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Robots at War: The New Battlefield

by P. W. Singer

It sounds like science fiction, but it is fact: On the battlefields of Iraq and Afghanistan, robots are killing America's enemies and saving American lives. But today's PackBots, Predators, and Ravens are relatively primitive machines. The coming generation of "war-bots" will be immensely more sophisticated, and their development raises troubling new questions about how and when we wage war.

There was little to warn of the danger ahead. The Iraqi insurgent had laid his ambush with great cunning. Hidden along the side of the road, the bomb looked like any other piece of trash. American soldiers call these jury-rigged bombs IEDs, official shorthand for improvised explosive devices.

The unit hunting for the bomb was an explosive ordnance disposal (EOD) team, the sharp end of the spear in the effort to suppress roadside bombings. By 2006, about 2,500 of these attacks were occurring a month, and they were the leading cause of casualties among U.S. troops as well as Iraqi civilians. In a typical tour in Iraq, each EOD team would go on more than 600 calls, defusing or safely exploding about two devices a day. Perhaps the most telling sign of how critical the teams' work was to the American war effort is that insurgents began offering a rumored $50,000 bounty for killing an EOD soldier.

Unfortunately, this particular IED call would not end well. By the time the soldier was close enough to see the telltale wires protruding from the bomb, it was too late. There was no time to defuse the bomb or to escape. The IED erupted in a wave of flame.

Depending on how much explosive has been packed into an IED, a soldier must be as far as 50 yards away to escape death and as far as a half-mile away to escape injury from bomb fragments. Even if a person is not hit, the pressure from the blast by itself can break bones. This soldier, though, had been right on top of the bomb. As the flames and debris cleared, the rest of the team advanced. They found little left of their teammate. Hearts in their throats, they loaded the remains onto a helicopter, which took them back to the team's base camp near Baghdad International Airport.

That night, the team's commander, a Navy chief petty officer, did his sad duty and wrote home about the incident. The effect of this explosion had been particularly tough on his unit. They had lost their most fearless and technically savvy soldier. More important, they had lost a valued member of the team, a soldier who had saved the others' lives many times over. The soldier had always taken the most dangerous roles, willing to go first to scout for IEDs and ambushes. Yet the other soldiers in the unit had never once heard a complaint.

In his condolences, the chief noted the soldier's bravery and sacrifice. He apologized for his inability to change what had happened. But he also expressed his thanks and talked up the silver lining he took away from the loss. At least, he wrote, "when a robot dies, you don't have to write a letter to its mother."

The "soldier" in this case was a 42-pound robot called a PackBot. About the size of a lawn mower, the PackBot mounts all sorts of cameras and sensors, as well as a nimble arm with four joints. It moves using four "flippers." These are tiny treads that can also rotate on an axis, allowing the robot not only to roll forward and backward using the treads as a tank would, but also to flip its tracks up and down (almost like a seal moving) to climb stairs, rumble over rocks, squeeze down twisting tunnels, and even swim underwater. The cost to the United States of this "death" was $150,000.

The destination of the chief's two-story concrete office building across from a Macaroni Grill restaurant and a Men's Wearhouse clothing store in a drab office park outside Boston. On the corner is a sign for a company called iRobot, the maker of the PackBot. The name was inspired by Isaac Asimov's 1950 science-fiction classic *I, Robot,* in which robots of the future not only carry out mundane chores but make life-and-death decisions. It is at places like this office park that the future of war is being written.

The PackBot is only one of the many new unmanned systems operating in the wars in Iraq and Afghanistan today. When U.S. forces went into Iraq in 2003, they had zero robotic units on the ground. By the end of 2004, the number was up to 150. By the end of 2005 it was 2,400, and it more than doubled the next year. By the end of 2008, it was projected to reach as high as 12,000. And these weapons are just the first generation. Already in the prototype stage are varieties of unmanned weapons and exotic technologies, from automated machine guns and robotic stretcher-bearers to tiny but lethal robots the size of insects, which look like they are straight out of the wildest science fiction. Pentagon planners are having to figure out not only how to use machines such as the PackBot in the wars of today, but also how they should plan for battlefields in the near future that will be, as one officer put it, "largely robotic."

The most apt historical parallel to the current period in the development of robotics may well turn out to be World War I. Back then, strange, exciting new technologies that had been the stuff of science fiction just years earlier were introduced and used in increasing numbers on the battlefield. Indeed, it was H. G. Wells's 1903 short story "Land Ironclads" that inspired Winston Churchill to champion the development of the tank. Another story, by A. A. Milne, creator of the beloved *Winnie the Pooh* series, was among the first to raise the prospect of using airplanes in war, while Arthur Conan Doyle (in "Danger") and Jules Verne (in *Twenty Thousand Leagues Under the Sea*) pioneered the notion of using submarines in war. These new technologies didn't really change the fundamentals of war. But even the earliest models quickly proved useful enough to make it clear that they weren't going to be relegated to the realm of fiction again anytime soon. More important, they raised questions not only about how best to use them in battle, but also about an array of new political, moral, and legal issues. For instance, the United States' and Germany's differing interpretations of how submarine warfare should be conducted helped draw America into a world war. Similarly, airplanes proved useful for spotting and attacking troops at greater distances, but also allowed for strategic bombing of cities and other sites, which extended the battlefield to the home front.

