HyspIRI Intelligent Payload Module(IPM) and Benchmarking Algorithms for Upload

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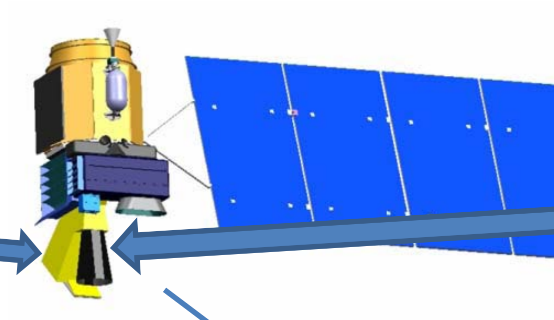
5-4-10

HyspIRI Science Symposium on

Ecosystem Data Products

HyspIRI Low Latency Data Production Concept

130.2 Mbps
Multispectral
Thermal InfraRed
(TIR) Scanner

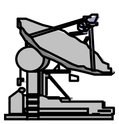


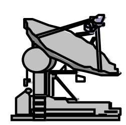
804 Mbps
Hyperspectral Visible
ShortWave InfraRed
(VSWIR) Imaging
Spectrometer

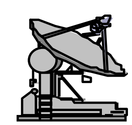
Spectral
Bands (8) 3.98 µm, 7.35 µm, 8.28 µm, 8.63 µm, 9.07 µm, 10.53 µm, 11.33 µm, 12.05
Spatial
IFOV 60 m
Range 600 km (25.3 at 626 km)

Direct
Broadcast

Spectral
Range 380 to 2500 nm
10 nm bands
Spatial
Range ~146 km
(13.2 deg. at 626km)
Cross-Track Samples >2560
Sampling 60 m



