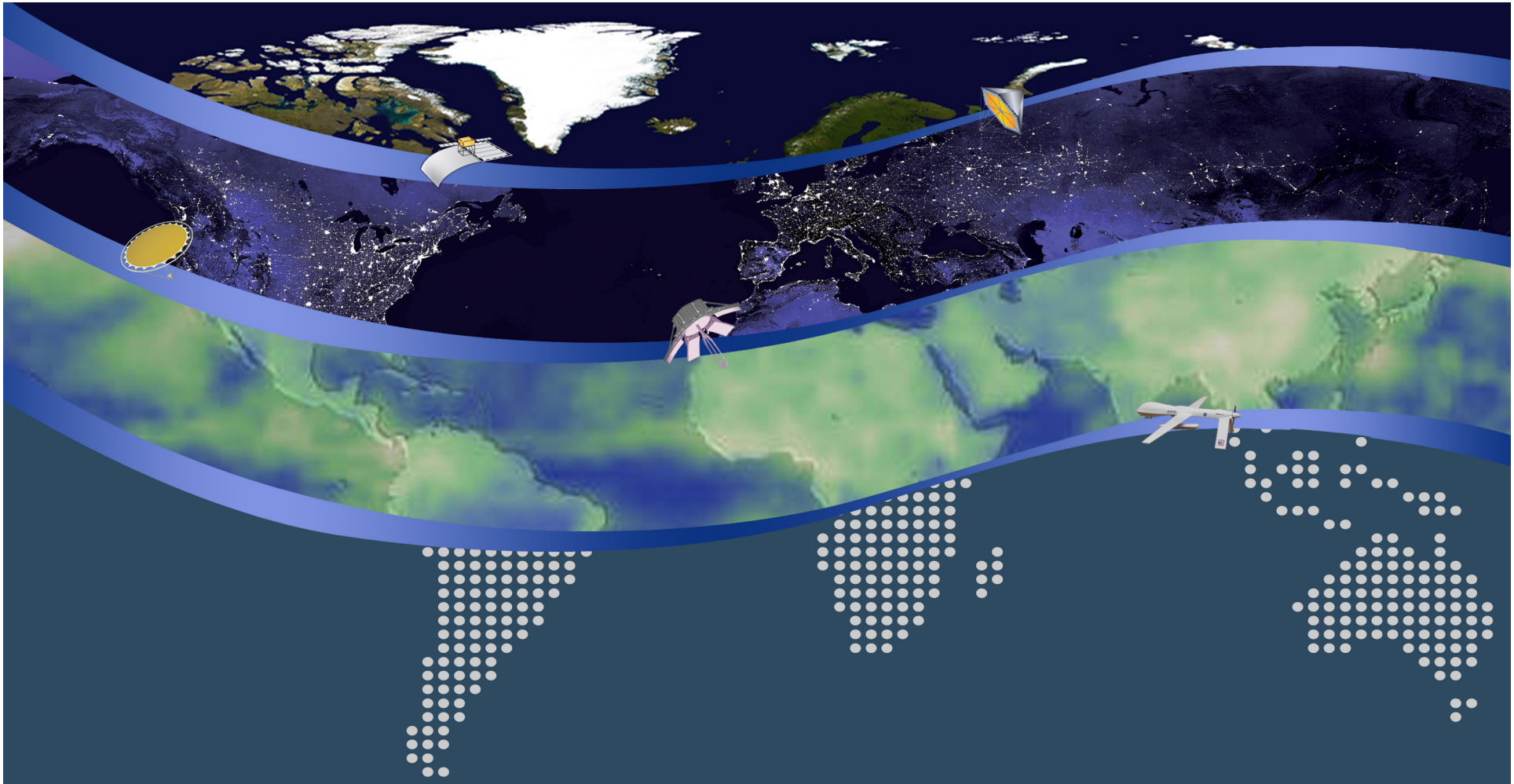

ESTO Investments in Support of the HyspIRI Mission Concept

2012 HyspIRI Science Workshop

October 16, 2012

Charles D. Norton

Jet Propulsion Laboratory, California Institute of Technology

Earth Science Technology Office (ESTO) Program Associate

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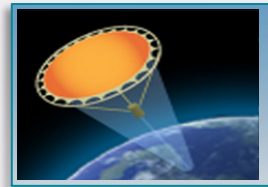
Technology Program Overview

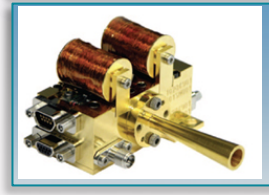
The Earth Science Technology Office (ESTO) is a ***targeted, science-driven, competed, actively managed, and dynamically communicated technology program*** and serves as a model for technology development.

