WANTED: Tougher antiterror sentries

Federal funding spurs R&D for sensors to detect bioagents, war chemicals, explosives, and radiation.

BY JIM STROTHMAN

The Free World knew terrorists planned biological attacks even before those unsettling days last September, when everyday mail carriers delivered letters containing anthrax to U.S. Senate and New York news media offices.

And although investigators appear convinced a U.S. citizen not involved with the 11 Sept. terrorist attacks mailed the anthrax, the letters triggered a torrent of new government money to develop advanced sensor-based instrumentation to guard the precious air we breathe and the water we drink.

Considering the possibilities, it's easy to understand why improved guardian instruments are urgently needed to assure utilities, government and business offices, industrial plants, and society in general are safer. For sensor and analytical instrument makers, it also means a rapidly growing business opportunity.

Besides anthrax, previously developed by Iraqi and USSR bioweapon programs, there are 27 other bacterial agents the U.S. Department of Justice lists that can kill humans—some in holocaust proportions.

"High-ranked" potentials include bubonic and pneumonic plague, which terrorists could distribute via fleas or aerosols, and Marburg

SensorTech

Chemical detection muscle grows

Compared with bioagents, progress detecting chemical agents is much further along.

John Barnes, ABB vice president and general manager of analytical process analytics subcontracts, said the government is interested in a variation of ABB's Questor Mass Spectrometer. Built to monitor petrochemical and industrial processes, one instrument monitors up to 40 agents in real time, Barnes said. "We're proposing [to the U.S. government] a sample system that can monitor up to 128 sample points on the same analyzer," he said. "We see it being used to monitor the environment in a building, such as embassies, the Senate, and other government office buildings—even malls and subways." Barnes said the mass spectrometer primarily monitors air, but users could also adapt it for water.

Variation of this ABB Questor Mass Spectrometer may be used to monitor environment government office buildings or even malls and subways.

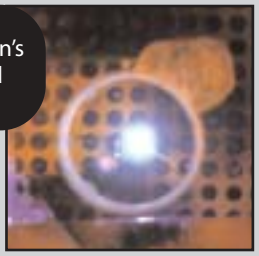
"The government is concerned about nerve gas, blister agents, blood agents, and we can detect all of those with our mass spectrometer," Barnes said. ABB's spec sheet says the analyzer detects gases or vapors with molecular weights ranging from 1 to 250 atomic mass units. Its lower detection limit is 10 parts per million with a Faraday detector or 10 parts per billion with a dual Faraday/multiplier detector.

Another ABB instrument, a Fourier transform infrared (FTIR) spectrometer, could detect chemical agents at considerable distances, he said. At first, ABB developed the FTIR instruments to monitor atmospheric pollution emissions at plastics, petroleum, chemical, and pharmaceutical plants.

Lawrence Livermore National Laboratories also developed a portable mass spectrometer it claims "provides laboratory quality analysis of complex simple matrices in the field" and prevents loss of samples that could deteriorate if transported to a remote lab. The 65-pound Gas Chromatograph-Quadrupole Mass Spectrometer can also be field serviced.

FLUORESCENCE-BASED SENSOR

Scientists at the U.S. Department of Energy's Ames (Iowa) Laboratory and the University of Michigan (UoM) demonstrated a novel, fluorescence-based chemical sensor its developers claim is more compact, more versatile, and less expensive than previous technology.



Ames Laboratory/ University of Michigan's fluorescence-based chemical sensor.

Ames senior physicist Joseph Shinar said the sensor could monitor oxygen, inorganic gases, volatile organic compounds, biochemical compounds, and biological organisms. Potential applications include detecting pathogens and other warfare agents, point-of-care medical testing, and high-throughput drug discovery. The sensor grew out of basic UoM research studying photophysics of luminescent organic thin films and organic light-emitting devices, which luminesce when a voltage is applied.

