HyspIRI Mission Concept Overview

National Aeronautics and
Space Administration

Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

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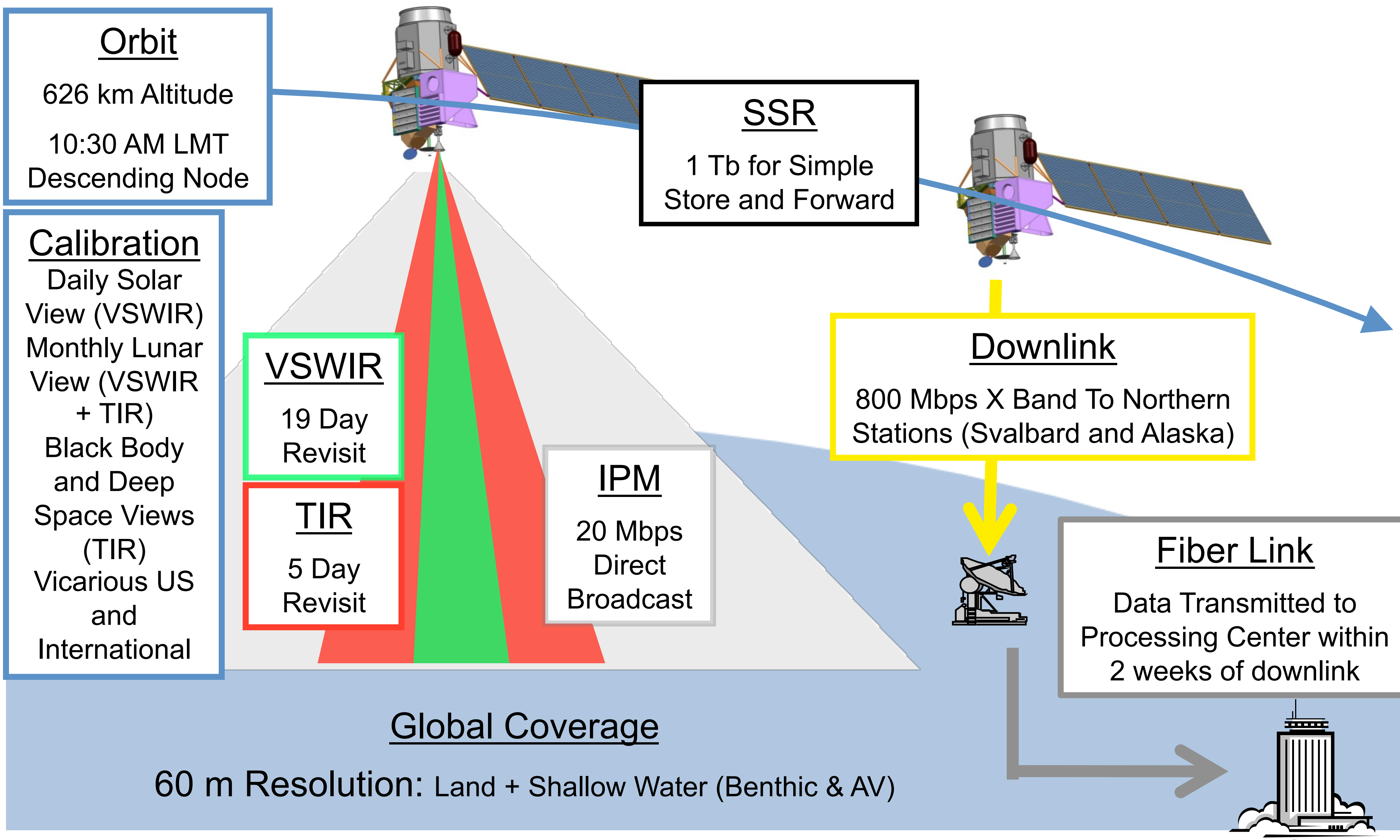
HyspIRI Mission Architecture



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HyspIRI Concept

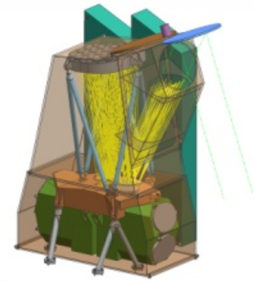
Payload

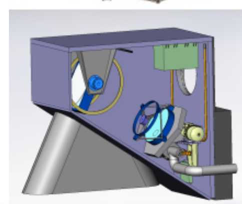
Science Instruments:

