Hyperspectral – Infrared Imager (HyspIRI) Mission

Science Workshop 2010

HyspIRI Global Coverage, Data Management, and Downlink Approach

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Ops Concept Overview

- Frequent Global Coverage:
  - VSWIR: 19 day global revisit
  - TIR: 5 day global revisit (1 day view + 1 night view)
  - 60 m resolution over land and shallow ocean
  - 1 km resolution over deep oceans, Greenland and Antarctica
- Tracking Network Meets Needs
  - Stations at Svalbard and Poker Flats
  - Existing capability for 800 Mbps dual-pol X band
  - Sufficient contacts to reduce SSR size to 1 Tb
- Regular On-Orbit Calibration of Instruments
  - VSWIR: Weekly Solar view + Monthly Lunar View
  - TIR: Monthly Lunar View + Black Body and Deep Space views
- Data Latency Does Not Drive System

VSWIR Ops:
- Pointing strategy to reduce sun glint
- Surface reflectance in the solar reflected spectrum for elevation angles >20
- Avoid terrestrial hot spots

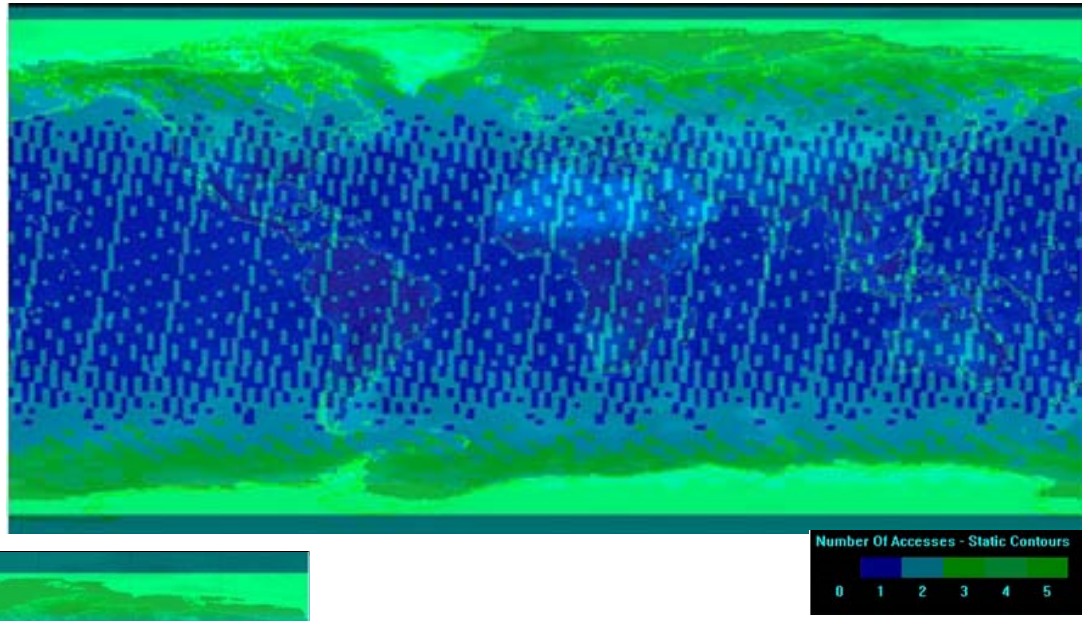
Key Requirements & Drivers

	Requirement	Status	Risk	Mitigation
Revisit	VSWIR: minimum every 19 days TIR: Minimum every 5 days	Met Met	None None	None None
Coverage	Global: TIR, VSWIR	Met	None	None
Data Rate	368 Mbps over land	Met	None	None
Data Volume	1.7 Pb per year	Met	None	None
SSR Size	Minimize it to reduce cost and risk.	Met with 1 Tb	Need to identify specific device	Identify specific device

All data and coverage requirements are met.

