Assessing the Threat of Biological Terrorism

As part of its national security mission, Lawrence Livermore conducts research directed at protecting against a broad range of methods terrorists might use in an attack against the U.S. Among the most potentially devastating scenarios is the dispersion of pathogenic biological organisms in densely populated areas. Biological warfare agents might be attractive to terrorists because the microbes can inflict high mortality rates, yet exposure cannot be detected by our physical senses. The organisms' ease of dissemination combined with the often delayed onset of symptoms after exposure would allow a terrorist to cause a high-consequence event with minimal risk of being detected.

Although several types of bioorganisms have the potential to kill or sicken humans or livestock, some are more difficult than others to produce for a large-scale attack. The Department of Homeland Security (DHS) is interested in knowing which microbes would be more accessible and easier for a terrorist to grow and disperse. Federal officials also want to develop tools to track the spread of a disease geographically over time and to devise better methods to distinguish a natural disease outbreak from an intentional release.

Coordinating Biodefense Knowledge

In 2004, DHS established the Biodefense Knowledge Center (BKC) at Livermore to coordinate biothreat assessments and biodefense information. The center is part of the Nonproliferation, Homeland and International Security (NHI) Directorate's Threat Awareness Program, which includes other modeling and assessment activities, including system studies and epidemiological and food-process modeling efforts. In the BKC, teams of scientists and engineers matrixed from across the Laboratory coordinate the development of authoritative biothreat assessments. This effort often includes input from external subject-matter experts from industry, academia, government institutions, and other national laboratories. Collaborators also include analysts and experts in

President George W. Bush signed the Project BioShield Act of 2004 on July 21, 2004.

information technology, bioinformatics, and computer simulation from DHS centers located at the University of Minnesota, University of Southern California, and Texas A&M University.

According to BKC director Tom Bates, "The BKC provides decision makers with rapid access to vetted technical information so they can better understand current and emerging bioterrorism threats." The infrastructure includes a 24-hour technical support line to DHS, in-depth threat analyses, awareness bulletins focused on potential nefarious uses of biotechnologies, and information management tools that provide unique knowledge discovery capabilities.

Threat Awareness and Characterization

DHS is concerned about agents that may have been involved in foreign state-sponsored bioweapon programs: *Bacillus anthracis* (anthrax), *Yersinia pestis* (plague), *Francisella tularensis* (tularemia), *Burkholderia* species (glanders and melioidosis), *Brucella* species (brucellosis), *Variola major* (smallpox), and *Clostridium botulinum* (botulism). As part of the Project BioShield Act of 2004, DHS is responsible for determining potential threat scenarios in which these agents and others could be used in attacks against the U.S. The BKC has conducted a series of threat assessments to consider the technical and operational feasibility of launching an attack using various biological agents. The assessments also estimate the number of people who could be exposed in a hypothetical attack.

A major goal of developing plausible bioterrorist scenarios is to help the Department of Health and Human Services prioritize countermeasure procurements, such as acquiring and stockpiling vaccines and antibiotics. "These assessments identify knowledge gaps that reduce our ability to accurately prepare countermeasures against a biological attack," says Livermore molecular biologist Erik Burnett.

Results and supporting research from the threat assessments are entered into a Web-based document management system that the BKC has developed to serve as a national biodefense library. The secure system will allow the biodefense community to view and update reference materials, store reports, and provide live feeds to other sources. The library will also help DHS's National Bioforensics Analysis Center in its effort to build a microbial forensics capability. (See *S&TR*, September 2006, pp. 13–19.)

Determining Threat Impact

Because bioterrorist events have been rare, statistical characterization of risks based on historical data alone is often inadequate to develop countermeasures for similar events in the future. Therefore, the systems analysis team in Livermore's Threat Awareness Program conducts system studies that examine the interplay between threats and defensive responses over time, from preattack through postattack consequence management. The team's analysis includes factors such as the type of biological agent used, how it is dispersed, the number of people exposed, and the potential human health and economic impacts. The goal of the studies is to recommend countermeasures to prevent or respond to such attacks.