- VSWIR: Imaging Spectrometer
  - 380-2500 nm in 10 nm bands
  - 60m spatial resolution
  - Day-side (23% duty cycle)
  - 55 Kg, 41 W
- TIR: Thermal Infrared Scanner
  - 8 bands between 3-12 μm
  - 60m spatial resolution
  - Day and night-side (100% duty cycle)
  - 60 Kg, 103 W

Intelligent Payload Module (IPM)

- 24/7 Direct Broadcast capability
- subset of science data
- X-band @ 20 Mbps
- 11 Kg, 86 W





Mission Architecture

- Orbit: 626 km Sun-Synchronous, 10:30am LTDN
- Repeat: 19 day VSWIR / 5 day TIR
- Downlink: Contacts nearly every orbit to Svalbard (Norway) and Poker Flatt (Alaska)
- Science Data: 5.3 Tbits/day
- Launch Vehicle: 2m fairing, 790 kg capability

Spacecraft

Launch Mass CBE: 520 kg, JPL DP Margin: 31%

Required Power CBE: 680W, 7.1 m^2 array (965 W capability)

P/L Data Rate: 384 Mbps

Downlink Data Rate: 800 Mbps Dual-pol X-band

Stabilization: 3-axis

System Pointing: Control = 4.5 mrad, 3σ/axis
Knowledge = 48 μrad, 3σ/axis
Stability = 100 μrad/sec, 3σ/axis

Implementation

Launch Date: ≥ 2022

Lifetime: 3 years, with consumables for 5

Mission Cost :$506M (reserve incl.)

Payload Cost :$140M + 30% reserve

Partners: JPL, GSFC

Mission Class: C, with selected redundancy

Hardware Model: Protoflight

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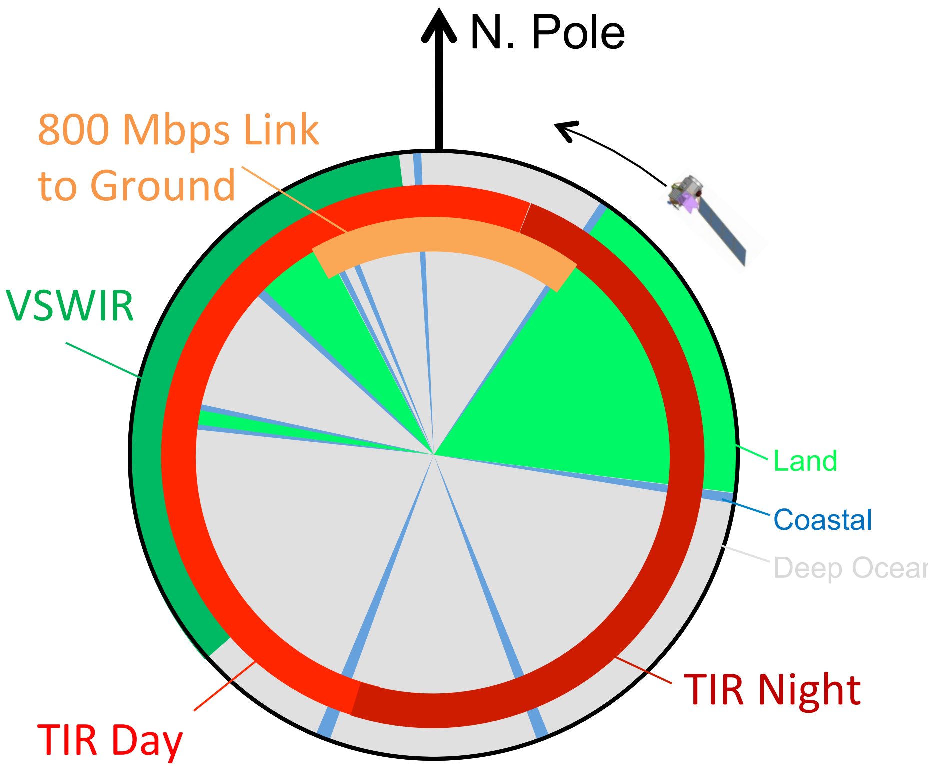
Data Acquisition Strategy

- Instrument modes change multiple times each orbit, but are clearly defined by geography and spacecraft location

