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μPanFTS – a GEO Hosted Instrument for Weather Forecasting

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NESDIS NSOSA Study
80-Series Architecture

Page 26, "Hybrid architectures support their GEO instruments as a mixture of commercially hosted payloads and traditional US Government satellites… significant cost advantages to using commercial hosting when the instruments are designed to be hostable and a wide range of hosting opportunities are available."

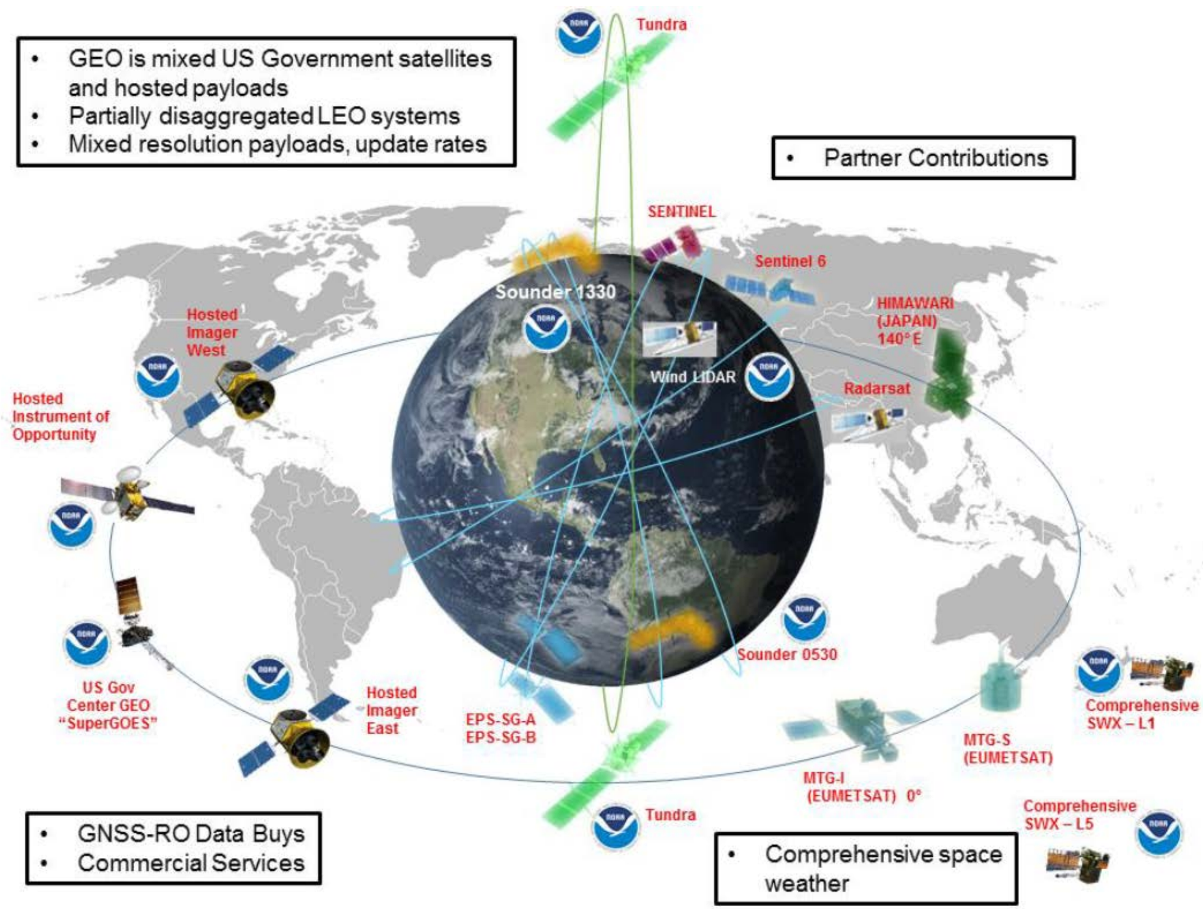

Figure 9 - 80-Series Hybrid Architecture Exemplar Constellation.

