a Cohort plc company

"Smart Microsystems" – A Feasibility Study to Investigate the Decentralisation of Space Systems with highly efficient Micronodes using advanced ASIC technologies

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Presented by John Cornforth

At the Fourth International Workshop on Analogue and Mixed Signal Integrated Circuits For Space Applications (AMICSA)

ESTEC 26th - 28th August 2012

Study Partners

SEA

Prime Contractor

SEA House, Building 660, Bristol Business Park, Coldharbour Lane, Bristol, England.

BAE Systems

Sub-Contractor

Advanced Technology Centre, FPC267, Golf Course Lane, PO Box 5, Filton, Bristol, England

ESA Technical Officer; R. Trautner

‘Smart Microsystems for Space Applications’ Study
part of ESA’s General Studies Programme (GSP)
Duration: Jan 2012 – Jan 2013

Content

- **Typical Centralised Architecture Overview**
- Benefits of De-centralisation
- Chosen Micronode Designs to take forward
- Summary of Micronode Advantages
- Packaging Solutions and MEMs Opportunities
- Usage in AIT
- ASIC 'Wish List'
- Ongoing work

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BAE SYSTEMS

sea

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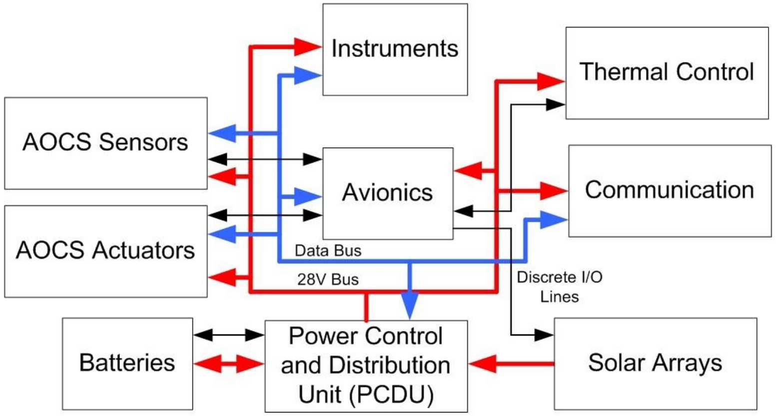
Centralised System Architecture

Traditional Centralised System

- Large Harness Mass (typically 9% of spacecraft mass).
- System Vulnerability to Failures.



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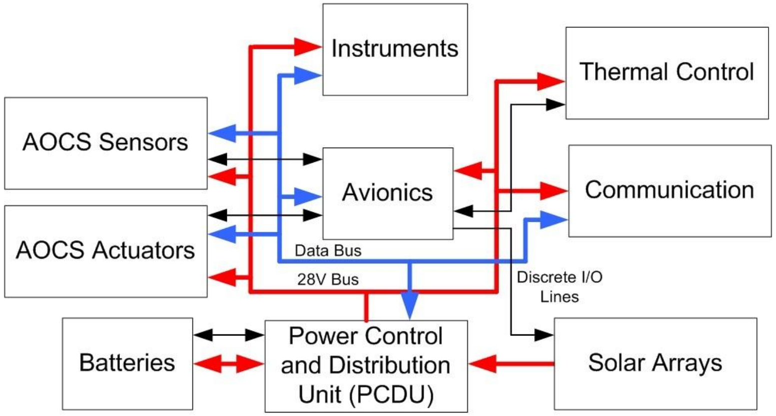
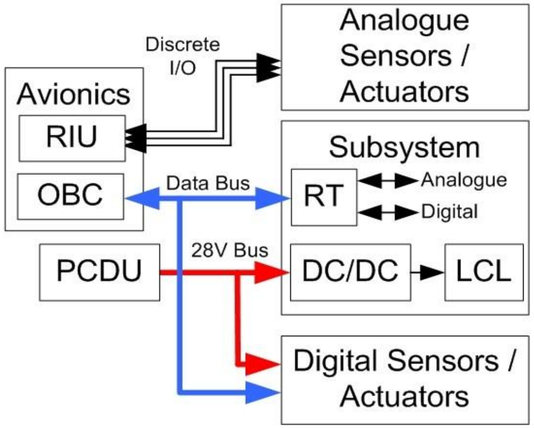
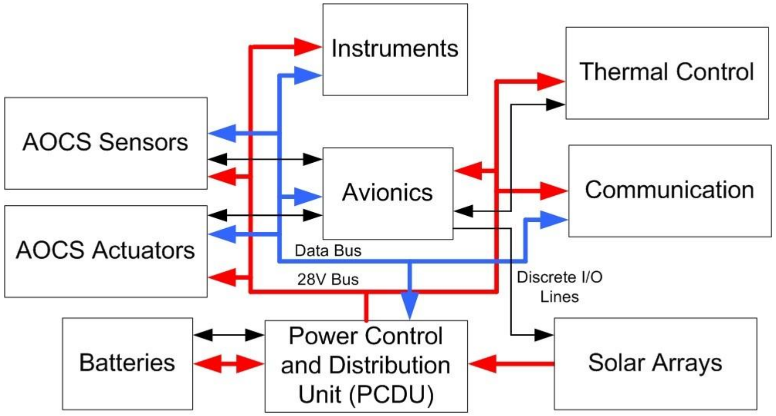


