



SpaceCube On-Board Science Data Processing

**AGU Fall Meeting
December 16, 2010**

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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

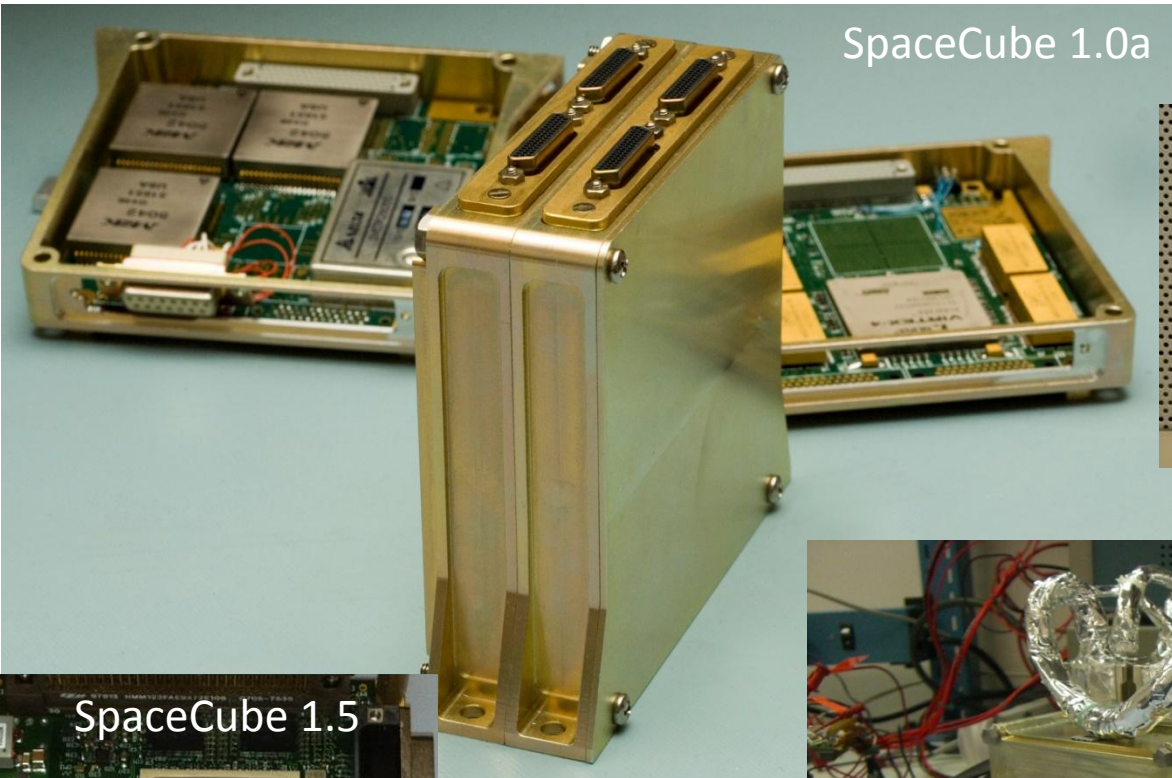


SpaceCube Family Overview

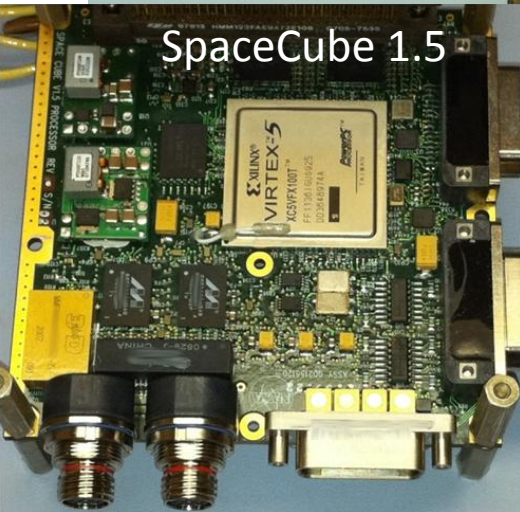
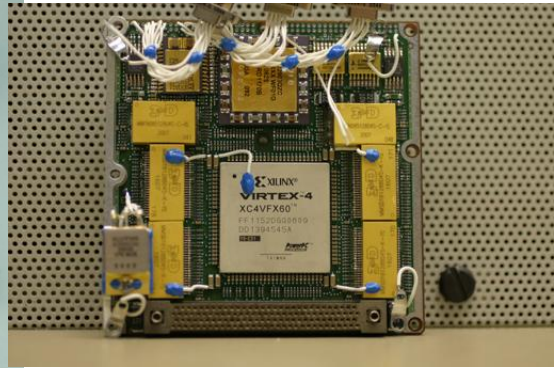
Unit	Mission	Notes	Specs	Stats	Status
SpaceCube 1.0a	Hubble Servicing Mission 4	Relative Navigation Sensors Experiment STS-125 May 2009	4"x4" card (2) Virtex4	Size: 5"x5"x7" Wt: 7.5 lbs Pwr: 37W	2009 Flight
SpaceCube 1.0b	MISSE-7 (ISS)	added RS-485, RHBS, STS-129 Nov 2009	4"x4" card (2) Virtex4	Size: 5"x5"x7" Wt: 7.5 lbs Pwr: 32W	In Flight
SpaceCube 1.0c	DEXTRE Pointing Package (ISS)	Original RNS unit, w/added 1553 & Ethernet	4"x4" card (2) Virtex4	Size: 5"x5"x7" Wt: 7.5 lbs Pwr: 40W	Final stages of Implementation
