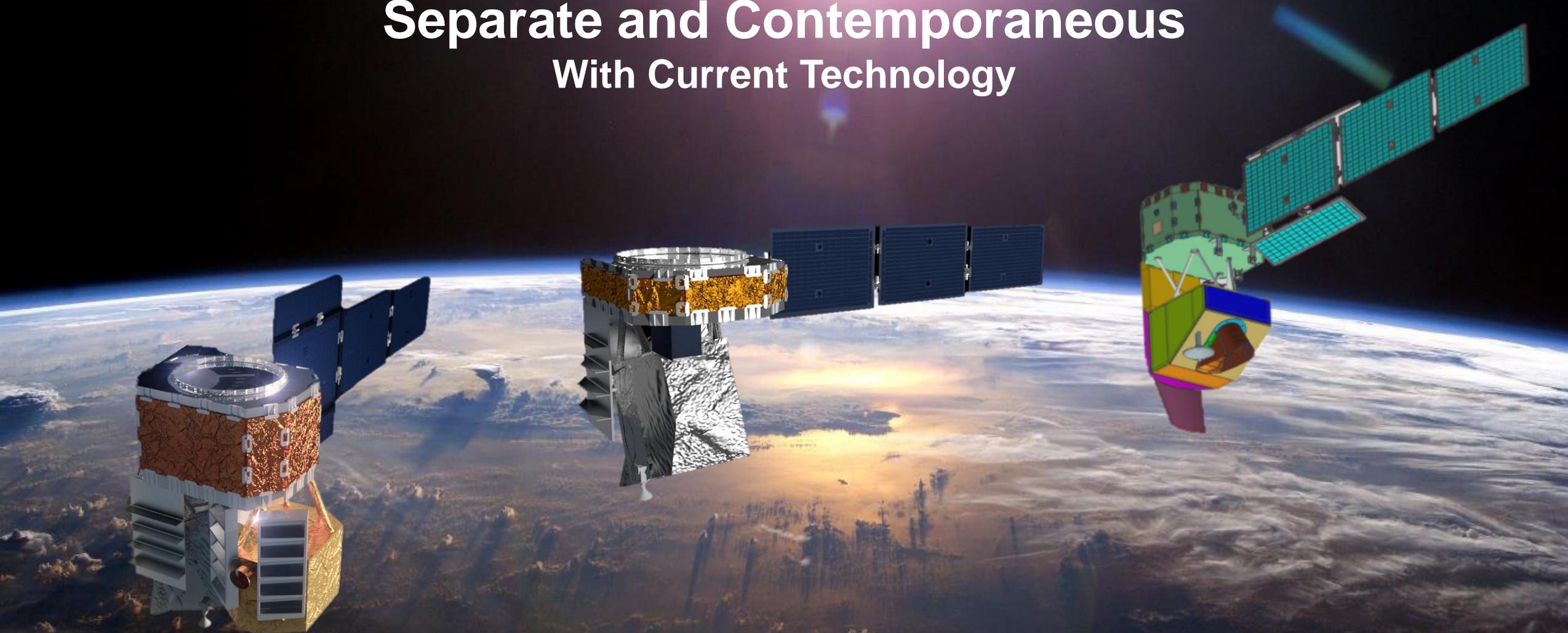


# 2018 HypIRI Mission Concept Study: VSWIR, TIR, IPM Separate and Contemporaneous With Current Technology



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HypIRI  
Workshop 2018





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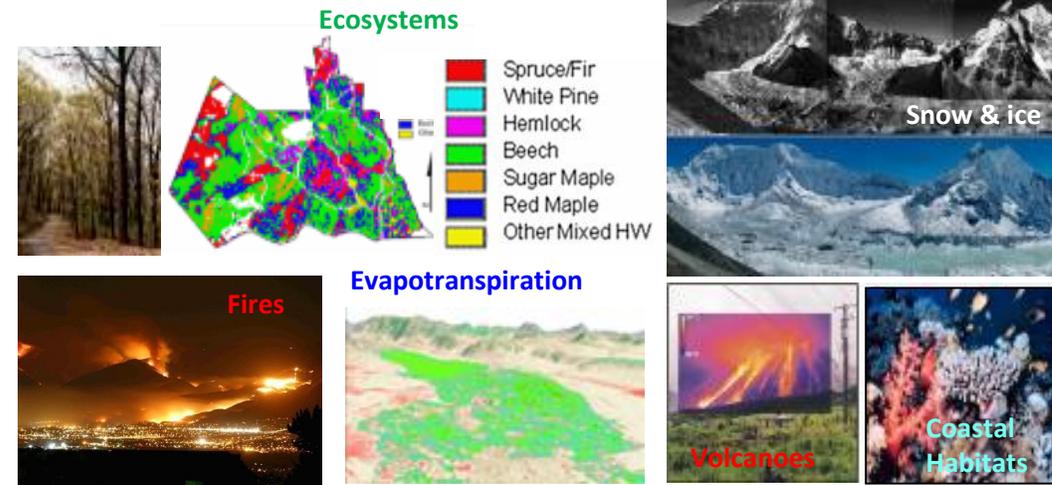
- Science Summary
- Mission Concept Lineage
- 2018 HypsIRI Baseline Concept Overview
- SmallSat Free Fliers
  - TIR SmallSat Free-Flier