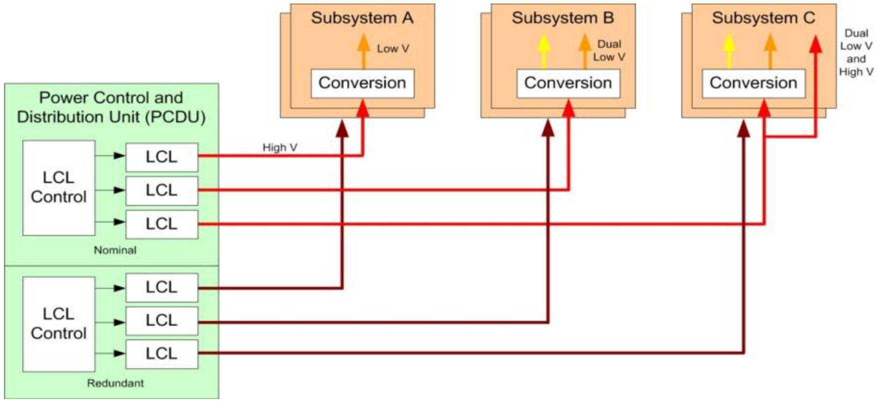


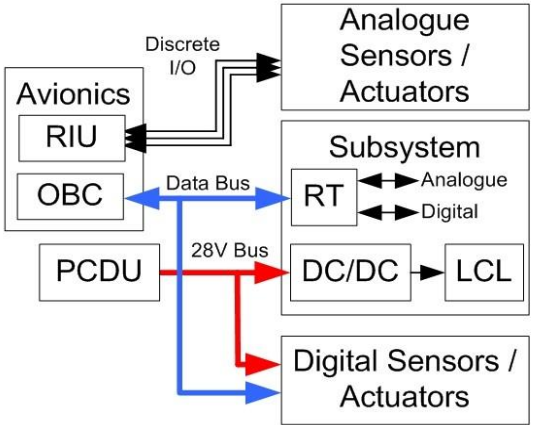
Centralised System Architecture

Traditional Centralised System

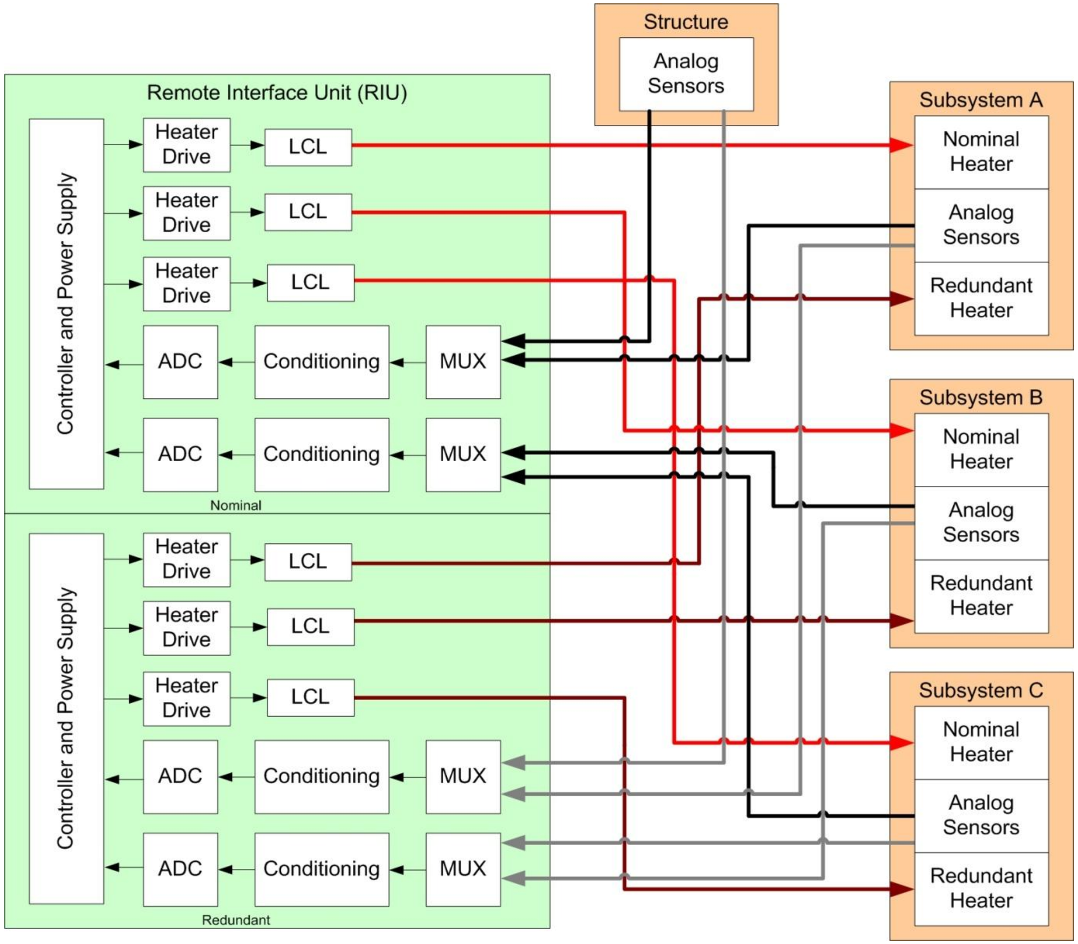
- Large Harness Mass (typically 9% of spacecraft mass).
- System Vulnerability to Failures.
- PDCU with separate Nominal and Redundant harnesses to each Spacecraft Module.







Centralised System Architecture including an RIU



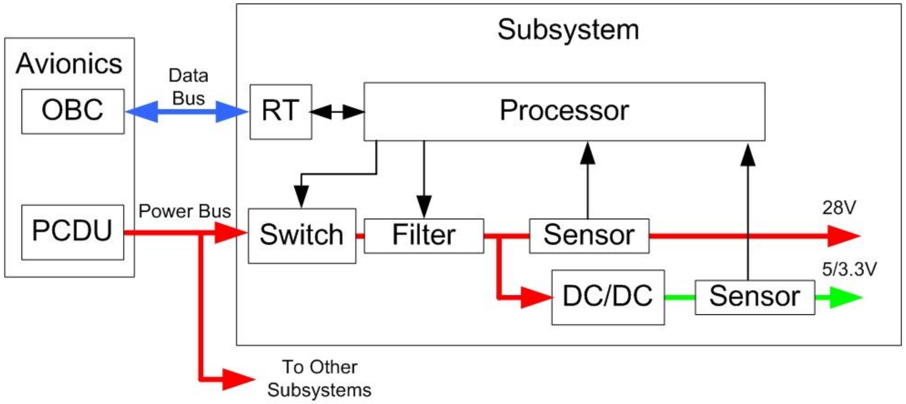
