HyspIRI Mission Concept

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HyspIRI Mission Concept

Orbit Selection

- Key Orbit Design Considerations
  - Local time of observations
    - Sun-synchronous
    - 11:00 +/- 30 minutes (descending node)
  - Altitude
    - Low Earth Orbit
    - Repeating Ground track
  - Global coverage in a minimum number of days given the swath-width of each instrument.
    - VSWIR: 19 days revisit at the equator
    - TIR: 5 day revisit at the equator (1 day + 1 night)
- 626 km altitude at equator suits the needs of both instruments

Orbit selection and operations concept meet science requirements with very infrequent ground commanding or maintenance.

Operations Concept

- Systematic mapping vs. pointing capability
- Target map driven - No need for uploading acquisition sequences
- High resolution mode and Low resolution mode
- Direct Broadcast capability
  - Uses Intelligent Payload Module
  - Applications-driven

Operational Requirement	VSWIR	TIR
11 am +/- 30 min. sun-sync orbit	✓	✓
626 km altitude at equator	✓	✓
19 days revisit at the equator	✓	
5 day revisit at the equator		✓
Day Observation	✓	✓
Night Observation		✓
Pointing strategy to minimize sun glint	✓	
Surface reflectance in the solar reflected spectrum for elevation angles >20	✓	
Avoid terrestrial hot spot	✓	
Monthly Lunar View calibration	✓	✓
Weekly Solar View Calibration	✓	
Blackbody View Calibration		✓
Deep Space View Calibration		✓

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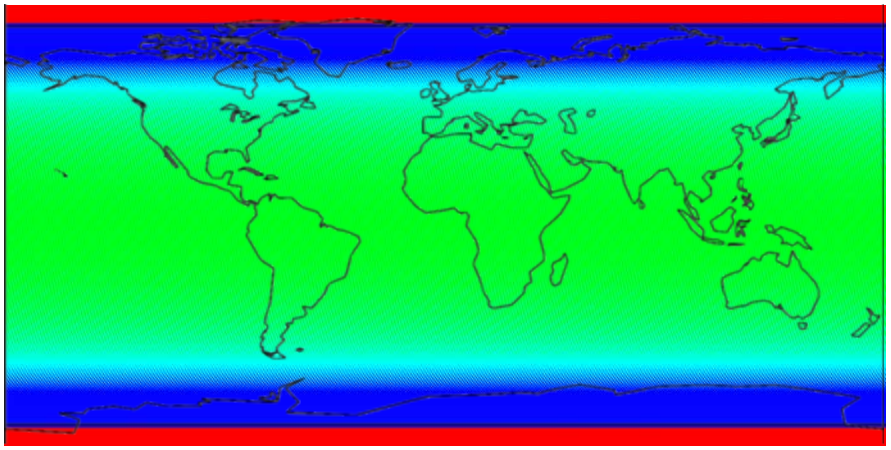
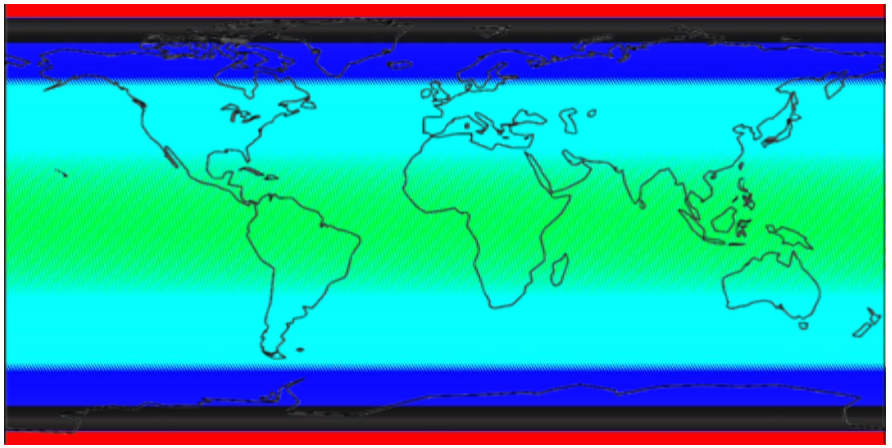
Complete Equatorial Coverage

Number of daytime VSWIR access (no nighttime)



- Number of daytime TIR access (nighttime is identical)



Revisit Requirement	VSWIR	TIR
Not Met	0	< 4
Met	1	4
Met, exceeded up to 2 times	2	4 to 8
Met, exceeded 2 to 4 times	2 to 19	8 to 19
Met, Daily opportunity	≥ 19	≥ 19

Effects of Sun illumination and clouds are not included.

