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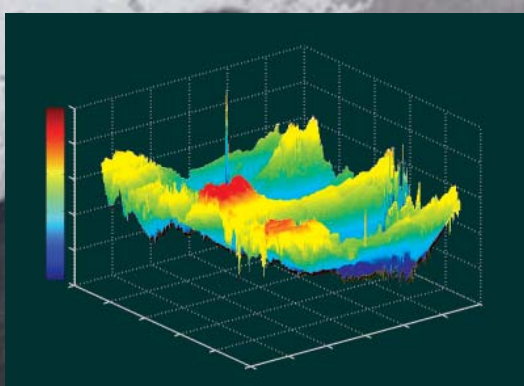


NASA Earth Science Technology Office

2007 Annual Report

On the cover:
Background image: Landsat image from 7/7/2001 shows the Jakobshavn Isbrae, Greenland's largest outlet glacier (image credit: NASA).

Four technology images (from top to bottom):
1) The NASA Gulfstream III aircraft carrying the UAVSAR radar, in a custom-built pod under the aircraft's fuselage, on a test flight over California (see page 5, image credit: Lori Losey); 2) One of several in-situ sensors that form the nodes of the Smart Sensor Web in Southeast Alaska (SEAMONSTER), a network that monitors the Lemon Glacier and Lemon Creek Watershed (see page 10, image credit: Logan Berner); 3) Vertically exaggerated basal topography from an ice sheet in western Greenland as measured by the Global Ice Sheet Mapping Orbiter airborne prototype from an altitude of 650 meters at 150 MHz (see pages 6 - 7, image credit: Ken Jezek); 4) The Analog Radio-Frequency Interference Suppression System (ARFISS) electronics board (see page 9, image credit: Joseph Knuble).

Executive Summary

As you will read in the pages that follow, 2007 has been another productive year for Earth science technology development. NASA's Earth Science Technology Office (ESTO) graduated 15 technology projects over the fiscal year, all of which advanced at least one Technology Readiness Level (TRL) during the course of funding. Competitive solicitations added 28 new projects under the Advanced Information Systems Technology (AIST) program and ESTO now has a portfolio of more than 520 active and completed technology investments.

ESTO also continues to build upon a strong history of technology infusion. In fiscal year 2007 (FY07), 9% of active ESTO technology projects achieved actual infusion in science measurements, system demonstrations, or societal applications. For the whole of ESTO's portfolio (active and completed investments), the infusion rate is nearly 30%.

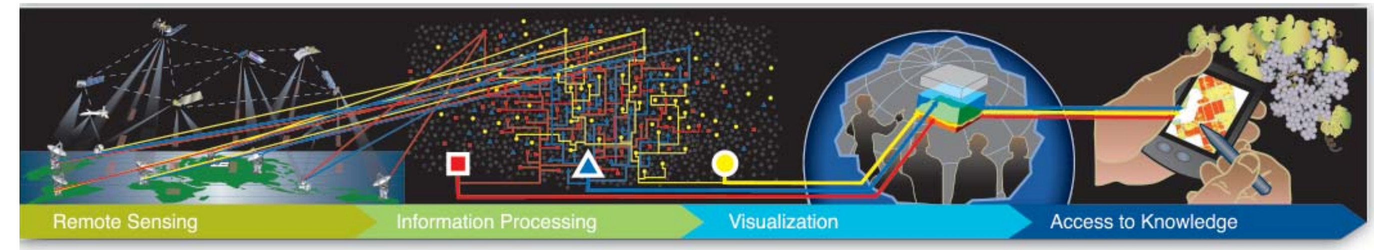
ESTO's success continues to be driven by several factors:
- *a commitment to competitive, peer-reviewed solicitations;*
- *a focus on active technology management; and*
- *a diverse research community – principal investigators are drawn from more than 100 organizations in 32 states.*

We continue to be very proud of the achievements of our principal investigators and the contributions they make to the future of Earth science and we look forward to another year of steady progress in FY08.

George J. Komar **Amy Walton**

Contents

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 520 emerging technologies that can enable and/or enhance future science measurements and an ever-growing number of infusion successes.

With more than 430 completed technology investments and a current, active portfolio of over 100 projects, ESTO is helping to build NASA's reputation for developing and advancing leading-edge technologies.

