U.S. Army soldiers from 1st Battalion, 504th Parachute Infantry Regiment, and attached to 2nd Infantry Brigade Combat Team, 2nd Infantry Division, patrol the Rusafa market area in Baghdad, Iraq.

U.S. Army photo by Staff Sgt. Bronco Suzuki

PREPARING WARFIGHTERS FOR THE URBAN STAGE

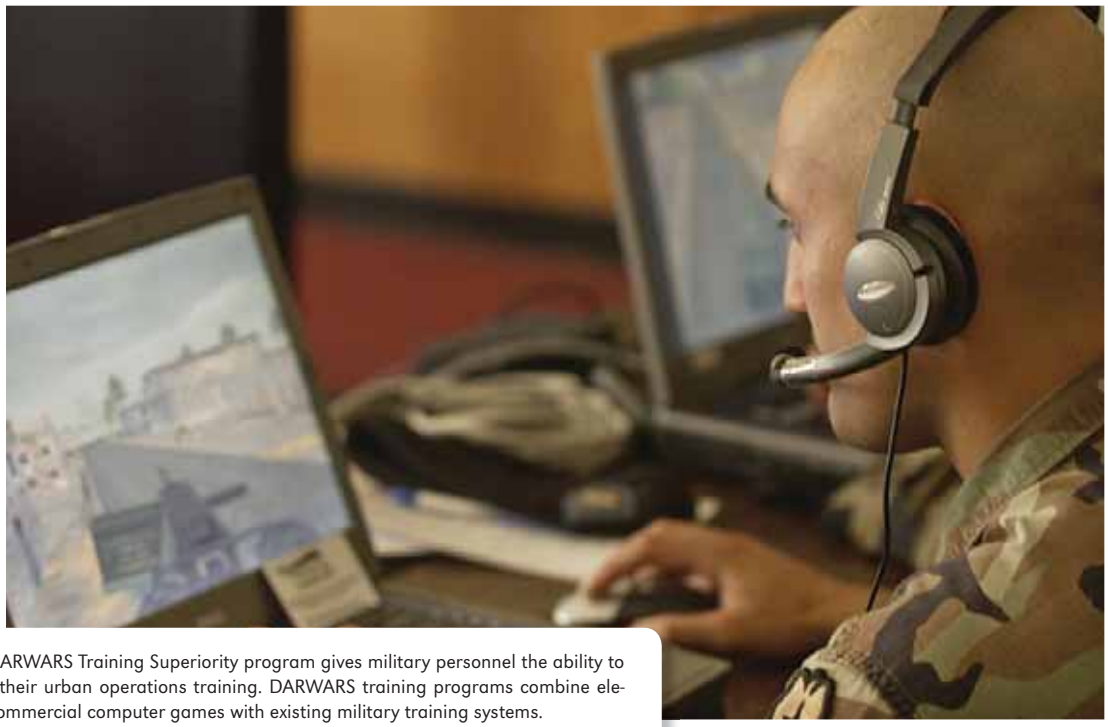
From Weapons Detection to Training Products, DARPA Technologies Give U.S. Forces an Edge

By Dr. James Richardson

Since 2003, DARPA has actively engaged in programs to address the complexity of conducting Military Operations in Urban Terrain, or MOUT. This thrust in Urban Area Operations is a response to the tactics of adversaries to draw U.S. military forces from a conventional battlefield into the three-dimensional urban terrain. DARPA is providing technological solutions to problems associated with strategic and tactical levels of urban operations, in particular, addressing fighting insurgents at the local level and mitigating the difficulties inherent in urban combat. This agency strategic thrust addresses a broad range of challenges unique to MOUT, including recognizing and defeating improvised explosive devices (IEDs), enhancing intelligence, surveillance, and reconnaissance in urban areas, developing pre- and post-conflict modeling, and training.

