

NASA Earth Science Technology Program

Presented to: **University of North Texas**

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Introduction

The Earth Science Technology Program

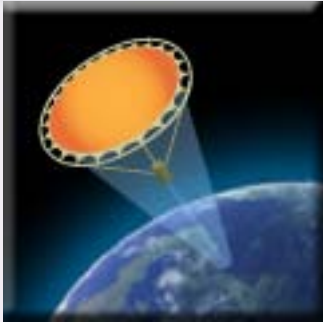
- *A science-driven, competed, actively managed and dynamically communicated technology program*
- Competitive, peer-reviewed proposals enable selection of best-of-class technology investment.
- Risk is retired before major dollars are invested: a cost-effective approach to technology development and validation
- *Managed by the Earth Science Technology Office (ESTO) at Goddard Spaceflight Center.*
- Since the Earth Science Decadal Survey was published in 2007, ESTO has focused on technologies to support Decadal Survey measurements

This has resulted in the award of 57 technology projects representing an investment of over \$105M directly related to the Earth Science Decadal Survey.



ESTO Programs

Observation Technologies:



Instrument Incubator Program (IIP)

Provides robust new instruments and measurement techniques

Advanced Component Technologies (ACT)

Provides development of critical component and subsystem technologies for instruments and platforms.

Information Technologies:

