

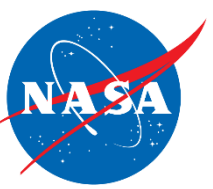
2018 HypsIRI Mission Concept Study: VSWIR, TIR, IPM Separate and Contemporaneous With Current Technology



Ernesto Diaz, Robert Green, Simon Hook, Bill Johnson, Peter Sullivan, Michael Mercury,
TeamX and HypsIRI Team

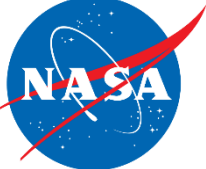
HypsIRI
Workshop 2018





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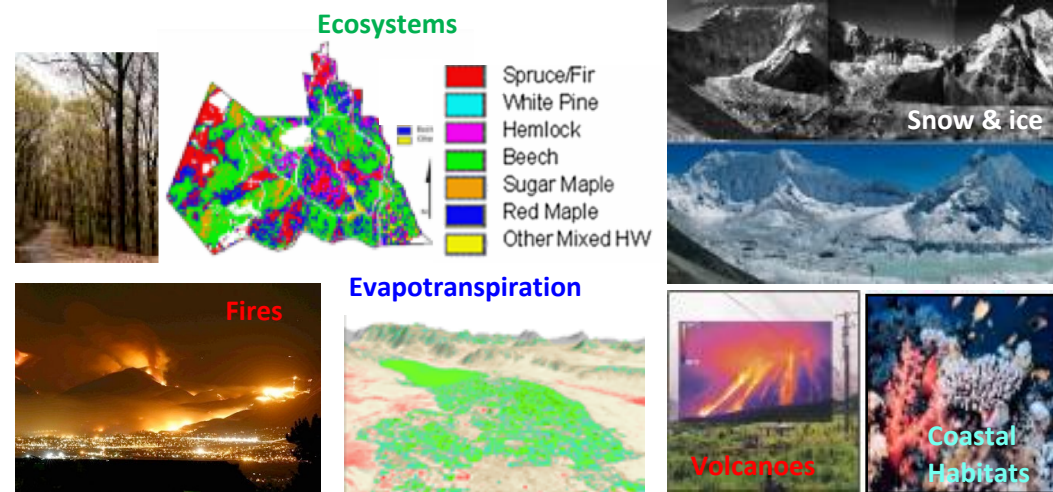
- Science Summary
- Mission Concept Lineage
- 2018 HypsIRI Baseline Concept Overview
- SmallSat Free Fliers
 - TIR SmallSat Free-Flier
 - VSWIR SmallSat Free-Flier
- Conclusion



HyspIRI Science Summary

HyspIRI Science

- **Climate:**
 - Ecosystem biochemistry, condition & feedback; spectral albedo; carbon/dust on snow/ice; biomass burning; evapotranspiration
- **Ecosystems:**
 - *Global* biodiversity, plant functional types, physiological condition, and biochemistry including agricultural lands
- **Fires:**
 - Fuel status; fire frequency, severity, emissions, and patterns of recovery *globally*
- **Coral reef and coastal habitats:**
 - *Global* composition and status
- **Volcanoes:**
 - Eruptions, emissions, regional and *global* impacts



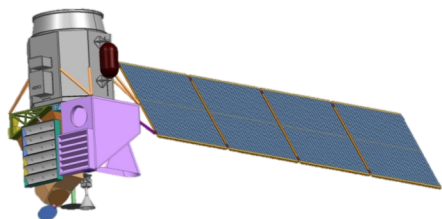
- **Geology and resources:**
 - *Global* distributions of surface mineral resources and improved understanding of geology and related hazards
- **Applications:**
 - Disasters, EcoForecasting, Health/AQ, Water

ECOSTRESS & Preparatory airborne campaigns have been advancing and refining science, applications, algorithms, and processing



Mission Concept Lineage

- **Level 1 Measurement Requirements**
 - Vetted by community at workshops and in literature (many refereed journal articles)
- **Implementation options:**