BepiColombo MPO Remote Interface Unit (RIU) built by SEA illustrating a typical centralised system with 360 Thermistor inputs, 56 Analogue inputs, 144 Relay Status and 32 Bi-level digital inputs.
16 Thruster Heater outputs, 8 Thruster Valve outputs and 8 Latch Valve outputs.

Connectors shown are nominal side only !

Why Use a Decentralised System ?

De-centralised System

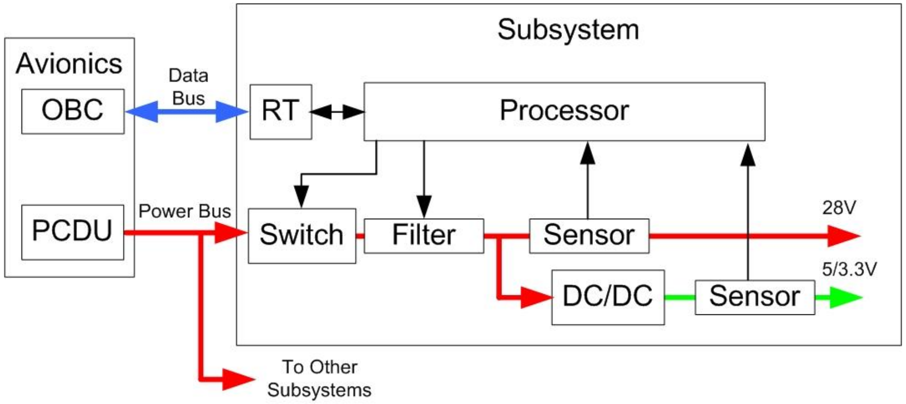
- Reduced Harness Mass.
- Localised Control Capability.
- Increased System Reliability due to less centralised architecture.