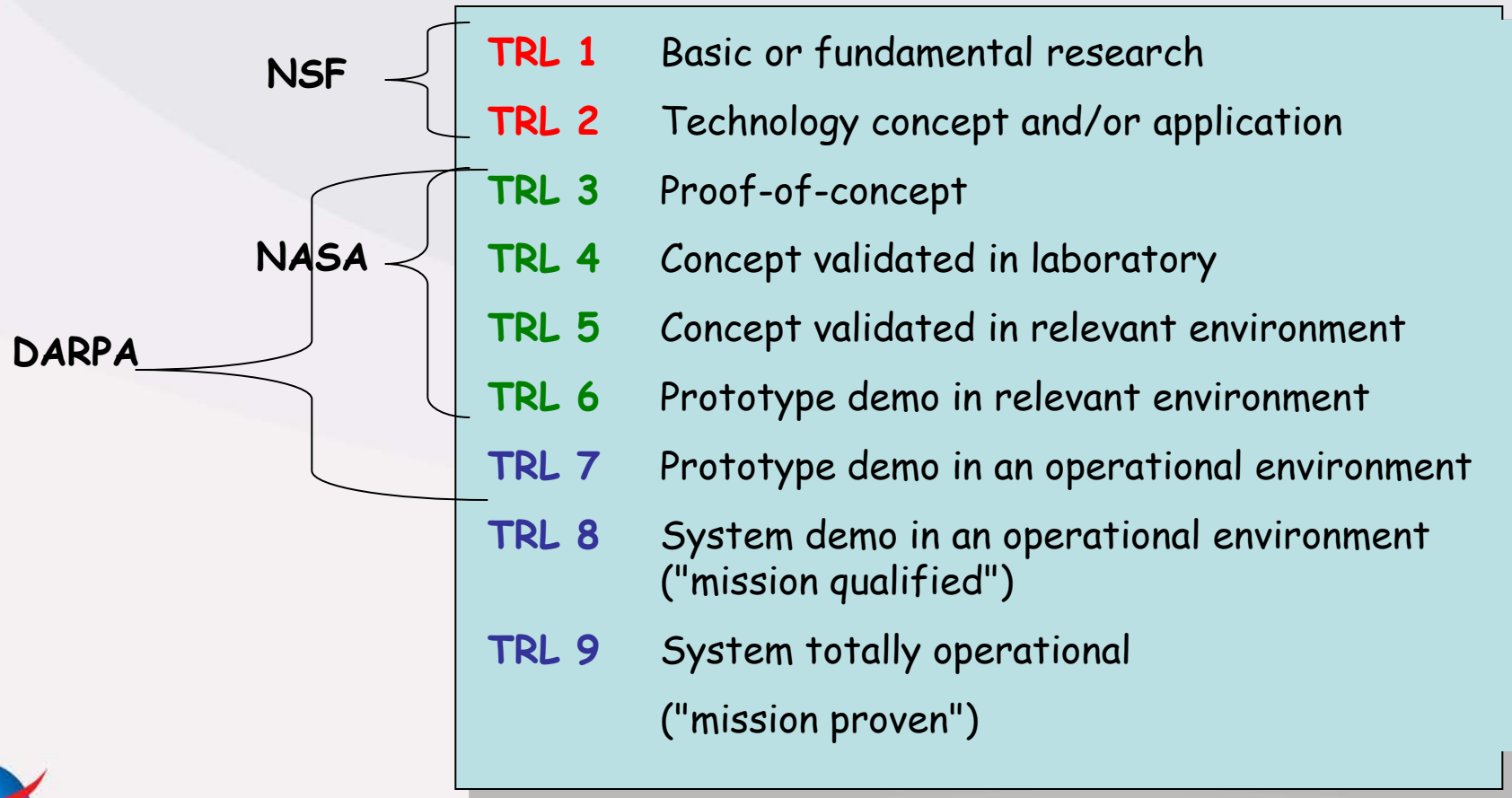


Advanced Information Systems Technology (AIST)

Provides innovative on-orbit and ground capabilities for communication, signal and data processing, and management of remotely sensed data, as well as the efficient generation of data products and the extraction of knowledge from those products.



Technology Readiness Levels for Federal Research Agencies



Program Schedule / Budget

	FY10				FY11				FY12				FY13				FY14				FY15				
	Q	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
ROSES Solicitations		▲				▲				▲				▲				▲							
IIP Solicitation NRA Release		IIP-10 ▲												IIP-13 ▲											
ACT Solicitation NRA Release						ACT-11 ▲												ACT-14 ▲							
AIST Solicitation NRA Release						AIST-11 ▲												AIST-14 ▲							
In-Guide Totals (\$M)		45.9				47.8				47.9				49.1				54.7				56.0			
Total ESD Budget (\$M)		1,392				1,197				1,211				1,231				1,261				1,291			
% of Total ESD Budget		3.3%				3.9%				4.0%				4.0%				4.2%				4.2%			



