“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

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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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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.
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

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- 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 was carried out, looking to;

• Maximise Mass Reduction
• Maximise Sensor/Actuator Integration
Micronode Selection

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- Maximise Mass Reduction
- Maximise Sensor/ Actuator Integration

Trade-off concluded on two types of Micronodes;

- Power Micronode
- Environmental Micronode
Power Management Micronode Architecture

Subsystem A (No Redundancy)
Power Control and Distribution Unit (PCDU)
LCL Control
LCL
LCL

Subsystem B (Redundant Halves)

Subsystem C (Cross-Strapped Redundant Halves)

Primary High V Bus A
Redundant High V Bus A

Primary Data Bus A
Redundant Data Bus A

On-Board Computer

BAE SYSTEMS

AMICSA 2012
Power Management Micronode

Micronode Control Module (MCM)
ADC and Conditioning

To PCDU
To Other Micronodes

Subsystems:
- Primary Power
- Secondary Power
- Isolated Power
- Non-Isolated Power
- Voltage Monitor
- Current Monitor
- Temperature Sensors
- Processor

Optional Components:
- EMC Filter
- DC/DC Converter
- Voltage Limiter
- Voltage Regulator
- Current Limiter
- Voltage Monitor
- Current Monitor
- Temperature Sensors
- Processor

Key:
- Discrete I/O
- Non-Isolated Primary Power
- Isolated Internal Power
- Non-Isolated Internal Power
- Isolated Secondary Power
- Component Input
- Component Supply
- Subsystem Primary Power
- Subsystem Relay Status Acquisition (RSA) Signals
- Subsystem Secondary Power
- Isolated 0V Ref
- Non-Isolated 0V Ref

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AAM – Analogue Acquisition Module
HDM – Heater Drive Module
EuN – Environmental 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
Micronode Modules could vastly simplify AIT environmental monitoring during Temp/ Vac for example when commercial options would not be a viable solution.
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)
The following ‘WISH-List’ is a starting point to identify potentially useful Micronode ASIC functionality;

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- Logic flash or non-flash programmable cells
- Oscillator (>4MHz <12MHz)
- 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
MICRONODE ASIC REQUIREMENTS ‘WISH-LIST’

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- Analogue Signal Interfaces for Type ANY / ANP/ AN1/ AN2/ RSA and BLD
- 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 ??