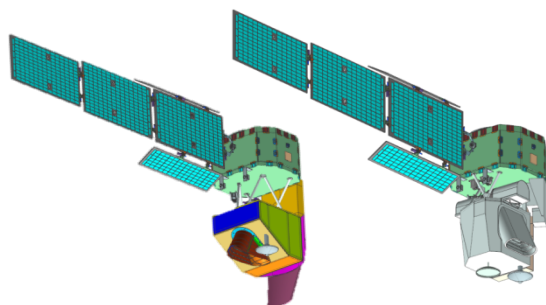


**Original HypsIRI Baseline
(2012)**

VSWIR 60 m / 19 day

TIR 60 m / 5 day

3-5 years

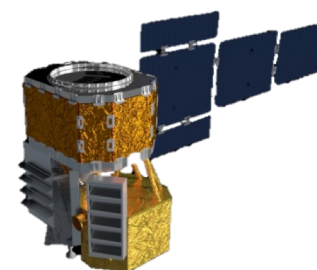


**SmallSat Free-Fliers
(2015)**

VSWIR 30 m / 16 day

TIR 60 m / 4 day

2 years

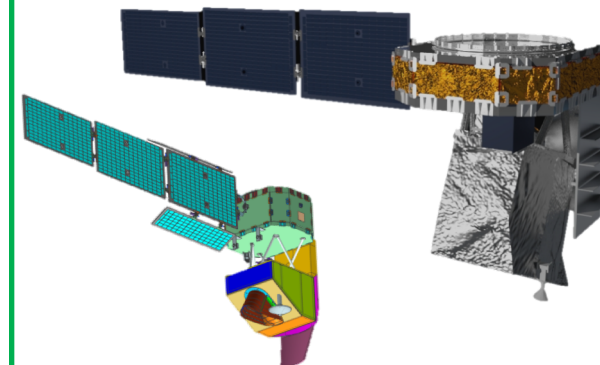


**Updated HypsIRI Baseline
(2016-2018)**

VSWIR 30 m / 16 day

TIR 50 m / near 4 day

3-5 years



**UPDATED
SmallSat Free-Fliers
(2018)**

VSWIR 30 m / 16 day + Pointing

2 years

TIR 50 m / 4 day

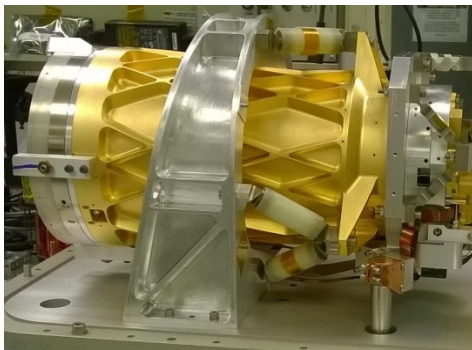
4 years



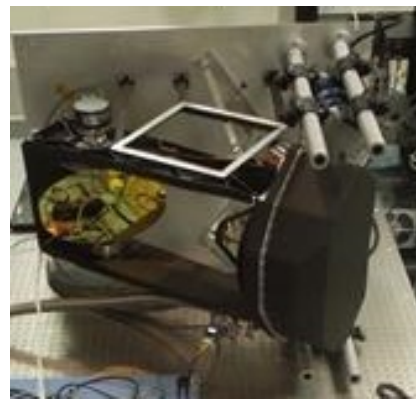
2018 HypIRI Baseline

Contemporaneous Concept Overview

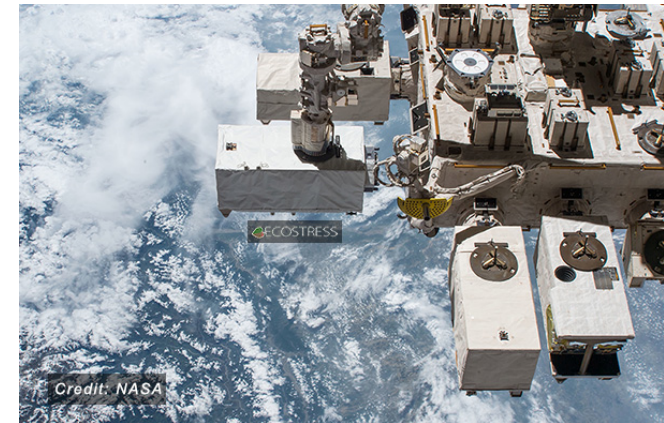
- Based on updated 2016-2018 Mission Concept Goal
 - Update the HypIRI mission concept baseline to use the latest developments in instrument, spacecraft and ground systems.
 - Use only existing technology
 - CWIS has brought the latest VSWIR to \geq TRL 6
 - PHyTIR, ECOSTRESS have brought latest TIR to \geq TRL 6-9
 - IPM based on Space cube 2.0 \geq TRL 6
 - Flight system, Ground System and Science Data System all use existing technology

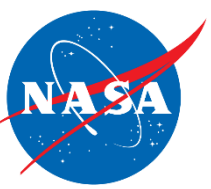


Dyson (CWIS)



PHyTIR

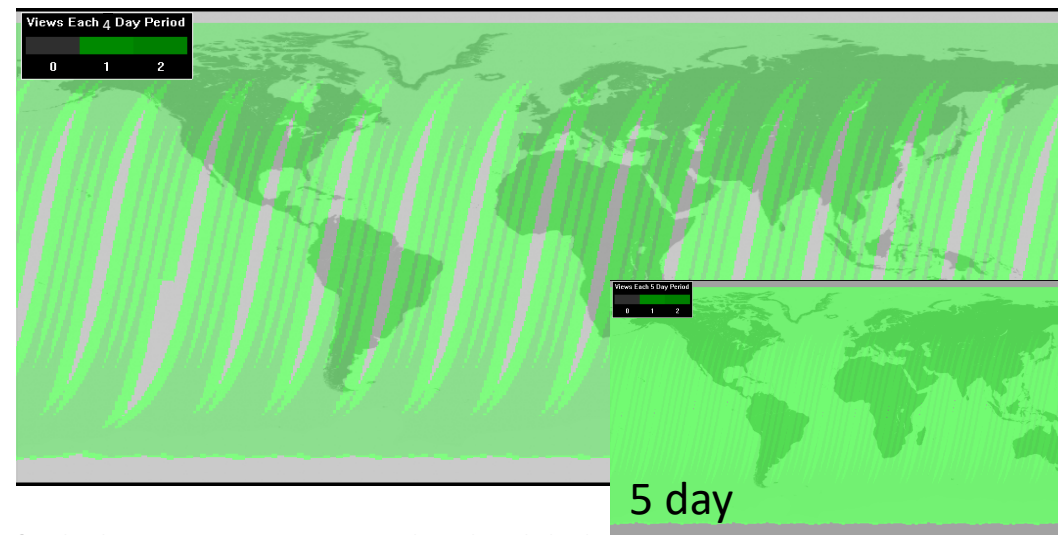




Orbit and Coverage

504 km Sun Synchronous Orbit (10:30 AM LMTDN)

