Protective Systems for Chemical, Biological, and Radiological Threats

Protecting people from exposure to chemical and biological agents has been a long term focus of the Special Projects Office. The best way to prevent this exposure is to develop systems that can rapidly sense the presence of dangerous levels of the threat materials and react to this knowledge with measures that counter the threat before it harms people and contaminates their surroundings.

A prime example of this protection paradigm is SPO's Immune Building Program. This program is focused on protecting the occupants of a building from the release of airborne chemical or biological agents in or near a structure. Over the past two years, the performers in this program have invented high efficiency agent filtration and neutralization technologies for a broad range of agents. They have developed chemical and biological sensor-activated HVAC control systems to minimize the spread of deadly contaminants through an occupied building. What began as a modeling and simulation study to discover protective strategies moved to an experimental verification phase that tested complete protective systems, at full scale. We are currently conducting a full-scale demonstration of the first fully functional Immune Building at Fort Leonard Wood, Missouri. From this initial demonstration, we expect to see a proliferation of Immune Building Technologies and Systems throughout the military and into the commercial world. We also expect that with the continued development of component technologies, particularly sensors, Immune Building Systems will see an expansion of protection capabilities.

Now let me tell you about an exciting effort underway this year that seeks to take this paradigm to the battlefield. The TACTIC – Threat Agent Cloud Tactical Intercept and Countermeasure program will take the concepts of detection and protection as typified by the Immune Building effort, and apply them to protecting the troops in the field in a way that will allow them to maintain their operational tempo. This approach seeks to protect operational military troops and their equipment from exposure to airborne chemical and biological agents that could be produced by direct attack from an adversary, or may arise from defensive measures against an adversary storing or deploying chemical or biological weapons. Regardless of the source, these agents could have devastating effects on military operations by harming military personnel and contaminating the battlespace with potentially deadly materials. Again, we want to move towards a proactive preventative approach, and feel the TACTIC Program will allow us to stop the release near its source, thereby preventing it from reaching the troops and contaminating the battlespace.

There are several opportunities for you to help. We have to invent the right way to approach the problem and the technologies that support these approaches. We need to develop radically new detection concepts that have similar detection performance to laboratory devices, but act at a distance as much as 10 km out and at speeds of a minute or two. We also need countermeasure technologies that can halt the spread of the agent cloud while it is simultaneously being neutralized. The countermeasures must be conducted with the minimum amount of materials and must be non-toxic to troops operating in the field. The BAAs that seek ideas on detection and countermeasures for TACTIC are currently open and we are extremely interested in any ideas or concepts that might solve the problem of detecting and defeating chemical and biological agents on the battlefield. Proposals are due in late April, however we are leaving the BAAs open for a full year to consider new concepts that come in after the first round of winners. The ideas that evolve from the first phase of the program will be integrated into the future TACTIC system. The mechanism for developing a system will be a new solicitation from DARPA aimed at funding system integrator teams to carry out this task. In about a year I will be holding a team building meeting where we will invite interested system integrators to learn about the technologies developed and performer results from initial experiments and testing. The winning proposal teams that result from the new solicitation will be funded to develop the prototype TACTIC system that will be tested at full scale in the open space.

While these systems approaches to proactively protecting humans from exposure are extremely exciting, we have to be prepared for even a partially successful attack perhaps using agents for which we still seek optimal detection systems.

The development of sensors for chemical and biological materials are of prime interest to the Special Projects Office, as you might expect. Obviously, you can't take active measures against an attack if you don't know that the attack ever occurred. An excellent example of a current day sensor system is being produced in the DARPA RAIDDS Program. The RAIIDS system provides a hands-off, end-to-end, automated, triggered, PCR-based biodetection sensor system for multiple pathogens that works well for low level, slow release threats, but on a several hour timescale. Another sensor system, operating on a similar timescale to RAIIDS, but with a greatly expanded list of threat agents, is TIGER. This approach uses universal PCR primers to amplify DNA and high precision mass spectrometry to sort and identify the products, ultimately leading to broadband detection.