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)



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
First Solicitation released in September 2012

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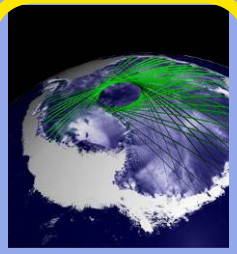
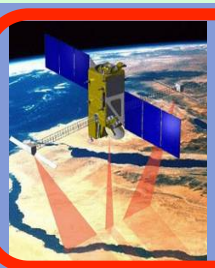
NASA Earth Science Decadal Survey Measurements

Soil Moisture Active Passive **(SMAP)**



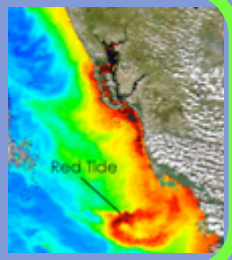
Ice, Cloud,and land Elevation Satellite II **(ICESat-II)**

Info Tech



Surface Water and Ocean Topography **(SWOT)**

Pre-Aerosol - Cloud - Ecosystems ***(PACE)***



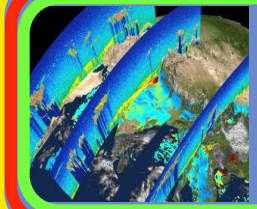
Active Sensing of CO2 Emissions **(ASCENDS)**

Hyperspectral Infrared Imager **(HYSPIRI)**

Geostationary Coastal and Air Pollution Events **(GEO-CAPE)**

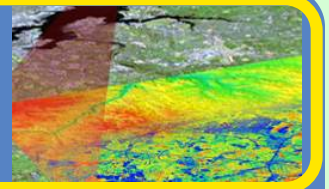
Deformation, Ecosystem Structure and Dynamics of Ice (Radar) **(DESDynI -R)**

Climate Absolute Radiance and Refractivity Observatory **(CLARREO)**



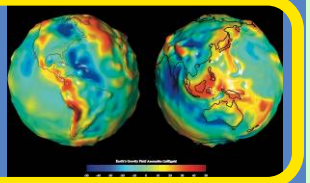
Aerosol - Cloud - Ecosystems **(ACE)**

LIDAR Surface Topography **(LIST)**



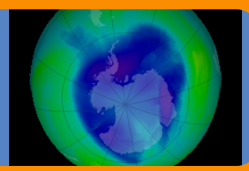
Precipitation and All-Weather Temperature and Humidity **(PATH)**