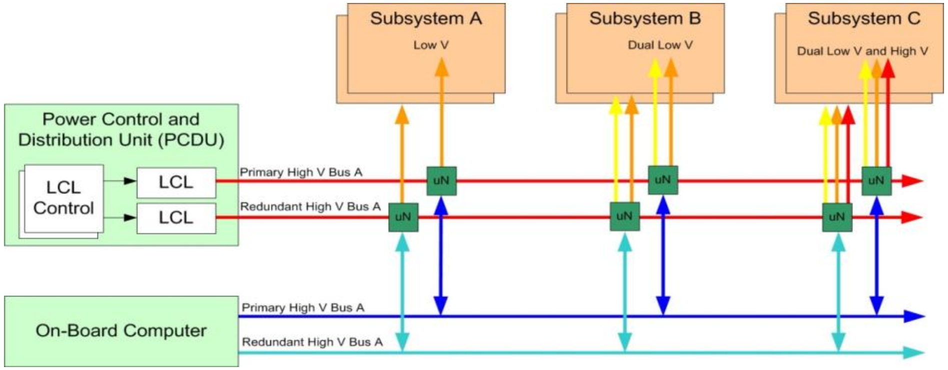


Why Use a Decentralised System ?

De-centralised System

- Reduced Harness Mass.
- Localised Control Capability.
- Increased System Reliability due to less centralised architecture.
- Micronode design using miniaturisation technologies to achieve low mass, power & volume standardised modules.
- Synergy with modern de-centralised Automotive Systems.





Micronode Selection

A trade-off to was carried out, looking to;

