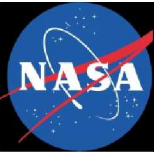


# Advanced Hybrid On-Board Science Data Processor - SpaceCube 2.0

ESTO Earth Science Technology Forum  
June 23, 2010

Tom Flatley – Branch Head  
NASA/GSFC Science Data Processing Branch



# On-Board Science Data Processing

## ESDS On-Board Processing

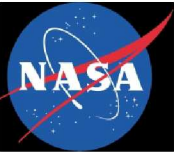
- Data Volume Reduction
- Compression
- Calibration / Correction
- Classification
- Product Generation
- Autonomy
- Event / Feature Detection
- Real-time / Direct Broadcast

## 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



STS-125 Payload Bay

## Long Range Camera on Rendezvous

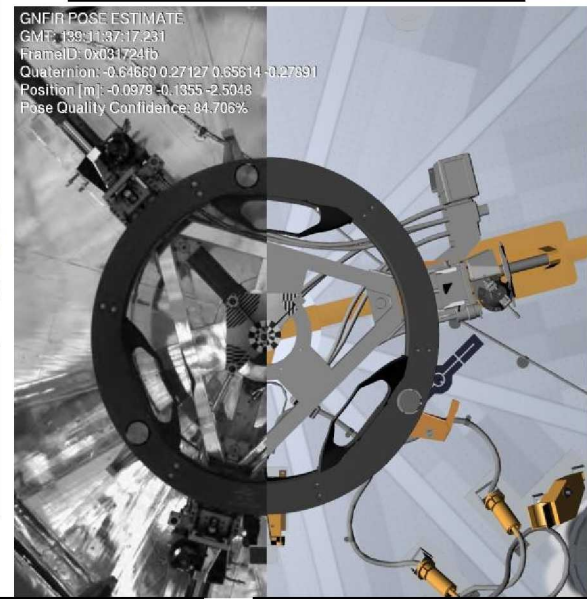


Flight Image

RNS Tracking Solution

GNFIR POSE ESTIMATE  
 GMT: 133:16:28:43.757  
 Frame ID: 0x73F13002  
 Quaternion: 0.72654, -0.67387, 0.03428, 0.12983  
 Position (meters): 1.4498, 7.8250, -81.4431  
 Pose Quality Confidence: 88.235%

## Short Range Camera on Deploy



Flight Image

RNS Tracking Solution

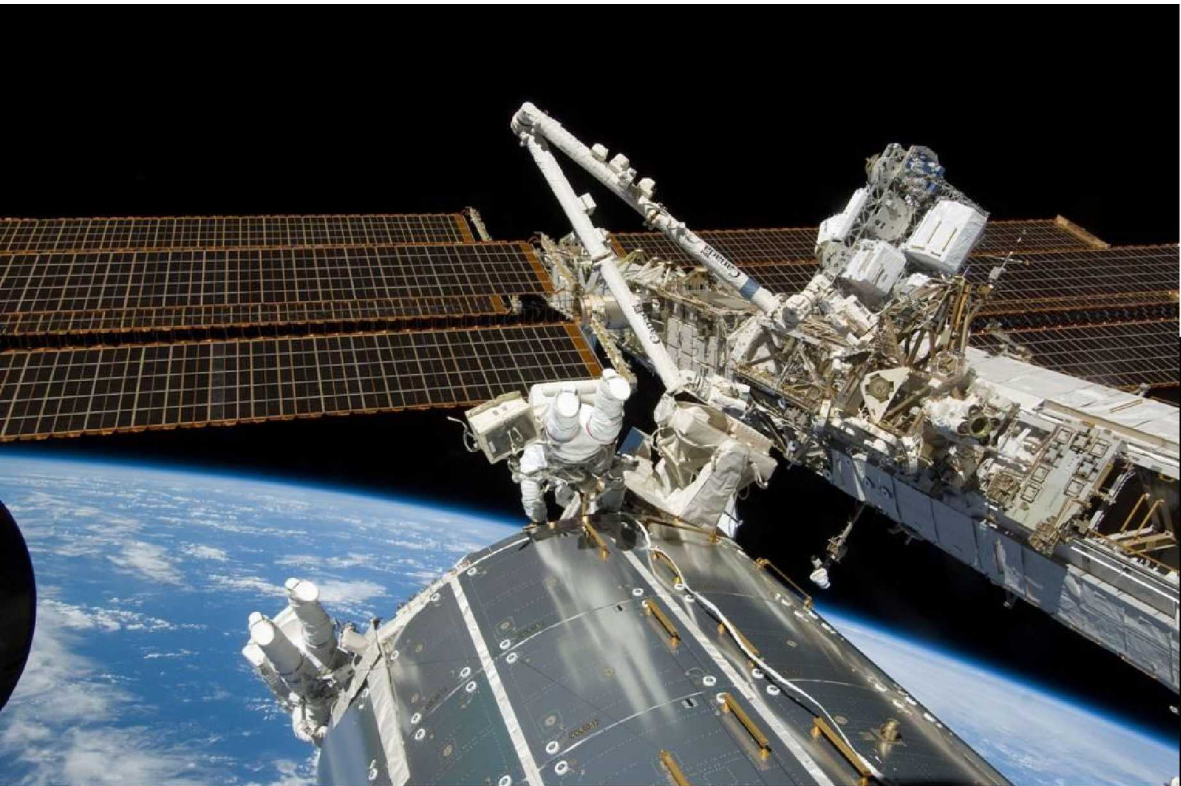
GNFIR POSE ESTIMATE  
 GMT: 139:11:37:17.231  
 Frame ID: 0x031724fb  
 Quaternion: -0.64660 0.27127 0.65614 -0.27691  
 Position [m]: -0.0979 -0.1355 -2.5048  
 Pose Quality Confidence: 84.706%