Panchromatic imaging Fourier Transform Spectrometer (PanFTS)

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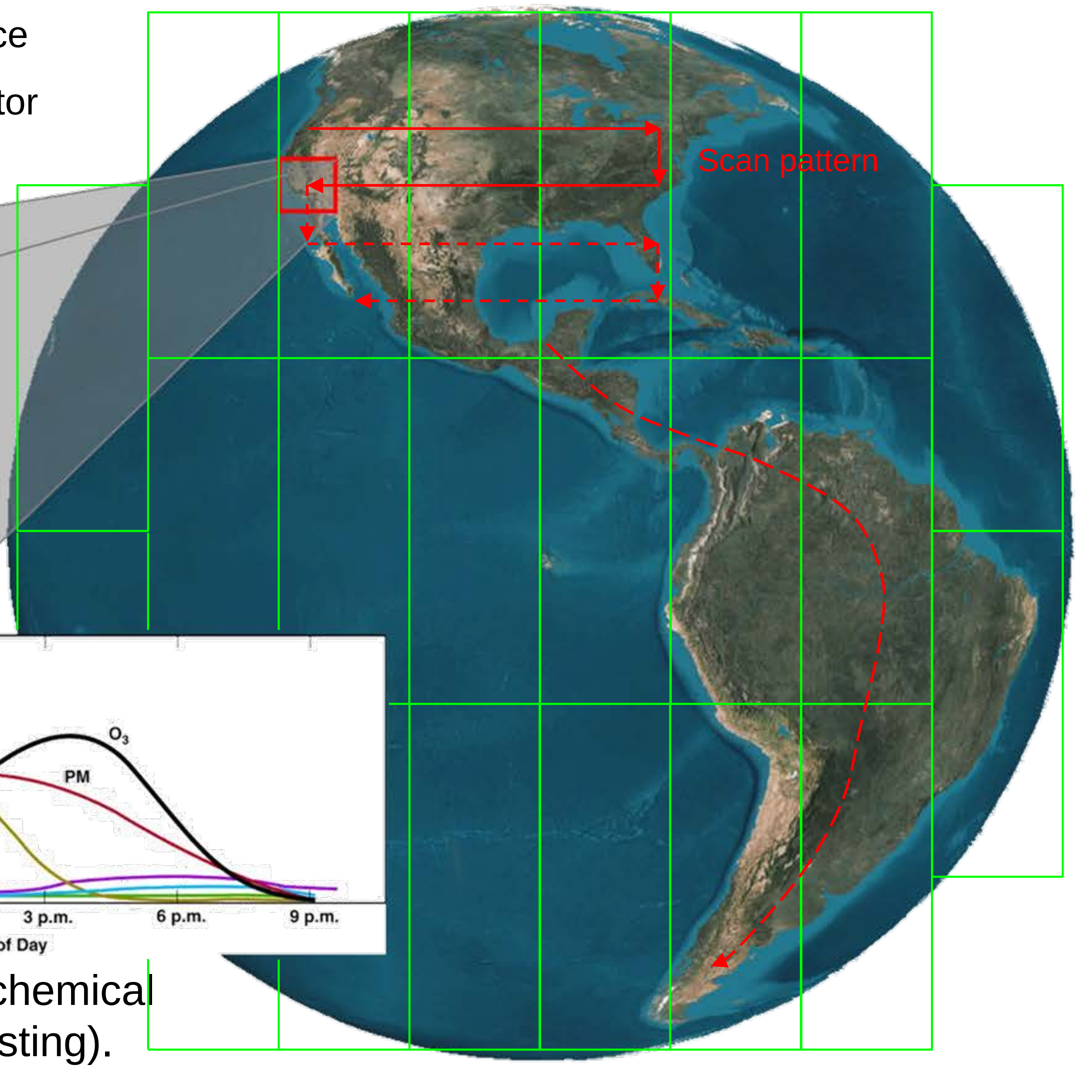
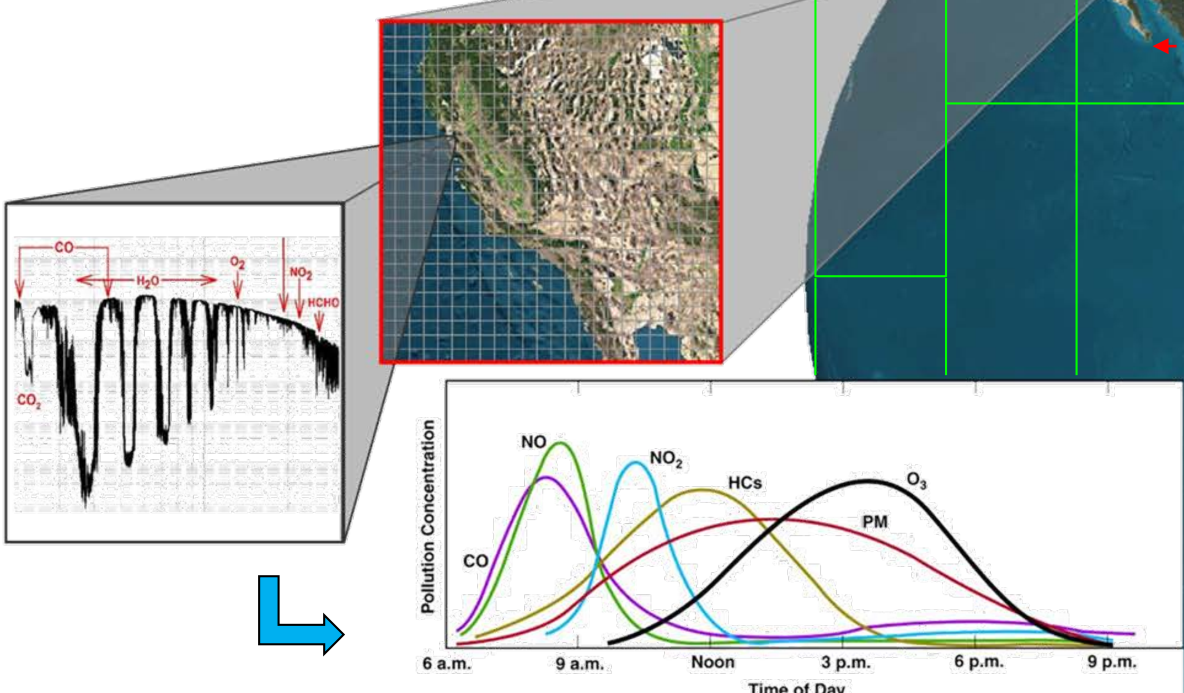
- Designed as a hosted payload on GEO commsats.
- Successfully completed a NASA Earth Science Technology Office (ESTO) Instrument Incubator Program (IIP) task in 2011.