  - VSWIR SmallSat Free-Flier
- Conclusion



# 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



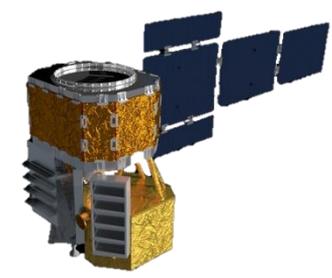
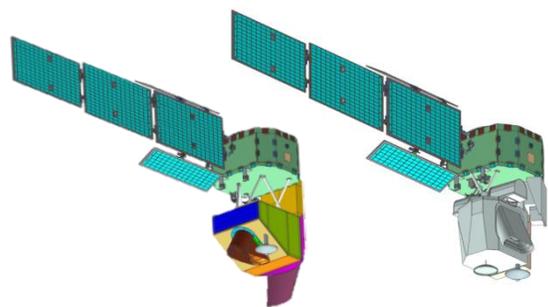
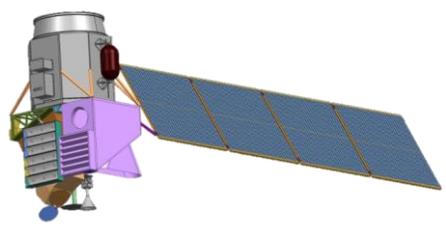
- **Geology and resources:**
  - *Global* distributions of surface mineral resources and improved understanding of geology and related hazards
- **Applications:**
  - Disasters, EcoForecasting, Health/AQ, Water

