

CubeSat Technology Flight Validation and the IPEX Mission

2014 HypIRI Science Workshop

June 5, 2014
With acknowledgement to all ESTO
Investigators

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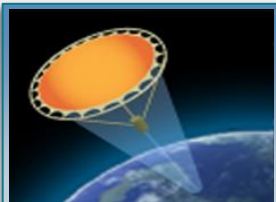
Technology Program Overview

The Earth Science Technology Office (ESTO) is a **targeted, science-driven, competed, actively managed, and dynamically communicated technology program** and serves as a model for technology development.

Competitive, peer-reviewed proposals enable selection of best-of-class technology investments that **retire risk** before major dollars are invested: a cost-effective approach to technology development and validation.

ESTO investment elements include:

Observation



Instrument Incubator Program (IIP)

provides robust new instruments and measurement techniques

16 new projects added in FY11 (total funding approximately \$67M over 3 years)

Information



Advanced Component Technologies (ACT)

provides development of critical components and subsystems for instruments and platforms

15 new projects added in FY11 (total funding approximately \$16M over 3 years)

Validation



Advanced Information Systems Technology (AIST)

provides innovative on-orbit and ground capabilities for communication, processing, and management of remotely sensed data and the efficient generation of data products

18 new projects added in FY12 (total funding approximately \$23M over 3-4 years)



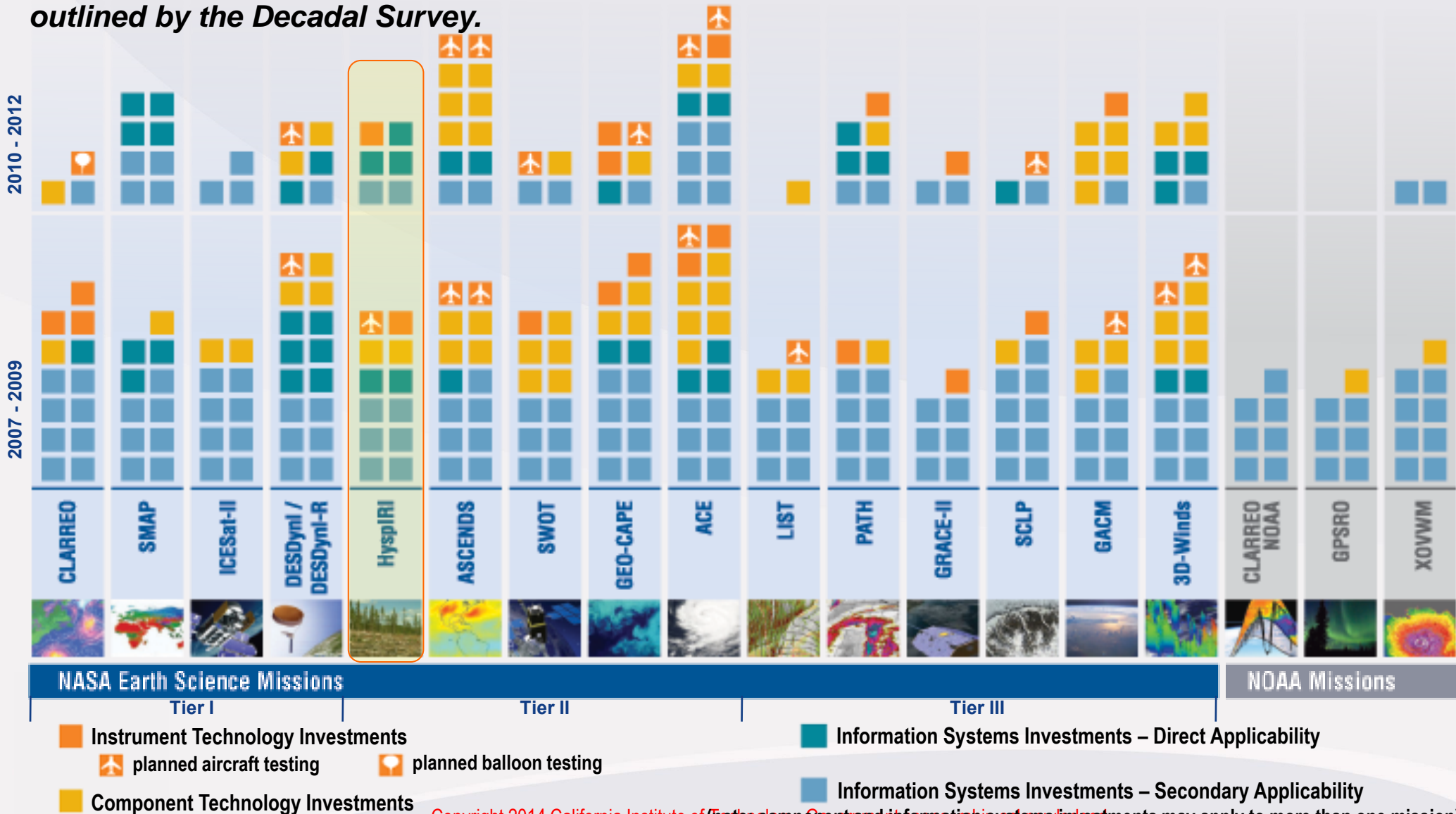
In-Space Validation of Earth Science Technologies (InVEST)

