Up Where We Belong

Enabling advanced missions on small platforms by cost effective avionics in the CubeSat form factor

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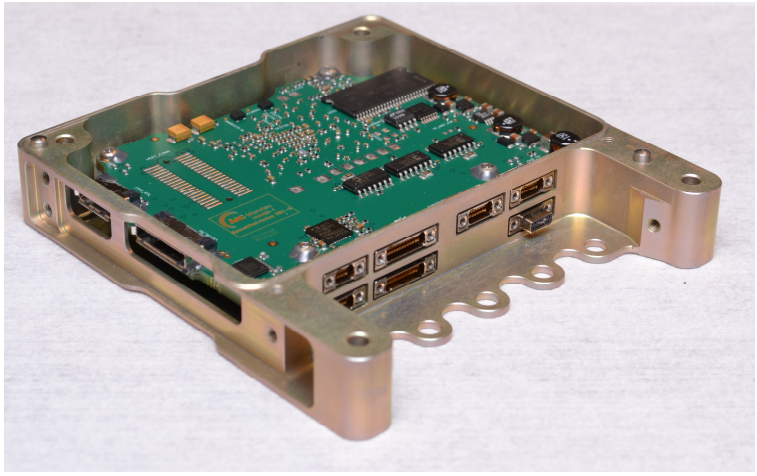
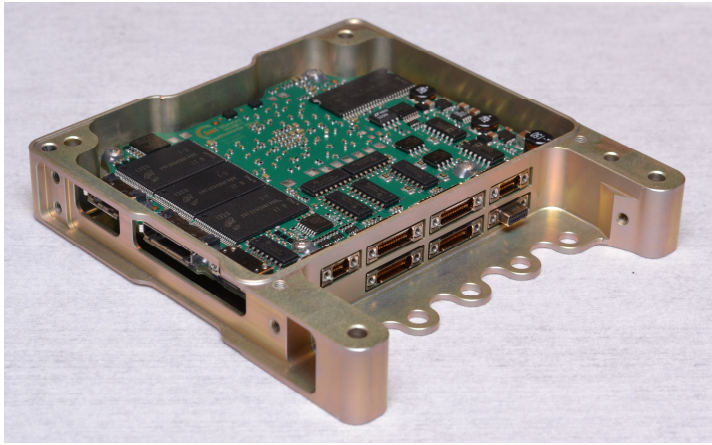
Enabling advanced missions…

- Development of a satellite Data Handling System
  - Choices made
  - Difficulties encountered
  - Mitigation methods





Presentation outline

- Background
- System decisions
- Advantages and drawbacks
- Conclusions

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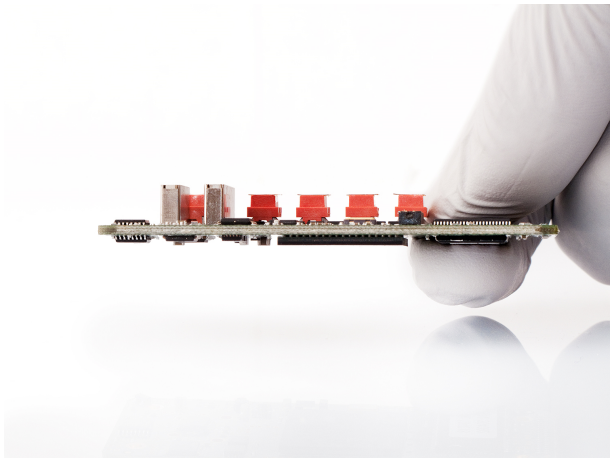
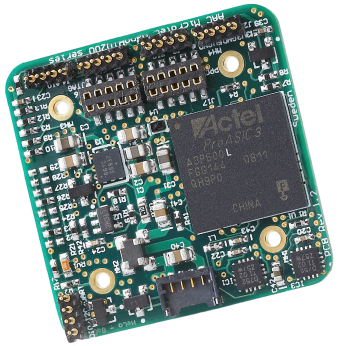
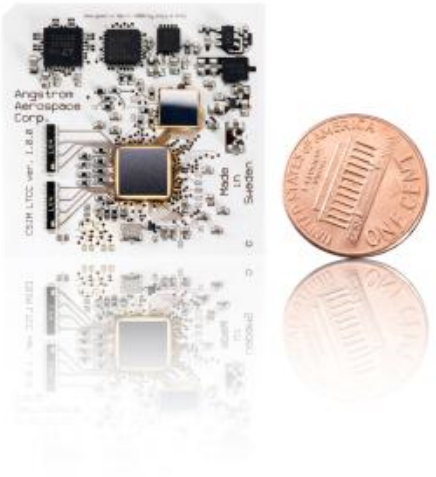
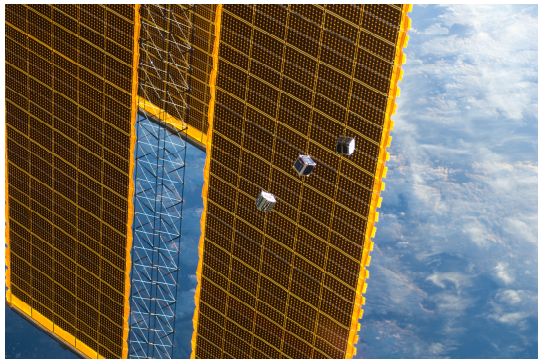
Background

- Earlier and current Data Handling Systems (DHS)
  - Miniaturized systems…
  - …to DHS family.