SpaceCube 1.5	SMART (DoD/ORS)	adds GigE & SATA, commercial parts, sounding rocket flight	4"x4" card (1) Virtex5	Size: 5"x5"x4" Wt: 4 lbs Pwr: < 20W	
SpaceCube 2.0	Earth/Space Science Exploration missions	Std 3U form factor, GigE, SATA, Spacewire, cPCI	4"x6" card (2) Virtex5 (1) SIRF	Size: 5"x5"x7" Wt: < 10 lbs Pwr: 20-40W	Under Development
SpaceCube 2.0 Mini	CubeSats, Sounding Rocket, UAV	"Mini" version of SpaceCube 2.0, CubeSat form factor	2.5"x2.5" card (1) Virtex5/SIRF	Size: 3.5"x3.5"x3.5" Wt: 3 lbs Pwr: <10W	



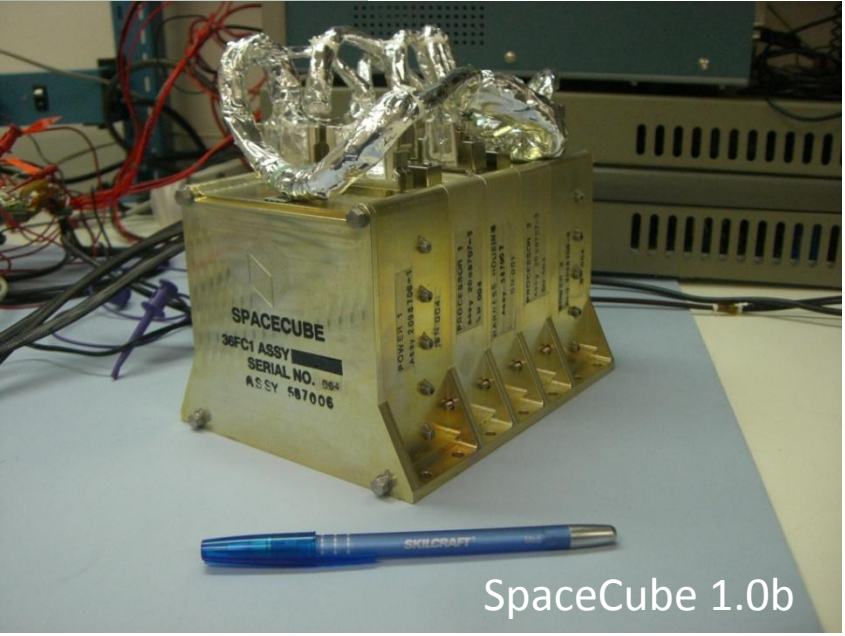
Current SpaceCube Systems



SpaceCube 1.0a



SpaceCube 1.5



SpaceCube 1.0b



Processor Comparison

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

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)



