ibration data. The software is capable of timing events as well as running scripts for semi-autonomous operation. The software also records this variety of data with proper timing.

This complex software package is composed of two primary parts: hardware communications and user interfacing. The hardware interfacing section allows for the computer to transfer data and commands (via digital or analog signals) to a wide variety of system components such as sensors, valves, transducers, analyzers, pumps, etc. The hardware interfacing section also allows for the recording of the transferred data/commands to be stored on the local computer. The user interface section gathers the data from the hardware interfacing section and presents it to the user in various user-configurable methods. The two most common methods of providing data to the user are via time-domain charting and real-time parameter value/status.

This work was done by C. Arkin, Charles Curley, Eric Gore, David Floyd, and Damion Lucas of Kennedy Space Center. Further information is contained in a TSP (see page 1). KSC-13643

Miniaturized Laser Heterodyne Radiometer (LHR) for Measurements of Greenhouse Gases in the Atmospheric Column

Instrument could be used to validate other Earth observing missions.

Goddard Space Flight Center, Greenbelt, Maryland

This passive laser heterodyne radiometer (LHR) instrument simultaneously measures multiple trace gases in the atmospheric column including carbon dioxide (CO_2) and methane (CH_4), and resolves their concentrations at different altitudes. This instrument has been designed to operate in tandem with the passive aerosol sensor currently used in AERONET (an established network of more than 450 ground aerosol monitoring instruments worldwide). Because aerosols induce a radiative effect that influences terrestrial carbon exchange, simultaneous detection of aerosols with these key carbon cycle gases offers a uniquely comprehensive measurement approach.

Laser heterodyne radiometry is a technique for detecting weak signals that was adapted from radio receiver technology. In a radio receiver, a weak input signal from a radio antenna is mixed with a stronger local oscillator signal. The mixed signal (beat note, or intermediate frequency) has a frequency equal to the difference between the input signal and the local oscillator. The intermediate frequency is amplified and sent to a detector that extracts the audio from the signal.

In the LHR instrument described here, sunlight that has undergone absorption by the trace gas is mixed with laser light at a frequency matched to a trace gas absorption feature in the infrared (IR). Mixing results in a beat signal in the RF (radio frequency) region that can be related to the atmospheric concentration. For a one-second integration, the estimated column sensitivities are 0.1 ppmv for CO_2, and <1 ppbv for CH_4.

In addition to producing a standalone ground measurement product, this instrument could be used to calibrate/validate four Earth observing missions: ASCENDS (Active Sensing of CO_2 Emissions over Nights, Days, and Seasons), OCO-2 (Orbiting Carbon Observatory), OCO-3, and GOSAT (Greenhouse gases Observational SATellite).

The only network that currently measures CO_2 and CH_4 in the atmospheric column is TCCON (Total Carbon Column Observing Network), and only two of its 16 operational sites are in the United States. TCCON data is used for validation of GOSAT data, and will be used for OCO-2 validation. While these Fourier-transform spectrometers (FTS) can measure the largest range of trace gases, the network is severely limited due to the high cost and extreme size of these instruments (these occupy small buildings and require personnel for operation). The LHR/AERONET instrument offers a significantly smaller (carry-on luggage size) autonomous instrument that can be incorporated into AERONET's much larger (450 instruments) global network.

This work was done by Emily Steel and Matthew McLinden of Goddard Space Flight Center. Further information is contained in a TSP (see page 1). GSC-16327-1

Anomaly Detection in Test Equipment via Sliding Mode Observers

Commercial applications of the algorithms exist in the oil, natural gas, and chemical industries for identifying and localizing leaks.

Stennis Space Center, Mississippi

Nonlinear observers were originally developed based on the ideas of variable structure control, and for the purpose of detecting disturbances in complex systems. In this anomaly detection application, these observers were designed for estimating the distributed state of fluid flow in a pipe described by a class of advection equations.

The observer algorithm uses collected data in a piping system to estimate the distributed system state (pressure and velocity along a pipe containing liquid gas propellant flow) using only boundary measurements. These estimates are then used to further estimate and localize possible anomalies such as leaks or foreign objects, and instrumentation metering problems such as incorrect flow meter orifice plate size.

The observer algorithm has the following parts: a mathematical model of the fluid flow, observer control algorithm, and an anomaly identification algorithm. The main functional opera-