ESD Technology Activities Managed by ESTO

ESTO manages specific sets of technology development and integration projects on behalf of the ESD Research and Flight programs.

**Sustainable Land Imaging-Technology (SLI-T)**
New technologies and reduced costs for future land imaging (Landsat) measurements
*First solicitation released in FY16 (average award: $3-7M)*

**Earth Venture Instruments – Technology**
funding from the Flight Program’s Earth Systems Science Pathfinder (ESSP) program to further develop promising, highly-rated Earth Venture proposals that require additional technology risk reductions *(average award: $5 - 8M)*

**Airborne Instrument Technology Transition (AITT)**
provides campaign ready airborne instrumentation to support the objectives of the R&A Program. AITT converts mature instruments into operational suborbital assets that can participate in field experiments, evaluate new satellite instrument concepts, and/or provide calibration and validation of satellite instruments. *(average award: $1M)*

**Ocean Biology and Biogeochemistry:**
Ocean Color Remote Sensing Vicarious Calibration Instruments
in situ vicarious calibration instrument systems to maintain global climate-quality ocean color remote sensing radiances and reflectance's *(average award: $2.3M)*
Aquarius – Launched 2011
- Ultra-Stable Radiometers (B. Wilson, IIP-01)
- Lightweight Feed (S. Yueh, ACT-02)
- Calibration Subsystem (J. Peipmeier, ACT-99)

SMAP – Launched 2015
- Digital RFI Detector (C. Ruf, IIP-04)
- SoilScape Cal/Val sensor web (M. Moghaddam, AIST-08)

SWOT – Launch NET 2020
- Deployable Ka-band Antennas (M. Thompson, ACT-08)
- Precision Deployable Mast (G. Agnes, ACT-10)
- 3-frequency Microwave Radiometer (S. Reising, ACT-08)

CYGNSS – NET 2016
- GPS Reflection Wind Speed System (S. Katzberg, ATI-03)

TEMPO – NLT 2021
- GeoSpec Spectrograph (S. Janz, IIP-02)
- GEO-TASO UV-Vis spectrometer (J. Leitch, IIP-10)

Hurricane and Severe Storm Sentinel (HS3) – 2011-14
- HAMSR Sounding Radiometer (B. Lambrigsten, IIP-98)
- HIWRAP Ku- and Ka-band Radar (G. Heymsfield, IIP-04)
- Tropospheric Wind Lidar (B. Gentry, IIP-04)
- EPOS Operational Assessment Tools (S. Kolitz, AIST-11)

DISCOVER-AQ – 2011-15
- GEO-TASO UV-Vis spectrometer (J. Leitch, IIP-10)

AirMOSS – 2010-15
- Microwave Observatory of Subcanopy and Subsurface (M. Moghaddam, IIP-01)
- Land Information System for AirMOSS (Moghaddam, AIST-11)
- UAVSAR (S. Hensley, IIP-04)
ESTO investments in Remote Sensing

ESTO Technology Development Program

AIST Program

IIP & ACT Programs

SLI-T & InVEST Programs

Infusion into NASA Earth Science Programs

Sustainable Land Imaging Program (for future Landsat)
Sustainable Land Imaging-Technology (SLI-T) Program Overview & Objectives

“New technologies and reduced costs for future land imaging (Landsat) measurements”

• The goals of the SLI-T program are to research, develop, and demonstrate new measurement technologies that improve upon the Nation’s current land imaging capabilities while at the same time reduce the overall program cost risk for future SLI measurements.

The SLI-T program seeks to:

• Reduce the risk, cost, size, volume, mass, and development time for the next generation SLI instruments, while still meeting or exceeding the current land imaging program capabilities;
• Improve the temporal, spatial, and spectral resolution of SLI measurements; and
• Enable new SLI measurements that can improve the future program’s operational efficiency and reduce the overall costs of the Nation’s land imaging capabilities.
FY15 SLI-T Summary

A ROSES call was made for technology development activities leading to new instrument component- and subsystem-level airborne and space based sustainable land imaging measurement techniques.