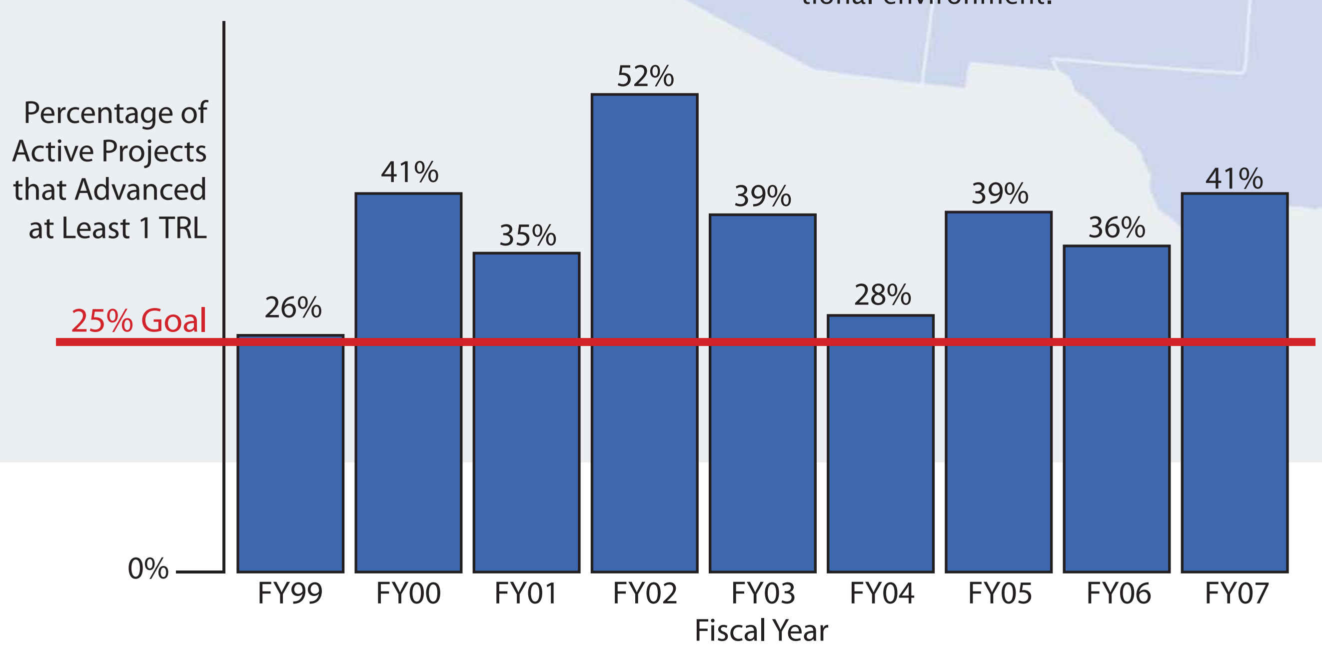
How did ESTO do this year?

Here are few of our successes for fiscal year 2007 (FY07), tied to NASA's performance goals for ESTO:

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

FY07 RESULT: 41% of funded technology projects advanced at least one TRL.

Each dot represents one of the over 520 projects (active and completed) in ESTO's portfolio as of May 2007



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

FY07 RESULT: Several ESTO projects satisfied this goal for FY07. Two of these – the Global Ice Sheet Mapping Orbiter (GISMO) and the Pathfinder Airborne Radar Ice Sounder (PARIS) – carry some additional significance during the observance of the International Polar Year. Both have greatly improved the ability to measure ice sheet thickness and bottom (basal) topography from airborne platforms. (Read more about these instruments on pages 6 and 7.)

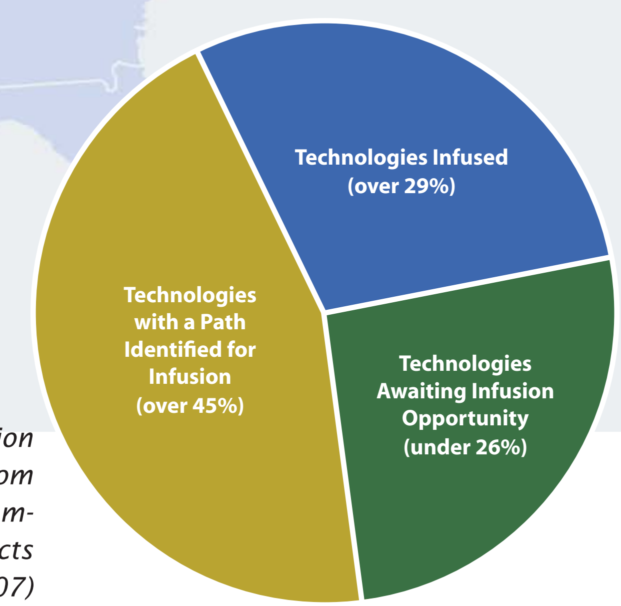
GOAL: Mature two to three technologies to the point where they can be demonstrated in space or in an operational environment.

SPOTLIGHT: NSTC2007

ESTO expanded its annual technology conference this year to integrate sessions and topics from across the NASA Science Mission Directorate – from Earth and Planetary Sciences to Heliophysics and Astrophysics. The NASA Science Technology Conference (NSTC2007) was held in June at the University of Maryland and included nearly 140 technical papers in four parallel tracks of sessions. A Plenary talk was given by Dr. John Mather, NASA Senior Astrophysicist and Goddard Fellow and luncheon talks were given by: Dr. Sridhar Anandakrishnan, Associate Professor in the Penn State Department of Geosciences; Brian McClendon, Director of Engineering for Google Earth; and Geoffrey Yoder, Senior Systems Engineer with the NASA Exploration Systems Mission Directorate. Total registration for NSTC2007 reached over 500 and included a balanced cross-section of representation from various NASA centers, industry, and academia. Full proceedings are available at the ESTO website.

