BASIS Counters Airborne Bioterrorism

ONE of the most frightening weapons in a terrorist's potential arsenal is the airborne release of deadly microbes such as those that cause anthrax or smallpox. In most cases, the prognosis for victims from such an attack depends on how quickly antibiotics, vaccines, or other medical treatment can be administered. And treatment options can't be determined until the pathogen has been accurately identified. A quick turnaround time can thus save lives.

The job of countering bioterrorism now has a potent weapon in BASIS, the Biological Aerosol Sentry and Information System, which won a 2003 R&D 100 Award. Designed by a team of researchers from Lawrence Livermore and Los Alamos national laboratories, BASIS is a detect-to-treat technology. That is, it's designed to detect and locate an aerosol release of a biothreat organism quickly and accurately enough for an effective response. For example, the survival rate from exposure to the anthrax bacterium is high when antibiotic therapy can be administered before symptoms appear, but after symptoms manifest, the survival rate diminishes significantly.

BASIS collects air samples at well-defined locations and at specified time intervals to help determine both the time and place of the release. Its mobile field laboratory rapidly tests samples for evidence of potentially lethal bacteria and viruses. Safeguards built into the system ensure a sample's integrity.

Aerosol releases of bacteria or viruses tend to quickly become diluted as their distance from the release site increases. BASIS is designed with extremely high sensitivity for detecting the most likely threat pathogens. By identifying a pathogen within hours, BASIS allows medical response units to mobilize while law-enforcement agencies begin the search for terrorists.

Key Goal Is No False Alarms

According to Dennis Imbro, the principal investigator for Livermore's BASIS effort, false alarms have the potential to cause immense disruptions and panic among civilians. Therefore, a primary goal in developing BASIS was to achieve a virtually zero rate of false-positive detections. To date, no false-positive events have been generated by deployed systems.

Livermore's BASIS team (left to right): Mark Wagner, Evan Skowronski, Cheryl Strout, Paula McCready, Julie Avila, Kris Montgomery, Linda Danganan, Linda Ott, Jackie Cofield, Patsy Gilbert, Paul Sargis, Virginia Montgomery, Tom Slezak, Dennis Imbro, Robert Johnson, Rich Parker, and Bruce Henderer.

BASIS is designed for indoor or outdoor use at high-visibility events or around likely terrorist targets. In 2001, the technology was successfully tested with live microbes inside a sealed chamber at the U.S. Army's Dugway Proving Ground. BASIS was first deployed in the month following the September 11 terrorist attacks. It was also deployed in Salt Lake City, Utah, for the 2002 Winter Olympic Games. During the Olympics, BASIS operated for 35 days at sports venues, urban areas, and transportation hubs. In all, 2,200 air samples were analyzed.

BASIS was later deployed in Albuquerque during the summer of 2002 and in New York City for the first anniversary of 9/11. BioWatch, a derivative of BASIS, is now deployed in major cities nationwide under the auspices of the U.S. Department of Homeland Security. BioWatch features elements of the BASIS technology but, instead of a mobile laboratory, uses laboratories that are part of the federal Laboratory Response Network operated by the Centers for Disease Control and Prevention (CDC).

Field Lab Tests for Pathogens

BASIS includes three major components. Aerosol collection hardware continually collects, time-stamps, and stores samples. A mobile field laboratory analyzes DNA from the samples and can identify and characterize a threat organism in less than half a day with a virtually zero false-alarm rate. Software designed by the BASIS team controls and integrates the operations.

The air samplers, called distributed sampling units (DSUs), suction air through filters that have microscopic-size pores and collect any regional microbes onto the filters' surface. DSUs can be deployed indoors, for example, at sports arenas or airline terminals or within heating and air-conditioning systems, and outdoors at airport drop-off areas, urban commercial centers, bridges, tunnels—any area with a significant threat of bioterrorism. DSUs are locked and password-protected to prevent unauthorized access and to guarantee the integrity of filters.

A semi-automated mobile field laboratory analyzes each filter, searching for DNA from target pathogens—those organisms identified by the CDC as high-priority threat agents. Inside the field lab, DNA is amplified via the polymerase chain reaction (PCR), a quick, reliable method for detecting DNA of specific microbes. Should a target pathogen be present, PCR amplifies its DNA while ignoring DNA from other microbes.

To confirm a positive finding and identification of the organism, the laboratory analyzes the target sample a second time. The characterization is so precise that a microbe can often be identified down to the strain level. The suspect DNA can then be sequenced to determine if genetic engineering has, for example, increased a microbe's virulence or has in any way engendered drug resistance.

When a positive identification has been confirmed, the field lab immediately notifies the appropriate response agencies. The entire process—from collecting samples to identifying a threat organism—typically requires only 8 to 10 hours.

BASIS features air samplers that suction air through filters and collect any airborne microbes onto a filter's surface. Above, the bar code of a single filter is scanned.

The BASIS software package runs on a standard laptop computer. The software is divided into two modules: the BASIS Operations Center (BOC) control package and the Sample Management System (SMS) filter-tracking package. The SMS uses bar codes to track filters at every point of the operation—from preparing a filter to processing the final results in the field laboratory. Each DSU can receive operational parameters via shielded cable, radio frequency, or cellular modem and can transmit them in real time to a BOC laptop.

BASIS is just one of a host of counterterrorism technologies and systems being developed at the national laboratories. Its success demonstrates that Livermore researchers are on the right track in the fight against terrorism.

—Arnie Heller

Key Words: BASIS (Biological Aerosol Sentry and Information System), BioWatch, bioterrorism, homeland security, polymerase chain reaction (PCR), R&D 100 Award.

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