Much the same sort of recalibration of thinking about war is starting to happen as a result of robotics today. On the civilian side, experts such as Microsoft's Bill Gates describe robotics as being close to where computers were in the early 1980s—still rare, but poised for a breakout. On the military side, unmanned systems are rapidly coming into use in almost every realm of war, moving more and more soldiers out of danger, and allowing their enemies to be targeted with increasing precision.

And they are changing the experience of war itself. This is leading some of the first generation of soldiers working with robots to worry that war waged by remote control will come to seem too easy, too tempting. More than a century ago, General Robert E. Lee famously observed, "It is good that we find war so horrible, or else we would become fond of it." He didn't contemplate a time when a pilot could "go to war" by commuting to work each morning in his Toyota to a cubicle where he could shoot missiles at an enemy thousands of miles away and then make it home in time for his kid's soccer practice.

As our weapons are designed to have ever more autonomy, deeper questions arise. Can the new armaments reliably separate friend from foe? What laws and ethical codes apply? What are we saying when we send out unmanned machines to fight for us? What is the "message" that those on the other side receive? Ultimately, how will humans remain masters of weapons that are immeasurably faster and more "intelligent" than they are?

The unmanned systems that have already been deployed to Iraq come in many shapes and sizes. All told, some 22 different robot systems are now operating on the ground. One retired Army officer speaks of these new forces as "the Army of the Grand Robotic."

One of the PackBot's fellow robo-soldiers in Iraq is the TALON, made by Foster-Miller Inc., whose offices are a few miles from iRobot's. Foster-Miller builds an EOD version of the TALON, but it has also remodeled the machine into a "killer app," the Special Weapons Observation Reconnaissance Detection System, or SWORDS. The new design allows users to mount different weapons on the robot—including an M-16 rifle, a machine gun, and a grenade or rocket launcher—and easily swap them out. Another robo-soldier is the MARCBOT (Multi-Function Agile Remote-Controlled Robot). One of the smallest but most commonly used robots in Iraq, the MARCBOT looks like a toy truck with a video camera mounted on a tiny, antenna-like mast. Costing only $5,000, this miniscule bot is used to scout

for enemies and to search under cars for hidden explosives. The MARCBOT isn't just notable for its small size; it was the first ground robot to draw blood in Iraq. One unit of U.S. soldiers jury-rigged their MARCBOTs to carry Claymore anti-personnel mines. If they thought an insurgent was hiding in an alley, they would send a MARCBOT down first and, if they found someone waiting in ambush, take him out with the Claymore. Of course, each insurgent killed in this fashion has meant $5,000 worth of blown-up robot parts, but so far the Army hasn't billed the soldiers.

The world of unmanned systems at war isn't confined to the ground. One of the most familiar unmanned aerial vehicles (UAVs) is the Predator. At 27 feet in length, the propeller-powered drone is just a bit smaller than a Cessna plane. Perhaps its most useful feature is that it can spend up to 24 hours in the air, at heights up to 26,000 feet. Predators are flown by what are called "reach-back" or "remote-split" operations. While the drone flies out of bases in the war zone, the human pilot and sensor operator are 7,500 miles away, flying the planes via satellite from a set of converted single-wide trailers located mostly at Nellis and Creech Air Force bases in Nevada. Such operations have created the novel situation of pilots experiencing the psychological disconnect of being "at war" while still dealing with the pressures of home. In the words of one Predator pilot, "You see Americans killed in front of your eyes and then have to go to a PTA meeting." Says another, "You are going to war for 12 hours, shooting weapons at targets, directing kills on enemy combatants, and then you get in the car, drive home, and within 20 minutes you are sitting at the dinner table talking to your kids about their homework."

Each Predator costs just under $4.5 million, which sounds like a lot until you compare it to the costs of other military aircraft. Indeed, for the price of one new F-35, the Pentagon's next-generation manned fighter jet (which hasn't even taken flight yet), you can buy 30 Predators. More important, the low price and lack of a human pilot mean that the Predator can be used for missions in which there is a high risk of being shot down, such as traveling low and slow over enemy territory. Predators originally were designed for reconnaissance and surveillance, but now some are armed with laser-guided Hellfire missiles. In addition to its deployments in Iraq and Afghanistan, the Predator, along with its larger, more heavily armed sibling, the Reaper, has been used with increasing frequency to attack suspected terrorists in Pakistan. According to news media reports, the drones are carrying out cross-border strikes at the rate of one every other day, operations that the Pakistani prime minister describes as the biggest point of contention between his country and the United States.

In addition to the Predator and Reaper, a veritable menagerie of drones now circle in the skies over war zones. Small UAVs such as the Raven, which is just over three feet long, or the even smaller Wasp (which carries a camera the size of a peanut) are tossed into the air by individual soldiers and fly just above the rooftops, transmitting video images of what's down the street or on the other side of the hill. Medium-sized drones such as the Shadow circle over entire neighborhoods, at heights above 1,500 feet, to monitor for anything suspicious. The larger Predators and Reapers roam over entire cities at 5,000 to 15,000 feet, hunting for targets to strike. Finally, sight unseen, 44-foot-long jet-powered Global Hawks zoom across much larger landscapes at 60,000 feet, monitoring electronic signals and capturing reams of detailed imagery for intelligence teams to sift through. Each Global Hawk can stay in the air as long as 35 hours. In other words, a Global Hawk could fly from San Francisco, spend a day hunting for terrorists throughout the entire state of Maine, then fly back to the West Coast.