- 16 day global coverage for VSWIR
- 4 day near-global coverage for TIR
 - Full coverage in 5 days





HyspIRI Payload

- VSWIR

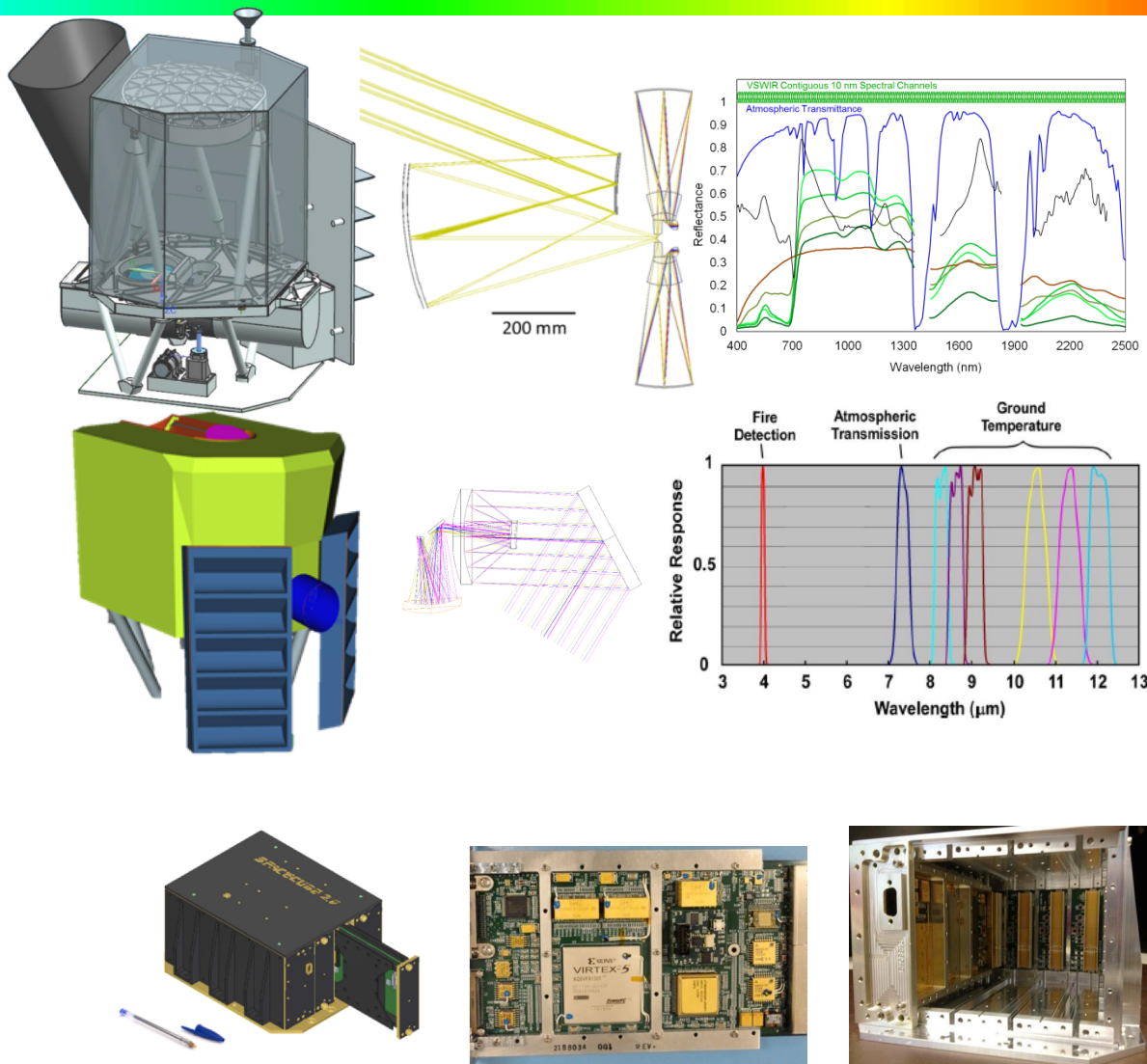
- 2x CWIS Dyson spectrometers
- 185 km swath
- 30 m resolution

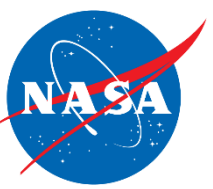
- TIR

- PhyTIR Demo on ECOSTRESS
- 518 km swath
- 50 m resolution

- IPM

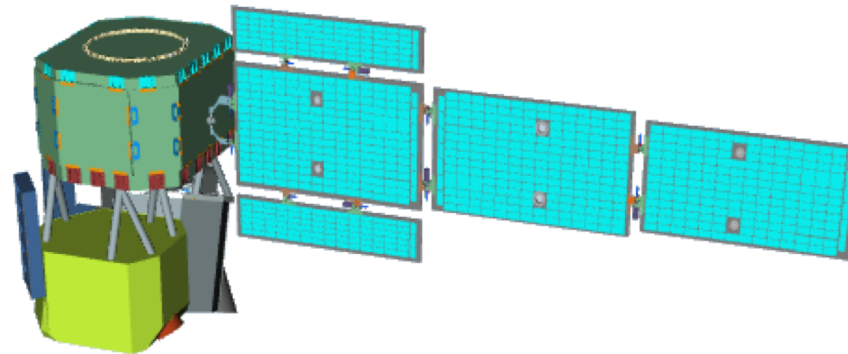
- Four Card Flight Unit
- 5 x 7 x 9 inches

