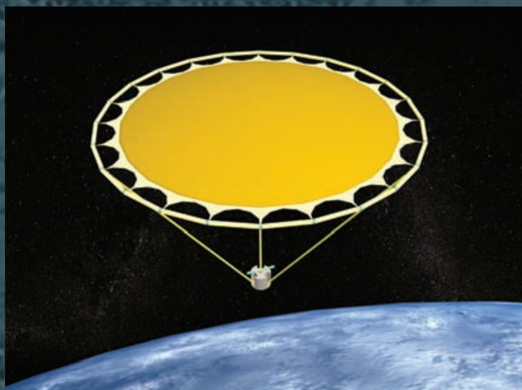
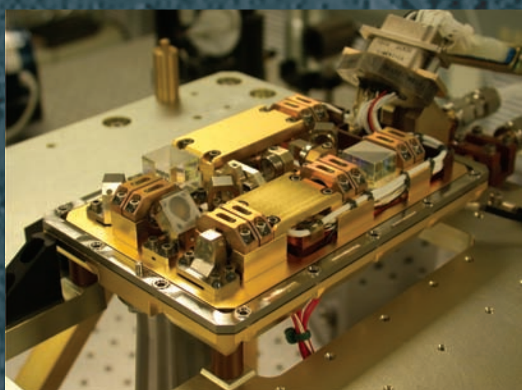
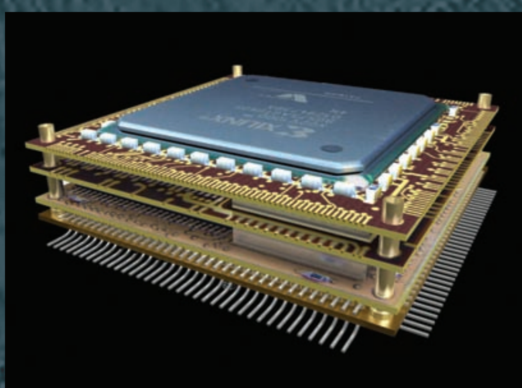
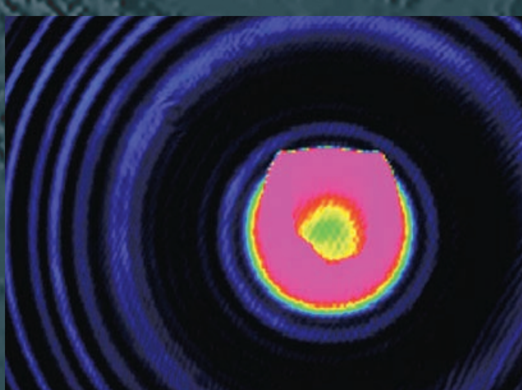
National Aeronautics and Space Administration
www.nasa.gov









NASA Earth Science Technology Office
2006 Annual Report

On the cover:
Four technology images from top to bottom are 1) an innovative Doppler radar antenna (see page 5), 2) a test laser similar to the Mercury Laser Altimeter (MLA) instrument aboard the MESSENGER spacecraft (see page 11), 3) a radiation-tolerant, intelligent memory stack (see page 13), and 4) a Fabry-Perot ring pattern from a laser test (see page 10). The background science image shows Earth's elevation and bathymetry in shaded relief.

Executive Summary

2006 has been another productive year for Earth science technology development. NASA's Earth Science Technology Office (ESTO) completed 41 technology projects over the fiscal year, of which nearly 90% advanced at least one Technology Readiness Level (TRL) during the course of funding. A competitive solicitation through the Advanced Information Systems Technology (AIST) program added 28 new awards to ESTO's portfolio of more than 500 active and completed projects.

The success of ESTO's portfolio continues to be driven by several factors:
- *A commitment to competitive, peer-reviewed solicitations*
- *A focus on active technology management*
- *A diverse research community – principal investigators are drawn from more than 100 organizations in 32 states*

ESTO continues to build upon a strong history of technology infusion. In fiscal year 2006 (FY06), 16% of active ESTO technology projects achieved actual infusion in science measurements, system demonstrations, or societal applications.

Finally, I would like to take this opportunity to thank George Komar for his vision and leadership since the inception of the ESTO program, and wish him well in his new technology role at NASA.

Amy Walton
Deputy Program Director, ESTO

Contents

About ESTO · · · · · · · · · · · · 1

The Year in Review:

Overview · · · · · · · · · · · 2

Instruments · · · · · · · · · 4

UAVSAR · · · · · · · · · · · · 6

Components · · · · · · · · 8

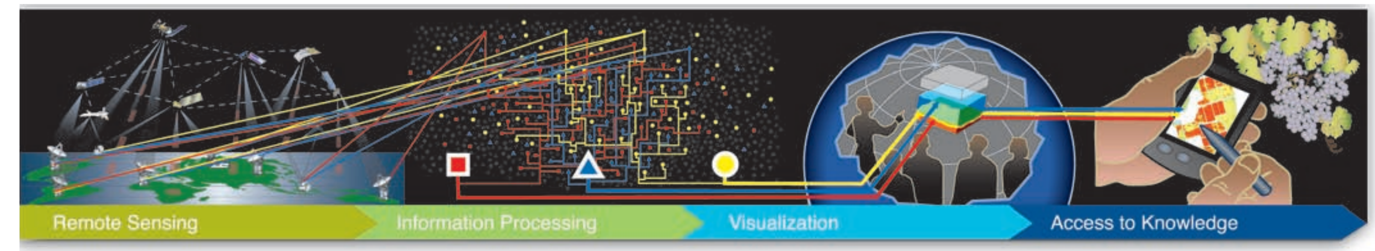
Lasers · · · · · · · · · · · · · 10

Information Systems · · 12

Future Challenges · · · · · · · 14

Additional Resources · · · · · 15

About ESTO



From instruments to data access, ESTO technologies enable a full range of scientific measurements

As the lead technology office within the Earth Science Division of the NASA Science Mission Directorate, the Earth Science Technology Office (ESTO) performs strategic technology planning and manages the development of a range of advanced technologies for future science measurements and operational requirements. ESTO technology investments attempt to address the full science measurement process: from the instruments and platforms needed to make observations, to the data systems and information products that make those observations useful.

