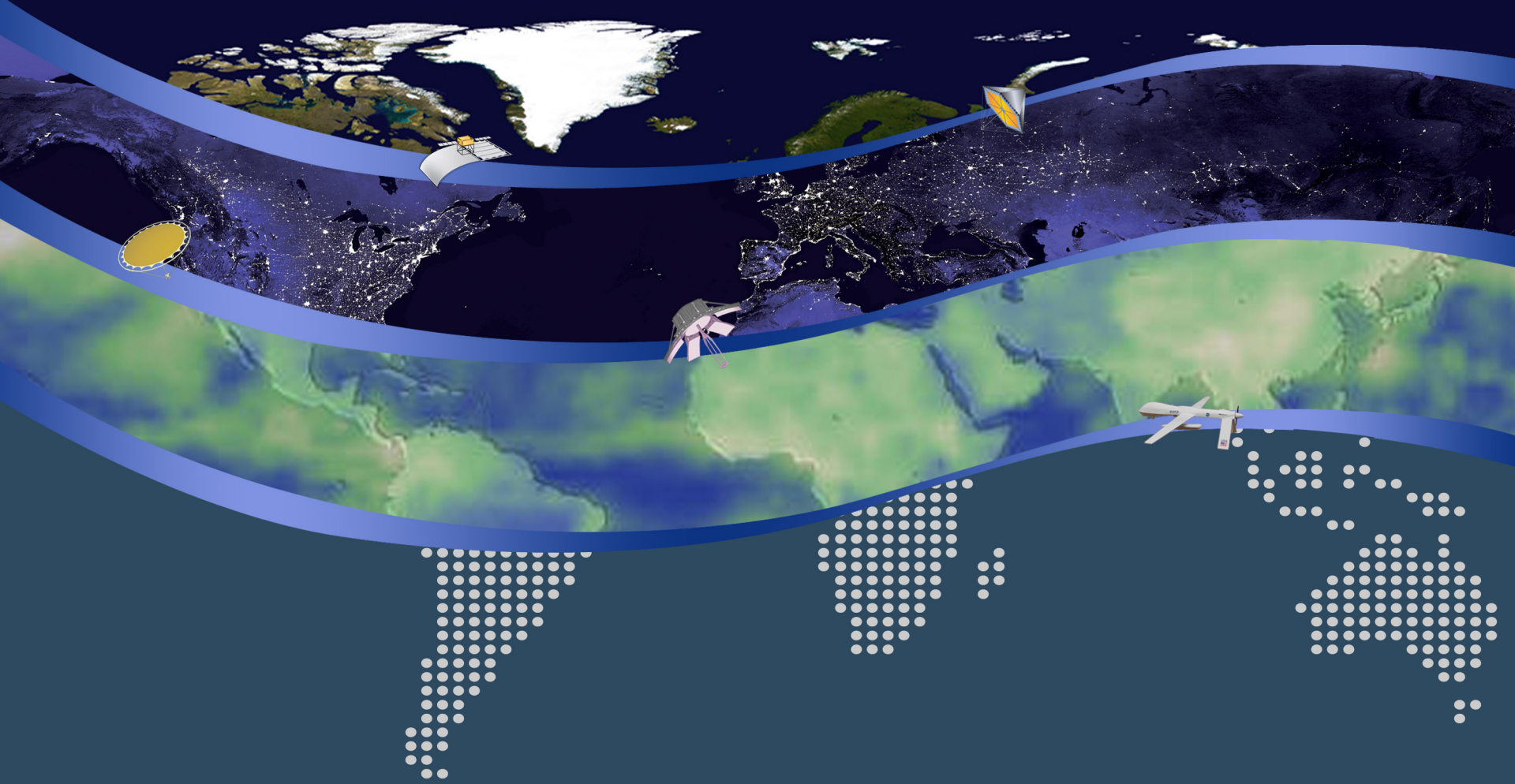


ESTO Investments in Support of the HyspIRI Mission Concept

2013 HyspIRI Science Workshop

Oct 15, 2013

With acknowledgement to all ESTO Investigators

Charles D. Norton

Jet Propulsion Laboratory, California Institute of Technology

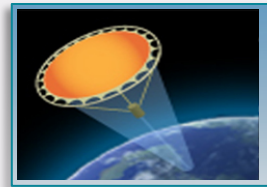
Earth Science Technology Office (ESTO) Program Associate

Technology Program Overview

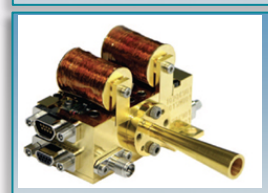
The Earth Science Technology Office (ESTO) is a ***targeted, science-driven, competed, actively managed, and dynamically communicated technology program*** and serves as a model for technology development.