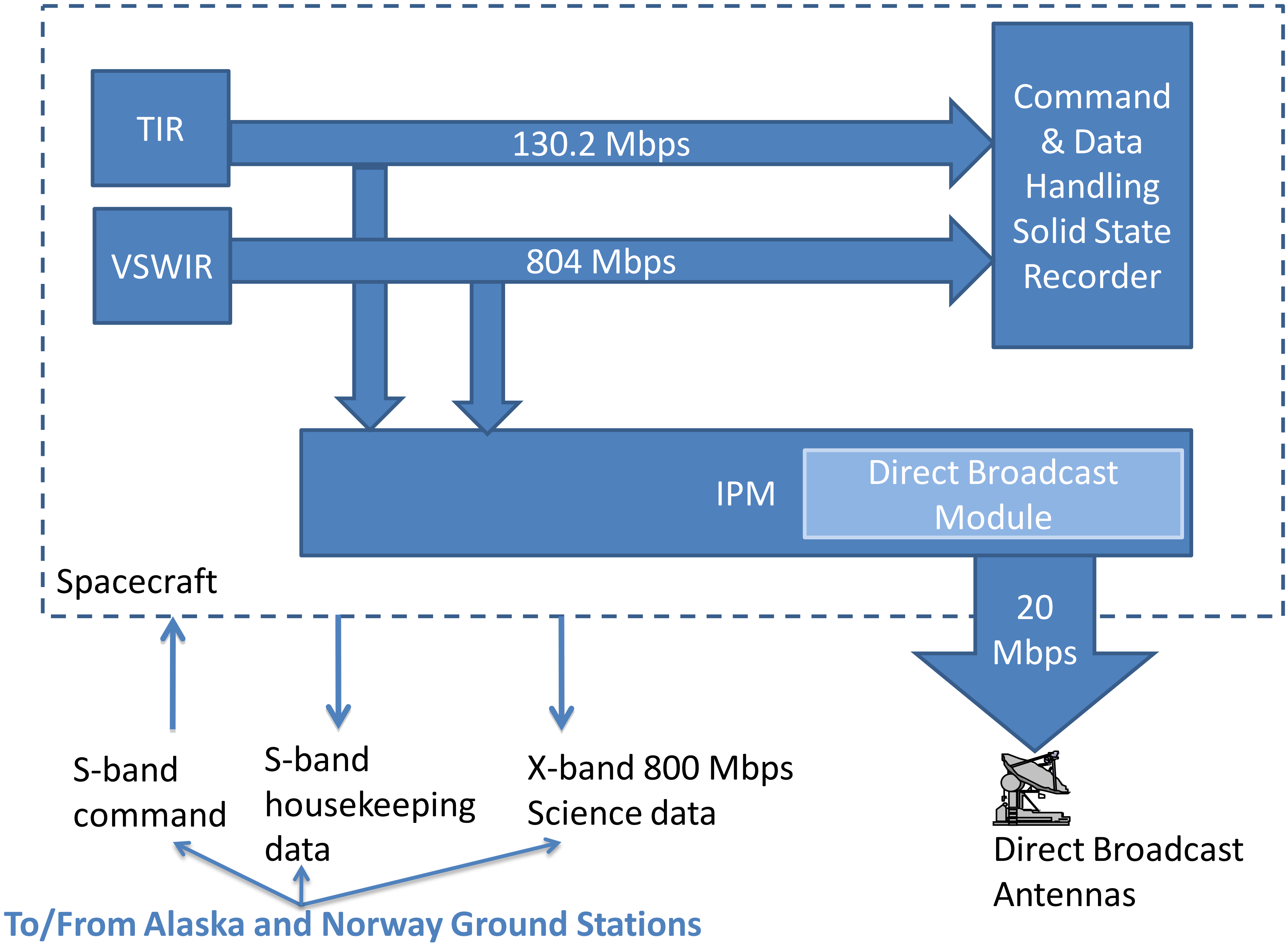




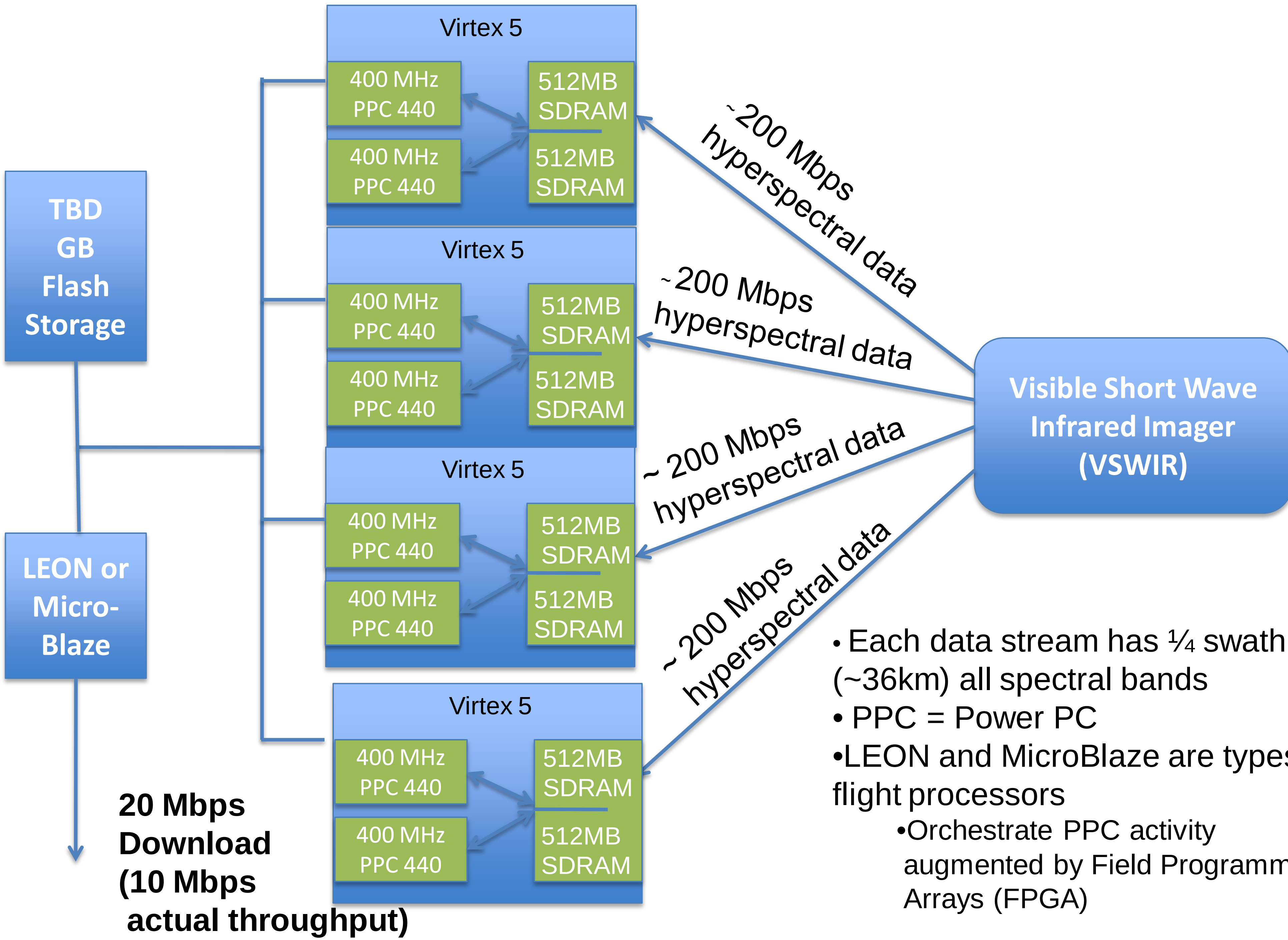
20 MBPS Direct Broadcast
(Net downlink throughput – 10 Mbps)
Downlink:
- Select Spectral Bands
- Select L-2 Products

