

The Army is struggling to equip the next generation of foot soldiers to wirelessly share text, photos, video, electronic maps, and other data the way most of us do now with our cellphones and BlackBerrys.



Wi-Fi Infantry

■ By Sydney J. Freedberg Jr.

FORT BLISS, Texas—You can hear the robot coming. It buzzes across the ground like an overgrown toy car, which in many ways it is, down to the Xbox-style remote in the hands of the young soldier operating it. Visiting reporters and Army officers, packed close on a rooftop, lean over to watch as the little robot running on tank-like tracks—formally a “Small Unmanned Ground Vehicle,” or SUGV—trundles into a mock village built for urban-warfare training in the scrublands of West Texas. As the 30-pound, knee-high bot scoots from one building to the next, it swivels its mechanical neck and looks around with a

set of cameras, feeding live video to its operator so he can scope out potential ambush sites before his squad advances on the simulated enemy.

Conveniently, the cinderblock structures in the training area don't have doors, just gaps in the wall. Later, examining the robot up close, one visitor asks how it could get into a building with doors that actually shut. The only answer is a soldier's wry chuckle. (The Army declined a request to discuss

a general trade anxious murmurs about the second scout robot to be demonstrated that day: a 14-inch-wide flying machine called the "Micro Air Vehicle," which looks less like a tiny helicopter than a militarized ceiling fan. As soldiers struggle to get the robot to take off, an officer from the unit running the field test explains, "It's run by GPS satellites, and the cloud cover is affecting the link." A public-affairs official leaps in to emphasize that the vehicle is just a prototype and that the next iteration will have



the door-opening capabilities of the SUGV.)

Bomb squads in Iraq and Afghanistan have used somewhat larger robots to check out potential booby traps, and the machines have indeed saved some lives. The Fort Bliss demonstration was meant to make the case for the robots in a much more challenging scenario: an infantry assault against living, breathing enemies who would presumably notice the bizarre mechanical apparition at their door, even if they didn't hear it coming. An attentive enemy might simply shoot the bot—or, worse, hide from its slow-swiveling sensors and set an ambush for the Americans following its path.

While soldiers wrap up the mock SUGV assault, a colonel and

■ DRONES AND ROBOTS:
The small robot (above) is designed to enter buildings and send pictures and data to foot soldiers during urban assaults. The "Micro Air Vehicle" (opposite) flies short distances to broadcast aerial photos.

a more robust uplink. Eventually, soldiers get what they call the "flying beer keg" into the air. It buzzes overhead, clearly audible and visible from the ground, as the operator shows it off. But even at a low altitude it would be a difficult target for an enemy rifleman. The commander of the field-testing task force, Col. Emmett Schail, remarks admiringly, "If

I'd had that thing, I probably wouldn't have gotten shot."

When Schail served in Iraq in 2005, he had far greater access to reconnaissance drones than most soldiers did at the time: He was the deputy commander of a Stryker brigade, the Army's most high-tech combat unit. Nevertheless, he could watch live feeds from his drones only at a dedicated ground control sta-

■ New Network



GETTY IMAGES/ROBERT NICKELBERG

■ Although the tanks and robots of the Army's Future Combat System get most of the attention, the program's real intent is to **create a vast and powerful digital network.**

■ The FCS is so big and spread across so many organizations, the Army has **a hard time synchronizing it all.**

■ Because a war zone doesn't have cell-phone towers and other telecommunications infrastructure, **a soldier's radio has to be 20 times more powerful** than a typical cellphone to send and receive signals.

tion. On the move in their Humvees, Schaill and his soldiers did not have unmanned aerial vehicles small and numerous enough to take with them, and the UAVs the brigade had could not even send them timely still images. Schaill said that it took him "hours" just to get photos and other critical intelligence from one part of the brigade to another.

So when the colonel and a small group of soldiers, on their way to visit the Iraqi police chief in Tal Afar, heard a car bomb explode, they could not send a robot to scout ahead. Going to investigate, they ran into insurgent gunmen. Schaill was shot in the arm. Today, he says he has recovered 90 percent of the nerve and muscle function. Having a "flying beer keg" along would hardly have guaranteed that Schaill and his soldiers would have spotted the ambush in time, but it would have given them a better chance.