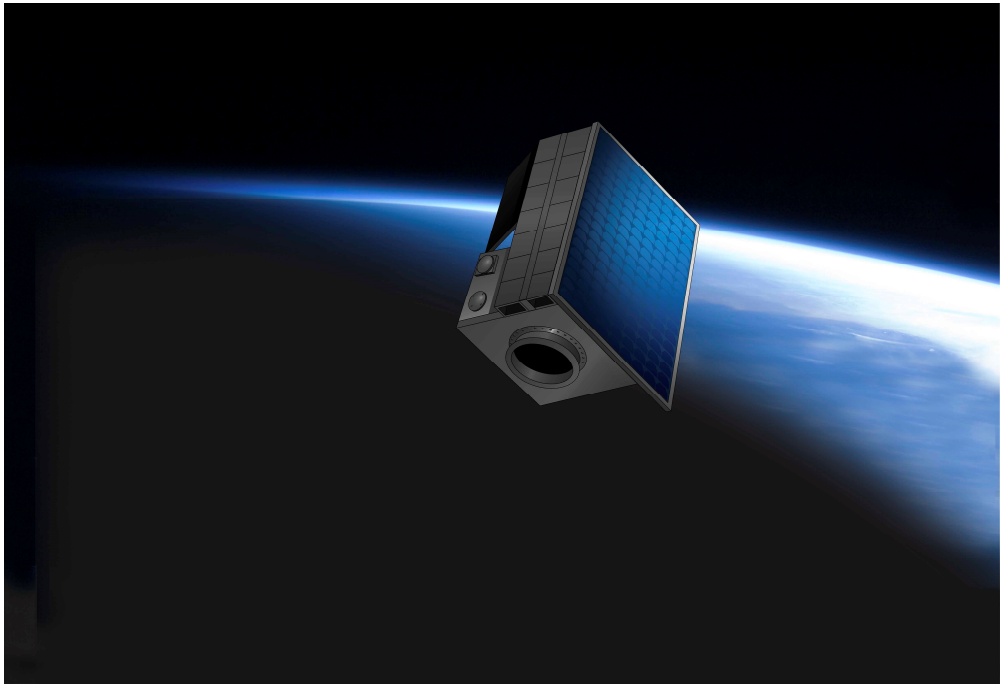






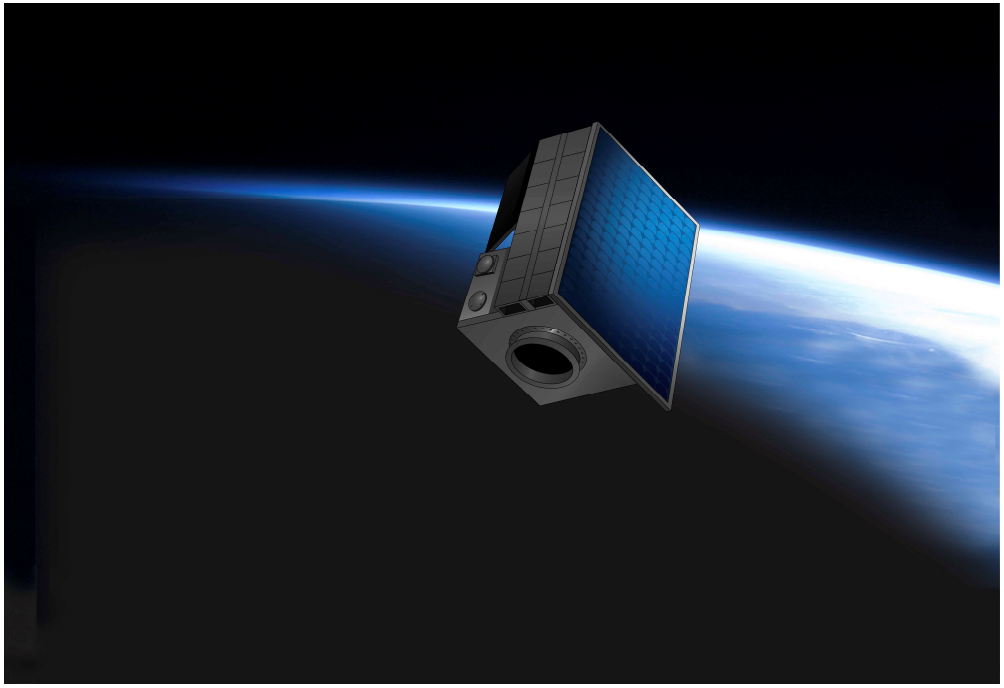
Background

- Reason and requirements
  - Current systems (Innosat, SPARC-1, MaMMoTH etc.)
  - Previous systems
  - Growing smallsat market
  - Improved usability



Background

- Requirements
  - 2 years
  - LEO
  - Microsatellite: 6U Cubesat to 0.5 m^3 and 50 kg
  - High reliability
  - Low cost