ESTO's approach to technology development is also end-to-end:

- Planning technology investments through comprehensive analyses of science requirements
- Developing technologies through competitive solicitations and partnership opportunities
- Making technologies available to scientists and mission managers for infusion

ESTO employs an open, flexible, science-driven strategy that relies on competitive, peer-reviewed solicitations to produce the best cutting-edge technologies. In many cases, investments are leveraged through partnerships to mitigate financial risk and to create a broader audience for technology infusion.

The results speak for themselves: a varied portfolio of over 500 emerging technologies that can enable and/or enhance future science measurements and an ever-growing number of infusion successes.

With more than 400 completed technology investments and a current, active portfolio of over 100 projects, ESTO has continually built upon NASA's reputation for developing and advancing leading-edge technologies.

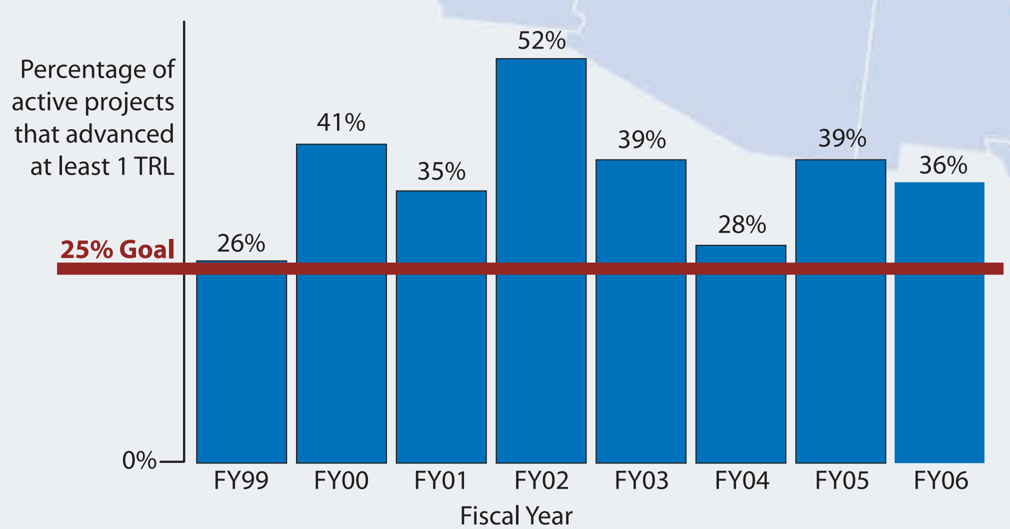
Each dot represents one of the over 500 projects (active and completed) in ESTO's portfolio as of June, 2006

How did ESTO do this year?

Here are few of our successes for fiscal year 2006 (FY06), tied to NASA's performance goals for ESTO:

GOAL: Annually advance 25% of funded technology projects one Technology Readiness Level (TRL).

FY06 RESULT: 36% of funded technology projects advanced at least one TRL.



GOAL: Enable one new science measurement capability or significantly improve performance of an existing one.

FY06 RESULT: The Multiband Reconfigurable Synthetic Aperture Radar Project has resulted in the fabrication and testing of a sixteen-element Synthetic Aperture Radar Small Array Demonstrator (SARSAD) system, capable of limited frequency tuning and azimuth/elevation steering under computer control. Although this technology still has some challenges to overcome, additional investment may enable a geostationary Earth orbit interferometric SAR that could measure crustal deformations (i.e. glaciers and volcano monitoring) and that might contribute to earthquake prediction capabilities.

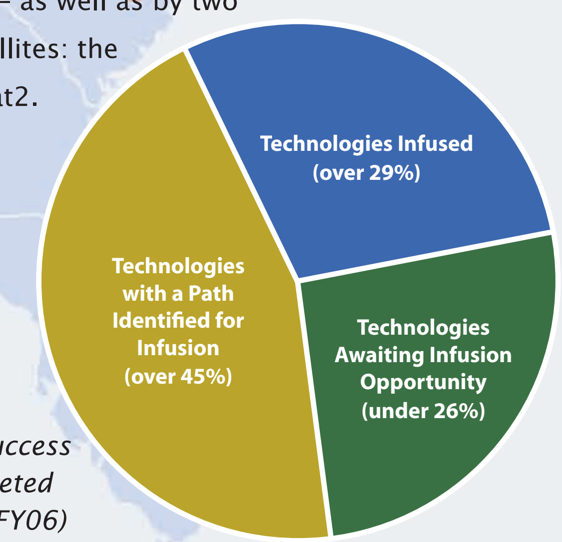
SPOTLIGHT: ESTC2006

ESTO held its sixth annual technology conference on June 26th-29th at the University of Maryland. This year's conference – ESTC2006 (Earth Science Technology Conference 2006) – included over 90 technical papers in three parallel session-tracks. A third session track was added this year to showcase technology developments from across the NASA Science Mission Directorate, including topics such as: astrophysics, planetary, propulsion, and sub-orbital technologies. More than 300 attendees hailed from NASA, academia, industry and federal labs. Full proceedings are available at the ESTO website.

GOAL: Mature two to three technologies to the point where they can be demonstrated in space or in an operational environment.

FY06 RESULTS: 20 technology projects that were funded in FY06 achieved actual infusion. Examples include:

- The Radiation Tolerant Intelligent Memory Stack (RTIMS) has been commercialized and successfully sold.
- The Spatial-Temporal Data Mining System for Tracking and Modeling Ocean Object Movement project has provided customized code to several NASA programs, NOAA, and the Florida Fish and Wildlife Research Institute for a wide array of applications.
- The Reconfigurable Hardware in Orbit (RHinO) project was selected by the Human and Robotic Technologies program in NASA's Exploration Office for implementation funding. RHinO has also been employed by the Cross Track Infrared Sounder – which will fly on NASA's NPP mission and the NPOESS satellites – as well as by two U.S. Air force satellites: the XSS-11 and TACSat2.