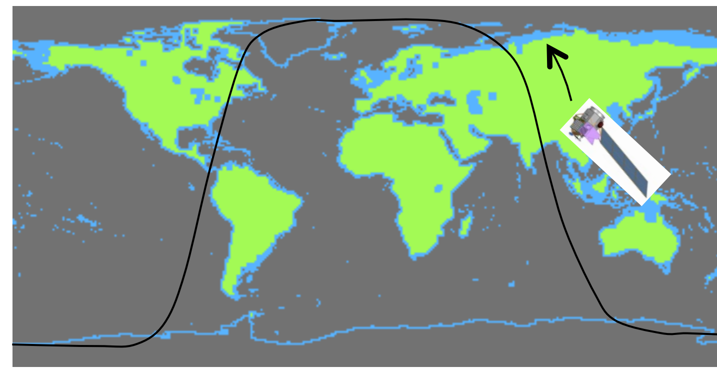


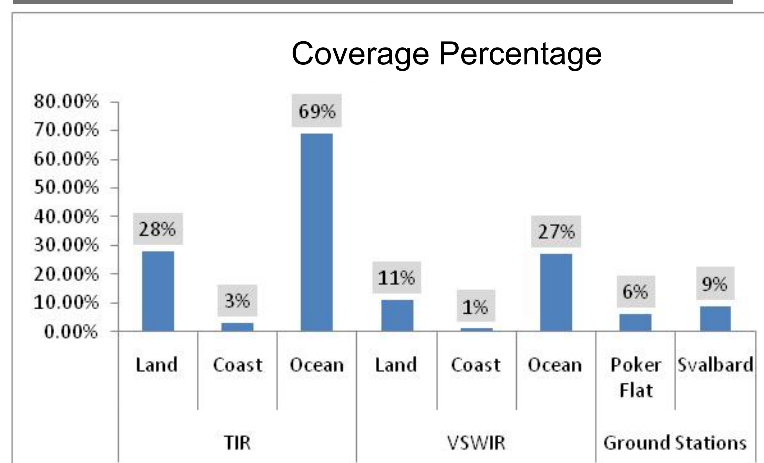
Cut away of earth with slice taken along plane of orbit

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

Target Map





HyspIRI FY 12 Activities/ Deliverables

- ✓Steering Committee, Science Study Group
- ✓FY12 Data Product Symposium
- ✓Science Workshop and Report
- ✓Science Requirements Review
- ✓L1 and L2 ATBD development – L1s to be documented in FY13
- ✓VSWIR compression efforts: 3:1 to 4:1 and SRR reduced from 0.9 to 0.5 Tb
- ✓Ongoing Instrument risk reduction
    - ✓Detectors, electronics, optics
- ✓TIR Band Study draft – just getting started
- ✓TRL Assessment – nearing closure
- ✓Independent Cost Assessment conducted by Aerospace Corp.
- ✓Geolocation – Knowledge Investigation
- ✓Support for Potential Airborne Campaign
- ✓Cloud Cover Studies – Published Remote Sensing of the Environment
- ✓Website management

Many of these topics are covered in a poster or will be spoken to directly during this workshop. ICE & TRL

HyspIRI Mission Concept

ICE

Aerospace Corp. conducted an independent cost estimate/ assessment of the HyspIRI Mission Concept.

The HyspIRI Mission Concept cost was validated

HyspIRI Mission Concept

JPL and GSFC provided Aerospace with extensive technical data package as inputs to their Independent Cost Estimate

- Mission Summary
- TRL Assessment
- Data Volume Supplemental Data
- Schedule Supplemental Data
- Cryocooler Supplemental Data
- ESTO IIP TIR Work in Progress Supplemental Data
- Onboard Compression Supplemental Data
- IPM Supplemental Data
- Pointing Performance Supplemental Data
- Orbital Debris Compliance
- MEL/PEL

ICE Summary

Aerospace conducted an independent cost estimate/ assessment of the HyspIRI Mission Concept.

ICE schedule-adjusted life cycle cost estimate (70th percentile) is $562M (FY12$M)

- As compared to $504M project estimate (based on NASA Earth Science Decadal Survey Implementation, March 2009) (within 12% of the JPL estimate!)

ICE range estimate is $493M (FY12$M) for the low and $647 (FY12$M) for the high

Cost difference between Aerospace ICE and project estimate due mainly to schedule risk. The ICE Estimate includes $103M of schedule risk

- Recommend lengthening proposed schedule to reduce risk

HyspIRI Schedule Discussion

- Aerospace schedule estimate (70th percentile) is 60 months
  - Proposed schedule does not appear sufficient when compared to analogous missions
  - Trying to meet an aggressive schedule and then slipping later in the development is less efficient than initially planning for a more realistic schedule

- Considered scenario where HyspIRI schedule was lengthened by 12 months
  - Same Phase B Start date; new launch date of 1/3/2021
  - All phases were stretched by the same percentage of time
  - Results in greater up-front cost, but greatly reduces schedule risk

Category	HyspIRI Proposed Schedule	HyspIRI "Stretched" Schedule
Total Mission Cost	**$ 458.5**	**$ 467.2**
Schedule Risk	$ 103.4	$ 26.7
Total w/Schedule Risk	**$ 561.9**	**$ 493.9**

TRL Status

A System Engineering Working Group (SEWG) was chartered to develop a more codified approach to TRL assessment for missions in formulation.