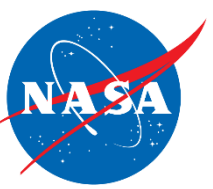




Spacecraft Payload Capability

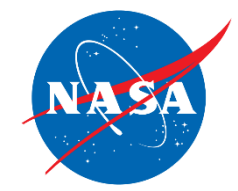
- Solutions from multiple vendors can accommodate payload (CBE):
 - 200 kg
 - 290 W
 - 450 Gb / orbit
 - 400 GB onboard storage (7 nominal orbits worth of storage)
 - Pointing (3 sigma):
 - 36 arcsec knowledge
 - 6 arcsec/frame stability
 - 0.25 deg control





Telecom, MOS/GDS, Onboard/Ground Processing

- Telecom Link
 - 1 Gbps Ka-Band single polarization link using QPSK modulation
 - Uses Ka Modulator (KAM) and Solid State Power Amplifier (SSPA) developed for NISAR Program (Launch in 2020)
 - 2 axis gimbal to maximize downlink time per orbit
- MOS/GDS
 - HyspIRI preparatory campaign data system experience
 - Uses ground stations operated by KSAT through the NEN in Svalbard and Antarctica
 - Ka-band already in use at those locations
- Onboard Processing
 - 4:1 Fast lossless compression (Klimesh, Kiely, Yeh)
 - Cloud screening using 0.45 and 1.25 μm channels (Thompson et al.)
- Ground processing
 - HyspIRI airborne preparatory campaign pipeline demonstrated



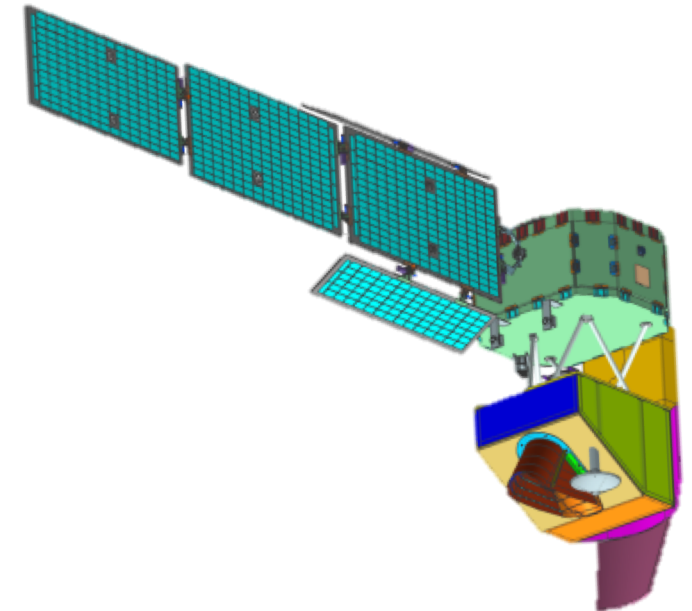
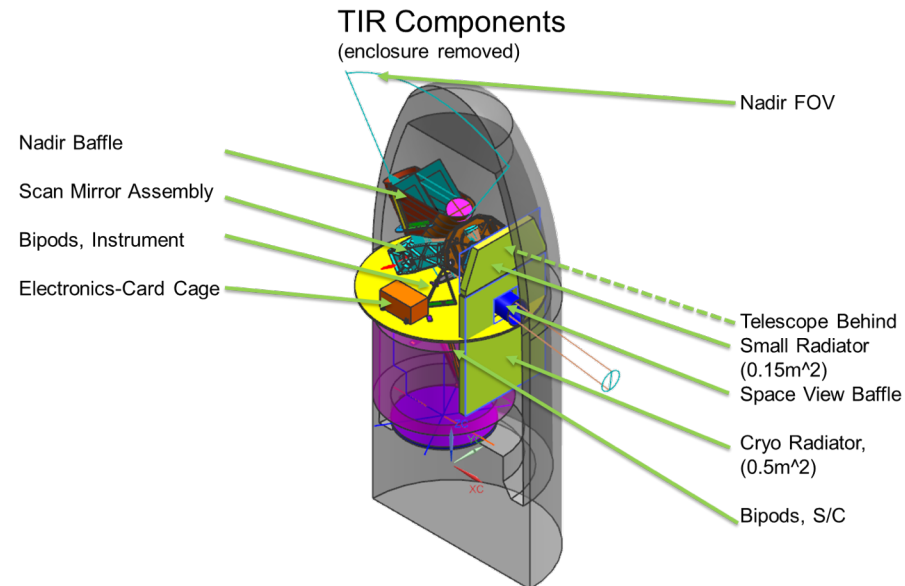
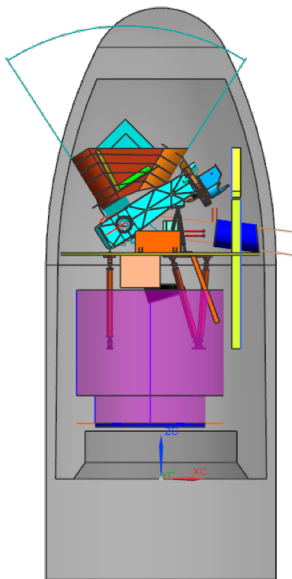
SmallSat Free-Fliers