**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

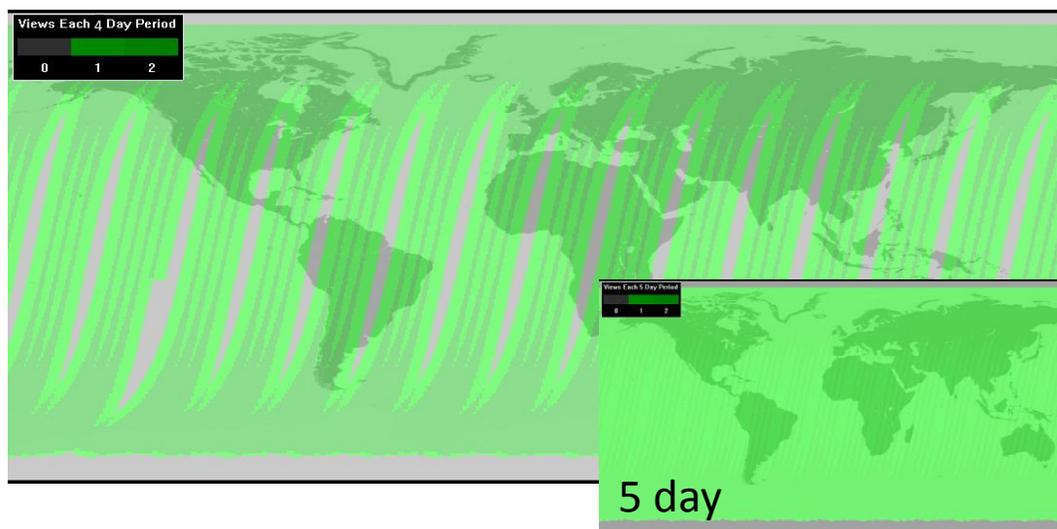




# Orbit and Coverage

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

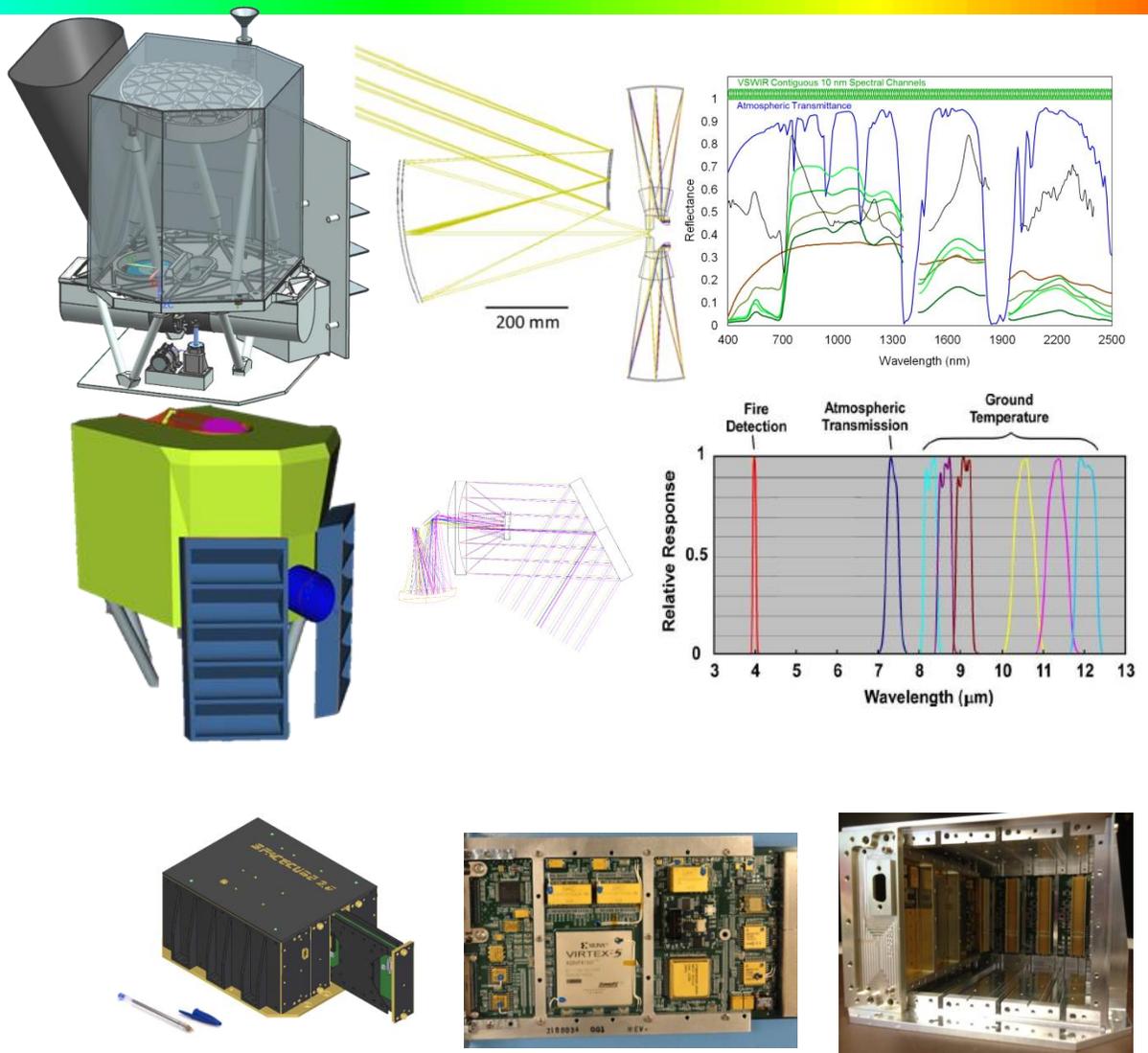
- 2x CWIS Dyson spectrometers
- 185 km swath
- 30 m resolution

