Assurance of COTS Boards for Space Flight

Jeannette Plante

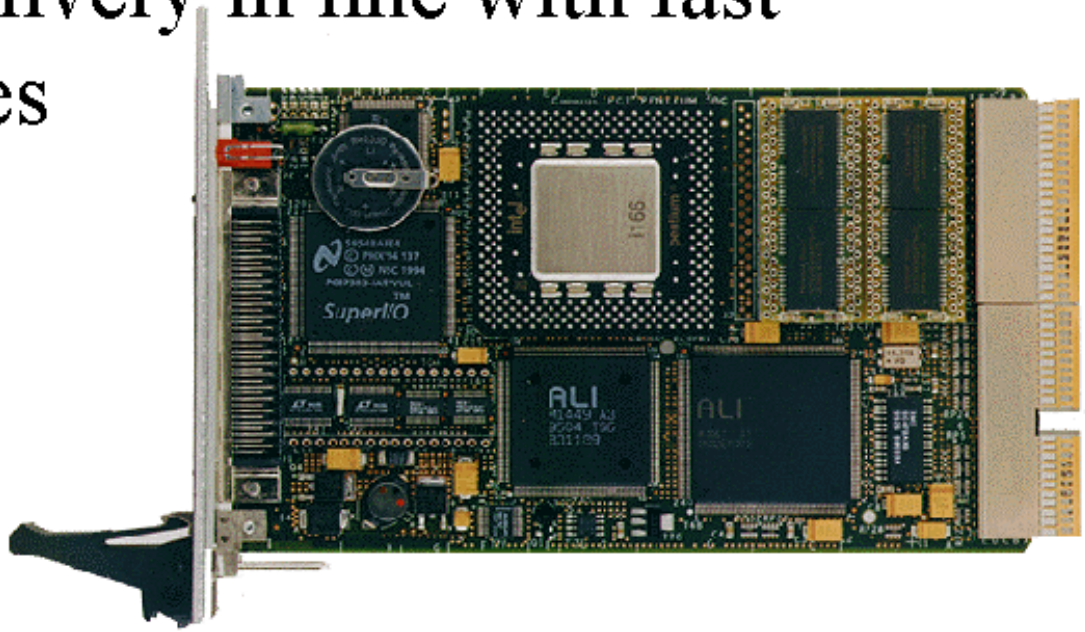
NASA GSFC Technology Validation Assurance Team

Dr. Michele Gates, Dr. Henning Leidecker, Harry Shaw
NASA Goddard Space Flight Center

Jeannette Plante, Norm Helmold, Clay Eveland, Melanie Ott,
Norma Lee Todd, Dr. Mark Fan
Swales Aerospace