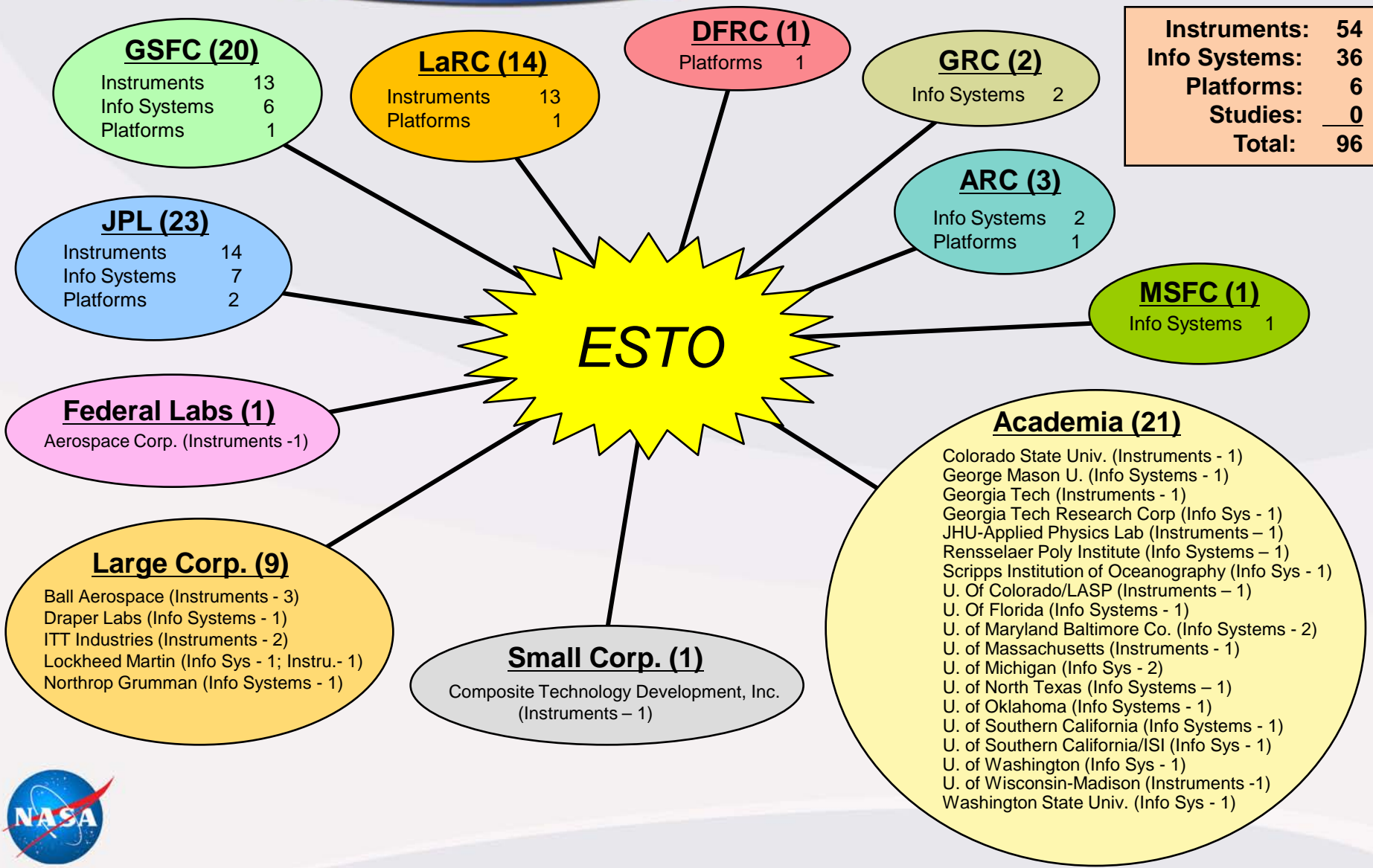
Progress to Date

Over the past 12 years, ESTO has issued fourteen competitive research solicitations, and funded and managed development on a wide range of technologies:

- 505 Projects Completed to Date (through FY09)
 - Principal Investigators from 102 different organizations located in 32 states and the District of Columbia:
 - 43 academic institutions
 - 43 companies
 - 11 national laboratories
 - 5 NASA centers
 - 365 projects (72%) advanced at least 1 technology level (TRL)
 - 172 projects (34%) already infused into missions/campaigns
 - 221 additional projects (44%) identified for infusion