provides in-space, orbital technology validation and risk reduction for components and systems that could not otherwise be fully tested on the ground or in airborne systems

Solicitation Announced in May 2013 (first year funding approximately \$3M)

Science Driven: Enabling the Earth Science Decadal Survey

Upon publication of the Earth Science Decadal Survey in 2007, ESTO investments **already supported all 18 of the recommended mission concepts**. Since then, ESTO has awarded **107 additional technology projects** representing an investment of **over \$211M directly related to the Earth Science priorities outlined by the Decadal Survey**.



ESTO Activities Directly Supporting HypIRI Development

- PHyTIR raised the TRL of TIR focal plane assembly to 6
- ESTO-supported AVIRIS-NG is providing risk reduction and will support cal/val and precursor science, flying since 2012
- ESTO-supported HyTES is providing risk reduction and supporting cal/val and Precursor science, makes 1st gas detection in 2013, flying since 2012
- IPEX CubeSat, designed for flight validation of IPM autonomous planning, scheduling, and low-latency product generation, delivered to VAFB and integrated onto Atlas-V for NROL-39 GEMSat launch on 12/5/13.
- “Plume Tracer: Mapping 3D composition of atmospheric plumes from remotely measured TIR radiance spectra”
- “A High Performance Onboard Multicore Intelligent Payload Module for Orbital and Suborbital Remote Sensing Missions”

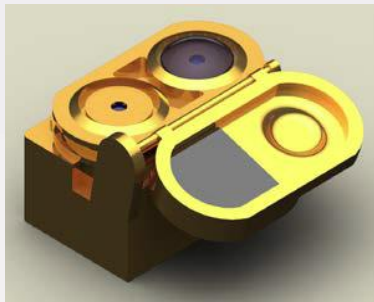
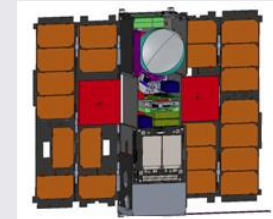


In-Space Technology Validation for Earth Science (InVEST) Awards

The need to space-validate new technologies is critical and ongoing. The In-Space Validation of Earth Science Technologies (InVEST) program is intended to fill the gap. The first four InVEST awards (out of 23 proposals) were selected in April 2013. The solicitation sought small instruments and instrument subsystems that will advance technology to enable relevant Earth science measurements and targeted the CubeSat platform. Total first-year funding is approximately \$3M.

