in a nondescript office near the pentagon, the scientists who broke iraq's back are already fighting the next war

THE MEN FROM DARPA

article By JOHN SEDGWICK IT WAS a war full of stunning images: the view from the "smart" bombs' nose-cone cameras; the sight of anti-aircraft fire spraying into the night skies over Baghdad, as the Iraqi gunners shot in vain at Stealth bombers they couldn't see, much less hit; the reports of the Cruise missile that made its way down a street in Baghdad, paused at the corner and took a left, like a commuter going to work.

These were the visions of the Nintendo war, a conflict so antiseptically high-tech that American soldiers weren't major players until the very end, and then only to round up the enemy like so many thousands of lost sheep. This war wasn't won by men but by machines—Stealth aircraft, smart weapons—that pounded the Iraqis into submission before they even had a chance to fight. These machines didn't come from the Army, Navy, Air Force or the Marines (though they happily took credit for them). They came from a little-known band of technological Green Berets called DARPA, or, to give it the full name no one ever uses, the Defense Advanced Research Projects Agency.

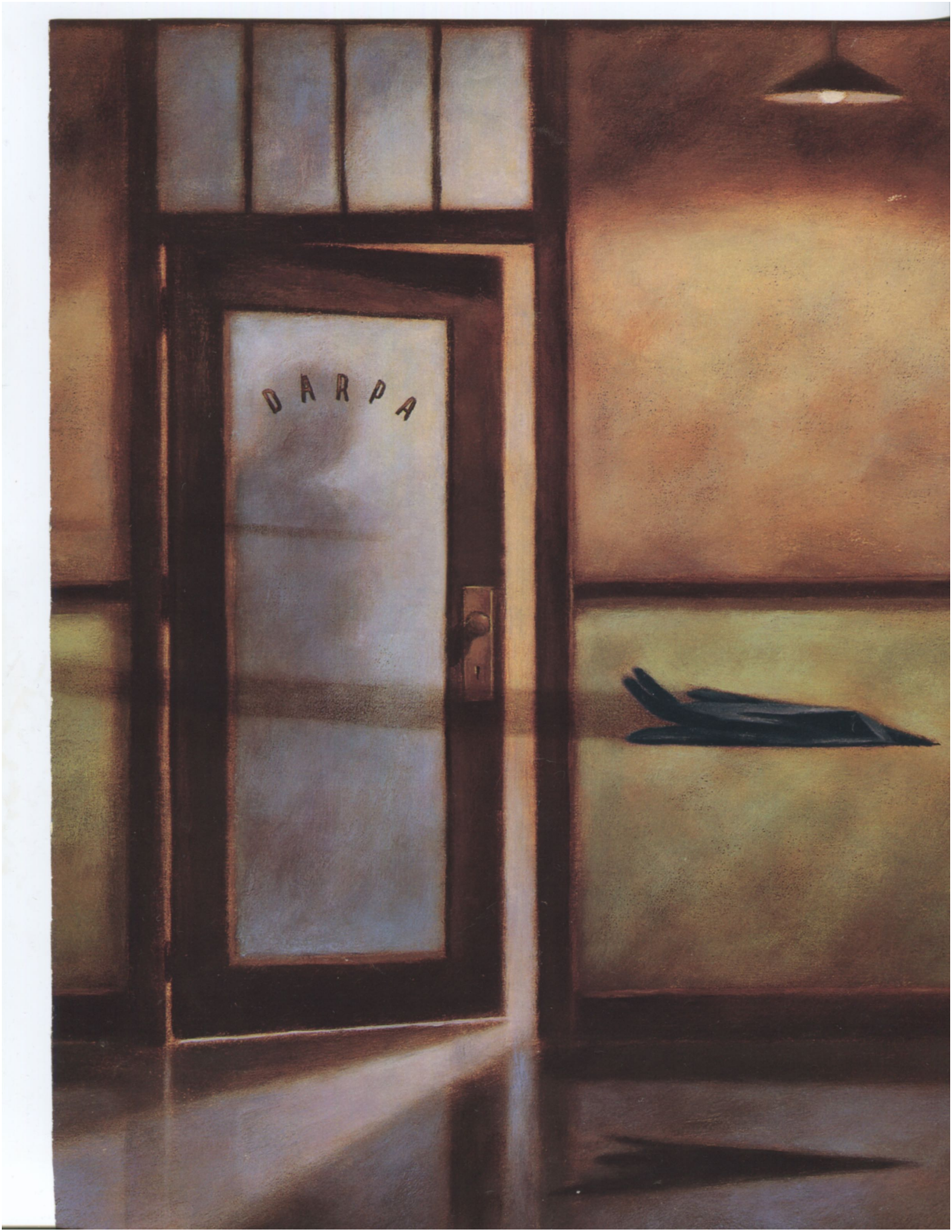
DARPA is a dust mite by Pentagon standards—just 160 civilian employees operating out of a single, nondescript office building in Rosslyn, Virginia, on a measly annual budget of a billion and change. But DARPA is the place where, as John Pike of the Federation of American Scientists puts it, "the toys come from." Since its creation in 1958, DARPA's job has been to investigate military technologies that are so far out (or "high-risk, high-payoff," in DARPA parlance) that they can take 20 years to turn into usable military hardware—if they ever make it at all.