INTRODUCTION

In urban operations, the U.S. military must operate on a deadly stage shared with terrorist players. Whether addressing fighters on their home ground or insurgent terrorist groups using the shelter and confusion of city streets, buildings, and crowds, conducting military operations in urban areas has always been difficult and particularly dangerous. From the siege machines of medieval times to the intense artillery barrages and carpet bombing of World War II, tactical operations have generally involved choices among bypassing the city, laying siege, or



DARPA's DARWARS Training Superiority program gives military personnel the ability to customize their urban operations training. DARWARS training programs combine elements of commercial computer games with existing military training systems.

fighting from building to building conducting military operations in urban areas. Today, only the last of these options seems viable, but finding ways to successfully confront the enemy, often on his own ground, greatly stresses available tactics and technologies.

In the first option, major cities and towns can no longer be arbitrarily bypassed or ignored. In fact, they are increasingly important objectives. As the world becomes more urbanized, with nearly 60 percent of its inhabitants now living in dense communities, a greater portion of human activity and social structure is vested in them. Perversely, these are the places where conflict and terrorism is often born and carried out. And, these are the places where this conflict and its issues must be confronted, so problems in dealing with failed or failing states, such as Somalia, Bosnia, and Iraq, must often be addressed in their major cities: Mogadishu, Sarajevo, and Baghdad, respectively.

According to Dr. Robert Leheny, DARPA's deputy director, laying siege is not an option. Victory attained through a population forced to capitulate by starvation and other deprivations would work against the United States' long-term goals of winning the goodwill of a people with whom it will be working in planning the future of their nation. And, today's comprehensive media coverage would complicate public acceptance of the harm being done.

"Remotely destroying cities and their infrastructure, and creating casualties among innocent civilians in the process, is against U.S. principles and contrary to our goals," says Leheny. "Collateral damage is too great in these operations, too often causing high casualty rates among the very people we are there to protect."

In cities and towns, guerrilla fighters mix with urban populations using civilians as both masks and shields to hide and conduct terrorist operations. With a thorough knowledge of the neighborhoods and streets, the enemy gains immense tactical advantage. Adversaries attempt to tie down U.S. troops in a maze of streets, bridges, buildings, and other obstacles while they unfold innovative operations and weapons, drawing more U.S. troops into combat, inflicting greater U.S. casualties, and causing costly mistakes that harm friendly forces, civilians, and neutrals. As pointed out in DARPA's strategic plan, "Bridging the Gap," "Unstable and lawless urban areas give insurgents sanctuary to recruit, train, and develop asymmetric capabilities, including the possibility of chemical, biological, and radiological weapons of mass destruction [WMDs]." By these means and by taking advantage of the United States' self-imposed restraint, intelligent yet relatively unsophisticated forces can challenge well-equipped and professionally trained U.S. troops.

While the United States has always relied on its superior technology to win battles, the reality of the environment of the world's urban areas erodes the effectiveness of many of its advanced systems. Communication often fails within city canyons. Surveillance is difficult where 70 to 90 percent of the

Photo courtesy of DARPA

Left: DARPA has delivered many "Boomerang" systems to operational forces. Boomerang microphones detect gunfire by both the shockwave that bullets create and by the muzzle blast from a weapon. Mounted onto a Humvee, the system provides distance, directions, and azimuth to the source of the gunfire. Below: Crosshairs, another DARPA program, expands on Boomerang's capability and detects rocket-propelled grenade and mortar threats. Crosshairs includes a weapon onboard that automatically tracks the shooter in the event that a decision to return fire is made.

Photo courtesy of DARPA

Photo courtesy of Marine Corps Warfighting Lab

terrain is enclosed and situational awareness suffers accordingly. Battle tempo is altered by obstacles and maneuver channeling. These same obstacles can lead to injuries and long exposure to fire. And, as U.S. troops are subjected to snipers and other enfilade fire, the prospect of collateral damage often limits the use of powerful defensive weaponry. Knowing they cannot win in an open battlefield, these and other capability shortfalls encourage adversaries to challenge U.S. forces in urban areas.

