

**Airborne Instrument Technology Transition**  
**Abstracts of selected proposals.**  
**(NNH12ZDA001N-AITT)**

The National Aeronautics and Space Administration (NASA) solicited proposals to integrate existing instruments, developed under the NASA Instrument Incubator Program (IIP) or other similar development programs, onto platforms supported by the NASA Airborne Science Program. The major goal of the Airborne Instrument Technology Transition (AITT) program is to provide campaign ready airborne instrumentation that can support the objectives of the Research and Analysis Program. This solicitation provides the opportunity to convert an IIP instrument end product into a useful suborbital instrument that can participate in field experiments, evaluate new satellite instrument concepts, and/or provide calibration and validation of satellite instruments. This opportunity was only for existing instruments, not development of new instrumentation. As projects would deal with data collection activities, proposed activities were to include specific attention enabling data availability of instrument products.

This solicitation specifically requested proposals that would support the objectives of one or more of the Earth science Focus Areas: Atmospheric Composition, Carbon Cycle and Ecosystems, Climate Variability and Change, Earth Surface and Interior, Water and Energy Cycle, and Weather. NASA advertised that six million dollars would be available over the next two and half years to fund approximately four to seven projects.

NASA received a total of 33 proposals, and 6 have been selected for either full or partial funding. The total funding awarded is \$6.7M over the next thirty months.

The selected projects will enhance six different instruments to be fully campaign ready and able to serve the NASA community. The projects involve remote sensing using a wide variety of remote sensing techniques and in various push the envelope to make new observation capabilities available to the scientific community. The instruments to be made campaign-ready will be useable in both satellite mission calibration and validation (i.e. GPM) as well as collecting data instrumental for planning and refining states of the near future (e.g. Hypsiri, PACE). Collectively the projects selected and described below will address objectives of all six of the NASA Earth science Focus Areas.

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**Stephen Durden / Jet Propulsion Laboratory**  
**A Three-frequency Atmospheric Radar for the NASA DC-8 Aircraft**

We propose to merge the Airborne 2nd Generation Precipitation Radar (APR-2, Ku-/Ka-band) and the CloudSat Validation Radar (CVR, W-band) to obtain a 3-frequency cloud and precipitation radar that will occupy only one nadir port and one zenith port on the NASA DC-8 and produce 3-frequency radar products and retrievals. Such data are used in a wide variety of studies that span several NASA Earth Science focus areas, specifically, water and energy cycle, climate variability and change, atmospheric composition, and weather. These data target the

needs of the Global Precipitation Measurement (GPM) and Aerosol/Cloud/Ecosystems (ACE) missions. The APR-2 has been operational on the NASA DC-8 since 2001 and it has been recently upgraded for the GRIP, GCPEX and SEAC4RS experiments with new radome, high power Ka-band amplifier and zenith antenna. This geometry is of particular interest for algorithm validation and development because it places the platform in the middle of the observed profile; in this configuration measurements from in situ probes installed on the same airplane can be directly correlated with the observed remote sensing profiles with no need of a second aircraft to fly in tandem. The CVR is a ground-based radar that has been deployed on experiments for CloudSat validation (e.g., C3VP, StormVEx). Both instruments acquire Doppler and polarimetric measurements for classification and motion detection. We plan to merge the two at the feed of the current APR-2 antenna system using mature technologies, so that all three frequencies will be collimated through the same parabola and scanned cross-track through the same reflector. We will also use a dual-frequency W/Ka-band lens antenna so that Ka- and W-band measurements will be available both above and below the aircraft, while Ku band measurements are limited to below the aircraft. Ultra-low loss waveguides will be used for the W-band zenith antenna as done in other W-band airborne radars. Therefore, the new radar will scan cross track below the plane at Ku, Ka and W-band, and simultaneously stare at zenith above the plane at Ka- and W-band. This will allow it to provide the remote sensing context surrounding the platform where in situ and other remote sensing instruments can be deployed as done in past campaigns. As such, the new radar will be able to support the goals of GPM and ACE without imposing on the DC-8 the demands of two separate radars in terms of ports and personnel. We will also adapt the current APR-2 Suite of Processing and Retrieval Algorithms (which produces Quicklook Level 1 imagery in quasi real-time and L1 and L2 products within 24 hrs) to process the W-band channels so that only one processing and data distribution stream is generated by the instrument. We will integrate and test the radar on the NASA DC-8 and perform science flights to demonstrate the instrument's campaign readiness.