- TIR

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

- IPM

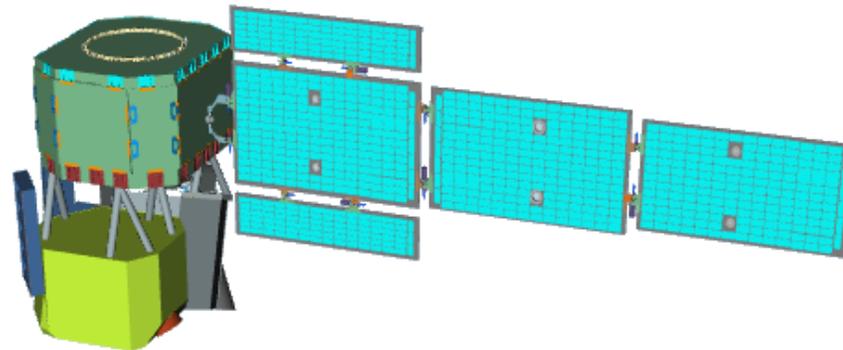
- Four Card Flight Unit
- 5 x 7 x 9 inches





# Spacecraft Payload Capability

- Solutions from multiple vendors can accommodate payload (CBE):
  - 137 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
  - HypIRI 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  $\mu\text{m}$  channels (Thompson et al.)
- Ground processing
  - HypIRI airborne preparatory campaign pipeline demonstrated

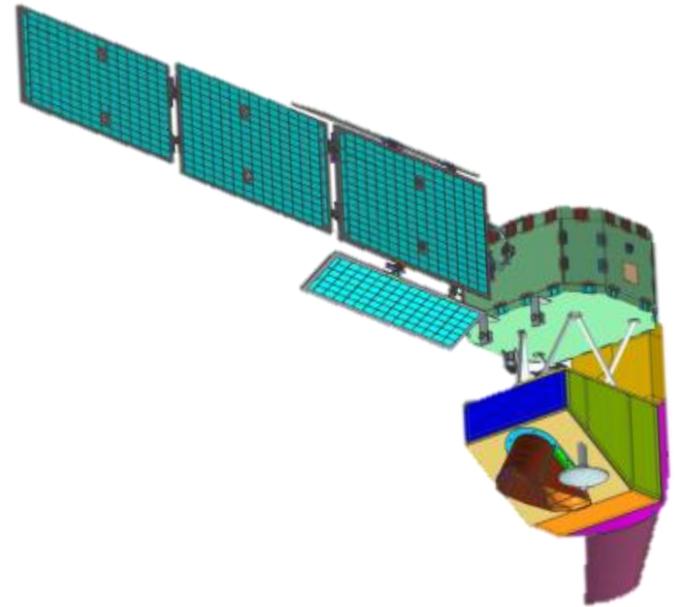
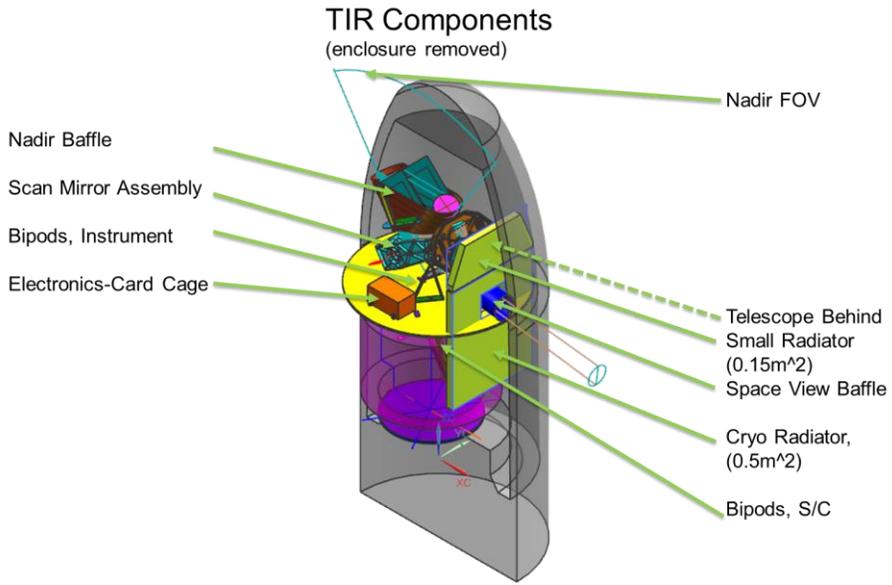
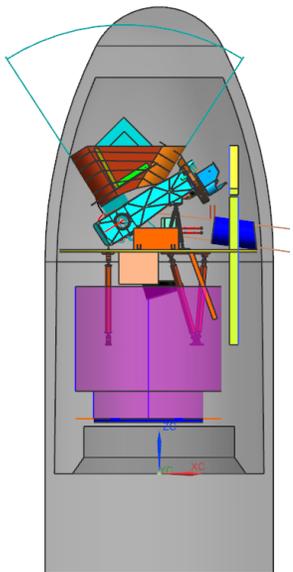