Temporal monitoring of rapidly changing chemical compositions (chemical weather forecasting).

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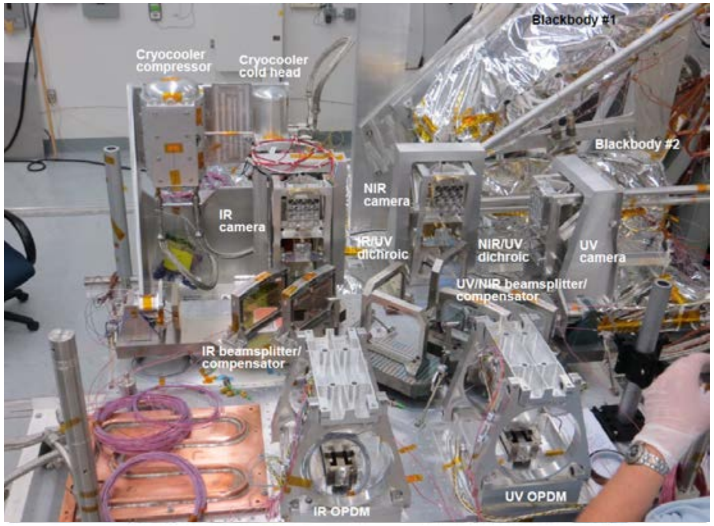
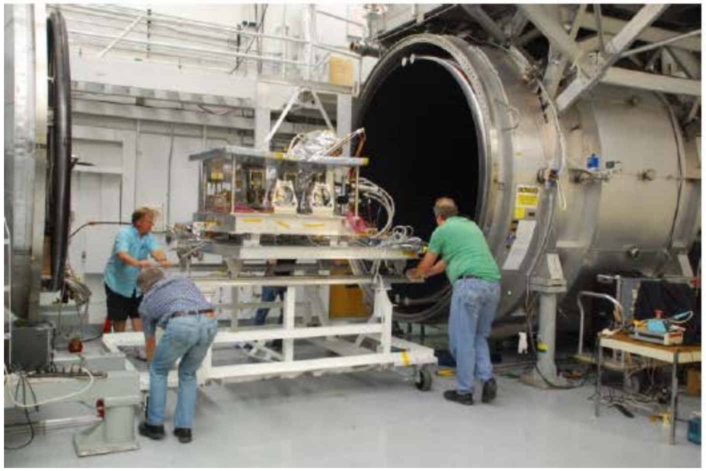
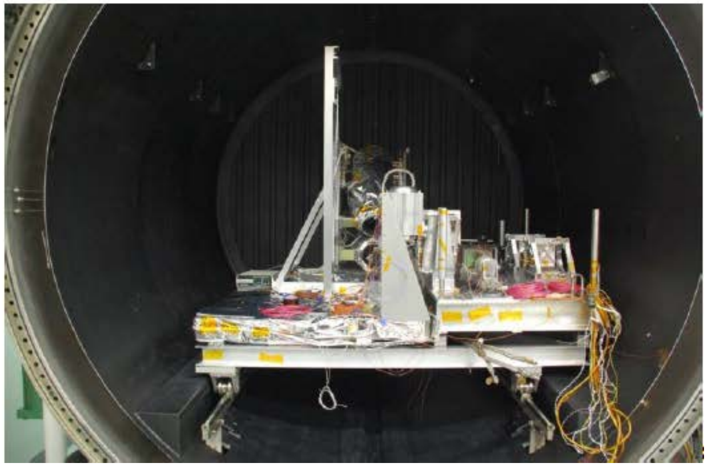
PanFTS Engineering Model (EM) validated at -100°C in thermal vacuum, reviewed by Aerospace Corp in 2011.







