GLOBAL SECURITY

Reducing the threat from terrorism and weapons of mass destruction and enhancing global strategic stability

A nuclear and radiochemistry researcher holds the prototype device for field-deployable nuclear forensics.

LNL develops innovative advanced technologies to help the government anticipate, identify, and address global security threats. Guided by intelligence-based science and technology and applying expertise in chemical, biological, radiological, nuclear, and explosive weapons, we develop and implement capabilities that enhance threat preparedness, prevention, protection, and response and recovery. In addition, Livermore innovations in space situational awareness and cyberdefense help strengthen security in an increasingly interconnected world.

NUCLEAR FORENSICS AT WORK

After a nuclear incident, time is of the essence to determine what radioactive material was used and where it originated. A team at LLNL developed a prototype chemistry-on-a-chip platform for field-deployable nuclear forensics. The assessment tool qualitatively identifies actinides, specifically radioactive elements such as uranium or plutonium, sampled from postdetonation nuclear debris. Using a chemical extractant, the device can separate out elements of interest from only a submilliliter microsample, limiting the exposure risk to operators and allowing for easy, safe analyses that take just 20 to 30 minutes to complete. After separation, the isotopic ratios of the sample are quantified using a combination of nuclear and optical spectrometric techniques. Further work will adapt the tool to effectively measure actinides from more realistic debris samples.

LLNL researchers and collaborators are also studying the formation of uranium oxides in energetic environments, such as conditions following a nuclear event. They discovered that the ambient concentration of oxygen strongly affects the type of compounds formed, while their structural composition is highly dependent on whether the plasma cools from 10,000 °C over microseconds or milliseconds. Hundreds of different types of possible molecules can form. These results will help refine computational models of nuclear explosions and improve predictive capabilities for particle formation and transport. Laboratory scientists also analyzed the massive detonation that occurred in a Beirut port in August 2020. They found that features, such as bodies of water, within the near-source environment can have a large effect on shock and blast waves, seismic motions, and crater formation, as well as cloud rise and fallout effects.

GEOPHYSICAL EVENT MODELING

Researchers at LLNL developed a new computational model that simulates the 3D seismic structure of the upper 400 kilometers of the Earth in the western United States. This work was motivated by the need to improve nuclear explosion monitoring methods by more accurately modeling short-period waveforms. The researchers performed more than 60,000 high-performance computing simulations of 72 earthquakes to update the subsurface model and improve its match with nearly 100,000 recorded seismograms. By more precisely representing the effects of wave propagation through the Earth, the new 3D model can provide improved estimates of seismic-event sources. Another research team used acoustic-gravity waves (AGW) to calculate the size of Tonga's Hunga volcano eruption in January 2022. AGWs propagate along the Earth's surface and are associated with very large atmospheric explosions from volcanic eruptions and nuclear tests. The study found that the Hunga volcano produced an atmospheric explosion the size of which has not been documented in the modern geophysical record and is comparable to that of the 1883 Krakatoa eruption in Indonesia.

COUNTERING BIOLOGICAL THREATS

A team of scientists, led by LLNL, is seeking to develop a multipathogen vaccine that will protect against three bacterial biothreats: tularemia, melioidosis, and plague. Funded by the Defense Threat Reduction Agency, this project builds on LLNL expertise using a nanotechnology—nanolipoprotein particles—as a platform to deliver vaccines against single pathogens. The next step is for the team's disease experts to add antigens that will protect against multiple pathogens simultaneously. A cost-effective, multipathogen vaccine will enable a simplified immunization regime in which warfighters can be fully vaccinated more quickly. Other researchers at the Laboratory are studying an emerging pathogen known as the Rift Valley Fever virus (RVFV). To date, outbreaks have been limited to Africa and the Arabian Peninsula. The team has discovered that RVFV infects special immune cells called mircoglia, which exist only in the brains of humans and other mammals. The researchers also found that the body recruits natural killer cells, which warrant further study, to assist microglia in fighting the infection.

LLNL researchers perform molecular characterization research for the brain's response to a Rift Valley Fever virus infection.

PROTECTING CRITICAL INFRASTRUCTURE

Researchers are combining cyberdefense expertise, network analysis, artificial intelligence, and collaborative-autonomy algorithms to develop a four-layer immune infrastructure framework for protecting the nation's industrial control systems from national security threats. The first layer focuses on understanding the networked system. LLNL developed a portfolio of capabilities that enable cyberdefenders to understand their asset inventory. Such capabilities include Livermore's widely used Network Mapping System, which produces a comprehensive representation of Internet-based computer network environments. For the second layer—keeping adversaries out—Livermore developed cyberdefense scalable tools to perform automatic binary analyses of software updates in search of malicious code. Layer three provides tools for detecting and responding to intrusions by developing intelligent detection capabilities that automatically respond to unknown threats. The team ran a large number of transmission and distribution simulations and applied deep-reinforcement, machine-learning techniques to characterize a healthy system and identify disruptive behavior. For the final layer—operating through compromise—LLNL is developing capabilities to facilitate infrastructure operations despite an attack by using collaborative autonomy to decentralize control of physical systems.

AN "A" GRADE IN ENVIRONMENTAL TEST

For the 12th consecutive year, the Laboratory received an "A" grade in its proficiency test for Organisation for Prohibition of Chemical Weapons (OPCW) certification. For the test, scientists at LLNL's Forensic Science Center had to correctly identify the reportable chemicals and—for the second straight year—perform their collaborative work with added precautions because of the COVID-19 pandemic. LLNL has served as one of two U.S. laboratories certified to test environmental samples for chemical weapons since 2003. The chemical analysis capability exercised in OPCW proficiency tests is foundational to much of the real-world sample analysis and research performed in LLNL's Forensic Science Center.