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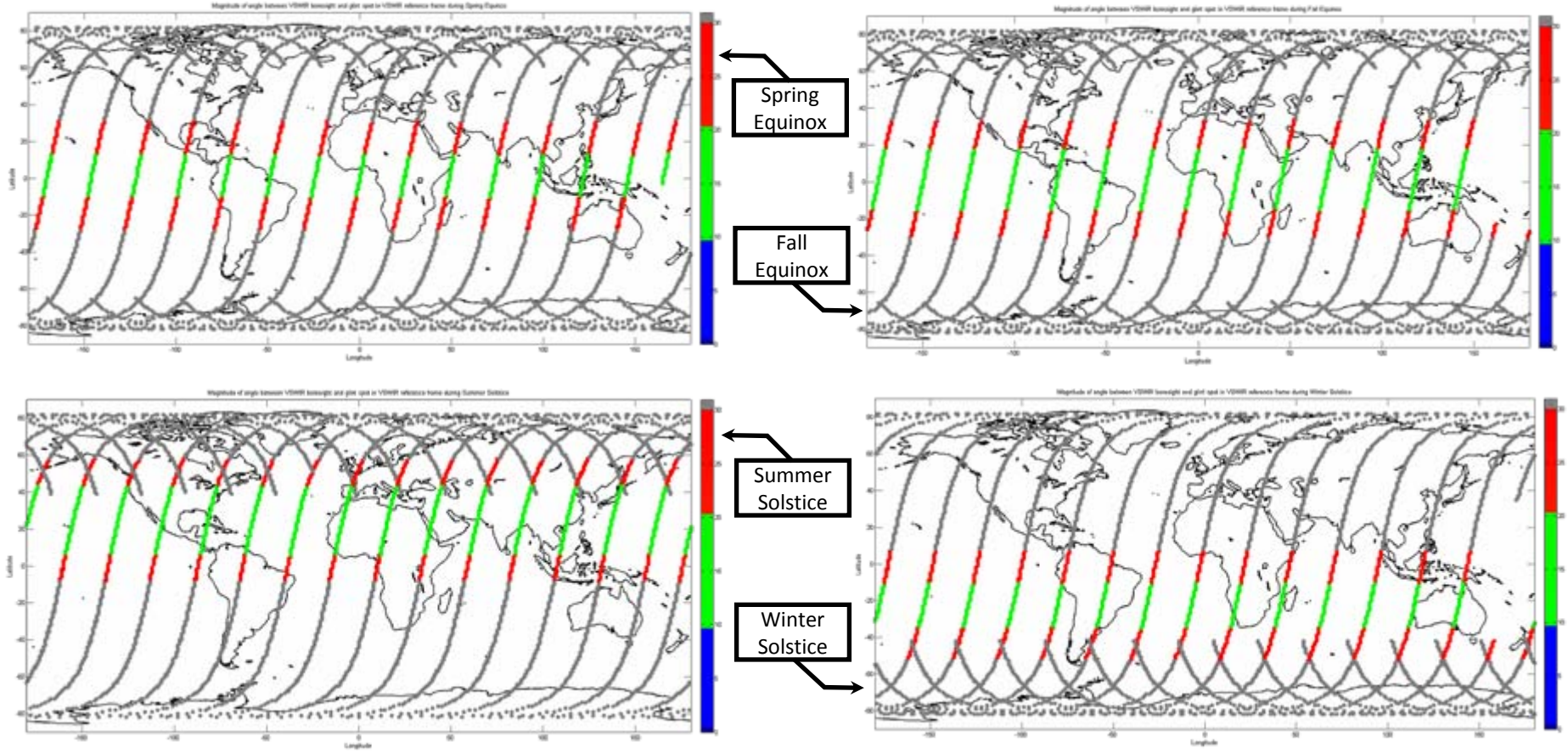
Sun Illumination Considerations: VSWIR

- Impact of the latitude variations of the sub-solar point
  - Latitude extent of VSWIR coverage varies seasonally
  - Sun illumination constraints reduces VSWIR coverage during local winter.
  - High latitude opportunities concentrated in local Summer – most active period
- VSWIR canted 4 deg in the back-scatter direction to help reduce effect of glint
- Swath located between the glint and the hot spot

Magnitude of angle between VSWIR boresight and glint spot in VSWIR reference frame



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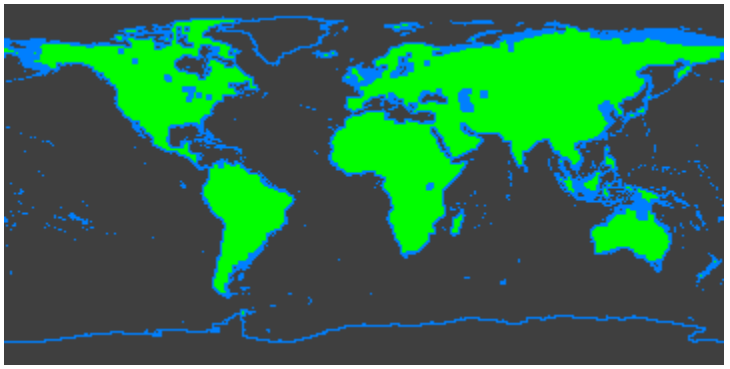
Data Acquisition Scenario

