Impact-Locator Sensor Panels
Panels can be electronically daisy-chained and assembled to cover large areas.

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Electronic sensor systems for detecting and locating impacts of rapidly moving particles on spacecraft have been invented. Systems of this type could also be useful on Earth in settings in which the occurrence of impacts and/or the locations of impacts are not immediately obvious and there are requirements to detect and quickly locate impacts to prevent or minimize damage. For example, occupants of a military vehicle could know immediately that someone was shooting at it and which side of the vehicle was taking fire. For another example, commercial transportation companies using these systems for remote monitoring of valuable cargo could know when and from what
direction impacts were jeopardizing the cargo, whether the impacts were from hailstones, burglary tools, vehicular collisions, or firearms.

The building blocks of a system of this type are sensor panels. Each panel is a thin multilayer structure wherein one of the layers is a commercially available film of poly(vinylidene fluoride) [PVDF], which is a piezoelectric polymer. Because of its piezoelectricity, the film generates an electric potential at the place and time of an impact. Electronic circuitry that is part of the multilayer structure (as described below) detects this potential, thereby detecting the impact. The panels are constructed identically and can have any convenient dimensions; a width of 16 in. (≈0.4 m) and a length of 24 in. (≈0.6 m) are typical. Multiple panels can be joined to cover an area as large as required.

The electronic circuitry includes electrodes and conductive traces, on the surfaces of the PVDF film (see figure), that subdivide the panel into pixels within which impacts can be located. Typical pixel dimensions are 2 by 2 in. (about 5 cm), but pixels could just as well be made larger or smaller as needed. Optionally, the PVDF film could also be scribed into pixels to enhance spatial resolution.

The conductive traces connect the pixel electrodes to an integrated circuit (typically either a field-programmable gate array or an application-specific integrated circuit) on the panel. The integrated circuit detects any impact signals, determines the pixel locations of the signals, determines the pixel location of the first signal, and stores these pixel locations in registers. The integrated circuit then generates a data-transmission word that includes all the pixel impact locations, the first-impact pixel location, and an address unique to the panel. The word is transmitted to an external digital-processor-and-display unit, which could be, for example, a laptop computer. The transmission is fundamentally a notice to the external unit that an impact has been detected at the noted location on the noted panel.

Each panel is connected to external circuits via only two wires, which serve for transmission of both data and power. Wires can be daisy-chained through as many panels as desired, so that only two wires are needed to make the external connections to an assembly of any number of panels. It is not necessary to supply power to operate the piezoelectric transducers; the only power that must be supplied is that required for operation of the integrated circuits on the panels and of the external digital-processor-and-display unit. Hence, the overall power demand of the system is relatively small.

This work was done by Eric L. Christiansen of Johnson Space Center and Terry Byers and Frank Gibbons of Lockheed Martin Corp. Further information is contained in a TSP (see page 1).

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 Patent Counsel, Johnson Space Center, (281) 483-0837. Refer to MSC-24263-1.