Gravity Recovery and Climate Experiment - II **(GRACE - II)**



Snow and Cold Land Processes **(SCLP)**

Global Atmospheric Composition Mission **(GACM)**

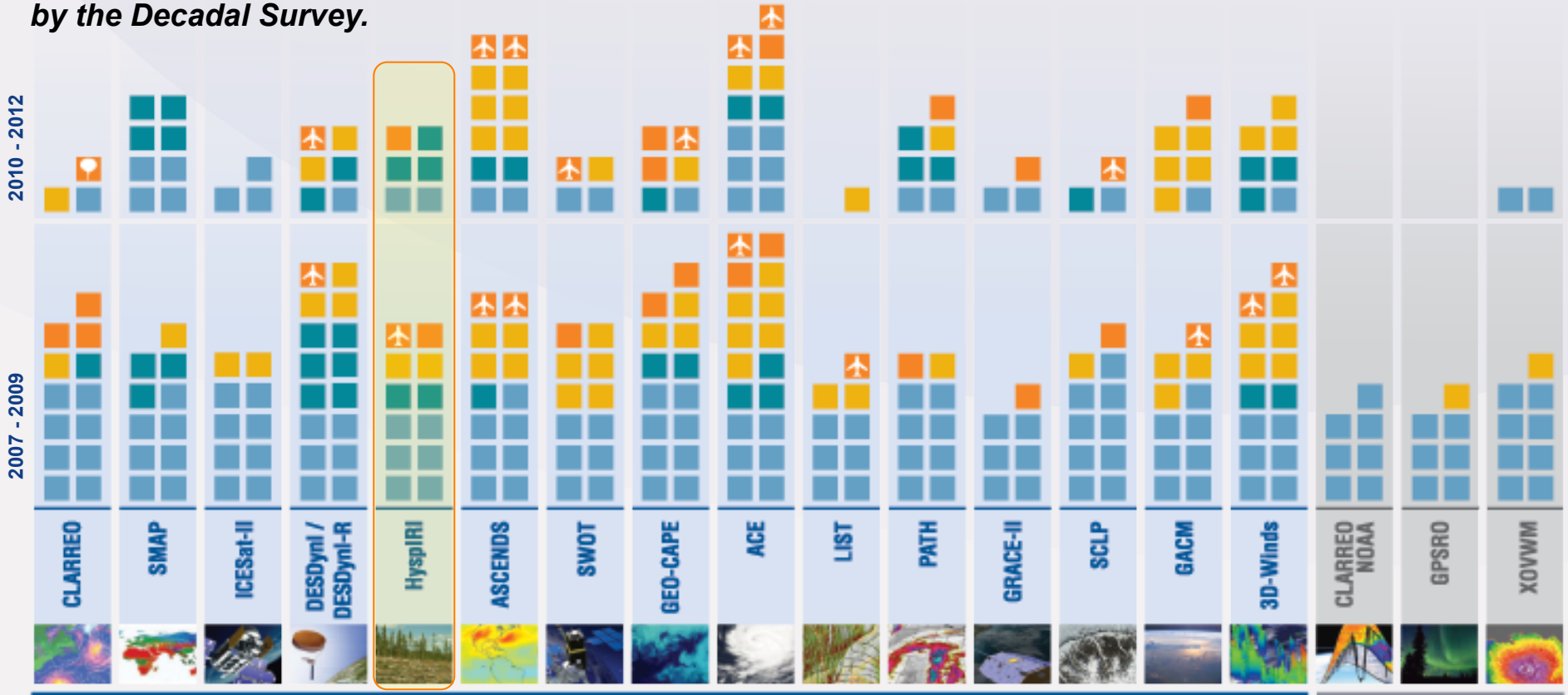


Three-Dimensional Winds from Space Lidar **(3D-Winds)**

Lasers Radars Passive Optics Passive Microwave

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.***



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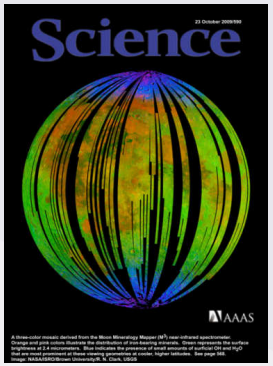
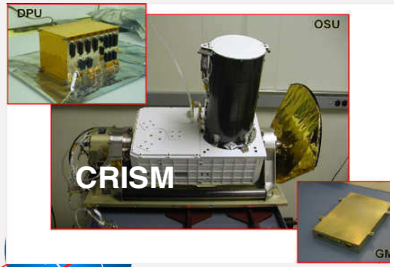
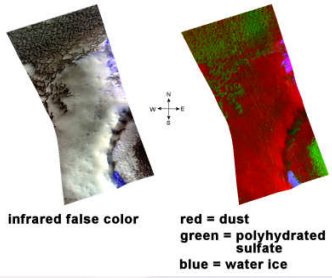
HysplRI Heritage and Key Technologies

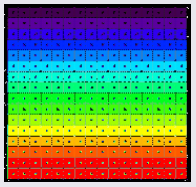
Although HysplRI is a high-heritage mission concept ESTO supports development of key instrument and information systems technology

NASA imaging Spectrometers

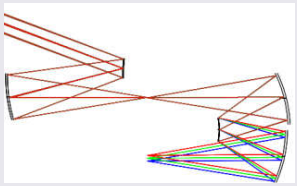


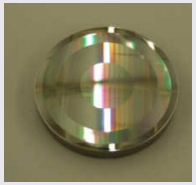




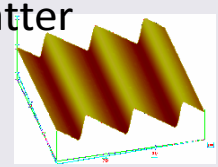


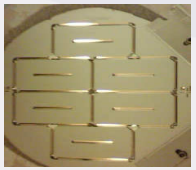
High SNR and high uniformity imaging spectrometer designs (Mouroulis et al., 2000)*



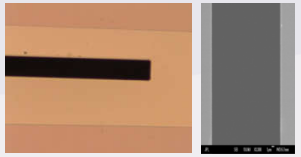


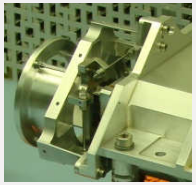
Electron-beam lithography low-scatter tuned-high-efficiency gratings on curved surfaces for space



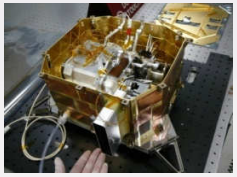


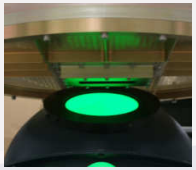
Ultra uniform 27 µm x 20 mm electron-beam lithography slit for space flight



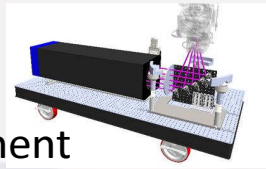


Component mounts with 0.25 micron feedback adjustment that are lockable for space flight





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

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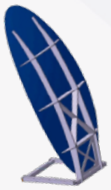
Instrument Incubator Program (IIP)
16 New Investments

16 proposals awarded funding under IIP in 12/2011.
Total dollar value is approximately $67 million.