- Systematic mapping vs. pointing capability
- Target map driven - No need for uploading acquisition sequences
- Data acquisition driven by land and coastal aquatic (<50m depth) coverage
  - Impact by low resolution modes on data volume is relatively small
- Both instruments on 24/7, but not acquiring data at 100% duty cycle
- Low-latency products available via Direct Broadcast system
  - Applications (not science) driven

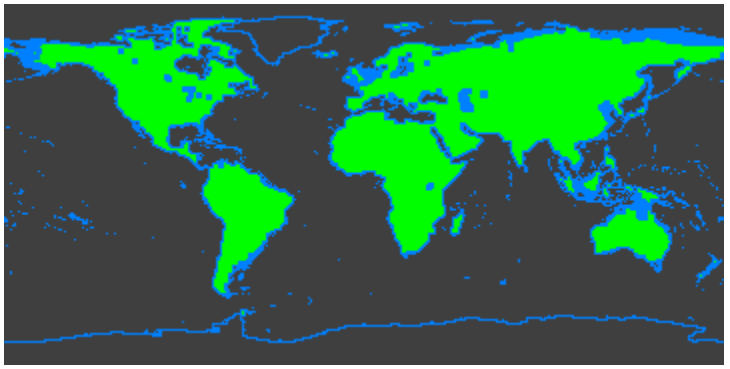
Imaging Mode

Instrument	Land	Coastal	Deep Ocean	Greenland	Antarctica
VSWIR	60 m	60 m	1 km	1 km	1 km
TIR	60 m	60 m	1 km	1 km	1 km

VSWIR target map



TIR target map



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Data Volume

	VSWIR	TIR	Combined
Raw Instrument Data (Mbps)	804.1	130.2	934.3
Compression Factor	3	2	-
Compressed Data Rate (Mbps)	268.0	65.1	333.1
Year long averaged Duty Cycle	11.3%	34.6%	-
Compressed Data Rate (average) (Mbps)	30.4	22.5	52.9
Data Volume Per Orbit (average) (Gb)	177.2	131.3	308.5
Daily Data Volume (average) (Gb)	2623.3	1944.9	4568.3
Overhead	10%	10%	-
Packetized Daily Data Volume (Gb)	2,885.7	2,139.4	5,025.1
Cloud Obscuration	20%	0%	-
Usable Daily Data Volume (Gb)	2,308.5	2,139.4	4,448.0
TOTAL DAILY DATA VOLUME (Gb)	2885.7	2139.4	5025.1

- Trade study for on-board storage vs. downlink capability is ongoing
  - Studies indicate that solution can be achieved with current and/or planned technology

- Lossless compression occurs within each instrument
- Compressed data is then passed to S/C CDH
- Duty cycle based on:
  - Target Masks for each instrument
    - Does not include coastal data
    - Does not include low-resolution data
- Other missions:
  - NASA
    - SMAP: 0.36 Tb/Day
    - DESDynI: 39.2 Tb/Day
  - Non-NASA
    - WorldView1: 331 Gb/orbit
    - WorldView2: 524 Gb/orbit

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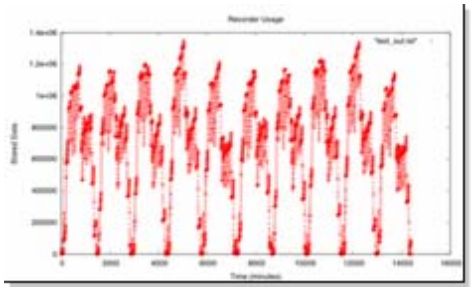
Managing Data Volume

- On-board storage (current baseline)
  - 3 Tb (50% used nominally)
  - WorldView-1 and -2 have 2.2 Tb
- Downlink method
  - X-band (current baseline)
    - Upgrade 3 (Svalbard, Poker Flats, U. Tasmania) existing stations to 740 Mbps
    - WorldView-1 (launched 2007/09) 800 Mbps
  - Other options:
    - NASA Ground and Space Networks ongoing study on Ka upgrades to Svalbard and Poker Flats to 1Gbps
      - Reporting to NASA HQ on 8/27/2009
      - SWOT has very similar data needs to HyspIRI
    - TDRSS
      - Ka option @ 1Gbps will be available in the HyspIRI operational timeframe
      - Current baseline for DESDynI
- Ground communications / latency
  - Back end infrastructure may also need upgrading to ensure timely delivery of data



HyspIRI will require more capabilities than currently used by NASA. Suitable solutions are being used by existing commercial missions.