FY07 RESULTS: Several technology projects achieved actual infusion in FY07. Three examples:

- The Earth Phenomena Observing Systems (EPOS) is currently in operational use by the Earth Observing-1 (EO-1) satellite to pick cloud-free targets.
- The Heterogeneous Agricultural Research via Interactive, Scalable Technology (HARVIST) project was chosen by the U.S. Department of Agriculture for use in analyzing soil salinity data from Red River Valley soil measurements.
- The Change Detection On-board Processor (CDOP) project recently demonstrated, in a laboratory environment, real-time image formation capability using satellite Synthetic Aperture Radar data with a custom designed prototype Field Programmable Gate Array-based processor.



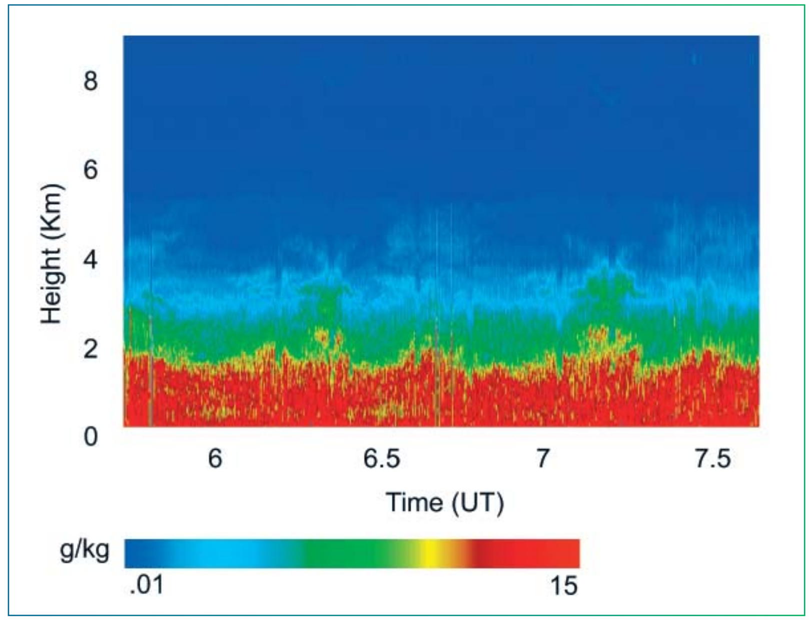
ESTO's Infusion Success (from over 430 completed projects through FY07)

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 31 active projects in FY07. More will be added in early 2008 – a new competitive solicitation released this year is broadly aimed at instrument development to address science measurement objectives put forward by the National Research Council decadal survey. These topics include: radiation balance; soil moisture; ice sheets; surface deformation; vegetation structure; land surface composition; carbon dioxide column integrals; water levels; atmospheric gases; ocean color; aerosol / cloud profiles; surface topography, temperature and humidity; gravity fields; snow accumulation; ozone and trace gases; and tropospheric winds.

The IIP also graduated four projects this year, all of which advanced at least one technology readiness level over the course of their funding. The FY07 graduates are as follows:

- Inter-Spacecraft Laser Ranging Measurement Electronics for Sub-nanometer Accuracy
- Geostationary Spectrograph (GeoSpec) for Earth and Atmospheric Science Applications
- Spaceborne Infrared Atmospheric Sounder for Geosynchronous Earth Orbit (SIRAS-G)
- Interferometric Range Transceiver (IRT) for Measuring Temporal Gravity Variations



This water vapor mixing ratio time series was one of several datasets acquired during the first flights of the IIP-funded Raman Airborne Spectroscopic Lidar (RASL) in summer 2007. RASL, which can take profile measurements of water vapor and various aerosol and cloud properties, is proving to be an important asset, particularly since recent satellite data has shown increases in atmospheric moisture content that may be linked to climate change. The RASL measurement capability may also provide new understanding of water cycle processes, which is crucial for improving global weather and climate models.

SPOTLIGHT: UAVSAR Project Sees First Flights, First Images in 2007

The Uninhabited Aerial Vehicle Synthetic Aperture Radar (UAVSAR) project completed important initial flight tests in 2007 on board the NASA Gulfstream III (G-III) aircraft. The flight tests, which will continue through mid-2008, are key to evaluating the instrument's potential operational use on unmanned aerial vehicles.

UAVSAR, a reconfigurable, polarimetric L-band SAR built at the Jet Propulsion Laboratory, is specifically designed to acquire airborne repeat pass SAR data for differential interferometric measurements. Repeat pass interferometry is a technique that requires the aircraft to fly each pass as close to the original flight line as possible. This feat is achieved using a sophisticated autopilot system developed at the NASA Dryden Flight Research Center that can repeat the flight path within a ten meter diameter tube.

Data collected by the UAVSAR instrument on each repeat pass are compared to examine changes, to millimeter-level resolution, in the Earth's surface. The resulting surface displacement measurements are useful for a variety of scientific objectives, such as volcano and earthquake activity, ice velocity, hydrology, erosion, and even archeology.

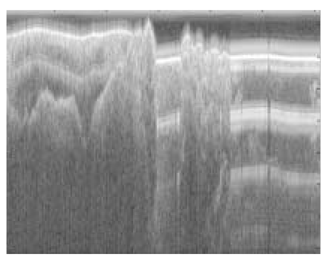
Once testing is complete, UAVSAR will be a powerful airborne instrument that can provide the calibration data and rapidly repeated images scientists need to augment data obtained from space.