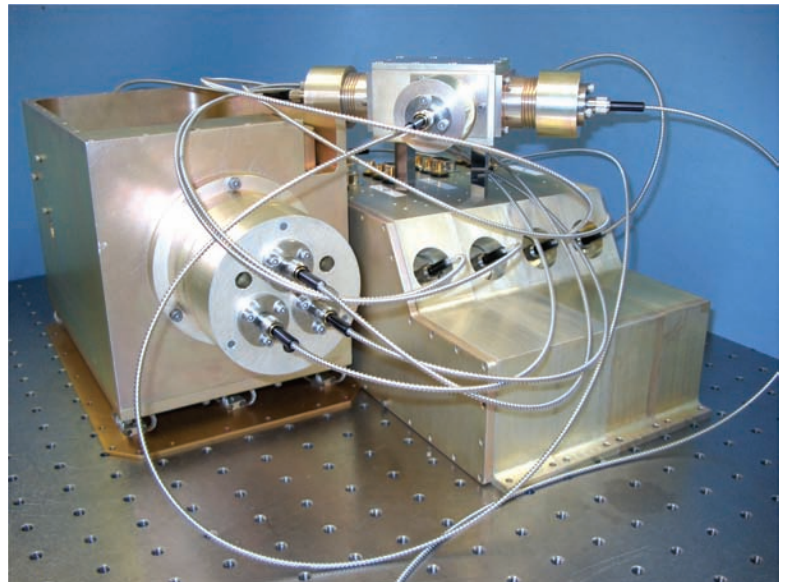


ESTO's Infusion Success (Over 400 completed projects through FY06)

The Instrument Incubator Program (IIP) provides funding for new instrument and measurement techniques, from concept development through breadboard and flight demonstrations. Instrument development of this scale outside of a flight project consistently leads to smaller, less resource intensive, and easier to build flight instruments. Furthermore, developing and validating these technologies before mission development improves their acceptance and infusion by mission planners, thereby significantly reducing costs and schedule uncertainties.

The IIP held some 35 active projects in FY06. 23 of these were added in FY05 as part of a competitive solicitation focused on high-priority science areas, including aerosol and trace gas measurements in the lower troposphere, ice topographic mapping, and tropospheric winds measurements. The IIP graduated seven projects this year, all of which advanced at least one technology readiness level. The FY06 graduates are as follows:

- Tropospheric Trace Species Sensing Fabry-Perot Interferometer (TTSS-FPI)
- Far IR Spectroscopy of the Troposphere (FIRST)
- Miniature Vector Laser Magnetometer
- Cryospheric Advanced Sensor: A Spaceborne Microwave Sensor for Sea Ice Thickness and Snow Cover Characteristics
- NEXRAD (Next Generation Weather Radar) In Space - A radar for monitoring hurricanes from geostationary orbit
- Prototype Geostationary Synthetic Thinned Aperture Radiometer (GeoSTAR)
- SVIP: Solar Viewing Interferometer Prototype for Observations of Earth Greenhouse Gases



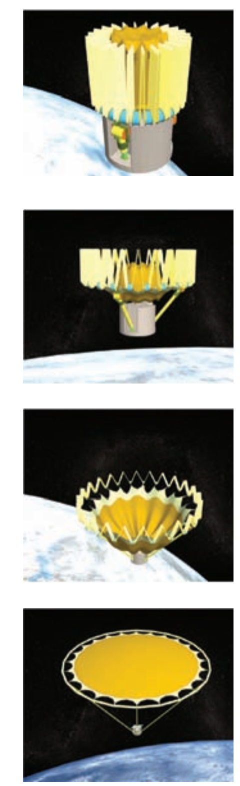
This assembled receiver is a key sub-system of the Tropospheric Wind Lidar Technology Experiment (TWiLiTE) instrument, an airborne Doppler lidar. Other technologies under development for the TWiLiTE project include a high-spectral-resolution, all-solid-state laser transmitter, optical filters, and a conically scanning holographic transceiver. Ground testing of TWiLiTE may begin in early 2007 and the project team anticipates a test flight on one of the NASA WB-57 high-altitude aircraft in 2008.

Spotlight: NEXRAD in Space

The IIP-funded NEXRAD in Space project, which graduated in FY06, has completed design, prototype, and performance study tasks on several critical technologies for this innovative Doppler radar instrument.

The NEXRAD instrument concept is a radar system that consists of a 30 meter, space-deployable antenna with a spiral scanning feed. This design could potentially monitor a 5300 km earth disk from geostationary Earth orbit, or about 36,000 km from Earth. The novel spiral scanning system eliminates the need to rotate or steer the antenna and significantly reduces the complexity of the system.

NEXRAD has been specifically designed to capture full lifetimes of all hurricane eyewall replacement cycles, an essential ingredient for significantly improved hurricane forecasting. Resolution is estimated to be 12 - 14 km horizontal and 300 m vertical using real-time data compression techniques.



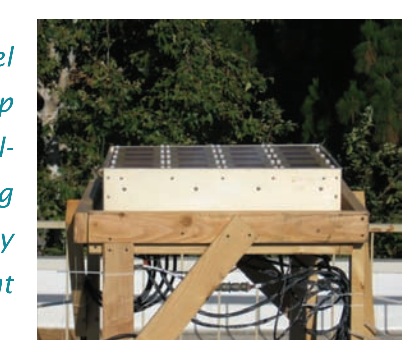
The NEXRAD deployment scenario

Spotlight: Four ESTO-Funded Projects Participate in Successful Joint Experiment, Data Used in Aquarius Validation

A joint experiment was performed recently among NASA, the University of Michigan, and the Ohio State University, which brought together four ESTO projects: two current Advanced Component Technology (ACT) efforts, one current IIP project, and one graduated IIP project. The goal of the experiment was to investigate and collect data on radio-frequency interference (RFI) seen in microwave radiometer measurements. The NASA Passive/Active L/S-band (PALS) microwave radar/radiometer, using a new ACT-developed flat-panel antenna (see spotlight on page 9), was placed on a building roof viewing the sky at the RF-noisy grounds of the NASA Jet Propulsion Laboratory. Three different RFI detectors (all IIP and ACT projects) collected PALS data and detected RFI.