COMBAT IN URBAN AREAS

Three years ago, DARPA Director Dr. Anthony J. Tether took up the gauntlet to dramatically improve the way the United States fights urban battles by creating a DARPA strategic thrust area titled Urban Area Operations. This thrust is currently budgeted at approximately $500 million and is planned to grow. DARPA programs in Urban Area Operations are aimed at creating technology to help make U.S. operations in cities as effective as operations in non-urban areas by seeking new urban warfare concepts and technologies that would make a smaller U.S. force conducting operations in an urban area more effective, suffer fewer casualties, and inflict less collateral damage.

DARPA is investing in a set of programs for Improved Urban Intelligence, Surveillance, and Reconnaissance to advance U.S. situational awareness in complex urban environments. This program will improve U.S. ability to detect insurgents and weapons systems hiding either in the urban environment or natural terrain features, and to greatly facilitate operational planning and execution.

The fog of war is particularly dense in urban zones, yet today there are few effective fog-cutting devices available at the company and platoon levels. Upon joining DARPA, Dr. Mari Maeda looked for ways to reduce the confusion that often results from the soldier's limited ability to simply and quickly capture, report, and share information before, during, and after combat operations. The Tactical Ground Reporting (TIGR) system enfolds information gathered by patrol leaders into a multimedia mission-planning and debriefing tool. The data are easily assembled and accessed by the soldier and present a clear and insightful picture of the local situation. For example, aerial imagery maps are enhanced with photographs, videos, GPS tracks, voice recordings, and other data captured by the soldier. Maeda notes, "Traditionally, military reporting tools have focused on feeding information to higher echelons' commanders. But counter-insurgency warfare requires feeding information to the junior officers leading the fight, and that is exactly what TIGR is doing."

TIGR taps into an intuitively searchable, geo-referenced database that defines events and situations on the battlefield. Users can easily visualize the dynamic tactical landscape and bring up photos of changes in the physical terrain (e.g., destroyed bridge, new barriers), information on friendly activities (e.g., new checkpoints set up, recent meetings with local leaders, building numbers and photos from neighborhood census data), and enemy activities (e.g., indirect fire attacks, new IED detonation devices). Spatial and temporal analysis tools can also be used in planning the next operation. Compressed media updates are transmitted and received despite network outages or low bandwidth availability on tactical networks. Introduced

This photo: Military personnel used the HURT system at a 2006 demonstration at Twentynine Palms, Calif. HURT has made it possible for U.S. forces to request imagery from manned and unmanned air assets and to receive data tailored by the system to meet their imagery needs. Below: DARPA is investing in programs to improve intelligence, surveillance, and reconnaissance capabilities in urban settings. One such program is the Tactical Ground Reporting (TIGR) system, screenshots of which are pictured here. TIGR serves as a multimedia mission-planning and debriefing tool that consolidates visual, voice, and GPS information into a searchable database.