Designer's Perspective

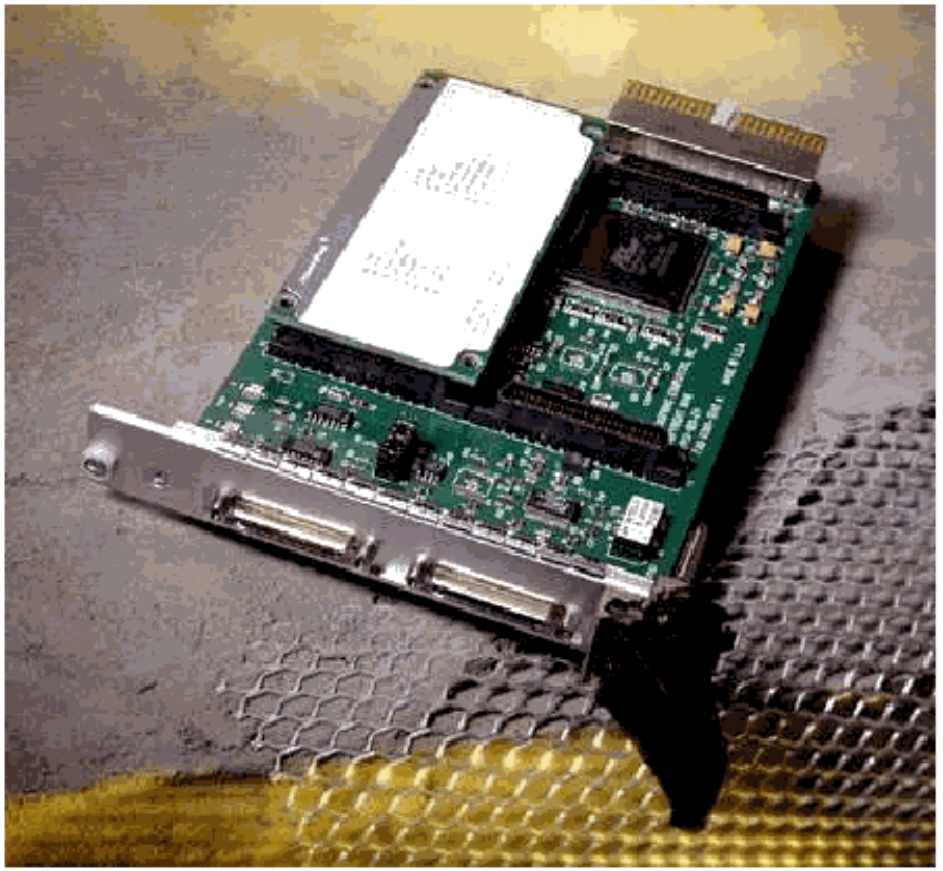
- Integration level comensurate with bench-top systems (PCI, VME, PC104, RS232)
- Software compatibility with desk-top and bench-top systems
- Cost and Delivery in line with fast program cycles



What Do You Get?

- Predictable electronic performance and compatibility with peripheral hardware

- Plastic connectors, fans and heat sinks, socketed parts, surface mount packages, mezzanine boards, unidentified parts with large number of pin-outs

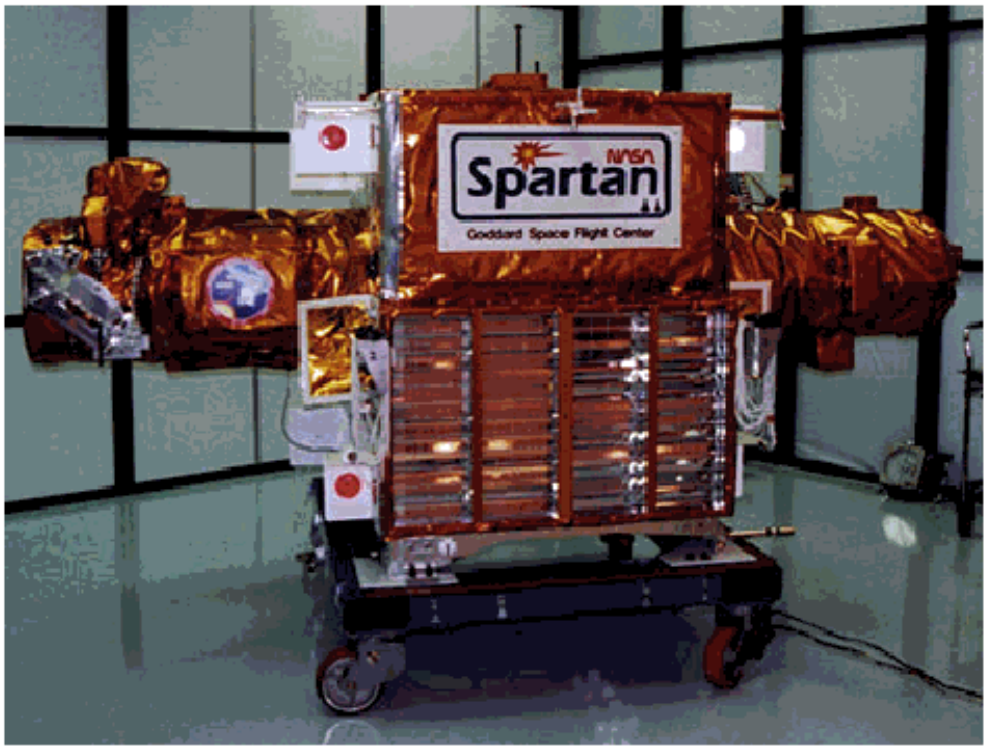


COTS Insertion: TVA Approach

- Mission duration will have a big effect on how the application environment is defined. We need to consider Days-to-3 years vs 10 to 30 years

