-007-N
5	MR-015-M	Local geomagnetic field – Measurement	Geomagnetic field strength and vector components (T)	MR-011-P MR-011-N
6	SC-005-M	Total ionizing dose – Measurement	Total ionizing dose rate (rad/h)	SC-005-N

Balázs Zábori | ELKH-EK-UR | TEC-EPS Final Presentation Days, ESA ESTEC, The Netherlands | 17/12/2019 | Slide 12

Measurement parameters – RM-RAD Radiation Monitor

Protons

- Energy range
- > Flux range
- Energy bins
- 10-10⁴ proton/cm² s sr 8 (log) 40°

1-500 MeV (1 GeV)

Electrons

> FoV

Energy range

> Flux range

10-10⁵ electron/cm² s sr

250 keV - 8 MeV

10-10⁴ particle/cm² s sr

- Energy bins 4 (log)
- > FoV

- 60°
- Heavy ions (a-particles [He3, He4], CNO group, Fe group)

8 (log)

40°

- Energy range 1.5-500 MeV/n
- Flux range
- Energy bins
- > FoV

Detector system type

- One silicon detector telescope
- Six silicon detectors included in the telescope
- Silicon detectors are manufactured by MICRON Semiconductors Ltd. (UK)







Measurement parameters – RM-MAG Magnetometer

Local Geomagnetic Field Strength and Vector Components

±[1-60,000] nT

<1 nT (TBC)

<30 pT_{rms}/sqrt(Hz) (@1 Hz @ 25°C)

- RangeNoise
- > Absolute accuracy
- Sampling rate

 1 Hz / 10 Hz
- > Orthogonal directions 3
- > Orthogonality error $\leq 0.1^{\circ}$

Detector system type

- > Two triaxial miniaturized fluxgate sensors (size: 2x2x2 cm³)
- > One sensor inside, one sensor outside (mounted on boom)
- > Fluxgate sensors are manufactured by Bartington Ltd. (UK)



Basic parameters – RM-RAD Radiation Monitor



RM-RAD Radiation Monitor			
Power	<1.5 W (without CEB) <3.0 W (with CEB)	Without CEB U _{in} : 12V With CEB U _{in} : 12V / 28V / 50V	
Mass	<0.9 kg (without CEB) <1.3 kg (with CEB)	Without margin	
Dimensions 1 (without CEB)	78 x 80 x 100 mm ³	0.63 L without CEB	
Dimensions 2 (with CEB)	100 x 80 x 100 mm ³	0.80 L with CEB	
Mounting Area	80 cm ² / 100 cm ²		
Data rate	<1 kbps		
Connector Types	MicroD-SUB DB9	<i>Without CEB: 1x1 S/C I/F</i> <i>With CEB: 2x2 S/C I/F (redundant)</i>	
Data I/F	RS-422 / CAN / MIL-STD-1553B	CAN & MIL-STD-1553B with CEB	
Thermal I/F	TBD W/K		
Operating Temperature	[-40;+65]°C		
Operating Vacuum Conditions	<10 ⁻⁴ Pa		

Basic parameters – RM-RAD-MAG Combined



RM-RAD-MAG Combined Instrument				
Power*	<4.0 W	U _{in} : 12V / 28V / 50V		
Mass*	<1.7 kg	Without margin		
Dimensions*	140 x 80 x 100 mm ³	1.12 L		
Mounting Area*	80 cm ² / 154 cm ²			
Data rate	<10 kbps (TBC)			
Connector Types	MicroD-SUB DB9 / DB15	2x2 S/C I/F (redundant) 2 for Fluxgate Sensors 1 for Boom Operation		
Data I/F	RS-422 / CAN / MIL-STD-1553B	Other upon request (TBC)		
Thermal I/F	TBD W/K			
Operating Temperature	[-40;+65]°C			
Operating Vacuum Conditions	<10 ⁻⁴ Pa			
* Values not includes the necessary third-party boom system.				

Basic parameters – RM-RAD-MAG + RAD Combined



RM-RAD-MAG + RAD Combined Extended Instrument

Power*	<5.5 W	U _{in} : 12V / 28V / 50V	
Mass*	<2.6 kg	Without margin	
Dimensions 1 (Core)*	140 x 80 x 100 mm ³	$1.7E \downarrow (total)$	
Dimensions 2 (External Monitor)*	78 x 80 x 100 mm ³	1.75 L (local)	
Mounting Area(s)*	80 cm ² / 154 cm ²		
Data rate	<10 kbps (TBC)		
Connector Types	MicroD-SUB DB9 / DB15	2x2 S/C I/F (redundant) 2 for Fluxgate Sensors 1 for Boom Operation 1 for External Radiation Monitor	
Data I/F	RS-422 / CAN / MIL-STD-1553B	Other upon request (TBC)	
Thermal I/F	TBD W/K		
Operating Temperature	[-40;+65]°C		
Operating Vacuum Conditions	<10 ⁻⁴ Pa		

* Values not includes the necessary third-party boom system.

Design Status – RM-RAD Radiation Monitor & RAD-MAG Magnetometer EBBs







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RADMAG-LITE (RM-XS) CubeSat application

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CubeSat application – RADMAG-LITE (RM-XS)

- Compact CubeSat space weather monitoring instrument
- GTSP IOD activity
- Combining cosmic ray and magnetic field measurements
- Miniaturized built-in boom system to support magnetic field measurements
- Relatively low-cost alternative for future space weather studies and in general radiation damage monitoring for commercial use
- Fitting into very small budgets
 - ~1.2U CubeSat standards
 - ≻ <4.5W
 - ➤ <1.2 kg</p>
 - > <20 bps
- To be used for space weather monitoring CubeSat constellations
- COTS components, however tested for SEE and TID to guarantee 3+ operational lifetime in LEO



SPACE DOSIMETRY RG

CubeSat application – RADMAG-LITE (RM-XS)

Parameters	Values, ranges
Dimensions	96[H]x94[W]x129[L] mm ³
Mass	1.2 kg
	4.5 W
Power Consumption	6.5 W peak
	9-14 V
Data Rate	<100 bps
Operational temperature range	[-40;+65]°C
No. of telescopes	2
Built-in boom system max. deployed length	80 cm
Measureme	ent ranges
Electrons	0.3 – 8 MeV
Protons	1 MeV – 1 GeV
Heavy ions	100 MeV/n – 1 GeV/n
Geomagnetic field	±60,000 nT
Dose rate ranges	1 nGy/h – 6 Gy/h





TRL level ~6-7! EQM in qualification



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CubeSat application – RADMAG-LITE (RM-XS)





TRL level ~6-7! EQM manufactured, assembled and in qualification

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Summary

D3S-EK-MAN-HO-403_i1.0 @ EK SPACELAB 2019.





D3S-RADMAG (RM): space weather service instrument package with high performance for SmallSat Missions/Constellations

- Combination of different instrument technologies into one (radiation monitor, magnetometer, boom, central electronics box)
- Reduced complexity, modularity, cost effectiveness by design
- > Built-in boom system operational capability
- Easy to adapt for different hosted mission possibilities
- Featuring in-flight services for possible hosting mission providers
- Capability to add new instrument subunits

RADMAG-LITE (RM-XS): space weather service instrument with low performance for CubeSat Missions/Constellations

> High TRL level, IOD demonstration is expected in 2021 (TBC)





Thank you for your attention!

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