The NASA G-III carries the UAVSAR radar in a custom-built pod under the aircraft's fuselage.

One of the first UAVSAR images taken on September 18, 2007 in a flight over the Rosamond Lake Bed in California. The image covers an area 11 km wide by 57 km long.

Toward NEW Ice Sheet Measurements

In 2007, two independent IIP-funded projects shared the spotlight for demonstrating state-of-the-art radar instruments in test flights over Greenland. Timed by coincidence to occur during the International Polar Year, the flights established these two instruments as key tools for future ice sheet thickness, layering, and basal (ice sheet bottom) topography measurements. Such measurements are sorely needed, especially over long time scales, for scientists to be able to accurately track and make predictions about changes in Earth's ice sheets. These instrument demonstrations represent a large step toward a future space-based, Earth-observing radar system and the underlying technologies form the basis for instruments that could eventually measure the Mars ice sheet or map the ocean beneath the icy surface of Jupiter's moon, Europa.



Top: a radar track (bold yellow line) from a May 4th PARIS flight over northern Greenland. The red section corresponds to the 'first look' data (bottom image) obtained from 1,500 ft.

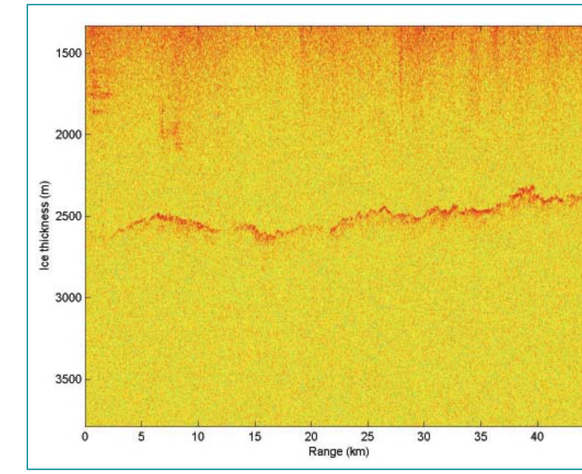
The **Pathfinder Airborne Radar Ice Sounder (PARIS)** instrument successfully completed 10 days of test flights and collected over 900 GB of data in May 2007 over northern Greenland. The PARIS radar, a 150 MHz airborne instrument built by a team from the Johns Hopkins University Applied Physics Lab, is designed to map the internal layering and basal topography of ice sheets from a high altitude.

Current ice-sheet sounding, as established through decades of field campaigns in Greenland and Antarctica, has been conducted exclusively from very low altitude platforms – either directly on the surface or at no more than 500 m high. On its test flights aboard the NASA P-3 aircraft, PARIS provided the first field demonstration of radar sounding of both ice sheet layering and basal topography from an airborne platform. The flights proved the feasibility of ice sounding from high altitudes (up to 8.5 km).

Data processing is ongoing but preliminary analysis shows the data collection was successful as the team has verified the signal return for bedrock – the basal signature. PARIS is in its third year of IIP funding.

The NASA P-3 aircraft readying for a PARIS test flight. Note the antenna on the underside of the left wing.

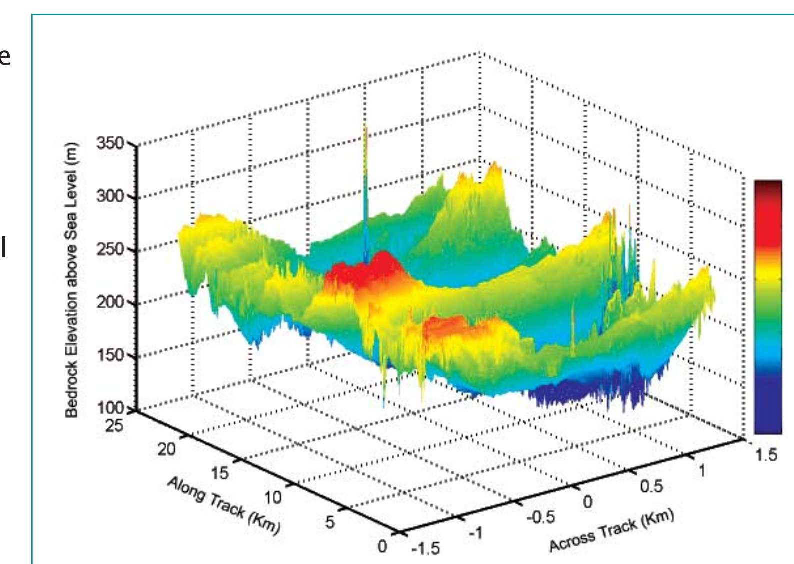
The **Global Ice Sheet Mapping Orbiter (GISMO), an** airborne prototype designed by a team of investigators from The Ohio State University, The University of Kansas, the Jet Propulsion Lab and Vexcel Corporation, completed a second round of airborne testing in September 2007. GISMO was flown on NASA's P-3 aircraft over Greenland's varied glacier areas to demonstrate its ability to make three-dimensional (3-D) measurements of the thickness and base (basal) topography beneath an ice sheet up to 5 km deep.