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**John Hair / NASA Langley Research Center**  
**Flight Demonstration of Global Ozone Lidar Demonstrator (GOLD) Instrument on the B200 and Global Hawk**

We propose to package the technologies developed under the Global Ozone Lidar Demonstrator (GOLD) instrument developed under the Instrument Incubator Program (IIP) into a robust airborne instrument for future NASA-sponsored science deployments on the NASA Global Hawk platform. The GOLD instrument provides simultaneous high vertical resolution measurements of ozone, aerosol, and cloud distributions from the lower stratosphere to the surface. This project proposed herein directly addresses the goal of the Airborne Instrument Technology Transition (AITT) to upgrade mature instruments developed under NASA's Instrument Incubator Program for operation from various platforms supported by NASA's Airborne Science Program. This effort also leverages investments made in the GOLD project through American Reinvestment and Recovery Act (ARRA) funding. Through IIP and ARRA funding, the GOLD instrument is mature and has been validated in an up-looking ground-based configuration. Under AITT funding, we propose to package the GOLD subsystems into a robust flight instrument and demonstrate airborne operations first on the NASA B-200 and then the NASA Global Hawk. In addition to enabling a new and valuable capability for NASA Science

Mission Directorate (SMD) airborne science missions focused on better understanding atmospheric composition, chemistry, and dynamics in the troposphere and lower stratosphere, the high-altitude Global Hawk deployments of GOLD will enable emulation of satellite-based ozone lidar techniques and assessment of technologies.

This 2.5-year project consists of the following main tasks: 1) integrate the transmitter and receiver into a robust and integrated mechanical structure, 2) fabricate the Global Hawk compatible environmental enclosure designed under ARRA, 3) evaluate and test the laser liquid cooling systems for the Global Hawk, 4) develop flight software algorithms, and 5) perform flight demonstrations on the B-200 and Global Hawk.

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**Thomas Hanisco / NASA Goddard Space Flight Center**  
**High Altitude In Situ Airborne Formaldehyde**

The accurate description of the mechanisms that transport pollutants from the boundary layer to the upper troposphere and lower stratosphere (UT/LS) is a key objective of NASA Earth Science. Particular emphasis is placed on reducing the uncertainty of convective transport mechanisms in the context of a changing climate and increased urban pollution. In situ observations of formaldehyde in the UT/LS can play a significant role in clarifying these processes as: (1) a chemical tracer of short lived species that affect photochemistry and cirrus cloud formation, and (2) a photochemically active intermediate in the production and loss of UT/LS HO<sub>x</sub> and ozone. Formaldehyde is a high priority measurement objective in the Atmospheric Composition focus area of Earth Science, particularly in the Discover-AQ venture mission, the SEAC4RS field campaign, and collaborative missions with NSF and NOAA. In addition, formaldehyde is a primary measurement objective in two proposed missions of the Decadal Survey (GEO-CAPE and GACM) that will require in situ observations for validation and algorithm development.

The capability to obtain these critical in situ measurements in the UT/LS does not currently exist at NASA. This project will modify and adapt the GSFC in situ airborne formaldehyde instrument (ISAF) that flew recently on the DC-8 to measure formaldehyde from NASA high altitude aircraft (ER-2, WB-57 and GlobalHawk). The small size, low power requirements and excellent performance (precision, accuracy and time response) make this instrument ideally suited for high altitude aircraft that have limited payload capacity and require several instruments to meet mission science goals.

We propose to modify the existing DC-8 ISAF instrument and to test fly it on the ER-2. The two-year project will 1) reduce the size; 2) establish low pressure and low temperature compatibility; 3) develop autonomous operation; and 4) ensure reliability for long duration flights and field campaigns.

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**Simon Hook / Jet Propulsion Laboratory**  
**Upgrading HyTES to Campaign-Ready Configurations**

The Hyperspectral Thermal Emission Spectrometer (HyTES) was recently completed under the ESTO Instrument Investigator Program and had its first flights in July 2012. HyTES was developed in support of the Decadal Survey Hyperspectral Infrared Imager (HyspIRI) mission and the NASA Earth Surface and Interior, and Carbon Cycle and Ecosystems focus areas. HyTES provides 256 spectral bands of data acquired between 7.5 and 12 micrometers and is currently configured for operation from a Twin Otter aircraft.

HyTES data have spatial resolutions between 2 and 5 m from the Twin Otter depending on flight altitude, without pressurization. Such operation avoids the need for a pressure-housing and automation since the Twin Otter can fly low and there is room for an operator onboard. However, the Twin Otter has a short range and limited flight altitude ceiling. In order for HyTES data to be of maximum scientific value, HyTES needs fly on aircraft with a greater range, without the need for an instrument operator and at higher altitudes with the ability to process and evaluate data in the field. This would allow data to be acquired from regions such as Hawaii for volcano studies or the Arctic for methane emission studies as part of extended flight campaigns.