# SmallSat Free-Fliers



# 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

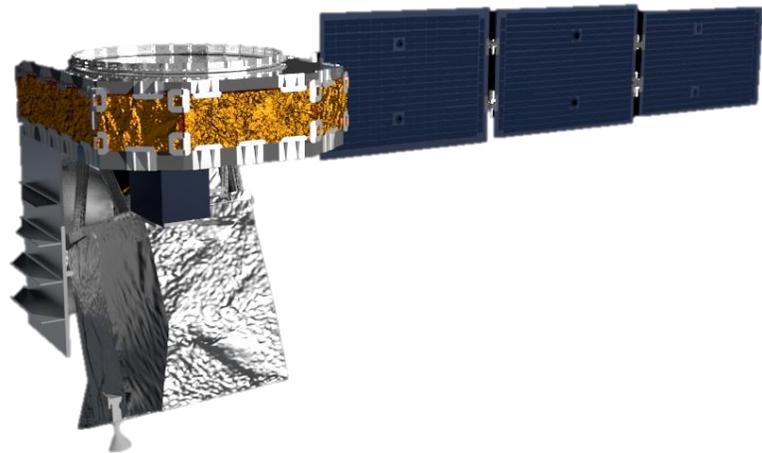
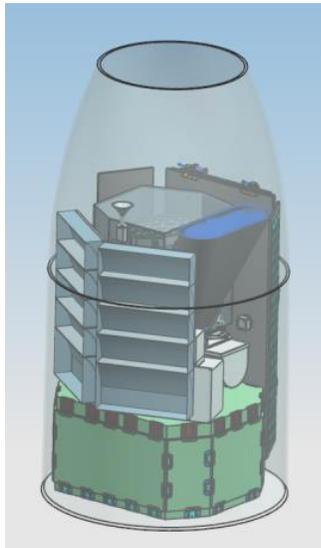
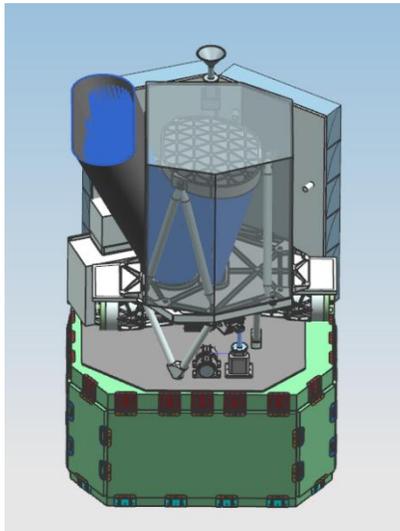
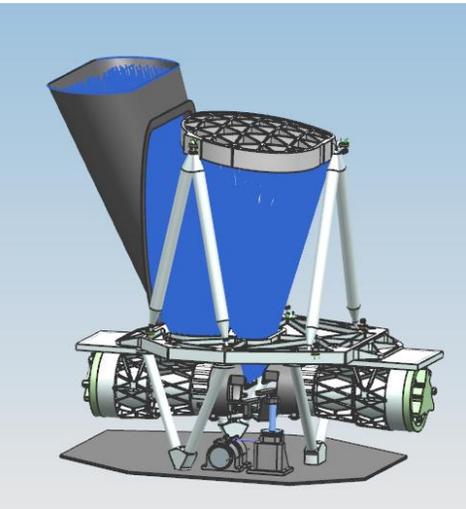
- Observational Scenarios
  - Day and night land and coastal regions at 50 m resolution
  - Oceans at 1 km resolution
  - Sun-synchronous (descending), overpass time 11:00 +/-30min
- Ground Network
  - 7.3m S/X/Ka-band KSAT stations at Svalbard and Trollsat
  - Lossless compressed data can be downlinked 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 um 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