- Maximise Mass Reduction
- Maximise Sensor/ Actuator Integration

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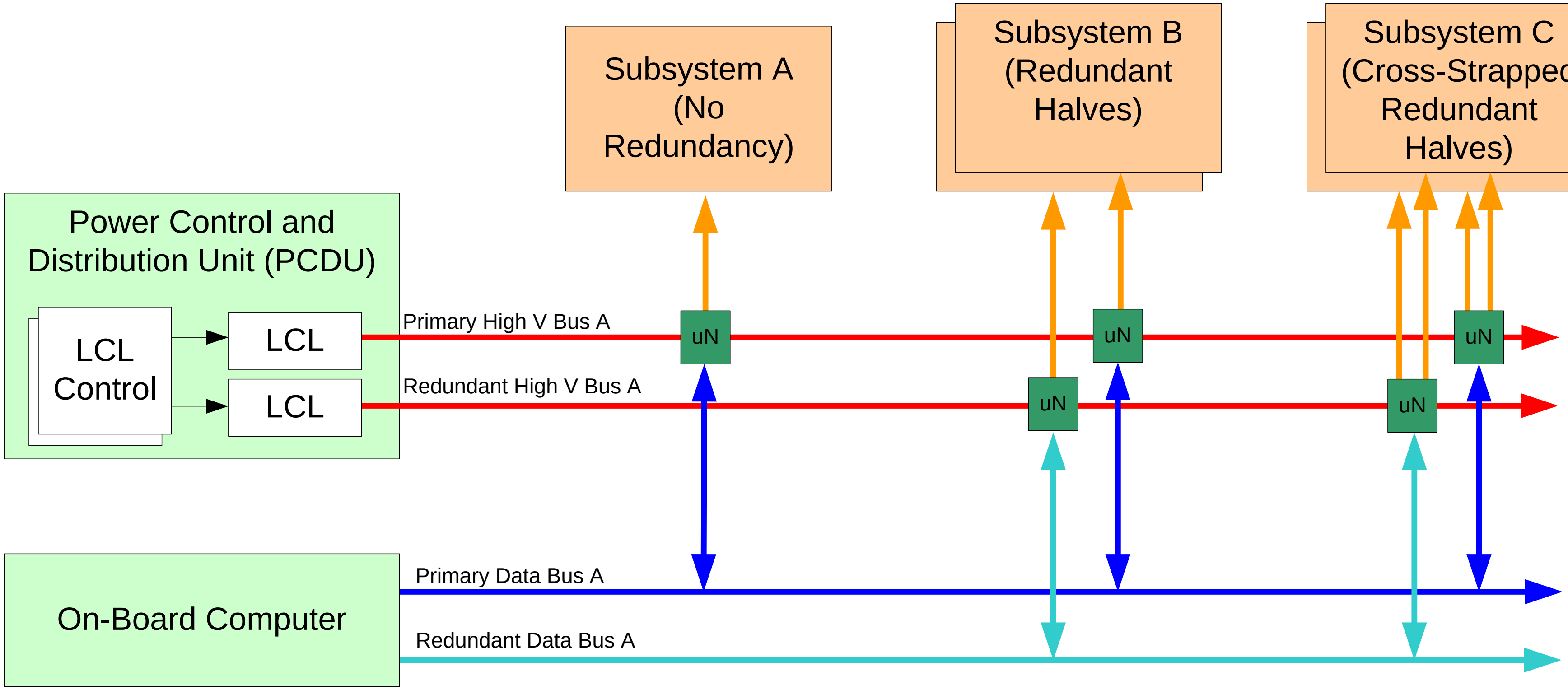
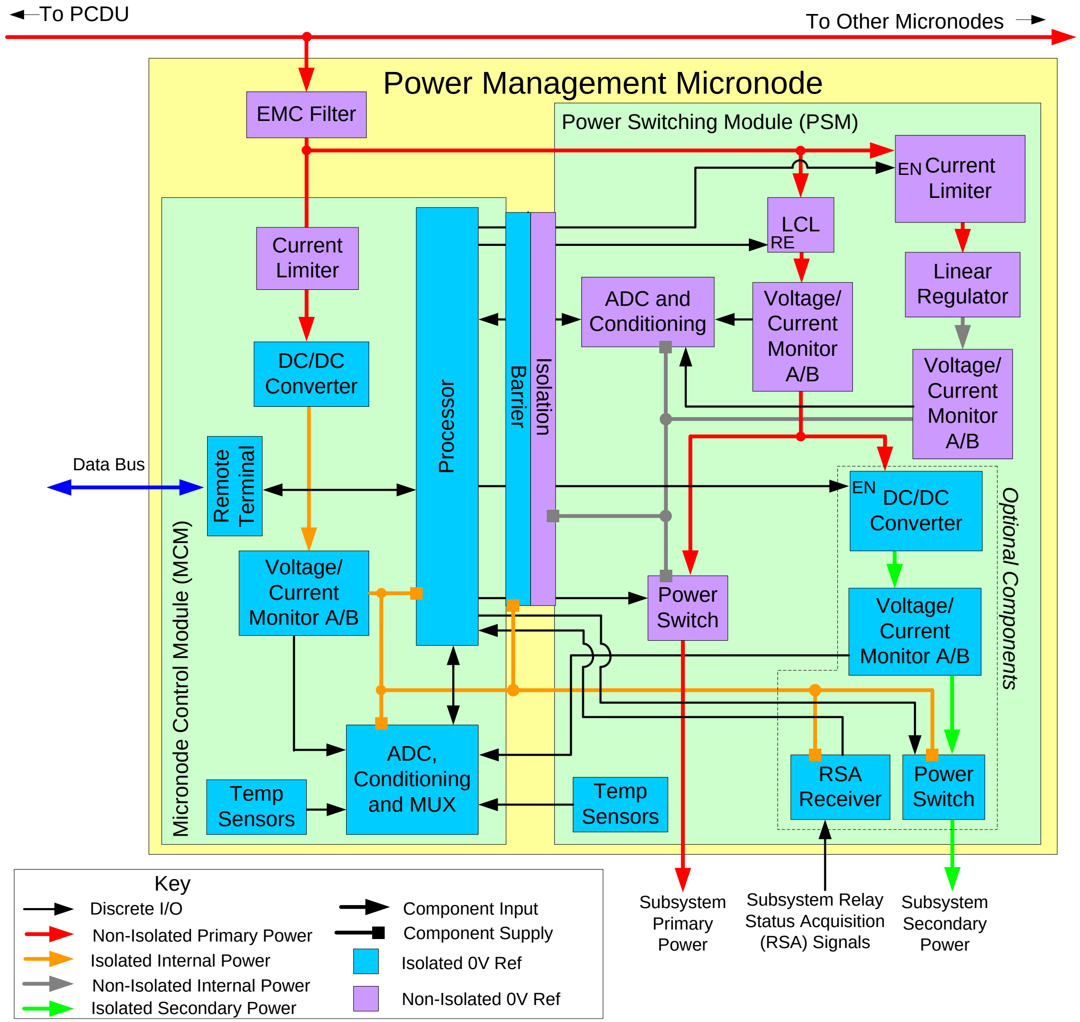
Trade-off Concluded on two types of Micronodes;