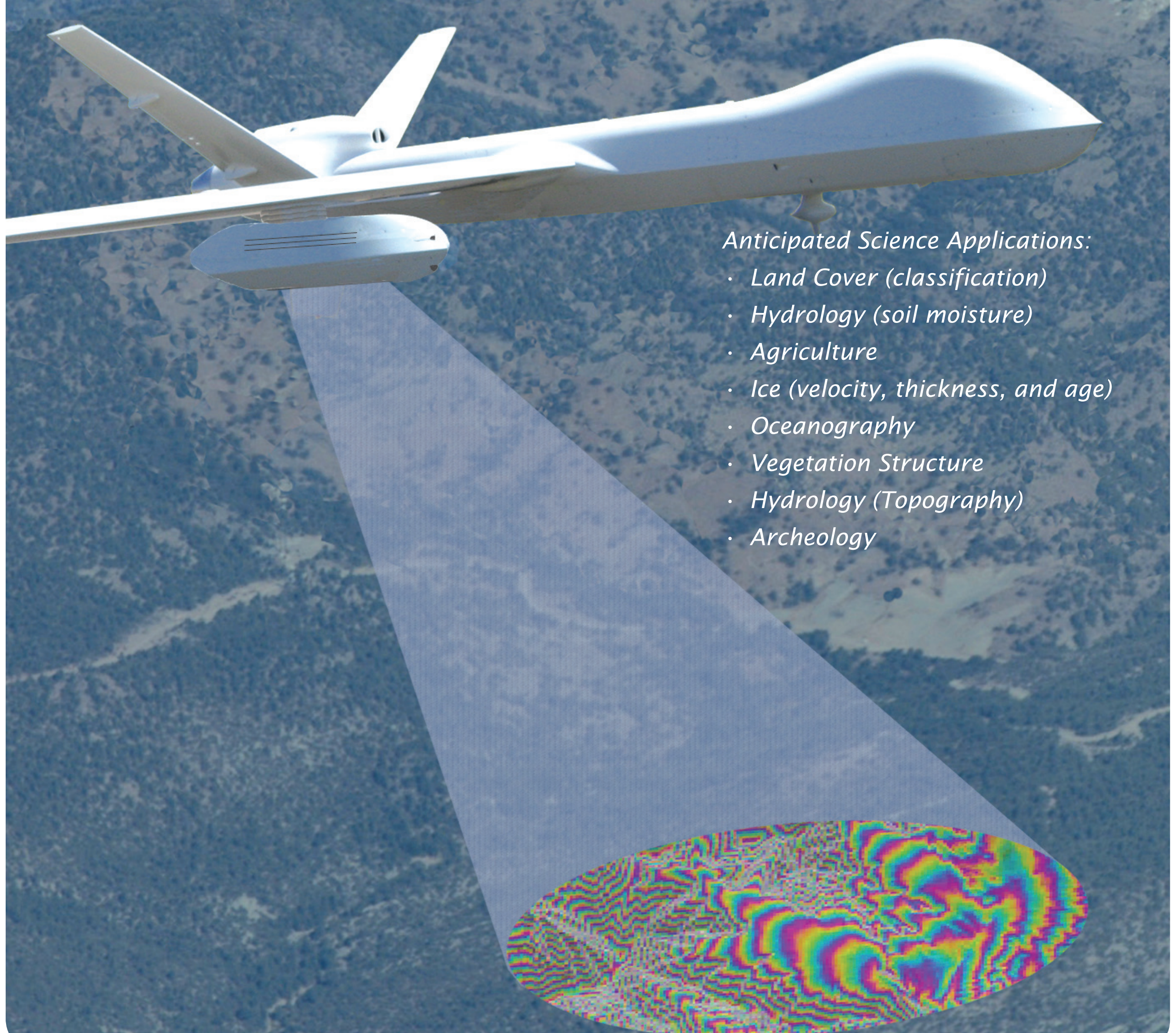
Initial analysis indicates the major source of RFI is likely an air-traffic control radar from the nearby airport. The data are being analyzed to compare the RFI detection and mitigation techniques utilized by the different systems. Data are also being used to validate a RFI mitigation algorithm being developed for the Aquarius radiometer.

The data are also proving to be invaluable for understanding the emerging technologies and how they functioned together. The integrated experiment provided a data set not attainable with any one individual project.



A setup of the flat-panel antenna – on a rooftop at the NASA Jet Propulsion Laboratory – during the joint radio-frequency interference experiment

The Uninhabited Aerial Vehicle Synthetic Aperture Radar (UAVSAR) project finds its origins in an Instrument Incubator Program investment at the Jet Propulsion Laboratory entitled: "Repeat Pass Deformation Measurement Capability for an Airborne Platform." That IIP investment was singled out for targeted funding to develop a SAR system and conduct flight testing on a NASA Gulfstream III aircraft. The SAR design is also capable of being flown on an Ikhana (Predator-B) UAV. With flight testing set to begin in early 2007, the UAVSAR project has met significant milestones: delivery of the first pod to the Jet Propulsion Laboratory for instrument integration, completion of all ground system hardware, integration and testing of flight radar components, and completion of necessary modifications to the Gulfstream III.



Anticipated Science Applications:

- *Land Cover (classification)*
- *Hydrology (soil moisture)*
- *Agriculture*
- *Ice (velocity, thickness, and age)*
- *Oceanography*
- *Vegetation Structure*
- *Hydrology (Topography)*
- *Archeology*

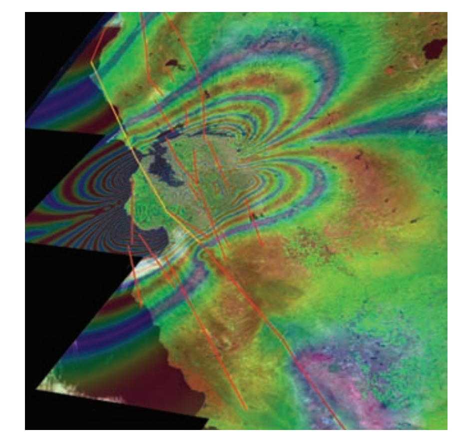
The UAVSAR will have the capability to conduct rapid repeat pass interferometry measurements with separations ranging from minutes to years, enabling measurements of surface deformation to mm level accuracy. Current space-based assets have a repeat orbit cycle of 24 to 44 days, limiting their effectiveness in the study of rapidly deforming features.

The design of the UAVSAR focuses on two key challenges. First, repeat pass measurements will need to be taken from flight paths that are nearly identical. The instrument will utilize real-time GPS that interfaces with the platform flight management system to confine the repeat flight path to within a 10 m tube. Second, the radar vector from the aircraft to the ground target area must be similar from pass to pass. This will be accomplished with an actively scanned antenna designed to support electronic steering of the antenna beam with a minimum of 1° increments over a range to exceed ±15° in the flight direction.