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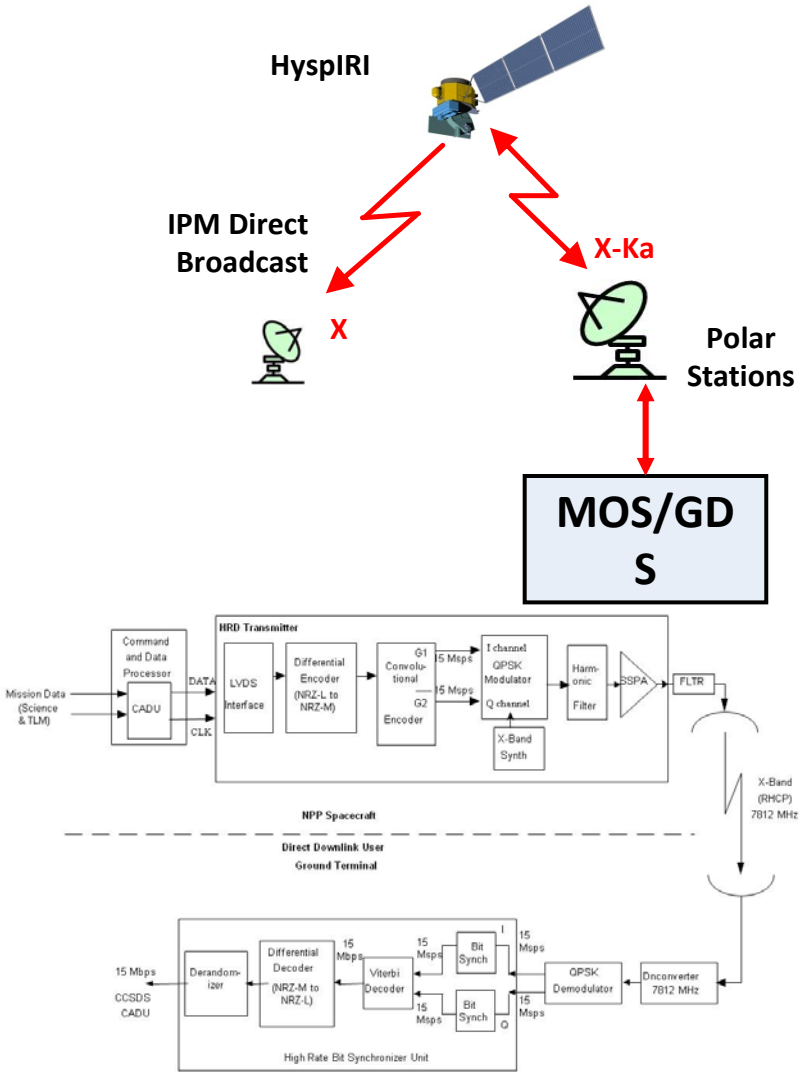
Low Latency Data – Direct Broadcast

- Direct Broadcast Capability
- Low latency data (<6hrs)
- Applications Driven, Targeted Science
  - Non-stop data acquisition
  - Decision making capability
- Not tech development
- Design taken from NPP's high rate data (HRD) broadcast system
- Baseline design
  - 15 Mbps X-band
  - An Earth-coverage dish estimated at 0.5 m diameter
    - Reflector is shaped to provide peak gain at ~60 degrees off boresight
  - Any user should be able to receive data when S/C is above 5 degrees

The DB capability will make use of high heritage technology and existing algorithms to enable the development of low latency data products and applications.