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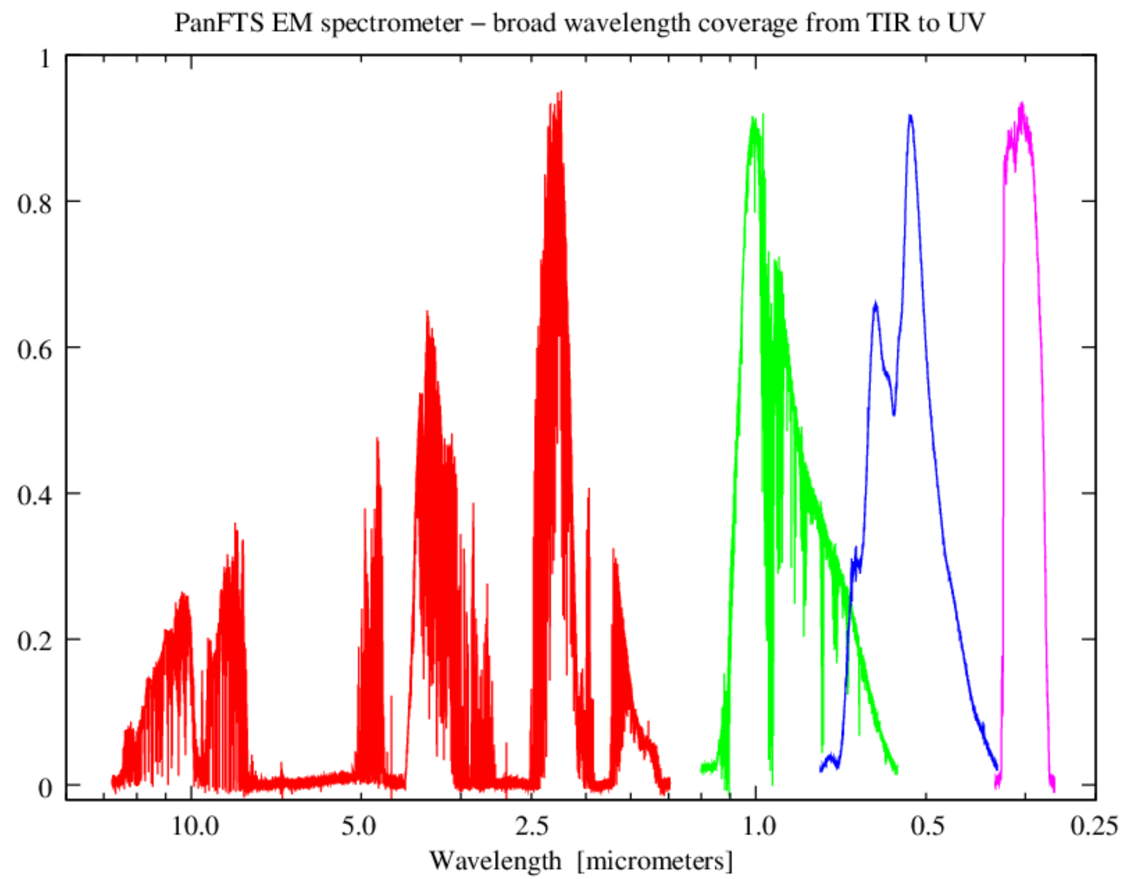
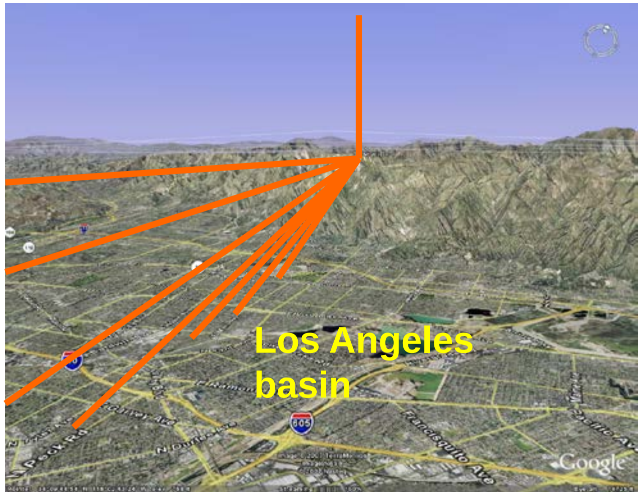
PanFTS – EM demonstrated TIR-to-UV coverage and 0.06 cm^{-1} spectral resolution at 2260 cm^{-1} wavenumber.

