Next-Generation Sensor Technology, Now

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U.S. warfighters must train to conduct military and peacekeeping operations in every possible environment, including those involving chemical, biological, radiological, and nuclear (CBRN) contamination. The Joint Requirements Office for CBRN Defense has recognized the limitations of the current chemical agent surface liquid detection capability and identified the need for an enhanced capability to detect the threat of chemical agent surface contamination. While the United States has introduced unmanned ground vehicles with mission-specific payload packages, no specific packages have yet been incorporated to perform surface or point CBRN reconnaissance or detection in limited access areas, restricted terrain, or military operations in urbanized terrain.

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The evolution of the CBRN Unmanned Ground Reconnaissance Advanced Concept Technology Demonstration (ACTD) exploits next-generation sensor technology to demonstrate enhanced capabilities for existing mounted reconnaissance platforms and the military utility of unmanned ground reconnaissance systems for CBRN applications.

Unlike an acquisition program, an ACTD program provides an expedited method of evaluating mature technology in an operational scenario to determine if it meets operational needs. ACTDs of a deployable capability rely on warfighter involvement during a residual phase that eventually affects the development of supporting concepts of operations and tactics, techniques, and procedures. The Office of the Deputy Under Secretary of Defense for Advanced Systems and Concepts and the Defense Threat Reduction Agency (DTRA) provided overarching program management for the CBRN ACTD.

The Need for a New Requirement

The CBRN Unmanned Ground Reconnaissance ACTD objective addressed current warfighting shortfalls and the present limitations of manned CBRN reconnaissance, including requirements for operators to dismount from their collective protection systems to survey potential contamination in vehicle-inaccessible areas. Previous CBRN reconnaissance systems used a double-wheel sampling system and a mobile mass spectrometer to detect surface contamination. The process involved rolling one of the silicon wheels behind the reconnaissance vehicle over a 55.5-meter stretch and raising it to a heated probe while the sec-

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ond wheel was lowered to traverse a second 55.5-meter stretch. The heated probe vaporized any chemical contaminants on the first wheel, which were then transported through the sampling line of an onboard mass spectrometer for analysis and comparison to its library of threat chemical spectra. Detection and identification were made after the second wheel went through this process. The procedure was time-consuming, maintenance-intensive, and speed-limiting. The equipment was also sensitive to surface conditions and did not provide flexible use options. Those limitations restricted the CBRN reconnaissance operational tempo, placing warfighters at risk.

Furthermore, existing platforms did not offer CBRN reconnaissance capabilities in limited access areas, forcing the warfighter to conduct dismounted CBRN reconnaissance operations in mission-oriented protective posture, or MOPP, which means protective gear had to be donned to protect the warfighter from a toxic environment. Effective, timely, and accurate CBRN reconnaissance is essential to protect the warfighter and minimize the degrading effects that increased MOPP levels can have on mission objectives. Line-of-site and field-of-view considerations also limit the current CBRN reconnaissance capability.

The Joint Requirements Office for CBRN Defense recognized those limitations and identified the need for a surface liquid and solid (traditional and non-traditional) agent detection system as one of its top requirements. The CBRN Unmanned Ground Reconnaissance ACTD was intended to bridge identified capability gaps by exploiting next-generation sensor technology to demonstrate the enhanced capability for existing mounted reconnaissance platforms and the military utility of unmanned ground reconnaissance systems for CBRN missions.

The CBRN Unmanned Ground Reconnaissance ACTD evaluated two complementary program efforts related to CBRN reconnaissance, which were demonstrated in two thrust areas that are discussed in the following sections.

A Lightweight Reconnaissance System

Thrust area one focused on the integration of a non-contact surface detector—the Joint Contaminated Surface Detector (JCSD)—into a modified joint Service, lightweight nuclear, chemical, and biological (NBC) reconnaissance system designated the CBRN Unmanned Ground Reconnaissance ACTD High Mobility Multipurpose Wheeled Vehicle Variant System, or CAHVS.

Thrust area one evaluated the JCSD as a replacement for the double-wheel sampling system for conducting route, area, and zone reconnaissance. The liquid chemical agent surface detection capability uses a combination of the vehicle-mounted mechanical double-wheel sampling system in conjunction with a time-delayed sample wheel contamination analysis by the mobile mass spectrometer. The double-wheel sampling system relies on ground contact to collect surface contamination on its silicone wheels and requires the host vehicle to limit its speed to as low as eight miles per hour—depending upon terrain—in order to maintain contact between the sampling wheels and the ground. Before the reconnaissance system can actually detect and identify agents, two of the double-wheel sampling system wheels must first traverse a required 111-meter contaminated path length of terrain, at which point the wheels are raised to the heated probe of the onboard mobile mass spectrometer for vaporization of the contaminants and subsequent analysis. In operational use, the maneuvering force had two choices: Reduce ground speed to accommodate the use of the double-wheel sampling system and mobile mass spectrometer, or press forward without knowing if the terrain is contaminated.