Courtesy of Patrick Coronado, Kelvin Brentzel, NASA DRL

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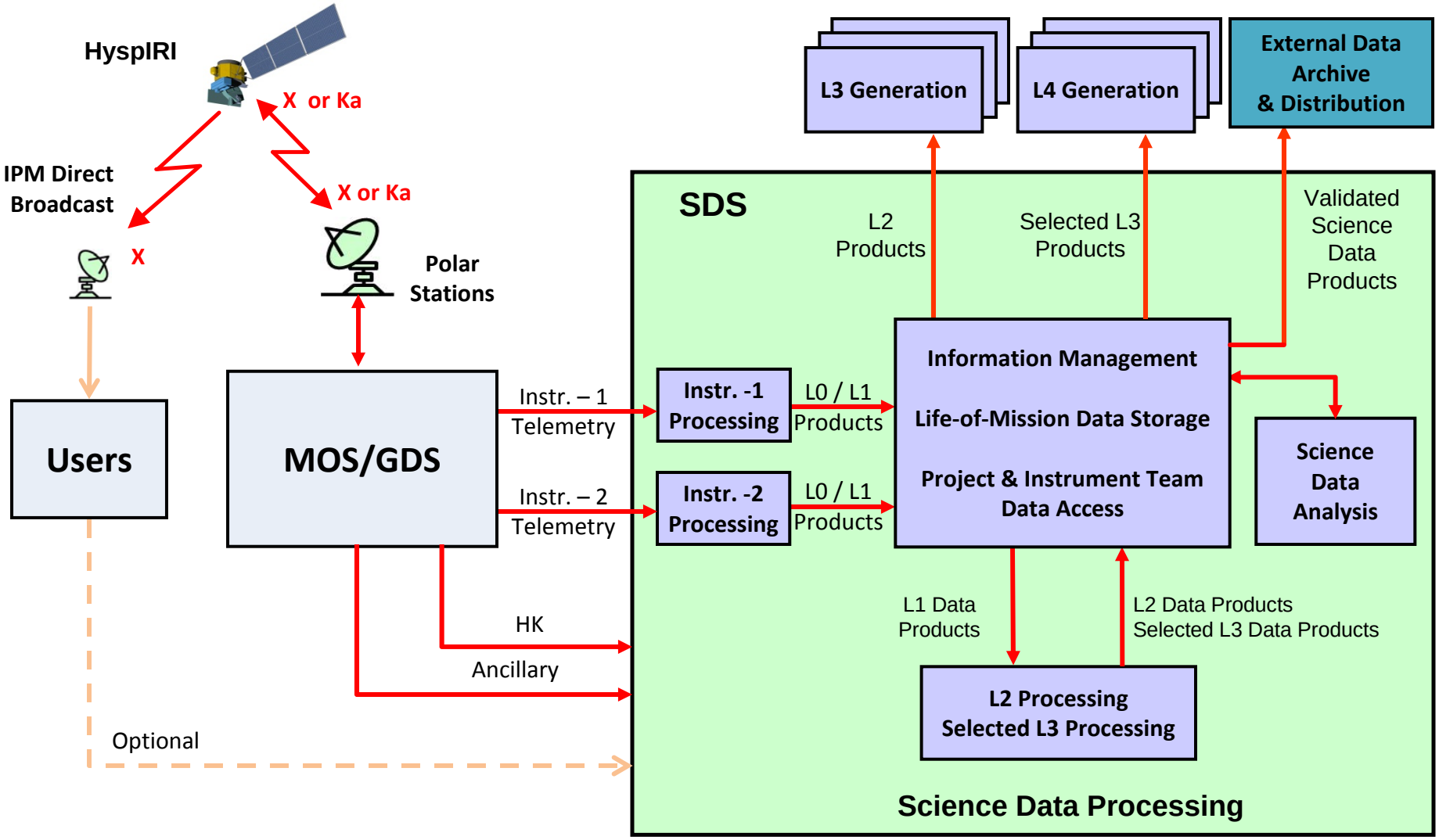
HyspIRI End-to-End Data Flow



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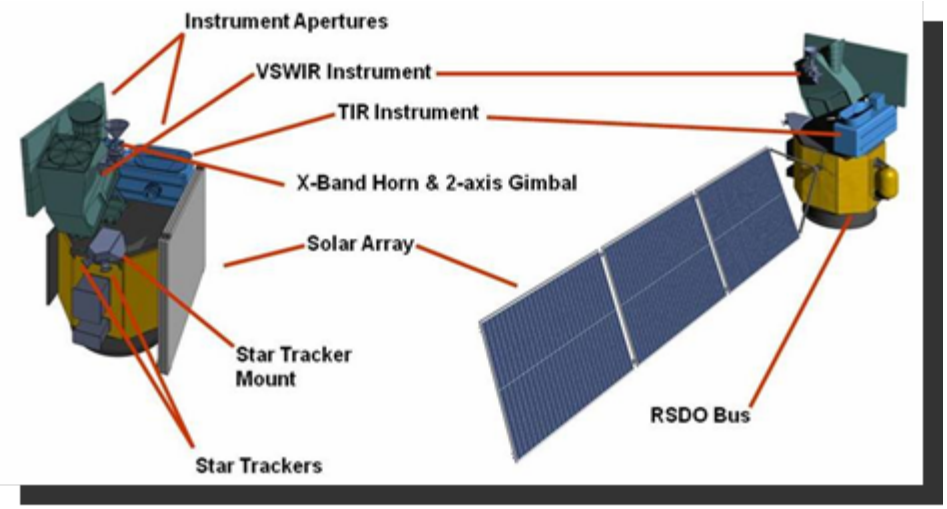
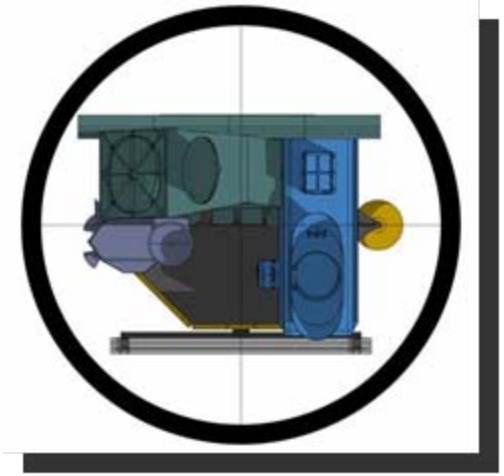
Flight System Concept