A massive change has thus occurred in the airspace above wars. Only a handful of drones were used in the 2003 invasion of Iraq, with just one supporting all of V Corps, the primary U.S. Army combat force. Today there are more than 5,300 drones in the U.S. military's total inventory, and not a mission happens without them. One Air Force lieutenant general forecasts that "given the growth trends, it is not unreasonable to postulate future conflicts involving tens of thousands."

Between 2002 and 2008, the U.S. defense budget rose by 74 percent to $515 billion, not including the several hundred billions more spent on operations in Afghanistan and Iraq. With the defense budget at its highest level in real terms since 1946 (though it is still far lower as a percentage of gross domestic product), spending on military robotics research and development and subsequent procurement has boomed. The amount spent on ground robots, for example, has roughly doubled each year since 2001. "Make 'em as fast as you can" is what one robotics

executive says he was told by his Pentagon buyers after 9/11.

The result is that a significant military robotics industry is beginning to emerge. The World War I parallel is again instructive. As a report by the Pentagon's Defense Advanced Research Projects Agency (DARPA) noted, only 239 Ford Model T cars were sold in 1908. Ten years later, more than a million were.

It's not hard to see the appeal of robots to the Pentagon. Above all, they save lives. But they also don't come with some of our human frailties and foibles. "They don't get hungry," says Gordon Johnson of the Pentagon's Joint Forces Command. "They're not afraid. They don't forget their orders. They don't care if the guy next to them has just been shot. Will they do a better job than humans? Yes."

Robots are particularly attractive for roles dealing with what people in the field call the "Three D's"—tasks that are dull, dirty, or dangerous. Many military missions can be incredibly boring as well as physically taxing. Humans doing work that requires intense concentration need to take frequent breaks, for example, but robots do not. Using the same mine detection gear as a human, today's robots can do the same task in about a fifth the time and with greater accuracy.

Unmanned systems can also operate in "dirty" environments, such battle zones beset by bad weather or filled with biological or chemical weapons. In the past, humans and machines often had comparable limits. When the early fighter planes made high-speed turns or accelerations, for example, the same gravitational pressures (g-forces) that knocked out the human pilot would also tear the plane apart. But now, as one study said of the F-16 fighter jet, the machines are pushing far ahead: "The airplane was too good. In fact, it was better than its pilots in one crucial way: It could maneuver so fast and hard that its pilots blacked out." As a result of the new technologies, an official at DARPA observed, "the human is becoming the weakest link in defense systems."

With continuing advances in artificial intelligence, machines may soon overcome humans' main comparative advantage today, the mushy gray blob inside our skull. This is not just a matter of raw computing power. A soldier who learns French or marksmanship cannot easily pass that knowledge on to other soldiers. Computers have faster learning curves. They not only speak the same language but can be connected directly to one another via a wire or network, which means they have shareable intelligence.

The ability to compute and then act at digital speed is another robotic advantage. Humans, for example, can only react to incoming artillery fire by taking cover at the last second. But the Counter Rocket Artillery Mortar (CRAM) system uses radar to detect incoming rockets and mortar rounds and automatically direct the rapid fire of its Phalanx 20 mm Gatling guns against them, achieving a 70 percent shoot-down capability. More than 20 CRAMs—known affectionately as R2-D2s, after the little robot in *Star Wars* they resemble—are now in service in Iraq and Afghanistan. Some think that the speed of such weapons means they are only the start. One Army colonel says, "The trend towards the future will be robots reacting to robot attack, especially when operating at technologic speed. . . . As the loop gets shorter and shorter, there won't be any time in it for humans."

Each branch of America's armed services has ambitious plans for robotic technologies. On the ground, the various Army robotics programs are supposed to come together in the $230 billion Future Combat Systems (FCS) program, which military robots expert Robert Finkelstein describes as "the largest weapons procurement in history . . . at least in this part of the galaxy." FCS involves everything from replacing tens of thousands of armored vehicles with a new generation of manned and unmanned vehicles to writing some 34 million lines of software code for a computer network that will link them all together. The Army believes that by 2015 it will be in a position to reorganize many of its units into new FCS brigades. The brigades will present a revolutionary new model of how military units are staffed and organized. Each is expected to have more unmanned vehicles than manned ones (a ratio of 330 to 300) and will come with its own automated air force, with more than 100 drones controlled by the brigade's soldiers. The aircraft will range in size from a small unit that will fit in soldiers' backpacks to a 23-foot-long robotic helicopter.

At sea, the Navy is introducing or developing various exotic technologies, including new "unmanned underwater vehicles" that search for mines or function as minisubmarines, launched from manned submarines in order to hunt down an enemy. The Navy has tested machine gun–wielding robotic speedboats that can patrol harbors or chase down pirates (one has been used on missions in the Persian Gulf, spooking local fisherman), as well as various robotic planes and helicopters designed to take off from surface ships or launch underwater from submarines.

In the air, the next generation of unmanned vehicles will likewise be a mix of upgraded current systems, convertible manned vehicles, and brand-new designs. “Unmanned combat aerial systems,” such as the Boeing X-45 and the Northrop Grumman X-47, are the centerpiece of U.S. military plans for drones. Described as looking most like “a set piece from the television program *Battlestar Galactica,*” this type of drone is designed to take over the ultimate human pilot role, fighter jock. Especially stealthy and thus suitable for the most dangerous roles, the unmanned fighter plane prototypes have already shown some impressive capabilities. They have launched precision guided missiles, been “passed off” between different remote human operators 900 miles apart, and, in one war game, autonomously detected unexpected threats (missiles that “popped up” seemingly out of nowhere), engaged and destroyed them, then did their own battle damage assessment. The Navy plans to test its drone on aircraft carriers within the next three years, while the Air Force has taken its program into the “black” world of top-secret-development.