- Power Micronode
- Environmental Micronode

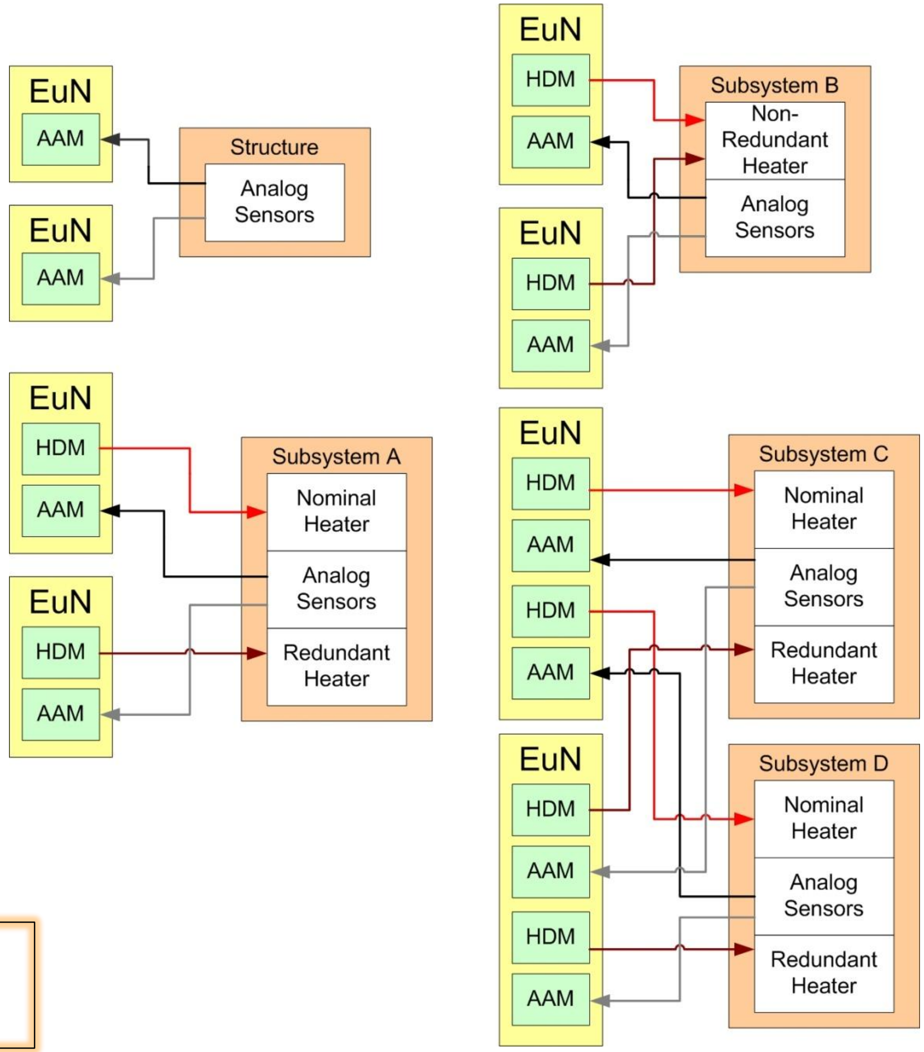
Power Management Micronode Architecture



Power Management Micronode

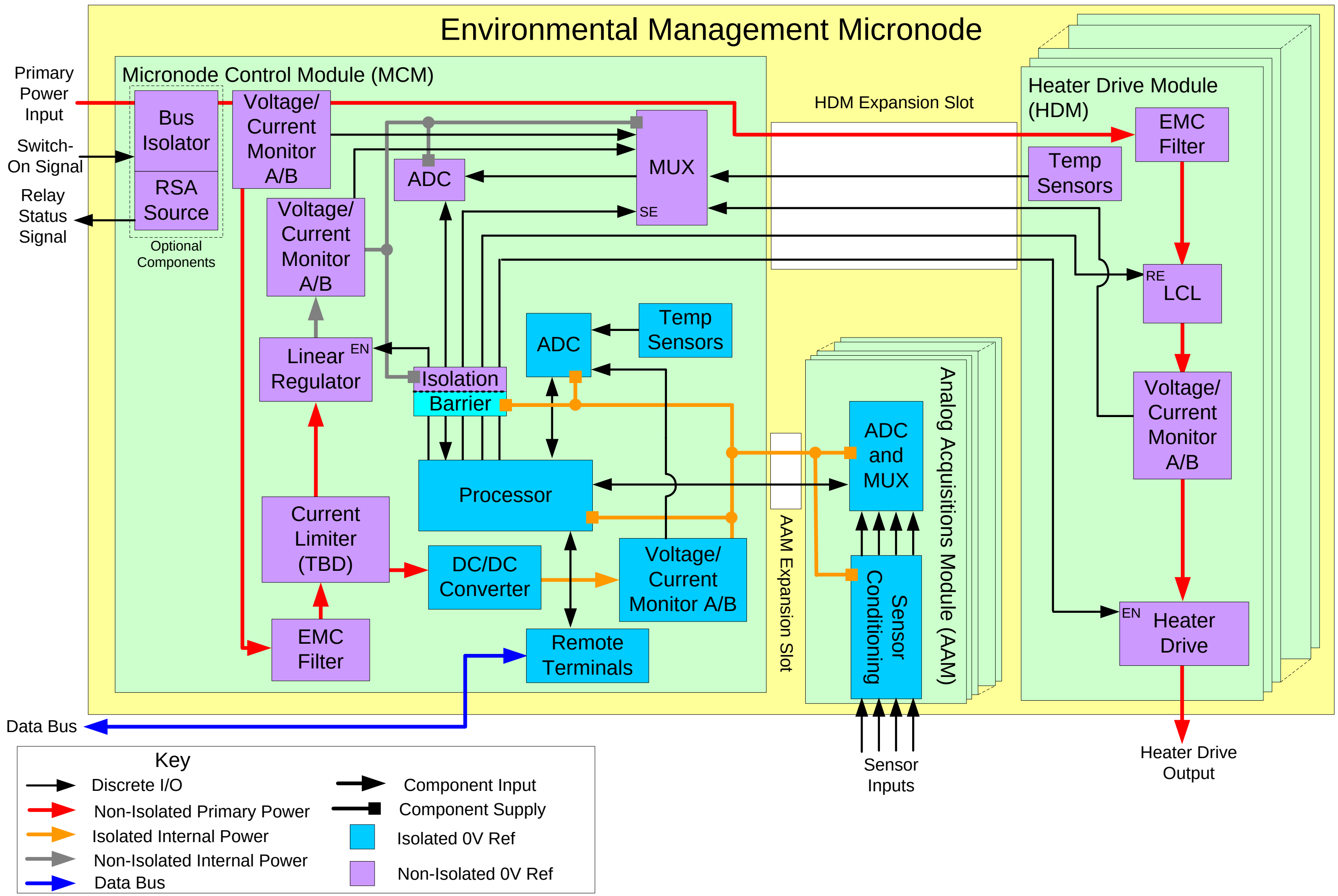


Environment Management Micronode Architecture



AAM – Analogue Acquisition Module
HDM – Heater Drive Module
EuN – Environmental Micronode

Environment Management Micronode