GSFC SpaceCube 1.0a - Hubble SM 4 (May 2009):

- Autonomous Rendezvous and Docking Experiment
- Hosted camera AGC and two Pose algorithms

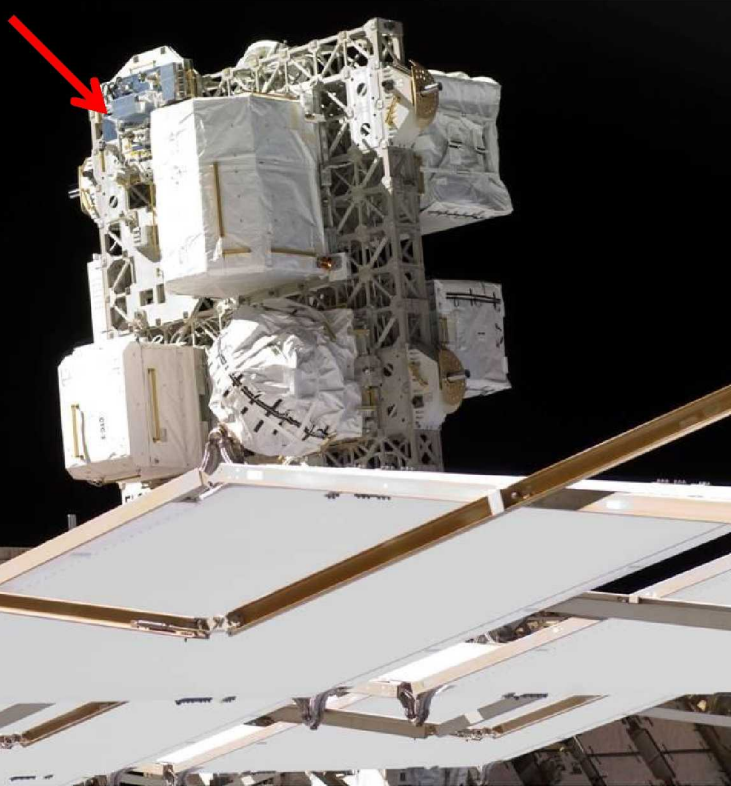


# Software Upset Mitigation

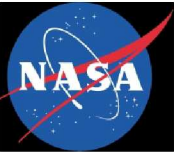


GSFC SpaceCube 1.0b (Nov 2009):

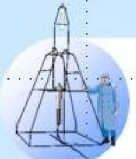
- “Radiation Hardened by Software” Experiment
- Autonomous Landing Application
- Collaboration with NRL