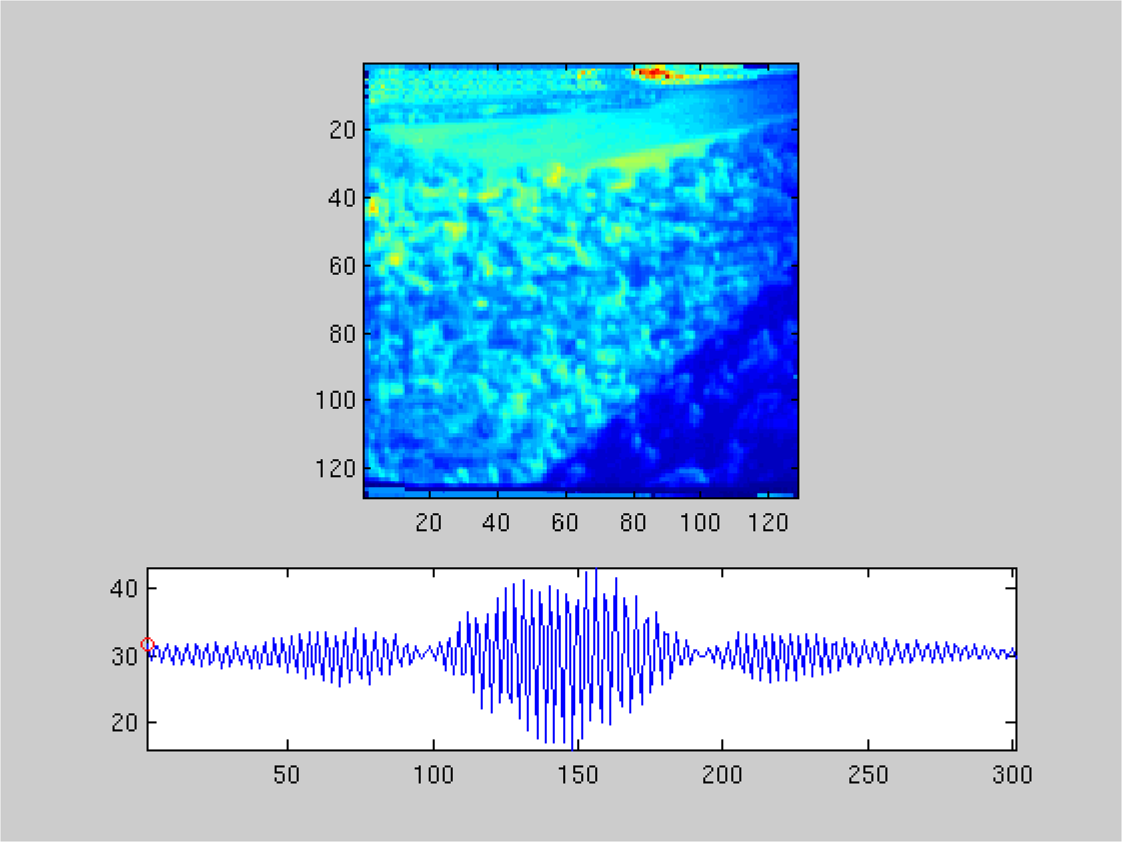
Spectral Region	Species	Rationale
UV	O_3	Surface AQ, transport, climate forcing
UV	HCHO	VOC emissions, chem.
UV	SO_2	SO_x emissions, chem.
UV	Absorbing aerosol	Climate forcing
UV	Aerosol index	Aerosol events
Vis	Aerosol	Surface AQ, aerosol sources and transport, climate forcing
Vis	NO_2	NO_x emissions, chem.
Vis	CHOCHO	VOC emissions, chem., aerosol formation
Vis	O_3	Surface AQ, transport, climate forcing
Vis	Aerosol centroid height	Aerosol plume height, large-scale transport, AOD to PM conversion
NIR	Aerosol centroid height	Aerosol plume height, large-scale transport, AOD to PM conversion
SWIR, MWIR	CO	CO emission, transport
SWIR	CH_4	CH_4 emissions
TIR	NH_3	NH_3 emissions
TIR	O_3	Provides higher vertical resolution info about surface AQ, transport, climate forcing



PanFTS-EM Observation from CLARS on Mt Wilson



A treetop scenery recorded with an early PanFTS FPA. Fourier transform of the recorded interferogram (lower time series plot) is the spectra in a pixel.