On-Board Image Processing



STS-125 Payload Bay

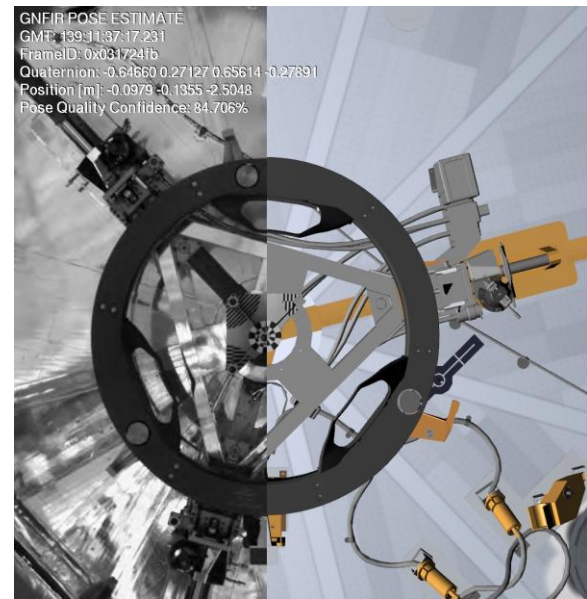
Long Range Camera on Rendezvous



Flight Image

RNS Tracking Solution

Short Range Camera on Deploy



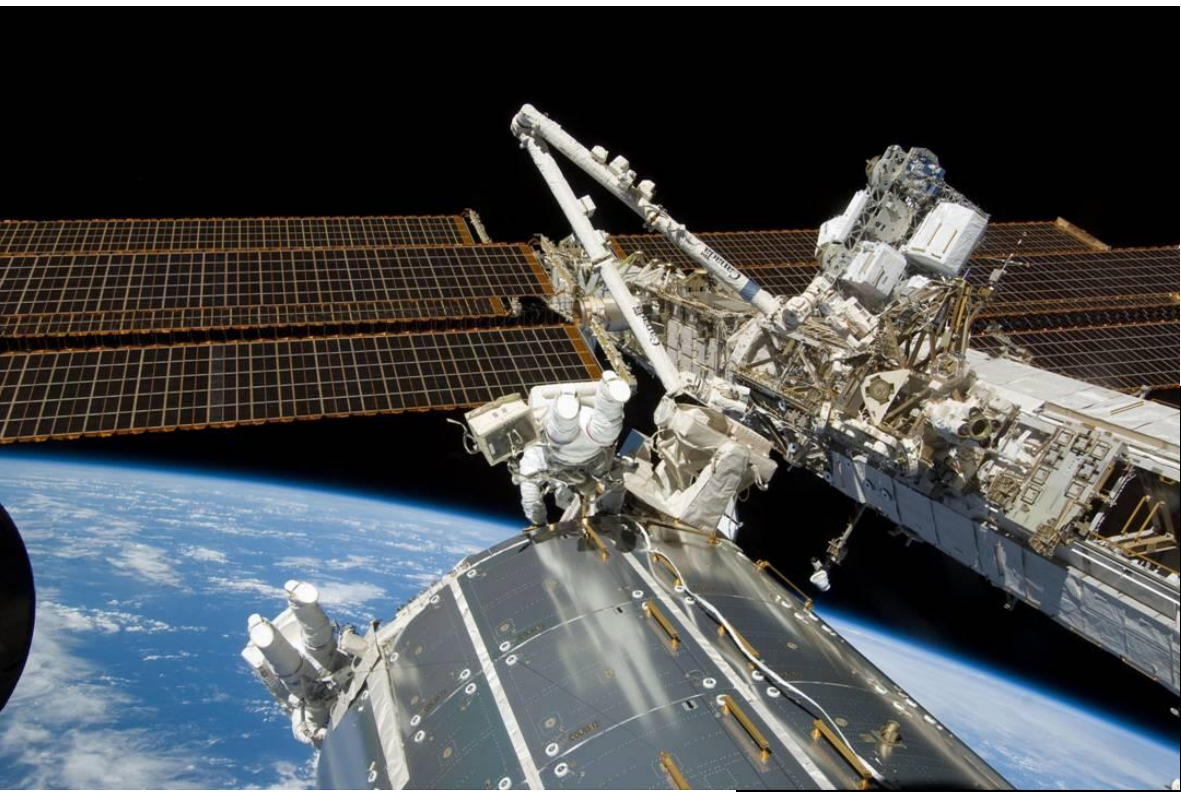
Flight Image

RNS Tracking Solution

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

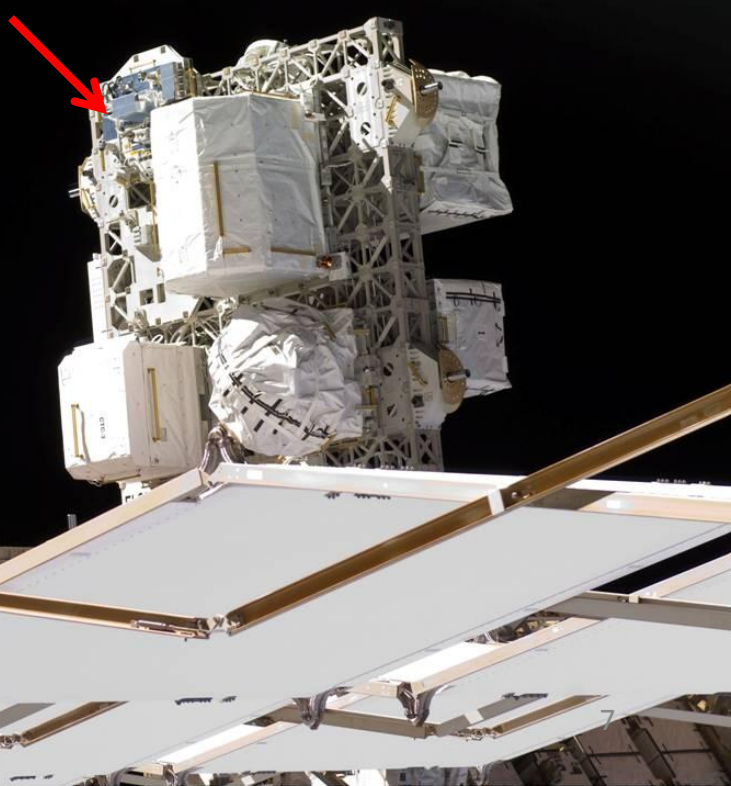


Software Upset Mitigation



GSFC SpaceCube 1.0b (Nov 2009)