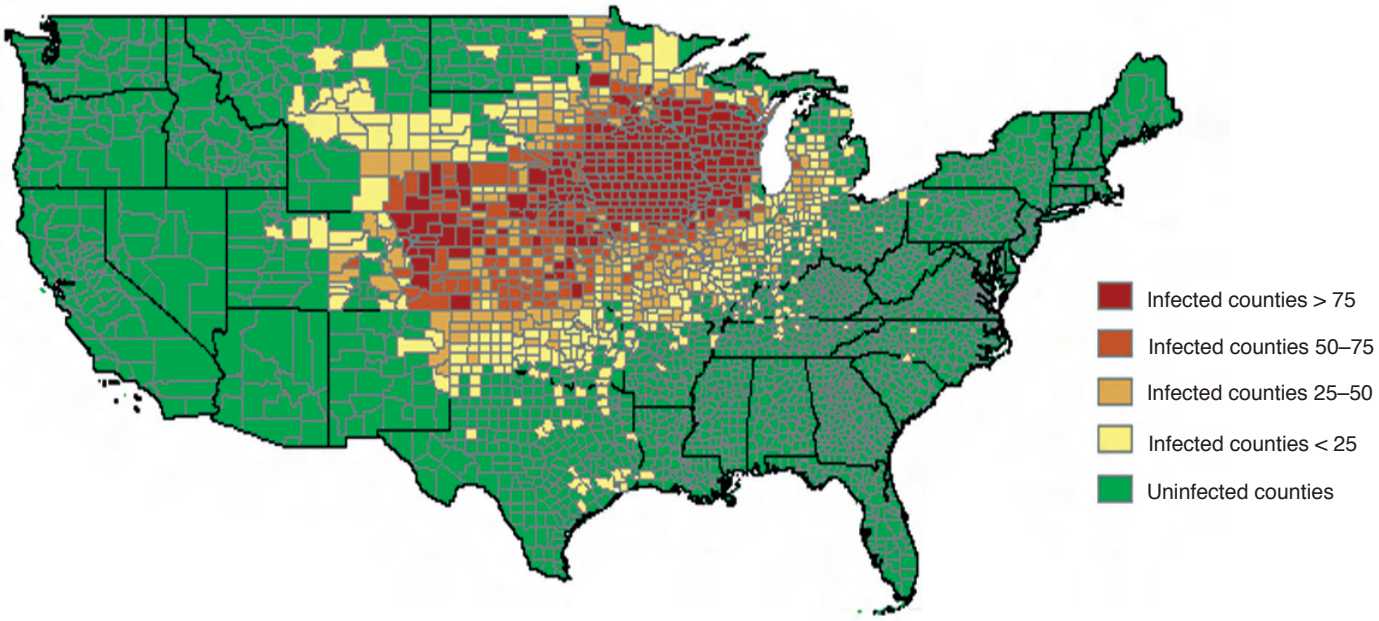
The systems analysis team includes researchers with a range of industry and academic experience in areas such as operations research, statistics, mathematics, economics, engineering, computer science, and the physical sciences. The team applies statistical methodologies for modeling the behavior of natural and engineered systems to assess the impact of catastrophic events on populations and critical infrastructure. "Systems studies link a threat to a response strategy," says systems analyst Richard Wheeler, who leads the team.

A response strategy can include investments in new technologies. "For example, a detector with enhanced capabilities might sense a threat earlier than is now possible," says Wheeler. "Mitigation could then happen more quickly, preventing the spread of the disease." Wheeler's team collects data from experiments, observational studies, simulations, and experts. "A good systems study can help inform system requirements in the design stage, especially when there are design trade-offs—for example, improved sensitivity versus speed of measurement in a detector," says Wheeler. The decision models outline possible alternatives and define uncertainties in the outcomes. Findings from the studies help influence programmatic and policy decisions.

Analyzing the Spread of Disease

In conducting systems studies on hypothetical agroterrorism attack scenarios, scientists in the Threat Awareness Program saw a need for a national-scale model to assess the potential impacts of an intentional release of a highly contagious threat agent. One disease that could have a catastrophic economic impact is foot-and-mouth disease (FMD), which affects livestock. Although it has not infected U.S. livestock since 1929, the disease is endemic in many areas around the world. (See *S&TR*, May 2006, pp. 11–17.) While the FMD virus could enter the U.S. unintentionally or intentionally, recent concerns regarding its use as a means of economic bioterrorism have stimulated a desire to better understand the potential threat and determine the best mitigation strategies for an intentional release.

Computer scientists Doug Speck and Carl Melius are working with a team that has developed a national-scale model to simulate various scenarios for the intentional introduction of FMD. The Livermore software, called Multiscale Epidemiological/Economic Simulation and Analysis (MESA), will be used by the U.S. Department of Agriculture (USDA), DHS, and other federal and state agencies to evaluate response options and countermeasures for controlling the extent and duration of outbreaks. MESA could also help the agencies form policies for preventing outbreaks by



The Multiscale Epidemiological/Economic Simulation and Analysis (MESA) model simulates outbreaks of foot-and-mouth disease. A simulation map shows the percentages of infected animal facilities by Day 50. Areas in red represent counties in which more than 75 percent of the facilities have been infected.

providing recommendations on issues such as how much vaccine should be stockpiled or the number of animals that must be tested and the frequency of tests to certify with confidence that a facility is free of disease. MESA uses census data provided by the USDA's National Agricultural Statistical Service on the nation's 1.2 million agricultural facilities. "MESA has a unique scaling capability," says Melius. "Other disease transmission simulations that model FMD scale to a maximum of 50,000 facilities."

Disease can be spread directly through animal-to-animal contact or indirectly, for example when a human or vehicle travels from an infected facility to another animal facility. MESA uses the contact data as one of the primary parameters to generate results. Because most disease progression occurs during the "silent spread," the period before the disease is detected, the team generates a model whose time frame begins two weeks before the disease was first observed and projects forward approximately one year. MESA displays a map showing the likely spread of an outbreak on a national scale and provides recommended response measures.

Livermore conducts its FMD research in close collaboration with DHS's Plum Island Animal Disease Center. Veterinarian Pam Hullinger of NHI has worked with researchers at Plum Island as well as around the world. In the 2001 outbreak of FMD in the United Kingdom, Hullinger assisted authorities in their investigations. Data from the outbreak are being used to verify MESA modeling results.

The Threat Awareness Program's systems studies and modeling efforts combined with BKC's material threat assessments and knowledge discovery tools help the homeland security community understand how adversaries of the U.S. might use biological organisms in an attack. Says Bates, "The tools we build are helping the nation construct effective measures to understand and counter emerging bioweapon threats."

—Gabriele Rennie

Key Words: Biodefense Knowledge Center (BKC), bioterrorism, foot-and-mouth disease (FMD), Multiscale Epidemiological/Economic Simulation and Analysis (MESA), systems studies, threat assessment, Threat Awareness Program.

For further information contact Tom Bates (925) 423-3055 (bates13@llnl.gov).