Continuous Earth-view Broadcast

HyspIRI Data Flow



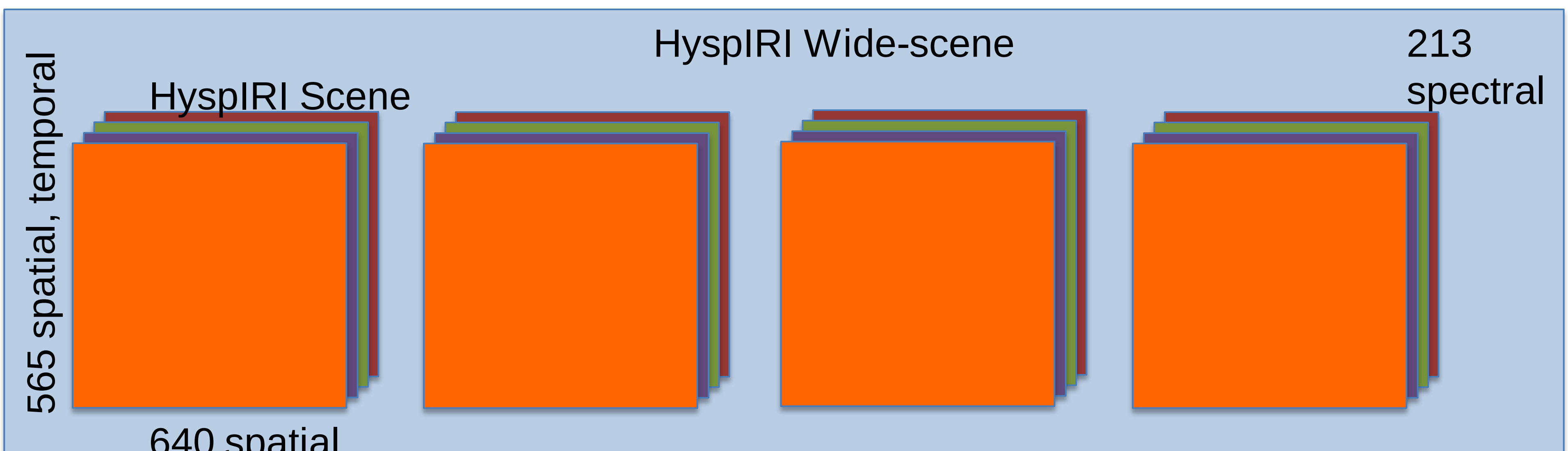
HyspIRI VSWIR Data Processing Architecture Only



- Each data stream has ¼ swath (~36km) all spectral bands
- PPC = Power PC
- LEON and MicroBlaze are types of flight processors
    - Orchestrate PPC activity augmented by Field Programmable Arrays (FPGA)

Testbed Approach for HyspIRI IPM VSWIR Processing

- 5 seconds of HyspIRI data captured at a time by PPC processors - 38 km x 34 km (640 pixels x 565 pixels x 213 bands)
    - Flight software will process 4 quarter swath HyspIRI Scenes in parallel
    - Migrate band stripping to FPGA's later
    - Each PPC processor will ping pong HyspIRI scenes, processing one scene while the next is flowing into memory
- Each 5 second scene will require 616 MB memory
- Scenes will be stored in memory in band sequential order in an array of words