A 45-km section, proceeding from east to west, of 450 MHz data across Greenland's North East Ice Stream taken in 2007 from an altitude of 500 m. Note the dark orange line that denotes the ice sheet base.

GISMO employs VHF (150 MHz) and P-band (450 MHz) interferometric radars. Both frequencies were used on alternating flights during the demonstrations at altitudes from 500 m to 4,400 m. The GISMO team is using the data from the test flights to further evaluate the data-filtering techniques and algorithms necessary for this kind of measurement. They are also examining the images for the radar signature that denotes water beneath the ice sheets – the basal water signature. A reliable, broad-scale measurement of basal water, and to what extent that water lubricates moving ice sheets and glaciers, is of particular interest to scientists.

During the first round of test flights in 2006 over Greenland, GISMO, which looks both directly downward and to both sides along the flight path, produced the first 3-D measurements (at 150 MHz) of basal topography and ice sheet thickness from an airborne platform. In fact, GISMO was the first demonstration of a simultaneous-left-right-down-looking SAR. 3-D processing of the 450 MHz data from the 2007 flights is ongoing. GISMO is in its third year of IIP funding and receives additional support for radar development from the National Science Foundation.



Basal topography measured by GISMO at 150 MHz from an altitude of 650 meters above western Greenland in 2006. To show detail the scale used here creates vertical exaggeration.

INSTRUMENTS

Year in Review: **Components**

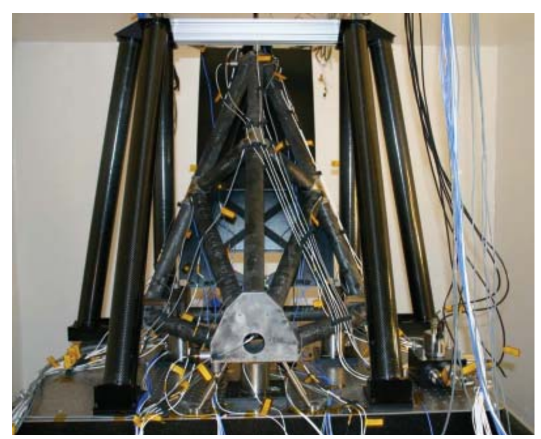
The Advanced Component Technology (ACT) program leads research, development, and testing of component- and subsystem-level technologies to advance the state-of-the-art of instruments, Earth- and space-based platforms, and information systems. The ACT program focuses on projects that reduce risk, cost,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

In FY07, the ACT program held 15 active projects, 14 of which were selected in FY05 as part of the 2005 NASA ROSES (Research Opportunity for Space and Earth Science) solicitation. The solicitation focused on a range of instrument component and subsystem topics, including: highly compact and low power instrument electronics, detector array devices, active and passive microwave antennas and components, electronics for L- and Ku-band large aperture radar applications, micro-electromechanical filters, miniature / low power radiometers, and radio frequency interference mitigation, among others.

The ACT program graduated two projects in FY07, both of which advanced two technology readiness levels:

- Development and Verification of Technology for an Earth Observing Deployed Lidar Telescope
- Full Spectropolarimetric Validation and Performance Enhancements for the Hyperspectral Polarimeter for Aerosol Retrievals (HySPAR)

The recently graduated Deployable Optics Modeling Experiments (DOME) project focused on developing the mechanical subsystems for a 6-petal deployable Lidar telescope (illustrated above). Large instruments often need to be deployed – unfolded, unrolled, or otherwise constructed – in space. The goal of this project was to ensure that these sensitive structures can be placed in exact, rigid positions. The photo below shows an apparatus built by the University of Colorado DOME project team to test the mechanical performance of a single petal.



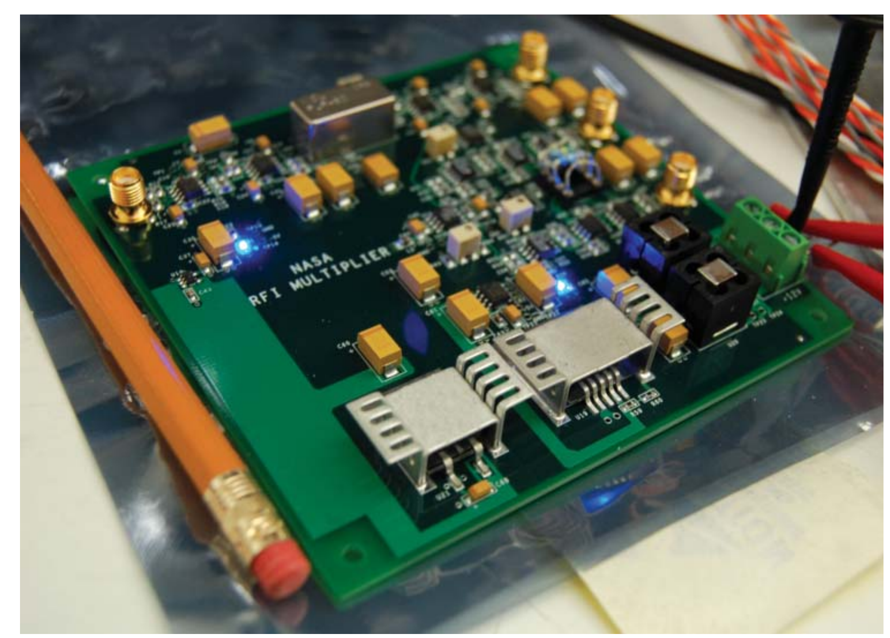
A critical component for single-pass interferometric radar systems is a phase-stable two channel down-conversion receiver (at left are the two halves of a Ku-band downconverter, Ku-band section, top, and L-band section, bottom). This ACT project will define the state-of-the-art in down-converter performance by providing unprecedented phase/amplitude stability and signal gain needed to achieve centimeter accuracy for kilometer resolutions in a small, off-the-shelf package.