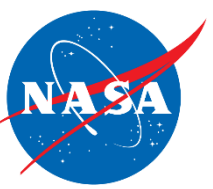


TIR

SmallSat Free-Flier

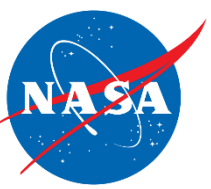
- All-reflective, compact telescope, Scanning mirror
 - 13.3um HgCdTe, PHyTIR/ECOSTRESS ROIC
 - 8 Thermal bands
 - FPA capability proven in ECOSTRESS ISS instrument
- Instrument is integrated with a commercial bus launched into a 503 km orbit
 - 4 day revisit
 - 50m Nadir Resolution





TIR Instrument Configuration

- Optics and Detector
 - All-reflective, compact telescope, Scanning mirror, 13.3um HgCdTe, PHyTIR/ECOSTRESS ROIC
- Electronics
 - Instrument electronics modeled after OCO-3 + ECOSTRESS
- Thermal
 - NGAS high efficiency cryocooler and electronics
 - Passive radiator to cool FPA housing
 - Larger radiator to reject cryocooler and instrument electronics heat
 - Ops heaters, survival heaters, PRTs
- Mass:
 - 102 kg w/ contingency
- Power:
 - 184 Watts w/ contingency
- Data Rate
 - ~55 Mbps orbit average data rate
 - ~0.546 Tb data volume worst-case per orbit



TIR

SmallSat Free-Flier

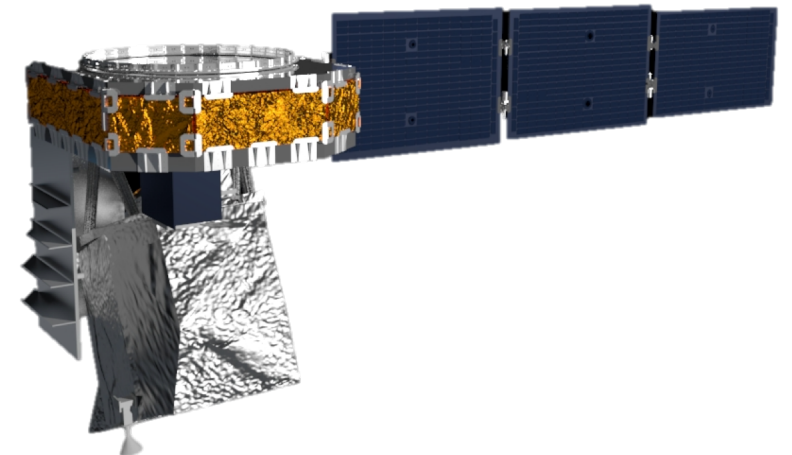
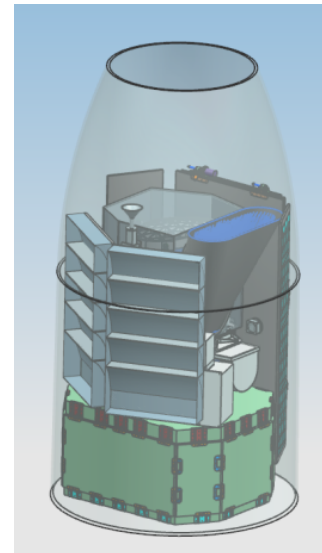
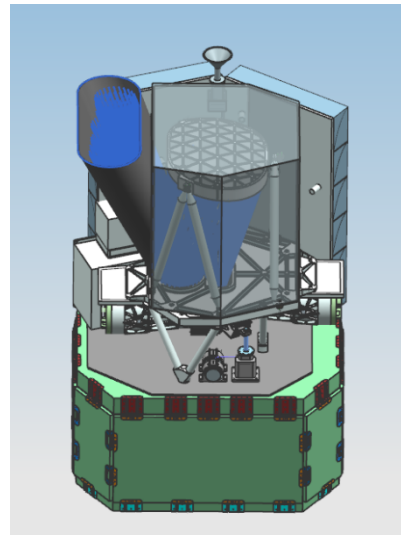
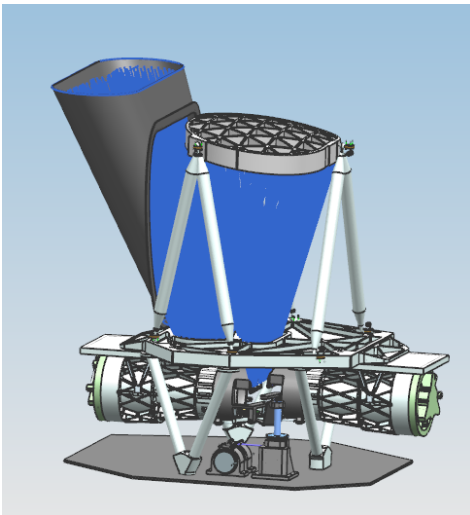
- Observational Scenarios
 - Day and night land and coastal regions at 50 m resolution
 - Oceans at 1 km resolution
 - Sun-synchronous (descending), overpass time 11:00 +/-30min
- Ground Network
 - 7.3m S/X/Ka-band KSAT stations at Svalbard and Trollsat
 - Lossless compressed data can be downlinked with two 7-minute passes per orbit
 - This uses a solution that is a subset of the NISAR implementation
- FPA designed specifically for HySpIRI TIR instrument
- FPA performance/capability demonstrated by ECOSTRESS instrument
- Software heritage from ECOSTRESS
 - Use of standard interface (cPCI, RS-422)
 - Reduced bandwidth on the processor and bus
 - Compression algorithm in firmware