The **Microwave Radiometer Technology Acceleration (MiRaTA*)** Cubesat would validate multiple subsystem technologies and demonstrate new sensing modalities that could dramatically enhance the capabilities of future weather and climate sensing architectures

- K. Cahoy, MIT

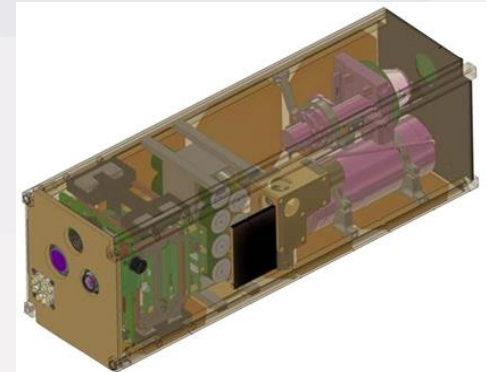


The **Radiometer Assessment Using Vertically Aligned Nanotubes (RAVAN*)** project would demonstrate a bolometer radiometer that is compact, low cost, and absolutely accurate to NIST traceable standards. RAVAN could lead to affordable CubeSat constellations that, in sufficient numbers, might measure Earth's radiative diurnal cycle and absolute energy imbalance to climate accuracies (globally at 0.3 W/m²) for the first time.

- W. Swartz, Johns Hopkins Applied Physics Laboratory

The **Cubesat Flight Demonstration of a Photon Counting Infrared Detector (LMPC* CubeSat)** would demonstrate in space, a new detector with high quantum efficiency and single photon level response at several important remote sensing wavelength detection bands from 0.9 to 4.0 microns.

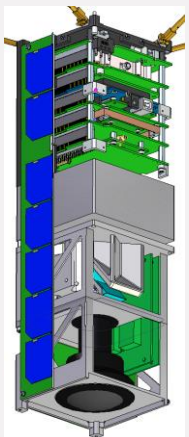
- R. Fields, The Aerospace Corporation



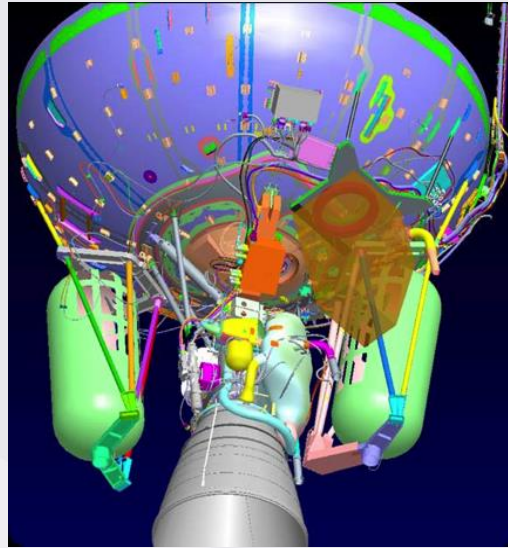
The **HyperAngular Rainbow Polarimeter HARP*-CubeSat** would validate a technology required by the Aerosol-Cloud-Ecosystem (ACE) mission concept and prove the capabilities of a highly-accurate, wide-FOV, hyperangle, imaging polarimeter for characterizing aerosol and cloud properties.

- J. V. Martins, University of Maryland, Baltimore County

Bus
HARP Inst.



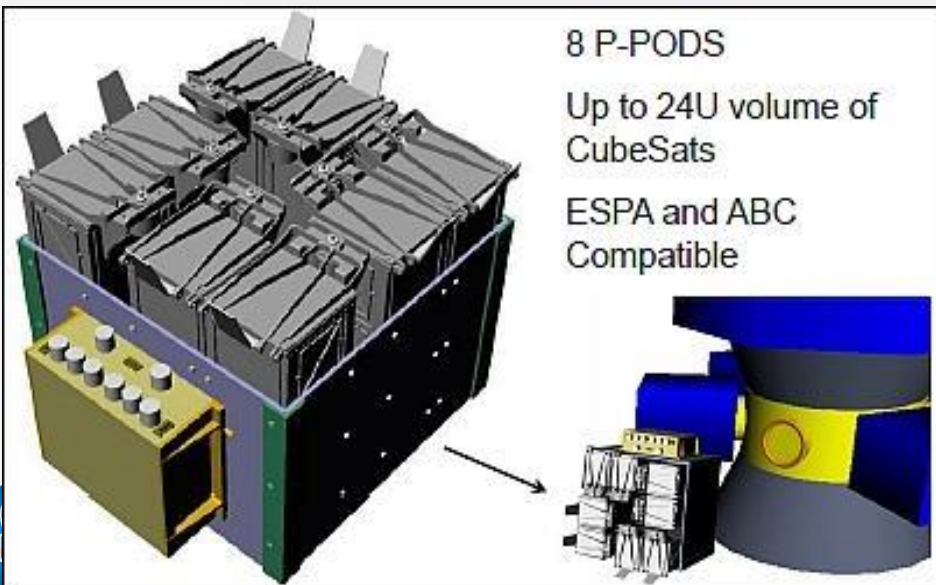
ELaNa-II GEMSat (NROL-39) December 5, 2013 RACE November, 2014 and GRIFEX December 2014