A Skeptical Congress

The field test that Schaill's task force ran in late July and early August at Fort Bliss, uncharacteristically cool and green from recent summer rains, was part of the Army's all-out push to show that its high-tech, high-cost Future Combat System is relevant to the grueling guerrilla warfare in Afghanistan and Iraq. The FCS, as it is invariably called, is a massive effort to develop a suite of equipment for Army brigades. The official (and optimistic) estimate of its total cost in 2008 dollars is \$128 billion. At last count, the repeatedly revised list of FCS equipment consisted of the two mini-robots; four larger ones (three on wheels, one in the air); eight armored vehicles built on a common chassis; an outhouse-sized missile launcher nicknamed "rockets in a box"; and an array of sensors that look rather like photographers' tripods with no camera on top.

This kitchen-sink approach makes it almost impossible for the Army to explain the FCS in less than an hour of PowerPoint slides. Bundling so many systems together also complicates the oversight of any particular component—and that only adds to Congress's anxieties about the program. "They want to look at it as one great big glob, and the truth of the matter is, it's a lot of separate capabilities," said Rep. Ike Skelton, the Missouri Democrat who chairs the House Armed Services Committee. "I don't know why they lump it all together into one thing."

The Army argues that only this all-in-one "system of systems" approach can ensure that all the individual gadgets work together. Yet, ironically, electronic communications capabilities essential to linking the different FCS components are being developed *outside* the program by three other independent programs. (See chart, p. 34.) Meanwhile, under congressional pressure to show near-term results, the Army has committed to fielding individual elements of the FCS piecemeal as each technology matures. So although the manned vehicles will not enter service until 2015, many unmanned systems are scheduled to be battle-ready in 2011.

In June, the Army announced the latest restructuring of the program: Instead of sending the first subset of FCS technologies to heavy armored units, the program would now focus on equipping the light infantry, which has suffered the worst casualties in Iraq.

Military officials touted this restructuring as an "acceleration." Engineers did indeed accelerate development of the two mini-robots on display at Fort Bliss, making them part of the 2011 deadline. (Early versions of both are already being used in Iraq.) But the Army delayed indefinitely two other program components: new electronics for its mainstay armored vehicles, the M1 Abrams tank and the M2 Bradley infantry carrier. Officials insist they pushed back these upgrades to the big tanks so they could focus resources on the light infantry. Key congressional staff members suggest that the Army simply could not get the systems for the armored units to work.

Whatever the reason, this summer's field test was downgraded from a rigorous formal assessment, run by the independent Army Test and Evaluation Command, to a "preliminary limited user test" that was overseen by the FCS program itself; the results, good or bad, will not be factored into the official Defense Department process to decide whether to keep funding the FCS. The test that counts has been postponed more than a year, to August 2009.

"This thing gets more bizarre by the day," fumed Rep. Neil Abercrombie, D-Hawaii, who chairs the House Armed Services subcommittee that oversees the FCS. "They're delaying the test by a year—how the hell is that an 'acceleration'?"

The program has already spent \$15 billion on research and

development, according to Abercrombie. “You’ll have to make your own judgment as to whether you see \$15 billion worth of modernization that will have a practical value for the Army,” he said. “The only thing they have to show is stuff like the little robot. Kids do that—I’ve seen them do it with little boats in the pond down at the park.” What the Army really needs to make work is the invisible electronic web that makes the individual FCS projects more than the sum of their parts. Abercrombie emphasized, “The key to all of this is the network.”

Mobile Networks at War

The real heart of the ambitious FCS is not, in fact, the robots that were put through their paces at Fort Bliss. It is not even the controversial lightweight armored vehicles that account for most of the Future Combat System’s cost and whose first prototype, a self-propelled howitzer, debuted on Capitol Hill in June.

All of this individual hardware depends on something hidden inside the cargo bay of a Humvee idling at the Fort Bliss test site—a series of unremarkable olive-drab boxes that hold the linchpin of the Future Combat System. The circuitry inside the boxes updates a flat-screen display jutting awkwardly from the dashboard of the already-crammed vehicle. Unlike the adorable and intermittently functional robots, these electronics are not photogenic. In fact, the computer screen, which looks like a militarized version of *Google Maps*, is off-limits to photography.