Low Fidelity HyspIRI IPM Testbed

Features

- Hardware
  - Xilinx Virtex-5 (SpaceCube 2)
  - 2 x 400MHz PPC
  - 100MHz Bus
  - 2 x 512MB SDRAM
  - Dual Gigabit Ethernet
- Support Linux kernel 2.6.31 (gcc version 4.2.2)
- Support software running in standalone mode for better performance
- Can stream raw data up to 800 Mbps
- Ready for operations

Software Application Examples

- Band-stripping
- Algorithms: cloud, sulfur, flood, thermal, SWIL, NDVI, NDWI, SIWI, oil spills, algae blooms, etc.
- Corrections: geometric, radiometric, atmospheric
- Core Flight System / dynamic software bus
- CCSDS File Delivery Protocol
- Delay Tolerant Network
- CASPER / onboard planning
- Fault monitoring / recovery software
- S/C command and telemetry software
- Data compression
- Sensor Web for Autonomous Mission Operations

Low Fidelity HyspIRI IPM Testbed

Data Generator Workstation

- Generates test data and streams it to the board at rate up to 800Mbps.

NETGEAR Gigabit Switch

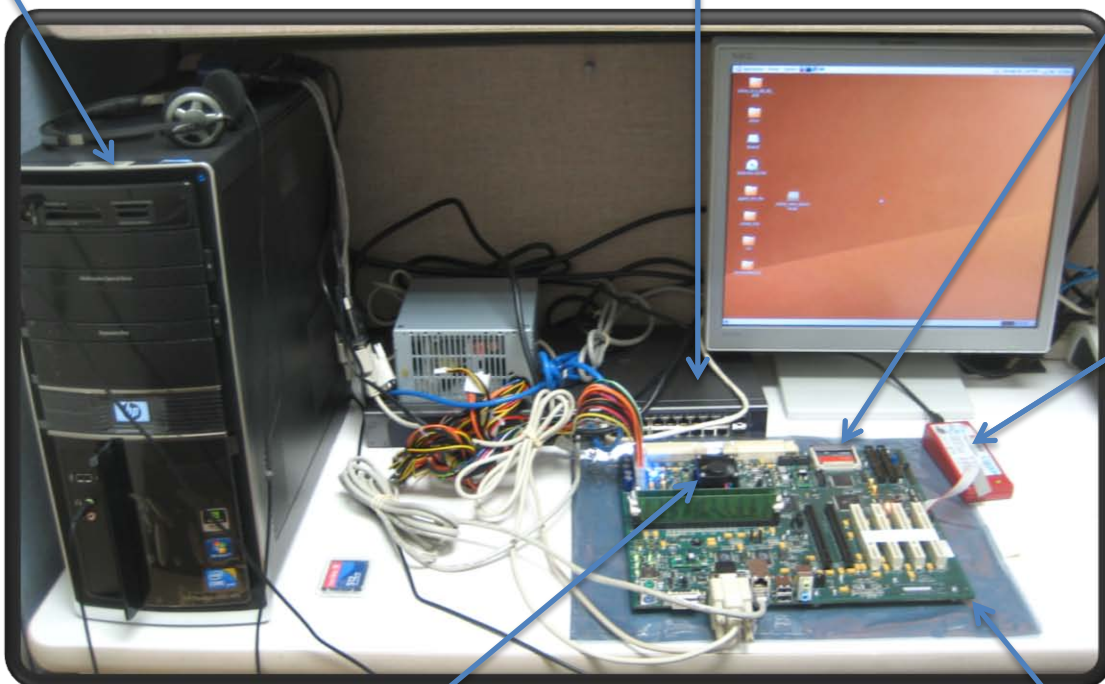
- Allows the board and the data generator workstation to connect at Gigabit speed.