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

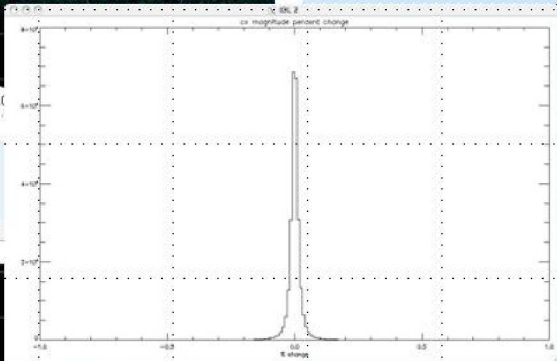
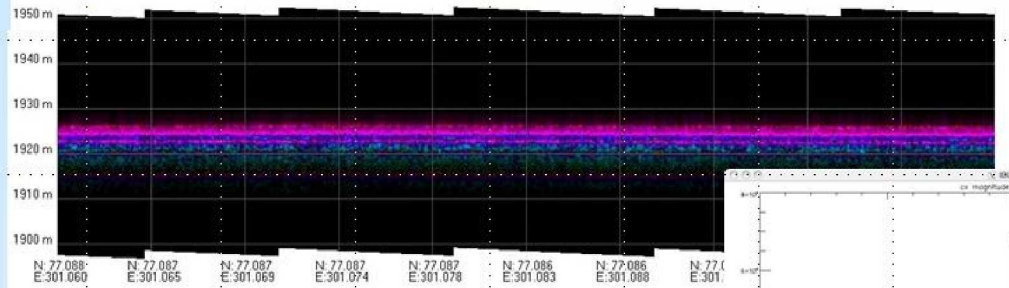


# On-Board Data Reduction

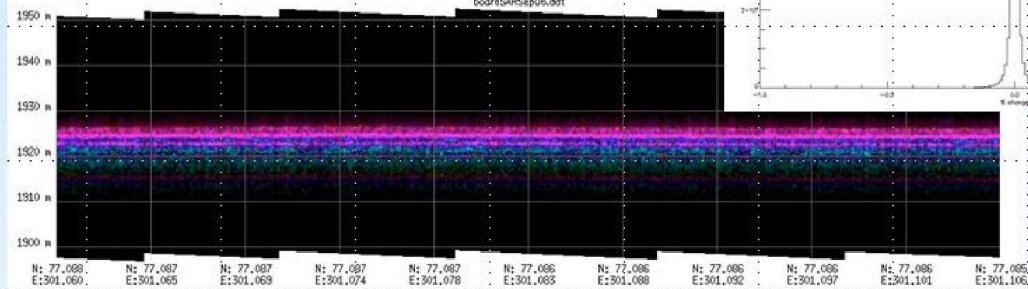


## Accomplishments

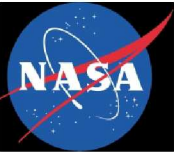
SAR Nadir Altimetry Results (FY07)