SPOTLIGHT: Radio Frequency Interference Suppression System may be Key for Clearer Microwave Radiometer Measurements

Microwave radiometers use allocated portions of the radio spectrum to measure Earth's environment. As wireless communications and other services proliferate and crowd the spectrum, these sensors can experience significant interference, especially over heavily populated areas. The Analog Radio-Frequency Interference Suppression System (ARFISS), invented and developed at the Goddard Space Flight Center, is a combination of detection hardware and algorithms designed to mitigate this radio frequency interference (RFI) problem. Integration of the ARFISS system into future instruments may lead to better measurements of the weather, climate, and environment.

ARFISS observes and analyzes the incoming signal to detect RFI contamination. It's analog circuits can detect the difference between the Earth's natural microwave emission and man-made radio signals. Successful ground-based field testing of ARFISS was conducted at the Jet Propulsion Lab using the Passive Active L-band Sensor (PALS) to detect pulsed RFI from nearby airport radars. The ARFISS design, which uses purely analog components at radio and/or intermediate frequencies, allows the system to easily augment conventional radiometer architectures used in both airborne and space borne instruments. Its architecture is low risk, making it appropriate for use on operational systems.

The ARFISS project is in its third year of ACT funding and the ARFISS team is working to package the electronics for possible flight testing onboard the NASA P-3 aircraft in 2008.



This image shows the current ARFISS electronics board; note the pencil for relative size. The project team is currently focused on packaging the system for airborne tests.

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 virtually 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.

For the past two years, the AIST program has focused on the architecture and system building blocks needed for future autonomous sensor webs. 28 new projects were added in 2006 through a competitive solicitation targeted at sensor web enabling technologies. The AIST program is actively engaging these investigators through a series of workshops in order to achieve consensus on sensor web architectural principles and spur collaborations.

The AIST program held 46 active investments in FY07, several of which graduated over the course of the year, including:

- Seamless Handover in Space Networks
- Multi-Satellite Virtual Private Network for Space-Based Applications (SpaceVPN)
- An On-Board Processor for a Spaceborne Doppler Precipitation Radar
- Mission Automation for "A Train" Correlative Measurements Using the Earth Phenomena Observing Systems (EPOS)
- Data Mining for Understanding the Dynamic Evolution of Land-Surface Variables: Technology Demonstration using the D2K Platform
- A Reconfigurable Computing Environment for On-Board Data Reduction and Cloud Detection
- On-Board Processor for Direct Distribution of Change Detection Data Products
- HARVIST: Heterogeneous Agricultural Research via Interactive, Scalable Technology

All of the FY07 AIST program graduates advanced at least one TRL over the course of their funding.

The Smart Sensor Web in Southeast Alaska (SEAMONSTER) project is implementing a sensor web in the Lemon Creek watershed that monitors numerous physical parameters, including those related to climate, glacier dynamics, and water quality. SEAMONSTER will manage the power use of the in-situ sensors, monitor observed data, and autonomously respond and adapt to transient events of interest such as the catastrophic drainage of lakes that form at the top of Lemon Creek Glacier (above).

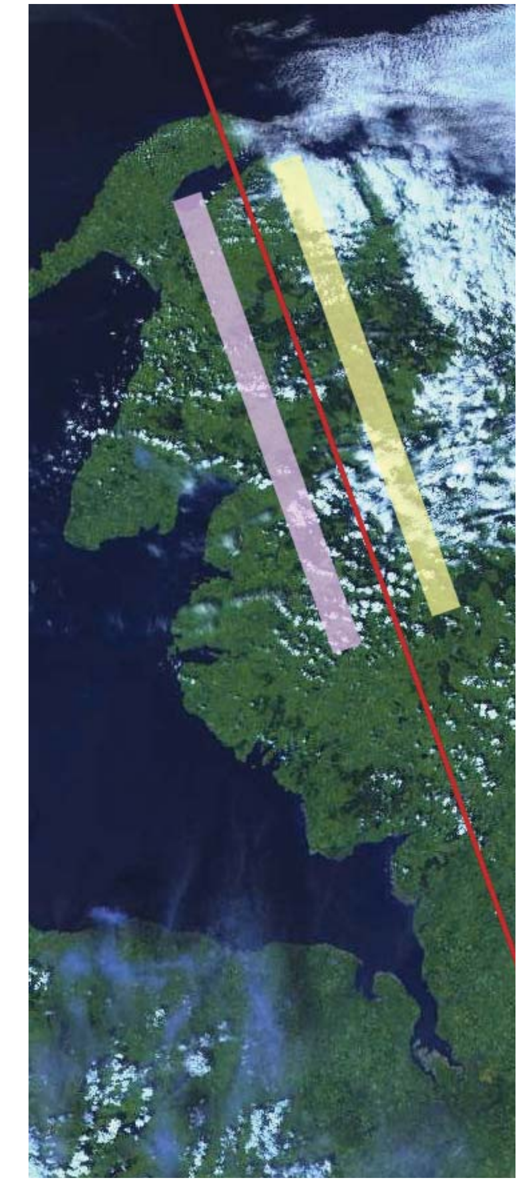
Spotlight: EPOS Clears the View for EOS Observations

