Advanced Hybrid On-Board Science Data Processor - SpaceCube 2.0

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NASA/GSFC Science Data Processing Branch
# On-Board Science Data Processing

<table>
<thead>
<tr>
<th>ESDS On-Board Processing</th>
<th>Hybrid Science Data Processing</th>
<th>GSFC SpaceCube On-Board Processor</th>
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</thead>
<tbody>
<tr>
<td>• Data Volume Reduction</td>
<td>• CPU</td>
<td>• 10x-100x computing performance</td>
</tr>
<tr>
<td>• Compression</td>
<td>• FPGA</td>
<td>• Lower power (MIPS/watt)</td>
</tr>
<tr>
<td>• Calibration / Correction</td>
<td>• DSP</td>
<td>• Lower cost (commercial parts)</td>
</tr>
<tr>
<td>• Classification</td>
<td></td>
<td>• Radiation tolerant (not hardened)</td>
</tr>
<tr>
<td>• Product Generation</td>
<td></td>
<td>• Software upset mitigation</td>
</tr>
<tr>
<td>• Autonomy</td>
<td></td>
<td></td>
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<tr>
<td>• Event / Feature Detection</td>
<td></td>
<td></td>
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<tr>
<td>• Real-time / Direct Broadcast</td>
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</tbody>
</table>
On-Board Image Processing

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

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

<table>
<thead>
<tr>
<th>ISS Orbit</th>
<th>Days Up</th>
<th>Total SEUs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>157 days 2 hours</td>
<td>56.00</td>
</tr>
<tr>
<td>Avg SEUs/FPGA</td>
<td>14.00</td>
<td></td>
</tr>
<tr>
<td>Avg SEUs/FPGA/Day</td>
<td>0.09</td>
<td></td>
</tr>
<tr>
<td>Avg SEUs/FPGA/Week</td>
<td>0.62</td>
<td></td>
</tr>
<tr>
<td>Avg SEUs/FPGA/Year</td>
<td>32.55</td>
<td></td>
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</table>
On-Board Data Reduction

Accomplishments

SAR Nadir Altimetry Results (FY07)

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

Accomplishments

SAR Mapping Results (FY09)

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

SpaceCube Output

Difference < 1%
On-Board Products

- Classification
- Product Generation
- Event Detection
HyspIRI Demonstration Testbed

HyspIRI SpaceCube IPM Testbed

- VSWIR Simulator: 816 Mbps
- TIR Simulator: 210 Mbps
- X-Band D/L Simulator: 15 Mbps

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

Spacecube 2.0 Development System

Cloud Classifier
SpaceCube 2.0 Block Diagram

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

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

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

GODDARD SPACE FLIGHT CENTER
# Processor Comparison

<table>
<thead>
<tr>
<th></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>20^2</td>
</tr>
<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)