As new prototypes of aerial drones hit the battlefield, the trend will be for the size extremes to be pushed in two directions. Some drone prototypes have wings the length of football fields. Powered by solar energy and hydrogen, they are designed to stay in the air for days and even weeks, acting as mobile spy satellites or aerial gas stations. At the other size extreme are what technology journalist Noah Shachtman describes as “itty-bitty, teeny-weeny UAVs.” The military’s estimation of what is possible with micro air vehicles is illustrated by a contract let by DARPA in 2006. It sought an insect-sized drone that weighed under 10 grams (roughly a third of an ounce), was less than 7.5 centimeters long, had a speed of 10 meters per second and a range of 1,000 meters, and could hover in place for at least a minute.

As our machines get smaller, they will move into the nanotechnology realm, once only theoretical. A major advance in the field occurred in 2007, when David Leigh, a researcher at the University of Edinburgh, revealed that he had built a “nanomachine” whose parts consisted of single molecules. When asked to describe the significance of his discovery to a normal person, Leigh said it would be difficult to predict. “It is a bit like when stone-age man made his wheel, asking him to predict the motorway,” he said.

Despite all the enthusiasm in military circles for the next generation of unmanned vehicles, ships, and planes, there is one question that people are generally reluctant to talk about. It is the equivalent of Lord Voldemort in *Harry Potter,* The Issue That Must Not Be Discussed. What happens to the human role in war as we arm ever more intelligent, more capable, and more autonomous robots?

When this issue comes up, both specialists and military folks tend to change the subject or speak in absolutes. “People will always want humans in the loop,” says Eliot Cohen, a noted military expert at Johns Hopkins who served in the State Department under President George W. Bush. An Air Force captain similarly writes in his service’s professional journal, “In some cases, the potential exists to remove the man from harm’s way. Does this mean there will no longer be a man in the loop? No. Does this mean that brave men and women will no longer face death in combat? No. There will always be a need for the intrepid souls to fling their bodies across the sky.”

All the rhetoric ignores the reality that humans started moving out of “the loop” a long time before robots made their way onto battlefields. As far back as World War II, the Norden bombsight made calculations of height, speed, and trajectory too complex for a human alone when it came to deciding when to drop a bomb. By the Persian Gulf War, Captain Doug Fries, a radar navigator, could write this description of what it was like to bomb Iraq from his B-52: “The navigation computer opened the bomb bay doors and dropped the weapons into the dark.”

In the Navy, the trend toward computer autonomy has been in place since the Aegis computer system was introduced in the 1980s. Designed to defend Navy ships against missile and plane attacks, the system operates in four modes, from “semi-automatic,” in which humans work with the system to judge when and at what to shoot, to “casualty,” in which the system operates as if all the humans are dead and does what it calculates is best to keep the ship from being hit. Humans can override the Aegis system in any of its modes, but experience shows that this capability is often beside the point, since people hesitate to use this power. Sometimes the consequences are tragic.

The most dramatic instance of a failure to override occurred in the Persian Gulf on July 3, 1988, during a patrol mission of the U.S.S. *Vincennes*. The ship had been nicknamed “Robo-cruiser,” both because of the new Aegis radar system it was carrying and because its captain had a reputation for being overly aggressive. That day, the

Vincennes's radars spotted Iran Air Flight 655, an Airbus passenger jet. The jet was on a consistent course and speed and was broadcasting a radar and radio signal that showed it to be civilian. The automated Aegis system, though, had been designed for managing battles against attacking Soviet bombers in the open North Atlantic, not for dealing with skies crowded with civilian aircraft like those over the gulf. The computer system registered the plane with an icon on the screen that made it appear to be an Iranian F-14 fighter (a plane half the size), and hence an "assumed enemy."

Though the hard data were telling the human crew that the plane wasn't a fighter jet, they trusted the computer more. Aegis was in semi-automatic mode, giving it the least amount of autonomy, but not one of the 18 sailors and officers in the command crew challenged the computer's wisdom. They authorized it to fire. (That they even had the authority to do so without seeking permission from more senior officers in the fleet, as their counterparts on any other ship would have had to do, was itself a product of the fact that the Navy had greater confidence in Aegis than in a human-crewed ship without it.) Only after the fact did the crew members realize that they had accidentally shot down an airliner, killing all 290 passengers and crew, including 66 children.

The tragedy of Flight 655 was no isolated incident. Indeed, much the same scenario was repeated a few years ago, when U.S. Patriot missile batteries accidentally shot down two allied planes during the Iraq invasion of 2003. The Patriot systems classified the craft as Iraqi rockets. There were only a few seconds to make a decision. So machine judgment trumped any human decisions. In both of these cases, the human power "in the loop" was actually only veto power, and even that was a power that military personnel were unwilling to use against the quicker (and what they viewed as superior) judgment of a computer.

The point is not that the machines are taking over, *Matrix*-style, but that what it means to have humans "in the loop" of decision making in war is being redefined, with the authority and autonomy of machines expanding. There are myriad pressures to give war-bots greater and greater autonomy. The first is simply the push to make more capable and more intelligent robots. But as psychologist and artificial intelligence expert Robert Epstein notes, this comes with a built-in paradox. "The irony is that the military will want [a robot] to be able to learn, react, etc., in order for it to do its mission well. But they won't want it to be too creative, just like with soldiers. But once you reach a space where it is really capable, how do you limit them? To be honest, I don't think we can."