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)



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)

Information

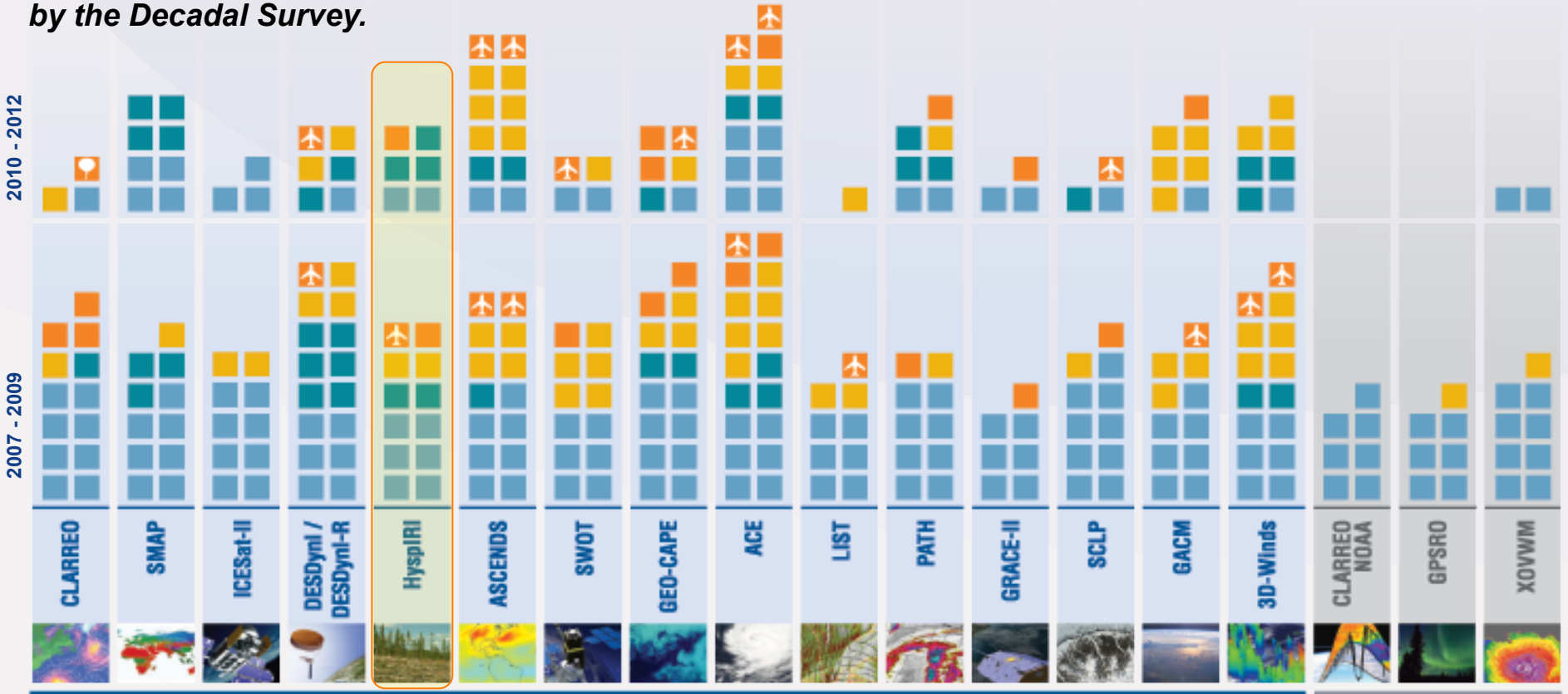
Advanced Information Systems Technology (AIST)
provides innovative on-orbit and ground capabilities for communication, processing, and management of remotely sensed data and the efficient generation of data products
18 new projects added in FY12 (total funding approximately $23M over 3-4 years)