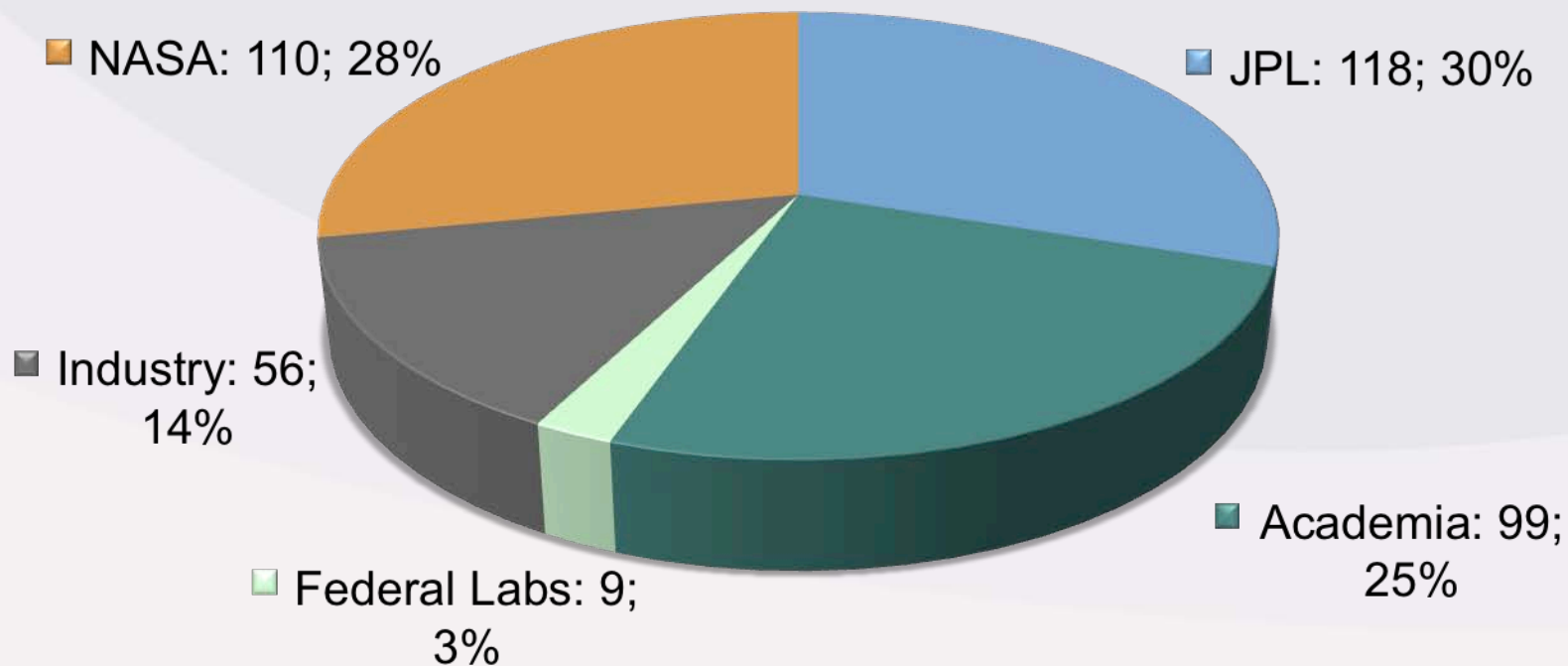


FY10 Technology Investments



ESTO Investigators

ESTO's 392 Active PIs and Co-Is Represent a Diverse Set of Institutions

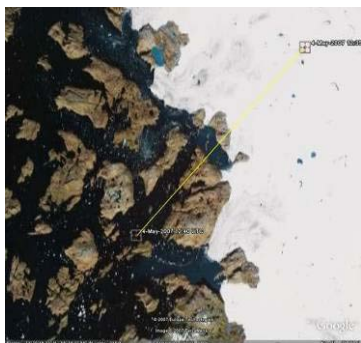


In 2009 alone, over 140 students from more than 39 institutions actively supported ESTO projects (138 ESTO projects were active during 2009). Approximately half are pursuing a Ph.D. Others are working toward masters or undergraduate degrees or are involved in a postdoctoral program.



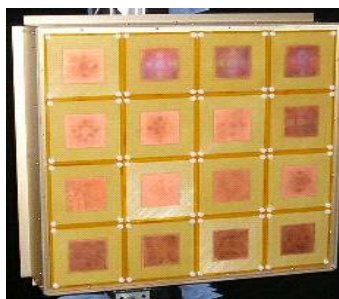
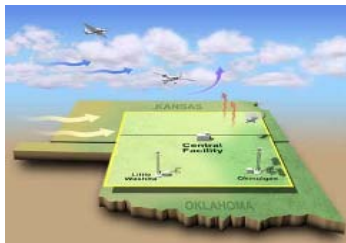
Highlights: Science Campaign Infusions

Greenland Campaign



Pathfinder Advanced Radar Ice Sounder (IIP-04: Raney)

CLASIC Campaign (Department of Energy)

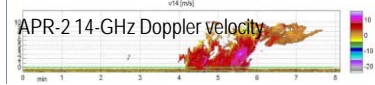
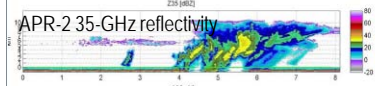
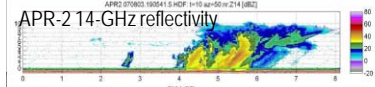
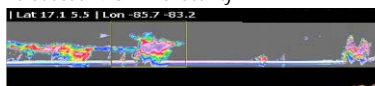


Lightweight Dual-Frequency Microstrip Antenna Feed for Future Soil Moisture and Sea Surface Salinity Missions (ACT-05: Yueh)

Tropical Composition, Cloud and Climate Coupling (TC4)



Cloudsat 94 GHz Reflectivity

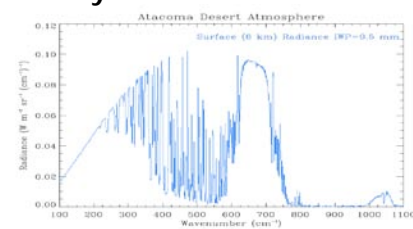


Advanced Precipitation Radar-2 (IIP-02: Im)