Simple military expediency also widens the loop. To achieve any sort of personnel savings from using unmanned systems, one human operator has to be able to "supervise" (as opposed to control) a larger number of robots. For example, the Army's long-term Future Combat Systems plan calls for two humans to sit at identical consoles and jointly supervise a team of 10 land robots. In this scenario, the humans delegate tasks to increasingly autonomous robots, but the robots still need human permission to fire weapons. There are many reasons, however, to believe that this arrangement will not prove workable.

Researchers are finding that humans have a hard time controlling multiple units at once (imagine playing five different video games simultaneously). Even having human operators control two UAVs at a time rather than one reduces performance levels by an average of 50 percent. As a NATO study concluded, the goal of having one operator control multiple vehicles is "currently, at best, very ambitious, and, at worst, improbable to achieve." And this is with systems that aren't shooting or being shot at. As one Pentagon-funded report noted, "Even if the tactical commander is aware of the location of all his units, the combat is so fluid and fast paced that it is very difficult to control them." So a push is made to give more autonomy to the machine.

And then there is the fact that an enemy is involved. If the robots aren't going to fire unless a remote operator authorizes them to, then a foe need only disrupt that communication. Military officers counter that, while they don't like the idea of taking humans out of the loop, there has to be an exception, a backup plan for when communications are cut and the robot is "fighting blind." So another exception is made.

Even if the communications link is not broken, there are combat situations in which there is not enough time for the human operator to react, even if the enemy is not functioning at digital speed. For instance, a number of robot makers have added "countersniper" capabilities to their machines, enabling them to automatically track down and target with a laser beam any enemy that shoots. But those precious seconds while the human decides whether to fire back could let the enemy get away. As one U.S. military officer observes, there is nothing technical to prevent one from rigging the machine to shoot something more lethal than light. "If you can automatically hit it with a laser range finder, you can hit it with a bullet."

This creates a powerful argument for another exception to the rule that humans must always be "in the loop," that is, giving robots the ability to fire back on their own. This kind of autonomy is generally seen as more palatable than

other types. “People tend to feel a little bit differently about the counterpunch than the punch,” Noah Shachtman notes. As Gordon Johnson of the Army’s Joint Forces Command explains, such autonomy soon comes to be viewed as not only logical but quite attractive. “Anyone who would shoot at our forces would die. Before he can drop that weapon and run, he’s probably already dead. Well now, these cowards in Baghdad would have to pay with blood and guts every time they shot at one of our folks. The costs of poker went up significantly. The enemy, are they going to give up blood and guts to kill machines? I’m guessing not.”

Each exception, however, pushes one further and further from the absolute of “never” and instead down a slippery slope. And at each step, once robots “establish a track record of reliability in finding the right targets and employing weapons properly,” says John Tirpak, executive editor of *Air Force Magazine,* the “machines will be trusted.”

The reality is that the human location “in the loop” is already becoming, as retired Army colonel Thomas Adams notes, that of “a supervisor who serves in a fail-safe capacity in the event of a system malfunction.” Even then, he thinks that the speed, confusion, and information overload of modern-day war will soon move the whole process outside “human space.” He describes how the coming weapons “will be too fast, too small, too numerous, and will create an environment too complex for humans to direct.” As Adams concludes, the new technologies “are rapidly taking us to a place where we may not want to go, but probably are unable to avoid.”

The irony is that for all the claims by military, political, and scientific leaders that “humans will always be in the loop,” as far back as 2004 the U.S. Army was carrying out research that demonstrated the merits of armed ground robots equipped with a “quick-draw response.” Similarly, a 2006 study by the Defense Safety Working Group, in the Office of the Secretary of Defense, discussed how the concerns over potential killer robots could be allayed by giving “armed autonomous systems” permission to “shoot to destroy hostile weapons systems but not suspected combatants.” That is, they could shoot at tanks and jeeps, just not the people in them. Perhaps most telling is a report that the Joint Forces Command drew up in 2005, which suggested that autonomous robots on the battlefield would be the norm within 20 years. Its title is somewhat amusing, given the official line one usually hears: *Unmanned Effects: Taking the Human Out of the Loop.*

So, despite what one article called “all the lip service paid to keeping a human in the loop,” autonomous armed robots are coming to war. They simply make too much sense to the people who matter.

With robots taking on more and more roles, and humans ever further out of the loop, some wonder whether human warriors will eventually be rendered obsolete. Describing a visit he had with the 2007 graduating class at the Air Force Academy, a retired Air Force officer says, “There is a lot of fear that they will never be able to fly in combat.”

The most controversial role for robots in the future would be as replacements for the human grunt in the field. In 2004, DARPA researchers surveyed a group of U.S. military officers and robotics scientists about the roles they thought robots would take over in the near future. The officers predicted that countermine operations would go first, followed by reconnaissance, forward observation, logistics, then infantry. Oddly, among the last roles they named were air defense, driving or piloting vehicles, and food service—each of which has already seen automation. Special Forces roles were felt, on average, to be least likely ever to be delegated to robots.