ACTIVE

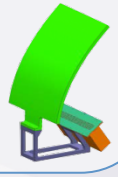
Radar

P-Band InSAR [DESDynI]
- Temilola Fatoyinbo, GSFC

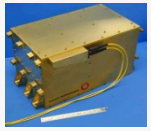


8-40 GHz Wideband SAR [SCLP]
- Tim Durham, Harris Corporation

Wide Swath Antenna [ACE]
- Paul Racette, GSFC



Laser

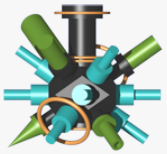


Laser Power Amplifier [ASCENDS]
- James Abshire, GSFC

Fiber Seeded Laser [ASCENDS]
- Narasimha Prasad, LaRC

Gradiometer

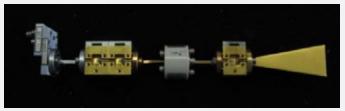
Gravity Gradiometer [GRACE-II]
- Nan Yu, JPL

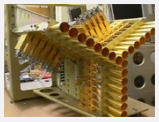


PASSIVE

Microwave

Airborne Microwave Radiometer [SWOT]
- Steven Reising, Colorado State University

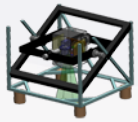




Synthetically Thinned Aperture Radiometer [PATH]
- Bjorn Lambrigtsen, JPL

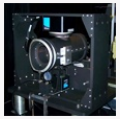
Deployable 4 m Broadband Limb Sounder Antenna [GACM]
- Richard Cofield, JPL

Optical



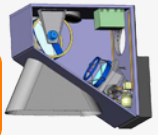
HyperSpectral Imager [CLARREO]
- Greg Kopp, University of Colorado /

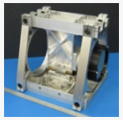
UV-SWIR Spectropolarimetric Imager [ACE]
- David Diner, JPL



Ocean Color Radiometer CCDs [ACE]
- Charles McClain, GSFC

Thermal Infrared Radiometer [HyspIRI]
- Simon Hook, JPL





Pan FTS [GEO-CAPE]
- Stanley Sander, JPL

Trace Gas/Aerosol Spectrometer [GEO-CAPE[- James Leitch, Ball Aerospace

Multi-Slit Offner Spectromter [GEO-CAPE]
- Tim Valle, Ball Aerospace

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Advanced Information Systems Technology (AIST)
18 New Investments

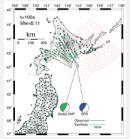
18 proposals awarded funding under AIST in 02/2012.
Total dollar value is approximately $23 million.

Weather

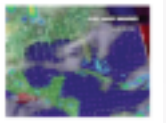
Automated Event Service [PATH]
- Tom Clune, GSFC

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

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

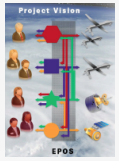


Atmospheric Composition

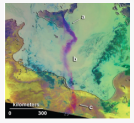


GPU Cloud Resolving Models [ACE]
- Wei-Kuo Tao, GSFC

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

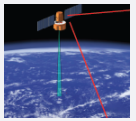


On-Board Processing [GEO-CAPE]
- Paula Pingree, JPL



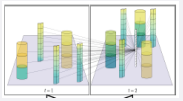
Interactive Plume Mapping via GPUs [HyspIRI]
- Alexander Berk, Spectral Sciences

Carbon Cycle and Ecosystems



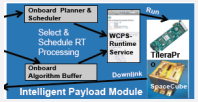
On-Board Processing for Science Instruments [ASCENDS]
- Jefferey Beyon, LaRC

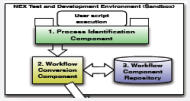
Multivariate Data Fusion and Uncertainty [ASCENDS]
- Amy Braverman, JPL



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

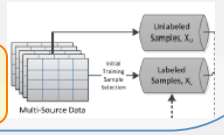
Onboard Multicore IPM [HyspIRI]
- Dan Mandl, GSFC





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

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Advanced Component Technologies (ACT) Program
15 New Investments

ACTIVE

Radar

Advanced W-Band MMICS [ACE]
- King Fung, JPL

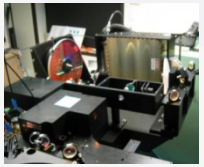
T/R Modules for DESDynI-class Instruments - James Hoffman, JPL