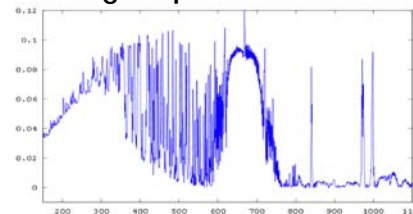
RHUBC-II Campaign (Cerro Toco Plateau, Chile)



Theory



First Light Spectrum - 8/21/09

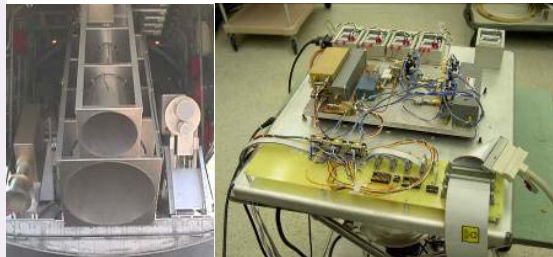


Far Infrared Spectroscopy of the Troposphere (FIRST) (IIP-04: Mlynczak)

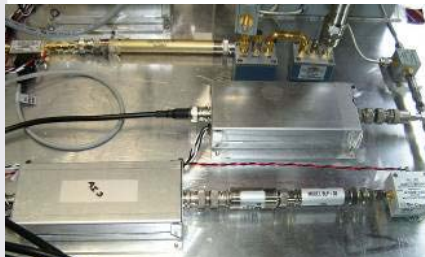


Highlights: Mission Infusions

Ultra-Stable Radiometers
IIP-02: Bill Wilson



RFI Suppression System for
Microwave Radiometers
ACT-02 and ACT-05: Jeff
Piepmeier and Joe Knuble



Controlled-Correlation
Calibration Subsystem
ACT-99: Ed Kim & Jeff
Piepmeier

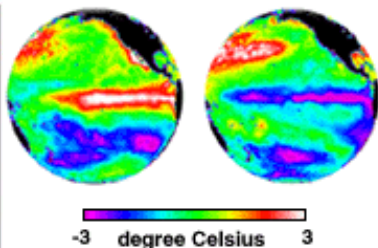


Launch: May 2010

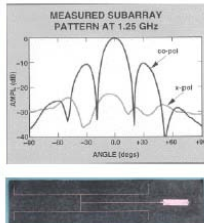


Aquarius ESSP

ParVox



Parallel Volume Rendering
CT-03: Peggy Li



Lightweight Feed For Future
Salinity Missions
ACT-02: Simon Yueh



Digital Detector for RFI
Detection (Ground Truth)
IIP-04: Christopher Ruf

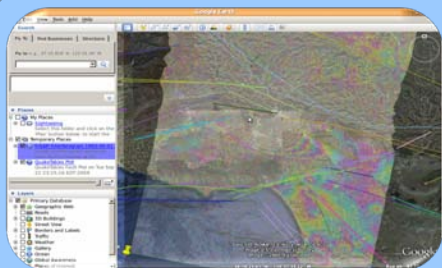


Highlights: Application Infusions



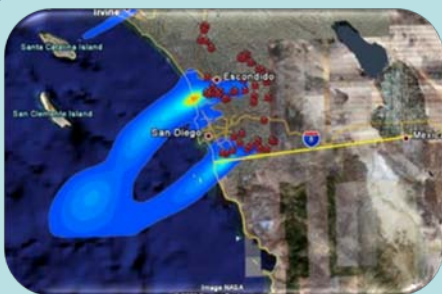
Disaster Response

The **Interoperable Sensor Architecture for Sensor Webs** project is working with over 40 partners world-wide to demonstrate automation and interoperability technologies for the rapid distribution of satellite data following various natural disasters. To date, the project has run numerous pilot projects that have substantively benefited society, including responses to several events in 2009 : the Station Fire in California, the Namibian floods (shown left), mudslides in Honduras and Guatemala, the Samoa Tsunami, and the Baja Mexico Hurricane. (AIST-05, Mandl)



Earthquake Forecasting

The **QuakeSim** project is advancing integration of both real-time and archival sensor data with computing applications to improve earthquake forecasts. The project has been in the news this year or work with the Los Angeles Department of Water and Power to analyze a rash of anomalous pipe breaks and any possible correlation to seismic activity. QuakeSim is also being applied to the DESDynI mission design and is being used for DAWN mission science analysis. (AIST-05 and AIST-08, Donnellan)



