this apparatus stores fewer than 20 bytes per waveform. The bandwidth needed to transmit the data to a remote recording or control station is reduced correspondingly. In addition, the dead time between subsequent triggers of this apparatus is only about 0.1 ms — less than a hundredth of that of the prior transient recorder.

This transient-voltage recorder can be configured for different input voltage ranges to accommodate the expected magnitudes of the transients to be monitored. Typical input ranges include ±10 V, ±50 V, and ±100 V. The input termination can be either single-ended or differential and selectable among impedances of 50, 120, or 10 kilohms. Either a positive or a negative transient can trigger sampling, real-time processing, and recording. Depending on the specific setup, data in multiple channels could be analyzed simultaneously, triggered by signal from any one of the channels.

A clock circuit is included to enable accurate time-stamping of any recorded waveform. Time stamping is necessary if a transient measured by this apparatus is to be correlated with measurements by such other apparatuses as a lightning-location system.

The power supply of the transient-voltage recorder includes backup batteries that can maintain operation for as long as 15 days when main AC power is lost. During normal operation when AC power is available, the batteries are charged automatically.

This work was done by Pedro Medelius of ASRC Aerospace Corp. for **Kennedy Space Center**. *For further information, contact:*

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This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Innovative Partnerships Office, Kennedy Space Center, (321) 867-8130. Refer to KSC-12494.

Measuring Humidity in Sealed Glass Encasements

This noninvasive technique helps in the preservation of valuable documents.

Langley Research Center, Hampton, Virginia

A technique has been devised for measuring the relative humidity levels in the protective helium/water vapor atmosphere in which the Declaration of Independence, the United States Constitution, and the Bill of Rights are encased behind glass panels on display at the National Archives in Washington, DC. The technique is noninvasive: it does not involve penetrating the encasements (thereby risking contamination or damage to the priceless documents) to acquire samples of the atmosphere. The technique could also be applied to similar glass encasements used to protect and display important documents and other precious objects in museums.

The basic principle of the technique is straightforward: An encasement is maintained at its normal display or operating temperature (e.g., room temperature) while a portion of its glass front panel is chilled (see Figure 1) until condensed water droplets become visible on the inside of the panel. The relative humidity of the enclosed atmosphere can then be determined as a known function of the dew point, the temperature below which the droplets condense.

Notwithstanding the straightforwardness of the basic principle, careful attention to detail is necessary to enable accurate determination of the dew point. In the initial application, the affected por-

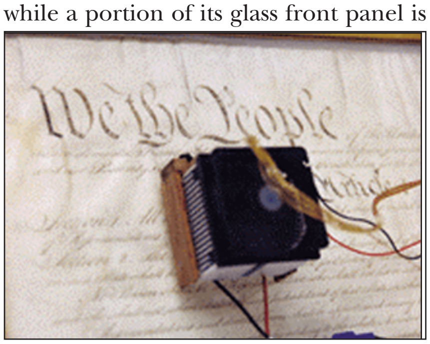

Figure 1. A **Thermoelectric Device** rests on the encasement.

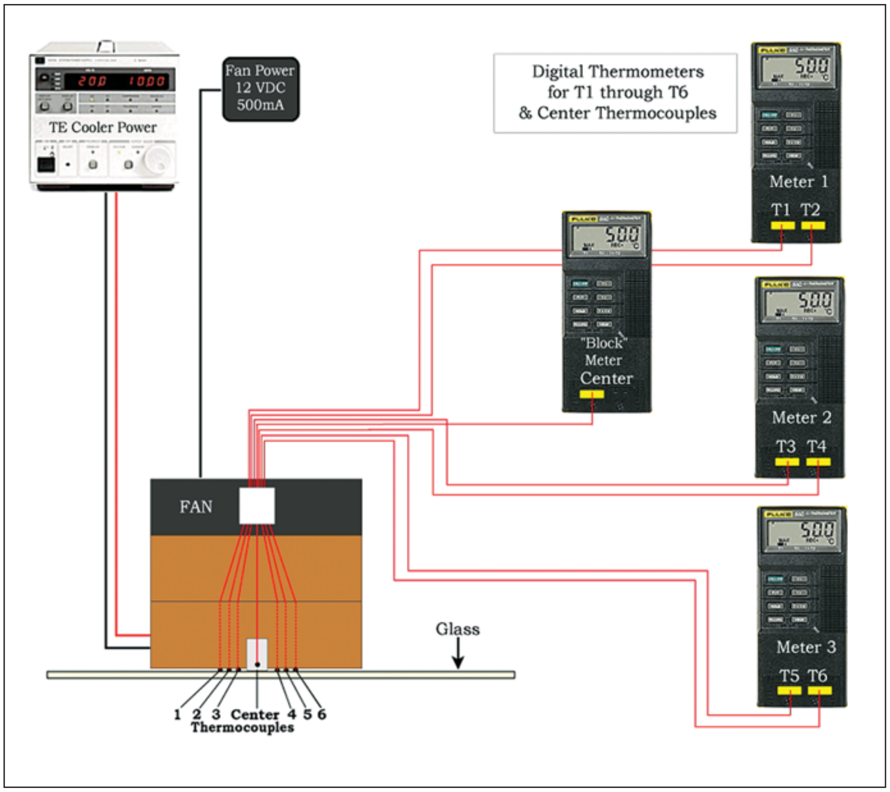

Figure 2. A **Thermoelectric Cooler** assembly and instrumentation has seven thermocouples to measure temperatures at different locations.

tion of the glass panel was cooled by contact with an aluminum plate that was cooled by a thermoelectric module, the exhaust heat of which was dissipated by a heat sink cooled by a fan. A thermocouple was used to measure the interior temperature of the aluminum plate, and six other thermocouples were used to measure the temperatures at six locations on the cooled outer surface of the glass panel (see Figure 2). Thermal grease was applied to the aluminum plate and the thermocouples to ensure close thermal contact.