Photo courtesy of Northrop Grumman

Images courtesy of DARPA

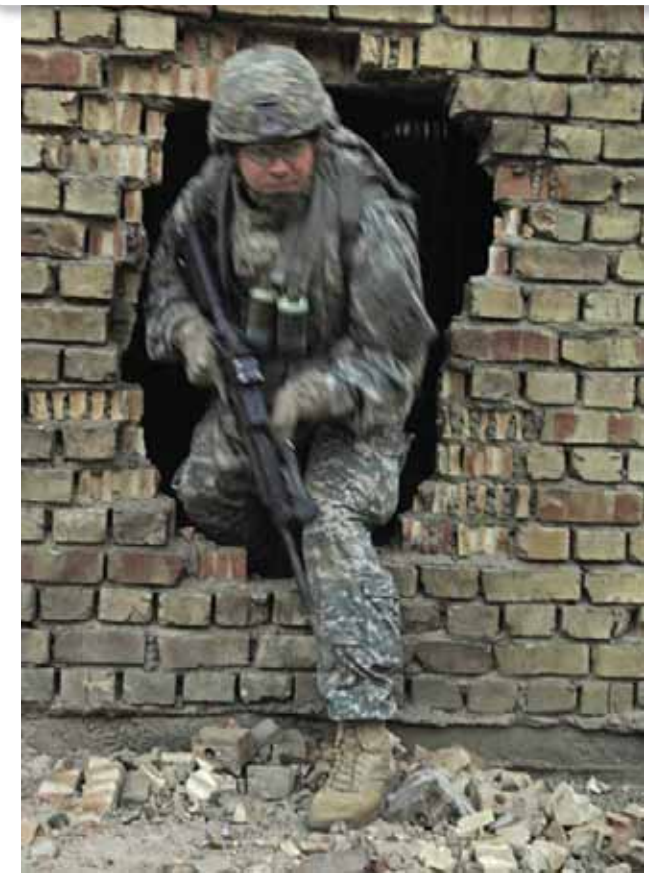
in Iraq starting January 2007, TIGR is being received with enthusiasm and is being used with creativity. As of January 2008, TIGR use has proliferated across four brigades. As suggested by a scout platoon leader in the 1st Brigade Combat Team, 1st Cavalry Division: "... a patrol is able to leave the gate knowing all the information needed to accomplish the mission. Seeing what I can know with TIGR, if I had to operate without it, I would feel as if I were in the dark."

TIGR facilitates horizontal information sharing at the lowest tactical level, so that combat patrol leaders benefit from the hard-won knowledge of their peers. TIGR is also proving to be indispensable in the relief in place-transfer of authority (RIP-TOA) process, where the incoming units can now be provided with battlefield information at a level of detail and granularity unseen in previous wars.

One of the most effective general surveillance tools available to assist today's soldier is the unmanned aerial vehicle (UAV), in particular one having a unique set of characteristics: small, agile, low-flying, and operated by small units. DARPA has developed just such a micro UAV, the Wasp. Two hundred of DARPA's half-pound, 14-inch-wingspan, electrically powered Wasp micro air vehicles are currently serving at the company level in Iraq, flying surveillance missions in and out of the "Wasp nest." With its color video cameras, GPS, altimeter, compass, and autopilot, the Wasp has already saved many lives.

HURT, the Heterogeneous Urban Reconnaissance Team, is a program designed to facilitate the job of tasking the Wasp and other UAVs to meet reconnaissance, surveillance, and target acquisition imagery needs. In the HURT system, the warfighter uses a simple touchscreen display to generate requests for imagery from manned- and unmanned-air assets, or from archived files. Each request is consolidated, prioritized, and expedited through an information processing and management service, which autonomously chooses the optimum platform or platforms for the mission. The platform controller

Below left: U.S. Army Staff Sgt. Alex Martinez of the 2nd Squadron, 2nd Stryker Cavalry Regiment, crawls out of a hole in the wall of an abandoned shopping center after checking for suspicious activity or materials during a presence patrol in the Dora district of Baghdad, Iraq. DARPA is developing technology that would allow U.S. troops to sense through walls to determine if adversaries are hiding inside buildings. Below right: DARPA developed the Tactical Language and Cultural Training program, which incorporates artificial intelligence, speech recognition, and gaming technologies in a simulated mission environment to prepare warfighters for urban operations.



U.S. Air Force photo by Tech. Sgt. Adrian Cadiz

Image courtesy of DARPA

receives and fulfills the consolidated request with imagery taken from optimum perspectives. Finally, HURT registers all imagery collected by the involved assets during the mission, tailoring it to satisfy the request, and sends the consolidated imagery back to the warfighter. Ultimately, the combination of HURT and TIGR will provide some of the most comprehensive life- and mission-saving information ever presented to the frontline soldier.

Unfortunately, neither the Wasp nor other UAV assets can directly detect underground facilities. But, under the Detection, Characterization, and Assessment of Underground Structures thrust, DARPA is developing several technologies to aid in the search and prosecution of terrorist threats when hidden in tunnels.