Anticipated Technology Benefits:

- Enable a repeat pass in as little as 20 minutes
- Greatly reduced mass and volume to existing airborne SAR technologies
- Modular design to allow integration on multiple airborne platforms
- Pre-programmed, autonomous operation without need for a radar operator
- Flexible digital system that can trade data rate for performance and accept additional frequencies and parameters in the future

Assembly of the first SAR pod, to be flown on the NASA Gulfstream III aircraft, viewed from the aft end of the pod. Note the two aft cooling ducts; these are critical to maintain the antenna and equipment at an appropriate temperature.



This illustration depicts synthetic aperture radar patterns of seismic deformations associated with a model earthquake on the San Francisco section of the San Andreas Fault (depicted in yellow).

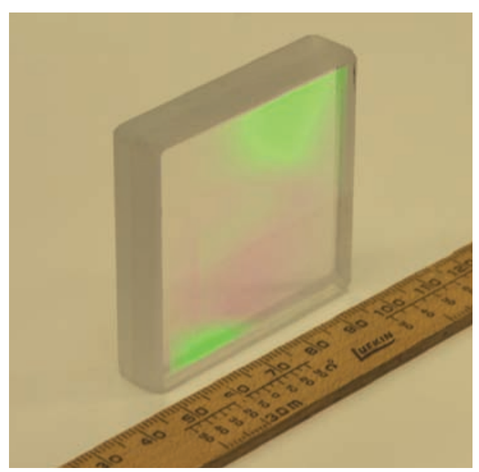
The Advanced Component Technology (ACT) program leads research, development, and testing of component- and subsystem-level technologies to advance the state-of-the-art of instruments, Earth- and space-based platforms, and information systems. The ACT program focuses on projects that reduce risk, cost, size, mass, and development time of technologies to enable their eventual infusion into missions.

In FY06, the ACT program held 31 active projects, 14 of which were selected in FY05 as part of the 2005 NASA ROSES (Research Opportunity for Space and Earth Science) solicitation. 92 proposals were received for this solicitation, which sought core component and subsystem technologies that could enable new Earth science measurements.

The ACT program also graduated 11 projects in FY06:

- Electro-Optic Imaging Fourier Transform Spectrometer
- Ultra-High Efficiency L-Band Transmit/Receive Modules for Large Aperture Scanning SAR Antennas
- Development of a 1K X 1K GaAs QWIP Far Infrared Detector Array
- Multiband Reconfigurable Synthetic Aperture Radar (SAR)
- Quantum Gravity Gradiometer for Sub-Surface Mapping
- Development of a Large Format Visible-NIR Blind Gallium Nitride UV Imager for Atmospheric Earth Science Applications
- Transmit/Receive Membranes for Large Aperture SAR Scanning Antennas
- Lightweight, Deployable, Dual-frequency / Polarization Microstrip Antenna array for Remote Sensing of Precipitation
- Low-power radio-frequency analog-to-digital converter (RF-ADC) for Digital Microwave Radiometry with application to Soil Moisture Remote Sensing
- Unified Onboard Processing and Spectroscopy (UniOPS)
- Compact, Lightweight Dual-Frequency Microstrip Antenna Feed for Soil Moisture and Sea Surface Salinity Missions

All of the FY06 graduates from the ACT program advanced at least one technology readiness level (TRL) and 8 of the 11 graduates advanced at least two TRLs.



This sample optic, one of several developed as part of the Shared Aperture Diffractive Optical Element (ShADOE) project, contains 5 holographic optical elements to collect and focus atmospheric laser backscatter. This optic is a critical component for the development of a novel UV holographic optical element telescope.

The project team expects to infuse the ShADOE technology into an IIP project, called The Tropospheric Wind Lidar Technology Experiment (TWiLiTE), aimed at developing an airborne and/or space borne Doppler Lidar instrument to measure tropospheric winds (see inset on page 4).

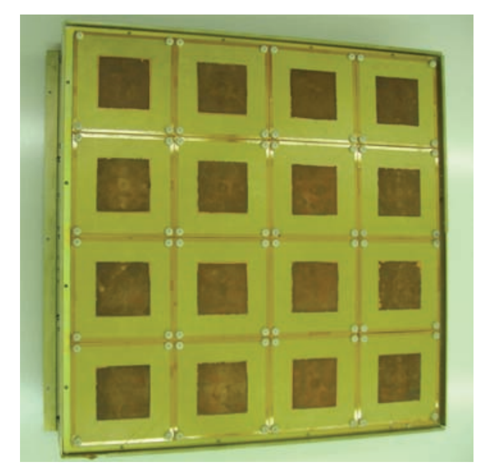
SPOTLIGHT: Million Pixel Infrared Detector Has Many Potential Applications

A Quantum Well Infrared Photodetector (QWIP) array, developed with funding by the ACT program, can now see invisible infrared light in a range of "colors," or wavelengths. The detector is the world's largest infrared detector technology that can sense infrared over a broad range (8 to 12 micrometers) – an important advance that has greatly increased the possible uses of the technology.

Potential applications include: tropospheric and stratospheric temperatures and atmospheric trace chemicals; tree canopy energy balance measurements; cloud layer emissivities, droplet size, composition and height; volcanic SO_2 and aerosol emissions; dust particle tracking; CO_2 absorption; coastal erosion; ocean and river thermal gradients and pollution; equipment and instrument analysis; ground based astronomy; and temperature sounding.

A false color image of a NASA engineer in the far infrared taken with the one megapixel QWIP camera. Warmer temperatures are orange, cooler temperatures are dark red. Notice the thermal handprint on her lab coat as she removes her hand from her pocket.

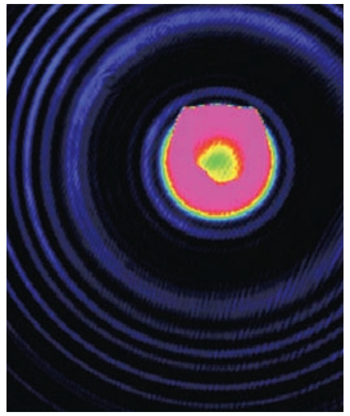
SPOTLIGHT: Microstrip Stacked-Patch Array (MSPA) Antenna Goes Airborne to Support DOE Cloud Land Surface Interaction Campaign (CLASIC)



The prototype design of the 16-element MSPA antenna to be installed on a Twin Otter aircraft in support of CLASIC.

