NMP ST8 Dependable Multiprocessor (DM)

Precis Presentation

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Dependable Multiprocessor

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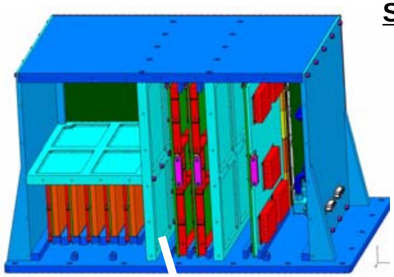

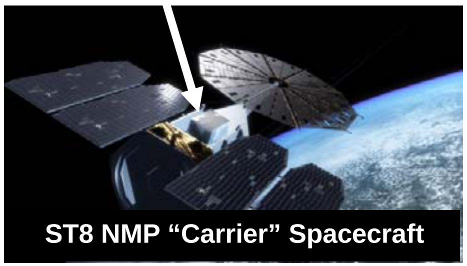

ST8 NMP “Carrier” Spacecraft

Software

Multi-layered system SW OS, Middleware, APIs, FT algorithms

SEU Immunity
- detection
- autonomous, transparent recovery

Multi-processing
- parallelism, redundancy
- combinable modes

Hardware

Dimensions 10.6 x 12.2 x 24.0 in. (26.9 x 30.9 x 45.7 cm)

Weight (Mass) ~ 61.05 lbs (27.8 kg)

Power ~ 120 Watts (max)

ST8 Dependable Multiprocessor Flight Experiment System

Description of technology advance

- Architecture and SW framework that enables COTS-based, high performance, scalable, cluster processing systems to operate in space - “SW-based SEU-tolerance enhancement”
- MPI-based for ease of porting applications from lab to space
- Adaptable to environment: radiation, mission, mode
- Validated models that can predict system performance in future missions & environments

Validation Objectives

- Demonstrate delivered onboard computational throughput capability 10x – 100x more than any computer flying in space today
- Demonstrate onboard processing throughput density > 300 MOPS/watt

Applications of DM Technology

- DM technology is applicable to a wide range of missions
- enables heretofore previously unrealizable levels of science and autonomy processing
  - -- NASA science missions
  - -- landers/rovers
  - -- robotic servicing of satellites
  - -- ground/lunar/Mars-based systems
- CEV docking computers - MKV video processor
- Unattended Airborne Vehicles (UAVs)
- Un-tethered Undersea Vehicles (UUVs)
- Stratolites
- Operationally Responsive Space (ORS)
- rad hard space applications

CY	‘05	‘06	‘07	‘08	‘09	‘10
Phase A - Concept Defn.	▲ TRL4 (7/04 - $0.5M)			NASA budget issues forced elimination of ST8 flight experiment per directive issued 8/3/07		
Phase B - Formulation	▲	▲ TRL5/PDR	▲			
Phase C/D - Implementation			▲ ▲ CDR	▲ TRL6	△ Final Report	
Phase E - Flight Exper.						
Funding	$1.2M	$2.5M	$4.0M	$3.6M	$1.0M	$TBD

DM TRL6 Status – Key Elements

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- **Radiation Testing**
  - proton and heavy ion testing established SEE rates for all components on COTS DP boards
  - system-level testing performed with one COTS DP board exposed to proton beam while running the flight experiment application suite (SAR, Matrix Multiply, 2DFFT, LUD, AltiVec (FFTW), stressing Logic test, and stressing Branch test) in a DM system context
    - -- DM flight experiment instrumentation including emulated ground station operated and post-experiment data analysis demonstrated
    - -- DMM middleware performed as designed
    - -- DM system successfully recovered from all radiation-induced faults
    - -- validated DM predictive Availability, "Computational Consistency" and Performance models

- **DM Markov Models**
  - demonstrated DM predictive Availability, "Computational Consistency" and Performance models
    - -- models based on component-level radiation test results and comprehensive SWIFI (Software-Implemented Fault Injection) campaigns
    - -- extrapolation to various radiation environments, i.e., orbits, and other applications

- **Demonstrated ability to meet NASA level 1 requirements/goals**
  - > 0.995 Availability
  - > 0.995 Reliability
  - > 300 MOPS per watt
    - -- > 307 MOPS/watt HSI application on 7447a processor with AltiVec (including System Controller power)
    - -- > 1077 MOPS/watt HSI application on PA Semi 1682 dual core processor with AltiVec

- **Demonstrated ease of use**
  - independent 3rd party with minimal knowledge of fault tolerance ported two (2) diverse applications to DM testbed in less than three (3) days including scalable parallelization, hybrid ABFT/in-line replication, 2D convolution and median filter ABFT library functions, FEMPI, and check-pointing