But if—if—the Army can get the technology to work, it will give every single squad what Schail lacked on the day that he got shot: the capability to receive pictures, and, theoretically, even video, across a high-speed mobile network. The objective of the Future Combat System is not simply to give the Army more drones, each feeding video to a single operator and whoever happens to be looking over his shoulder, which is the current state of the art. The goal is to let every soldier in the field get real-time reconnaissance imagery from any drone or human comrade who is on the network.

“The kids here in the United States think it’s their God-given right to have a cellphone that can take pictures,” said Rickey Smith, a retired colonel now working on the FCS for the Army’s

Training and Doctrine Command. “But the line soldier today does not have a cellphone capability. I can’t take a picture and send it to my buddy.”

It may seem strange that American soldiers lack the kind of mobile networks that American civilians with their iPhones and BlackBerrys increasingly take for granted. But all of our on-the-go conveniences depend on a multibillion-dollar infrastructure that is very much fixed in place. The only reason your cellphone is small enough to slip into your pocket is that its low-power transmissions are relayed by a system of repeaters and cell towers all over the country. The only reason your laptop can go online from your table at Starbucks is that its wireless signal has to carry only a few yards to the Wi-Fi access portal built into the wall.

In a war zone, that kind of fixed infrastructure is unavailable. The military equivalents of cell towers and wireless hubs have to be compact enough for soldiers to haul across the battlefield, which drastically limits the amount of data they can transmit and receive. As a result, a soldier’s radio “must radiate 10 to 20 times the amount of power as a normal cellphone,” said Chris Brady, a vice president in the military communications division of General Dynamics, which is developing the handheld version of what the military calls its new “Joint Tactical Radio System.” Moreover, Brady said, the radios “don’t have the benefit of a strong transmitter on a tower, so the ‘receive’ side of the radio must have a significant amount of processing power to interpret signals off a small antenna.”

The larger, vehicle-mounted versions of the new mobile networking equipment also pose technical problems. The Army has successfully installed a prototype FCS network on the Humvee, a relatively roomy cargo hauler. But the M1 Abrams and, especially, the M2 Bradley infantry carrier are already packed with electronics that have been added piecemeal during their 27 years in service. These vehicles, originally designed in the 1970s, have only so much available capacity for electricity-hungry upgrades such as jammers to deactivate roadside bombs. In certain configurations, Bradleys actually suffer brownouts, forcing soldiers to turn off some systems before activating others. Once the FCS network gear is added to the Bradley, Schail said, “it’s on the edge.”

It is these network upgrades to the Bradley and the Abrams that the Army postponed when it “accelerated” the FCS program this summer. Officials have not released a revised timeline for the enhancements.

The official date for fielding the complete package of FCS equipment, including the new hybrid-electric tanks and the full-up network, is 2015. The technological challenge is immense. A hundred different contractors are working on the estimated 95 million lines of computer code, four times as much as needed to operate other large weapon systems, such as the Air Force’s F-35 Joint Strike Fighter. Overall, the FCS involves some 44 “critical technologies”; 26 of those are directly related to the functioning of the network, and the Government Accountability Office rated only two sets of technologies “fully mature” in March 2008.

Yet the Army has staked its future on the Future Combat System network. For a generation, the service struggled to bring rapidly evolving information technology to the battlefield. Since the Afghanistan and Iraq wars began, soldiers have seen real benefits—and

■ Col. Emmett Schail



SPYDER J. FRIEDBERG JR.

An Iraq war veteran, Schail commands the task force that is field-testing the new robots and wireless networks.

■ One Mission, Many Schedules

The Army describes its Future Combat System program as a comprehensive technological upgrade for its entire force—but three other independent programs are producing equipment necessary to make the FCS function. Coordinating the disparate parts of the program is proving difficult.

Future Combat System (FCS)

A \$128 billion suite of robots and manned vehicles with a mobile network to make them function as an integrated force.

KEY COMPONENT

Infantry brigade enhancements

STATUS REPORT

2008 2009 2010 2011 2012 2013 2014 2015

DEVELOPMENT

Prototype equipment being tested by program managers.

REFINEMENT

Testing conducted by independent evaluators.

FIELDING

Equipment being issued to operational units.

DESCRIPTION

Starting in 2011, the Army plans to issue to infantry brigades a subset of FCS equipment called “Spin-Out 1”: a Humvee-based interim network, a missile launcher, and a series of unmanned sensors, some stationary, some robotic, and some flying.