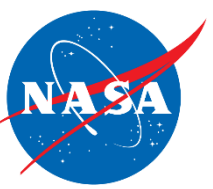


VSWIR

SmallSat Free-Flier

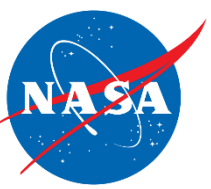
- Two F/1.8 Compact Dyson-VSWIR Imaging Spectrometer (380 to 2510 nm)
 - CWIS like design
 - Two CHROMA-D ROIC – 3K x 512 pixels; 18 μm pixels
- Instrument is integrated with a commercial bus launched into a 429 km SSO
 - Pegasus XL with a 16-day revisit
 - 185 km with 30 m sampling





VSWIR Instrument Configuration

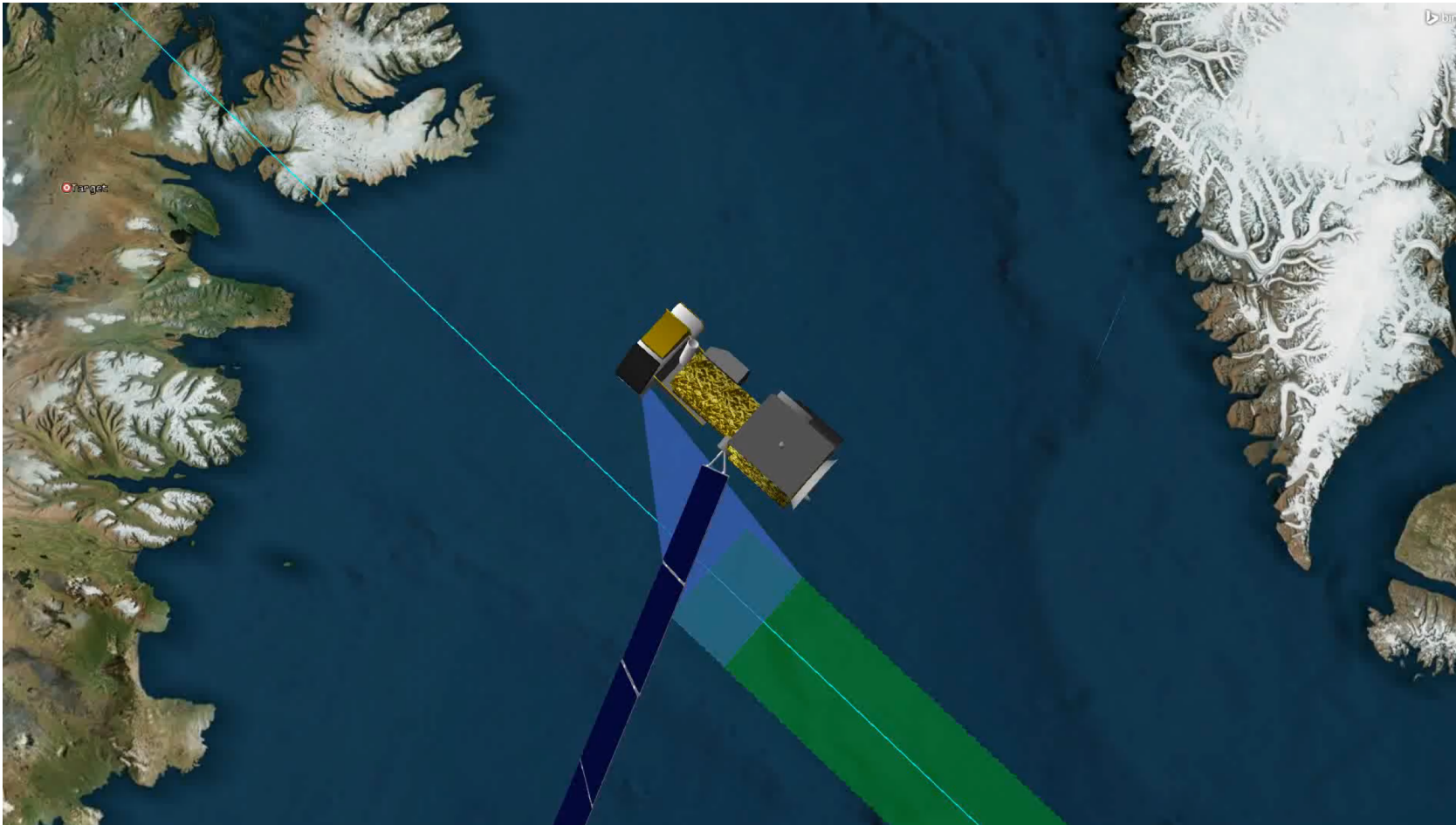
- Instrument configuration includes:
 - Telescope assembly
 - 2 Dyson spectrometers
 - Single cryocooler and electronics
 - Thermal heaters/sensors
 - Passive radiator
 - IPM and instrument electronics
- Mass: 129 kg with contingency
- Power: 117 W
- Data Rate
 - 1 Gbps peak SSR write from C&DH unit (IPM read/write TBD)
 - ~375 Gbit/sec orbital average data accumulation rate