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



Orbit	ISS
Days Up	340 days
Total SEUs	95
Avg SEUs/FPGA/Year	25.5
Functional Errors	0



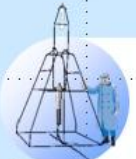
On-Orbit Upset Locations



©2010 Google - Imagery ©2010 NASA, Map data ©2010 AND, Geocentre Consulting, MapData Sciences Pty Ltd

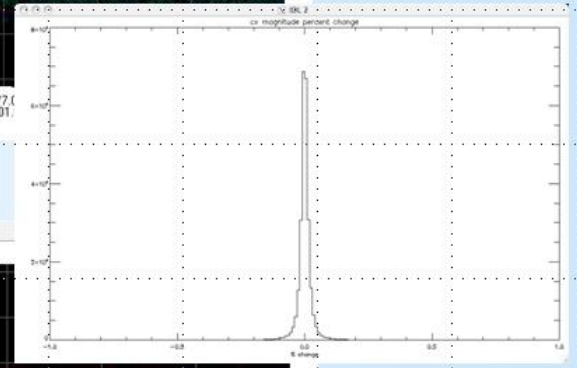
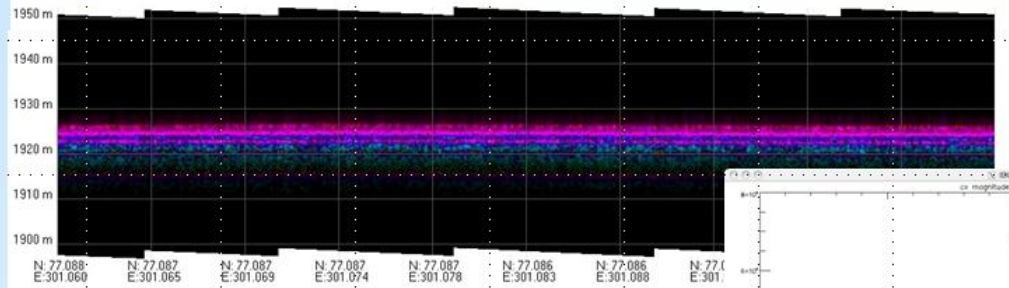


