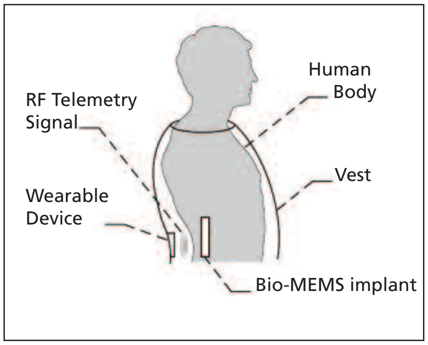


Relative location of the **Bio-MEMS** implantable sensor and the garment integrated wearable device.

cessing circuits. During operation, this external unit would be positioned in proximity to the implanted or ingested unit to provide for near-field, inductive coupling between the loop antennas, which we have as the primary and secondary windings of an electrical transformer.

In the first of two parts of an operational sequence, the loop antenna in the sensor unit would receive a pulse of RF energy transmitted via the loop antenna in the external powering/interrogating unit. This pulse would charge the capacitor in the pressure sensor and thereby excite decaying oscillations in the resonant circuit constituted by the sensor capacitance and the loop inductance. In the second part of the operational sequence, some of the power of the decaying oscillations would be coupled from the loop in the sensor unit to the loop in the interrogating unit. The frequency of the decaying oscillation would be the resonance frequency, which would vary with the sensor capacitance and, hence, with the sensed pressure. Therefore, the frequency of the signal received by the external unit during the second part of the operational sequence would be measured, and any change in the frequency from a previous value would be taken as an indication of a change in pressure.

The proposed system would offer several advantages over prior invasive physiological-monitoring sensor systems:

- The sensor materials (high-resistivity silicon and gold) would not react with body fluids.
- High-resistivity silicon would cause less attenuation of signals in comparison with other substrate materials.
- The multi-loop antenna in the external unit could be fabricated inexpensively as a printed circuit.
- The inductive-powering scheme eliminates the need for a battery in or alongside the sensor unit, thereby reducing the potential for leakage of toxic material into the patient's body.
- Because the sensor circuit would operate only when interrogated by the external unit, power dissipation in the patient and the consequent local heating and discomfort would be minimized and the operational lifetime of the sensor unit would be extended.
- Feed-through wires for power and telemetry, used in some other systems, would be eliminated, thereby greatly enhancing the patient's mobility and reducing the risk of infection.

This work was done by Rainee N. Simons, Félix A. Miranda, and Jeffrey D. Wilson of Glenn Research Center and Renita E. Simons of John Carroll University. 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-18222-1.

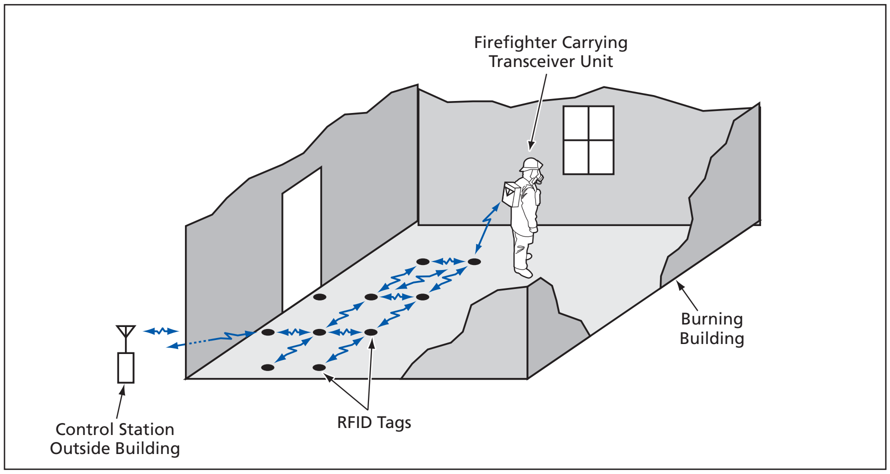
Electronic Escape Trails for Firefighters

Routes would be traced among RFID tags equipped with sensors showing temperatures.

Ames Research Center, Moffett Field, California

A proposed wireless-communication and data-processing system would exploit recent advances in radio-frequency identification devices (RFIDs) and software to establish information lifelines between firefighters in a burning building and a fire chief at a control station near but outside the building. The system would enable identification of trails that firefighters and others could follow to escape from the building, including identification of new trails should previously established trails become blocked.

The system would include a transceiver unit and a computer at the control station, portable transceiver units carried by the firefighters in the building, and RFID tags that the firefighters would place at multiple locations as they move into and through the building (see figure). Each RFID tag, having a size of the order of a few centimeters, would include at least standard RFID circuitry and possibly sensors for measuring such other relevant environmental parameters as temperature, levels of light and sound, concentration of oxygen, concentrations of hazardous chemicals in smoke, and/or levels of nuclear radiation. The RFID tags would be activated and interrogated by the firefighters' and control-station transceivers. Preferably, RFID tags would be config-



RFID Tags would be dropped by a firefighter at numerous locations while moving through a burning building. The tags would serve as waypoint marks that would be interrogated by an RFID transceiver unit carried by the firefighter. The RFID tags would also relay sensory and position data to the control station outside the building ured to communicate with each other and with the firefighters' units and the control station in an ordered sequence, with built-in redundancy.

In a typical scenario, as firefighters moved through a building, they would scatter many RFID tags into smoke-obscured areas by use of a compressed-air gun. Alternatively or in addition, they would mark escape trails by dropping RFID tags at such points of interest as mantraps, hot spots, and trail waypoints. The RFID tags could be of different types, operating at different frequencies to identify their functions, and possibly responding by emitting audible beeps when activated by signals transmitted by transceiver units carried by nearby firefighters.

It would be necessary to distribute the RFID tags densely enough to ensure reliable communication. A typical RFID of a type now commercially available is a passive device that operates at a carrier frequency of about 433 MHz, and can communicate with another such RFID, using one of several standard serial digital-data-communication protocols, over a distance of as much as about 7 m. In the proposed system, supplementary units could be dispersed along with the RFID tags to increase signal power sufficiently to ensure communication with firefighter's transceiver units and/or with the control station, which would otherwise be out of range.

In a typical application of a basic version of the system, inexpensive RFID tags having limited range would be dispersed densely enough to enable a firefighter to go from one waypoint to another. The tags could include temperature sensors to alert firefighters to dangerously hot waypoints. If more than one tag were dropped within communication range, a tag indicating a safe temperature could become an alternate waypoint for a route out of the building.

In a more advanced version of the system, the RFID tags could communicate with each other via local daisy chains, relaying data on hot spots to the fire chief at the control station. The dispersed RFID tags could also constitute elements of an indirect positioning system. If the system were designed to measure signal-propagation delays among the various tags and firefighters' transceivers, then the relative positions of the tags and the firefighters could be computed from these delays. The software for computing the relative positions could be integrated into a more comprehensive computer program that would correlate the positions with a three-dimensional map or graphical display of the building. In that case, locations of firefighters, hot spots, and mantraps, could all be presented on a single building display that would assist the fire chief in planning safe escape routes.

This work was done by Charles Jorgensen and John Schipper of Ames Research Center and Bradley Betts of Computer Science Corp.

This invention is owned by NASA and a patent application has been filed. Inquiries concerning rights for the commercial use of this invention should be addressed to the Ames Technology Partnerships Division at (650) 604-2954. Refer to ARC-15487-1.