VAFB Manifest of MCubed-2 and IPEX on GEMSat
NRO L-39 12/5/13 launch and operational

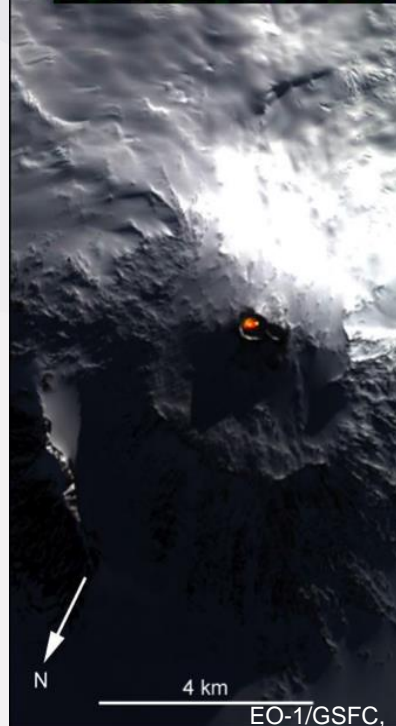
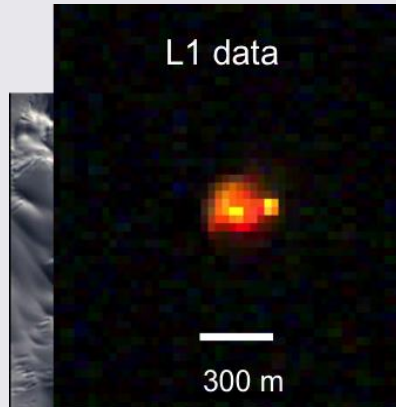


RACE with CRS-4 launch in 10/2014
GRIFEX with SMAP launch on 11/05/14 launch



Intelligent Payload Experiment (IPEX)

Low Latency & Autonomous Science Product Generation



Mission Description

- NASA JPL, GSFC, and Cal Poly SLO Project
 - JPL provides processing payload
 - Cal Poly SLO provides spacecraft
- Advances technology for autonomous and near real-time product generation from high data rate Earth observing instruments
- Will enable 20x data reduction for thermal, visible, and near infrared spectroscopy science
- Orbit: High inclination polar
- Launched: Dec. 2013 from VAFB on NROL-39 GEMSat Atlas V (NASA CSLI)