Antenna for Digital Beamforming SAR [DESDynI] - Rafael Rincon, GSFC

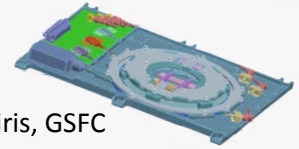
Laser / Lidar

Mid-IR Laser Development [GACM / CLARREO / ASCENDS] - James Anderson, Harvard University

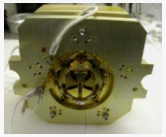
Combined HSRL and Optical Autocovarience Wind Lidar Demo [ACE / 3D-Winds]
- Thomas Delker, Ball Aerospace



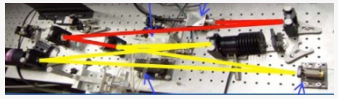
02 Subsystem Advancement [ASCENDS]
- Jeremy Dobler, ITT Industries



Compact Lidar for Methane [GACM / ASCENDS] - Haris Riris, GSFC



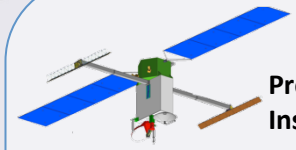
2-Micron Pulsed Laser [3D-Winds]
- Upendra Singh, LaRC



2-Micron Pulsed Laser Transmitter for Column CO2 [ASCENDS] - Jirong Yu, LaRC

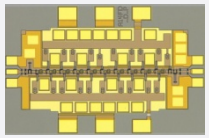
PASSIVE

Microwave



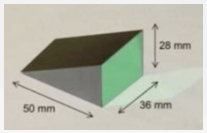
Precision Deployable Mast for KaRIn Instrument [SWOT] - Gregory Agnes, JPL

Hyperspectral Receiver Subsystem [PATH]
- William Blackwell, MIT Lincoln Lab



Receiver Front Ends for Submillimeter-Wave Sounders [GACM]
- Goutam Chattopadhyay, JPL

Optical



Immersion Gratings for High Resolution Imaging [GACM / ASCENDS / GEO-CAPE]
- Daniel Jaffe, University of Texas

Infrared Avalanche Photodiode Single Photon Detector Arrays [LIST / ASCENDS / GACM]
- Xiaoli Sun, GSFC

Fabry-Perot for Integrated Direct Detection Lidar [3D-Winds]
- Sara Tucker, Ball Aerospace

15 proposals awarded funding under ACT in September 2011.
Total dollar value is approximately $16million.

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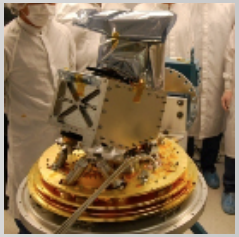
History of ESTO HyspIRI-Related Investments

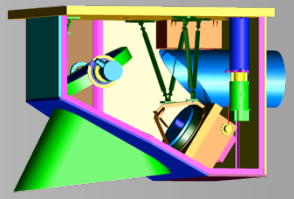
Targeted, Science-Driven, Competed, Actively Managed Technology Program

Past ESTO Investments Supporting HyspIRI

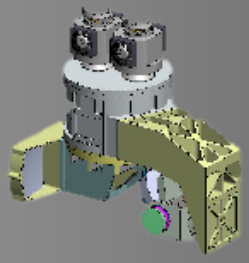
AVIRISng: Next Generation Airborne Visible InfraRed Imaging Spectrometer
PI: Robert Green
ATI-2009/JPL



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

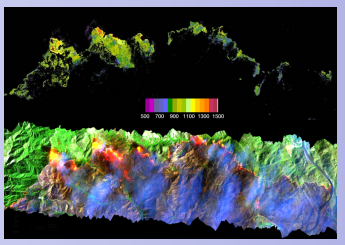


Mineral & Gas Identification Using a High-Performance Thermal Infrared Imaging Spectrometer
PI: Jeff Hall
IIP-2007/Aerospace