While RAIDDS and TIGER are critical parts of the biological detection arsenal, DARPA is seeking a paradigm shift for biosensing to timescales that could trigger active countermeasures (such as in the Immune Building program) to prevent humans from becoming exposed. This requires sensors that are simultaneously fast and accurate- key goals of the recently initiated program, Spectral Sensing of Biological Aerosols. This program uses spectral signatures across a broad band of phenomena including particle size distributions, ultraviolet excitation/emission and lifetime measurements, ultraviolet and visible Raman spectrometry, and real-time single particle mass spectrometry measurements to achieve lower false alarm rates while maintaining the speed of a trigger. These sensors have the potential to provide identification of biological agents at timescales that enable active countermeasures to attacks, thus protecting people from any exposure.

In a similar vein, the challenge from chemical threats continues to grow, for example, hazards like toxic industrial chemicals (TICs) are rising as key concerns. Many of these materials are shipped in large quantities and could present threats to the populace through accidental or terrorist instigated releases. This makes them prime weapons of opportunity in the urban environment and thus key concerns to urban operations that Paul Benda will discuss shortly. The many chemicals and potential scenarios for releases greatly complicate chemical detection technology development. The broad range of substances that must be sensed, the discrimination against common chemicals, and the speed of deadly effects of TICs, places severe constraints on the types of sensors that could be employed for detection and warning .

The detection of TICs in a complex background is challenging. Detectors must target a wide range of molecular weights, volatilities, and concentrations. Of course, the sensors must have very low false alarm rates against the complex background of chemicals that could potentially inhibit or interfere with them. We are very interested in concepts that can combine these features in sensors that act quickly enough to provide triggering of protective measures such as Immune Building and TACTIC.

Until these advanced detection systems are developed and deployed, we must be prepared to deal with the consequences of even a partially successful attack that leaves contaminated structures and equipment. The keys to restoring safe operation following a chem/bio event are detection of the concentration of agent on surfaces and rapidly inactivating a broad spectrum of agents. Through DARPA SPO efforts, significant advances have been made in the latter using chlorine dioxide. However, decontamination of the Hart Senate Office Building and later the Brentwood and Hamilton Township postal facilities, were not optimized, partially due to the unavailability of a rapid surface detection system than could scan for the presence of any remaining active agent. In those operations, the decontamination teams had to rely on collecting surface samples and subjecting them to analysis by microbial culture that had a turnaround time of at least one day. Development of technologies that could detect the surface concentrations of chemical and biological agents (with emphasis on discrimination of active versus inactive agents) are key needs to optimize such operations. We are very interested in new ideas that may provide this key technology need.

Now let me tell you about a reasonably new area of interest in the Special Projects Office that moves beyond chemical and biological threats. This interest comes from the recognition of the threat to people from the detonation of a bomb containing radiological materials. Obviously we would like to be able to detect such a device before it is used, so that we could proactively prevent its use, however we must be prepared for a terrorist detonation of a Radiological Dispersal Device on or upwind of a military installation. Such an attack could spread radiological contamination at levels that are not immediately toxic but make work in the area untenable due to the risk of long-term radiological health effects.

The DARPA Radiation Decontamination Program (RD) is cooperating with Department of Homeland Security, in developing technologies to detect radioactive contamination in real-time over wide areas and to rapidly decontaminate buildings. This is obviously very analogous to other efforts ongoing in SPO but with a completely different set of sensor and decontamination concepts.

The RD program is developing application systems to place detection technologies in close proximity to the radioactive materials where the signal is strong, and developing wide area detector systems to carry out the interrogation. Once the radioactive contamination is detected, decontamination is necessary. Radioactive residues are difficult to remove because of the strong chemical bonds that are formed between the radioisotopes and the building surfaces. We are developing technologies to break these bonds and allow efficient “wash down” of building surfaces. The radioactive materials can then be efficiently concentrated, and properly disposed of enabling people to reoccupy the structures

However, in order to carry out these decontamination efforts, people must go in harms way. We are very interested in providing enhanced protection to first responders and critical military personnel carrying out such operations. Can we enable them to work without increasing the risks to them? One potential approach to protect personnel is the use of a topical lotion that prevents free-radical damage to the skin from radiation exposure. Other approaches to protect troops would be methods to stabilize DNA and protect it from both direct and indirect radiation damage, and better technologies to remove internal contamination if it occurs. We are interested in your concepts for these technology needs.

In summary, the Special Projects Office is acutely aware of the ever expanding threat to humans from chemical, biological and radiological materials. We are interested in novel technologies for faster, more accurate detection, countermeasures to defeat the agents, and more efficient decontamination techniques. When these components are combined into systems, we have the opportunity to remove these threats from the arsenal of our adversaries and proactively protect our troops and populace.