The agency, of course, doesn't think of itself as chief toymaker to the American military. In DARPA lingo, it simply does "interesting work." The only frustrating part of the process is waiting for God and man to produce a war in which all this technology can actually be useful. One after another, highly promising (from DARPA's standpoint, at least) American military conflicts pooped out into limited-scale, low-tech no-shows. Grenada, Libya and Panama were over before the DARPA guys warmed up their computers.

But then, finally, Saddam Hussein showed up with a war so perfectly suited to DARPA's needs and interests that it might actually have been set up as a monthlong DARPA technology demo. It was fought out in the open, with almost six months' notice, against an enemy competent enough to justify bringing out all our best weaponry but not so competent that we had to worry about losing much of it. And the result was—well, you know what the result was.

None of the equipment in the Persian *(continued on page 122)*

ILLUSTRATION BY MIKE BENNY


DARPA

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"The missiles used sensors to home in on Iraqi tanks and then explode, shooting a jet of molten metal."

Gulf war had the DARPA logo on it, because DARPA is not in the business of actually manufacturing aircraft, land vehicles, communications networks or weapons systems. Its role is to devise the supersophisticated "enabling technology"—the raw technological ingredients—for the Army, Air Force and Navy to work up into usable military equipment. The Services themselves may come up with a pipe dream for DARPA to try to realize; sometimes a military contractor will pitch DARPA on a promising innovation which it requires money to research. Primarily, though, DARPA concocts its own projects. However the ideas come along, it usually tests out the technology by developing a cheap, small-scale version of the project, then stages a demonstration for whichever Service is interested. If a Service is sold on the idea, it takes over the D side of the R&D and then stamps its name on the final product.

With so many secret activities, or "black projects," as they are known in the defense-procurement trade, DARPA generally prefers to operate by cover of darkness. And in the war's warm afterglow, it knows better than to steal the spotlight from its big-shot patrons at the Army, Navy and Air Force. Probably for these reasons, no current DARPA officials chose to cooperate in the preparation of this story. But just because DARPA won't talk about the Persian Gulf war doesn't mean DARPA wasn't there.

Let's start with the Stealth technology that allowed the F-117A to succeed so well against Iraq. According to Air Force statistics, the plane accounted for three percent of the allied aircraft used in the Persian Gulf but destroyed 43 percent of all targets. Stealth was conceived in the late Seventies, and the futuristic styling is pure DARPA. With all its bizarre radar-deflecting angles, the F-117A looks more like the world's largest *origami* project than the most sophisticated airplane on earth. The Air Force may be bursting with pride over the F-117A now, but when DARPA first laid out the idea of an airplane that would be invisible to radar, the Air Force was entirely able to contain its enthusiasm. "They didn't think it would work," says Jim Tegnelia, a former DARPA deputy director now with Martin Marietta. So DARPA had to come up with a functioning prototype. The Air Force is now so protective of the technology that Lieutenant General Thomas R. Ferguson, Jr., the Air Force's chief of aircraft development, speculated that if any of the planes had gone down in Iraq, our military commanders would have obliterated the remains before the Iraqis could take a close look.