Power was supplied to the thermoelectric module in small increments, based on previous laboratory tests. A small flashlight and a magnifying glass were used to look for water droplets condensing on the inner surface of the glass. The temperature readings of the thermocouples were taken during cool-down and upon observing condensation.

In determining the dew point, it was necessary to make a correction for the differences between the temperatures measured on the chilled outer surface of the glass and the temperature of the inner surface, where the condensation took place. The correction was derived from a laboratory test on a measurement setup that was nearly identical, except that the dew location on the inner surface was also instrumented with a thermocouple. The test showed that the temperature at the dew location on the inner surface of the glass panel was 0.9 C° above the temperature determined from the measurements on the chilled outer surface of the panel.

This work was done by James W. West, Cecil G. Burkett, and Joel S. Levine of **Langley Research Center**. *Further information is contained in a TSP (see page 1).*
LAR-16422-1

Adaptable System for Vehicle Health and Usage Monitoring

Safety can be increased, while costs and downtime can be reduced.

Langley Research Center, Hampton, Virginia

Aircraft and other vehicles are often kept in service beyond their original design lives. As they age, they become susceptible to system malfunctions and fatigue. Unlike future aircraft that will include health-monitoring capabilities as integral parts in their designs, older aircraft have not been so equipped.

The Adaptable Vehicle Health and Usage Monitoring System is designed to be retrofitted into a preexisting fleet of military and commercial aircraft, ships, or ground vehicles to provide them with state-of-the-art health- and usage-monitoring capabilities. The monitoring system is self-contained, and the integration of it into existing systems entails limited intrusion. In essence, it has "bolt-on/bolt-off" simplicity that makes it easy to install on any preexisting vehicle or structure. Because the system is completely independent of the vehicle, it can be certified for airworthiness as an independent system.

The purpose served by the health-monitoring system is to reduce vehicle operating costs and to increase safety and reliability. The monitoring system is a means to identify damage to, or deterioration of, vehicle subsystems, before such damage or deterioration becomes costly and/or disastrous. Frequent monitoring of a vehicle enables identification of the embryonic stages of damage or deterioration. The knowledge thus gained can be used to correct anomalies while they are still somewhat minor. Maintenance can be performed as needed, instead of having the need for maintenance identified during cyclic inspections that take vehicles off duty even when there are no maintenance problems. Measurements and analyses acquired by the health-monitoring system also can be used to analyze mishaps. Overall, vehicles can be made more reliable and kept on duty for longer times.

Figure 1 schematically depicts the system as applied to a fleet of n vehicles. The system has three operational levels. All communication between system components is by use of wireless transceivers operating at frequencies near 433 MHz. Electromagnetic-interference tests have demonstrated that the radio-frequency emissions from the transceivers do not influence civilian

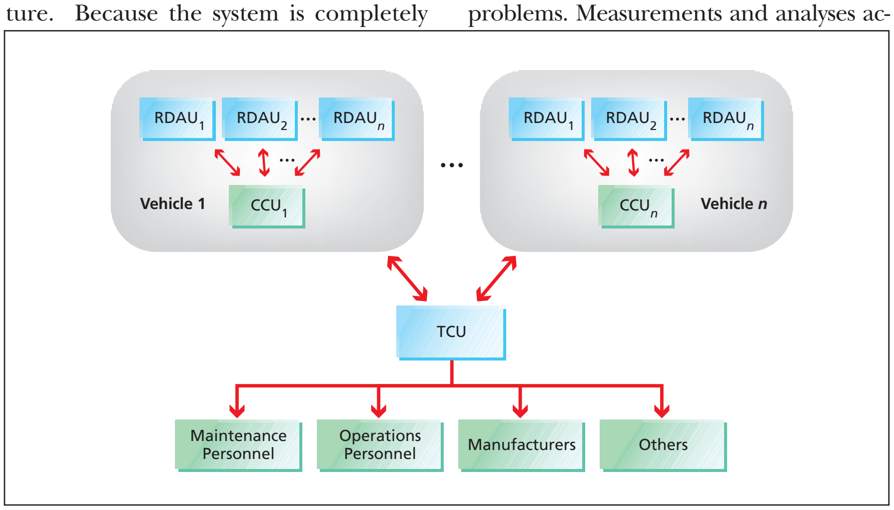

Figure 1. The **Adaptable Vehicle Health and Usage Monitoring System** is characterized by three levels of operation and analysis.

Left Main Landing Gear With RDAU

RDAU Mounted on Tow Fitting of Landing Gear

Figure 2. An **RDAU Mounted on a Landing Gear** was used to perform a rigorous test of the system.