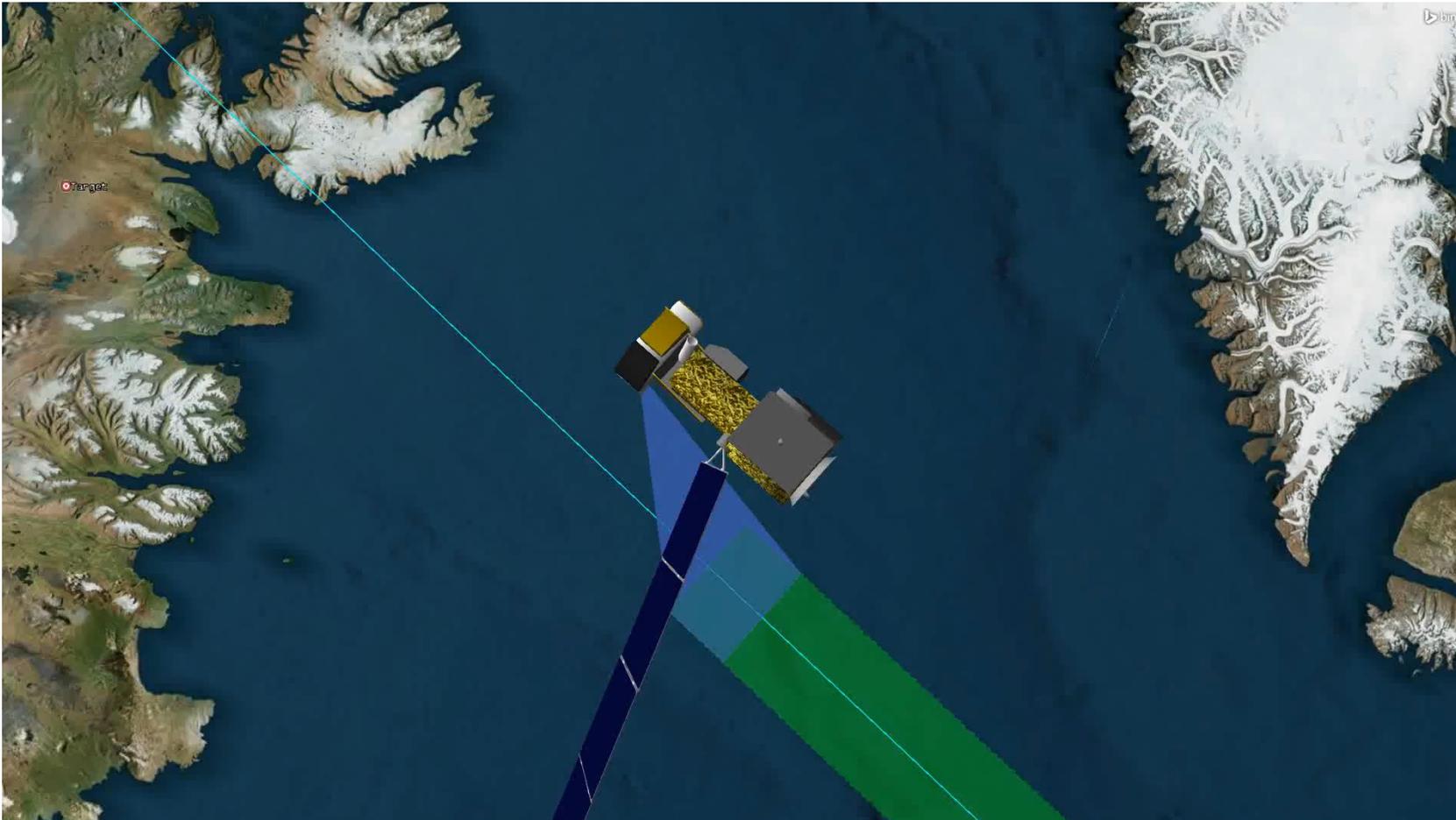
- Instrument configuration includes:
  - Telescope assembly
  - 2 Dyson spectrometers
  - Single cryocooler and electronics
  - Thermal heaters/sensors
  - Passive radiator
  - IPM and instrument electronics
- Mass: 129 kg with contingency
- Power: 117 W
- Data Rate
  - 1 Gbps peak SSR write from C&DH 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