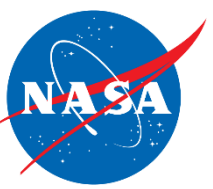


VSWIR

SmallSat Free-Flier

- Ability to select specific revisit targets (e.g. estuaries, lakes) and targets of opportunity (e.g. active volcanoes and forest fires)

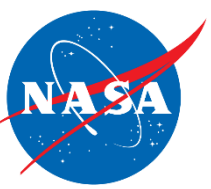




VSWIR

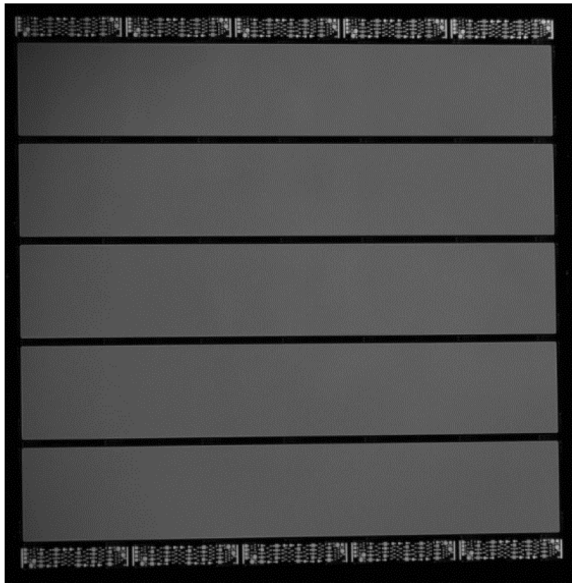
SmallSat Free-Flier

- Onboard Processing
 - 4:1 Fast lossless compression (Klimesh, Kiely, Yeh)
 - Cloud screening using 0.45 and 1.25 μm channels (Thompson et al.)
 - C&DH passes data from SSR to IPM for processing; writes L2 science data products from IPM back to SSR
 - S/C downlinks SSR-stored data to ground station
- Ground processing
 - HypsIRI airborne preparatory campaign pipeline demonstrated
- The subsystem design, accommodation, interface, heritage, and technology readiness are adequate:
 - CHROMA-D ROIC is based on the heritage designs from 6604A / CHROMA ROICs
 - Electronics design based on EVI-4 selected EMIT
 - Flight Performance Heritage from ARTEMIS / M3 (among others)

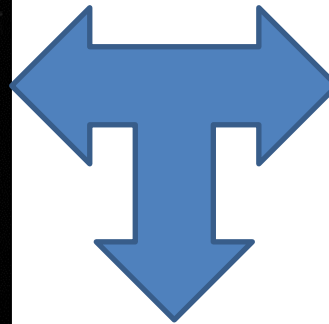
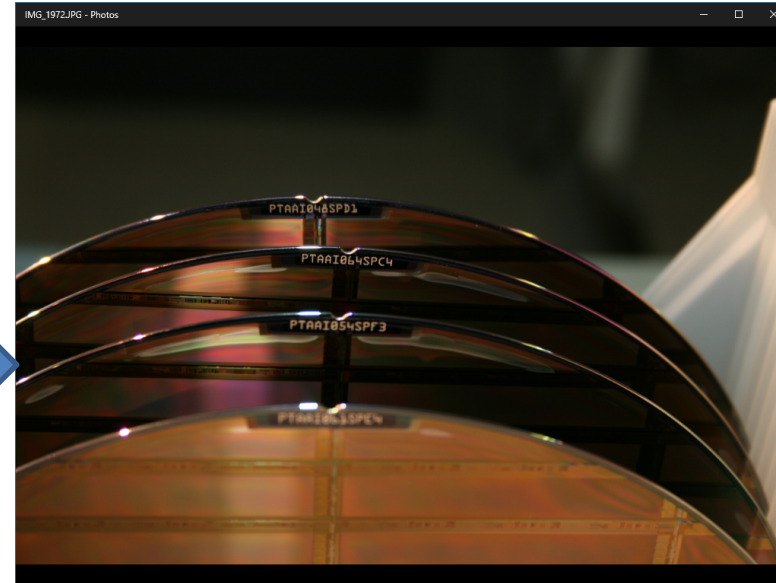