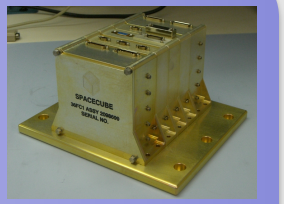


Observation Technologies

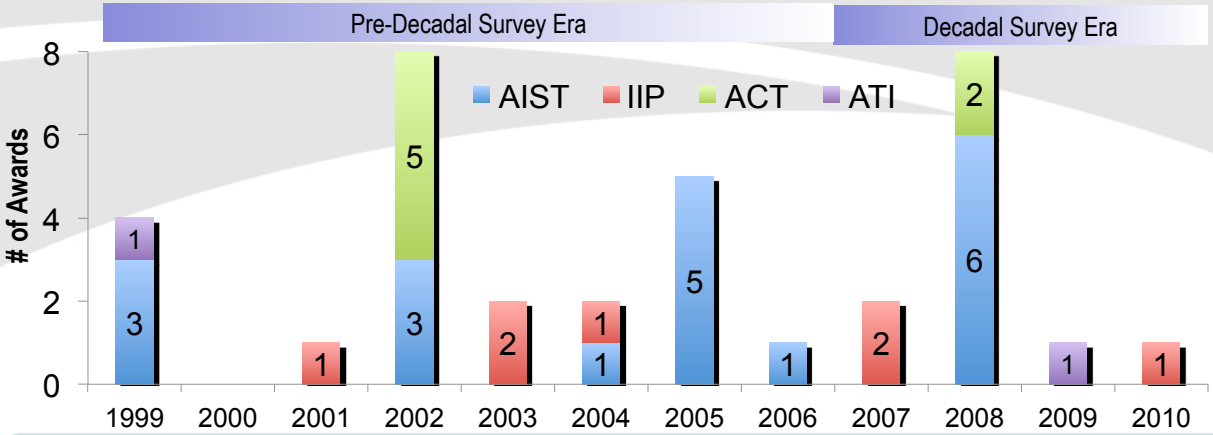
IPM: Sensor Web 3D Intelligent Payload Module Custom Products
PI: Dan Mandl
AIST-2008/GSFC



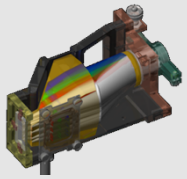
Autonomous On-board Processing for Sensor Systems
PI: Matthew French
AIST-2008/USC-IS



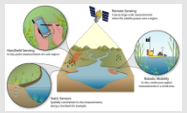
Information Technologies



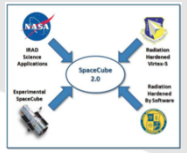
Supporting Technologies



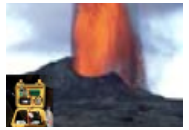
HyTES: Hyperspectral Thermal Emission Spectrometer for HyspIRI
PI: Simon Hook, IIP-2007/JPL



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

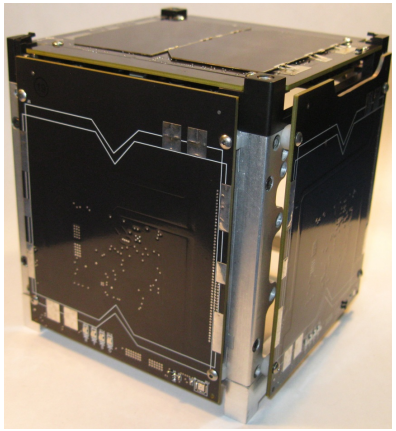
From FY'07-'11, ESTO has 12 HyspIRI-related technology development tasks with a total investment of ~$19.5M

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

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
04/15/13 Delivery for Launch Integration
10/01/13 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

In development for April 2013 delivery for launch integration.

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IPEX Balloon Test at 100,000 Feet

Organized by Colorado Space Grant Consortium

Windsor CO on 7/28/2012

- Rapid prototype structure with 8 cameras
- 1050 test images taken
- Received telemetry beacons from IPEX Balloon Unit during entire flight
- 2 hour 25 minute flight where balloon burst at 108,000 ft
- ~350 CASPER activities scheduled and executed through FSW with telemetry
- 2500x1600 pixels capability with ~50 deg FOV