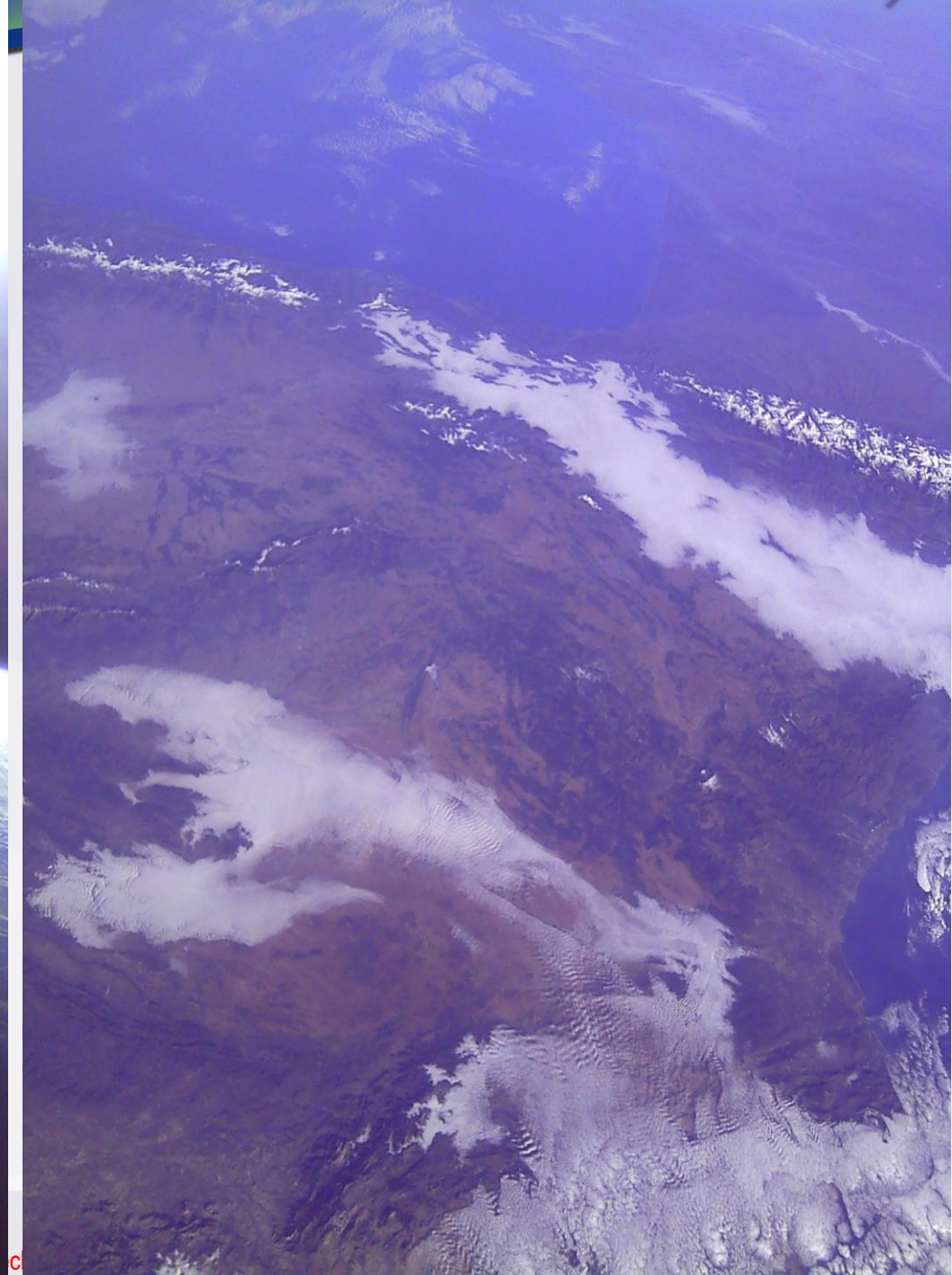


Sponsored by NASA's Earth Science Technology Office (ESTO)

Intelligent Payload Experiment (IPEX)

On-Orbit Imagery (Full Resolution)