Summary of Advantages

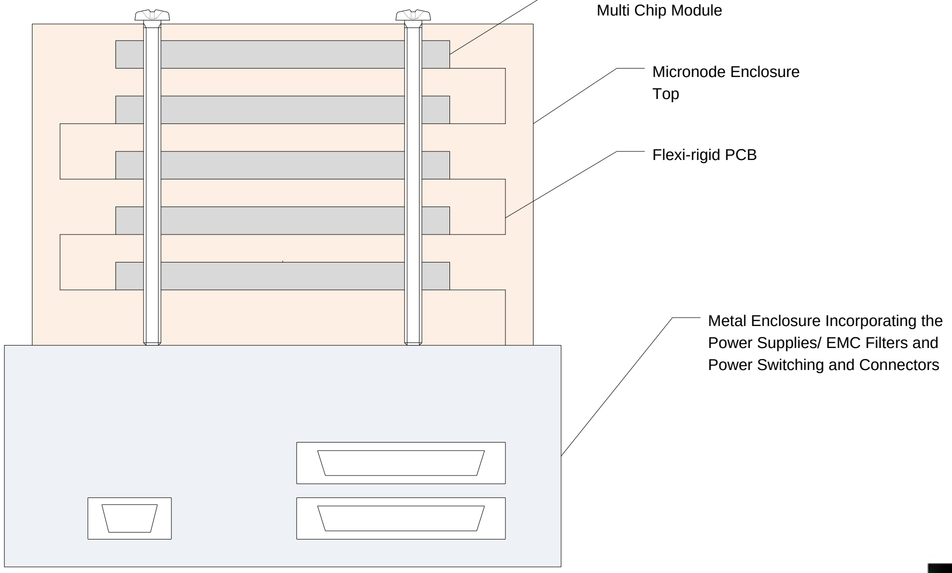
Decentralised Environmental Management Micronode

- Health/ Status Monitoring
- Harness Reduction
- Modular Architecture
- Autonomous Control
- Shorter Sensor Data Paths
- Can implement LCL's for Heater Control etc….
- Large number of Compatible Environmental Sensors i.e. Accelerometers/ strain gauges/ Thermistors….