Air Quality Monitoring

The **Sensor-Analysis-Model Interoperability Technology Suite (SAMITS)** pilot project was used to analyze the impact of the 2008 California wild fires on air quality (visualization at left). The project, which fosters two-way data and control flow between active sensors and data analysis and modeling tools, has created collaborations to apply the technology to air quality forecasting and public health alert systems. SAMTIS is part of the GEOSS Air Quality and Health pilot program and is also being infused into the CEOS Atmospheric Composition Portal. (AIST-05, Falke)



Highlights: UAVSAR

Heritage



Status



Future



UAVSAR Capabilities:

- 2X better resolution than AIRSAR
- Agile waveform
- Multimode operation
- Over 1.2 million km² of L-Band Radar imagery
- Supporting DESDynI, SMAP and IPY
- Global Hawk UAV will carry two pods to enable increased range and Single Pass Interferometry

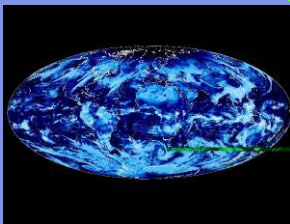
	First Flight	Mass	Power	Volume
AirSAR	1988	3840 lbs	> 10 KW	> 1500 cu ft
UAVSAR	2008	~1000 lbs	2.1 KW	81 cu ft

Today, UAVSAR is a fully capable airborne instrument for measurements of surface features – from glacier movement and seismic activity to vegetation change to land subsidence and groundwater use.



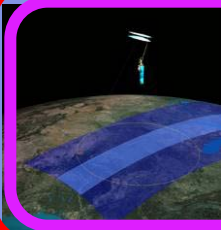
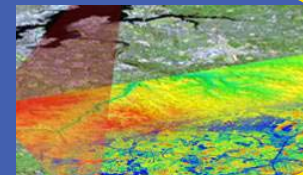
NASA Earth Science Decadal Survey Missions

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



Hyperspectral
Infrared Imager
(**HYSPIRI**)

LIDAR Surface
Topography
(**LIST**)



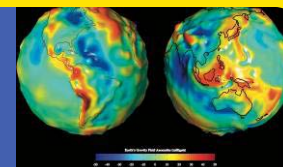
Soil Moisture Active
Passive (**SMAP**)

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

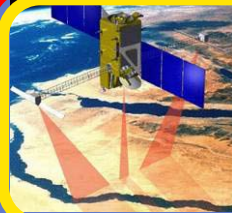
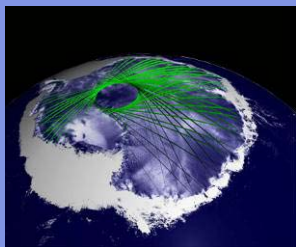


Precipitation & All-
Weather Temp &
Humidity (**PATH**)

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



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



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



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

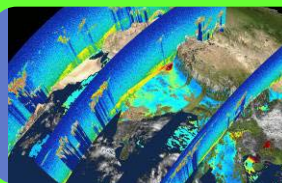
Geostationary
Coastal and Air
Pollution Events
(**GEO-CAPE**)



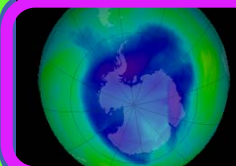
Three-Dimensional
Winds from Space
Lidar (**3D-Winds**)



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



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



Global Atmospheric
Composition Mission
(**GACM**)

Lasers

Radars

Passive Optics

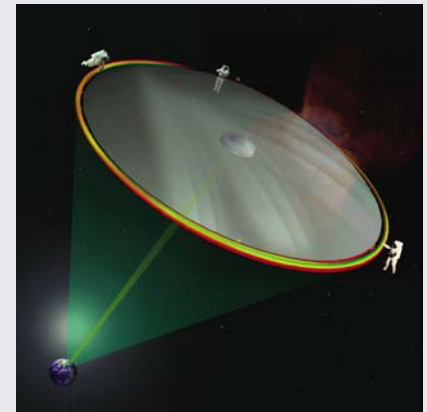
Passive Microwave

Earth Science Technology Challenges

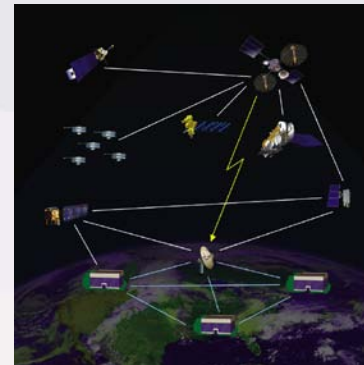
Active Remote Sensing Technologies to enable atmospheric, cryospheric and earth surface measurements