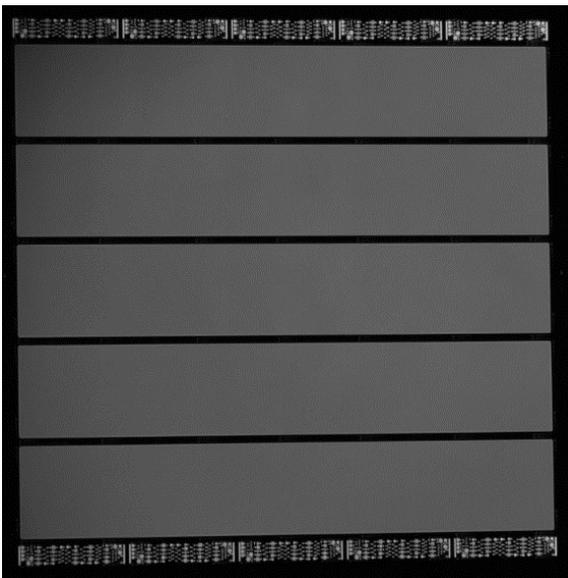
## SmallSat Free-Flier

- Onboard Processing
  - 4:1 Fast lossless compression (Klimesh, Kiely, Yeh)
  - Cloud screening using 0.45 and 1.25  $\mu\text{m}$  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)

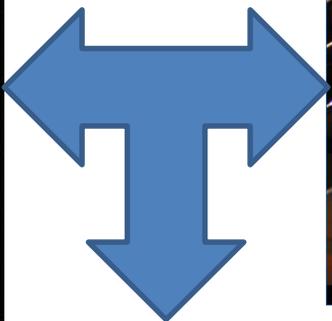
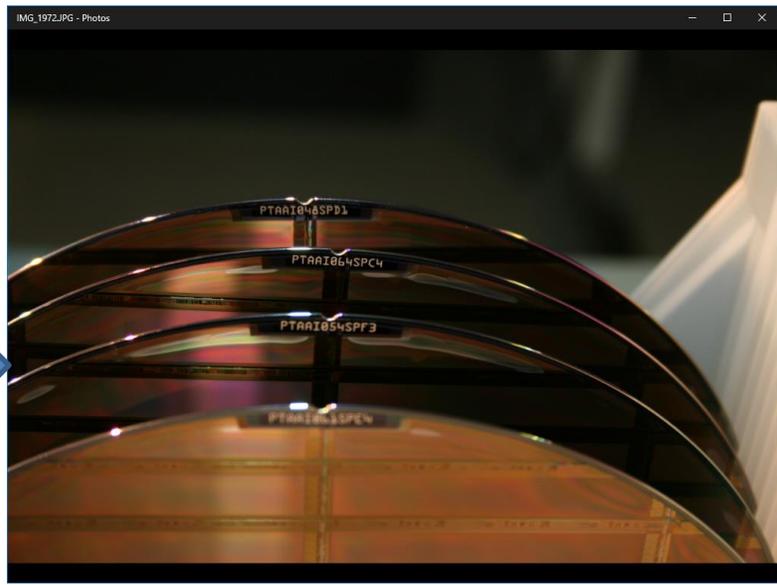


