Technology Focus: Sensors

Active and Passive Hybrid Sensor

The sensor acquires active and passive measurements to map ocean winds.

Goddard Space Flight Center, Greenbelt, Maryland

A hybrid ocean wind sensor (HOWS) can map ocean vector wind in low to hurricane-level winds, and non-precipitating and precipitating conditions. It can acquire active and passive measurements through a single aperture at two wavelengths, two polarizations, and multiple incidence angles. Its low profile, compact geometry, and low power consumption permits installation on aircraft platforms, including high-altitude unmanned aerial vehicles (UAVs).

The primary innovation enabling both active and passive measurements through a single system, while allowing for beam scanning, is the separation of transmit and receive beam synthesis process. With this approach, the antenna comprises several linear arrays, each with its own transceiver. The key components to this system are the transceiver, antenna, and multichannel digital receiver subsystems. The antenna design was described in "Low-Profile, Dual-Wavelength, Dual-Polarized Antenna" (GSC-15706), *NASA Tech Briefs*, Vol. 34, No. 1 (January 2010), p. 26.

A novel capability of this design is that each transceiver has an internal calibration loop that is interconnected with adjacent transceivers. This allows the relative phase of the waveform generators and LO (local oscillator) signals to be directly measured. With environmental changes, the relative phase distribution can change, which potentially degrades the antenna pattern due to phase errors and biases. Direct measurement of the LO phase and transmit phase alleviates this problem.

The system will operate at C and Ku-bands with beams at 30° and 40° incidence. The retrieval processor will use the active and passive measurements to map the ocean vector wind with a pixel resolution of approximately 2×2 km. With a more than 100-MHz bandwidth, it can operate in a high-resolution mode to provide very high-resolution imagery.

The system design operates in two separate modes: transmission and reception. During transmission, the phase and amplitude distribution of the array are controlled through the transceivers. Every *n*-th transmission cycle, the internal calibration circuits are used to measure the relative phase and amplitude differences introduced by the circuits themselves so that these offsets can be accounted for in forming the transmitted beam pattern. During reception, the receivers amplify and down-convert the receive backscatter and observed scene emission. The digitized signals are sent to the digital receiver subsystem, which applies phase and amplitude weightings to form the desired receive antenna pattern. The receiver circuit also contains a Dicke switch and noise diode circuit to implement Dicke-Hach mode receiver. The bandwidth of the antenna and receiver paths is large enough that the passive signal is filtered from the active signal so that both may be measured simultaneously.

HOWS is useful for monitoring surface winds during severe ocean storms. Search and rescue missions can benefit from both the imaging capabilities of this system as well as the retrieved products. Although this system is focused on ocean vector winds, its ability to collect dual-wavelength, dual-polarized active and passive measurements and image over a range of incidence angles in a conically scanning or fixed pointing mode has broad use for remote sensing and surveillance purposes. Potential uses other than wind applications include mapping land, snow, and ice features. Its capabilities also can aid in target or scene classification, as well as high-resolution imaging from airborne or ground surveillance applications.

This work was done by James R. Carswell of Remote Sensing Solutions, Inc. for Goddard Space Flight Center. Further information is contained in a TSP (see page 1). GSC-15707-1

Quick-Response Thermal Actuator for Use as a Heat Switch

Thermal actuators have many applications in aerospace, automotive, and energy storage.

NASA's Jet Propulsion Laboratory, Pasadena, California

This work improves the performance of a heat switch, or a thermal actuator, by delivering heat to the actuator in a more efficient manner. The method uses a heat pipe as the plunger or plug instead of just using a solid piece of metal. The heat pipe could be one tailored for fast transient thermal response.

A heat switch/thermal actuator works by using the expansion of a paraffin wax as it melts as a means of moving a piston/plug/plunger to perform a function. Typically, this function is to close a small gap and increase heat transfer across a boundary, but it also could be used to move a latch. These devices are usually slow, and the stroke of the piston/plunger is very small.

A device of this kind could replace the need for heat switches that require power to operate on a spacecraft in a safe-mode condition. This device would require no power to operate except for the waste heat of the device it is protecting. It may also be used as an energy-harvesting device by using waste heat to move a piston back and forth much faster than could be accomplished otherwise.

The device uses waste heat that flows through the plunger pedestal into the heat pipe and out towards the paraffin wax to cause actuation of the plunger due to phase change of the wax from solid to liquid. For use as a heat switch on a spacecraft, multiple devices may be permanently attached to a radiator via the plunger, and the body attached to a rigid structure. During a safe mode orbital maneuver if the radiator should face the Sun, the device will then push off the radiator, disengaging it from the spacecraft bus. The device could be mounted as a pull device as well, pulling the radiator closer to the thermal bus to increase the thermal conductance between bus and radiator.