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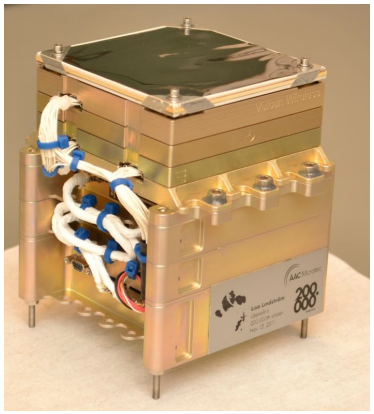
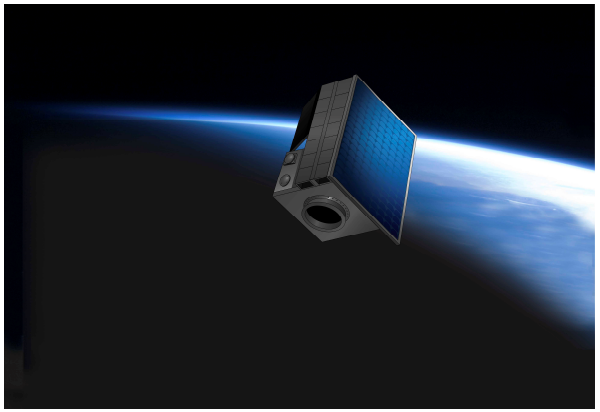
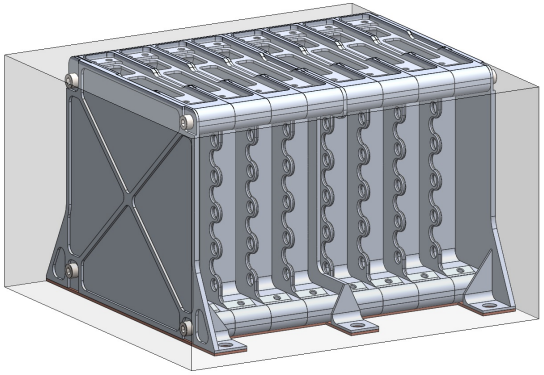
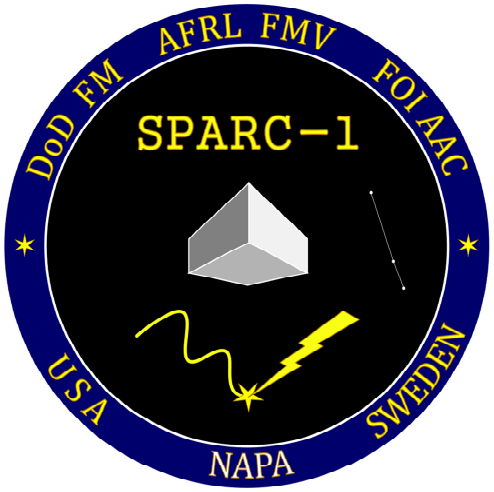
System decisions