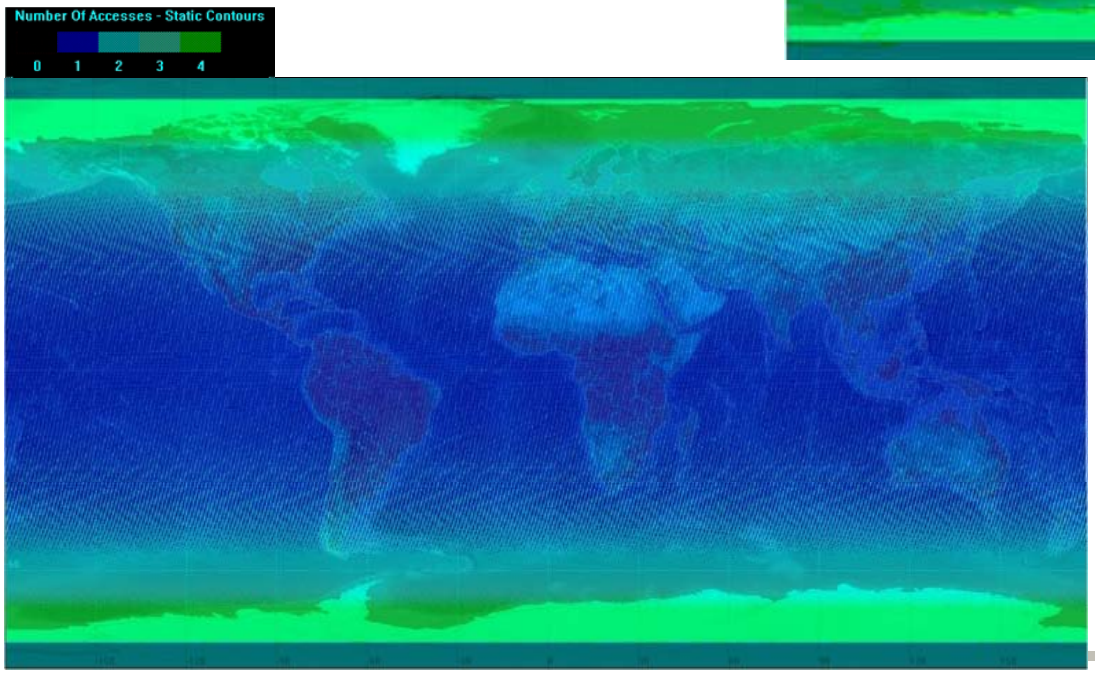
HyspIRI Global Coverage

- Due to the min 20 deg Sun elevation angle constraint on the VSWIR acquisition, the latitudes covered change with the seasons