- ROSES15 A.47 NNH15ZDA001N-SLIT released December 18, 2015

Two areas were solicited:
- **Advance Technology Demonstrations** (Systems/Instruments) -
  ~80% of SLI-T funding targeting the next Landsat mission (LS10)

- **Technology Investments** (Subsystems/Components) –
  ~20% of the SLI-T funding targeting the next Landsat mission +1 (LS11)

- Selected three ATD and three TI tasks in August 2016
**Sustainable Land Imaging-Technology-15 Status**

Completed first interim reviews for all awards

<table>
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<tr>
<th>PI Name</th>
<th>PI Org</th>
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<td>Compact Hyperspectral Prism Spectrometer</td>
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<td>Sandor -</td>
<td>Northrop Grumman</td>
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<td>Leahy</td>
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<td>Multi-Spectral, Low-Mass, High-Resolution Integrated Photonic Land Imaging Technology</td>
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Thomas Kampe, Ball Aerospace & Tech Corp.
Mature Ball Compact Hyperspectral Prism Spectrometer (CHPS) small form factor VSWIR imaging spectrometer for SLI Demo mission. Advance TRL through airborne demonstration validating instrument low stray light light performance.

Jeff Puschell, Raytheon
Demonstrate compact low mass Advanced Technology Land Imaging Spectrometer (ATLIS) design approach with wide field of view (WFOV, freeform fast optics, large format small detector digital FPS and on-chip Time delay Integration (TDI) to SLI-T VSWIR requirements.

Paula Wamsley,
Ball Aerospace & Technology Corporation
Develop a compact multispectral instrument for SLI and perform an airborne demonstration. Key technologies include: scan mechanism to perform step-stare motion, jitter removal, and image motion correction.
SLI-T 15 Advanced Technology Demonstrations

Thomas Kampe, Ball Aerospace & Tech Corp.

Mature Ball Compact Hyperspectral Prism Spectrometer (CHPS) small form factor VSWIR imaging spectrometer for SLI Demo mission. Advance TRL through airborne demonstration validating instrument low stray light performance

- Space borne instrument concept development is on-going
- CHPS VSWIR imaging spectrometer with separate TIR instrument feasible within volume approaching Reduced Instrument Volume Requirement – 0.5 m cube
- Radiometric Math Model adapted to spaceborne system – SLI-T CHPS Flight Concept Meets SNR Requirements at the Binned RMA Bands and at Nearly All Single-Pixel Wavelengths

![Graphs showing L-Typical and L-High SNR Performance for 30um Single Pixels and Binned RMA Bands.](image-url)
Jeff Puschell, Raytheon

Demonstrate compact low mass Advanced Technology Land Imaging Spectrometer (ATLIS) design approach with wide field of view (WFOV, freeform fast optics, large format small detector digital FPS and on-chip Time delay Integration (TDI) to SLI-T VSWIR requirements

- New and emerging optical and focal plane technology enables much smaller land imagers than current systems
- Innovative signal processing methods to RER slope and SNR and lead to further reductions in land imager size, mass and power
- ATLIS-P supports both a disaggregated architecture and a full spectrum instrument and provides a testbed that can be used in future technology demonstrations
- Key ATLIS-P technology (free form reflective telescope, digital FPA) benefits many other NASA Earth Science missions, especially those involving small satellite systems
SLI-T 15 Advanced Technology Demonstrations

Paula Wamsley, Ball Aerospace & Technology Corporation

Develop a compact multispectral instrument for SLI and perform an airborne demonstration. Key technologies include: scan mechanism to perform step-stare motion, jitter removal, and image motion correction.