MSPA, a compact, lightweight, dual-frequency antenna feed technology, will be flown on an aircraft in support of CLASIC in June 2007. Based on technology originally developed for a large, lightweight, L-band, space-deployable antenna, the MSPA will be used in CLASIC to help enable airborne remote sensing of soil moisture during the three-month study in Oklahoma.

It is hoped that CLASIC will provide new insights about the relationship between land surface processes and observed cloud cover, and vice versa. CLASIC is jointly supported by the US Department of Energy Atmospheric Radiation Measurement Program and NASA.

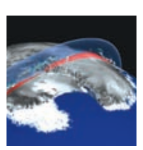


Fabry-Perot ring pattern from a sequence of 22 laser shots by a 15 mJ, 40 to 100 Hz, Diode pumped Nd:Cr:YAG laser during a vacuum life test

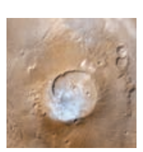
The Laser Risk Reduction Program (LRRP) was established in 2001 by the NASA administrator under the recommendation of the Earth Science Independent Laser Review Panel. LRRP works to formalize design, testing, and development procedures for durable laser/lidar systems and architectures, particularly in the critical 1- and 2- micron wavelengths. In doing so, the LRRP aims to:

- demonstrate laser technologies that can be reliably and confidently infused;
- prepare technologies well in advance of missions;
- maintain NASA's in-house laser expertise and capabilities
- investigate science-technology trade-offs; and
- test engineering flight models in final configurations.

Laser/lidar remote sensing techniques can satisfy a variety of measurement and operational requirements:

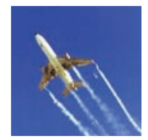


Earth Science: Clouds/Aerosols, Tropospheric Winds, Ozone, Carbon Dioxide, Biomass, Water Vapor, Land, Ice, and Ocean, Surface Mapping, and Laser Altimetry



Space Science: Surface Materials, Physical State, Surface Topography, Molecular Species, and Atmospheric Composition / Dynamics

Exploration: Lander Guidance/Control, Atmospheric Winds, Biochemical Identification, Optical Communication, and Automated Rendezvous & Docking



Aeronautics: Turbulence Detection, Wind Shear Detection, and Wake Vortices

The LRRP currently funds 18 projects at NASA Goddard Space Flight Center and NASA Langley Research Center. Partners and collaborators include: American University, Boston College, the Jet Propulsion Laboratory, Johns Hopkins University Applied Physics Laboratory, Montana State University, Sandia National Laboratory, the University of Maryland, and numerous industrial partners. The investments also cover a broad range of laser/lidar challenge areas, including:

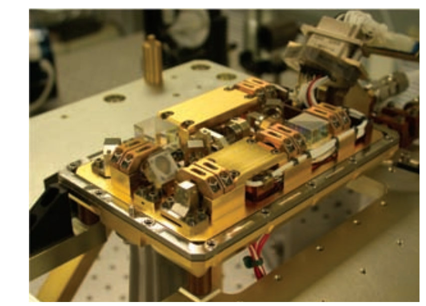
- High-performance 1- and 2- Micron Lasers
- High-reliability Pump Laser Diode Arrays
- Space Radiation Tolerance
- Frequency Control and Wavelength Conversion
- Electrical Efficiency
- Heat Removal and Thermal Management
- Contamination Tolerance
- Photoreceiver and Detector Development

SPOTLIGHT: MESSENGER's Earth Flyby Provides Opportunity for Ground Return Tests, Sets Record for Laser Communication

A 20 milli-Joule (mJ) laser developed with LRRP funding was successfully used to communicate with the Mercury Laser Altimeter (MLA) instrument aboard the MESSENGER spacecraft during an Earth fly-by in May 2005. The laser, a diode pumped High Output Maximum Efficiency Resonator (HOMER), was installed at the NASA's Goddard Geophysical and Astronomical Observatory in Maryland and exchanged laser pulses with the MLA, approximately 15 million miles away.

An artist's depiction of MESSENGER's Earth flyby

The successful tests set a new distance record for back-and-forth exchange of laser signals (the Galileo probe received a one-way laser transmission from Earth at a distance of about 4 million miles in 1992).



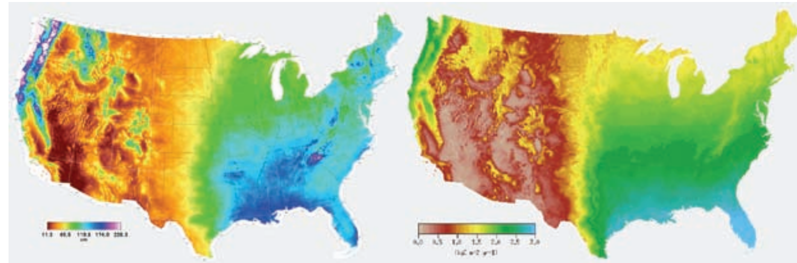
An MLA-type laser, used for testing and evaluation

While this milestone is noteworthy, the real objective of these tests was to verify the MLA's ability to detect and respond to a returned laser signal. Once MESSENGER is in orbit around Mercury, the MLA will measure the round trip time of its transmitted laser pulses that are reflected off the surface of the planet. These measurements, taken together with data obtained from other instruments on MESSENGER, will provide high-precision mapping of Mercury's topography and libration, the slight wobble in a planet's motion that can give insights about its core.

Goddard technologists used this 48-inch telescope tracking facility at the Goddard Geophysical and Astronomical Observatory to transmit the 20 mJ laser return signal to the MESSENGER spacecraft

Advanced information systems are used to process, archive, access, visualize, and communicate science data. Advanced computing and communications concepts that permit the transmission and management of terabytes of data are essential to NASA's vision of a unified observational network. ESTO's Advanced Information Systems Technology (AIST) program employs an end-to-end approach to evolve these critical technologies – from the space segment, where the information pipeline begins, to the end user, where knowledge is advanced.