DARPA also developed the J-STARS (that's the Joint Surveillance Target Attack Radar System) surveillance planes that supervised the battlefields much as the better known AWACS (Airborne Warning and Control System) planes monitored the skies. An AWACS plane, however, is little more than a flying airport control tower. J-STARS is something else again. From a height of 35,000 feet, its radar gives a full, detailed, computer-enhanced video image of all ground activity as far as 90 miles away, day or night, regardless of cloud cover. Developed by DARPA in the mid-Seventies, J-STARS had nearly been axed in 1990 by Congress as a needless extravagance. It was not scheduled to be deployed in the Gulf, but General Norman Schwarzkopf was so impressed with its capabilities during a demonstration flight in Europe last October that he immediately ordered two, forcing Grumman Corp. and other military contractors to work around the clock through the Christmas holidays to ready them in time for the war.

It's not hard to see why Schwarzkopf was so keen to get hold of J-STARS. Ever since men first banded together to attack their enemies in an organized fashion, battle commanders have been desperate to know how things are going once the killing starts. Karl von Clausewitz, the grand old man of military strategists, called this ignorance "the fog of war." By generating nearly photographic-quality, real-time images of the ground action on video screens at allied headquarters, the J-STARS went a long way toward dispersing that fog, and it proved especially invaluable in the Gulf after the Iraqis set fire to the oil fields to try to conceal their troop movements. "You could argue that Iraq lost because it didn't know what was going on," says John Mansfield, a former DARPA director of strategic technologies.

DARPA also helped develop the precision-guided smart bombs that flew down air shafts to destroy military targets from the inside out, leaving neighboring buildings untouched. Smart bombs evolved out of a long-standing DARPA interest in what it termed "stand-off weapons," so named because they could reach their targets on their own. The weapons have transformed military strategy. "We've always looked at warfare as being speed, mass and surprise," said Air Force Brigadier General Buster C. Glosson. "We've changed that forever to speed, precision and surprise."

DARPA did early work on the Patriot missile, too, though nobody connected to DARPA is particularly pumped up about it. Jack Ruina, DARPA's director from 1961 to 1963, points out that the Scud is the Model T of ballistic missiles—"an old clunker," he calls it—that was launched one at a time and was much slower than the ICBMs that DARPA had been concentrating on. And the Patriot was unable to distinguish the warhead from other innocuous parts of the Scud missile. "It went after the biggest thing it saw," says Ruina. As a result, it let a number of the warheads through. "Just think if the Scuds had been carrying nuclear warheads," he says. "There would be no Haifa, Riyadh or Tel Aviv today."

DARPA made other contributions to the war effort—less publicized, perhaps, but just as crucial. Soldiers, pilots and sailors carried wallet-sized Global Positioning System (G.P.S.) monitors that, by receiving signals from a cluster of overhead satellites, allowed them to figure out exactly where they were in the featureless desert, in the air or out at sea. DARPA devised the technology for ATACMS (Army Tactical Missile Systems) long-range surface-to-surface missiles that used sensors to home in on the tops of Iraqi tanks and then explode over them, shooting a jet of molten metal through the tank. The agency came up with the remote-controlled, pilotless planes that circled a battlefield, sending back television pictures to headquarters. DARPA also produced the unmanned undersea vehicles, or U.U.V.s, that were used in the Gulf for classified missions believed to involve mine detection and general reconnaissance.

Based on what we now know about the Iraqi military, the war would most likely have been won without DARPA's contributions. But, as Martin Marietta's Tegnelia puts it, "DARPA certainly helped it go a lot quicker."

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Like so much of the American military, DARPA owes its creation to the Soviets; specifically, to the 1957 Sputnik rocket that raised the shocking prospect of the Communists' conquering outer space.

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that his *drahhve*?"

Carole, toting Yokoi's golf bag, stayed a discreet and very Asian ten yards behind her man as he strode through a dispiriting round. His gallery numbered two—Alan and Ilene Murakami had driven over from Texas to support their old friends. "A few years ago, Mickey and Carole had a chance to settle down. Mickey could have been an assistant pro," said Alan, a comfy suburbanite who is an account manager with a computer firm, "but they wanted to keep the dream alive." Watching one of Yokoi's three-foot putts lip out and return to sender, Alan Murakami shook his head. "Mickey always misses out, just by a hair." Then Alan, who carries a 16 handicap as a weekend golfer, said, "I still envy him. He gets to live the fantasy all of us golfers have."