Miniaturizing PanFTS (μPanFTS) for SWaP at JPL

- **Design approach:**
  - PanFTS-EM had a series of dichroic beam splitters, 2 interferometers, 3 camera optics, 3 FPA's, and 3 FPA readout electronics.
  - μPanFTS has 1 interferometer, 1 camera optics, 1 FPA, and 1 FPA readout electronics. The large-format 2-color FPA is the enabling element.
- **JPL Planetary Sciences Program Office funded task, FY19, to miniaturize the front end.**
  - < 12U cubesat volume (design target)
  - < 15 kg mass (design target)
  - < 60 W power (design target)
- **JPL Earth Sciences Program Office funded task, FY19-21, back end onboard data processing.**
  - ~20x data compression
- **Aligned with NOAA's next generation weather satellite concept.**
  - GEO and LEO satellite systems
  - Design for SWaP and agility

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FTS Payloads around the Globe…

Weather Payload	IRS	GIIRS	CrIS	mPanFTS
Status	2021 launch	In space	In space	Proposed here
Provider	EU	China	NOAA	NOAA/JPL
Orbit	GEO	GEO	Polar	GEO
Spacecraft	Dedicated	Dedicated	Dedicated	Hosted payload
GSD (km)	4 (and bin to 12)	16	14	3.5 (and bin to 7)
Spectral range (cm-1)	700 – 1210 1600 – 2175	650 – 1136 1210 – 1750 2155 – 2250	650 – 1095 1210 – 1750 2155 – 2550	650 – 8000
Resolution (cm-1)	0.625	0.625	0.625	0.625
Full Disk Revisit Time (hr)	1	2 – 3	12	0.2
Mass (kg)	460	315	146	< 15 (design target)
Power (W)	736	not available	105	< 60 (design target)
Detector Format (pixel)	2 of 160x160	12 of 32x4	3 of 3x3	1 of dual-color 1280x480 FPA
Detector temp (K)	56	has a cryo cooler	81	55

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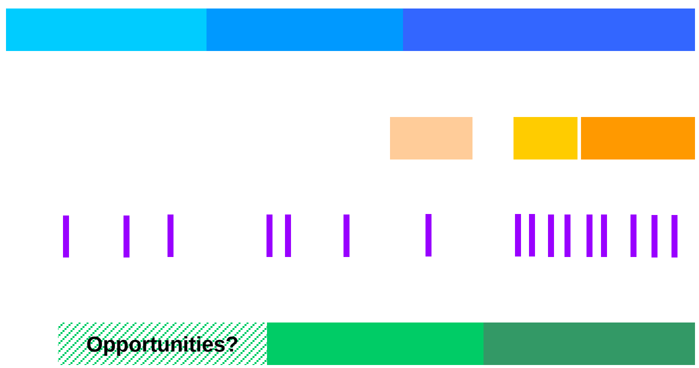
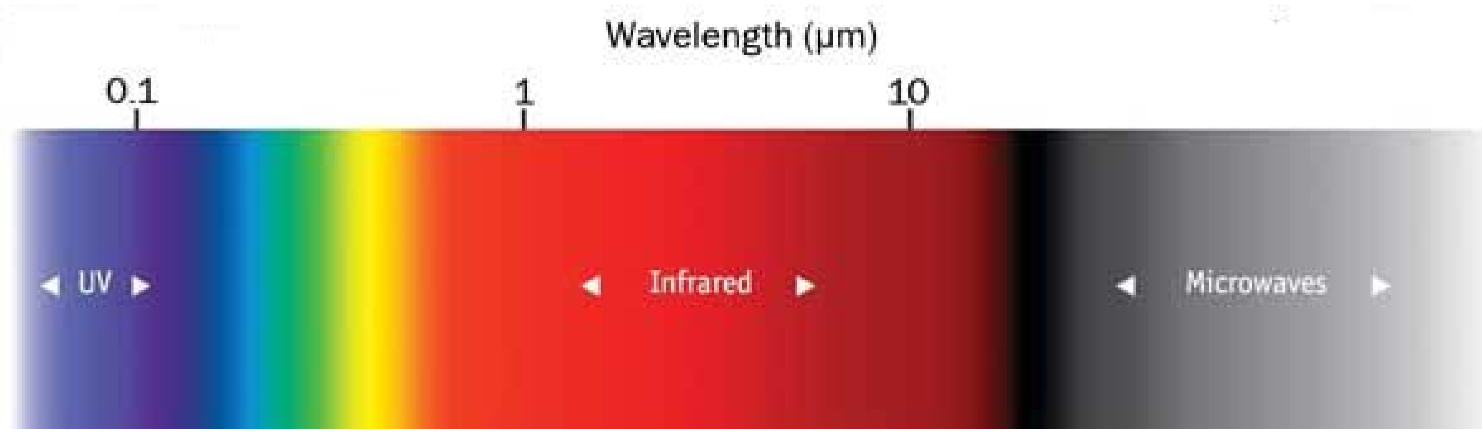
Comparison of Spectral and Spatial Coverages