- Reusability



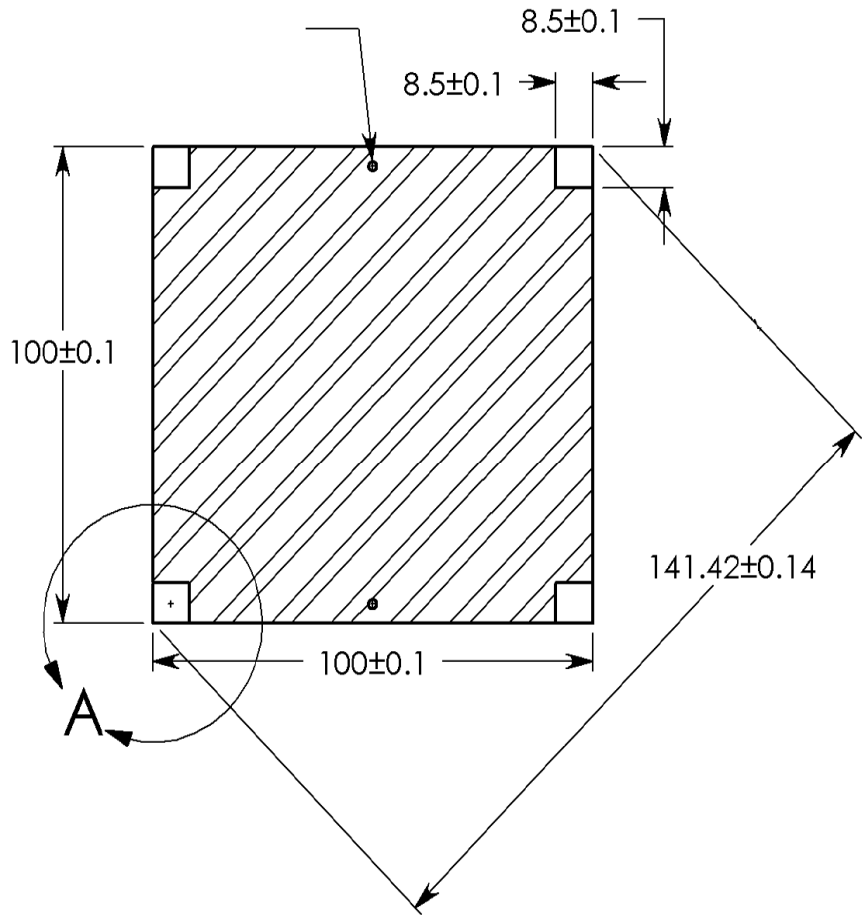






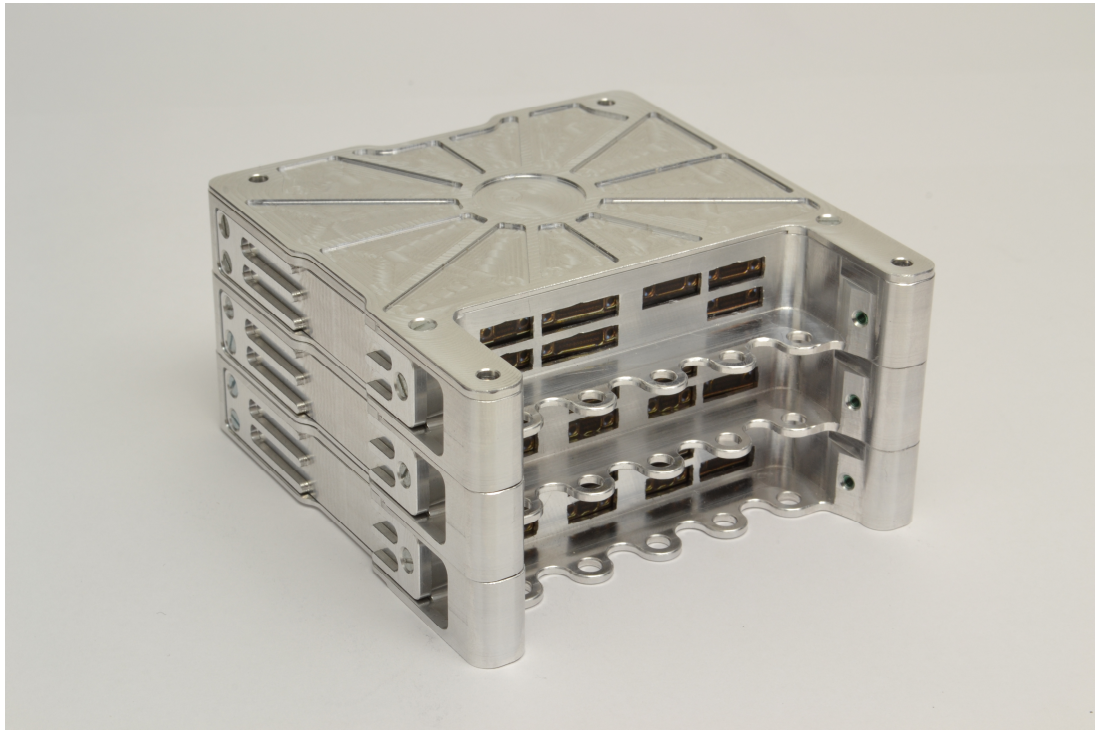
System decisions

- Cubesat formfactor



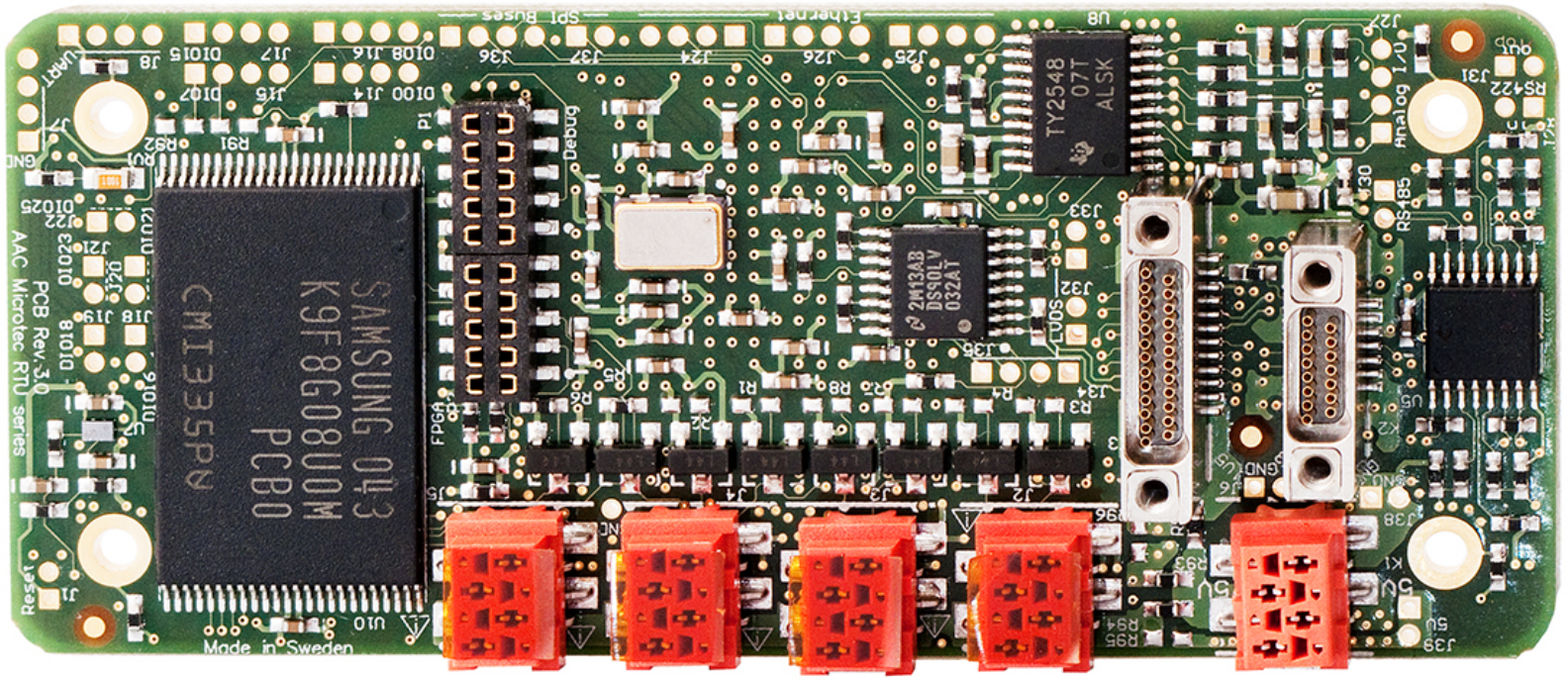
System decisions

- Modularity



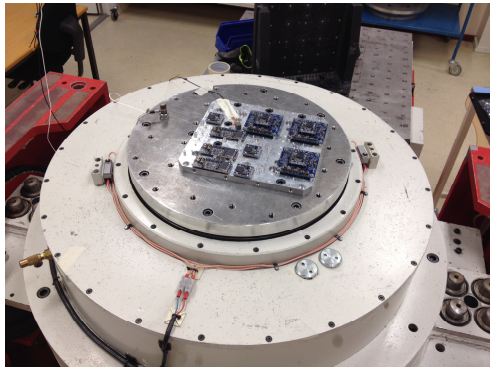
System decisions

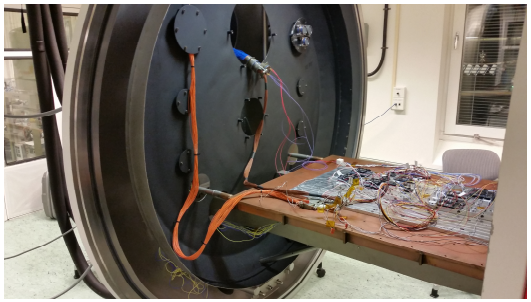
- Commercial off-the-shelf (COTS) components