On-Board Data Reduction

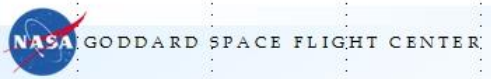
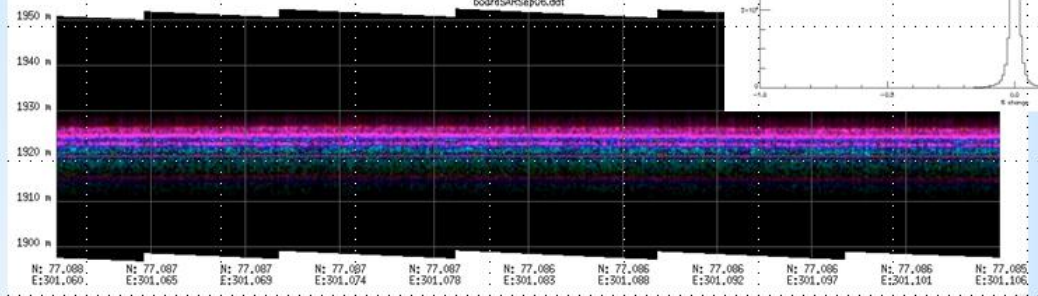


Accomplishments

SAR Nadir
Altimetry
Results (FY07)



Difference < 0.1%



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

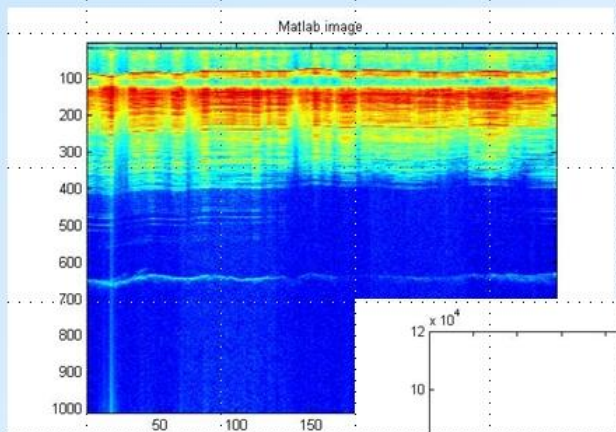


On-Board Data Reduction



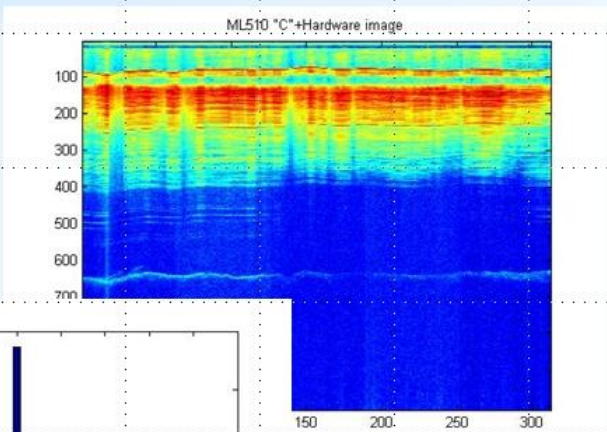
Accomplishments

SAR Mapping Results (FY09)