Compact Flash

- Ext3 formatted file system with Linux libraries and tools

Platform Cable USB

- Provides an easy method for debugging software running on the board



Virtex-5 FPGA

- SpaceCube 2 core FPGA
- Configured as dual 400MHz PPC design
- Capable of running with Linux or in a standalone mode

Xilinx ML510 Development Board

- Enables the development team to verify the Virtex-5 while the SpaceCube 2 is finalizing the design

Initial Benchmark Results

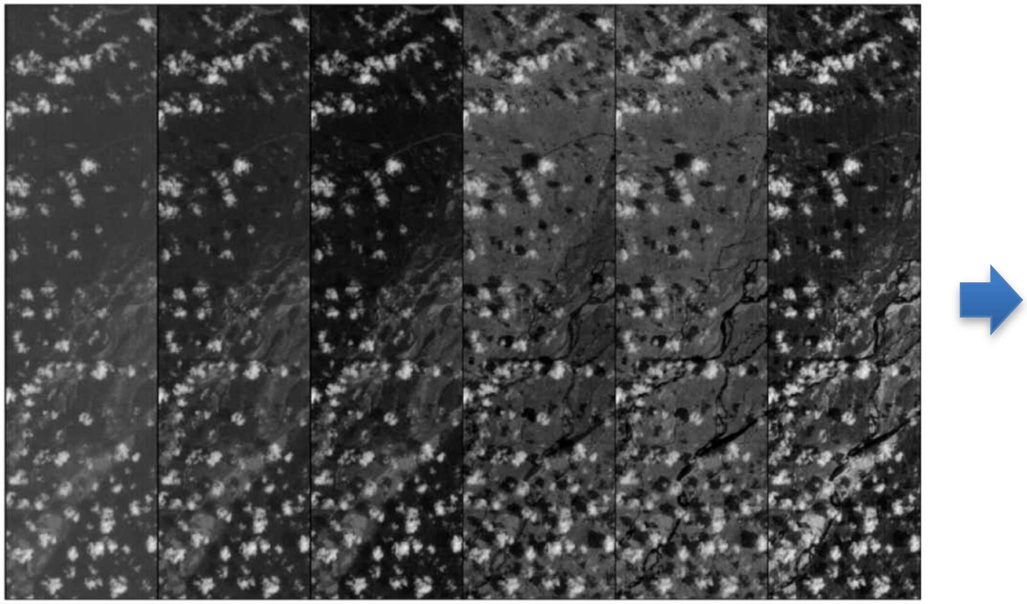
32-bit Memory Test	Write (ms)	Read + Verify (ms)
128MB	711	1179
256MB	1564	2365
512MB	2942	4731
1024MB	6673	10670

Not Optimized!
FPGA not leveraged

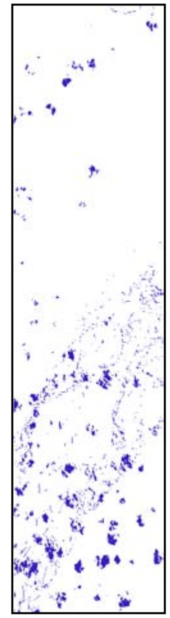
Algorithms	Linux (ms)	Standalone (ms)	Linux (ms)	Standalone (ms)
	EO1 scene (256 x 1000 pixels)		HyspIRI ¼ swath (640 x 565 pixels)	
Cloud	1791	431	2170	589
Flood	3024	937	3782	1311
SWIL	7350	2872	10226	4058
Sulfur	116362	29515	164978	42026
Thermal	1103	304	1475	431
SIWI	580	44	823	62
NDVI	630	44	904	62
NDWI	589	44	836	62

Disclaimer: Code not optimized. Performance based on a 400MHz PPC design.