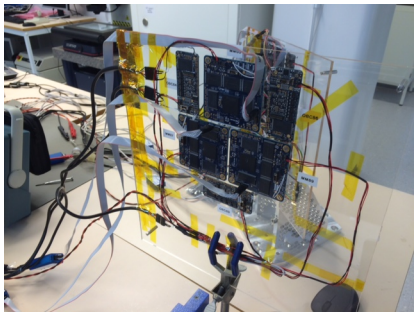


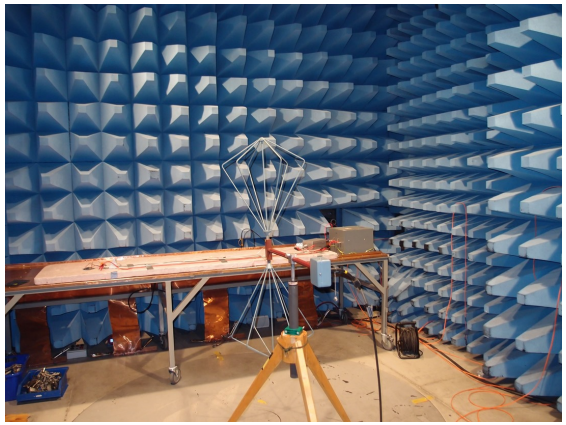
System decisions

- Thorough unit level testing









System decisions

- Standards
  - ECSS
  - NASA
  - Military and Industrial standards

EUROPEAN COOPERATION
ECSS
FOR SPACE STANDARDIZATION

1.0 INTRODUCTION

1.1 Background

Marshall Space Flight Center – Specification (MSFC-SPEC)-521 was initially published in 1978 to (1) interpret and integrate the various electromagnetic compatibility (EMC) requirements found in Shuttle, Spacelab, and payloads system documentation, and (2) document them for payload subsystems and equipment. The requirements of this specification, from its basic revision through revision B, were primarily derived from the Spacelab Payload (SLP) Accommodation Handbook, SLP-2104; the Orbiter/Spacelab Interface Control Document (ICD), 2-05301; Military Standard (MIL-STD)-461; National Space Transportation System (NSTS)-SL-E-0002; the Material Science Laboratory (MSL) User's Handbook, JA655; and the Space Shuttle Payload Accommodations Handbook, Volume XIV of NSTS 07700.

Although written specifically for Spacelab payloads, the specification became a *de facto* EMC standard for MSFC hardware where equipment and system level requirements did not exist or were unknown at the beginning of the development process.

Currently, MIL-STD-461, "Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment," and MIL-STD-464 "Electromagnetic Environmental Effects Requirements for Systems," are the engineering standards endorsed by the National Aeronautics and Space Administration (NASA) Office of Chief Engineer for electromagnetic interference (EMI) control and system-level EMC. MIL-STD-461 and MIL-STD-464 are applicable to all activities and agencies of the Department of Defense (DoD). Because of the broad applicability of these standards, the documents allow for tailoring of requirements commensurate with the intended installation and operation of the equipment and subsystems.

CHAPTER 9. SOLDERING STANDARD IMPLEMENTATION

9.1 APPLICABLE SOLDERING STANDARD

9.1.1 J-STD-001ES contains baseline soldering requirements for mission hardware. This section defines requirements which are applicable to and/or in addition to those found in the baseline document.

Note: J-STD-001, Class 3 is not an authorized substitute for the most recent revision of IPC J-STD-001ES.

9.2 USE OF CANCELLED NASA WORKMANSHIP SOLDERING STANDARDS

9.2.1 NASA-STD-8739.2 and NASA-STD-8739.3 are cancelled documents as of October 2011. Use of these standards without waiver is allowed for programs and projects that have assurance baseline documents which were published prior to their cancellation. Programs and projects shall obtain waiver approval prior to using cancelled standards in their baseline requirements (Requirement).

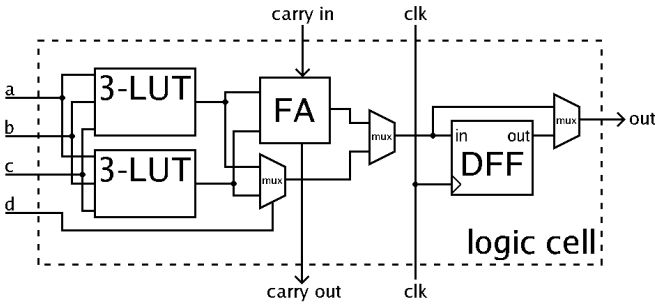
9.2.2 Programs and projects that have invoked NASA-STD-8739.2 and NASA-STD-8739.3 in their baseline requirements prior to October 2011 may use IPC J-STD-001ES for soldering new mission hardware without waiver approval. Inspectors trained to J-STD-001ES may inspect hardware built to cancelled NASA soldering standards in accordance with the accept/reject criteria of the cancelled standard, however, when an artifact is identified that is considered a defect in accordance with IPC J-STD-001ES criteria, authorized technical experts and contract authorities shall disposition the defect (e.g., use or repair) based on mission risk. Programs and projects that are building, replacing, modifying, or repairing equipment defined by drawings which invoke the cancelled NASA soldering standards may work to the requirements and training certifications of IPC J-STD-001ES without waiver.