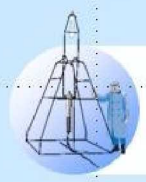
Difference < 0.1%



*On-board processing yields lossless 6:1 data volume reduction*

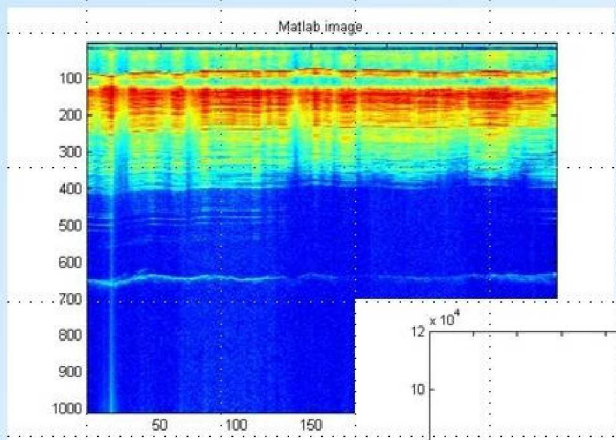


# On-Board Data Reduction



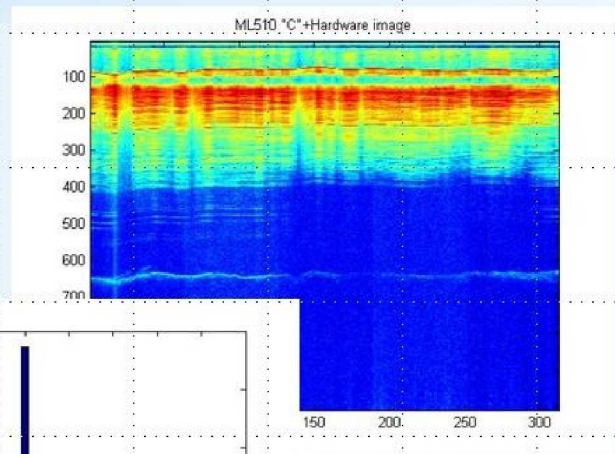
## Accomplishments

### SAR Mapping Results (FY09)



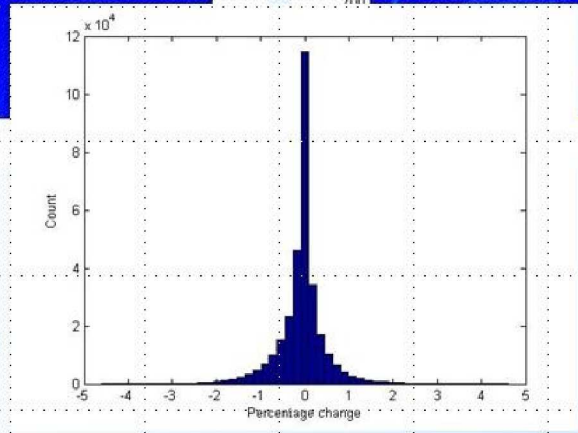
Original Matlab Output

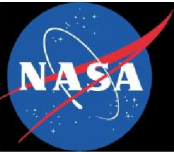
*On-board product generation yields factor of 165x data volume reduction*



SpaceCube Output

Difference < 1%





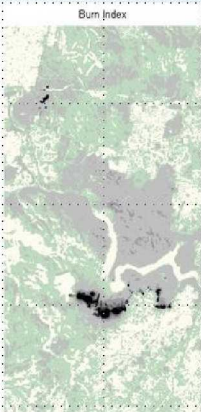
# On-Board Products



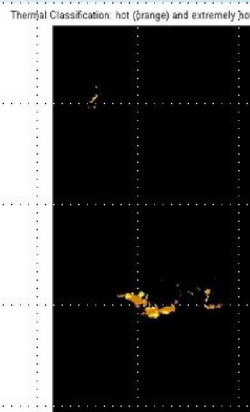
## Accomplishments



California2007Oct123-bands33-43-155.jpg



Burn Index



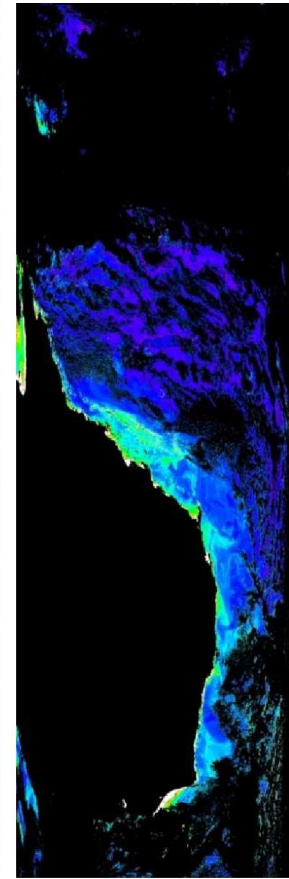
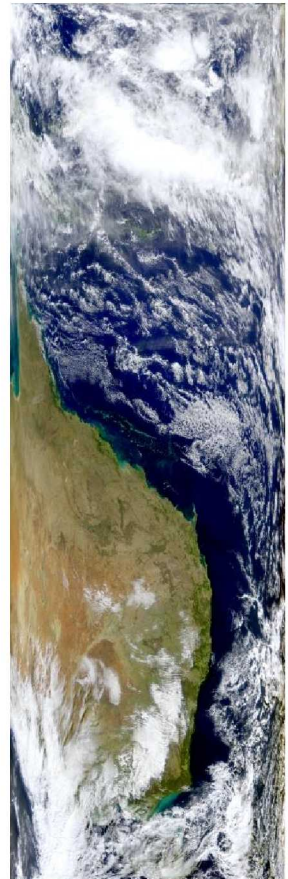
Thermal Classification: hot (orange) and extremely hot (yellow)