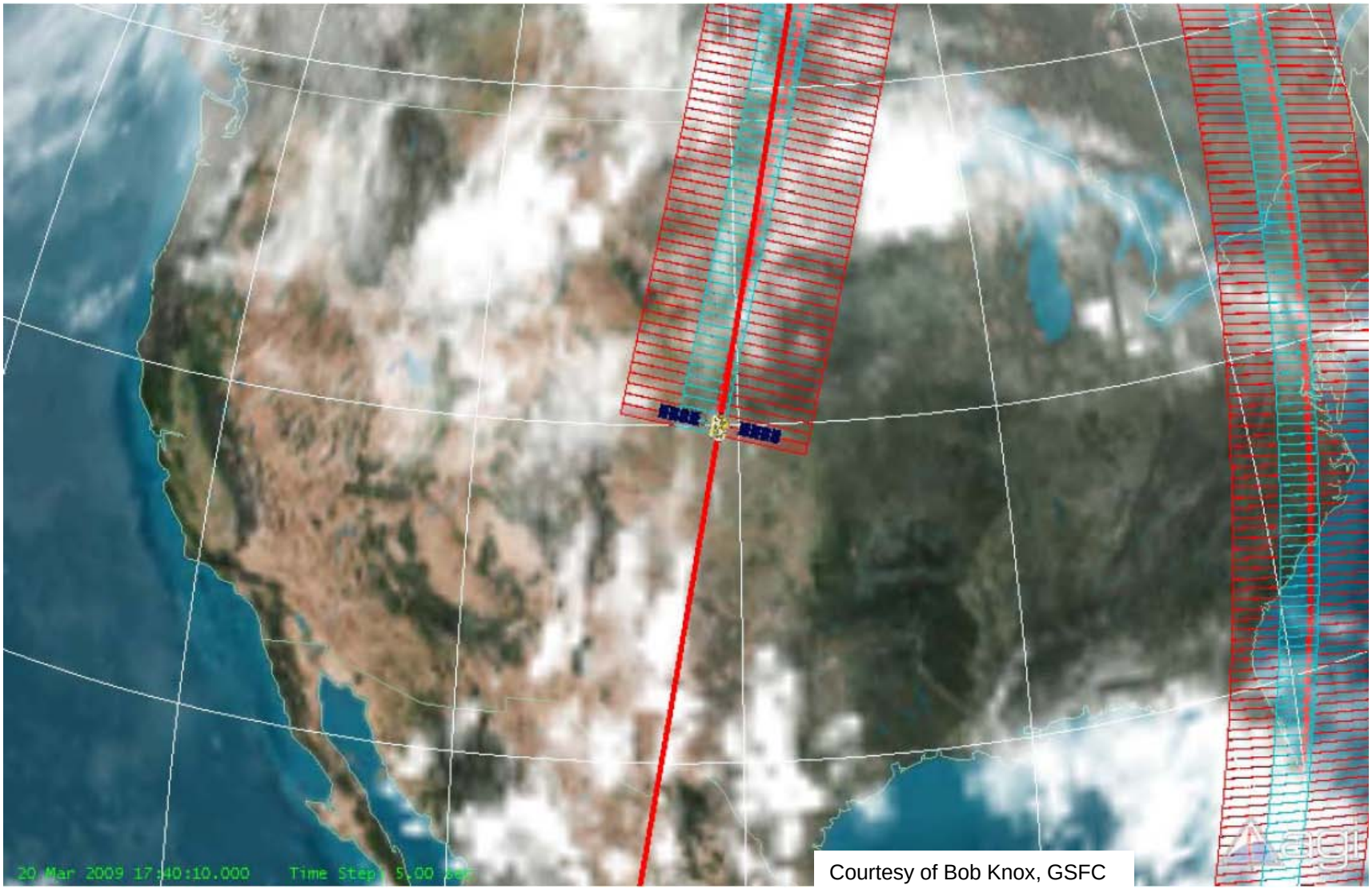


TIR Coverage after 5 days

VSWIR Coverage after 19 days



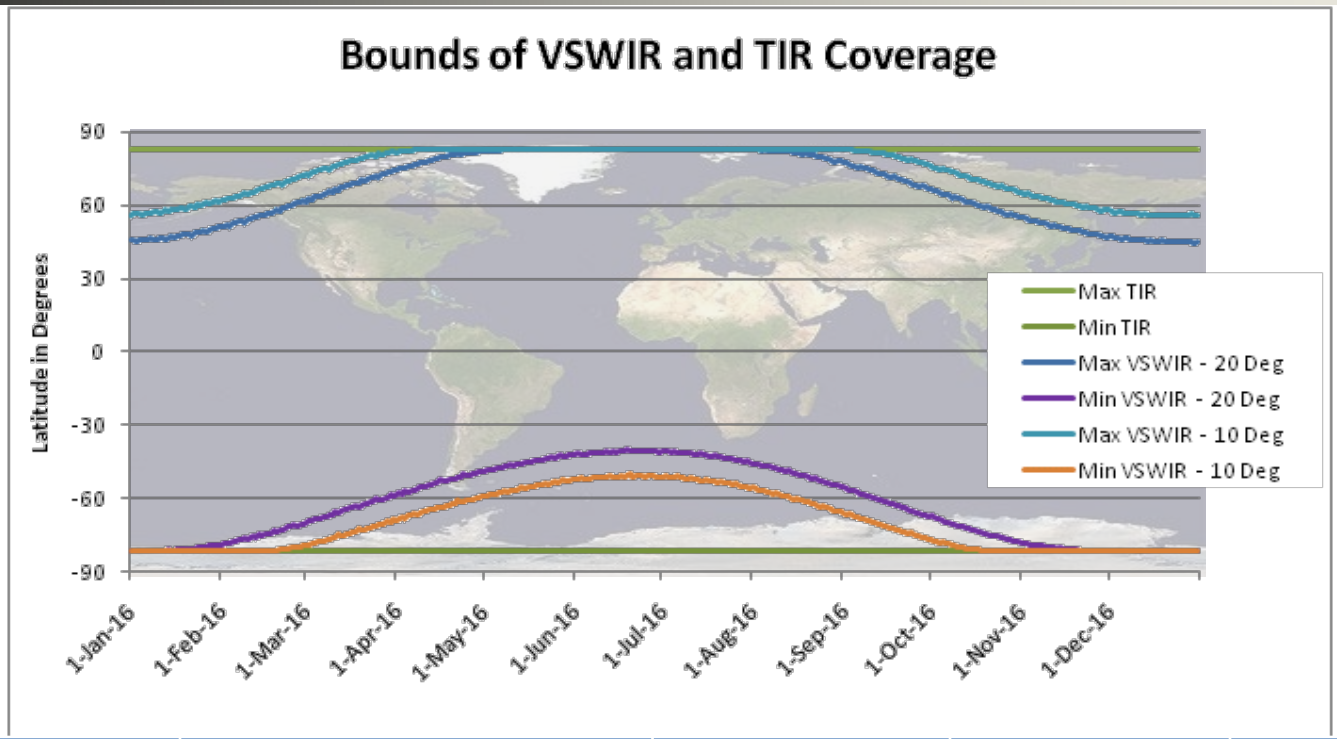
Swath Width Illustration



Courtesy of Bob Knox, GSFC

Coverage Video

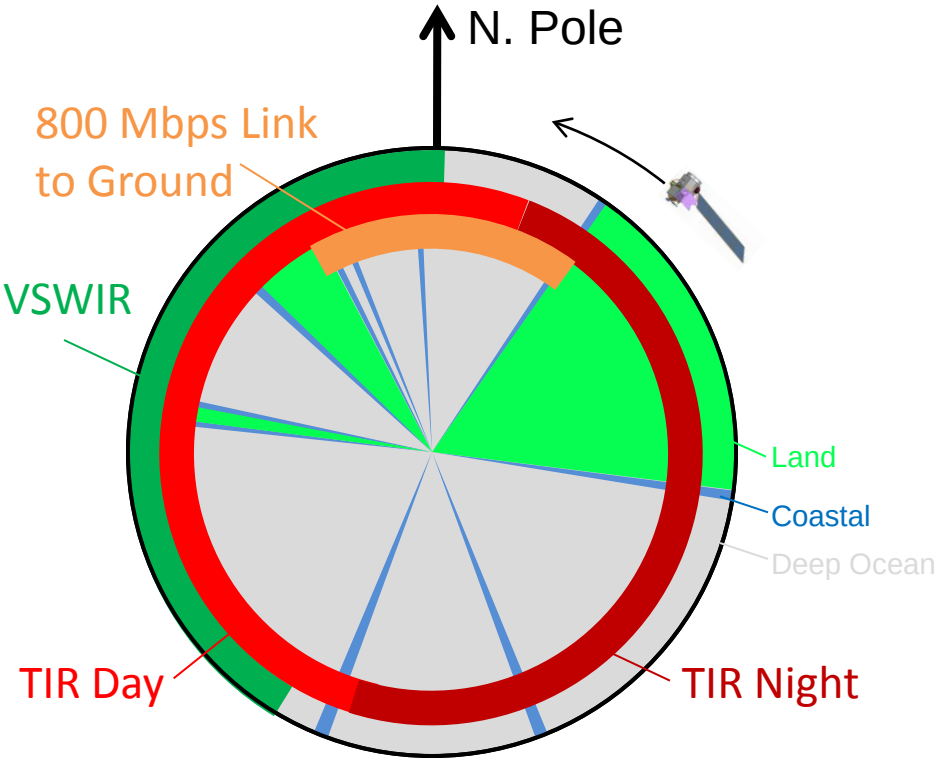
Coverage Change with Seasons



		VSWIR (20°)	VSWIR (10°)	TIR
Northern Hemisphere	Max Latitude [deg]	82.6	82.6	82.6
	Min Latitude [deg]	44.4	55.6	82.5
Southern Hemisphere	Max Latitude [deg]	-40.1	-50.1	-81.7
	Min Latitude [deg]	-81.8	-81.8	-81.8