DARPA's Tagging, Tracking, and Locating Capabilities programs focus on the urban scene and are aimed at persistently monitoring targets or equipment of interest; tagging, tracking, and locating enemy activities; tracking and detecting weapon fabrication and movement; and precisely discriminating threat from non-threat entities against severe background clutter.

The Weapons for Urban Operations program will develop ultra-precise, beyond-line-of-sight infantry weapons for use in congested urban areas. This program set is featuring a high-precision, long-range laser designator and an all-weather sniper scope. Also being pursued are electromagnetic mortar, optically designated attack munitions, and advanced sighting systems.

The Asymmetric Warfare Countermeasure program will advance mission capabilities to detect, prevent, or mitigate asymmetric warfare techniques, such as suicide bomber, IED, and WMD attacks – including radiological dispersal devices.

The IED and the suicide bomber threats are the most deadly that U.S. forces confront in Iraq (credited with more than half of the U.S. combat deaths). Although increasing the levels of armor protection is helpful, these weapons are often extremely powerful; DARPA is working on ways to find them rather than to simply shield against them. The Recognize Improvised Explosive Devices and Report program is developing and will demonstrate a capability for standoff detection of IEDs, and the Human-carried Explosive Detection Stand-off System program will allow the rapid identification of human-carried explosives at a standoff range between 50 and 150 meters.

As dangerous and effective as the IED has been, it is only one of the offensive weapons used against convoys and individual vehicles. Rifles (especially sniper fire), rocket-propelled grenade launchers (RPGs), mortars, and other munitions, typically launched covertly, also pose deadly risks. In the din of traffic, vehicle crews are often unaware that they are being fired upon, and can seldom determine the direction of the incoming rounds. DARPA began investigating ways to protect U.S. vehicles against these threats many years ago and today those investigations have begun to pay off. Dr. Karen Wood is the program manager for Boomerang and Crosshairs, and Deepak Varshneya is the program manager for C-Sniper, programs that offer increasing capabilities in these areas.

Former Vice Chairman of the Joint Chiefs of Staff Navy Adm. Edmund P. Giambastiani poses a question about the Command Post of the Future to U.S. Army Capt. John Davis, 25th Combat Aviation Brigade tactical planner, during a briefing at Camp Speicher, Iraq, June 20, 2007.

U.S. Air Force photo by Tech. Sgt. Adam M. Stump

At $15,000 and weighing only 45 pounds per system, Boomerang has been field-tested and is already in Iraq (it took 66 days to transform laboratory prototypes to fieldable operational systems), with thousands more being procured. These devices provide 360-degree acoustical cueing for vehicle crews experiencing sniper fire. According to the contractor, BBN, "Aural and visual alerts inform vehicle occupants of the position of the shooter relative to the vehicle's direction of travel (within one second after the shot). Although the system is calibrated to detect infantry small arms, it also detects larger and smaller supersonic rounds … If multiple shooters fire simultaneously, Boomerang identifies the first shooter and then continues to detect and report at approximately one-second intervals. If multiple shooters fire at greater than one-second intervals, the system identifies each shooter. An auditory alert ('shot 2 o'clock, 150 meters') reports the relative direction and range to the shooter, and the liquid crystal display (LCD) provides additional information, including azimuth, range, and elevation of the shooter." An improved version is being tested and will be deployed soon.

Of course, it would be far better to find the shooter before he fires and this is the goal of the C-Sniper program, which employs a radar to locate shooter optics or incoming munitions. Crosshairs, being developed by Mustang Corp., will broaden the targeted threats to include RPGs and mortars. This system will also provide an onboard weapon to automatically track the shooter in preparation to return fire (although the return-fire decision will be left to the operator as required by rules of engagement) and (in the case of RPGs and mortars) to defeat the incoming munitions before impact. Ultimately, all three systems will be integrated to form the world's most capable vehicle self-protection system.

DARPA is developing pre- and post-conflict capabilities to model and understand social indicators that precede the onset of hostility and conflict, coupled with tools to formulate strategies to stabilize an urban area and assist U.S. civil affairs units.