At the 18th hole, a 527-yard par five, Yokoi hit a jumbo drive and a six iron that landed ten feet from the flag. Too bad it hit hot; the ball skipped into a trap behind the green. His bunker shot and Pyrrhic birdie putt drew applause but still meant 73-76. Yokoi didn't need to check the scoreboard to know he had missed the cùt. He went straight to the sun deck at Southern Trace, where he and Carole and the Murakamis ordered gumbo, sandwiches and lemonade. Sitting in the sun with his wife/caddie and his friends/gallery, enjoying his view of the 18th green, he made a fist and hit himself on the head. "I hate it," Yokoi said. "I hate missing cuts at a place like this. It's so nice being out here, then you have to leave so soon."

His eighth Q School was eight months away.

"We were made for each other. I like fast cars and sex outdoors and he has a Porsche with a sun roof."

MEN FROM DARPA

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The idea of establishing a far-out research group to work on military space technology (and, later, on other kinds of military technology) apparently came from President Eisenhower's Secretary of Defense, Neil McElroy, who in civilian life had set up a kind of department of creativity at Proctor and Gamble. The three military Services balked, but their very opposition clinched the deal, for Eisenhower had begun to weary of all the ridiculous competition among the Services. On February 7, 1958, he signed the bill authorizing ARPA, as it was initially called. (The word Defense was added later by Congress to underscore the primacy of its military mission.)

Defense Secretary McElroy also established the essential organizational principles of DARPA that have made it so effective. First, he decided that it should operate as a kind of venture-capital firm, funneling seed money to promising projects being developed at outside laboratories and relying on its program managers to take full command of their projects, paying for whatever research is needed without bureaucratic interference. "There were very few echelons at DARPA," Ruina recalls. "Everybody in the agency had easy and direct access to me and I reported directly to the Department of Defense's Undersecretary for Research and Engineering."

That freedom from bureaucratic encumbrance is the major lure to get hotshot scientists to work round-the-clock jobs for $50,000 a year. As former DARPA scientist Mansfield says, "If you can come up with the right project, DARPA gives you the money and gets out of the way. It's a wonderful atmosphere for a scientist."

Because the military's logistical problems aren't all that different from those of, say, Federal Express, DARPA has also, almost inadvertently, come up with a few innovations that have improved life in the private sector. In this country, it developed the computer before civilians saw its significance, leading MIT's professor John Deutch to assert that "the computer strength of the United States came out of DARPA." The agency's computer research has led to such fixtures of modern life as bank cash machines, computer graphics, work stations and the computer mouse. DARPA has also worked on such emerging hot technologies as superconductivity, artificial intelligence and neural networks.

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In its early days, DARPA concentrated on developing satellites, antiballistic missile systems and nuclear-test detection technology. But it branched into ground warfare during the early days of Vietnam. "Of all the things we did," says Ruina, who was director at the time, "that's

the program I am least fond of."

Vietnam just wasn't DARPA's kind of war. Its most original, not to say outlandish, solutions never quite fit, such as its plans for a four-legged robot to carry heavy loads along jungle trails. A later director, Eberhardt Rechtin, killed the project as a "damn-fool" idea; he was afraid Congress would get wind of it and question the entire DARPA endeavor.

The one worthwhile contribution DARPA made to the Vietnam war was to encourage the adoption of the AR-15 as the Army's standard-issue rifle. Tragically, later modifications by the Army ruined most of the gun's good points. It was not uncommon to find American soldiers dead, bent over a jammed M-16. The rifle acquired such a reputation that the Viet Cong, who routinely scavenged the equipment of dead GIs, left the M-16s right where they were. It took three years, but the Army eventually demodified the gun.