The Earth Phenomena Observing System (EPOS) is an autonomous, dynamic re-tasking technology currently in operational use by EO-1. Developed at Draper Laboratory with AIST funding, EPOS schedules instruments onboard EO-1, specifically the Advanced Land Imager (ALI) and the Hyperion Imaging Spectrometer, to take images of target areas when those areas are most likely to be free of cloud cover. EPOS has demonstrated its utility for increasing the science value of a variety of Earth observations and the technology can play a significant role in developing future sensor web systems.

EPOS can be broadly defined as the combination of two key capabilities: 1) information exploitation and 2) planning and execution. A web service interface receives cloud cover forecast inputs and target requests via email from scientists at NASA and the U.S. Geological Survey. EPOS then generates an optimized schedule for the space-based instruments to target those areas of interest. The system operates autonomously with minimal human intervention.

During initial testing, EPOS demonstrated a success rate of 77% for its target scheduling choices. A 'success' is defined as an image with less than 20% cloud cover. Based on historical data, EPOS effectively reduces the overall number of imaging attempts by instruments on board EO-1 by approximately 14% – a reduction that will reap benefits in scientific value and cost.

The underlying EPOS technology is applicable to many situations in which there are multiple sensors of many types and/or a potentially large set of desired target locations. A sensor web, along with the replanning capability of EPOS, could help to characterize a number of local temporal events: severe weather, algal blooms, volcanic activity, ice movement, seismic events, and even oil spills or search and rescue activities.

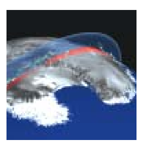


This artist's depiction illustrates how EPOS is used to identify the least cloudy path for EO-1 observations. For the orbit track depicted here (red line), EPOS identified the sensor orientation (pink band) that would provide observations with the least cloud cover within the area of interest. The yellow band depicts the preset, scheduled sensor orientation, which would have observed significant cloud cover.

Year in Review: Lasers

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. The LRRP has worked to formalize design, testing, and development procedures for durable laser/lidar systems and architectures, particularly in the critical 1- and 2- micron wavelengths.

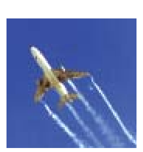
Laser/lidar remote sensing techniques satisfy a variety of measurement and operational requirements:



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

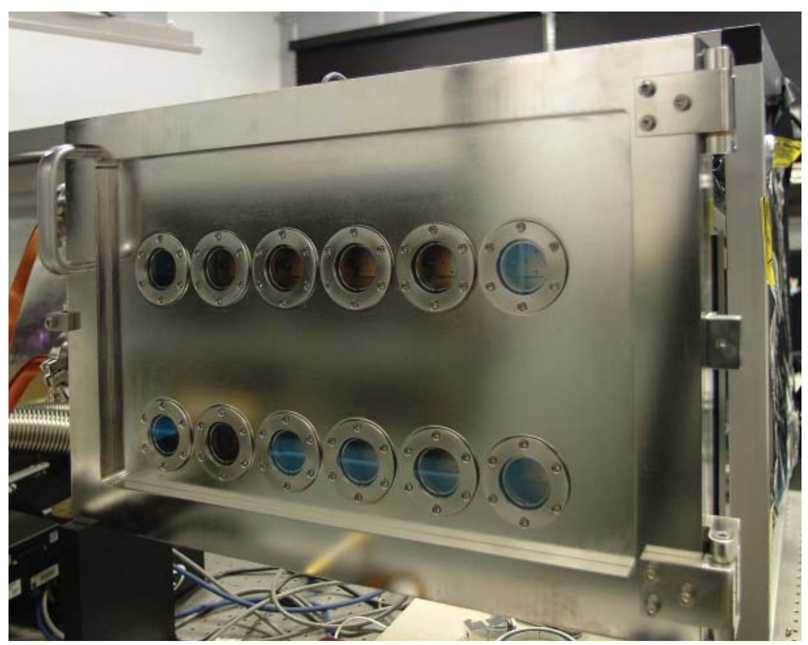
Exploration: Lander Guidance/Control, Atmospheric Winds, Biochemical Identification, Optical Communication, and Automated Rendezvous & Docking



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

In FY07, the LRRP funded 14 projects at NASA Goddard Space Flight Center and NASA Langley Research Center. Partners and collaborators on these projects included: 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 covered 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



