The cuboidal positioning system can be used to calibrate or evaluate single, dual, or triaxial packages. The system employs a simplified, linear mathematical model that is a function of gravitational components.

At the time of this reporting, NASA has built six systems in support of program operations. Further development is expected to expand the system's capabilities to other instruments and to complete temperature characterization.

This work was done by Tom Finley and Peter Parker of Langley Research Center. For further information, contact the Langley Innovative Partnerships Office at (757) 864-8881. LAR-17163-1

Pupil Alignment Measuring Technique and Alignment Reference for Instruments or Optical Systems

This technique can be used in any instrumentation that requires measurement of pupil alignment, such as optical instruments and cameras.

Goddard Space Flight Center, Greenbelt, Maryland

A technique was created to measure the pupil alignment of instruments *in situ* by measuring calibrated pupil alignment references (PARs) in instruments. The PAR can also be measured using an alignment telescope or an imaging system. PAR allows the verification of the science instrument (SI) pupil alignment at the integrated science instrument module (ISIM) level of assembly at ambient and cryogenic operating temperature. This will allow verification of the ISIM+SI alignment, and provide feedback to realign the SI if necessary.

This innovation consists of a 10-mm reflective patch on the +V1 face of a filter or closed position of the SI pupil wheel. The PAR will have a centered alignment crosshair and a minimum of two concentric circular fiducials representing a reference for the SI pupil alignment. The fiducials need not be exactly centered to the nominal SI pupil position, but their alignment relative to the nominal pupil position must be known to 0.2-percent of the pupil diameter. A clocking reference point should also be included in one quadrant to provide a reference.

The SI teams will reference their pupil alignment to the PAR during their instrument alignment, and measure the PAR in the +V1 horizontal and +V1 down orientation at ambient temperature relative to the nominal V Coordinate system. The teams must demonstrate by test and analysis that the SI internal pupil alignment (from the kinematic feet up) is within the 0.5-percent placement allocation in 0-G. In addition, the SI team must demonstrate by test and analysis that the pupil alignment is within the 1-percent placement allocation in 1-G to a knowledge tolerance of 0.5 percent.

For ISIM, the PAR will be used at ambient temperature to verify that the SI has been installed to within allocated tolerances, and that its alignment does not shift due to vibration and other environmental test exposures. Ambient temperature measurements are performed using a PAR ISIM reference fixture to place alignment telescopes along the nominal chief center ray of each SI. The alignment telescopes will measure the offset of each SI PAR from nominal, and verify that the ISIM+SI alignment is within tolerance at ambient temperature. This also allows a non-invasive means of checking SI alignment to ISIM (without removing the ISIM enclosure) after shipping to observatory testing.

During the ISIM level verification, the OSIM will be aligned to ISIM and the optical telescope element (OTE) SIMulator (OSIM) pupil reference fiducials will be projected onto the SI PARs, and the pupil alignment will be mapped. A Global Nominal Pupil (GNP) position, optimizing all of the SIs, will be determined, and used to align the ISIM to the OTE to minimize common path pupil alignment error. The pupil alignment measurement will also verify that the ISIM+SI pupil alignment is within allocated tolerances for all SIs in the +V1 down orientation. Therefore, it is crucial that the SI pupil alignments are known in both orientations for each SI. The final opportunity to discover and correct ISIM+SI pupil alignment errors at cryogenic operating temperature is during ISIM level testing, so it is crucial that a standardized reference (SI PAR) be available. These references will be measured relative to Pupil Imaging Modes for NIRCam and MIRI to verify that the alignment has not changed downstream of the Pupil reference due to shifts of optics, and is the only way to deterministically demonstrate an unvignetted field at the observatory level of assembly.

This work was done by John G. Hagopian of Goddard Space Flight Center. For further information, contact the Goddard Innovative Partnerships Office at (301) 286-5810. GSC-15783-1

Autonomous System for Monitoring the Integrity of Composite Fan Housings

John H. Glenn Research Center, Cleveland, Ohio

A low-cost and reliable system assesses the integrity of composite fan-containment structures. The system utilizes a network of miniature sensors integrated with the structure to scan the entire structural area for any impact events and resulting structural damage, and to monitor degradation due to usage. This system can be used to monitor all types of composite structures on aircraft and spacecraft, as well as automatically monitor in real time the location and extent of damage in the containment structures. This diagnostic information is passed to prognostic modeling that is being developed to utilize the information and provide input on the residual strength of the structure, and maintain a history of structural degradation during usage. The structural health-monitoring system would consist of three major components: (1) sensors and a sensor network, which is permanently bonded onto the structure being monitored; (2) integrated hardware; and (3) software to monitor *in-situ* the health condition of in-service structures.

This work was done by Xinlin P. Qing, Christopher Aquino, and Amrita Kumar of Acellent Technologies, Inc. for Glenn Research Center.

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Innovative Partnerships Office, Attn: Steve Fedor, Mail Stop 4–8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-18396-1.

A Safe, Self-Calibrating, Wireless System for Measuring Volume of Any Fuel at Non-Horizontal Orientation

This system can be used for any fluid, including cryogenic and caustic liquids.