New-type FCS brigades

2008 2009 2010 2011 2012 2013 2014 2015

2015 is the target date to field the FCS “core program,” which includes the manned armored vehicles, the remaining robots, and the full-up wireless network.

Joint Tactical Radio System (JTRS)

An effort to develop new “digital” radios for all four services: Army, Navy, Marines, and Air Force. Estimated Army cost: \$15 billion.

JTRS portable radios

2008 2009 2010 2011 2012 2013 2014 2015

The Ground Soldier Ensemble (see below) will use portable versions of the new JTRS radio to bring network capabilities to troops on foot.

JTRS radios for vehicles

2008 2009 2010 2011 2012 2013 2014 2015

The FCS program’s manned and unmanned vehicles will rely on JTRS ground-mobile radios to exchange data over the new network.

Warfighter Information Network–Tactical (WIN-T)

Connects units in the field to headquarters to share data. Estimated cost: at least \$7.4 billion.

Current version

2008 2009 2010 2011 2012 2013 2014 2015

The military is now issuing the “Joint Network Node,” considered the first increment of WIN-T, to stationary command posts in Afghanistan and Iraq.

Interim version

2008 2009 2010 2011 2012 2013 2014 2015

An upgraded version, called “Increment 2,” will be designed for quick set-up and take-down in mobile command posts.

Full version

2008 2009 2010 2011 2012 2013 2014 2015

Increment 3 of WIN-T will provide the capability to communicate continuously over the network while on the move, which is essential to the FCS vision.

Ground Soldier Ensemble

Formerly called Land Warrior, this program brings networking capabilities to foot soldiers. Estimated cost: \$4 billion to \$5 billion.

2008 2009 2010 2011 2012 2013 2014 2015

SOURCES: Government Accountability Office; U.S. Army; *National Journal* estimates

real limits—in the current generation of technology. The Army’s bid to maximize those benefits, and surpass those limits, is what the FCS is all about.

Blue Force Tracker

Starting in the 1980s, the Army developed multiple networks, each designed to operate over limited bandwidth for a specific, narrow purpose. Separate systems transmitted intelligence reports, artillery target coordinates, and supply requests, with no easy way to share data between one system and another. And the fundamental battlefield function of figuring out what units are where and where they should go next was not automated at all.

“You’ve got a leader who’s thirsting for information so he can devise the best tactics, and he’s struggling with a paper map,” said Col. James Riley, an Iraq war veteran who works on mobile networks at the Army’s Infantry Center at Fort Benning, Ga. At headquarters, he went on, “you’re trying to use little stickies, little map pins, to plot the locations, and the only way to get the information is to call and say, ‘Where are you?’”—a slow and error-prone process.

By the 1991 Persian Gulf War, troops were carrying handheld Global Positioning System locators into the field, but they still had to translate the coordinates into their actual position on a paper map and then verbally relay that information to headquarters by radio. If two units were out of radio range or simply belonged to different formations using different frequencies, they had no information about each other.

“I was a company commander in Desert Storm,” Riley said. “I remember one particular day when, just over a small rise in the terrain, it sounded like all hell was breaking loose. I had no idea what was going on over there. We had no real idea of what the enemy might look like, and only some idea of what the formation right next to us might look like.”

By the time Riley went back to Iraq for his second war, however, a revolution in military communications had taken place. On the eve of the 2003 invasion, select Army and Marine Corps units were issued a new mobile network called “Blue Force Tracker.” Linked to GPS satellites, Blue Force Tracker gave each user a computerized map display that showed not only his own current location—in itself a huge help in navigating across unfamiliar and unfriendly territory—but also the position of every other friendly unit (“blue forces,” in Army jargon) that was equipped with the system. Troops could even use the network and its satellite uplink to send text messages when conventional radio communications were blocked.

“You went from a paper map to a computer map that moved with you down the road,” said Maj. Bill Venable, who fought in Iraq in 2004 and now works as a liaison between the FCS program and Fort Benning. “My higher headquarters was able to track where all of my vehicles were, and rather than having to take time out of the operation to ask each of the platoon leaders, ‘Where are you?’ I could see that at a glance.” With Blue Force Tracker, Venable said, “I was able to conduct operations 40 to 50 miles away from my headquarters and still stay in contact.”