9.3 IPC J-STD-001ES TRAINING PROGRAMS

Three training program approaches, as described below, are available and recognized as valid for students seeking operator and inspector training to IPC J-STD-001ES. Suppliers are responsible for determining how they meet the training requirement for operators and inspectors, whether through IPC® course offerings or through a locally developed training program. See Appendix A, sections A.2 through A.6 for NASA workmanship certification requirements.

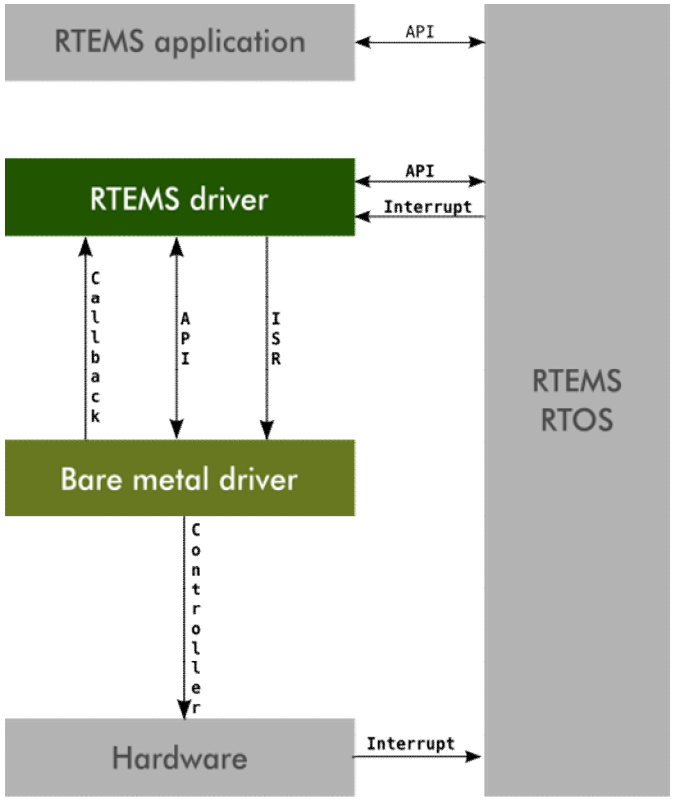
System decisions

- FPGA
  - Flexibility
  - Radiation protection



System decisions

- Real-time operating system
  - RTEMS



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Advantages and drawbacks

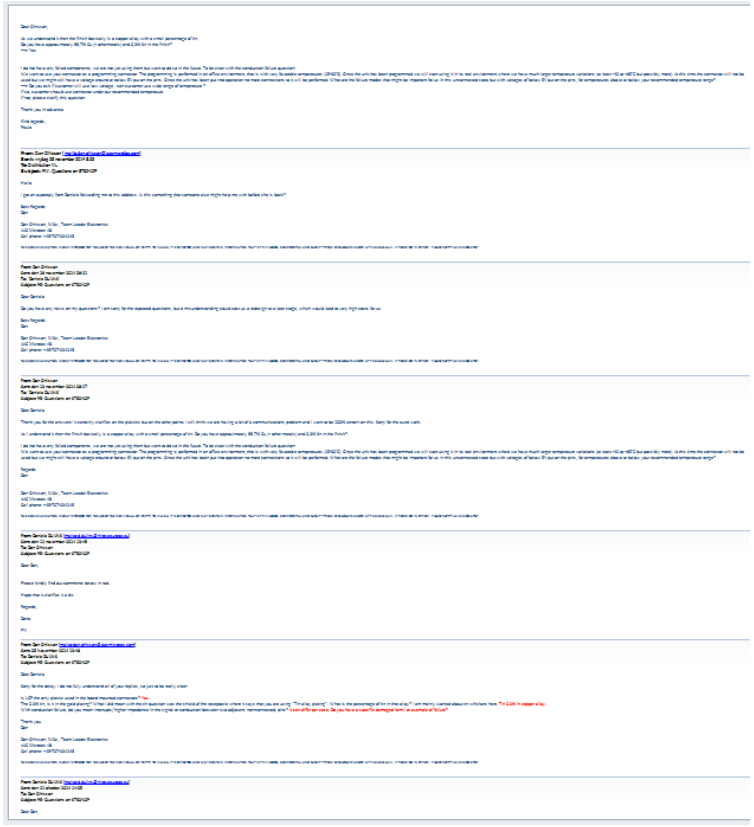
COTS

Advantages and drawbacks

- Component selection important
  - Functionality
  - Performance
  - Cost
  - Power
  - Temperature
  - Size
  - Radiation
  - Outgassing
  - Quality
  - Package
  - Availability
  - Termination
  - Vacuum
  - ITAR
  - Vibration