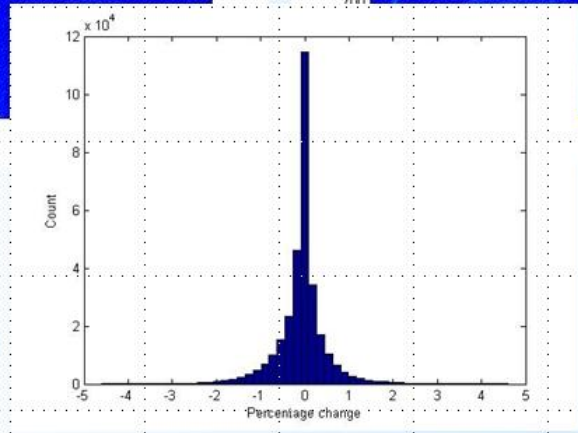
Original Matlab Output

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



SpaceCube Output

Difference < 1%





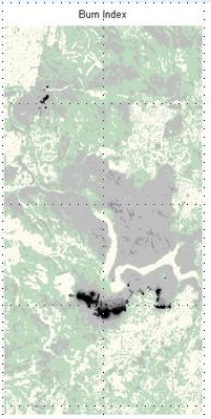
On-Board Products



Accomplishments



California2007Oct23-bands33-43-155.jpg



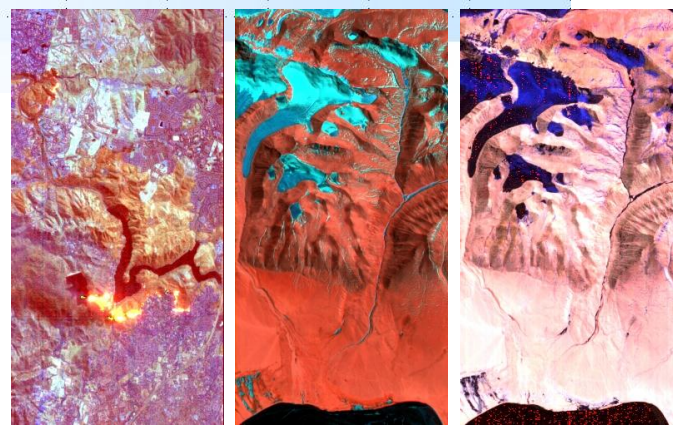
Burn Index



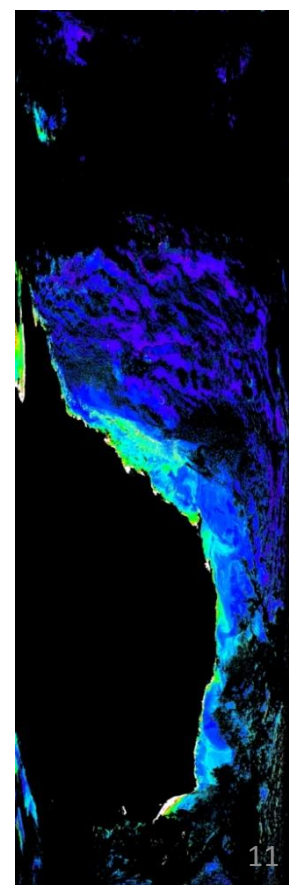
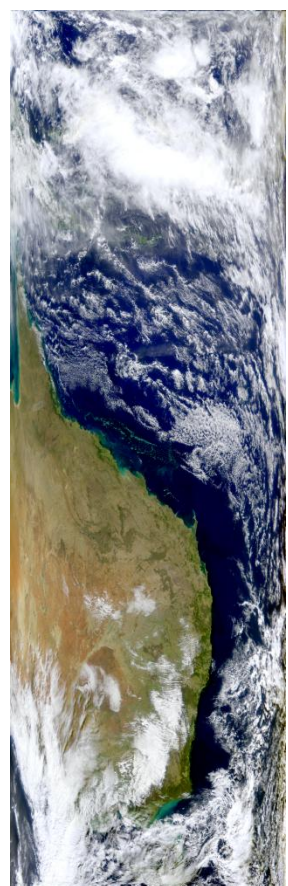
Thermal Classification: hot (orange) and extremely hot (yellow)