Blue Force Tracker and a more sophisticated cousin called FBCB2 became high-demand items in Afghanistan and Iraq. Originally reserved for commanders’ vehicles, the systems are now commonplace in Humvees on routine patrols. Troops use the network to see which roads go where and which are relatively safe from roadside bombs. “Intel is constantly updating,” said Petty Officer 2nd Class Elizabeth Lopez, a seabee in the Navy

Reserve who served as a Humvee gunner escorting convoys in Iraq. “Sometimes you’re on a road that’s ‘green,’ and five minutes later it’s ‘red’ because somebody got hit.”

But the current networks have limits. The most obvious is that they cannot transmit reconnaissance pictures from aerial drones, or even photos from the digital cameras that troops routinely use to take snapshots of suspected insurgents or potential targets. “That was definitely a shortfall,” Venable said. On one raid against an insurgent safe house, he recounted, “I was told to go to a certain grid coordinate to a yellow two-story house with a wall around it and a blue gate. When I got to the neighborhood, even

“They want to look at it as one great big glob, and the truth of the matter is, it’s a lot of separate capabilities.”

—House Armed Services Committee Chairman Ike Skelton

in the proximity of the grid coordinate, there were several yellow houses and more than one blue gate. Other operators had driven by the house and taken pictures earlier in the day, but that wasn’t available to me. What I had to do was cordon off that entire area.” Each extra house the soldiers had to check meant more time, more exposure to danger, and more innocent Iraqi families alienated by foreign troops searching their home.

Blue Force Tracker simply has too little bandwidth to handle digital imagery. It can perform only one specialized function at a time, just like the other networks that the military uses. A typical Army brigade has at least three other systems to handle logistics, intelligence, and artillery. The core of the Future Combat System is a single, integrated network with enough bandwidth to perform all of these currently separate functions plus the ability to transmit still images or even video.

Land Warrior

Blue Force Tracker’s deadliest weakness however, is something that the Future Combat System program, as originally conceived, did not address. Both systems have power and weight requirements that restrict their use to vehicles: As soon as troops get out on foot, they drop off the network. The military issues far more handheld radios than it did before 2003, but even so, foot soldiers still have to coordinate their operations the old, slow, error-prone way, with voice communications and paper maps.

The chaos of boots-on-the-ground combat, especially in maze-like urban neighborhoods, can be lethal. In one “friendly-fire” incident, Riley recounted, “the squad leader had his lead team enter the building, but unfortunately what [they] did not realize was, another squad from the platoon had already entered that building from another direction.” When the first soldier went through the door, weapon at the ready and steeled for a potential ambush, “the first thing he saw was the muzzle of a rifle,” Riley said. “He engaged—and unfortunately he shot another U.S. soldier.”

Since the 1990s, a chronically troubled Army program called “Land Warrior” had been struggling to develop a high-tech kit for individual foot soldiers. The proposed gear was too expensive and too heavy, however, adding 17 pounds to soldiers already overburdened by ammunition and body armor. In 2007, the Army officially canceled Land Warrior, but it is now resur-

recting the program under the less romantic name “Ground Soldier Ensemble.”

Before the cancellation, some 450 prototype Land Warrior sets had been issued to the Army’s 4th Battalion, 9th Regiment, a Stryker unit headed for Iraq. After awkward initial experiences in training, said Col. Bill Prior, the battalion’s commander, “we took some of our noncommissioned officers—platoon sergeants, squad leaders—and sat them around the table with some of the Land Warrior folks and the industry guys, and took it apart piece by piece.” The ad hoc effort stripped off 7 pounds. Out went an extra battery; a loose cable; and a much-touted digital camera, mounted periscope-like on the rifle barrel, meant to let soldiers see around a corner without exposing themselves. In fact, the battalion nixed Land Warrior altogether for most of its infantrymen. It kept only the mobile networking features, and reserved those for leaders: commissioned officers, sergeants, and corporals leading at least three other soldiers.

The stripped-down Land Warrior gave foot soldiers what they had already come to appreciate from Blue Force Tracker in their vehicles: a digital map displaying the location of the wearer and friendly units. (Land Warrior also had limited text messaging.) The map was displayed on an eyepiece that flipped up onto the wearer’s helmet when it wasn’t in use. A handheld controller let the soldier designate locations digitally with a quick click—a “digital chem light” added at the insistence of the battalion’s veteran sergeants.