"Integration and miniaturization of fluorescence-based chemical sensors is highly desirable. It is the first step toward the development of fluorescence-based sensor arrays that could be used for analysis of living cells and organisms and biochemical compounds," said Shinar.

Fluorescence-based chemical sensing devices, in general, include three components: a light source that excites the sensing element; the sensing element that produces the fluorescence (usually a fluorescent dye used to tag the sample under investigation); and a photodetector that responds to the sensor's fluorescence.

Conventional sensors use lasers or inorganic light-emitting devices as light sources, but they present problems: Not only are they expensive, but they are also bulky and cannot integrate with other sensor components.

FINDS BURIED EXPLOSIVES

A computer program developed at NASA's Jet Propulsion Laboratory in Pasadena, Calif., provides real-time sensor fusion and display capabilities for detecting buried mines and other explosives. Called U-Hunter, it finds buried, unexploded ordnance and explosive waste via magnetic and electromagnetic sensors. U-Hunter uses data from a variety of sensors, including magnetometers, synthetic aperture radar systems, and pulsed eddy current sensors. The software's data enhancement subsystem preprocesses and conditions input data for analysis and an analysis engine subsystem. A visualization subsystem generates displays showing geophysical data as 3-D surface models and 2-D color maps. Future U-Hunter developments include extending data display capabilities to produce data overlays, aerial photography, and geophysical data.

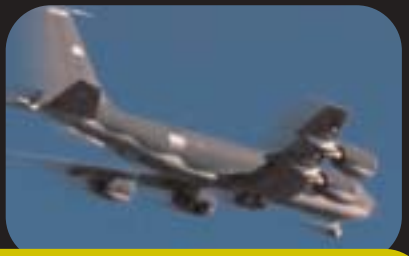
virus, which can lead to internal and external bleeding in five days. A former Soviet Union biological program turned that virus into a weapon in aerosol form.

Venezuelan equine encephalitis brings on sudden illness, with spiking fevers. The U.S. and USSR turned it into a weapon in liquid and dry aerosol forms. Yellow fever, distributed by mosquitoes, kills up to 20% of those infected.

Saxitoxin, contaminated shellfish, is highly toxic in aerosol form. Yet another, Q fever, is not the most deadly agent but could be one of the most effective because of its ability to spread easily through the air and cause widespread, debilitating illness.

Biological war agents can be effective in low doses, so detection systems must be highly sensitive. They must also discriminate between biological agents and normal particulates in air or water, such as dust, dirt, and pollen. Finally, speed is of the essence. They must report danger fast—in time to save lives.

Biodetection systems typically consist of four components: a trigger/cue, which first



Joint biological point detection systems (at left), which earned a $23.4 million initial funding contract, are designed to automatically detect and identify very low levels of biowarfare agents in the air, then trigger local and remote warning systems.

Source: Photo courtesy of Battelle

Radiation detector market glows

Spurred by concern that terrorists may have nuclear weapons, federal agencies are investing in better radiation detectors. For example, Lawrence Livermore National Laboratory (LLNL) scientists working with Lawrence Berkeley National Laboratory engineers developed a mobile, handheld, mechanically cooled germanium radiation spectrometer that detects signature gamma rays from radioactive materials.

Called Cryo3, it has clear applications for homeland security, said LLNL physicist John Becker. It determines types of radioactive materials no matter where they might

Livermore and Berkeley's 10-lb portable Cryo3 radiation detector.

be located, he said. It detects the presence of hard X and gamma radiation and provides data on the quantities.

A handheld gamma ray spectrometer called Radsmart, which was developed by Scientific Applications International Corp., is a fully integrated, rugged, lightweight, nuclear materials identification system designed for ease of use in many diverse applications. These include

Radsmart handheld gamma ray spectrometer.

emergency response, environmental monitoring, regulatory compliance, and waste evaluation.