- Ability to mitigate problems resides in the ability to characterize what you've got

- Need to be part of the fast-cycle benefit of COTS



- Need to find efficient (power, weight, cost) techniques for simulating the terrestrial environment - need to prolong the dormancy of hardware flaws

Spartan 251 CUE-Box

Central Unit Electronics made up of COTS boards. Based on a PCI architecture. Delivery schedule is Feb of 1999

Hardware Sought:

Processor Boards	9 Types 3 Mfrs	$500 to $6000 each
Memory Board (64 MB DRAM)	1 Type 1 Mfr	$1600 each
Backplane (PCI, 8 slots)	1 Type 1 Mfr	$400 each
IP Carriers	3 Types 2 Mfrs	$600 to $1200 each
Analog Input	2 Types 2 Mfrs	$500 each
Analog Output	1 Type 1 Mfr	$800 each
Digital I/O (16 to 48 channels)	6 Types 2 Mfrs	$300 each
Serial I/O	2 Types 2 Mfrs	$400 each

The Facts of Life for COTS Boards

- Little to no parts identification
- Unknown or no use of NASA design rules (derating, redundancy, fault tolerance)
- Little to no materials traceability (parts, solder, pc board, etc)
- Little to no lot control (die & part level as well as board-to-board)
- Unknown use of controlled assembly/manufacturing procedures
- Generally not designed or built for exposure to temperatures or mechanical stresses associated with a "rugged" or "military" environment
- Use of convective methods for thermal management
- Electrical tests cannot be done below the system level
- "Screening" and "Qualification" testing begin to merge

The TVA Approach

We start from a position that we are very familiar with:

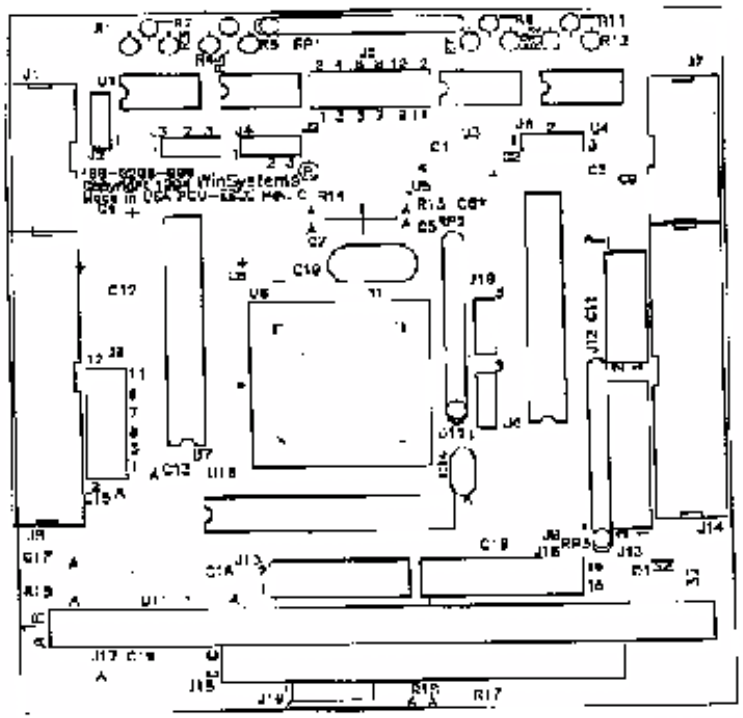
Procurement

The Usual Suspects:

- Radiation Effects
- Thermal Effects
- Shock and Vibration Effects
- Contamination

Start with Procurement:

- ask for parts lists
- ask for manufacturing lot traceability
  (or consecutive serial numbers)
- ask about return policies
- ask about materials used
- ESD control
- procure extra units for destructive tests and spares
- begin screened stores stock system



Can the manufacturer tell you?

