and motion controller to create a complete CT TD-THz imaging system prototype. A data collection software script was developed that takes multiple z-axis slices in sequence and saves the data for batch processing. The data collection software was integrated with the ability to batch process the slice data with the CT TD-THz image reconstruction software. The time required to take a single CT slice was decreased from six minutes to approximately one minute by replacing the 320 ps, 100-Hz waveform acquisition system with an 80 ps, 1,000-Hz waveform acquisition system.

The TD-THZ computed tomography system was built from pre-existing commercial off-the-shelf subsystems. A CT motion control gantry was constructed from COTS components that can handle larger samples. The motion control gantry allows inspection of sample sizes of up to approximately one cubic foot (≈ 0.03 m^3). The system reduced to practice a CT-TD-THz system incorporating a COTS 80-ps/l-kHz waveform scanner. The incorporation of this scanner in the system allows acquisition of 3D slice data with better signal-to-noise using a COTS scanner rather than the "chirped" scanner. The system also reduced to practice a prototype for commercial CT systems for insulating materials where safety concerns cannot accommodate x-ray. A software script was written to automate the COTS software to collect and process TD-THz CT data.

This work was done by David Zimdars of Picometrix LLC, subsidiary of Advanced Photonix, Inc. (Amex: API) for Glenn Research Center. Further information is contained in a TSP (see page 1).

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Innovative Partnerships Office, Attn: Steven Fedor, Mail Stop 4–8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-18776-1.

Adaptive Sampling of Time Series During Remote Exploration
The challenge is addressed as an "active learning" problem.

NASA's Jet Propulsion Laboratory, Pasadena, California

This work deals with the challenge of online adaptive data collection in a time series. A remote sensor or explorer agent adapts its rate of data collection in order to track anomalous events while obeying constraints on time and power. This problem is challenging because the agent has limited visibility (all its datapoints lie in the past) and limited control (it can only decide when to collect its next datapoint). This problem is treated from an information-theoretic perspective, fitting a probabilistic model to collected data and optimizing the future sampling strategy to maximize information gain. The performance characteristics of stationary and nonstationary Gaussian process models are compared.

Self-throttling sensors could benefit environmental sensor networks and monitoring as well as robotic exploration. Explorer agents can improve performance by adjusting their data collection rate, preserving scarce power or bandwidth resources during uninteresting times while fully covering anomalous events of interest. For example, a remote earthquake sensor could conserve power by limiting its measurements during normal conditions and increasing its cadence during rare earthquake events. A similar capability could improve sensor platforms traversing a fixed trajectory, such as an exploration rover transect or a deep space flyby. These agents can adapt observation times to improve sample coverage during moments of rapid change.

An adaptive sampling approach couples sensor autonomy, instrument interpretation, and sampling. The challenge is addressed as an "active learning" problem, which already has extensive theoretical treatment in the statistics and machine learning literature. A statistical Gaussian process (GP) model is employed to guide sample decisions that maximize information gain. Nonstationary (e.g., time-varying) covariance relationships permit the system to represent and track local anomalies, in contrast with current GP approaches.

Most common GP models are "stationary," e.g., the covariance relationships are time-invariant. In such cases, information gain is independent of previously collected data, and the optimal solution can always be computed in advance. Information-optimal sampling of a stationary GP time series thus reduces to even spacing, and such models are not appropriate for tracking localized anomalies. Additionally, GP model inference can be computationally expensive.

This work was done by David R. Thompson of Caltech for NASA's Jet Propulsion Laboratory. For more information, contact iaoffice@jpl.nasa.gov. NPO-48430

A Tracking Sun Photometer Without Moving Parts
This reliable instrument is used to collect valuable information about the atmosphere.

Ames Research Center, Moffett Field, California

This innovation is small, lightweight, and consumes very little electricity as it measures the solar energy attenuated by gases and aerosol particles in the atmosphere. A Sun photometer is commonly used on the Earth's surface, as well as on aircraft, to determine the solar energy attenuated by aerosol particles in the atmosphere and their distribution of sizes. This information is used to determine the spatial and temporal distribution of gases and aerosols in the atmosphere, as well as their distribution sizes.