The SEWG has produced a set of instructions and a work sheet for this effort.

HyspIRI has populated the instrument portion of the TRL assessment work sheet.

The worksheet has been discussed with current members of the SEWG at JPL, GSFC and ESTO.

The group has not formally reviewed and concurred with the assessment yet. That meeting is planned for next week.

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TRL Status

Product breakdown			*Technology Level Assessment*			*Implementation Approach*	
System / Subsystem	**Assembly**	**Component**	**Key Technology Items***	**TRL**	**Justification**	**Implementation Method**	**Vendors (if applicable)**
HyspIRI							
Target Environment =	**Space**						
TIR Focal Plane + Electronics							
	Focal Plane Assembly			**5**	Asembly at lowest component TRL		Teledyne
		Detector Material	HgCdTe Material in a larger array format than has flown for NASA	5	IIP Expected TRL 6 in 2012 - LWIR HgCdTe has flown on TES, AIRS, HIRDLS and was developed for GIFTS	Fabricating detector material and mating to ROIC and vacuum cryo testing - IIP	Teledyne
		ROIC	~2x higher pixel rate then demonstrated by CRISM and M3	5	IIP Expected TRL 6 in 2012, Standard CMOS technology. Much high frame rates have been demonstrated for non-NASA tasks	Fabricating detector material and mating to ROIC and vacuum cryo testing. Commercial foundary - IIP	Teledyne
		Filters	Packaging presents engineering challenges	7	LWIR filters flown on HRDLs, AIRS and TES	Butcher block, specify and procure	Barr, JDSU, DSI, IML
		Flex Print Cable	None	7	M3, TES, AIRS, HRDLs	Design and procure	Pioneer, Tyco
	Electronics			**6**	Asembly at lowest component TRL	Standard mil-883 PCB with descrete EE parts	JPL
		Signal Chain Elec.	2X higher data rates than what has flown	6	Limited breadboards planned on PHyTIR	Standard mil-883 PCB with descrete EE parts	JPL
		Housekeeping Elec.	None	7	Standard design and componenets	Standard mil-883 PCB with descrete EE parts	JPL
		Power Electronics	None	7	Flight qualified power converters	Standard mil-883 PCB with descrete EE parts	JPL
		Compression Algorithm	None	7	Engineering feasibility fully demonstrated with same 2:1 compression by ASTER	RICE algorithm	JPL
		Digital Electronics	New FPGA due to obselescence	6	Uses Virtex 5 QV (SIRF) flying on cubesat. Went through environmental testing on the ground	Standard mil-883 PCB with descrete EE parts	JPL, Xilinks

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Target Environment =	**Space**						
TIR Mechanical							
	Scanning Mirror Assembly	Actuator and encoder	High precision and stability is required to meet TIR pointing requirements, presents an engineering challenge	7	mechanism fle on GIFTS and WISE. It is changed from a one sided to a two sided mirror and mirror rotates at a constant velocity, rather than oscillating. TIR's requiremetns are exceeded by the heritage assembly	Specify and procure, with demonstration via IIP	Moog,
	All other items		None	7	Telescope Bench, Enclosure and Focal Plane Assembly Mounts use technologies flown on DIVINIR, MER and M3 (respectively)	Specified, designed, fabricated/procured	JPL
TIR Thermal							
	Electronics Radiators		None	7	technology has flown on M3, TES, MISR, AIRS, MICAS and MLS. Design is change to suit this configuration	Specified, designed, fabricated/procured	JPL
	Cryo-cooler		None	7-9	includes cryo cooler (TRL 9), thermal straps, heaters and controllers, finishes and MLI	Specified, designed, fabricated/procured	NGST
	Passive Cooler		None	7	Scaled version of M3 passive cooler (2x larger)	Specified, designed, fabricated/procured	JPL
	Thermal Enclosure and vent		None	7	Common aluminum enclosure, design changed to meet configuration and thermal reqts	Specified, designed, fabricated/procured	JPL
	Heat Pipes		None	7	technology has flown, specific design is custom to the geometry and heat loads of this configuration	Specified, designed, fabricated/procured	Thermacore, various