The average year the soldiers predicted that humanoid robots would start to be used in infantry combat roles was 2025. Their answer wasn’t much different from that of the scientists, who gave 2020 as their prediction. To be clear, these numbers only reflect the opinions of those in the survey, and could prove to be way off. Robert Finkelstein, a veteran engineer who now heads Robotic Technologies Inc. and who helped conduct the survey, thinks these projections are highly optimistic and that it won’t be until “2035 [that] we will have robots as fully capable as human soldiers on the battlefield.” But the broader point is that many specialists are starting to contemplate a world in which robots will replace the grunt in the field well before many of us pay off our mortgages.

However, as H. R. “Bart” Everett, a Navy robotics pioneer, explains, the full-scale replacement of humans in battle is not likely to occur anytime soon. Instead, the human use of robots in war will evolve “to more of a team approach.” His program, the Space and Naval Warfare Systems Center, has joined with the Office of Naval Research to support the activation of a “warfighters’ associate” concept within the next 10 to 20 years. Humans and robots would be integrated into a team that shares information and coordinates action toward a common goal. Says

Everett, “I firmly believe the intelligent mobile robot will ultimately achieve sufficient capability to be accepted by the warfighter as an equal partner in a human-robot team, much along the lines of a police dog and its handler.”

A 2006 solicitation by the Pentagon to the robotics industry captures the vision: “The challenge is to create a system demonstrating the use of multiple robots with one or more humans on a highly constrained tactical maneuver. . . . One example of such a maneuver is the through-the-door procedure often used by police and soldiers to enter an urban dwelling . . . [in which] one kicks in the door then pulls back so another can enter low and move left, followed by another who enters high and moves right, etc. In this project the teams will consist of robot platforms working with one or more human teammates as a cohesive unit.”

Another U.S. military–funded project envisions the creation of “playbooks” for tactical operations by a robot-human team. Much like a football quarterback, the human soldier would call the “play” for robots to carry out, but like the players on the field, the robots would have the latitude to change what they did if the situation shifted.

The military, then, doesn’t expect to replace all its soldiers with robots anytime soon, but rather sees a process of integration into a force that will become, as the Joint Forces Command projected in its 2025 plans, “largely robotic.” The individual robots will “have some level of autonomy—adjustable autonomy or supervised autonomy or full autonomy within mission bounds,” but it is important to note that the autonomy of any human soldiers in these units will also be circumscribed by their orders and rules.

If the future is one of robot squad mates and robot wingmen, many scientists think it puts a premium on two things, both very human in nature. The first is good communication. In 2004, Lockheed tested an unmanned jet that responded to simple vocal commands. A pilot flying in another plane would give the drone some broad mission, such as to go to a certain area and photograph a specific building, and the plane would carry it out. As one report explains, “The next war could be fought partly by unmanned aircraft that respond to spoken commands in plain English and then figure out on their own how to get the job done.” The robot’s responses may even sound human. WT-6 is a robot in Japan that has a human-sounding vocal system, produced from an artificial tongue, lips, teeth, vocal cords, lungs, and soft palate made from polymers.

To work well together, robots and human soldiers will need to have confidence in each other. It sounds funny to say that about the relationship between a bucket of bolts and a human, but David Bruemmer, a scientist at the Idaho National Laboratory, actually specializes in how humans and robots work together. “Trust,” he says, without any irony, “is a huge issue for robot performance.”

Trust is having a proper sense of what the other is capable of, as well as being correct in your expectations of what the other will do. One of Bruemmer’s more interesting findings is that novices tend to make the best use of robotic systems. They “trust” robot autonomy the most and “let [the robot] do its job.” Over time, Bruemmer predicts, robots will likely have “dynamic autonomy” built in, with the amount of “leash” they are given determined less by any principle of keeping humans “in the loop” than by their human teammates’ experience and trust level.

Lawrence J. Korb is one of the deans of Washington’s defense policy establishment. A former Navy flight officer, he served as assistant secretary of defense during the Reagan administration. Now he is a senior fellow at the Center for American Progress, a left-leaning think tank. Korb has seen presidential administrations, and their wars, come and go. And, as the author of 20 books and more than 100 articles, and a veteran of more than a thousand TV - news-show appearances, he has also helped shape how the American news media and public understand these wars. In 2007, I asked him what he thought was the most important overlooked issue in Washington defense circles. He answered, “Robotics and all this unmanned stuff. What are the effects? Will it make war more likely?”

Korb is a great supporter of unmanned systems for a simple reason: “They save lives.” But he worries about their effect on the perceptions and psychologies of war, not merely among foreign publics and media, but also at home. As more and more unmanned systems are used, he sees change occurring in two ways, both of which he fears will make war more likely. Robotics “will further disconnect the military from society. People are more likely to support the use of force as long as they view it as costless.” Even more worrisome, a new kind of voyeurism enabled by the emerging technologies will make the public more susceptible to attempts to sell the ease of a potential war. “There will be more marketing of wars. More ‘shock and awe’ talk to defray discussion of the costs.”

Korb is equally troubled by the effect that such technologies will have on how political leaders look at war and its costs. “It will make people think, ‘Gee, warfare is easy.’ Remember all the claims of a ‘cakewalk’ in Iraq and how the Afghan model would apply? The whole idea that all it took to win a war was ‘three men and a satellite phone’? Well, their thinking is that if they can get the Army to be as technologically dominant as the other services, we’ll solve these problems.”

Korb believes that political Washington has been “chastened by Iraq.” But he worries about the next generation of policymakers. Technologies such as unmanned systems can be seductive, feeding overconfidence that can lead nations into wars for which they aren’t ready. “Leaders without experience tend to forget about the other side, that it can adapt. They tend to think of the other side as static and fall into a technology trap.”