DM TRL6 (Phase C/D) Flight Testbed

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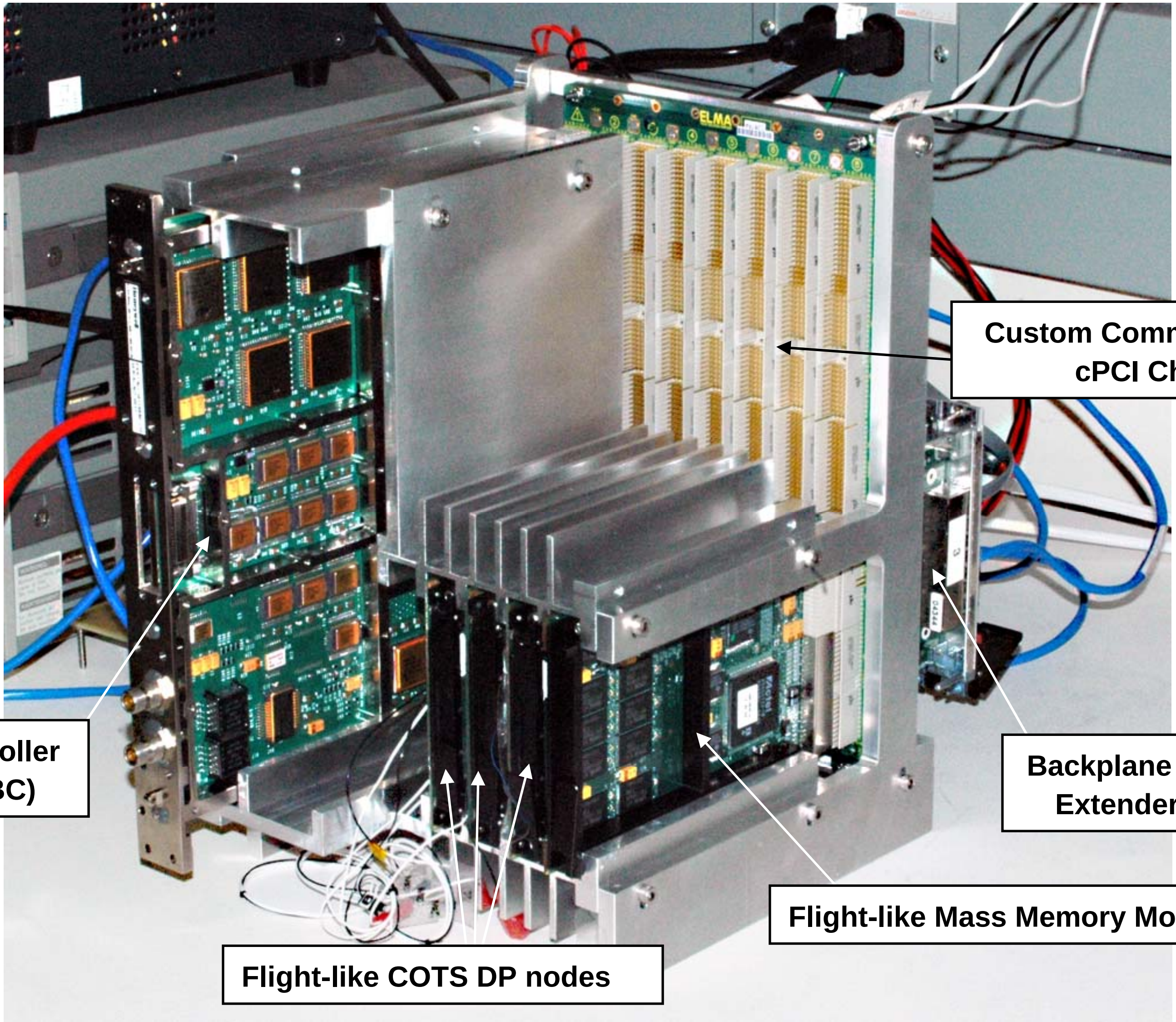

DM System-Level Radiation Test Setup at IUCF

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Summary & Conclusion

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- Flying high performance COTS in space is a long-held desire/goal
  - Space Touchstone - (DARPA/NRL)
  - Remote Exploration and Experimentation (REE) - (NASA/JPL)
  - Improved Space Architecture Concept (ISAC) - (USAF)
- NMP ST8 DM project is bringing this desire/goal closer to reality
- DM technology independence has been demonstrated on wide variety of platforms
  - x86, PPC clusters
  - PA Semi dual core technology
  - FPGAs
  - VxWorks, Linux OS
- DM technology ease-of-use has been demonstrated
  - GSFC Neural Basis Function (NBF) Synthetic Neural System (SNS algorithms for autonomous rendezvous and docking
  - NOAO multiple cosmic ray elimination applications (CRBLASTER & QLWFP2C (Dr. Ken Mighell)
- Multiple applications have been successfully ported to and demonstrated on DM testbeds
  - SAR, HSI, NBF-SNS, CRBLASTER, QLWFP2C, Matrix Multiply, 2DFFT, LUD