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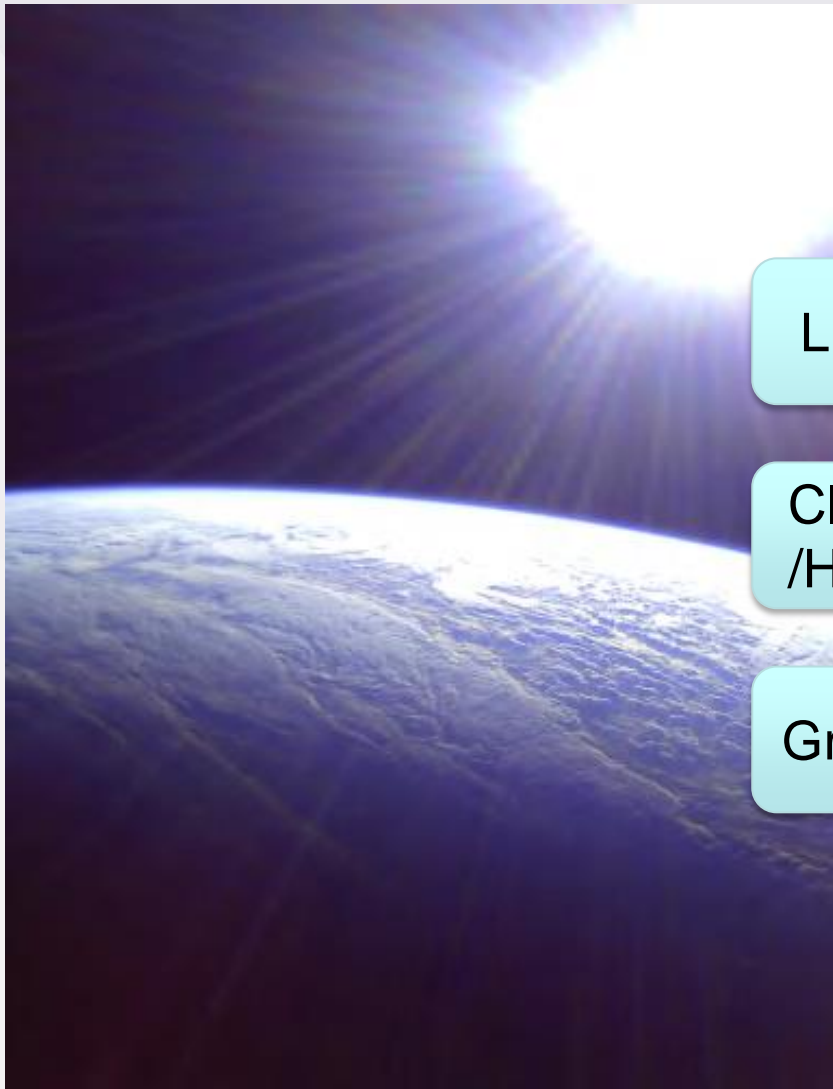


PolySat

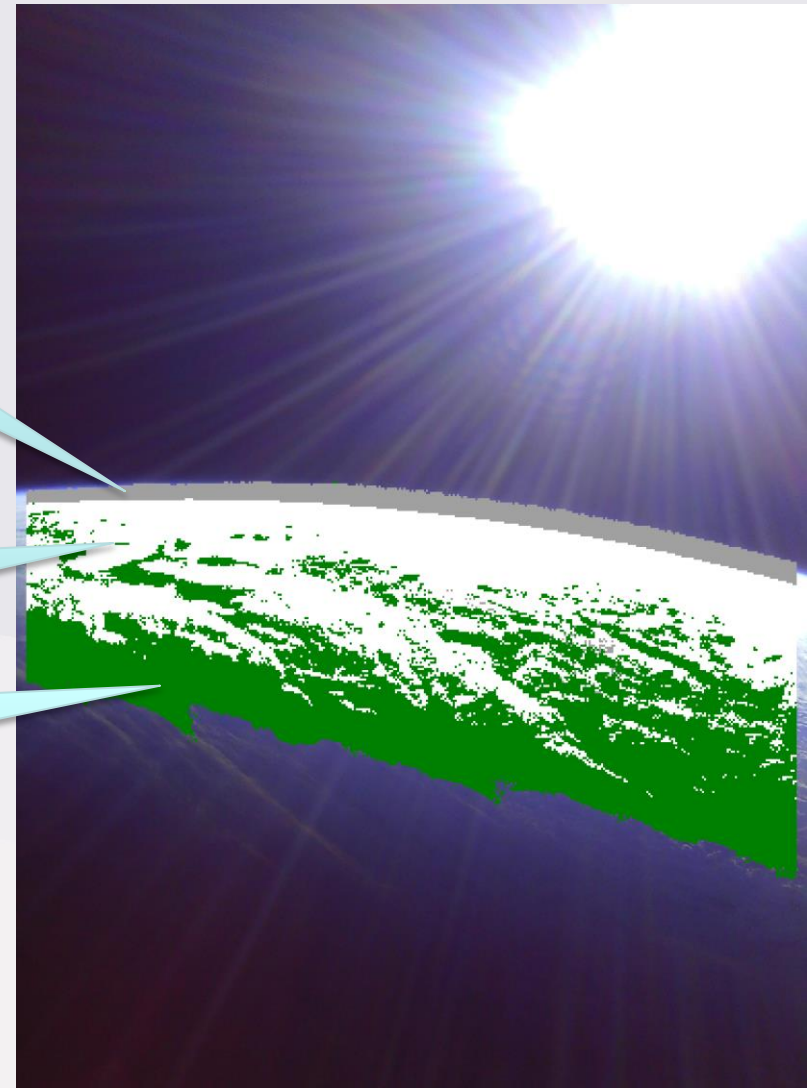
Picture taken by IPEX (Cal Poly / JPL) on Dec. 6th 2013