“We’ll have more Kosovos and less Iraqs,” is how Korb sums up where he thinks we are headed. That is, he predicts more punitive interventions such as the Kosovo strikes of 1999, launched without ground troops, and fewer operations like the invasion of Iraq. As unmanned systems become more prevalent, we’ll become more likely to use force, but also see the bar raised on anything that exposes human troops to danger. Korb envisions a future in which the United States is willing to fight, but only from afar, in which it is more willing to punish by means of war but less willing to face the costs of war.

Immanuel Kant’s *Perpetual Peace* (1795) first expressed the idea that democracies are superior to all other forms of government because they are inherently more peaceful and less aggressive. This “democratic peace” argument (cited by presidents across the partisan spectrum from Bill Clinton to George W. Bush) is founded on the belief that democracies have a built-in connection between their foreign policy and domestic politics that other systems of government lack. When the people share a voice in any decision, including whether to go to war, they are supposed to choose more wisely than an unchecked king or potentate.

Colonel R. D. Hooker Jr. is an Iraq veteran and the commander of an Army airborne brigade. As he explains, the people and their military in the field should be linked in two ways. The first is the direct stake the public has in the government’s policies. “War is much more than strategy and policy because it is visceral and personal. . . . Its victories and defeats, joys and sorrows, highs and depressions, are expressed fundamentally through a collective sense of exhilaration or despair. For the combatants, war means the prospect of death or wounds and a loss of friends and comrades that is scarcely less tragic.” Because it is their blood that will be personally invested, citizen--soldiers, as well as their fathers, mothers, uncles, and cousins who vote, combine to dissuade leaders from foreign misadventures and ill-planned aggression.

The second link is supposed to come indirectly, through a democracy’s free media, which widen the impact of those investments of blood to the public at large. “Society is an intimate participant [in war] too, through the bulletins and statements of political leaders, through the lens of an omnipresent media, and in the homes of the families and the communities where they live. Here, the safe return or death in action of a loved one, magnified thousands of times, resonates powerfully and far afield,” Hooker says.

The news media’s role in a free system, then, is not merely to report on a war’s outcome, as if reporting on a sporting event. The public’s perceptions of events on distant battlefields create pressures on elected leaders. Too much pressure can lead an elected leader to try to interfere in ongoing operations, as bad an idea in war as it would be in sports for the fans to call in the plays for their favorite team. But, as Korb and Hooker explain, too little public pressure may be worse. It’s the equivalent of no one even caring about the game or its outcome. War becomes the -WNBA.

Many worry that this democratic ideal is already under siege. The American military has been at war for the past eight years in places such as Afghanistan and Iraq, but other than suffering the indignity of smaller bottles of shampoo in its carry-on luggage, the American nation has not. Since the end of the draft, most Americans no longer have to think about whether their husband, wife, son, or daughter would be at risk if the military were sent to war. During World War II, by comparison, more than 16 million men and women, about 11 percent of the American populace, served in the military—the equivalent of more than 30 million today.

By the start of the 21st century, even the financial costs on the home front had been displaced. After September

11, industry didn't need to retool its factories, and families didn't need to ration fuel or food, or even show their faith in the war effort by purchasing bonds. (Instead, a tax cut lightened the burden on Americans, especially the affluent.) When asked what citizens could do to share in the risks and sacrifices of soldiers in the field, the response from the commander in chief was, "Go shopping." The result is an American public that is less invested in and linked to its foreign policy than ever before in a democracy.

With this trend already in place, some worry that robot technologies will snip the last remaining threads of connection. Unmanned systems represent the ultimate break between the public and its military. With no draft, no need for congressional approval (the last formal declaration of war was in 1941), no tax or war bonds, and now the knowledge that the Americans at risk are mainly just American machines, the already falling bars to war may well hit the ground. A leader won't need to do the kind of consensus building that is normally required before a war, and won't even need to unite the country behind the effort. In turn, the public truly will become the equivalent of sports fans watching war, rather than citizens sharing in its importance.

But our new technologies don't merely remove human risk, they also record all they experience, and in so doing reshape the public's link to war. The Iraq war is literally the first conflict in which you can download video of combat from the Web. By the middle of 2007, there were more than 7,000 video clips of combat footage from Iraq on YouTube alone. Much of this footage was captured by drones and unmanned sensors and then posted online.

The trend toward video war could build connections between the war front and home front, allowing the public to see what is happening in battle as never before. But inevitably, the ability to download the latest snippets of robotic combat footage to home computers and iPhones turns war into a sort of entertainment. Soldiers call these clips "war porn." Particularly interesting or gruesome combat footage, such as video of an insurgent being blown up by a UAV, is posted on blogs and forwarded to friends, family, and colleagues with subject lines like "Watch this!" much as an amusing clip of a nerdy kid dancing around in his basement might be e-mailed around. A typical clip that has been making the rounds shows people's bodies being blown into the air by a Predator strike, set to the tune of Sugar Ray's snappy pop song "I Just Want to Fly."

From this perspective, war becomes, as one security analyst put it, "a global spectator sport for those not involved in it." More broadly, while video images engage the public in a whole new way, they can fool many viewers into thinking they now have a true sense of what is happening in the conflict. The ability to watch more but experience less has a paradoxical effect. It widens the gap between our perceptions and war's realities. To make another sports parallel, it's the difference between watching an NBA game on television, with the tiny figures on the screen, and knowing what it feels like to have a screaming Kevin Garnett knock you down and dunk over your head. Even worse, the video segments that civilians see don't show the whole gamut of war, but are merely the bastardized ESPN *SportsCenter* version. The context, the strategy, the training, the tactics—they all just become slam dunks and smart bombs.