Validation

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

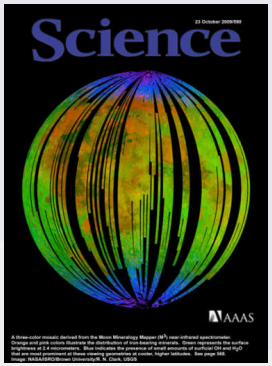
Upon publication of the Earth Science Decadal Survey in 2007, ESTO investments **already supported all 18 of the recommended mission concepts**. Since then, ESTO has awarded **107 additional technology projects** representing an investment of ***over $211M directly related to the Earth Science priorities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

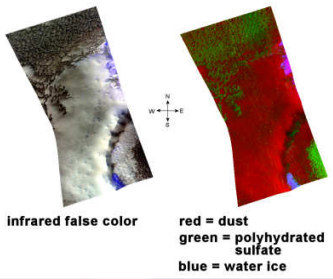


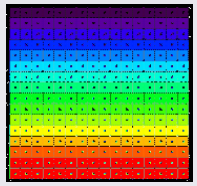
HysplRI Heritage and Key Technologies

Although HysplRI is a high-heritage mission concept ESTO supports development of key instrument and information systems technology

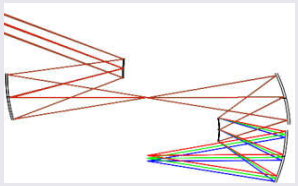
NASA imaging Spectrometers

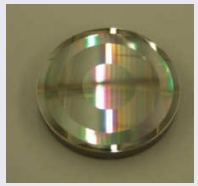




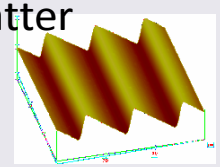


High SNR and high uniformity imaging spectrometer designs (Mouroulis et al., 2000)*

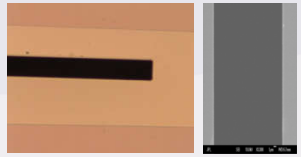


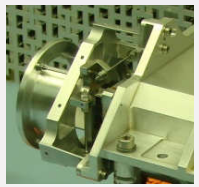


Electron-beam lithography low-scatter tuned-high-efficiency gratings on curved surfaces for space

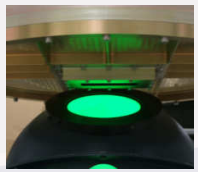


Ultra uniform 27 µm x 20 mm electron-beam lithography slit for space flight

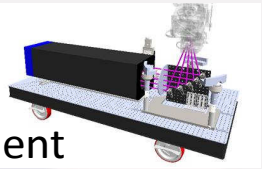




Component mounts with 0.25 micron feedback adjustment that are lockable for space flight



Unique set of alignment and calibration sources and tools for imaging spectrometer development



*Mouroulis P., Green R. O., Chrien T. G., "Design of pushbroom imaging spectrometers for optimum recovery of spectroscopic and spatial information," APPL OPTICS 39: (13) 2210-2220 MAY 1 2000

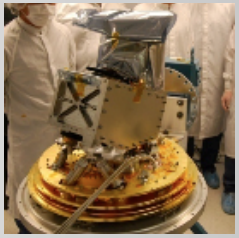
History of ESTO HyspIRI-Related Investments

Targeted, Science-Driven, Competed, Actively Managed Technology Program

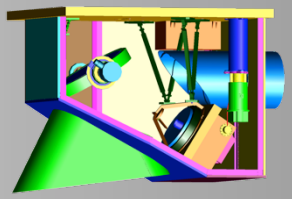
Past ESTO Investments Supporting HyspIRI

Observation Technologies

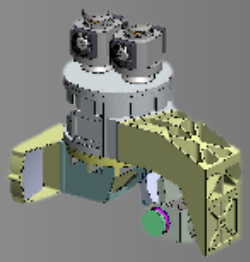
AVIRISng: Next Generation Airborne Visible InfraRed Imaging Spectrometer
PI: Robert Green
ATI-2009/JPL



PHyTER: Prototype HyspIRI Thermal Infrared Radiometer for Earth Science
PI: Simon Hook
IIP-2010/JPL

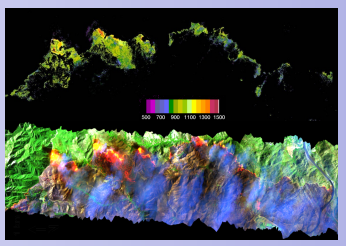


Mineral & Gas Identification Using a High-Performance Thermal Infrared Imaging Spectrometer
PI: Jeff Hall
IIP-2007/Aerospace