# CHROMA-D - 2017

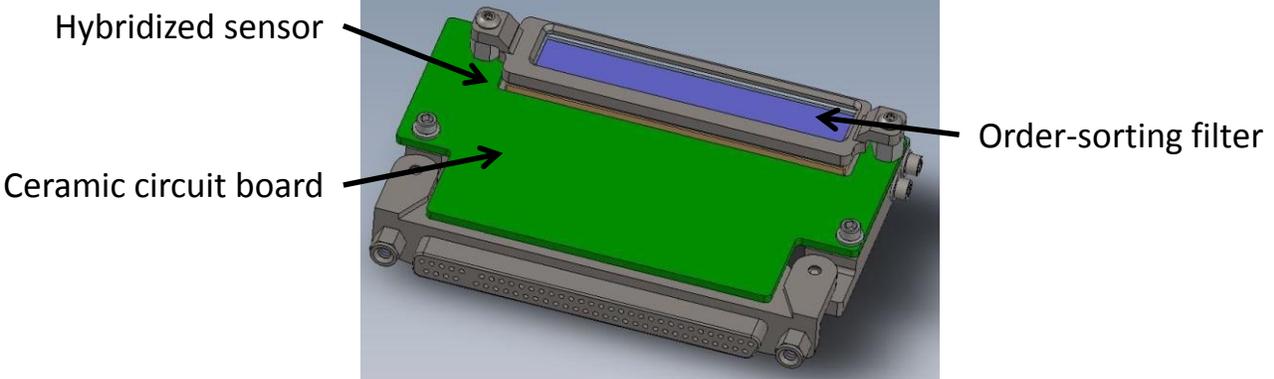
HgCdTe grown in 3072x512 format



Existing 3072x512 ROICs have been probe-tested



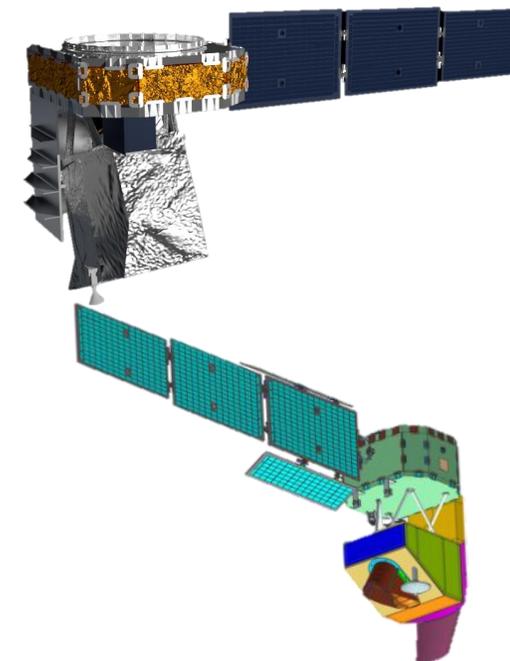
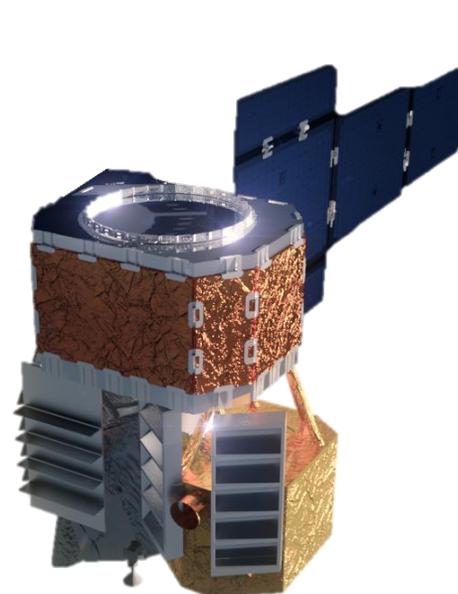
Concept 3072x512 Package Design



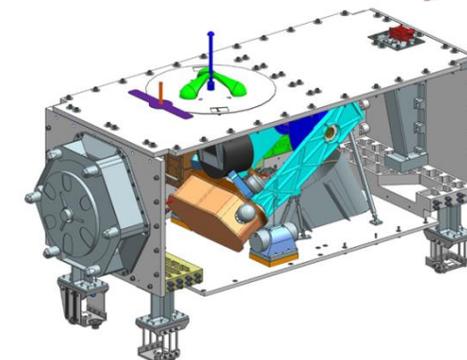


# Conclusion

- 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