	GSD (km)	Detector Format (pixel)
PanFTS	4	3 of 128x128 FPA (49,152 pixels)
CrIS	14	3 of 3x3 single pixel detector (27 pixels)
ABI	0.5/1/2	16 of 1x~500 linear array (7,856 pixels)
μPanFTS for weather forecasting	2.8	1 of dual-color 1280x480 FPA **(614,400 pixels, larger formats are available.)**



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Earth Science Decadal Survey

- **PanFTS is designed to address these two science and application areas.**
- **Let's leverage on the NASA's investments, tailor it to μPanFTS, and advance NOAA's mission.**

Science and Applications Area	Science and Applications Questions Addressed by Most Important Objectives
Coupling of the Water and Energy Cycles	**(H-1)** How is the water cycle changing? Are changes in evapotranspiration and precipitation accelerating, with greater rates of evapotranspiration and thereby precipitation, and how are these changes expressed in the space-time distribution of rainfall, snowfall, evapotranspiration, and the frequency and magnitude of extremes such as droughts and floods? **(H-2)** How do anthropogenic changes in climate, land use, water use, and water storage interact and modify the water and energy cycles locally, regionally, and globally, and what are the short- and long-term consequences?
Ecosystem Change	**(E-1)** What are the structure, function, and biodiversity of Earth's ecosystems, and how and why are they changing in time and space? **(E-2)** What are the fluxes (of carbon, water, nutrients, and energy) *between* ecosystems and the atmosphere, the ocean, and the solid Earth, and how and why are they changing? **(E-3)** What are the fluxes (of carbon, water, nutrients, and energy) *within* ecosystems, and how and why are they changing?
Extending and Improving Weather and Air Quality Forecasts	**(W-1)** What planetary boundary layer (PBL) processes are integral to the air-surface (land, ocean, and sea ice) exchanges of energy, momentum, and mass, and how do these impact weather forecasts and air quality simulations? **(W-2)** How can environmental predictions of weather and air quality be extended to seamlessly forecast Earth system conditions at lead times of 1 week to 2 months? **(W-4)** Why do convective storms, heavy precipitation, and clouds occur exactly when and where they do? **(W-5)** What processes determine the spatiotemporal structure of important air pollutants and their concomitant adverse impact on human health, agriculture, and ecosystems?
Reducing Climate Uncertainty and Informing Societal Response	**(C-2)** How can we reduce the uncertainty in the amount of future warming of the Earth as a function of fossil fuel emissions, improve our ability to predict local and regional climate response to natural and anthropogenic forcings, and reduce the uncertainty in global climate sensitivity that drives uncertainty in future economic impacts and mitigation/adaptation strategies?
Sea-Level Rise	**(C-1)** How much will sea level rise, globally and regionally, over the next decade and beyond, and what will be the role of ice sheets and ocean heat storage? **(S-3)** How will local sea level change along coastlines around the world in the next decade to century?
Surface Dynamics, Geological Hazards, and Disasters	**(S-1)** How can large-scale geological hazards be accurately forecasted in a socially relevant time frame? **(S-2)** How do geological disasters directly impact the Earth system and society following an event? **(S-4)** What processes and interactions determine the rates of landscape change?

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Questions?

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