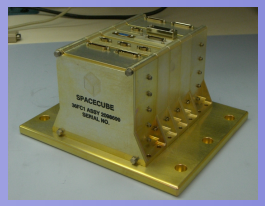


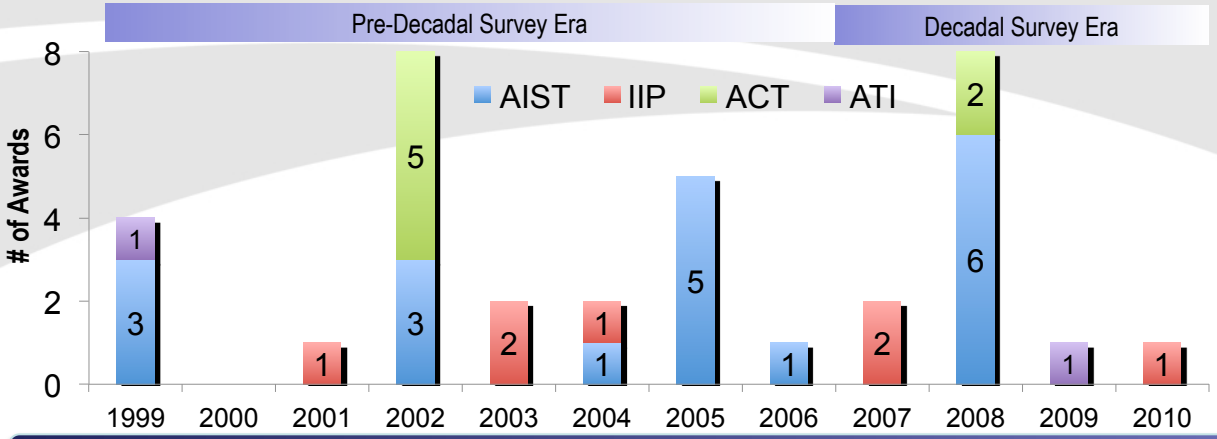
Information Technologies

IPM: Sensor Web 3D Intelligent Payload Module Custom Products
PI: Dan Mandl
AIST-2008/GSFC

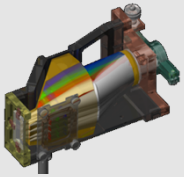


Autonomous On-board Processing for Sensor Systems
PI: Matthew French
AIST-2008/USC-IS



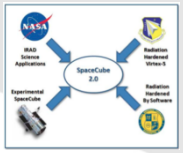


Supporting Technologies

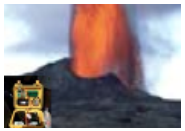


HyTES: Hyperspectral Thermal Emission Spectrometer for HyspIRI
PI: Simon Hook, IIP-2007/JPL

Sensor Webs for Earth Observations
PI: Young Cho, AIST-2005/USC-ISI



Advanced Hybrid Onboard Autonomous Processor
PI: Thomas Flatley, AIST-2008/GSFC



Science Model Driven Autonomous Sensor Web
PI: Ashley Davies, AIST-2006/JPL

From FY'07-'11, ESTO has 12 HyspIRI-related technology development tasks with a total investment of ~$19.5M

Advanced Information Systems Technology (AIST)
18 New Investments

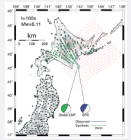
18 proposals awarded funding under AIST in 02/2012.
Total dollar value is approximately $23 million.

Weather

Automated Event Service [PATH]
- Tom Clune, GSFC

Automated Event Service [3D-Winds]
- Svetla Hristova-Veleva , JPL

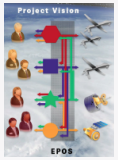
Geodetic Station Sensor Web [PATH]
- Yehuda Bock, UCSD



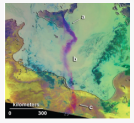
Atmospheric Composition

GPU Cloud Resolving Models [ACE]
- Wei-Kuo Tao, GSFC

Sensor Web Coordination [HS3]
- Stephan Kolitz, Draper Labs

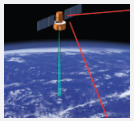


On-Board Processing [GEO-CAPE]
- Paula Pingree, JPL



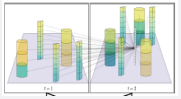
Interactive Plume Mapping via GPUs [HyspIRI]
- Alexander Berk, Spectral Sciences