- Industry procured spacecraft bus
  - SA-200HP (option 6) used as an example for the study to identify and cost needed modifications
- HyspIRI specific
  - Payload integrated on the top plate (TIR, VSWIR) and inside the S/C (systematic data system, low-latency data system)
  - Bus equipment is arranged to minimize/eliminate thermal impacts on the payload radiators
- Taurus 3210 can meet the mission needs
  - Closest fit among currently NASA approved launchers
  - 29% margin (dry-mass CBE) with a Taurus-class launch vehicle
  - Fits dynamic volume envelope
  - Need to evaluate upcoming launchers
- Launch window
  - Mapping orbit reachable once per day





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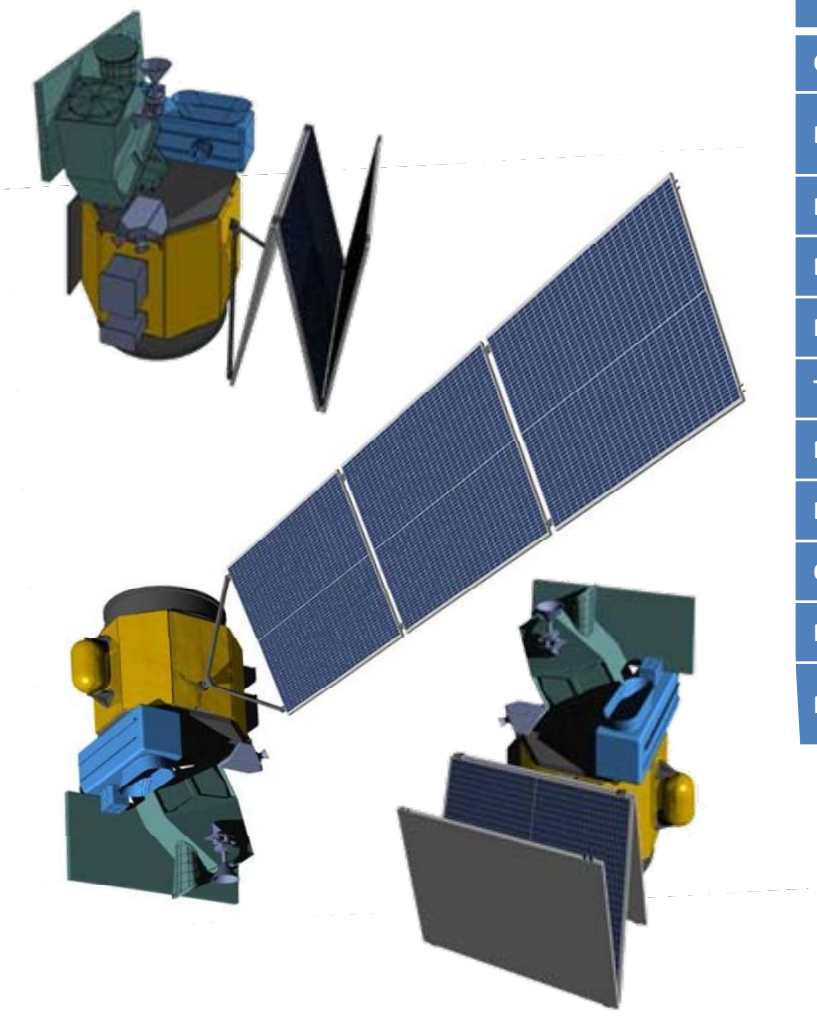
RSDO SA-200HP Modifications



	Requirements	RSDO SA-200HP	Modifications
Orbit	626 km 11:00 LTDN	✓	-
Mission duration	3 years, selective redundancy	✓	-
Pointing Knowledge	2 arcsec (3σ/axis)	.5 arcsec (3σ)	Ball CT-602 star tracker to protect against deformation between bus and payload
Pointing Accuracy	165 arcsec (3σ/axis)	16 arcsec (3σ)	
Pointing Stability	5 arcsec/sec (3σ)	0.1 arcsec/sec (3σ)	
Thermal	Passive architecture	✓	-
Downlink	740 Mbps	80Mbps	Dual-pol X-band
Propellant	42 m/s	131 m/s	-
Onboard recorder	3 Tb	100 Gbits	SEAKR SSP-R
Payload mass	132kg	666 kg	-
Payload + SSR power	217 W	650 W	Single wing configuration

Current concept based on modified catalog spacecraft.
Next iteration will be based on industry's response to RFI.