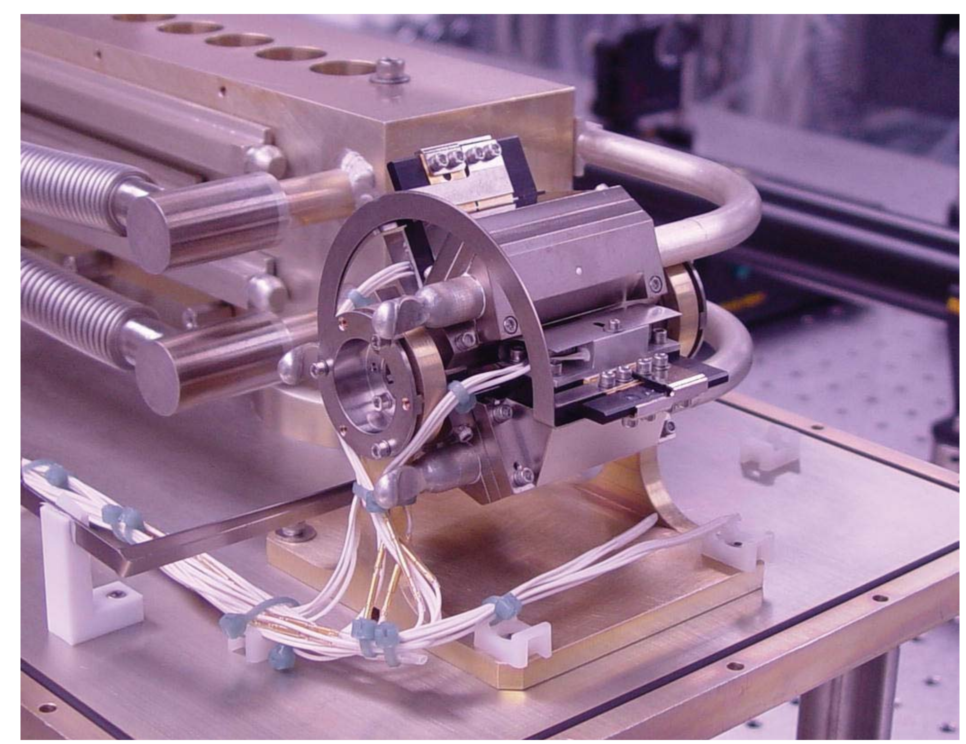
This custom vacuum chamber at NASA Goddard Space Flight Center has improved testing of laser diode arrays with 12 test positions with windows for continuous inspection.

SPOTLIGHT: World Record Power Output Demonstrated for Solid State 2 Micron Laser

An LRRP-funded team at the NASA Langley Research Center in Virginia has produced a record-breaking, state-of-the-art solid-state 2-micron laser. The laser generates greater than one joule per pulse energy with excellent beam quality and was demonstrated with an oscillator / two amplifier system.

The goal of this LRRP task was to develop a reliable, long-life, eye-safe, high-energy, efficient, all-solid-state laser transmitter as an integral component of a coherent Doppler Lidar system for global atmospheric wind measurement as well as a Differential Absorption Lidar (DIAL) system for carbon dioxide measurement.

The laser gain medium used, a Tm:Ho:LuLF (Thulium:Holmium:Lutetium Lithium Fluoride) crystal, was defined by a previous LRRP quantum mechanical modeling task at Langley Research Center. When grown and tested, this laser medium proved to be a superior efficiency gain medium over more conventional mediums such as Tm:Ho:YLF (Thulium:Holmium:Yttrium Lithium Fluoride) or Tm:Ho:YAG (Thulium:Holmium:Yttrium Aluminium Garnet. This compact 2-micron transmitter may be a key component in a UAV wind lidar transceiver system.



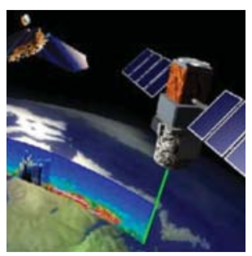
A conductively cooled oscillator designed for a high energy 2-micron laser.

Future Challenges

In 2007, the National Research Council released a report entitled "Earth Science and Applications from Space: National Imperatives for the Next Decade and Beyond" that lays out a consensus vision and priorities for future Earth science endeavors. This 'decadal survey' advises, among other strategies, that the cost risk of future missions be reduced by "investing early in the technological challenges."

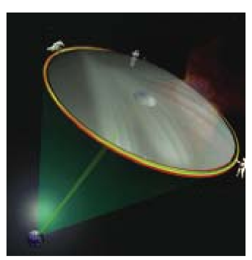
We recognize the importance of this statement. In fact, ESTO investments are currently buying down the risk of nearly all of the Earth science measurements recommended by the decadal survey. This is a testament to ESTO's best practices for technology development: competitive, peer-reviewed solicitations; active technology management; and broad-based, inclusive strategic planning. ESTO continues to monitor and match investments to the evolving needs of the Earth science community.

In addition to established technology goals, we have identified four 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 geostationary orbit
- 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 decisionsupport systems

Additional Resources

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

More about the ESTO approach to technology development, ESTO programs, and strategic planning

Information about ESTO solicitations and awards

Abstracts, papers and presentations from the 2007 NASA Science Technology Conference (NSTC2007) as well as from previous ESTO conferences

A fully searchable database of ESTO investments

An active, regularly updated area for news items and announcements

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Goddard Space Flight Center
Greenbelt, MD 20771

http://esto.nasa.gov