Thermal actuators of this kind are somewhat common, except that this device uses a heat pipe as a plunger, so this is an improvement. Most other devices require heat transfer through the wax chamber body, not through the plunger itself. This device will have three distinct advantages over other versions:

- Fast actuation due to quick heat transfer.
- Large stroke and stroke velocity.
- Mass savings as there is no need for thick metallic sections for conducting heat.

The actuation stroke could be designed to be large and quick enough to be used as an energy-harvesting device, converting waste heat into mechanical energy.

This work was done by Juan Cepeda-Rizo of Caltech for NASA's Jet Propulsion Laboratory. Further information is contained in a TSP (see page 1). NPO-46679

System for Hydrogen Sensing

John H. Glenn Research Center, Cleveland, Ohio

A low-power, wireless gas-sensing system is designed to safeguard the apparatus to which it is attached, as well as associated personnel. It also ensures the efficiency and operational integrity of the hydrogen-powered apparatus. This sensing system can be operated with lower power consumption (less than 30 nanowatts), but still has a fast response. The detecting signal can be wirelessly transmitted to remote locations, or can be posted on the Web. This system can also be operated by harvesting energy.

The electrical signal response of the sensor to the hydrogen gas can be amplified by a differential detection interface (DDI) connected to the low-power gas sensor. A microcontroller is connected and programmed to process the electrical signal, which is then wirelessly transmitted. The system also includes a central monitoring station with a wireless receiver configured to receive the sensor data signal from the wireless transmitter of the sensor device. The system further includes a power source with at least one vibrational energy harvester, solar energy harvester, and a battery.

This work was done by Jenshan Lin, David P. Norton, Stephen J. Pearton, and Fan Ren of the University of Florida 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: Steve Fedor, Mail Stop 4–8, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-18484-1.

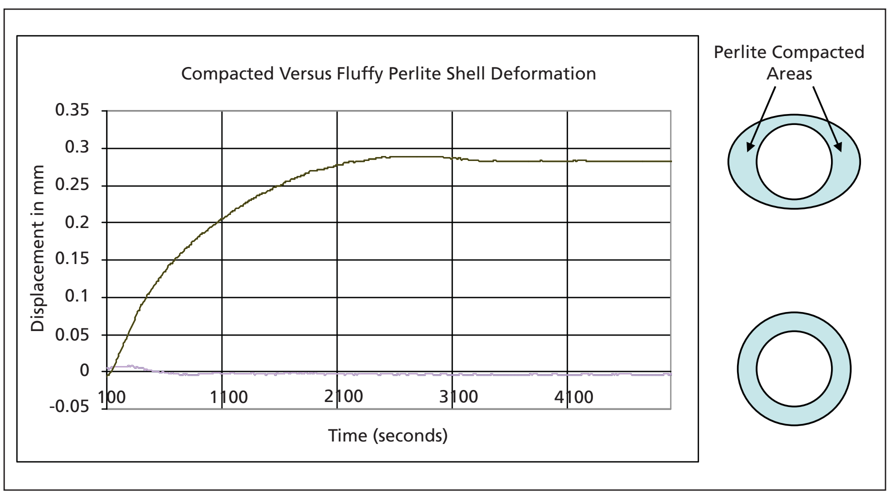
Method for Detecting Perlite Compaction in Large Cryogenic Tanks

This technique could be applied by companies using rail cars and trucks to deliver liquid cryogens.

John F. Kennedy Space Center, Florida

Perlite is the most typical insulating powder used to separate the inner and outer shells of cryogenic tanks. The inner tank holds the low-temperature commodity, while the outer shell is exposed to the ambient temperature. Perlite minimizes radiative energy transfer between the two tanks. Being a powder, perlite will settle over time, leading to the danger of transferring any loads from the inner shell to the outer shell. This can cause deformation of the outer shell, leading to damaged internal fittings.

The method proposed is to place strain or displacement sensors on several locations of the outer shell. Loads induced on the shell by the expanding inner shell and perlite would be monitored, providing an indication of the location and degree of compaction.



Strain/Displacement Measurements for the detection of perlite compaction. The curves show the differential motion of the outer tank as the inner tank thermally expanded with fluffy perlite (lower curve) and compacted perlite (upper curve).