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Payload Accommodation and System Margins

Accommodations	VSWIR	TIR
Mass (CBE)	66 kg	85 kg
Mass (w/ contingency)	81 kg	99 kg
Volume	1.6 x 1.6 x 1 m	1.2 x 0.5 x 0.4 m
Power	38 W	78 W
Data Rate (raw)	804 Mbps	132 Mbps
Data Rate (compressed)	268Mbps	66.1 Mbps
Avg. Daily Data Volume	2.89Tbits	2.14 Tbits

	Required (CBE)	Design	Margin (D-CBE)/D
Swath width VSWIR	140 km	146 km	4%
Swath width TIR	558 km	600 km	7%
Recorder capacity	1.4 Tb	3 Tb	53%
Downlink capacity	5.8 Tb/day	8.4 Tb/day	31%
Power	217 W	650 W	66%
LV mass capability	561 (includes propellant for EOL maneuver)	790 kg	29%

Next Steps

- Assess impact of workshop
- Support work on Level 1 requirements with NASA HQ
- Continue preparations for the Mission Concept Review

BACKUP

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Key Science-Derived Instrument Requirements

- Coverage/Revisit
  - VSWIR: 19 days
  - TIR: 5 days
  - Desire for some real-time stream (latency of a few hours)
- Spectral
  - VSWIR: 380 to 2500 nm in 10nm bands; 0.5nm accuracy
  - TIR: 7 bands between 7.5-12 µm and 1 band at 4 µm; 0.01 µm accuracy

Spatial Coverage

Instrument	Swath Width	Cross-track Samples	IFOV
VSWIR	146 km	2,540	60 m
TIR	600 km	9,224	60 m

Data Rate/Downlink

Instrument	Raw Data rate (Mbps)	Compressed Data rate (Mbps)	Avg. Daily Data Volume (Tb)
VSWIR	804	268	2.89
TIR	132.2	66.1	2.14

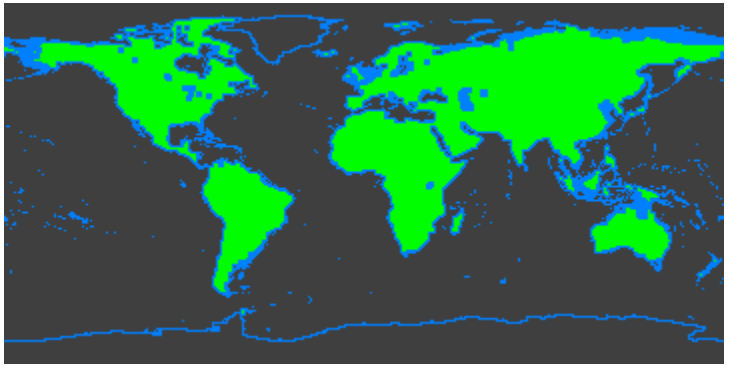
On-Orbit Calibration

Instrument	Lunar View (radiometric)	Surface Cal Experiment (radiometric)	Surface Cal Experiment (spectral)	Solar Cover Views (radiometric)	Blackbody Views (radiometric)	Deep space Views (radiometric)
VSWIR	1/month	3/year	3/year	1/week	-	-
TIR	1/month	2 (d/n)/ 5 days	1/year	-	1/scan	1/scan

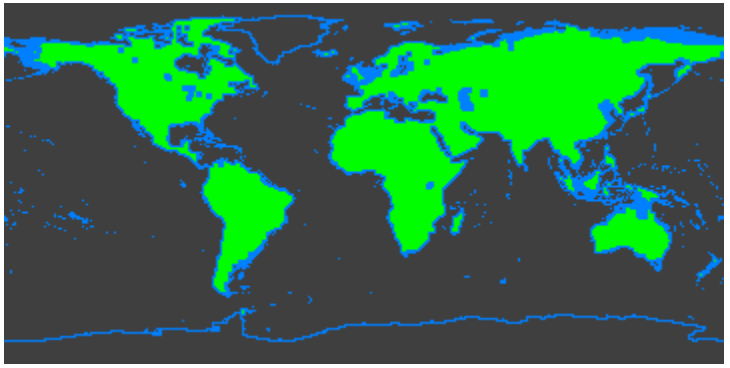
Imaging Mode

Instrument	Land	Coastal	Deep Ocean	Greenland	Antarctica
VSWIR	60 m	60 m	1 km	1 km	1 km
TIR	60 m	60 m	1 km	1km	1km