Carbon Cycle and Ecosystems



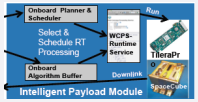
On-Board Processing for Science Instruments [ASCENDS]
- Jefferey Beyon, LaRC

Multivariate Data Fusion and Uncertainty [ASCENDS]
- Amy Braverman, JPL



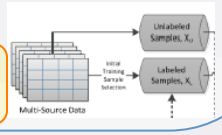
Land Info System Integration [SMAP]
- Mahta Moggadham, USC

Onboard Multicore IPM [HyspIRI]
- Dan Mandl, GSFC



HEC Workflow Synthesis for NEX [SMAP]
- Rama Nemani ARC

Classification of Multi-Source Data [HyspIRI]
- Melba Crawford, Purdue U.



Climate Variability and Change

Data/Climate Model Integration [SMAP]
- Bo Wen Shen, University of Marland

Water and Energy

Terrestrial Hydrology Simulation w/LIS [SMAP]
- Christa Peters-Lidard, GSFC

Instrument Simulation Suite [GPM]
- Simone Tanelli, JPL

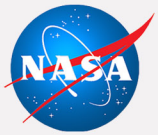
Earth Surface and Interior

QuakeSIM Data Intensive Science [DESDyNI-R]
- Andrea Donnellan, JPL

Hazard Imaging and Analysis [DESDyNI-R]
- Hook Hua, JPL

ESTO Activities Directly Supporting HyspIRI 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.
- Recent award of “Plume Tracer: Mapping 3D composition of atmospheric plumes from remotely measured TIR radiance spectra”
- Recent award of “A High Performance Onboard Multicore Intelligent Payload Module for Orbital and Suborbital Remote Sensing Missions”

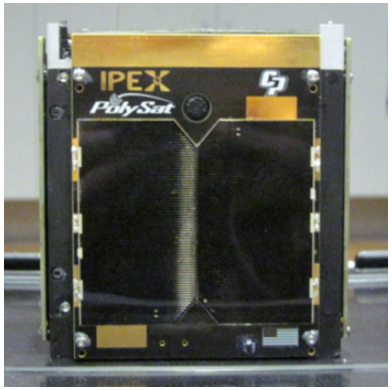


Intelligent Payload Experiment (IPEX)

PI: Steve Chien (JPL)

JOHN F. KENNEDY SPACE CENTER

LAUNCH SERVICES PROGRAM



IPEX Partners:
Jet Propulsion Laboratory
Cal Poly, San Luis Obispo
NASA GSFC

Mission Description

IPEX will validate direct broadcast, autonomous science, and product delivery technologies supporting TRL advancement of the Intelligent Payload Module (IPM) targeted for the proposed Hyperspectral Infrared Imager (HyspIRI) Earth science decadal survey mission. Specifically:

- 20x reduction in Gbps instrument raw data rate.
- Web-based autonomous payload operations with event/over-flight-based product generation.

Major Milestones

05/01/11	CIR
03/24/11	Quad Chart
08/04/11	PDR
02/29/12	CDR
12/04/12	Delta CDR
02/15/13	Environmental Testing
03/15/13	MRR
06/21/13	Delivery for Launch Integration
12/05/13	Launch Date

Spacecraft Specifications

- MASS: 1.28 kg
- RF Power: 1W (< 5W on orbit avg. power)
- Orbit: 400 x 700 km @ 120 Deg Inclination
- Size: 10x10x10cm (1U CubeSat)

Status

FM in final environmental testing and on schedule for delivery for launch integration.

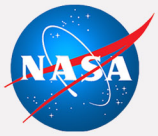
IPEX Mission Objectives

Mission Goals:

- Demonstrate autonomous operations of both spacecraft engineering activities using CASPER/ASPEN and onboard instrument product generation using HyspIRI-like image processing algorithms
- Demonstration of onboard generation of low-latency instrument science and application products with 20-times data rate reduction from raw HyspIRI baseline observations to onboard derived product(s).