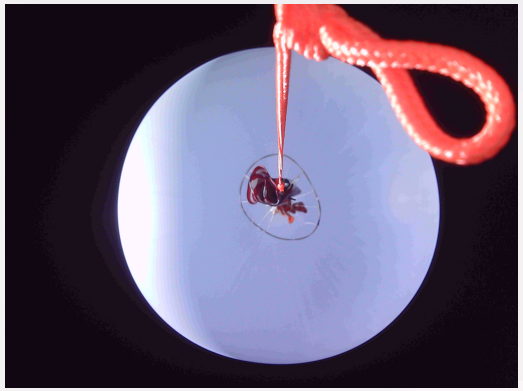
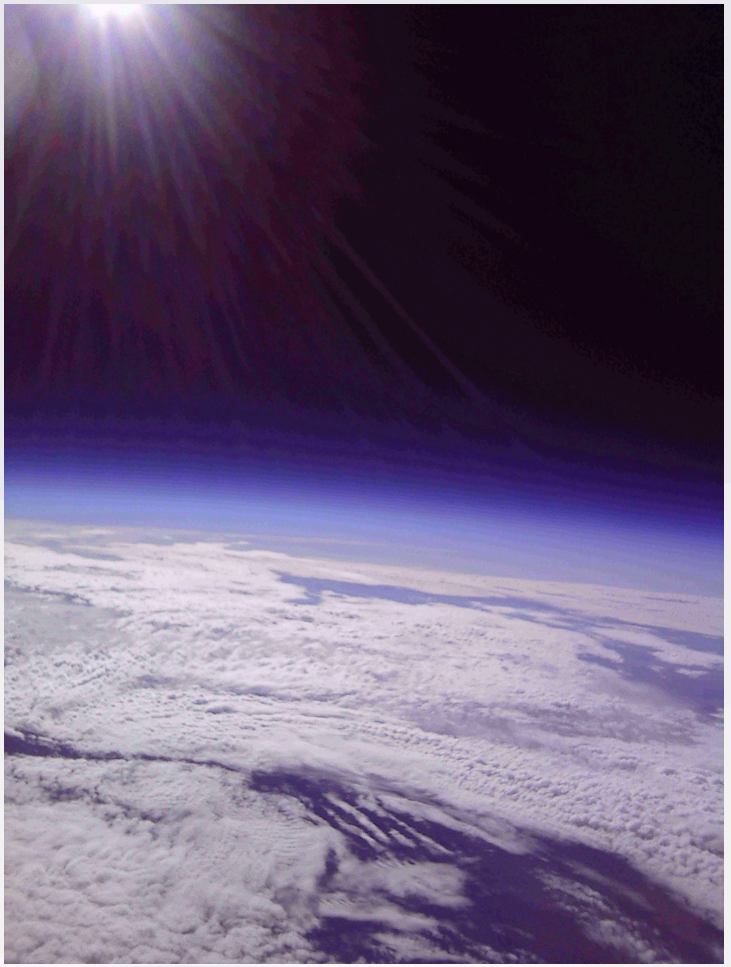


Image of Earth at 100,000 ft



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ESTO Activities Directly Supporting HyspIRI Development

Current IIP-funded PHyTIR is raising TRL of TIR focal plane assembly from 5 to 6 by March of 2013

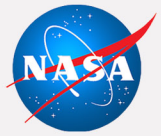
ESTO-supported AVIRIS-NG is providing risk reduction and will support cal/val and precursor science, flying in 2012

ESTO-supported HyTES is providing risk reduction and will support cal/val and precursor science, flying in 2012

HyspIRI airborne-related and other applicable ROSES opportunities

Multiple IPM related ESTO-funded efforts for HyspIRI

EO-1 leveraging for imaging spectrometry, including data processing



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ESTO-Supported TRL Assessments

Product breakdown			*Technology Level Assessment*			*Implementation Approach*	
System / Subsystem	**Assembly**	**Component**	**Key Technology Items***	**TRL**	**Justification**	**Implementation Method**	**Vendors (if applicable)**
HyspIRI Target Environment =	**Space**						
TIR Focal Plane + Electronics							
	Focal Plane Assembly			**5**	IIP Expected TRL 6 in 2013		
		Detector Material	HgCdTe Material slightly new doping	5	IIP Expected TRL 6 in 2012	Fabricating detector material and mating to ROIC and vacuum cryo testing	Teledyne
		ROIC	high frame rate	5	IIP Expected TRL 6 in 2012	Fabricating detector material and mating to ROIC and vacuum cryo testing	Teledyne
		Filters		7			
	Flex Print Cable			7			
	Electronics			**6**			
		Signal Chain Elec.	2X higher data rates than what has flown	6	Limited breadboards planned on PHyTIR		
		Housekeeping Elec.		7			
		Power Electronics		7			
		Compression Algorithm		6	Engineering feasibility fully demonstrated with same 2:1 compression by ASTER		
		Digital Electronics	New FPGA due to obselescence	6	Uses Virtex 5 QV (SIRF) flying on cubesat. Went through environmental testing on the ground		
TIR Mechanical							
	Scanning Mirror Assembly			7	mechanism fle on GIFTS and WISE. It is changed from a one sided to a two sided mirror and mirror rotates at a constant velocity, rather than oscillating. TIR's requiremetns are exceeded by the heritage assembly		
	All other items			7	Telescope Bench, Enclosure and Focal Plane Assembly Mounts use technologies flown on DIVINIR, MER and M3 (respectively)		
TIR Thermal							
	Electronics Radiators			7	technology has flown on M3, TES, MISR, AIRS, MICAS and MLS. Design is change to suit this configuration		
	All other items			7-9	includes cryo cooler (TRL 9), thermal straps, heaters and controllers, finishes and MLI		
	Passive Cooler			7	Scaled version of M3 passive cooler (2x larger)		
	Thermal Enclosure and vent			7	Common aluminum enclosure, design changed to meet configuration and thermal reqts		
	Heat Pipes			7	technology has flown, specific design is custom to the geometry and heat loads of this configuration		

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ESTO-Supported TRL Assessments