VSWIR target map



TIR target map



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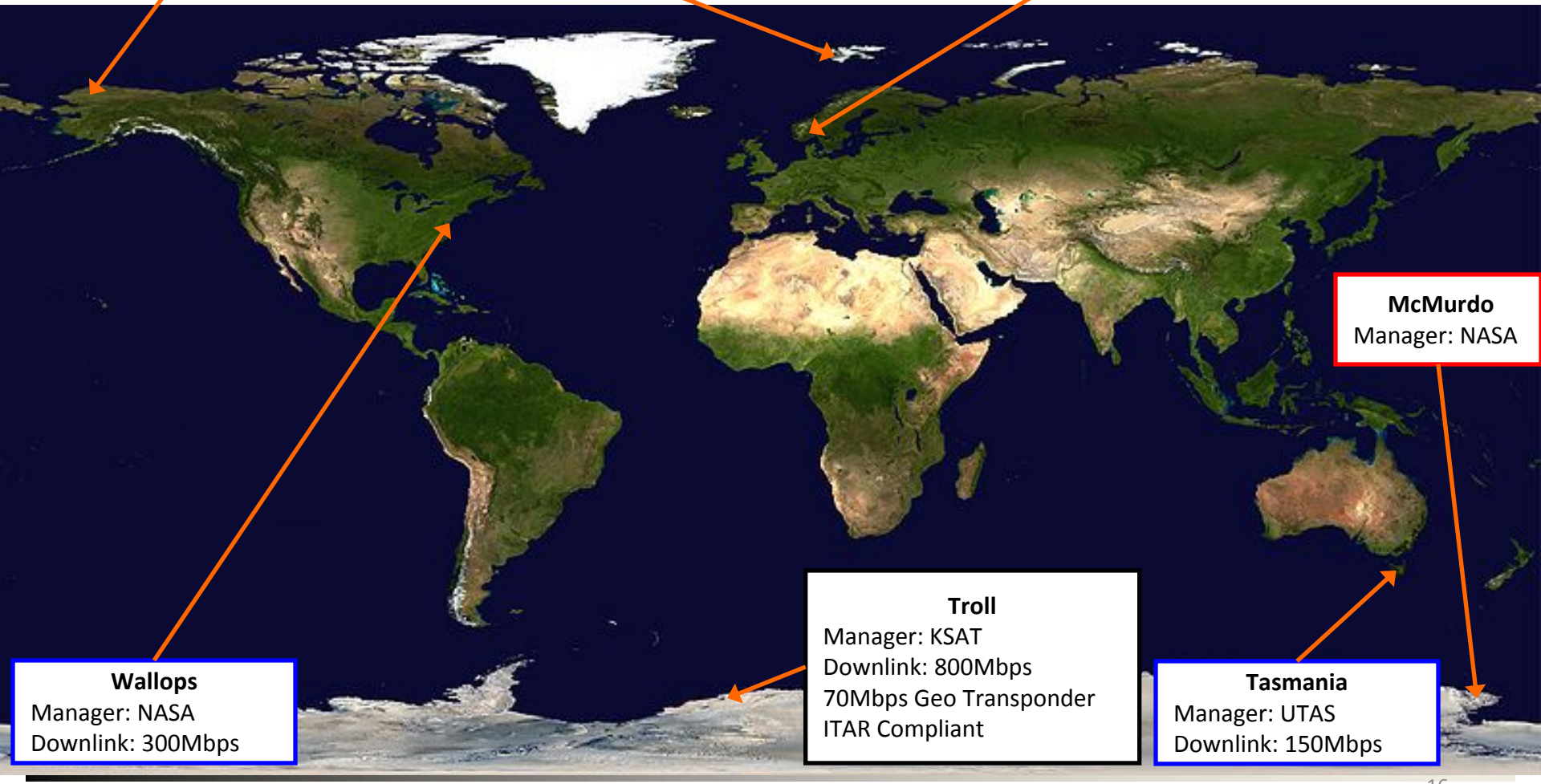
Ground Station Capability

Poker Flats
Manager: USN
Downlink: 150Mbps

Svalbard
Manager: KSAT
Downlink: 800Mbps

Tromsø
Manager: KSAT
Downlink: 800Mbps

NASA
Non-NASA
Not Used



McMurdo
Manager: NASA

Troll
Manager: KSAT
Downlink: 800Mbps
70Mbps Geo Transponder
ITAR Compliant

Wallops
Manager: NASA
Downlink: 300Mbps

Tasmania
Manager: UTAS
Downlink: 150Mbps