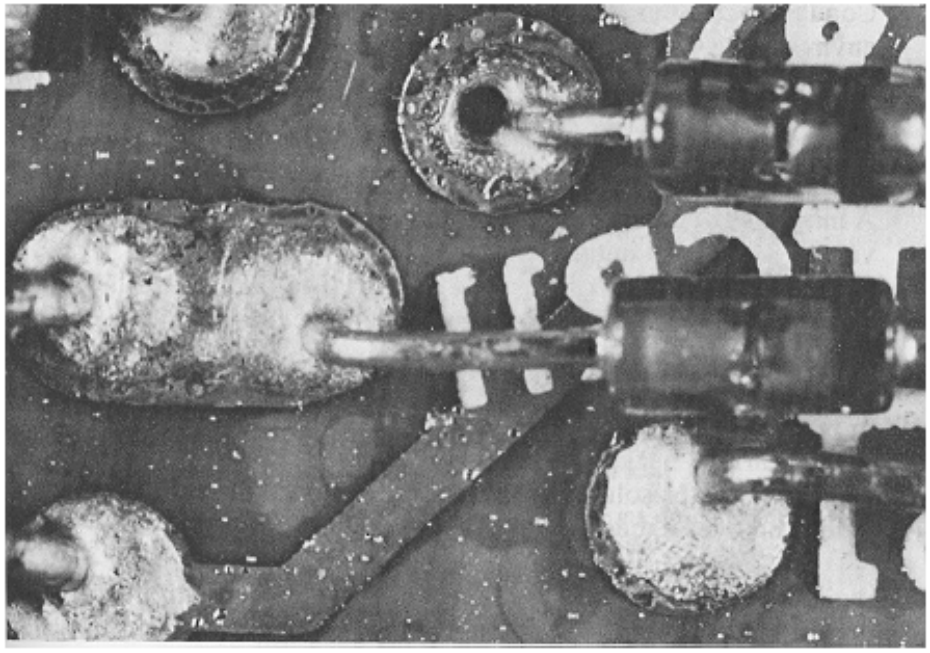
"we **cannot guarantee** that the components on these boards will have been manufactured in the same lot code or even in **the same process technology**……"

"...**mounting details and electrical connections** can be furnished at an appropriate charge."

"Consecutive serial numbers … can be supplied for a 10% price adder per unit plus a **16 week lead time**…"

Visual Inspection

- Jumper wires not glued down, no insulation
- Hardware covered by different design revisions
- Solvent/cleaner residue
- Heat damage (possibly from rework)
- Need to carefully inspect traces and solder joints for evidence of lack of quality control



Spartan 251 COTS Board Radiation Plan

Proton testing of COTS boards - SEE, Cumulative Dose

- 1 board, high proton fluence - statistics on SEEs of Board

- Flight board, low fluence - confidence that devices on flight board respond similarly to proton environment as high fluence tested board.

Board-level Testing Issues

- Device characterization challenges
  - How is each device being tested?
  - How are errors being monitored?
  - How are errors being captured?
- Monitoring current for latchup detection
- Application sensitivity
- Devices on both sides of boards
- Card density vs. beam profile
  - Probably hitting nearby devices on each side

Proton Test Results (Spartan 400)