Mechanical Packaging Concept Complete

- Initial packaging complete
- The VNIR and SWIR channels can be packaged within the allocated volume.
- Inclusion of the TIR Channel will likely cause the system to exceed the space allocation and may require a larger baseplate to hold all three channels (still a manageable option)
**SLI-T 15 Technology Investments**

**David Ting, NASA Jet Propulsion Laboratory**
Demonstrate a high-performance long-wavelength infrared (LWIR) focal plane array (FPA) technology with the flexibility to meet a variety of possible future land imaging needs.

**Stephanie Sandor-Leahy, Northrop Grumman**
Develop next-generation compact SLI instrument based on NGAS photonic waveguides
Reduce instrument volume by x25, mass by x7 compared to current multispectral approach

**S J Ben Yoo, UC Davis**
Design, fabrication and testing of an electro-optical (EO) imaging sensor concept that provides a low mass, low volume alternative to the traditional bulky optical telescope and focal plane detector array
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SLI-T 15 Technology Investments

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- Objectives
  - Planar “flat panel” telescope with NO large optics
  - Large field of view with NO precision gimbals for line of sight steering

- Concept Description
  - Light input by large area lenslet array “wired” into interferometer channels using nanophotonics (leverages commercial high density optical interconnect 3D computer chip technology)
  - Scalable to larger apertures using fiber coupling of multiple interferometer chips
SLI-T 15 Technology Investments

David Ting, NASA Jet Propulsion Laboratory

Demonstrate a high-performance long-wavelength infrared (LWIR) focal plane array (FPA) technology with the flexibility to meet a variety of possible future land imaging needs.

- Discrete 200 \( \mu \text{m} \times 200 \mu \text{m} \) devices
- 9.8 \( \mu \text{m} \) cutoff (50% peak QE)
- QE=40% (\( \lambda \)=8.5 \( \mu \text{m}, \) no AR coating)
- Zero-bias turn-on
- \( J_0 \) (0.1V, 77K) = 0.8x10^{-5} A/cm²
- Near-diffusion-limited dark current behavior to below 77K

Additional studies:
IIP Investments in Landsat technology

Phil Ely, DRS Technology
Demonstrate an Eight Band Radiometric Imager utilizing low cost, uncooled Focal Plane Array for Earth Science applications. Utilize a Piezo Backscan stage to image stabilize and allow for multi-frame stacking. Use of DRS patented TCOMP to provide radiometric accuracy (<2% error).

Tomasz Tkaczyk, Rice University
Develop a low-resource highly-capable tunable hyspectral imager for a range of Earth observations. Technologies include innovative fiber optic light-guide, snapshot imaging and tunability for specific line selection for spatial/spectral pixel distribution.

Ronald Lockwood, MIT/LL
Demonstrate the CCVIS design in a breadboard to mature the technology.
Quantify the scattered light contamination in an imaging spectrometer for both e-beam microlithographic and diamond machined gratings.
**AIST Investments**

**Dan Mandl, NASA GSFC**
Dramatically improve onboard processing capability for data rate missions (e.g. 1Gbps instrument data rates using processors consuming <20W and radiation tolerant)

**Petya Campbell, UMBC**
Develop and demonstrate innovative software systems for producing and disseminating science-quality spectral data from Unpiloted Aerial Vehicles (UAC) with capability to multi-source data integration.

**Melba Crawford, Purdue University**
Improve the use of land cover data by developing an advanced framework for robust classification using multi-source datasets. Utilize first results to query new samples to significantly improve classification performance and accuracy
Infrared Transfer Radiometer
Validate an uncooled imaging infrared (7.5 um to 13 um) radiometer designed for high radiometric performance from LEO

Infrared Atmospheric Sounder
Demonstrate ability to measure spectrum of upwelling infrared radiation and validate 2D infrared detector material, a micro pulse tube cryocooler, and a grating spectrometer
Looking Ahead

- Develop technology relevant for missions
- Smaller, less resource-intensive instrumentation
- High-resolution optical and infrared sensors
- Formation flying
- Nano-satellites / CubeSats
- Fractionated spacecraft
- Autonomous operations
- High-resolution ensemble models
- Rapid, error-free data transfer

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