On-Board Products

NASA GODDARD SPACE FLIGHT CENTER



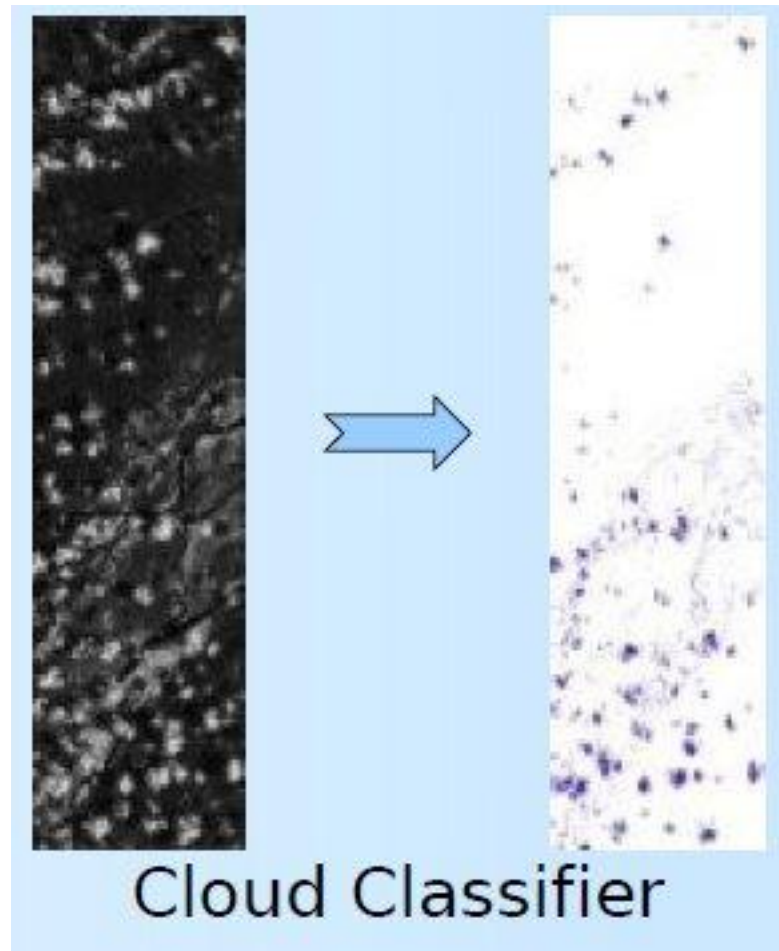
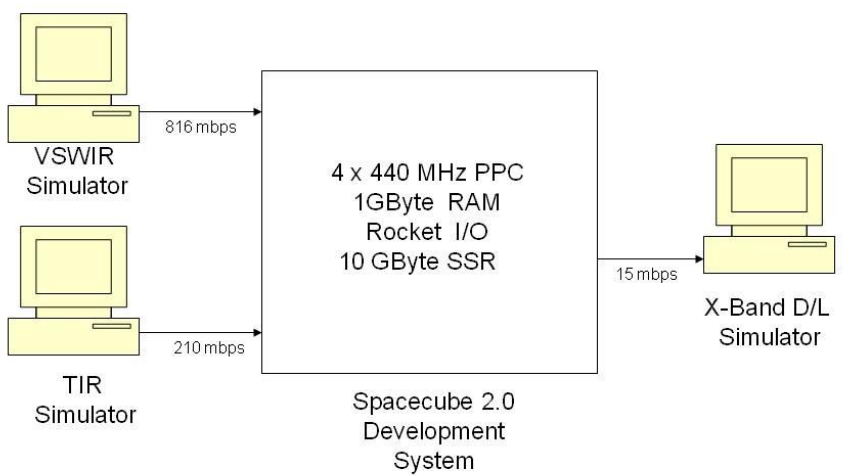
- Classification
- Product Generation
- Event Detection