Other CPU IPM Processor Benchmarks



bands (21, 31, 51, 110, 123, 150 }



Cloud benchmark
pixels detected
as a cloud in blue

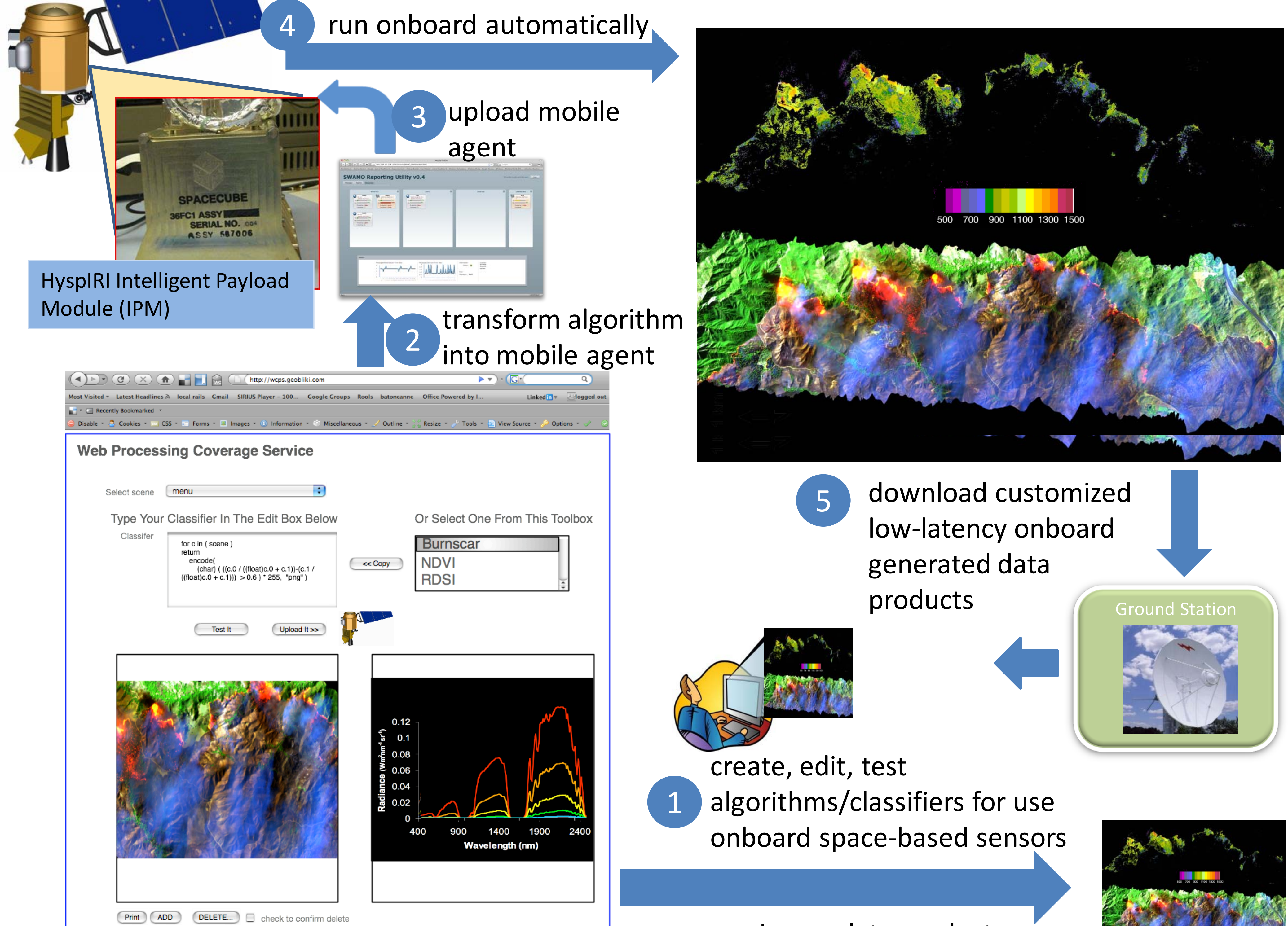
GSFC Benchmark	MHz	Thermal CPU%	Cloud CPU%
Aeroflex LEON3	75	80	110
BAE RAD750	133	50	80
Xilinx PPC 440	440	20	30

JPL Benchmark	MHz	Thermal CPU%	Cloud CPU%	Flood CPU%	SWIL SVM CPU%	SULPHUR SVM CPU%
Mongoose V	12	tbd				
Atmel LEON2	100	597	684	823	1784	14935
RAD750	200	294	383	441	1030	4856
GESPEC	150	166	190	230	520	2202
PPC 440	440	156	181	299	966	23223
GESPEC	500	120	156	180	421	1985

- Benchmark numbers need reconciliation to understand differences
- More sophisticated algorithms will clearly require FPGA acceleration

Vision for Development of IPM Process Chain

Processes	Ground	Flight
Level 0	Yes	-
Level 1R	Yes	-
Atmospheric Correction	Automation in progress	-
Dynamic Algorithms	JPL WCPS/SWAMO	In Testbed
Geometric Correction	L1G	-
Compression	CCSDS	Card Available
Downlink	N/A	-



One Possible HyspIRI IPM Ops Concept

Image data products-
Phil Dennison 2008