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HyspIRI							
Target Environment =	**Space**						
VSWIR Focal Plane + Electronics							
	Focal Plane Assembly			**6**	Asembly at lowest component TRL		Teledyne
		Detector Package	None	7	identical technology to M3, CRISM and ARTEMIS packages	Same fabrication, processes and materials in a new design	Teledyne
		Detector Material	Twice the length of previously flown detector arrays (M3, ARTEMIS, CRISM).	7	Has been tested in vacuum, cryo, radiation, vibration and had performance validated in space	Teledyne standard bake-stable process	Teledyne
		6604 B ROIC	Twice the size of 6604 A with new digital components	6	Scaled up from 6604A Vacuum, and cryo tested with Si detectors. Design uses standard cells of previously flown and qualified designs	Have mated it to HyViSi detectors and tested vacuum, cryo.	Teledyne
		Filter	None	7	Identical to ARTEMIS and current airborne designs but 2 x larger in one dimension	Contract procurement to existing specification	Barr, JDSU
		Flex Print Cable	None	7	Identical technology as M3	Contract procurement with JPL design based upon Teledynes electrical ICD	Pioneer, Tyco

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HyspIRI							
Target Environment =	**Space**						
Electronics				**6**	Identical technology to numerous flight instruments	Standard mil-883 PCB with descrete EE parts	JPL
	Signal Chain Elec.	None		7	Signal chain has flown on airborne CAO, NEON, AVIRIS NG and all EE parts available, meet radiation req'ts and are class B+.	Standard mil-883 PCB with descrete EE parts	JPL
	Housekeeping Elec.	None		7	Standard design and componenets	Standard mil-883 PCB with descrete EE parts	JPL
	Power Electronics	None		7	Flight qualified power converters	Standard mil-883 PCB with descrete EE parts	JPL
	Compression Algorithm	Algorithm		6	Engineering feesibility fully demonstrated by compressing AVIRIS, MARS and Next Gen Imaging Spectrometer at better than 3:1	Fully tested on CAO, NEON and AVRISNG	JPL
	Digital Electronics	New FPGA due to obselescence		6	Uses Virtex 5 QV (SIRF) flying on cubesat. Went through environmental testing on the ground	Standard mil-883 PCB with descrete EE parts	JPL

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HyspIRI							
Target Environment =	**Space**						
VSWIR Mechanical							
	All items		None	7-9	Strucutres are Al, composite. Standard opto-mechnical packaging	Specified, designed, fabricated/procured	JPL
VSWIR Thermal							
	Electronics Radiators		None	7	technology has flown on M3, TES, MISR, AIRS, MICAS and MLS. Design is modified to suit this configuration	Specified, designed, fabricated/procured	JPL
	All other items		None	7-9	includes thermal straps, heaters and controllers, finishes and MLI	Manufactured or procured by JPL, thermal straps procured from SDL	JPL
	Passive Cooler		None	7	Scaled version of M3 passive cooler (3x larger)	Specified, designed, fabricated/procured	JPL
IPM Software							
	Ground Operations		None	7			GSFC
	Onboard Algorithms		None	7-9	Only high heritage algorithms are used		GSFC
	Flight Software		None	8	Flown in SpaceCube		GSFC

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HyspIRI FY13 Proposed Plan

Real Year	2012	2013			
Fiscal Years	**2013**				**2014**
HyspIRI FY 2013 Milestone Schedule	**Q1**	**Q2**	**Q3**	**Q4**	**Q1**
Management - JPL					
Science					
SSC Telecons					
SSG Telecons					
HyspIRI Science Workshop	◆				◆
Science Workshop Reports	◆				
HyspIRI International SG		◆		◆	
L1 VSWIR ATBD Draft				◆	
L1/L2 Algorithms Testing		◆		◆	
L3/L4 Product Definition					
Science Data System Scalable Test Bed				◆	
Band Study Report - Preliminary				◆	
HyspIRI Preparatory Science Support					
HyspIRI Airborne Data Processing (L1/L2)				◆	
HyspIRI Airborne Flight Coordination				◆	
Instrument Risk Reduction					
TIR Configuration Study				◆	
VSWIR Spectrometer Testbed				◆	
Detector Electronics Risk Reduction			◆		
Compression Risk Reduction			◆		
Mission					
Geolocation Knowledge Assessment				◆	
Alternate Spacecraft Compatibility Studies		◆		◆	
AM/PM Crossing Time Study				◆	
ICE Recommendation Studies (Over Guide)				◆	
Team X Support		◆			
Management - GSFC					
Science					
I. GSFC Symposium (March 2013)			◆		
II. Technology Development (IPM & Web based tools)					
III. Prototype Product Development, Level 2 (IPM)-Level 4					
IV.Support Airborne Campaign Planning & Implementation					
V. Cal/Val & International activities					
Symposium Reports			◆		