U.S. Navy Storekeeper 1st Class Michael Lake, attached to Mobile Inshore Undersea Warfare Unit 109, prepares to launch a Wasp unmanned aerial vehicle during an annual field exercise at Camp Pendleton, Calif., Aug. 18, 2007. The Wasp UAV system, a DARPA-sponsored program, is designed to provide small units with persistent intelligence, surveillance, and reconnaissance data on what is over the next hill or on the next block.

U.S. Navy photo by Mass Communication Specialist 3rd Class Daisy Abonza

The DARWARS Training Superiority program recognizes that training for urban operations and anti-terrorist activities is as challenging as it is important. It is also uniquely driven by the complex situations that dominate urban operations, and in recognition of this it is tailored by those who understand this kind of warfare. The originator of these programs and former DARPA Program Manager Dr. Ralph Chatham suggests that the motto of these programs should be, "'We now return control of your training to you.' User-authoring lets soldiers themselves build their own training locally to cope with the rapidly changing world they encounter."

The Training Superiority program is designed to assure continuously available, on-demand, mission-level training for all forces at all echelons. New kinds of cognitive training systems are enabled that feature human-tutor interactions and the emotional involvement of computer games enriched by feedback from the Army's Combat Training Center. These training programs combine the persistent, massive multiplayer online interactions found in commercial computer games with existing military training systems within a self-sustaining architecture to allow what Chatham describes as "continuous on-demand training anywhere, anytime, for everyone."

Two program successes bear recognition. First are the development and transition of the Tactical Language and Culture Training PC-game-based tutors that provide working knowledge of gesture, culture, and mission-oriented vocabulary for the soldier. The training system uses arcade games and a simulated mission environment where the student must recognize and respond to conversational Iraqi Arabic and Afghani Pashto. This PC-game-based technology is made possible through the integration of artificial intelligence, speech recognition, learning, and gaming technologies. "Every soldier or Marine preparing to train the Iraqi forces can now use these tools. In all, over 6,000 American troops used the tactical language tools in 2006," Chatham notes.

The second training tool to transition was DARWARS *Ambush!*, a squad-level, multi-user, lessons-learned tool that trains squads and their commanders to recognize and respond to the perils of convoy ambushes. During 2006, this tool trained more than 20,000 soldiers, Marines, and airmen across the United States and at bases in Germany, Italy, Afghanistan, and Iraq.

Command, Control, Communications (C3), and Intelligence for Urban Warfighting will produce new approaches to all-echelon C3 and new intelligence analysis tools specifically suited for urban operations. These new assets will allow warfighters to see and understand what is happening throughout the urban battlespace in real time. For example, Command Post of the Future (CPOF), a program of record in the Army, was a major DARPA initiative to provide an overarching system of planning and mapping tools that rapidly process and correlate combat information in real time. This advanced distributed, collaborative decision-making system replaces fixed command posts with mobile, distributed C3. Its ability to provide composability, collaboration, and visualization across the entire battlefield and to create virtual command posts greatly facilitates the ability to coordinate the treatment of the urban area within the larger aspects of the battle operations.

CPOF's highly intuitive visualizations allow officers to quickly exchange and review one another's data to support the unique demands of urban battlefield awareness with the help of a broad range of information resources, such as charts, tables, and customized appliances. Further, integration with existing systems, critical for providing accurate broad-based situational awareness to CPOF operators, is achieved through a DARPA-developed data bridge.

FUTURE PLANS AT DARPA

Efforts conducted under various agency technology thrusts, particularly Urban Operations, are exerting an immense influence on all phases and facets of this critically important aspect of modern warfare and will continue to do so in the future. In the years to come, given the global trend toward greater urbanization of population increases, the importance and pervasiveness of urban warfare will grow accordingly. Adversaries will continue to improve their tactics and weaponry, making urban operations even more difficult and dangerous. It is clear that the U.S. military must find and adopt better solutions to the challenge of urban battle and it is also clear that innovative new technologies will be the key to those solutions.