Product breakdown			*Technology Level Assessment*			*Implementation Approach*	
VSWIR Focal Plane + Electronics							
		Detector Package		7			
		Detector Material	Twice the size of previously flown detector (M3, ARTEMIS, CRISM).	7	Has been tested in vacuum, cryo, radiation, vibration and had performance validated	Fabricate more lots than for previously flown detectors	Teledyne
		6604 B ROIC	Twice the size of 6604 A with new digital components	6	Scaled up from 6604A Vacuum, and cryo tested	Have mated it to HyViSi detectors and tested vacuum, cryo. SEL testing is needed.	Teledyne
		Filter		7			
	Flex Print Cable			7			
	Electronics			**6**			
		Signal Chain Elec.		7	Signal chain has flown on airborne CAO, NEON, AVIRIS NG and all EE parts available, meet radiation req'ts and are class B+.		
		Housekeeping Elec.		7			
		Power Electronics		7			
		Compression Algorithm		6	Engineering feesibility fully demonstrated by compressing AVIRIS, MARS and Next Gen Imaging Spectrometer at better than 3:1		
		Digital Electronics	New FPGA due to obselescence	6	Uses Virtex 5 QV (SIRF) flying on cubesat. Went through environmental testing on the ground		
VSWIR Mechanical							
	All items			7-9			
VSWIR Thermal							
	Electronics Radiators			7	technology has flown on M3, TES, MISR, AIRS, MICAS and MLS. Design is change to suit this configuration includes thermal straps, heaters and controllers, finishes and MLI		
	All other items			7-9			
	Passive Cooler			7	Scaled version of M3 passive cooler (3x larger)		
IPM Software							
	Ground Operations			7			
	Onboard Algorithms			7-9	Only high heritage algorithms are used		
	Flight Software			8	Flown in SpaceCube		

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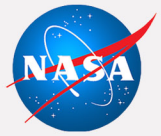
ESTO Program Philosophy

- 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.



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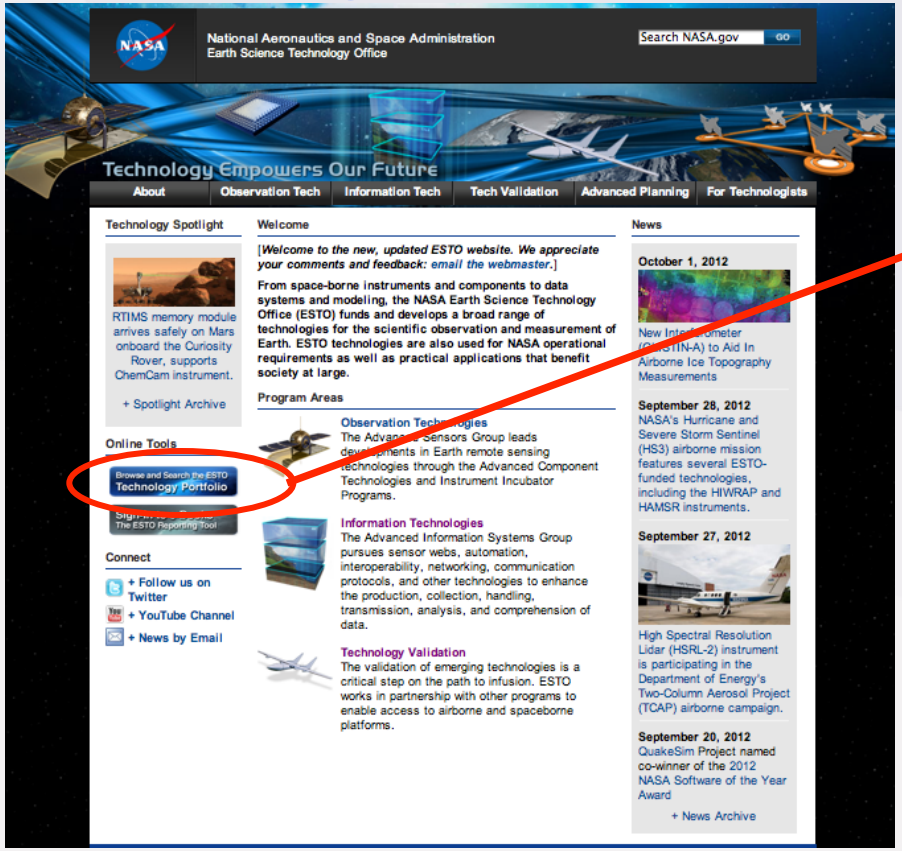
To Learn More…

Visit the NEW ESTO Website:
esto.nasa.gov



And Browse the ESTO Technology Portfolio

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Visit us at esto.nasa.gov

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