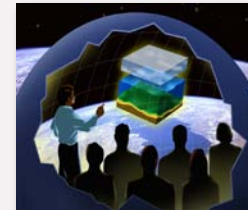
Large Deployables to enable future weather, climate and natural hazards measurements



Intelligent Distributed Systems using advanced communication, on-board reprogrammable processors, autonomous network control, data compression, high density storage



Information Knowledge Capture through 3-D visualization, holographic memory and seamlessly linked models.



Conclusions and Current Status

- A focused, science-driven approach
- Peer-reviewed process
- Open, competitive program
- Frequent solicitations ensure current approaches and create regular, multiple opportunities for PIs
- 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.
- In 2007-2008, 57 new awards for instrument, component, and information system technologies were selected by NASA and awarded over \$105M in funding. These technologies are providing new capabilities that will enable the Earth Science Decadal Survey missions.





Technology Enables our Future



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Backup Slides

Instrument Incubator Program 2007 Awards vs. Decadal Survey Missions

2007 Instrument Incubator Awards versus Decadal Survey Missions

	CLARREO	SMAP	ICESat-II	DESDynI	HypIRI	ASCENDS	SWOT	GEO-CAPE	ACE	LIST	PATH	GRACE-II	SCLP	GACM	3D-Winds	CLARREO-NOAA	GPSRO	XOVMW
Abshire/GSFC - column CO2, lidar						✈												
Diner/JPL - aerosols and clouds, polarimetric imager									✈									
Durden/JPL - clouds and precipitation, profiling radar																		
Folkner/JPL - time-varying gravity, laser frequency stabilization																		
Fu/JPL - surface water and ocean topography, interferometric SAR																		
Grund/Ball - tropospheric winds, Doppler lidar																		✈
Hackwell/Aerospace - mineral and gas, TIR spectrometer					✈													
Heaps/GSFC - column CO2, lidar						✈												
Hook/JPL - mineral/water resources, hyperspectral TIR spectrometer																		
Kavaya/LaRC - tropospheric winds, Doppler lidar																		✈
Kopp/CU - radiation balance, UV-SWIR hyperspectral imager	■																	
Lambrigtsen/JPL - T, water vapor, precipitation; microwave sounder																		
McClain/GSFC - ocean color, UV-SWIR radiometer																		
Mlynczak/LaRC - radiation balance far-IR spectrometer	■																	
Neil/LaRC - boundary laser CO, gas correlation radiometer																		
Papapolymerou/GT - snow-water equivalent, X-band phased array																		
Revercomb/UWM - radiation balance, SI-traceable IR calibration	■																	
Sander/JPL - air pollution and coastal imaging, panchromatic FTS																		
Stek/JPL - atmospheric composition, microwave limb sounder																		✈
Weimer/Ball - vegetation canopy, steerable lidar				✈														
Yu/GSFC - topography and vegetation structure, swath-mapping lidar										✈								