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In the Seventies, DARPA developed the Stealth technology that would make such a difference in the Persian Gulf. Although the Republicans are taking full credit for the victory that Stealth helped win, it was entirely a Democratic enterprise. Indeed, Stealth might never have made it onto an airplane if it hadn't been for William Perry, who served as Undersecretary of Defense for Research and Engineering during the Carter Administration. Perry was so captivated by the idea of an "invisible" plane that he once walked into a Stealth briefing with an empty model-airplane stand and declared, "Here's the Stealth bomber."

Still, it wasn't an easy sale. DARPA often has trouble with what's known as "technology transfer," the process of marketing its inventions to the Services. A large part of the problem is cultural. Whenever people start talking about DARPA, the word nerd, or even dweeb, is bound to come up. Academically trained DARPA scientists tend to approach military problems a little differently from career soldiers. DARPA dreams about particle beams; the military wants a reliable peashooter.

Then, too, the DARPA wizards have had their setbacks. For instance, they enlisted Gerald Bull, famed for the Supergun he was supposedly developing for the Iraqis before he was assassinated, to develop similar technology for the United States back in the early Sixties. Bull happily took the money but never produced, and DARPA "cut him off pretty quickly," recalls George Rathjens, a DARPA chief scientist in the early years.

"With all of DARPA's assignments, there is a high probability for failure," says military observer Richard Fieldhouse. "That's why they're DARPA projects. People come up with some far-out idea and say, 'It would be great if this works, but for lots of reasons, it probably won't, so you take it.'"

And then, lots of times, DARPA's blue-sky research generates technology that does work, but it's so kookie that no one can figure out what to do with it. Such as the Talking Heads project.

The Talking Heads project was developed for DARPA by a freewheeling MIT computer-science laboratory tapped to address the question of how top Government and military officials could communicate during a nuclear attack. Clearly, the key people in the Government couldn't hole up in the same nuclear shelter; but if they were dispersed, how could they effectively communicate? This got the MIT researchers thinking about the broader questions of "the transmission of presence."

So the group came up with a truly wild idea: to create sets of plastic masks of the faces of the President, Vice-President, Secretary of State, and so on, one set for each participant to array around him, re-creating (albeit eerily) the experience of being in a regular meeting with these dignitaries. The TV image of the actual person would be projected inside each mask, lighting up the George Bush mask, for instance, with George Bush's televised face. Each mask would be mounted on gimbals, so that as the officials sadly shook their heads in response to Dan Quayle's latest suggestion, the masks would twist back and forth.

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If you thought the Persian Gulf war was an astonishingly bloodless affair (for the Allies, anyway), wait till you see the next one. At least there were living, breathing American soldiers in the Gulf. If DARPA has its way, during the next war, we'll be tying yellow ribbons for the safe return of our robots.

"The whole idea is to get the human being out of harm's way," says Roger Schappell, the director of Martin Marietta's advanced automation technology group in Denver, Colorado, which is doing much of the military robotics work for DARPA. Technicians have completed the Autonomous Land Vehicle, which looks like a small, free-ranging locomotive. It can chug along a road at about ten miles an hour and can cut cross-country at about three and a half. By 1997, the A.L.V. should be available to scout deep behind enemy lines, take over for American soldiers in war zones that have been subjected to nuclear, biological or chemical attack and blast tanks and enemy fortifications—all on its own.

Some critics are leery of robots' making war. "You have enough problems with friendly fire on the battlefield as it is," says John Pike of the Federation of American Scientists. "From what I hear, the A.L.V. is still having a hard time staying on the road. If the robot isn't smart enough to stay on the road, I'm not sure I want to give it a shotgun."

Unmanned technology is further

along in its air and undersea versions, largely because they operate in environments that are far less complex than open countryside. Besides the unmanned undersea vehicle that has already been put to successful use in the Persian Gulf, Martin Marietta is completing an unmanned plane that makes the current generation of smart missiles look really dumb.

In the Persian Gulf, human beings still had to tell those bombs where to fly and what to hit. The next generation of smart bombs will do much of that on their own. They will consult a list of targets and then decide for themselves what to go for and how to approach it, depending on local weather conditions, enemy defenses, etc.

For planes that still require human pilots, DARPA has also been developing a sophisticated on-board computer system called the Pilot's Associate, which helps sort out the bewildering array of information that inundates a pilot. It keeps tabs on everything and alerts the pilot to a near-empty fuel tank, say, or an incoming SAM missile. "I call it God-is-my-copilot," says Pike.