Example Orbit

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

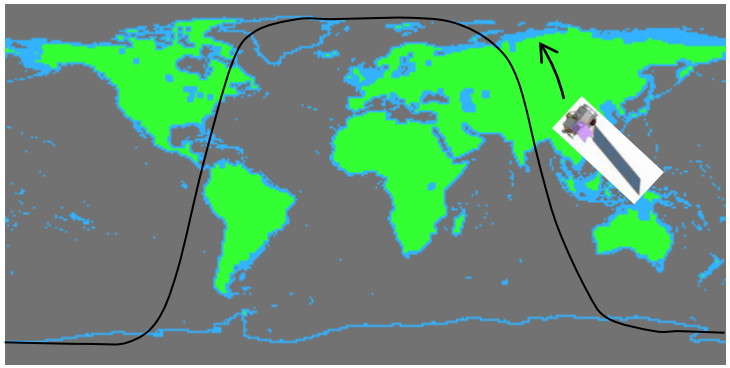


Cut away of earth with slice taken along plane of orbit

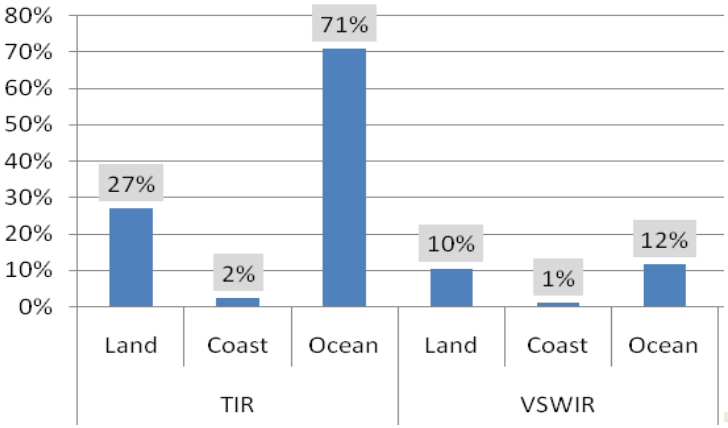
Imaging Mode

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

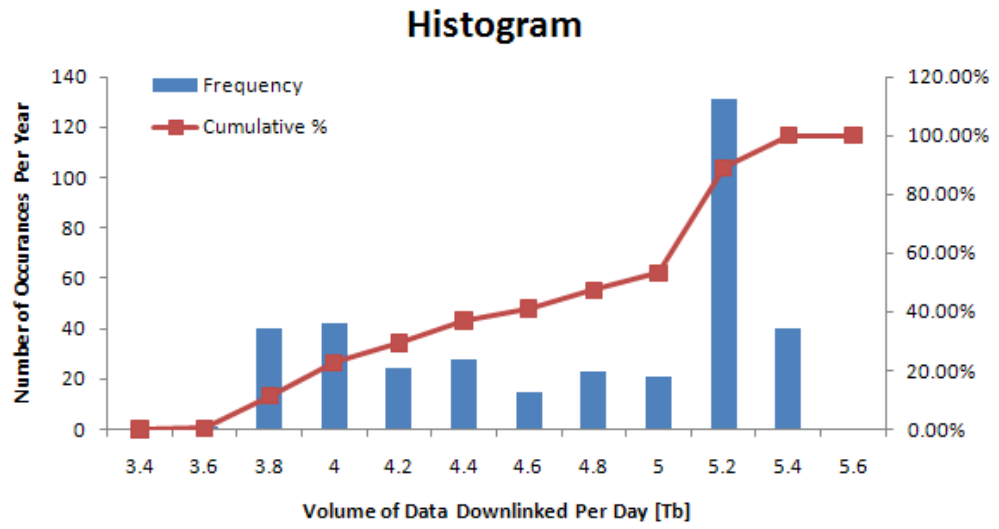
Target Map

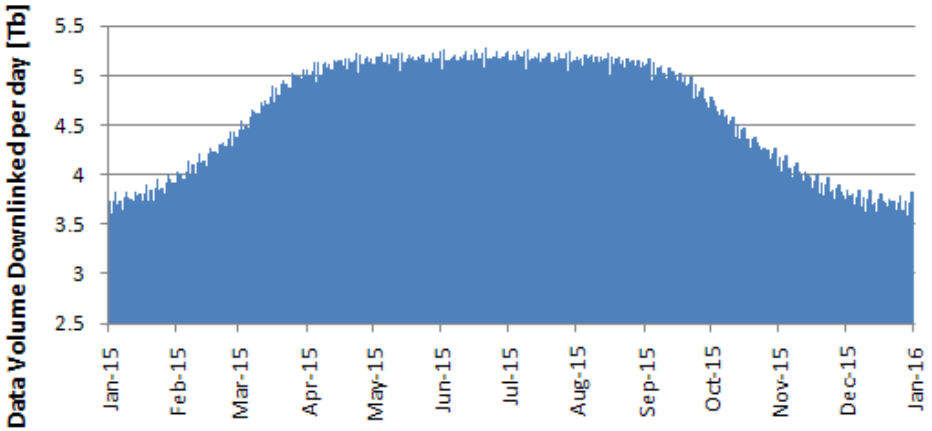


Duty Cycles



Data Volume Analysis



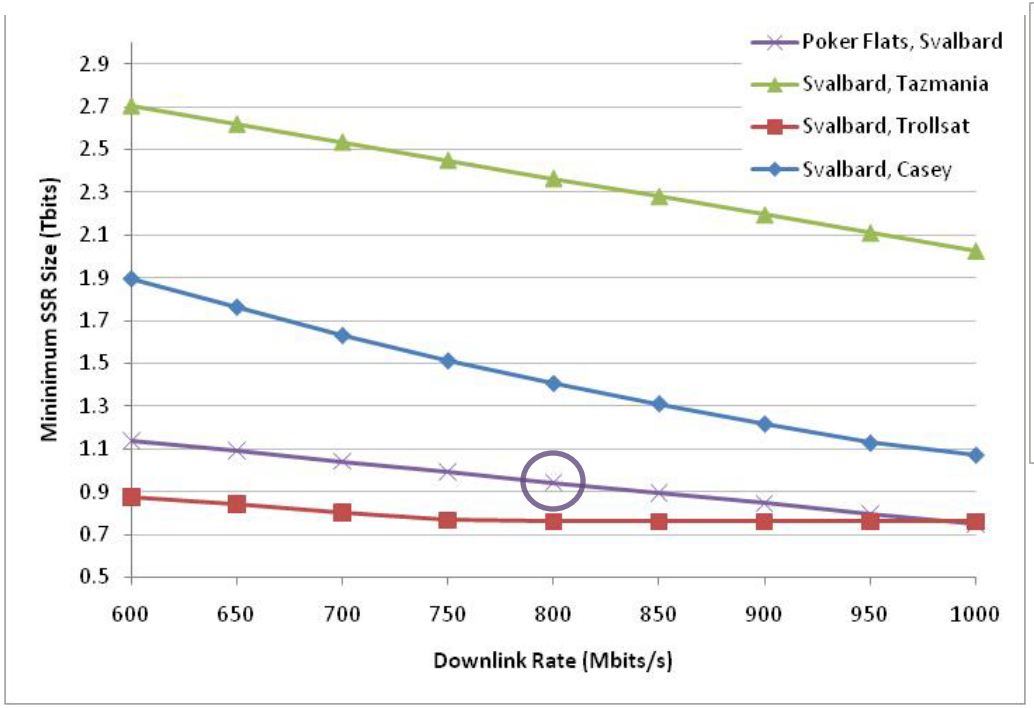


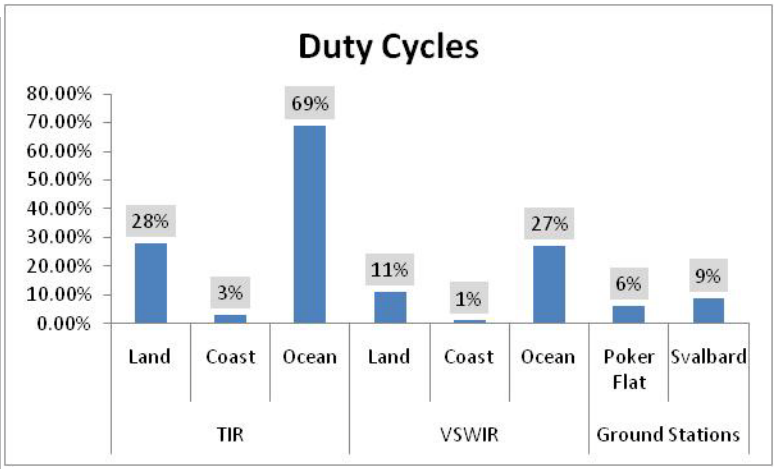
	Rate (Mbps)	On-board Compression
VSWIR: land	804.1	3:1
VSWIR: shallow	865.9	3:1
VSWIR: ocean	3.9	3:1
TIR: land	130.2	2:1
TIR: shallow	130.2	2:1
TIR: ocean	0.6	2:1

	Avg (Tb)	Min (Tb)	Max (Tb)
Per Day	4.64	3.59	5.29
Per Orbit	0.31	0.00	0.81

Total data volume for the 3 year mission: 5024 Tbits

SSR Sizing





- 5° ground station mask
- 10 second acquisition time
- Any pass shorter than 250 seconds (incl. acquisition time) is not used
- 20 Deg VSWIR sun illumination angle constraint

	Rate	On-board Compression
VSWIR_land	804.1 Mb/s	3:1
VSWIR_shallow	865.9 Mb/s	3:1
VSWIR_ocean	3.9 Mb/s	3:1
TIR_land	130.2 Mb/s	2:1
TIR_shallow	130.2 Mb/s	2:1
TIR_ocean	0.6 Mb/s	2:1

Wrap Factors	
Contingency	30%
Overhead	10%

Ground Station Options

Stations (Dlink rate Mbps)	# passes per year	# of passes per day	SSR Size [Tb]	Minimum Pass Duration [min]
Svalbard (800)	4783	13.1	2.6	4
Svalbard (800)	5398	14.8	2.2	0.5
Svalbard (800) + Poker Flat (800)	5879	16.1	1.9	8
Svalbard (800) + Poker Flat (800)	7375	20.2	1.3	6
Svalbard (800) + Poker Flat (800)	8375	22.9	0.9	4
Svalbard (800) + Poker Flat (800)	9106	24.9	0.9	0.5