### On-Board Products

NASA GODDARD SPACE FLIGHT CENTER



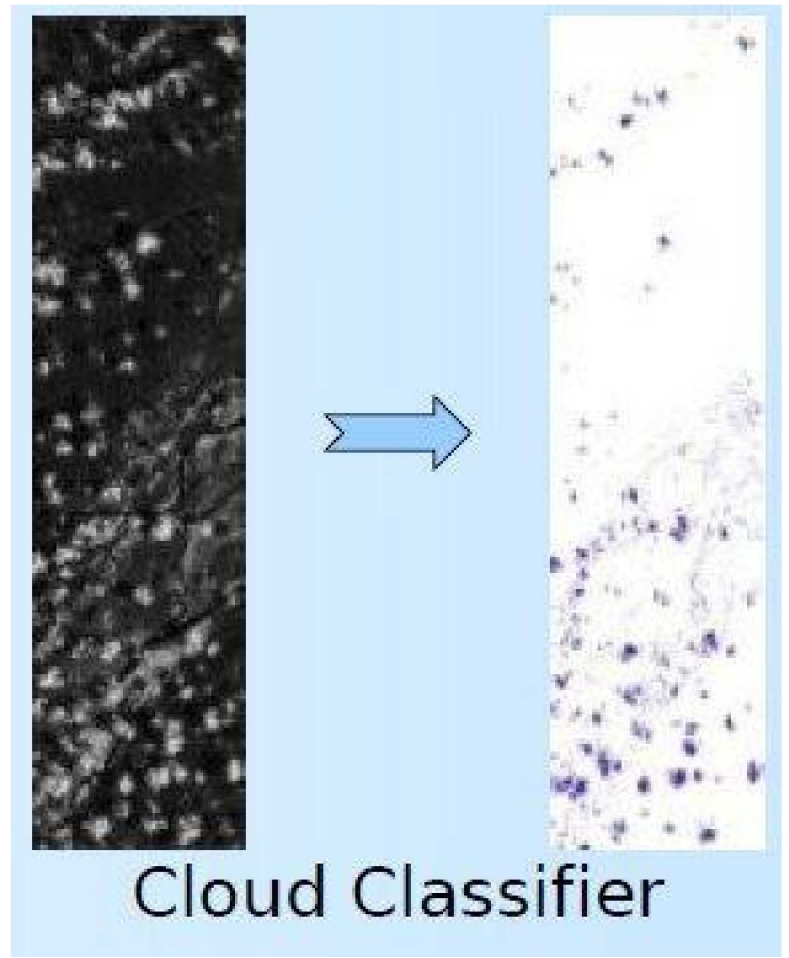
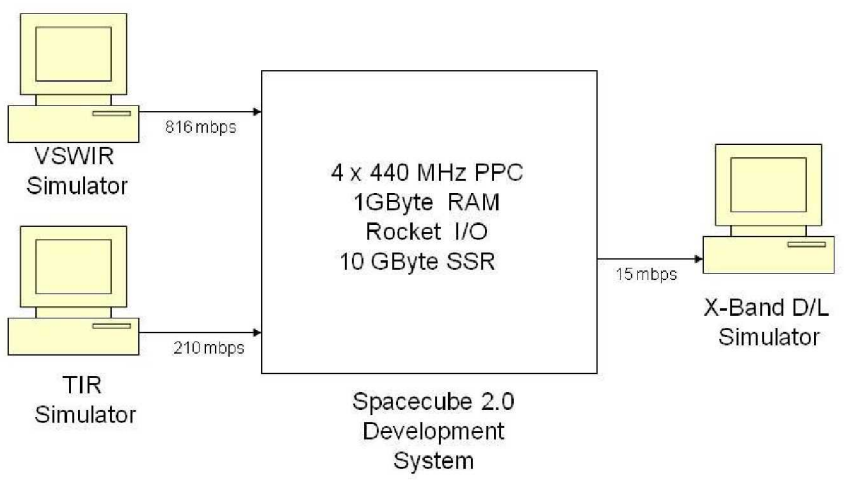
- Classification
- Product Generation
- Event Detection