Centrally located keys and cursor control on Radsmart's handle allow for one-handed operations. The instrument has a high-resolution LCD display that provides graphical spectra, bar chart, and alphanumeric data. It includes adjustable settings for dose rates, alarm thresholds, and low battery alert. A user enables communication with laptop or PC via wireless IrDA or RS-232 serial ports.

determines whether there's a change in the sensor's particulate background; a collector, which separates the new particle from normal particulates; a detector, which determines whether the foreign particle is biological in origin; and an identifier, which reports the specific type of biological agent collected.

While some biodetection systems are commercially available, most are costly and respond to only a small number of agents. Improved versions are in the research and early development stages. Because bioagents involve complex molecules, biodetection systems are much more complex than systems designed to detect chemical agents.

"In fact, the need for high-efficiency collection and concentration of the sample, high sensitivities, and high selectivities make all chemical detectors in their current form unusable for biological agent detection," said a December 2001 U.S. Department of Justice report.

DETECTOR EARNS $23.4M CONTRACT

Fueled by federal funding, detection technology today marches at a quick-time pace. In February, the U.S. Army Robert Morris Acquisition Center in Edgewood, Md., awarded Advanced Technology Products Inc.'s Intellitec division $23.4 million in initial funding to begin producing joint biological point detection systems (JBPDS).

Two plants will perform the work. One will be at Intellitec's DeLand, Fla., plant and the other at the Columbus, Ohio, facilities of team partner Battelle, a nonprofit laboratory advancing technologies. MIT's Lincoln Laboratory largely developed the JBPDS software.

JBPDS automatically detects and identifies very low levels of biowarfare agents in the air, triggers local and remote warning systems, then reports threat information over standard communications systems. It detects up to 10 agents at once while operating on land, light-armored vehicles, and ships.

According to an Intellitec/Battelle spec sheet, the trigger/detector uses laser-induced fluorescence to evaluate the atmospheric aerosol background. Florescence technology uses light, typically in the ultraviolet region, to excite molecular components. When an excited component spontaneously reverts to an unexcited state, it emits a light pattern that specifically identifies it.

When the algorithm detects something suspicious, the collector/concentrator automatically samples hundreds of liters per minute and provides a few milliliters of liquid sample containing the suspected bioagent.

Using handheld assays, similar to pregnancy tests, JBPDS then tests the sample for specific biowarfare agents. Positive tests trigger alarms.

Separately, MesoSystems Technology Inc. developed a handheld biosampling device, the Biocapture BT-500 Air Sampler. It uses that company's BioVIC aerosol collector, a front-end air sampler that captures large numbers of microbes in an aqueous sample. A whole cell rapid detection, nucleic acid, or other liquid-based sensor system analyzes the sample.

Researchers are also developing sensors that would use live cells to detect biological agents. For example, when a heart or liver cell is under invasion, it might release protein or change in some other way sensors can detect. One of the live-cell sensors' many challenges, however, is to keep the cells alive.

'STANDOFF' DETECTION

Also under development are "standoff" technologies that detect and identify biological agents at a distance, far away from a detection sensor's location. Typically, they use a bright light source, usually laser light detecting and ranging (Lidar) technology.

Lidar systems transmit a short laser pulse through the atmosphere, then a portion reflects back from particles such as molecules, aerosols, clouds, or dust. Some Lidars can "see" bioagent particles up to 30 miles away.

According to sources, another remote sensing technology, called a "DNA sequencer," is under development to specifically identify bacteria types in the air. The California National Guard, which like all guard units has a rapid response team to defend against biological or chemical warfare acts, is reportedly testing the technology.

$90M PROGRAM TO GUARD WATER

Last March, the U.S. Environmental Protection Agency launched a nearly $90 million national effort to protect drinking water and wastewater utilities as quickly as possible.

The largest drinking water systems, those regularly serving more than 100,000 people, will be eligible to apply for grants of up to $115,000 to help complete vulnerability assessments and other security planning.

The assessments will identify potential vulnerabilities and suggest security upgrades. ST