Decentralised Power Management Micronode

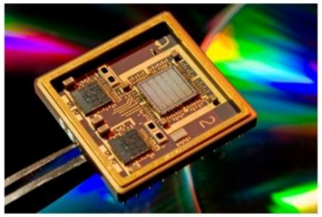
- Health/ Status Monitoring
- Harness Reduction
- Modular Architecture
- Design/ Verification Time Reduction
- Standardised DC/DC Converters, Filters and Switching

Micronode Packaging Options



Potential Packaging Technologies;

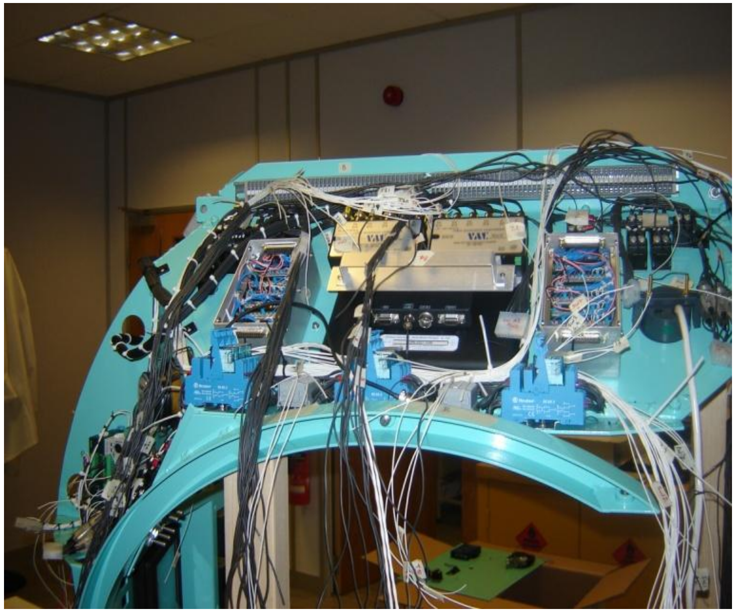
- Flip Chip with Through Silicon Vias (TSV)
- System in Package (SiP)
- 3D Packaging
- Multi Chip Module (MCM) Packaging
- Wafer Level Packaging (WLP)
- ASIC development either Mixed Signal or separate Digital and Analogue ASICs



Micronode MEMS Opportunities

- Integrated Sensor/ ASIC capabilities using WLP
- Isolation Barrier Data Transfer
- Low power DC/DC Conversion

Harness Reduction during AIT



Micronode Modules could vastly simplify AIT environmental monitoring during Temp/ Vac for example when commercial options would not be a viable solution.

MICRONODE ASIC REQUIREMENTS ‘WISH-LIST’

The following ‘WISH-List’ is a starting point to identify potentially useful Micronode ASIC functionality;

- Micro-controller (ie. LEON ‘Lite’ FPGA Core)
- Logic flash or non-flash programmable cells
- Oscillator (>4MHz <12MHz)
- EEPROM/ PROM/ RAM allowing for in flight S/W uploads from the OBC (size TBC)

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- EEPROM/ PROM/ RAM allowing for in flight S/W uploads from the OBC
- Low Offset Low Drift Rail to Rail Operational amplifiers with adjustable gain
- Multiplexers with built in input protection (similar to SMD 5962-96742)
- PWM controllers for DC/DC PSU and POL (similar to SMD 5962-02511)
- Communication Interface (i.e. CAN/1553/RS485/I2C/SPI/Spacewire/Data over Power)
- Maximise the use of the ESA DARE Library wherever possible
- 12/16 bit ADC and 12 bit DAC
- Analogue Signal Interfaces for Type ANY/ ANP/ AN1/ AN2/ RSA and BLD
- General I/O voltages tolerant to 5V and 3V3

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- General I/O voltages tolerant to 5V and 3V3
- Lifetime in excess of 7 years in orbit +2 years on the ground
- Thermal operation -40°C to +70°C with a non operating range of -50°C to +125°C
- Reliability ≥ 0.95
- > 30KRads TID, >100MeV SEE (SEU/SET)

Ongoing Work

- Finalise the detailed Micronode Requirements Specification
- Undertake a technology survey for breadboard prototype’s
- Compile a Micronode Prototype Development Plan

THANKYOU !

QUESTIONS ??