CHROMA-D - 2017

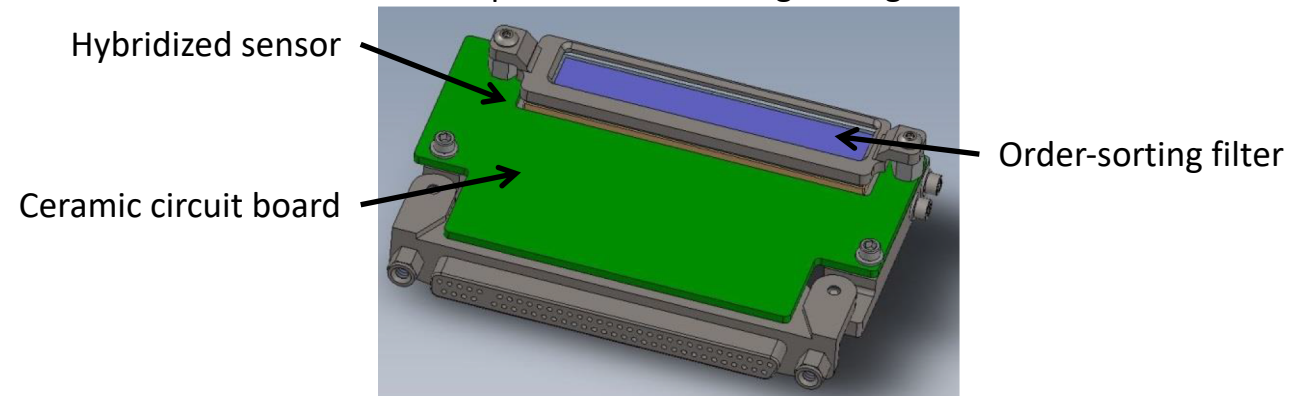
HgCdTe grown in 3072x512 format

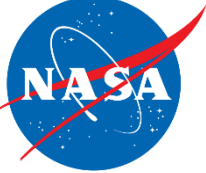


Existing 3072x512 ROICs have been probe-tested



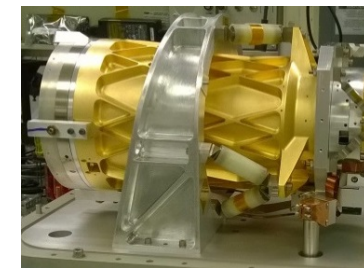
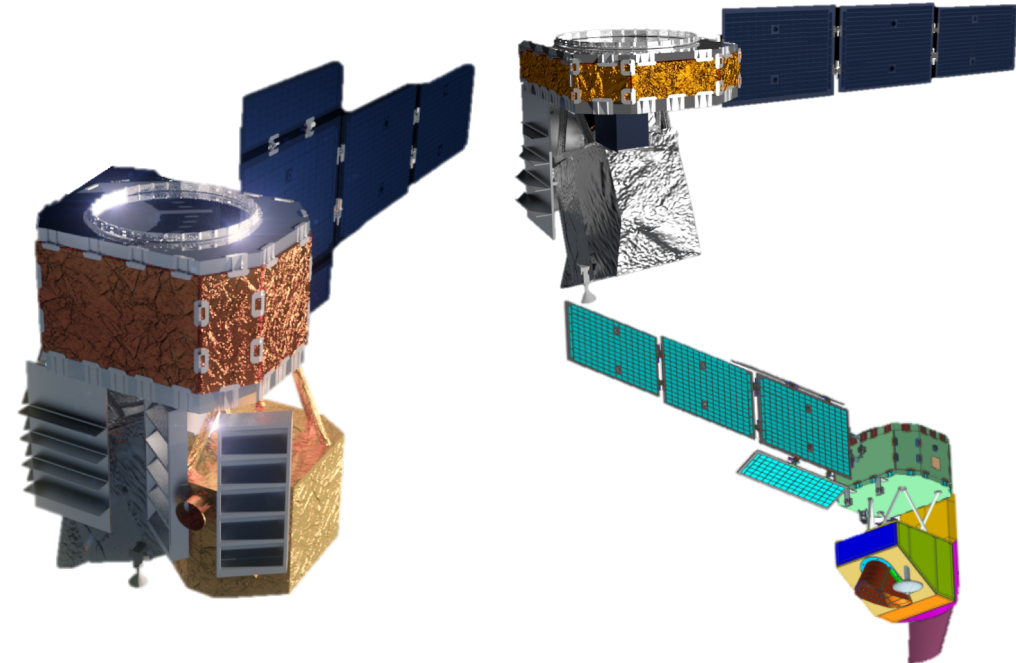
Concept 3072x512 Package Design



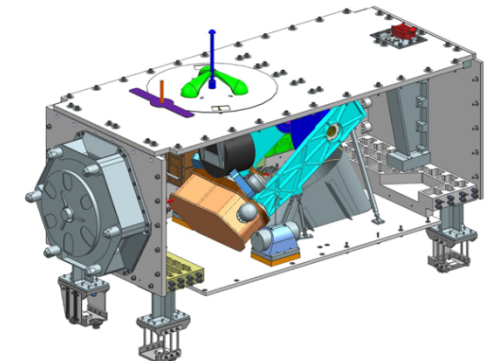


Conclusion

- 2018 HypIRI Mission Concepts:
 - Contemporaneous
 - VSWIR: 16 day / 30 m
 - TIR: near 4 day / 50 m
 - Separate but contemporaneous Free-Fliers
 - VSWIR 30 m / 16 day + Pointing
 - TIR 50 m / 4 day
- Enabled by:
 - Existing technologies
 - Onboard data compression and cloud screening
 - Proven Ka-Band link to ground
- Builds upon:
 - ECOSTRESS EV-I selected instrument on ISS
 - CWIS Spectrometer development
 - Detector development
 - EVI-4 selected EMIT (ISS)
 - HypIRI Airborne Preparatory Campaign



(CWIS)



ECOSTRESS