Education Goals:

- For students to design, build, test, and operate the spacecraft
- Enhance NASA/JPL/University partnership by engaging students and faculty in small satellite missions



IPEX Project Overview

1. **Spacecraft** –1U CubeSat spacecraft to support the flight demonstration of onboard processing. **Cal Poly**
2. **Instrument processing hardware** – Onboard computing package to fit within a 1U spatial footprint to provide onboard computing and onboard storage. **Cal Poly**
3. **Instrument data processing software** – Provide a benchmark portfolio of instrument processing algorithms relevant to the proposed HyspIRI mission. **JPL**
4. **Autonomous Instrument Operations Software** –Provide flight and ground software to enable web-based autonomous operations of the instrument payload including tasking, correction, and product generation. **JPL**
5. **Experiment operations** – All investigators will support the flight of the IPEX Cubesat. JPL will provide the CASPER/ ASPEN software for use in automating ground mission planning similar to the HyspIRI IPM operations concept.

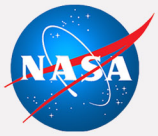
Onboard Products/Algorithms

Algorithm Name	Description
Generalized Normalized Difference Ratio Normalized Ratios*	Wide range of band ratios for vegetation, burn severity, ice, …
TextureCam*	General classification, decision forests
ICER*	Image compression
Salience Feature Identification*	Landmark Identification
Scale Invariant Feature Transform (SIFT)	Landmark Identification
Maximally Stable Extremal Regions (MSER)*	Correspondence detection
Below in progress:	
Thermal anomaly detection	*Estimation of thermal output to detect volcanic activity, wild fires*
*Support Vector Machine (Machine learned)**	*Wide range of classifiers and regressions*
Superpixel segmentation	*Similar region identification*
Sequential Maximum Angle Convex Cone (SMACC) / Endmember Selection	*Spectral unmixing, material identification*

* - routinely run

ESTO Program Philosophy

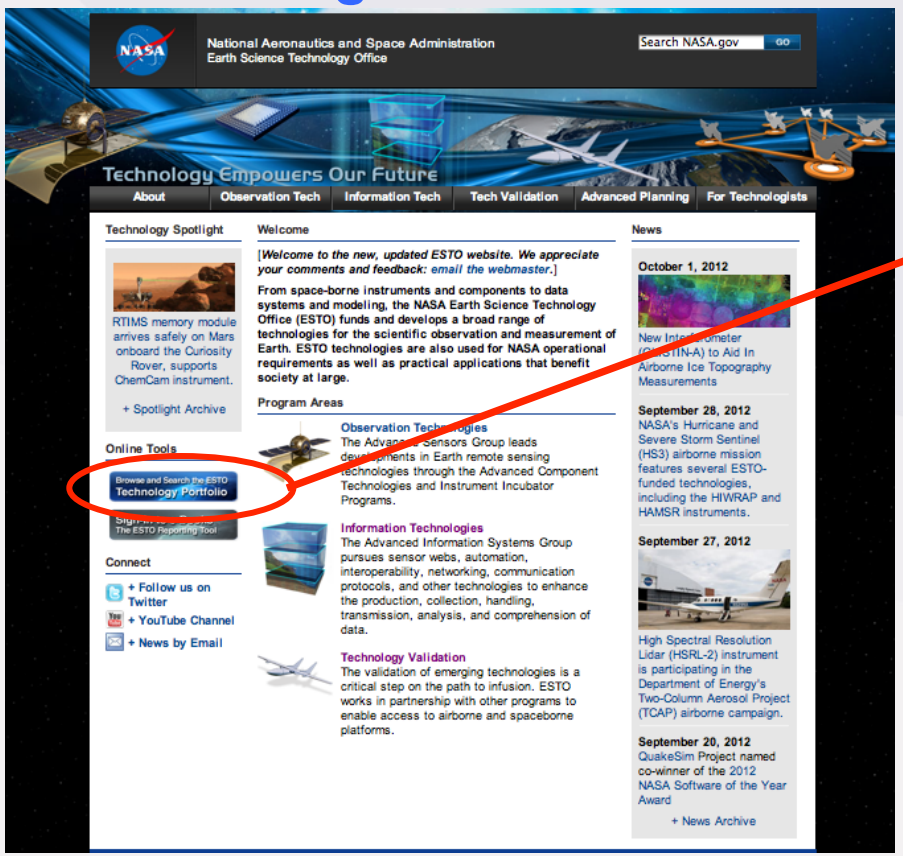
- Open, competitive program
- Frequent solicitations ensure current approaches and create regular, multiple opportunities for PIs
- Focused, science-driven approach
- Peer-reviewed process
- Technology options rather than point solutions
- Technologies selected for infusion by principal investigators 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