In FY06, the AIST program added 28 new projects through a competitive solicitation under the 2005 NASA Research Opportunities in Space and Earth Sciences (ROSES) announcement. The AIST solicitation was targeted at funding component technologies to enable sensor webs that can achieve future Earth science objectives. The awards are as follows:



An example of a simulation by the Grid-BGC project, a continental-scale carbon cycle modeling system. The left image shows one input to the model: total precipitation (18-year annual Mean). The right image, showing potential gross primary productivity for evergreen needleleaf forest (18-year annual Mean), is an output from the model, which produces estimates of state and flux variables for carbon, nitrogen, and water cycles.

- A Smart Sensor Web for Ocean Observations
- Implementation Issues and Validation of SIGMA (Seamless IP-diversity based Generalized Mobility Architecture) in Space Network Environment
- Virtual Sensor Web Infrastructure for Collaborative Science (VSICS)
- Increasing the Technology Readiness of SensorML for Sensor Webs
- A Framework and Prototypes for the Self-Adaptive Earth Predictive Systems (SEPS)
- Telesupervised Adaptive Ocean Sensors
- QuakeSim: Enabling Model Interactions in Solid Earth Science Sensor Webs
- Satellite Sensornet Gateway (SSG)
- Sensor-Analysis-Model Interoperability Technology Suite
- Sensor Management for Applied Research Technologies (SMART)
- SEAMONSTER: A Smart Sensor Web in Southeast Alaska
- An Expandable Reconfigurable Instrument Node for a Web Sensor Strand
- Land Information Sensor Web
- Reconfigurable Sensor Networks for In-Situ Sampling
- Autonomous, Intelligent Controller for Distributed Sensor Webs
- Sensor Web Dynamic Replanning
- An Objectively Optimized Sensor Web
- Sensor-Web Operations Explorer (SOX)
- Autonomous Disturbance Detection and Monitoring System for UAVSAR
- An Inter-operable Sensor Architecture to Facilitate Sensor Webs in Pursuit of GEOSS (Global Earth Observing System of Systems)
- Soil Moisture Smart Sensor Web Using Data Assimilation and Optimal Control
- Harnessing the Sensor Web through Model-based Observation
- Efficient Sensor Web Communication Based on Jointly Optimized Distributed Wavelet Transform and Routing
- Sensor Web Modeling and Data Assimilation System Architectures
- Optimized Autonomous Space - In-situ Sensorweb
- The Multi-agent Architecture for Coordinated, Responsive Observations
- An Adaptive, Negotiating Multi-Agent System for Sensor Webs
- Intelligent Agents for an Autonomous Mission Operations Web

The AIST program held some 56 active investments, several of which graduated over the course of FY06, including:

- Reconfigurable Hardware in Orbit (RHinO)
- TCP/IP Router Board (TRB) with Ethernet Interfaces
- Radiation Tolerant Intelligent Memory Stack (RTIMS)
- 10/100 mb/sec Flight Ready Ethernet Hardware
- Reconfigurable Protocol Chip for Satellite Networks
- Realtime-Reconfigurable Distributed-Computing for Adaptive Science Ops in Satellite Formations using Heterogeneous CPUs & Heterogeneous Connectivity
- Coupling High Resolution Earth System Models Using Advanced Computational Technologies
- Implementing a Supercomputer-Based Grid Compute Engine for End-to-end Operation of a High-Resolution, High Data-Volume Terrestrial Carbon Cycle Model
- Complexity Computational Environments: Data Assimilation SERVO (Solid Earth Research Virtual Observatory) Grid
- Integration of OGC and Grid Technologies for Earth Science Modeling and Applications
- Hybrid Ground Phased Array for Low Earth Orbiting Satellite Communications
- Mining Massive Earth Science Data Sets for Climate and Weather Forecast Models
- Spatiotemporal Data Mining System for Tracking and Modeling Ocean Objects
- Selection Technique for Thinning Satellite Data for Numerical Weather Prediction
- Rapid Characterization of Causal Interactions among Climate/Weather System Variables

Nearly 90% of FY06 AIST program graduates advanced at least one TRL over the course of their funding.

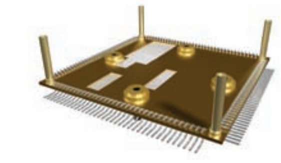
SPOTLIGHT: Radiation Tolerant Intelligent Memory Stack (RTIMS)

Future space missions will require increased resolution, improved data quality, and additional capacity for raw and processed data. This radiation-tolerant stacked memory array, suitable for both geostationary and low Earth orbit missions, can efficiently handle the large data sets of tomorrow, increase the accessibility and utility of data, and reduce the risk, cost, size and development time of space-based systems.

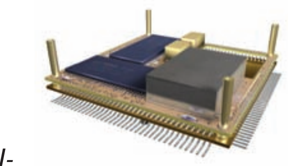
The RTIMS module is a major step forward in the state of the art for space based memory arrays. Its features provide advanced functionality and allow standardized hardware to be used for radically different missions.

RTIMS features:

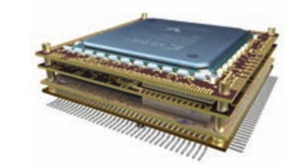
- *Low mass (60 grams) and low volume (42.7 mm x 42.7 mm x 13.0 mm) package*
- *Large memory array (2 Gigabits of error-corrected or 1 Gigabit of triple redundant digital memory)*
- *Radiation, thermal, vibration, and lifespan tested*
- *Reprogrammable Xilinx based controller*



Quad Flat Package (QFP)