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Onboard Product: TextureCam Classification



Original Image



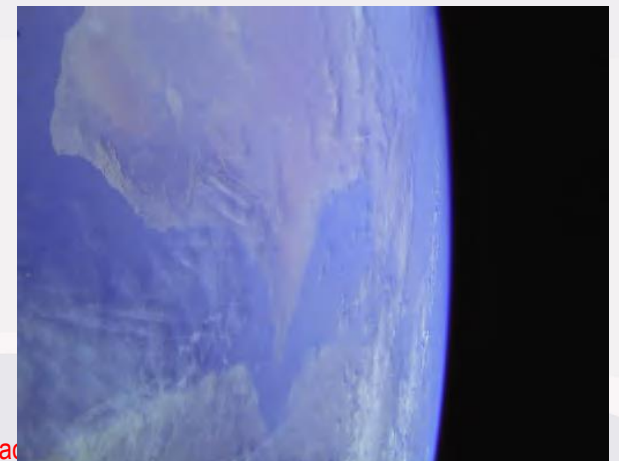
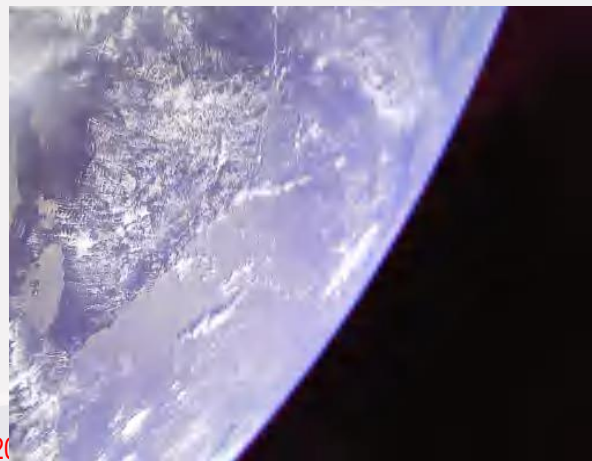
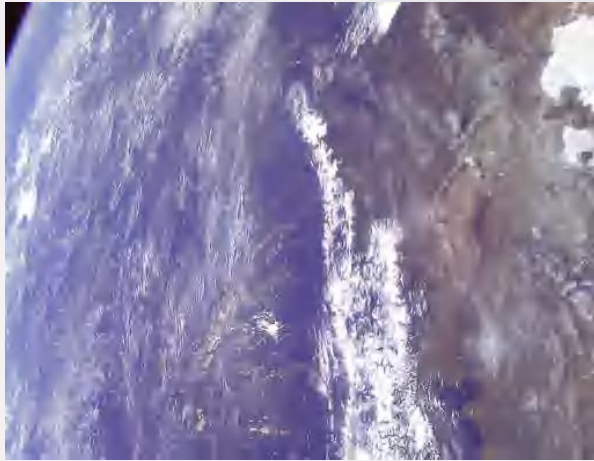
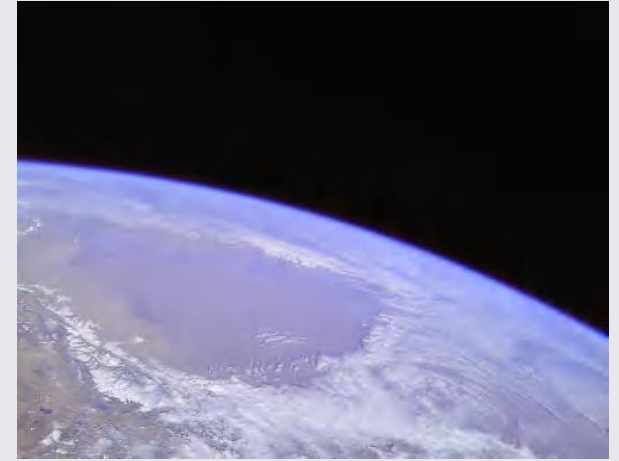
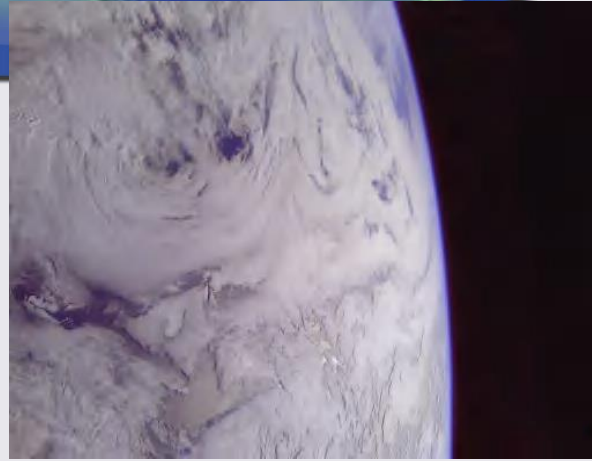
Original Image showing onboard product as generated on ground