The JCSD brings next-generation sensor technology to the warfighter, offering ground surface chemical contamination detection in real time and providing the following capabilities:

- Liquid and solid detection of traditional chemical warfare agents, toxic industrial chemicals, and non-traditional agents
- Reconnaissance operations, conducted at maneuver speeds
- Concurrent detection/identification of multiple classes of compounds.

The JCSD employs Raman technology to detect and identify chemical contaminants on surfaces in less than three seconds at maneuver speeds up to 45 miles per hour. When light from its 248-nanometer laser bounces off the chemical contaminant, a small fraction shifts slightly to another wavelength. By analyzing that shift (called the Raman shift), the JCSD can identify the chemical by comparing its spectra with those in its onboard library. It also has the capability to record unknown spectra for subsequent analysis should the threat chemical not be contained within its library.

Testing the Vehicle

The Edgewood Chemical Biological Center (ECBC) Research and Technology Directorate tested the JCSD against the chemicals on the current chemical biological mass spectrometer Block II agent list, a number of non-traditional agents, and 10 to 12 liquid toxic industrial chemicals. The selected chemical agents are priorities on the U.S. Army CBRN School threat list.

The CAHVS configuration included a NBC detection suite integrated into a M1113 HMMWV with a hard cab and a modified S-788 lightweight multipurpose shelter. The NBC detection suite included the JCSD, the mobile mass spectrometer, a point chemical agent monitor, a chemical agent detector alarm, a radiation detection device, a navigation suite, secure communications, an area marking system, a meteorological device, and collective protection. To offset the weight increase associated with the JCSD, the team replaced the joint biological point detection system with a reconnaissance variant, which consisted of a biological agent warning sensor IV, portal shield purge assembly, and a dry filter unit. The chemical biological mass spectrometer received an additional biological box to augment the biological capabilities of the joint biological point detection system reconnaissance variant. The CAHVS modifications maintained the original platform's CBRN defense capabilities.

During the course of the CBRN Unmanned Ground Reconnaissance ACTD, the JCSD successfully completed technical and operational demonstrations and surety testing. Demonstrations confirmed the JCSD can detect chemicals on various surfaces while moving at speeds of up to 45 miles per hour as it is operated by the warfighter. Surety tests showed the JCSD can detect traditional chemical agents, non-traditional agents, and toxic industrial chemicals on various surfaces as well as in the presence of common battlefield interferents.

The operational manager, U.S. Army Pacific, has expressed great satisfaction with the results of the operational demonstrations and provided a positive joint military utility assessment in June 2009. The Office of the Joint Project Manager for Nuclear, Biological, and Chemical Contamination Avoidance designated the Stryker Armored Vehicle as the platform for JCSD integration. The JCSD transitioned as a program of record to the Joint Program Executive Office for Chemical and Biological Defense/Office of the Joint Project Manager for Nuclear, Biological, and Chemical Contamination Avoidance in June 2009.

An Unmanned Ground Vehicle

Thrust area two, the CBRN Unmanned Ground Vehicle (CUGV), focused on the integration of existing chemical and radiological detectors onto an existing robotic platform to evaluate a new capability of conducting dismounted reconnaissance in confined spaces. The CUGV was originally viewed as an additional tool for manned reconnaissance vehicles, which are used for area, route, and zone reconnaissance. In the performance of such missions, the vehicle crew can remain safely inside the collective protection of the host reconnaissance vehicle. However, the reconnaissance vehicle is often too large to allow the investigation of buildings, tunnels, caves, or other confined spaces that may be encountered on the battlefield, requiring warfighters to dismount the collective protection of the reconnaissance vehicle to perform a manned reconnaissance.

Thrust area two's effort involved providing a deployable, unmanned reconnaissance capability for areas inaccessible to vehicles. Midway through the CBRN Unmanned Ground Reconnaissance ACTD, emphasis shifted from providing a deployable reconnaissance asset out of the manned reconnaissance vehicle to providing an unmanned platform in support of assessment operations.

The CUGV improves the conduct of dismounted ground reconnaissance and sensitive site assessment by having robotic first entry into potentially hostile environments instead of the warfighter. This ability will create greater flexibility on the battlefield and increase the protection of warfighters in CBRN-contaminated environments.