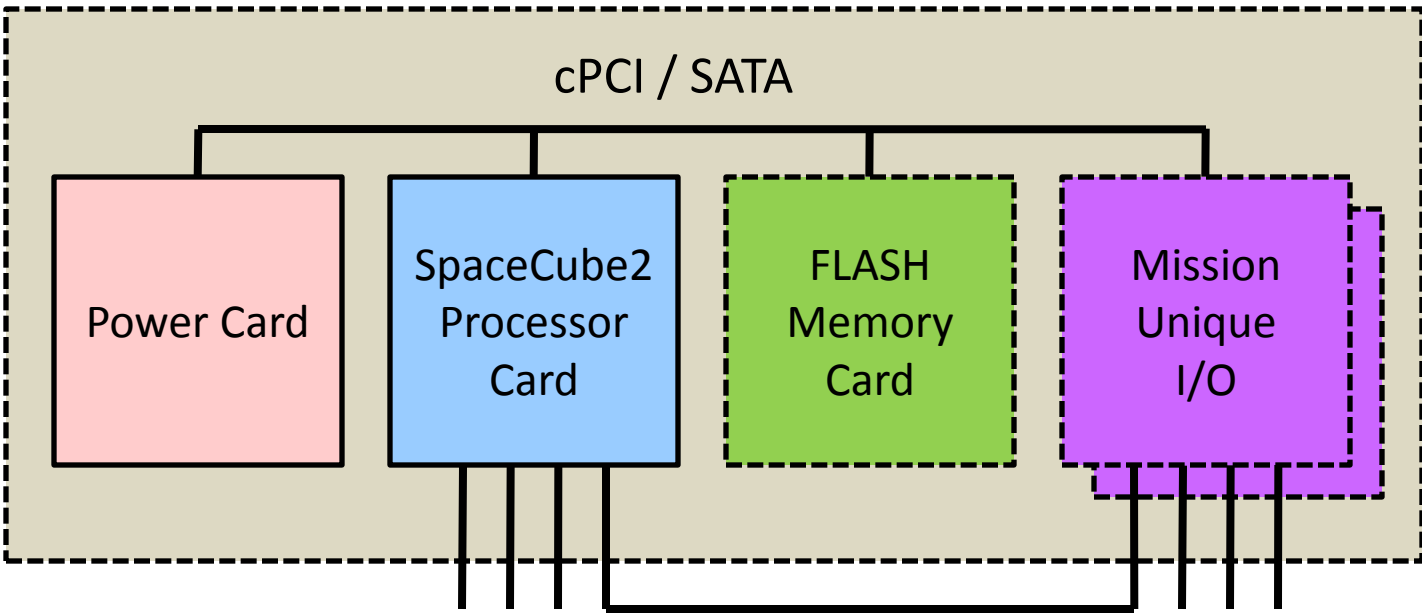
HyspIRI Demonstration Testbed

HyspIRI SpaceCube IPM Testbed





SpaceCube 2.0 Block Diagram

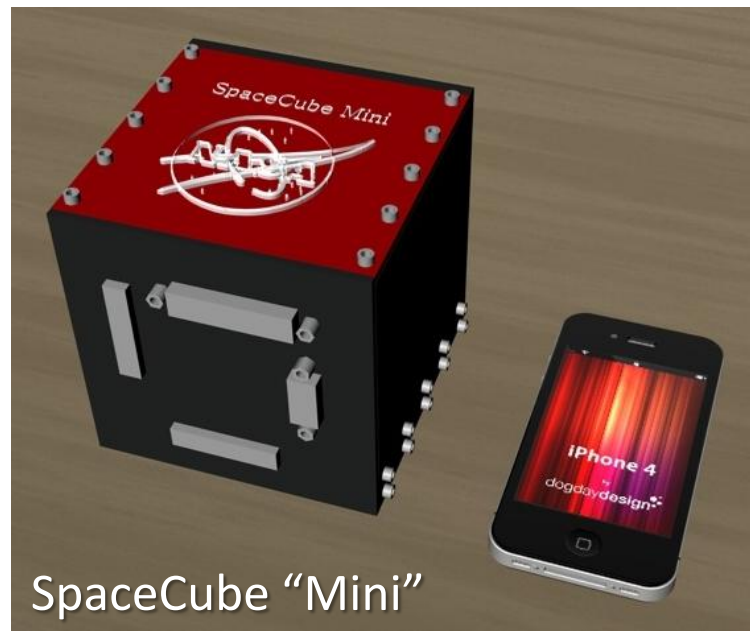
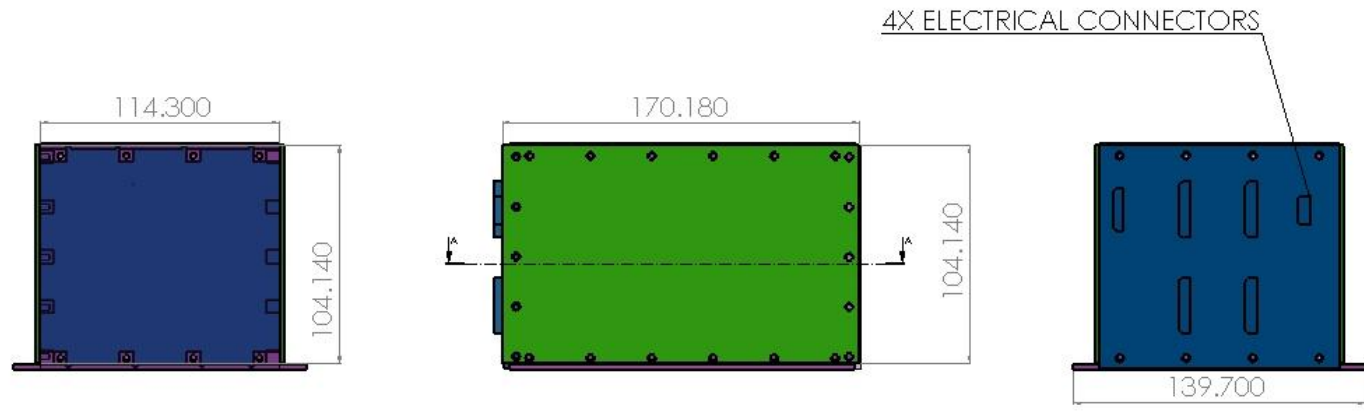


Spacewire / LVDS / MGT / GigE / Mission Unique High-speed

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



Coming Soon ...



SpaceCube 2.0

