Advanced Hybrid On-Board Science Data Processor - SpaceCube 2.0

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Tom Flatley – Branch Head
NASA/GSFC Science Data Processing Branch
ESDS On-Board Processing
• Data Volume Reduction
• Compression
• Calibration / Correction
• Classification
• Product Generation
• Autonomy
• Event / Feature Detection
• Real-time / Direct Broadcast

Hybrid Science Data Processing
• CPU
• FPGA
• DSP

GSFC SpaceCube On-Board Processor
• 10x-100x computing performance
• Lower power (MIPS/watt)
• Lower cost (commercial parts)
• Radiation tolerant (not hardened)
• Software upset mitigation
On-Board Image Processing

Long Range Camera on Rendezvous

Short Range Camera on Deploy

GSFC SpaceCube 1.0a - Hubble SM 4 (May 2009):
- Autonomous Rendezvous and Docking Experiment
- Hosted camera AGC and two Pose algorithms

STS-125 Payload Bay
Software Upset Mitigation

GSFC SpaceCube 1.0b (Nov 2009):
- “Radiation Hardened by Software” Experiment
- Autonomous Landing Application
- Collaboration with NRL

ISS Orbit
Days Up: 157 days 2 hours
Total SEUs: 56.00
Avg SEUs/FPGA: 14.00
Avg SEUs/FPGA/Day: 0.09
Avg SEUs/FPGA/Week: 0.62
Avg SEUs/FPGA/Year: 32.55
On-Board Data Reduction

Accomplishments

SAR Nadir Altimetry Results (FY07)

Difference < 0.1%

On-board processing yields lossless 6:1 data volume reduction
On-Board Data Reduction

Accomplishments

On-board product generation yields factor of 165x data volume reduction

SAR Mapping Results (FY09)

Original Matlab Output

SpaceCube Output

Difference < 1%
On-Board Products

Accomplishments

- Classification
- Product Generation
- Event Detection
HyspIRI Demonstration Testbed

HyspIRI SpaceCube IPM Testbed

VSWIR Simulator

TIR Simulator

816 mbps

210 mbps

4 x 440 MHz PPC
1 GByte RAM
Rocket I/O
10 GByte SSR

Spacecube 2.0
Development System

15 mbps

X-Band D/L
Simulator

Cloud Classifier
SpaceCube 2.0 Block Diagram

- Power Card
- SpaceCube2 Processor Card
- FLASH Memory Card
- Mission Unique I/O

Connections:
- Spacewire / LVDS / MGT / GigE / Mission Unique High-speed

Specifications:
- Standard 3U Card Form Factor
- Nominal Box Level Parameters:
  - Size 5”x5”x7”, Weight 10-15 lbs, Power 10-20 watts
## Processor Comparison

<table>
<thead>
<tr>
<th>Processor</th>
<th>MIPS</th>
<th>Power</th>
<th>MIPS/W</th>
</tr>
</thead>
<tbody>
<tr>
<td>MIL-STD-1750A</td>
<td>3</td>
<td>15W</td>
<td>0.2</td>
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<tr>
<td>RAD6000</td>
<td>35</td>
<td>10-20W</td>
<td>2.33(^1)</td>
</tr>
<tr>
<td>RAD750</td>
<td>300</td>
<td>10-20W</td>
<td>2(^2)</td>
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<tr>
<td>SPARC V8</td>
<td>86</td>
<td>1W(^3)</td>
<td>86(^3)</td>
</tr>
<tr>
<td>LEON 3FT</td>
<td>60</td>
<td>3-5W(^3)</td>
<td>15(^3)</td>
</tr>
<tr>
<td>GSFC SpaceCube 1.0</td>
<td>3000</td>
<td>5-15W</td>
<td>400(^4)</td>
</tr>
<tr>
<td>GSFC SpaceCube 2.0</td>
<td>5000</td>
<td>10-20W</td>
<td>500(^5)</td>
</tr>
</tbody>
</table>

### Notes:
1 – typical, 35 MIPS at 15 watts
2 – typical, 300 MIPS at 15 watts
3 – processor device only ... total board power TBD
4 – 3000 MIPS at 7.5 watts (measured)
5 – 5000 MIPS at 10 watts (calculated)