Intelligent Payload Experiment (IPEX)

On-Orbit Imagery and Validation Candidates (Low Resolution)

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ESTO Program Philosophy

- Open, competitive program
- Frequent solicitations ensure current approaches and create regular, multiple opportunities for PIs
- Focused, science-driven approach
- Peer-reviewed process
- Technology options rather than point solutions
- Technologies selected for infusion by principal investigators and mission managers, not ESTO
- Currently funded technologies are providing state-of-the-art instruments, components, and information systems capabilities for a wide range of Earth science measurements.



To Learn More...

Visit the NEW ESTO Website:
esto.nasa.gov

And Browse the ESTO
Technology Portfolio

The screenshot shows the main ESTO website homepage. At the top, there is a NASA logo and the text "National Aeronautics and Space Administration Earth Science Technology Office". Below this is a search bar for "Search NASA.gov". The main header reads "Technology Empowers Our Future" with a navigation menu including "About", "Observation Tech", "Information Tech", "Tech Validation", "Advanced Planning", and "For Technologists". The main content area is divided into several sections: "Technology Spotlight" featuring the RTIMS memory module on Mars; "Welcome" with a message from the webmaster; "Program Areas" including "Observation Technologies", "Information Technologies", and "Technology Validation"; "Online Tools" with a button for "Browse and Search the ESTO Technology Portfolio" circled in red; "Connect" with social media links; and "News" with several recent articles dated October 1, 2012, and September 28, 2012.

The screenshot shows the ESTO Technology Portfolio website. It features a NASA logo and the text "National Aeronautics and Space Administration Earth Science Technology Office". The main header reads "Technology Empowers Our Future" with a "Back To ESTO" link. The main content area is titled "Welcome to ESTO Technology Portfolio" and includes a "Keyword Search" box, a "Technology Category & Organization Search" section with radio buttons for "ESTO Projects", "Other Projects", and "All", and a grid of technology categories: "Sensors", "Information Systems", "Platforms", and "Computational Technology". The "Sensors" category is expanded to show sub-categories like "Active Microwave", "Passive Microwave", "Active Optical", "Passive Optical", and "Other". The "Information Systems" category is also expanded to show sub-categories like "Data and Information Production", "Data Collection and Handling", "Search, Access, Analysis and Display", "Systems Management", and "Transmission and Dissemination". The "Organization" section lists "Academia", "Industry", "NASA Centers", and "Federal Labs". There are "Search" and "Reset" buttons at the bottom.