The purpose of this work is to enhance HyTES to 1) enable in-flight data evaluation and field data processing; 2) develop an automated operation capability and pressure housing for high altitude acquisitions from the ER-2; 3) manufacture a spare Focal Plane Array (FPA) since, the FPA is the single item with a long lead time for replacement, if damaged.

The period of performance is 2 years.

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**Pantazis Mouroulis / Jet Propulsion Laboratory**  
**Enhancing the Utility of the Portable Remote Imaging Spectrometer to Coastal Ocean Science.**

This proposal addresses the NASA Earth Science focus area of Carbon Cycle and Ecosystems specifically in enhancing the understanding of coastal ecosystems and the impact of natural or anthropogenic hazards.

The Portable Remote Imaging Spectrometer (PRISM) recently completed its development and proof stage, and underwent a flight trial over Monterey Bay/Elkhorn Slough mapping eelgrass beds and habitat. Successful integration on two different Twin Otter aircraft (NASA GRC and Twin Otter International) was demonstrated. PRISM was built to serve primarily the needs of coastal ocean science. The proposed work will upgrade PRISM to fly on pressurized platforms that avail much higher altitude and/or extended range, thus increasing spatial coverage by more than an order of magnitude. A larger sampling domain will allow investigators to address more regional-scale features related to sediment, phytoplankton growth and carbon flux in coastal ecosystems. Optimization of PRISM for pressurized platforms will require the addition of a special window designed to minimize the impact on its polarization characteristics. Additional

important upgrades will improve vacuum life consistent with longer missions, improve calibration knowledge and stability, and permit pilot-controlled operation. With these upgrades, PRISM will be able to fly in aircraft such as the NASA ER-2 or Orion P-3B and serve the full range of needs of the ocean science community. These extended capabilities will be demonstrated through two flights on the ER-2 and P-3B platforms. The first flight will take place over Long Island Sound using the P-3B plane, and will demonstrate range sufficient to cover the entire Sound with a swath width of 4km. The second flight will test the instrument at a high altitude flight and low pressure environment using the ER-2 platform over Monterey Bay, with a swath of 10km.

This work will take place over a period of two years.

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**Philip Russell / NASA Ames Research Center**  
**Upgrade of 4STAR for Full Science Capability of Sun-Sky-Cloud-Trace Gas Spectrometry in Airborne Science Deployments**

We propose to (1) upgrade the NASA 4STAR (Spectrometer for Sky-Scanning, Sun-Tracking Atmospheric Research) instrument to its full science capability of measuring (a) direct-beam sun transmission to derive aerosol optical depth spectra, (b) sky radiance to retrieve aerosol absorption and type (via complex refractive index spectra, shape, and mode-resolved size distribution), (c) zenith radiance for cloud properties, and (d) hyperspectral signals for trace gas retrievals, and (2) demonstrate in flight its suitability for deployment in challenging NASA airborne multi-instrument campaigns.

4STAR, which builds on the long and productive heritage of the NASA Ames Airborne Tracking Sunphotometers (AATS-6 and -14), will provide critical measurements, unattainable by other means, to address the NASA Earth science focus areas: Atmospheric Composition, Climate Variability and Change, and Carbon Cycle and Ecosystems. By combining satellite validation with key measurements not yet made from space, 4STAR is especially suited to Earth Venture-Air missions and to support the Climate Continuity and Decadal Survey missions Pre-ACE, ACE and Geo-CAPE, plus ongoing measurements by the A-train and Soumi NPP missions.

4STAR combines spectrometers with fiber optic links to a unique tracking, scanning head. In July 2012 4STAR flew on a G-1 aircraft in its first science mission, the DOE Two-Column Aerosol Project (TCAP). 4STAR measurements in TCAP, while yielding several scientifically valid products, also demonstrated that achieving 4STAR's full science potential requires upgrades in: (1) Calibration stability for both direct-beam irradiance and sky radiance, (2) Light collection and usage, and (3) Flight operability and reliability. The proposed research will address these needs by a suite of upgrades that includes development of a unique field-portable calibration source and detector, improved sun and sky light collectors, an improved fiber optic rotating joint and cables, spectrometer protection from humidity-induced degradation, and improved software and electronics. Proposed period of performance is two and half years.