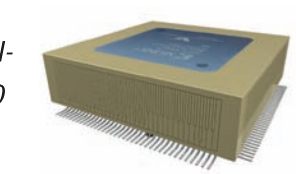


First active layer of components



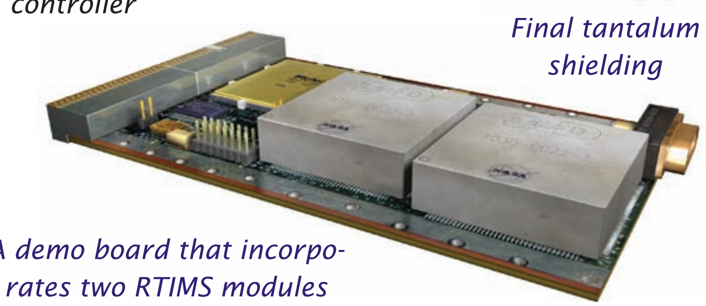
Layers fully assembled

Pure epoxy resin molding



Nickel and gold plating

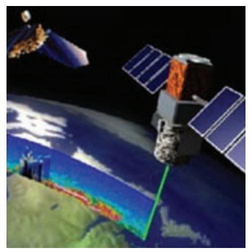
Final tantalum shielding



A demo board that incorporates two RTIMS modules

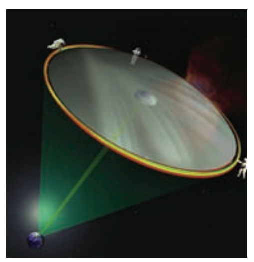
Future Challenges

While ESTO is uniquely situated to pursue a wide range of technology requirements, we have identified five crosscutting technology areas that will serve a multitude of science disciplines:



Active Remote Sensing Technologies to enable measurements of the atmosphere, hydrosphere, biosphere, and lithosphere.

- Atmospheric chemistry using lidar vertical profiles
- Ice cap, glacier, sea ice, and snow characterization using radar and lidar
- Tropospheric vector winds using lidar

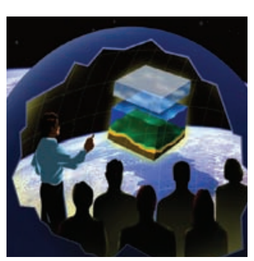


Large Deployable Apertures to enable future weather, climate, and natural hazards measurements.

- Temperature, water vapor, and precipitation from GEO
- Soil moisture and sea surface salinity using L-band
- Surface deformation and vegetation using radar

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

- Long-term weather prediction linking observations to numerical models
- Interconnected sensor webs that share information to enhance observations

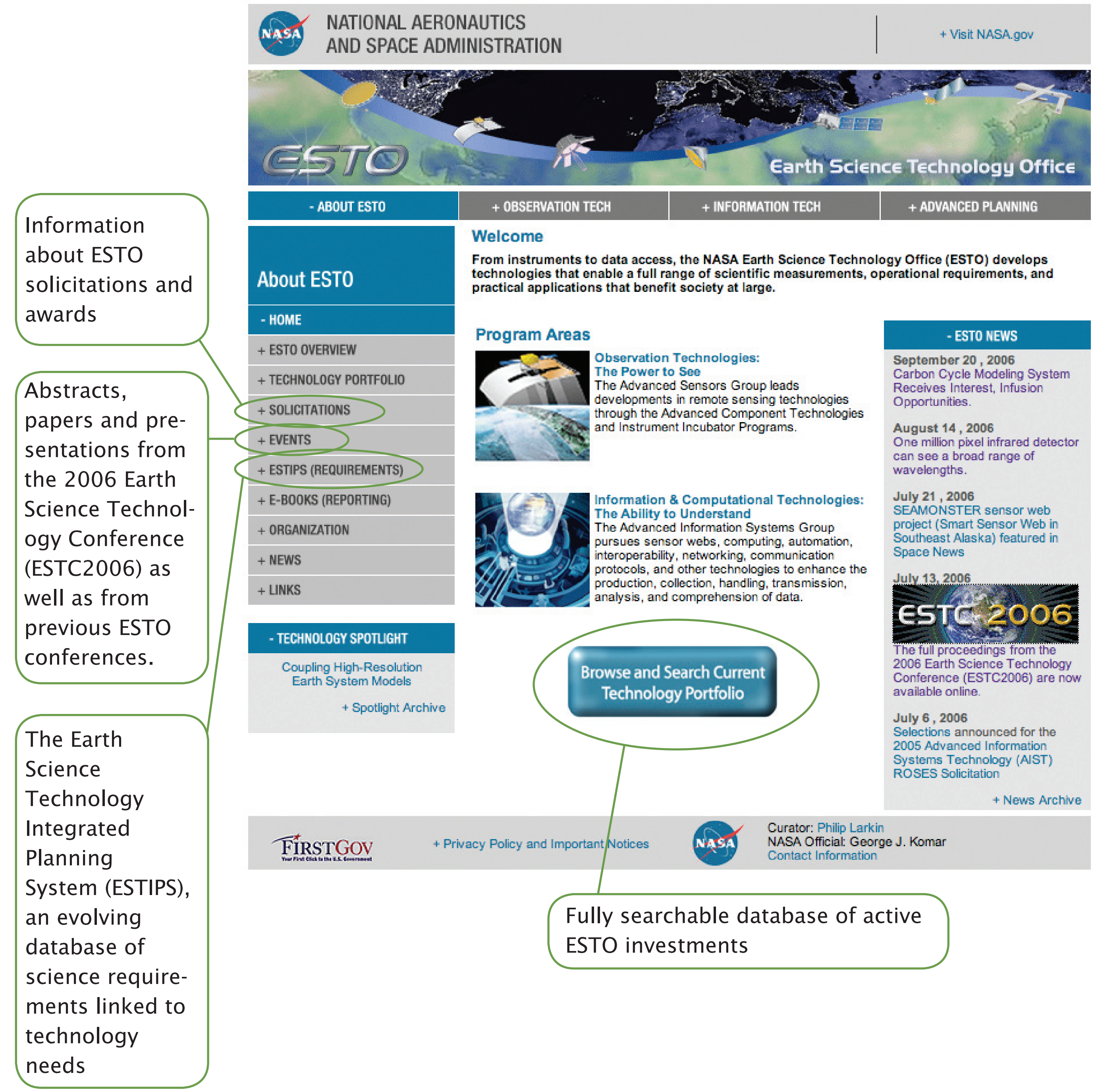


Information Knowledge Capture through novel visualizations, memory and storage advances, and seamlessly linked models.

- Intelligent data fusion to merge multi-mission data
- Discovery tools to extract knowledge from large and complex data sets
- Real time science processing, archiving, and distribution of user products to drive decision-support systems

Additional Resources

A wealth of additional materials is available online at the ESTO homepage – http://esto.nasa.gov – including:



Earth Science Technology Office
Goddard Space Flight Center
Greenbelt, MD 20771

http://esto.nasa.gov