The design for this Sun photometer uses a combination of unique optics and a charge coupled device (CCD) array to eliminate moving parts and make the instrument more reliable. It could be self-calibrating throughout the year. Data products would be down-welling flux,

the direct-diffuse flux ratio, column abundance of gas phase constituents, aerosol optical depth at multiple-wavelengths, phase functions, cloud statistics, and an estimate of the representative size of atmospheric particles. These measurements can be used to obtain an estimate of aerosol size distribution, refractive index, and particle shape.

Incident light is received at a light-reflecting (inner) surface, which is a truncated paraboloid. Light arriving from a hemispheric field of view (solid angle 2π steradians) enters the reflecting optic at an entrance aperture at, or adjacent to, the focus of the paraboloid, and is captured by the optic. Most of this light is reflected from an inner surface. The light proceeds substantially parallel to the paraboloid axis, and is detected by an array detector located near an exit aperture. Each of the entrance and exit apertures is formed by the intersection of the paraboloid with a plane substantially perpendicular to the paraboloid axis. Incident (non-reflected) light from a source of limited extent (the Sun) illuminates a limited area on the detector array. Both direct and diffuse illumination may be reflected, or not reflected, before being received on the detector array. As the Sun traverses a path in the sky over some time interval, the track of the Sun can be traced on the detector array.

A suitably modified Sun photometer might be used to study the dynamics of an environment on another planet or satellite with an atmosphere.

This work was done by Anthony W. Strawa of Ames Research Center. Further information is contained in a TSP (see page 1). ARC-15443-1

Surface Temperature Data Analysis

Goddard Space Flight Center, Greenbelt, Maryland

Small global mean temperature changes may have significant to disastrous consequences for the Earth's climate if they persist for an extended period. Obtaining global means from local weather reports is hampered by the uneven spatial distribution of the reliably reporting weather stations. Methods had to be developed that minimize as far as possible the impact of that situation.

This software is a method of combining temperature data of individual stations to obtain a global mean trend, overcoming/estimating the uncertainty introduced by the spatial and temporal gaps in the available data. Useful estimates were obtained by the introduction of a special grid, subdividing the Earth's surface into 8,000 equal-area boxes, using the existing data to create virtual stations at the center of each of these boxes, and combining temperature anomalies (after assessing the radius of high correlation) rather than temperatures.

This work was done by James Hansen and Reto Ruedy of Goddard Space Flight Center. For further information, contact the Goddard Innovative Partnerships Office at (301) 286-5810. GSC-16243-1

Modular, Autonomous Command and Data Handling Software With Built-In Simulation and Test

Commercial markets include telecommunications, remote sensing, and GIS imagers.

Goddard Space Flight Center, Greenbelt, Maryland

The spacecraft system that plays the greatest role throughout the program lifecycle is the Command and Data Handling System (C&DH), along with the associated algorithms and software. The C&DH takes on this role as cost driver because it is the brains of the spacecraft and is the element of the system that is primarily responsible for the integration and interoperability of all spacecraft subsystems. During design and development, many activities associated with mission design, system engineering, and subsystem development result in products that are directly supported by the C&DH, such as interfaces, algorithms, flight software (FSW), and parameter sets.

A modular system architecture has been developed that provides a means for rapid spacecraft assembly, test, and integration. This modular C&DH software architecture, which can be targeted and adapted to a wide variety of spacecraft architectures, payloads, and mission requirements, eliminates the current practice of rewriting the spacecraft software and test environment for every mission. This software allows mission-specific software and algorithms to be rapidly integrated and tested, significantly decreasing time involved in the software development cycle.

Additionally, the FSW includes an Onboard Dynamic Simulation System (ODySSy) that allows the C&DH software to support rapid integration and test. With this solution, the C&DH software capabilities will encompass all phases of the spacecraft lifecycle. ODySSy is an on-board simulation capability built directly into the FSW that provides dynamic built-in test capabilities as soon as the FSW image is loaded onto the processor. It includes a six-degrees-of-freedom, high-fidelity simulation that allows complete closed-loop and hardware-in-the-loop testing of a spacecraft in a ground processing environment without any additional external stimuli. ODySSy can intercept and modify sensor inputs using mathematical sensor models, and can intercept and respond to actuator commands.

ODySSy integration is unique in that it allows testing of actual mission sequences on the flight vehicle while the spacecraft is in various stages of assembly, test, and launch operations — all without any external support equipment or simulators. The ODySSy component of the FSW significantly decreases the time required for integration and test by providing an automated, standardized, and modular approach to integrated avionics and com-