Link Assumptions

Spacecraft To Ground

- 800 Mbps dual-pol X band to Poker Flat and Svalbard
- Analysis performed over one year of data
  - Assumes a 5 degree elevation mask at each ground station
  - Assumptions for contact threshold
    - 10 s acquisition time subtracted from each access
    - Throw out any contacts that are shorter than 4 minutes (after 10 s acquisition is subtracted)
- 1.67 Petabits of data must be downlinked each year
- Require 8375 contacts per year of varying duration (in minutes)
  - Minimum: 4, Maximum: 10.5, Mean: 10.4

Ground to Ground

- All data needs to be transferred to a science data processing center at JPL within 2 weeks of downlink
- Occasional high priority requests for a limited volume of regional data to JPL within 6-48 hours of downlink

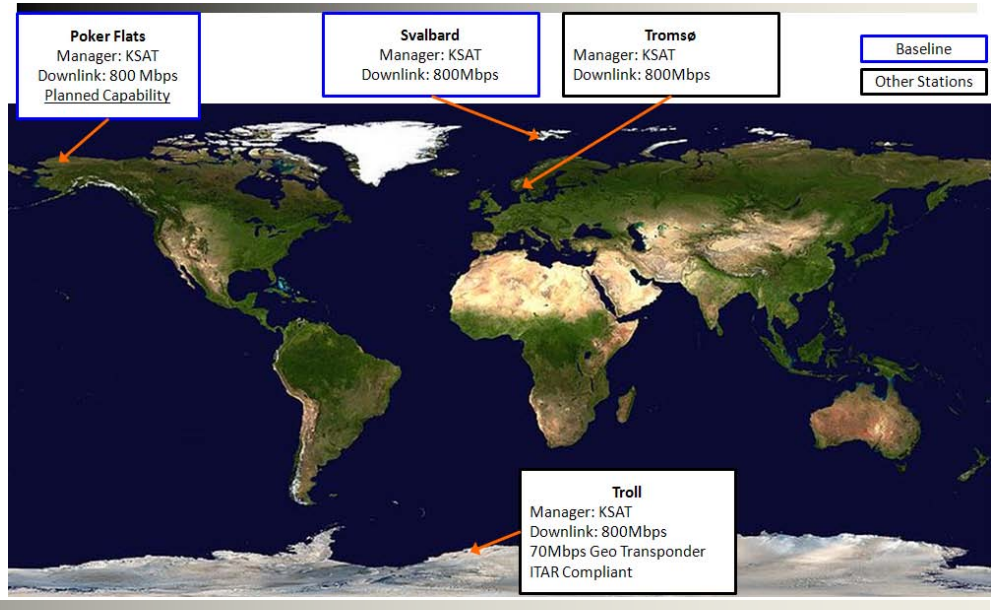
Managing Data Volume

Robust On-Board Storage

- On-board storage capacity
  - 1 Tb
    - 0.33 Tb/orbit
  - WorldView-1 and -2 have 2.2 Tb SSR
    - WorldView1: 0.33 Tb/orbit
    - WorldView2: 0.52 Tb/orbit
- 30% margin added to calculated required SSR size

Robust Downlink Design

- Downlink method
  - 800 Mbps, dual-pole X-band to Svalbard and Poker Flat (KSAT)
    - WorldView-1 and GeoEye-1 use similar downlink architecture
- Ground communications / latency
  - Back end infrastructure does not need upgrading to ensure timely delivery of data



Summary

All Coverage, data management and downlink requirements met with baseline architecture:

- Revisit and Coverage:
  - 626 km altitude with VSWIR 150 km swath and TIR 600 km swath
- Data Rate / Data Volume / SSR Size
  - Svalbard and Poker Flat provide enough accesses to get down all 1674 Tb per year with a minimized SSR size