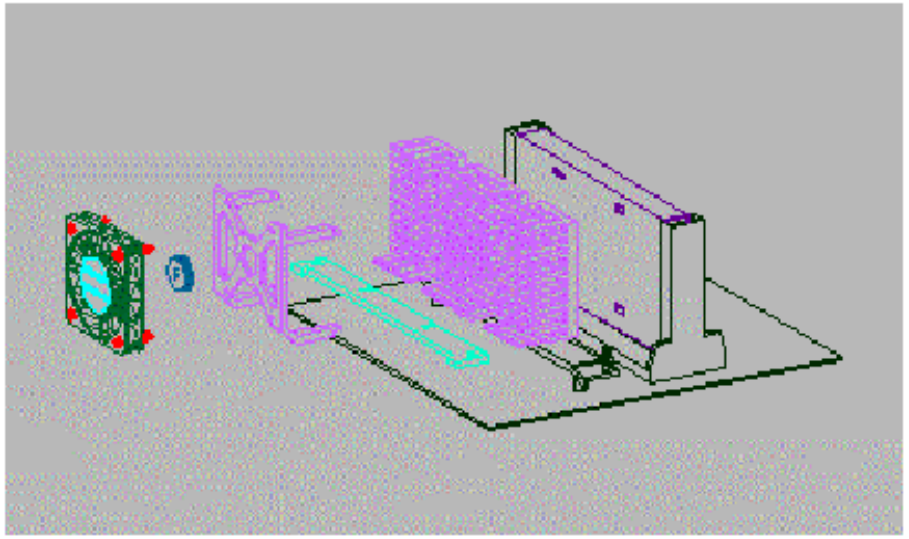
Processor Card	
Pentium 166	SEFIs requiring warm reset
PCI Master (1E11 part./cm^2)	no SEEs observed
DRAM	SEUs
1449 Memory Interface Chip	Functional failures, Latchup? (□I 50 mA)
IP Carrier Card	
Altera IP Interface Chip	Latchup
PLX 9060 PCI Interface Chip	No SEEs observed (1.7E11 part./cm^2)
1553 IP Interface Module	No SEEs Observed (3.5E10 part./cm^2)
IP Universal Serial Interface Module	No SEEs Observed (7E10 part./cm^2)

- *Indiana University Cyclotron Facility: 195 MeV incident protons,@ 1E 10 protons/cm^2*
- *fluence per test run, @ 6 krad-Si per board (Spartan 400 reqmnt)*

Thermal Management

- Determine the heat producing parts through specifications, through testing with thermocouples or by using IR imaging.
- Use thermal models to identify sufficiency of existing thermal paths. Identify the system's thermal "ground"
- Identify the need for diffusion, conduction and convection mechanisms when designing thermal management solutions.

  Solutions may include, copper heat straps, CVD diamond, fluid embedding



Shock and Vibration

- Know your launch vehicle's qualification level requirements
- Consider the placement of the parts and the clamping mechanisms
    - 6u vs 3U footprint
    - mezzanine cards
    - large pin-out flat-packs
    - connectors

- Characterize a "martyr" board
- Ruggedize the boards with stiffeners, staking, bolted down mezzanine cards, board edge clamping, etc.

Contamination

Sources can be the connectors, plastic packages, cleaner residues, cabling

Re-evaluate the standard outgassing requirement's applicability for the project

Configuration testing can be done using SP-R-0022

Progress with Spartan 250 Boards

Procurement - Finished

Radiation Testing - 1st round completed, 2nd round 6/14/98

Thermal Characterization - In Progress. Will use vacuum chamber with IR transparent window, and emissivity mapping software to measure the temperature of hot spots. Will measure temperatures in flight configuration using thermal couples in vacuum. Still looking at thermal strapping and fluid embedding to manage heat.

Progress with Spartan 250 Board cont.

Mechanical Characterization - In Progress. Characterizing modal behavior of the various type of boards. Boards with mezzanine cards that are bolted down performed better than "empty" card. Empty card found to have >30 modes below 2000 Hz.

Contamination - Level of control required is being researched as is configuration testing methods.

Insertion Plan - In progress. Provides a guideline for procuring, characterizing, ruggedizing, and testing COTS boards and systems.

Summary

NASA designers are drawn to COTS by their availability and their compatibility with existing bench-top systems.

Though manufacturers do less then we'd like to ensure hardware reliability on earth or in space, there are things we can do to provide confidence and reduce risk

Traditional TVA tools & parts engineering can be used to characterize COTS and identify means to sufficiently ruggedize them for mission use.

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