Advantages and drawbacks

- Inexperienced suppliers



ÅAC Microtec

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Author Dan Ohlsson
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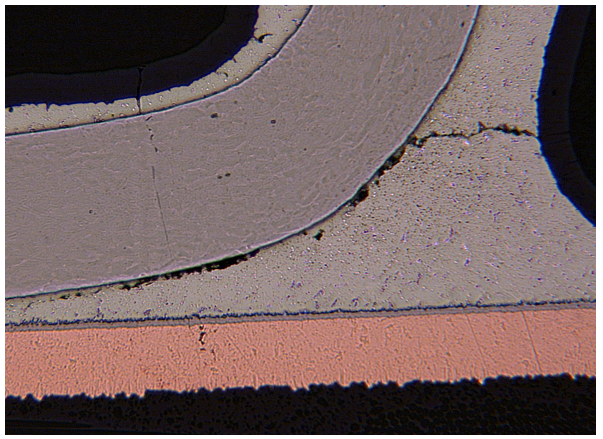
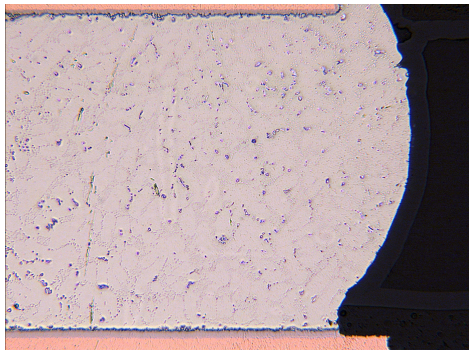
Lot Traveler 104335 nanoRTU 222 FM 2.0

Step	Parameter	Rejected units (S/N)	NCR ID	Unbroken ESD chain	Sign.	Date and time
4. Component placement TOP	Program: 001087-R01 TOP Machine: MY 13668 Special mounting: Component(s): J16, J17 Technique: Hand First panel control performed:			OK	DB BM BR	130408 130408
5. Soldering TOP	Program: 001087-R01 TOP Profile: Adjustments: Machine: Rehm V8.1			OK	DB BM	130408

Advantages and drawbacks

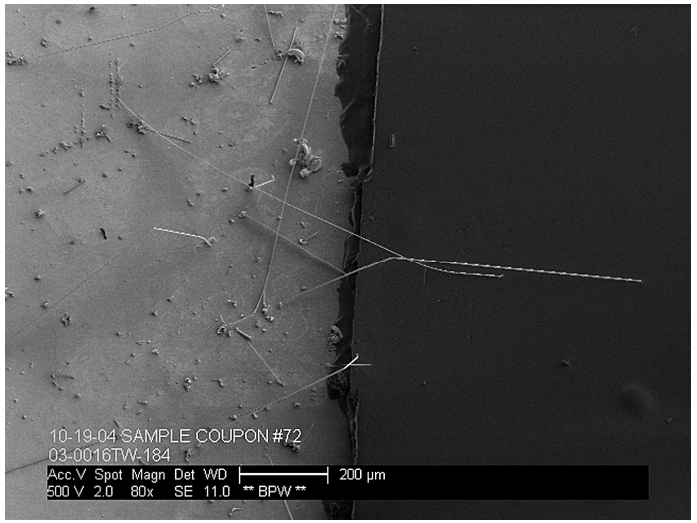
- Unleaded solder
  - Temperature cycling
  - Tin whiskers
  - Industrial standard





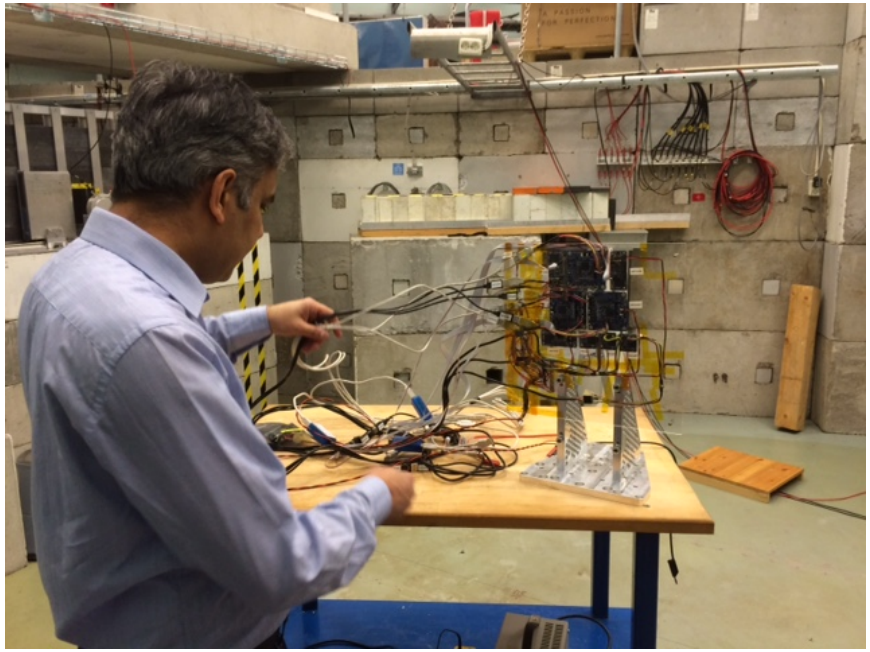
RoHS

Compliant



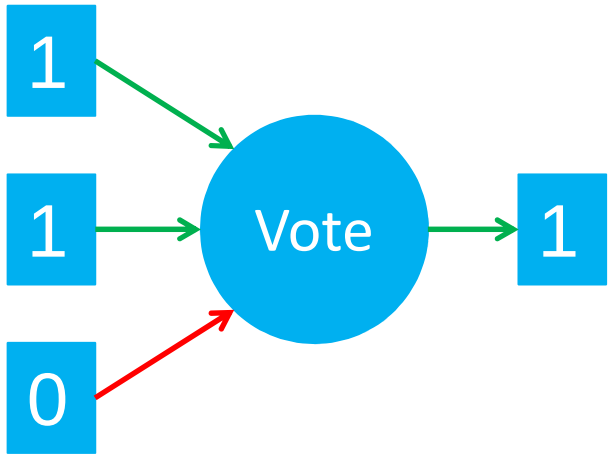
Advantages and drawbacks

- Component manufacturer test philosophies



Advantages and drawbacks

- Radiation sensitivity
  - Triple Modular Redundancy
  - Power monitoring
  - Hardware housekeeping
  - System on Chip housekeeping
  - Error detection and correction
  - Watchdog