BACK UP

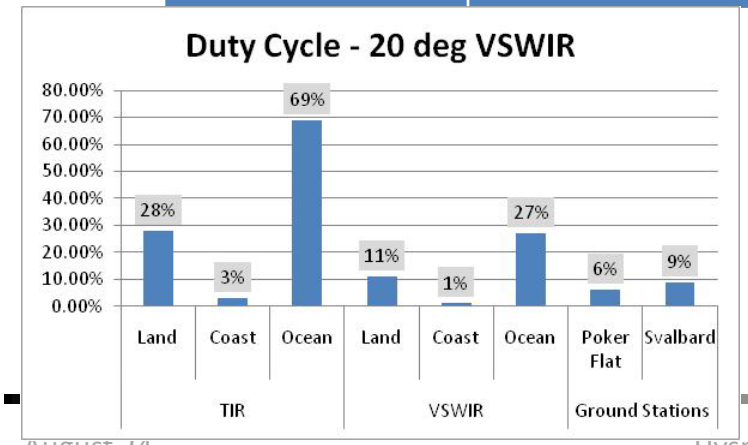
Crude Sanity Check on Data Volume

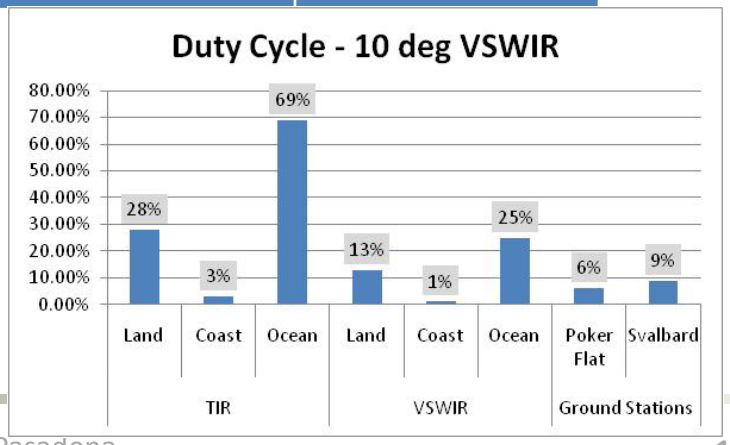
	Units	VSWIR			TIR		
		Land	Coast	Ocean	Land	Coast	Ocean
Uncompressed Data Rate	Mbps	804	866	4	130	130	1
Compression Factor		3	3	3	2	2	2
Compressed Data rate	Mbps	268	289	1	65	65	0.3
Duty Cycle	%	11%	1%	27%	28%	3%	69%
Data Volume Per Orbit	Tb	0.17	0.01	0.002	0.11	0.01	0.001
Total Data Volume Per Orbit	Tb	0.30					
Orbits Per Day		14.8					
Data Volume per Day	[Tb]	4.5					
Data Volume Per Year	[Tb]	1630					
Downlinks Per Year		8375					
Avg Downlinks Per Orbit		1.5					
Avg Downlink Duration	sec	621					
Downlink Rate	Mbps	800					
Available Downlink Vol.	Tb/year	4162.911					

VSWIR Solar Constraint

- 800 Mbps dlink to Troll and Poker Flat

VSWIR min Solar illumination angle [deg]	Mission Data Volume [Tb per year]	VSWIR Land Duty Cycle [%]	VSWIR Ocean Duty Cycle [%]	SSR Size for no missed ground stations [Tb]
10	1904	13	27	1.0
20	1675	11	25	1.0
Difference	**229 (12 %)**	**2 (15%)**	**2 (7%)**	**0 (0%)**





Swath Overlap Calculation

VSWIR

starting at repeat	starting at swath with		
140.9436506	150.5	km	swath width crosstrack
142.2954768	151.9435	km	swath with along the equator
6378	6378	km	radius of earth at equator
40074.15589	40074.16	km	circumference at equator
281.626351	263.7438	passes	number of passes to get full coverage
5829	5829	sec per orbit	
86400	86400	sec per day	
14.82243953	14.82244	orbits per day	
14.82243953	14.82244	passes per day	
19	17.79355	days to cover (with one view of equator per orbit)	

Calculation Direction

Required to meet current requirements

Current Baseline

6.35%of a swath Overlap between swaths

TIR

starting at repeat	starting at swath with		
535.5859	599.5	km	swath width crosstrack
540.7228	605.25	km	swath with along the equator
6378	6378	km	radius of earth at equator
40074.16	40074.16	km	circumference at equator
74.1122	66.21092	passes	number of passes to get full coverage
5829	5829	sec per orbit	
86400	86400	sec per day	
14.82244	14.82244	orbits per day	
14.82244	14.82244	passes per day	
5	4.466938	days to cover (with one view of equator per orbit)	

Calculation Direction

Required to meet current requirements

Current Baseline

10.66%of a swath Mean overlap between swaths