■ IIP-07 Award Linkage

✈ IIP-07 Award Linkage with
Airborne Testing Planned

Advanced Component Technology Program 2008 Awards vs. Decadal Survey Missions

2008 Advanced Component Technology Awards versus Decadal Survey Mission	CLARREO	SMAP	ICESat-II	DESDynI	HypIRI	ASCENDS	SWOT	GEO-CAPE	ACE	LIST	PATH	GRACE-II	SCLP	GACM	3D-WINDS	CLARREO-NOAA	GPSRO	XOVWM
Dobbs/ITT - corrugated mirror telescope array for lidar			■	■		■			■	■				■	■			
Fang/JPL - large deployable reflector for Ka- and W-band									■	■								
Hoffman/JPL - thermal packaging for RF hybrids, radar				■			■							■				
Illing/Ball - polarization scrambler, spectroscopy					■			■	■									
Janz/GSFC - visible NIR blind GaN focal plane array, hyperspectral								■										
Krainak/GSFC - NIR optical receiver, lidar			■	■		■			■	■					■			
Marx/GSFC - hybrid doppler wind lidar transceiver															■			
McGill/GSFC - detector technology for cloud aerosol lidar									■						■			
Meehan/JPL - RF ASIC for digital beamforming, GNSS															■		■	
Mlynczak/LaRC - FIR detectors for Earth radiation	■																	
Phillips/LockMart - CO2 laser absorption spectroscopy						■												
Reising/Colo. St. Univ.- radiometer for wet-tropospheric correction							■											
Rider/JPL - analog to digital converter from UV to mid-IR					■			■	■						■			
Siqueira/Univ. Mass. - low power, high BW receiver, Ka-band							■											
Taylor/Composite Tech. Dev. - large aperture, deployable reflector		■					■				■		■					■
Thomson/JPL - deployable Ka-band reflect array							■											

■ ACT-08 Award Linkage



Advanced Information Systems Technology 2008 Awards vs. Decadal Survey Missions

2008 Advanced Information Systems Technology Awards versus Decadal Survey Mission

	CLARREO	SMAP	ICESat-II	DESDynI	HypIRI	ASCENDS	SWOT	GEO-CAPE	ACE	LIST	PATH	GRACE-II	SCLP	GACM	3D-WINDS	CLARREO-NOAA	GPSRO	XOVWM	Broad App.
Bock/Scripps, UCSD – Solid Earth – Data fusion				■							■						■		
Braverman/JPL – Carbon/eco – Data fusion	■					■													
Donnellan/JPL – Solid Earth – Cloud computing				■															
Flatley/GSFC – Broad app. – On-board data/signal processing									■										
French/USC/ISI – Broad app. – On-board data & signal processing				■	■														
Goodman/MSFC – Climate – Data manipulation								■											
Ivancic/GRC – Atm. comp. – Sensor web enablement																			■
Leptoukh/GSFC – Atm. Comp. - Ontology								■											
Lou/JPL – Solid Earth – On-board data & signal processing				■															
Mandi/GSFC – Carbon/eco – Data manipulation					■														
Moghaddam/U. Mich – Water/energy – Mission simulation & design		■																	
Nemani/ARC – Carbon/eco – Mission management		■																	
Peters-Lidard/GSFC – Water/energy – Algorithms & modeling		■																	
Pingree/JPL – Climate – On-board data & signal processing									■										
Rosen/JPL – Climate – Algorithms & modeling				■															
Schneider/U. Florida – Weather – Data manipulation															■				
Seablom/GSFC – Climate – Mission management																			
Shen/UMBC – Weather – High-performance computing	■																		
Tanelli/JPL – Climate – Mission/system simulation & design									■										
Von Allmen/JPL – Solid Earth – Algorithms & modeling				■															



■ AIST-08 Award Primary Linkage
 □ AIST-08 Award Secondary Linkage

Accomplishments: Innovative Technology Development



Climate / Radiation Balance: At left, a balloon launch of the Far Infrared Spectroscopy of the Troposphere (FIRST) instrument, which provided the first-ever infrared emission spectrum of Earth in the 10-100 micron range, a spectral region that contains over 50% of the Earth's long wave radiation.



Weather: Above is the High-Altitude MMIC Sounding Radiometer (HAMS R) on board the ER-2 aircraft. This miniaturized sounder can measure water vapor, temperature, clouds and rain.



Earth's Surface: Above, the Uninhabited Aerial Vehicle – Synthetic Aperture Radar (UAVSAR) pod on the NASA G-III aircraft. UAVSAR has the potential to measure and monitor a wide range of surface features – from glacier movement and seismic activity to vegetation change to land subsidence and groundwater use.



Ice Sheets: At left, the Pathfinder Airborne Radar Ice Sounder (PARIS) in Greenland aboard NASA's P-3 aircraft. PARIS took the first high altitude soundings of the internal layering, basal topography, and thickness of Greenland's ice sheet.

The Earth Science technology portfolio of over 550 science-focused, competitively-selected projects – one-third of which have already been infused – is helping NASA realize every one of the Earth Science Decadal Survey mission goals.