# HyspIRI Demonstration Testbed

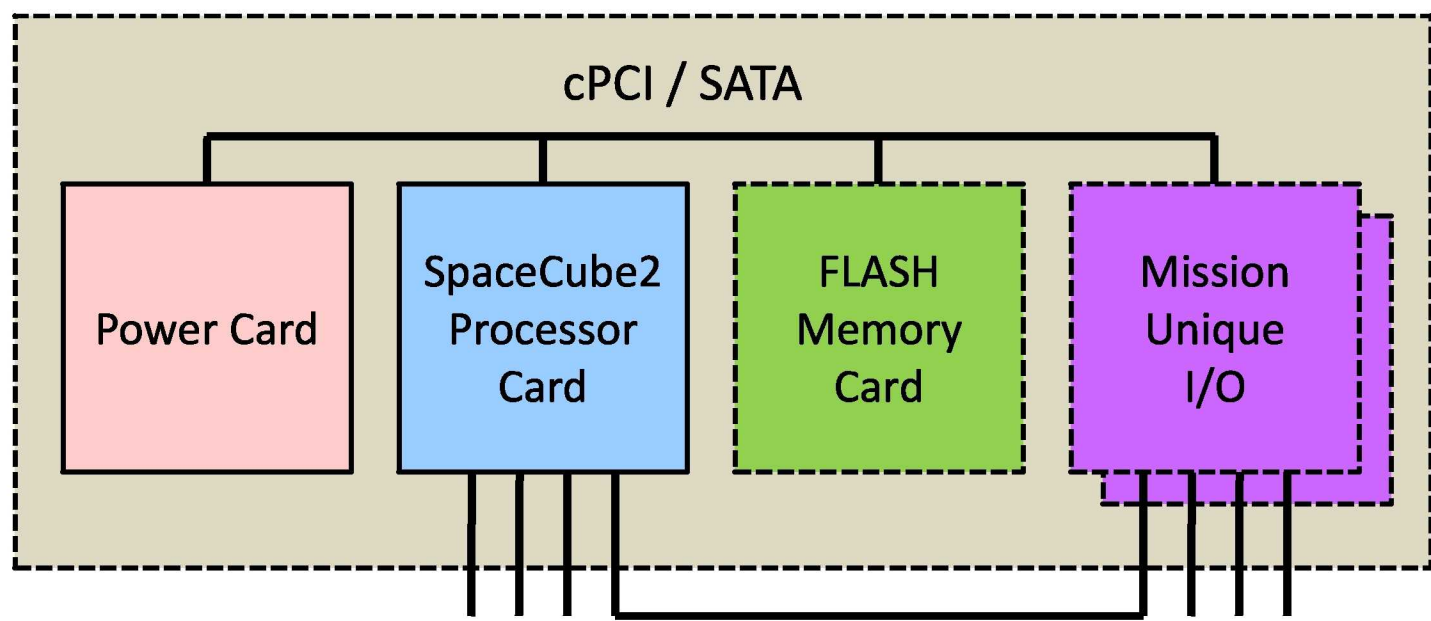
## HyspIRI SpaceCube IPM Testbed





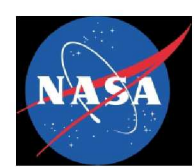


# SpaceCube 2.0 Block Diagram



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



# Processor Comparison

	<b>MIPS</b>	<b>Power</b>	<b>MIPS/ W</b>
<b>MIL-STD-1750A</b>	3	15W	0.2
<b>RAD6000</b>	35	10-20W	2.33 <sup>1</sup>
<b>RAD750</b>	300	10-20W	20 <sup>2</sup>
<b>SPARC V8</b>	86	1W <sup>3</sup>	86 <sup>3</sup>
<b>LEON 3FT</b>	60	3-5W <sup>3</sup>	15 <sup>3</sup>
<b>GSFC SpaceCube 1.0</b>	3000	5-15W	400 <sup>4</sup>
<b>GSFC SpaceCube 2.0</b>	5000	10-20W	500 <sup>5</sup>

**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)