The ACTD CUGV was successful in delivering a new deployable capability that would allow the warfighter to conduct unmanned chemical and radiation detection.

The CUGV effort concentrated on combining currently available chemical and radiological sensors onto an existing robotic platform to address various areas of risk identified by combatant commanders. Specifically, the CUGV effort selectively integrated chemical warfare agents, toxic industrial chemicals, and radiation detectors into a flexible payload module that provided warfighters with the ability to configure the payload elements for specific mission profiles. Primary CUGV capabilities are:

- Remotely operating unmanned chemical and radiation detection in areas where tactical vehicles cannot access or the threat to the warfighter is too great (e.g., urban terrain, caves)
- Determining oxygen levels, volatile organic compounds, lower explosive limits, temperature, humidity, and detection of toxic industrial chemicals in confined areas
- Collecting chemical air and surface samples for subsequent analysis
- Transmitting chemical and radiation detection information from the CUGV to the operator control unit situated in the reconnaissance vehicle and/or held by the dismounted warfighter in the clean zone.

Fielding the Vehicle

The 95th Chemical Company, U.S. Army Alaska, employed the CUGV during the operational demonstration in Sep-

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tember 2006, and U.S. Army Pacific provided a favorable joint military utility assessment in April 2007. The CBRN Unmanned Ground Reconnaissance ACTD team then provided two CUGV systems to the 95th Chemical Company for fiscal years 2007 and 2008 to execute the residual phase of the program. During those two years, the CBRN Unmanned Ground Reconnaissance ACTD team maintained the CUGV systems for the 95th.

In addition to the official residual systems, the CBRN Unmanned Ground Reconnaissance ACTD Team also provided CUGV systems to U.S. Army Pacific and the U.S. CBRN School for use in further concepts of operations and tactics, techniques, and procedures development. At the conclusion of the ACTD in October 2008, the operational manager requested to keep three CUGV systems. With approval from DTRA, the technical manager at ECBC refurbished and upgraded the systems. The U.S. Army Development Test Command provided the safety confirmation for the CUGVs' return to U.S. Army Pacific and U.S. CBRN School.

The CUGV transitioned to the Office of the Joint Project Manager for Nuclear, Biological, and Chemical Contamination Avoidance in June 2007. The CUGV is currently being considered for inclusion in some of the monitoring and surveying sets, kits, and outfits part of the Joint NBC Reconnaissance System Increment II.

The DTRA Joint Science and Technology Office assigned the ECBC Engineering Directorate the role of technical manager for the CBRN Unmanned Ground Vehicle ACTD. ECBC became responsible for program management, budgeting, and the technical effort. Under the leadership and supervision of Peter F. Annunziato, a co-author of this article, the program ensured a swift transition of the CUGV to four government organizations—the Office of the Joint Project Manager for Nuclear, Biological, and Chemical Contamination Avoidance; the Navy Explosive Ordnance Disposal Technical Division; the Future Combat System Small Unmanned Ground Vehicle; and the Joint Product Manager Consequence Management—for production and fielding.

In addition to the four government transitions, ECBC and iRobot Corporation established a cooperative research and development agreement in February 2008. The agreement provides great benefit to the Department of Defense by allowing the CUGV team to implement additional improvements to the vehicle. It also involves providing iRobot with the technical data necessary to enable commercialization of the CUGV, potentially benefiting the warfighters and first responders by providing a commercial alternative for robotic reconnaissance in times of urgent need.

Overall, the ACTD CUGV thrust was successful in delivering a new deployable capability that would allow the warfighter to conduct unmanned chemical and radiation detection. The capability was delivered within a two-year timeframe with a substantial $3.18 million savings; the funds were used to improve the JCSD performance capability and its software and hardware reliability.

The technical innovations proven through this program are leading the way for rapid technology demonstrations that adjust in near-real time to changes on the battlefield and new defensive requirements. As operational realities shift, development and demonstration of new defensive capabilities in the CBRN arena become even more urgent to ensure that the military can fight and win in any condition and properly prepare for the threats of tomorrow.

The CBRN Unmanned Ground Reconnaissance ACTD "exemplifies the Department of Defense's ability to quickly develop a prototype and get it in the hands of the warfighter. The ACTD was a model of teamwork between military services and industry partners," said Col. Humberto E. Galarraga, U.S. Army ECBC Detection Decontamination Engineering Group leader and co-author of this article.

NOTE: Annunziato's technical acuity and ability to simultaneously manage the two thrusts of the ACTD earned him the 2009 Gold Award for "Outstanding Supervisor Grade 13 and Above" by the Baltimore Federal Executive Board.

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