tion against overheating and thereby damaging nearby instrumentation leads through the use of conventional furnace brazing or any other technique that involves heating the entire BBS and its surroundings. The problem is further complicated by another application-specific prohibition against damaging the thin tantalum thermocouple sheaths through the use of conventional welding to join the thermocouples to the ring.

The first BBS rings were made of graphite. The tantalum-sheathed thermocouples were attached to the graphite rings by use of high-temperature graphite cements. The ring/thermocouple bonds thus formed were found to be weak and unreliable, and so graphite rings and graphite cements were abandoned.

Now, each BBS ring is made from one of two materials: either tantalum or a molybdenum/titanium/zirconium alloy. The tantalum-sheathed thermocouples are bonded to the ring by laser brazing. The primary advantage of laser brazing over furnace brazing is that in laser brazing, it is possible to form a brazed connection locally, without heating nearby parts to the flow temperature of the brazing material. Hence, it is possible to comply with the prohibition against overheating nearby instrumentation leads. Also, in laser brazing, unlike in furnace brazing, it is possible to exert control over the thermal energy to such a high degree that it becomes possible to braze the thermocouples to the ring without burning through the thin tantalum sheaths on the thermocouples.

The brazing material used in the laser brazing process is a titanium-boron paste. This brazing material can with-stand use at temperatures up to about 1,400°C. In thermal-cycling tests performed thus far, no debonding between the rings and thermocouples has been observed. Emissivity coatings about 0.001 in. (≈0.025 mm) thick applied to the interior surfaces of the rings have been found to improve the performance of the BBS sensors by raising the apparent emissivities of the rings. In thermal-cycling tests, the coatings were found to adhere well to the rings.

Wrap-Around Out-the-Window Sensor Fusion System

Lyndon B. Johnson Space Center, Houston, Texas

The Advanced Cockpit Evaluation System (ACES) includes communication, computing, and display subsystems, mounted in a van, that synthesize out-the-window views to approximate the views of the outside world as it would be seen from the cockpit of a crewed spacecraft, aircraft, or remote control of a ground vehicle or UAV (unmanned aerial vehicle). The system includes five flat-panel display units arranged approximately in a semicircle around an operator, like cockpit windows. The scene displayed on each panel represents the view through the corresponding cockpit window. Each display unit is driven by a personal computer equipped with a video-capture card that accepts live input from any of a variety of sensors (typically, visible and/or infrared video cameras).

Software running in the computers blends the live video images with synthetic images that could be generated, for example, from heads-up-display outputs, waypoints, corridors, or from satellite photographs of the same geographic region. Data from a Global Positioning System receiver and an inertial navigation system aboard the remote vehicle are used by the ACES software to keep the synthetic and live views in registration. If the live image were to fail, the synthetic scenes could still be displayed to maintain situational awareness.

Wide-Range Temperature Sensors With High-Level Pulse Train Output

John H. Glenn Research Center, Cleveland, Ohio

Two types of temperature sensors have been developed for wide-range temperature applications. The two sensors measure temperature in the range of –190 to +200 °C and utilize a thin-film platinum RTD (resistance temperature detector) as the temperature-sensing element. Other parts used in the fabrication of these sensors include NPO (negative-positive-zero) type ceramic capacitors for timing, thermally-stable film or wire-wound resistors, and high-temperature circuit boards and solder.

The first type of temperature sensor is a relaxation oscillator circuit using an SOI (silicon-on-insulator) operational amplifier as a comparator. The output is a pulse train with a period that is roughly proportional to the temperature being measured. The voltage level of the pulse train is high-level, for example 10 V. The high-level output makes the sensor less sensitive to noise or electromagnetic interference. The output can be read by a frequency or period meter and then converted into a temperature reading.

The second type of temperature sensor is made up of various types of multivibrator circuits using an SOI type 555 timer and the passive components mentioned above. Three configurations have been developed that were