There will be a copilot for generals back at command headquarters, too, in the form of a computerized "battle manager" that will speedily test-run alternative scenarios and analyze statistical probabilities to help commanders develop their battle strategies.

To the extent that American soldiers will still be required to fight a war, computers are now helping them train for it. At Fort Knox, Kentucky, the Army has installed what amounts to the world's largest interactive video game. It's called Simulator Networking, or SIMNET, and it features 60 ersatz M-1 tanks, Bradley fighting vehicles and other Army vehicles inside a hangar the size of a football field. Video screens provide computer-generated images of what the soldiers would be seeing through their viewers, plus a kind of Sensurround impression of war—blasts of artillery shells, the chugging of machine-gun fire over loudspeakers, the frantic shouts of commanders coming over the squawk box and the shaking and rumbling of vehicles whenever a shell hits too close.

SIMNET can also add air attacks into the mix with SIMNET–linked helicopters and fighter planes, to re-create a full-scale air–land battle. The tanks can split up to fight battles; in the future, they may even hook up to fight long distance with Fort Stewart or Fort Benning, or even with the Army base at Grafenwöhr in Germany. SIMNET also helped the 24th Infantry Division—some of the troops who sprinted across the desert to encircle the Iraqis—to quickly get familiarized with its equipment and fight a realistic war before it faced real bullets.

"SIMNET seems like a game at first, because the images are cartoonish," says Colonel Larry Mengel, the Army's systems manager for SIMNET. "But your brain accepts them after a while, and after two hours, they seem so real that if an enemy tank comes up out of the woods, it sends a chill down your spine."

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DARPA is making some of its heaviest investment in experimental planes. Some of them seem to reflect nothing more than an urge to show off: The X-29 is a normal plane in most respects, except that the wings are on backward, sweeping forward into the line of flight. That's a bit like Mozart playing the piano upside down. The plane is supposedly much more maneuverable, but it is also so hard to fly that if the computers ever fail, the pilot is on orders to eject immediately. DARPA also came up with the needle-nosed X-31, capable of awesome vertical climbs. And it is working up an odd cargo plane that looks like a flying trimaran, with two sets of unusually long wings that are joined by two tubular "pods" on either side of the fuselage. The ticktacktoe-board configuration helps the plane lift off from extremely short runways.

But the most ambitious plane in DARPA's experimental fleet is surely the X-30, the National Aero-Space Plane (NASP) that is intended to take off from a runway like a regular plane, then hit Mach 25 speeds on its way into orbit. (The supersonic Concorde flies at a sluggish Mach 2.) The plane would essentially be one long jet engine, with a wind tunnel running through the center of the fuselage. The air rushing into the nose would be mixed with liquid hydrogen, be ignited and then blown out the back as thrust. It remains to be seen whether combustion can occur with air shooting through the fuselage so fast. Said Robert R. Barthelemy, director of the National Aero-Space Plane Joint Program Office at Wright Patterson Air Force Base, "It's like lighting a match in a hurricane."

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For DARPA, the Persian Gulf war could not have come at a better time. Its director Craig Fields was assigned to the Pentagon last year; he had been accused of straying too far over the fine line that separates military from civilian interests. He had ventured into such projects as high-definition TV, gallium-arsenide computer chips (which can handle as many as 1000 more functions than current silicon chips) and lithium polymer batteries (more durable, powerful and versatile than conventional nickel-cadmium ones), and into programs such as the SEMATECH semiconductor consortium—all of which were not strictly military ventures but certainly provided military spin-offs. This technological adventurism did not please such free-market theologians as Budget Director Richard Darman and Chief of Staff John Sununu; Fields left the Government in May 1990.

For a while, there was some anxiety in Washington over the fate of DARPA itself. But after its performance in the Persian Gulf, it can breathe a lot easier. Few other 160-man Government agencies can claim to have made the Bush White House look so good, let alone to have changed something so fundamental as the nature of warfare. And we can expect that, in the next war, its latest gadgets will be there once more to clobber our foes, protect our soldiers and dazzle the folks back home. That is, if there's another enemy out there who's dumb enough to take on DARPA.