Langley Research Center, Hampton, Virginia

A system for wirelessly measuring the volume of fluid in tanks at non-horizontal orientation is predicated upon two technologies developed at Langley Research Center. The first is a magnetic field response recorder that powers and interrogates magnetic field response sensors [“Magnetic Field Response Measurement Acquisition System,” (LAR-16908), *NASA Tech Briefs*, Vol. 30, No. 6 (June 2006), page 28]. Magnetic field response sensors are a class of sensors that are powered via oscillating magnetic fields and when electrically active respond with their own magnetic fields whose attributes are dependent upon the magnitude of the physical quantity being measured. The response recorder facilitates the use of the second technology, which is a magnetic field response fluid-level sensor [“Wireless Fluid-Level Sensors for Harsh Environments,” (LAR-17155), *NASA Tech Briefs*, Vol. 33, No. 4 (April 2009), page 30].

The method for powering and interrogating the sensors allows them to be completely encased in materials (Fig. 1) that are chemically resilient to the fluid being measured, thereby facilitating measurement of substances (e.g., acids, petroleum, cryogenic, caustic, and the like) that would normally destroy electronic circuitry. When the sensors are encapsulated, no fluid (or fluid vapor) is exposed to any electrical component of the measurement system. There is no direct electrical line from the vehicle or plant power into a fuel container. The means of interrogating and powering the sensors can be completely physically and electrically isolated from the fuel and vapors by placing the sensor on the other side of an electrically non-conductive bulkhead (Fig. 2). These features prevent the interrogation system and its electrical components from becoming an ignition source.

Measuring fuel volume while the tank is not level would benefit aircraft during uncoordinated roll and pitch maneuvers, boat fuel tanks in heavy waves, and trucks, trains, and automobiles moving on steep inclines. The system can be used for any fluid, including cryogenic and caustic liquids. If the geometry of the tank is known, the surface defining the liquid/air interface can be determined by measuring the frequency re-

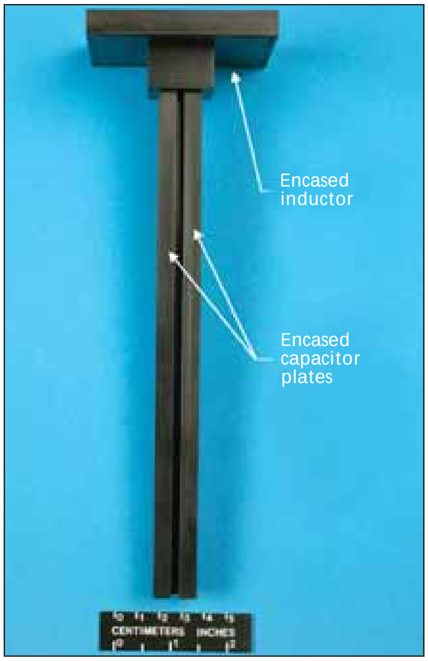

Figure 1. **Magnetic Field Response Fluid-Level Sensor** completely encapsulated in Ertalyte PET-P plastic.

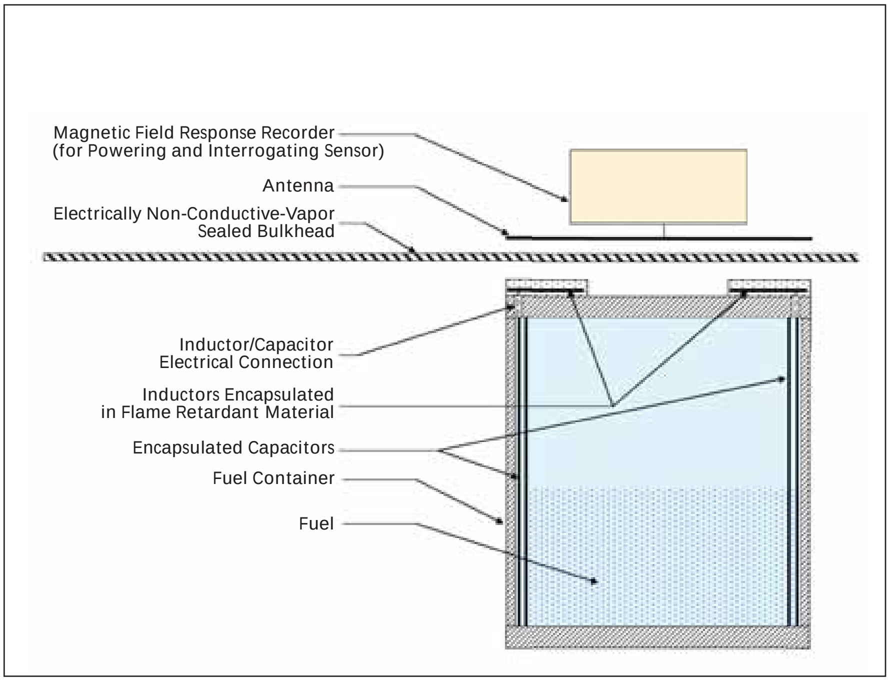

Figure 2. **Fuel Tank With Encapsulated Sensors** outboard bulkhead. Magnetic field response recorder and antenna are on other side of bulkhead.