Lt. Daniel Lowe found that function particularly useful one night in the Iraqi town of Baquba in 2007. Another unit had been raiding an insurgent safe house when the booby-trapped building blew up, killing one American soldier. Lowe’s platoon, about 35 men on foot with 15 Land Warrior systems among them, moved out to help. But as they came around a corner, insurgents opened fire and Lowe’s men took cover—the lead squads on one street, the rearguard on another, the two groups unable to see each other. Meanwhile, Iraqi police at nearby checkpoints heard the fighting and opened fire indiscriminately.

“We’re stuck in the middle; the Iraqi police are shooting at us, as well as the insurgents. We’re separated in two different elements, and we don’t really have radio communications,” Lowe recalled. “But I’m able to see [the other half of the platoon] on Land Warrior.” The buildings between the two groups garbled their voice transmissions, but the relatively small bursts of data to update their digital maps got through. “I dropped a blue icon on a road just south of our location,” Lowe went on, “and that was our linkup point.” Both halves of the platoon converged quickly on the rendezvous—without shooting each other by accident in the dark—and then went on the offensive.

Such success stories are why the Army is ordering more than 900 additional Land Warrior kits for a brigade headed for Iraq. Just as Land Warrior shares Blue Force Tracker’s advantages, however, it also shares its glaring limitation: the inability to transmit imagery. “That’s something we really wanted,” Prior said. The Land Warrior program kept upgrading the battalion’s equipment based on such feedback; eventually, “we did get the capacity to send still images, but we got it fairly late, about a month before we redeployed” out of Iraq, the colonel said. Giving digital imagery to troops on foot is one of the major goals of the revived program.

Four Programs, Many Problems

Ultimately, military leaders envision a network that will connect command posts to foot soldiers and vehicles in the field. But the Army has complicated this technological challenge with a largely self-imposed organizational muddle. The service has four different programs developing equipment critical to making this networking vision a reality—and each operates under its own management and on its own schedule. At some point, the Army must synchronize all four.

The first of the four is the Future Combat System program itself, which is by far the largest single chunk of the Army’s modernization budget. But the FCS office is developing the network kits for vehicles only. Extending the network to troops on foot is up to the Ground Soldier Ensemble office, which remains an independent entity.

Both the FCS and the Ground Soldier Ensemble, in turn, rely on a third independent program, the Joint Tactical Radio System, to produce the radios that soldiers will use. Inauspiciously pronounced *jitters*, the JTRS program has been repeatedly delayed, restructured, and scaled down since its inception in 1997. The Fort Bliss task force currently is working with a set of proto-prototypes, literally hand-built, that fall far short of what the FCS requires in range and encryption. Yet without the high-bandwidth, all-digital radios that JTRS is meant to produce, there is simply no way to transmit the vast amount of data that the new networks will require.

Finally, the independent Warfighter Information Network-Tactical, or WIN-T, is developing the connections between the FCS-equipped brigades in the field and higher Army headquarters. An early, ad hoc version of WIN-T built from commercially available equipment is already in service in Iraq, but these systems are in such demand that the Fort Bliss task force does not yet have one to experiment with.

And it is only at Fort Bliss that the products of all four programs come together in the hands of soldiers tasked with making them work as an integrated whole. “When you put the formation out there,” Col. Schaill said, “and it all starts working together in the network, you find things that you don’t find in the lab.”

That, Schaill and his comrades say, is the reason the testing task force was created in the first place. With 60 percent of its personnel having experience in Iraq or Afghanistan, the task force is testing the new equipment under field conditions with real soldiers—and combat veterans, at that—to give the developers swift feedback on the prototypes. The reported problems, the Army insists, are simply the result of tougher scrutiny at an earlier stage than comparable programs ever dared to risk in the past.

Can the Army fix those problems in time for the formal assessment in 2009? Next year is a year of reckoning for the Future Combat System, Rep. Abercrombie warned. “This go/no-go is coming up very rapidly,” he said, “and the Army has to decide where its priorities are.” ■

Since 2004, National Journal Staff Correspondent Sydney J. Freedberg Jr. has conducted in-depth interviews with more than 110 military service members about their experiences in Afghanistan and Iraq. The resulting series of articles has covered subjects ranging from rules of engagement to National Guard call-ups to the role of armored vehicles in urban combat. For more information and links to past articles, see www.nationaljournal.com/OralHistory. The author can be reached at sfreedberg@nationaljournal.com.