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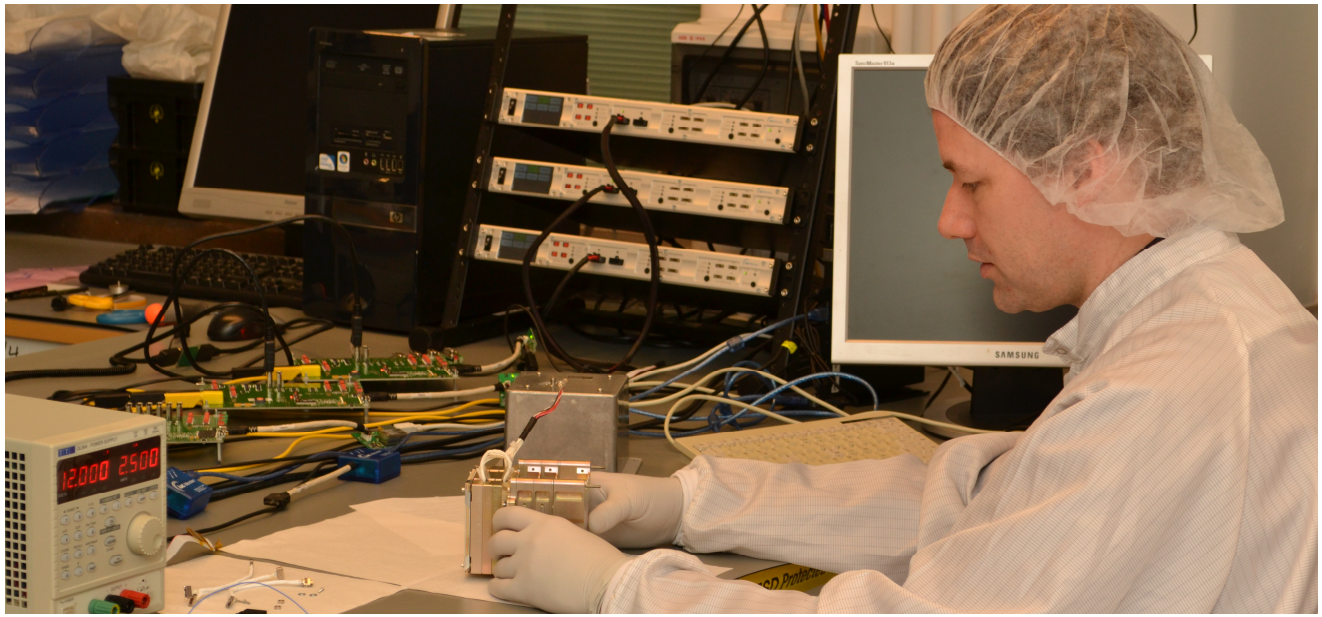
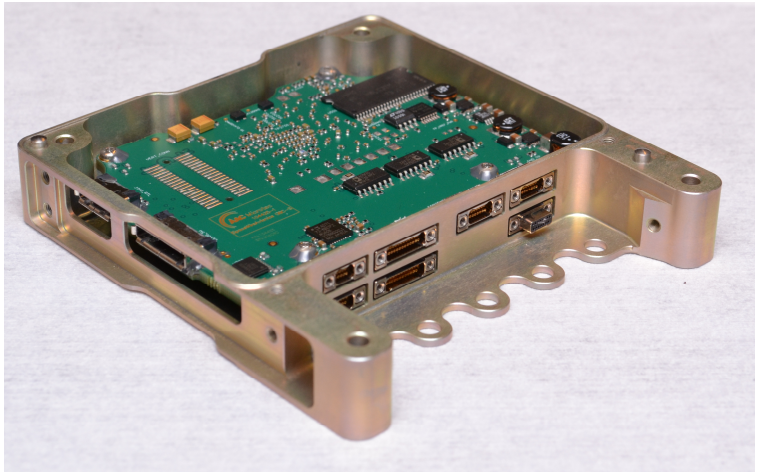
Conclusions

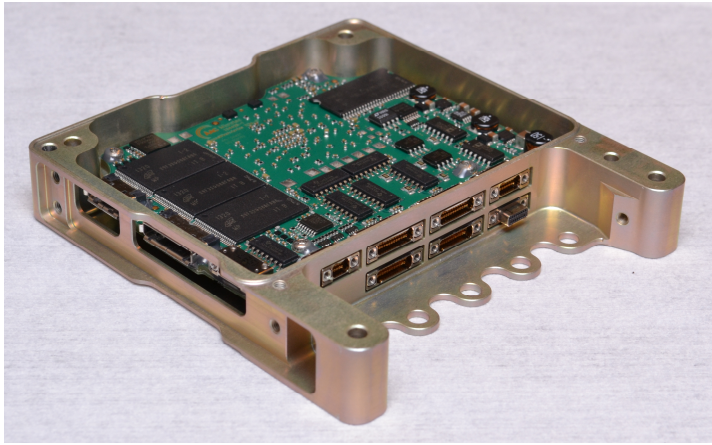
- Future work
  - Tech demo in 2016
  - Finalization of platform design
  - Adding interfaces
  - Continuously fine-tune cost vs. reliability



Conclusions

- Development of Data Handling System (DHS)
  - Choices made
  - Difficulties encountered
  - Mitigation methods





Thank you for your attention

Questions