War porn tends to hide other hard realities of battle. Most viewers have an instinctive aversion to watching a clip in which the target might be someone they know or a fellow American; such clips are usually banned from U.S.-hosted websites. But many people are perfectly happy to watch video of a drone ending the life of some anonymous enemy, even if it is just to see if the machines fighting in Iraq are as "sick" as those in the *Transformers* movie, the motive one student gave me for why he downloaded the clips. To a public with so much less at risk, wars take on what analyst Christopher Coker called "the pleasure of a spectacle with the added thrill that it is real for someone, but not the spectator."

Such changed connections don't just make a public less likely to wield its veto power over its elected leaders. As Lawrence Korb observed, they also alter the calculations of the leaders themselves.

Nations often go to war because of overconfidence. This makes perfect sense; few leaders choose to start a conflict thinking they will lose. Historians have found that technology can play a big role in feeding overconfidence: New weapons and capabilities breed new perceptions, as well as misperceptions, about what might be possible in a war. Today's new technologies are particularly likely to feed overconfidence. They are perceived to help the offensive side in a war more than the defense, plus, they are improving at an exponential pace. The difference of just a few years of research and development can create vast differences in weapons' capabilities. But this can generate a sort of "use it or lose it" mentality, as even the best of technological advantages can prove fleeting (and

the United States has reasons for concern, as 42 countries are now working on military robotics, from Iran and China to Belarus and Pakistan). Finally, as one roboticist explains, a vicious circle is generated. Scientists and companies often overstate the value of new technologies in order to get governments to buy them, but if leaders believe the hype, they may be more likely to feel adventurous.

James Der Derian is an expert at Brown University on new modes of war. He believes that the combination of these factors means that robotics will "lower the threshold for violence." The result is a dangerous mixture: leaders unchecked by a public veto now gone missing, combined with technologies that seem to offer spectacular results with few lives lost. It's a brew that could prove very seductive to decision makers. "If one can argue that such new technologies will offer less harm to us and them, then it is more likely that we'll reach for them early, rather than spending weeks and months slogging at diplomacy."

When faced with a dispute or crisis, policymakers have typically regarded the use of force as the "option of last resort." Unmanned systems might now help that option move up the list, with each upward step making war more likely. That returns us to Korb's scenario of "more Kosovos, less Iraqs."

While avoiding the mistakes of Iraq certainly sounds like a positive result, the other side of the tradeoff would not be without problems. The 1990s were not the halcyon days some recall. Lowering the bar to allow for more unmanned strikes from afar would lead to an approach resembling the "cruise missile diplomacy" of that period. Such a strategy may leave fewer troops stuck on the ground, but, as shown by the strikes against Al Qaeda camps in Sudan and Afghanistan in 1998, the Kosovo war in 1999, and perhaps now the drone strikes in Pakistan, it produces military action without any true sense of a commitment, lash-outs that yield incomplete victories at best. As one U.S. Army report notes, such operations "feel good for a time, but accomplish little." They involve the country in a problem, but do not resolve it.

Even worse, Korb may be wrong, and the dynamic may yield not fewer Iraqs but more of them. It was the lure of an easy preemptive action that helped get the United States into such trouble in Iraq in the first place. As one robotics scientist says of the new technology he is building, "The military thinks that it will allow them to nip things in the bud, deal with the bad guys earlier and easier, rather than having to get into a big-ass war. But the most likely thing that will happen is that we'll be throwing a bunch of high tech against the usual urban guerillas. . . . It will stem the tide [of U.S. casualties], but it won't give us some asymmetric advantage."

Thus, robots may entail a dark irony. By appearing to lower the human costs of war, they may seduce us into more wars.

Whether it's watching wars from afar or sending robots instead of fellow citizens into harm's way, robotics offers the public and its leaders the lure of riskless warfare. All the potential gains of war would come without the costs, and even be mildly entertaining.

It's a heady enticement, and not just for evil warmongers. The world watched the horrors of Bosnia, Rwanda, and Congo but did little, chiefly because the public didn't know or care enough and the perceived costs of doing something truly effective seemed too high. Substitute unmanned systems for troops, and the calculus might be changed. Indeed, imagine all the genocides and crimes against humanity that could be ended if only the human barriers to war were lowered. Getting tired of some dictator massacring his people? Send in your superior technology and watch on YouTube as his troops are taken down.

Yet wars never turn out to be that simple. They are complex, messy, and unpredictable. And this will remain the case even as unmanned systems increasingly substitute for humans.

But let's imagine that such fantasies of cheap and costless unmanned wars were to come true, that we could use robots to stop bad things being done by bad people, with no blowback, no muss, and no fuss. Even that prospect should give us pause. By cutting the already tenuous link between the public and its nation's foreign policy, pain--free war would pervert the whole idea of the democratic process and citizenship as they relate to war. When a citizenry has no sense of sacrifice or even the prospect of sacrifice, the decision to go to war becomes just like any other policy decision, weighed by the same calculus used to determine whether to raise bridge tolls. Instead of widespread engagement and debate over the most important decision a government can make, you get popular

indifference. When technology turns war into something merely to be watched, and not weighed with great seriousness, the checks and balances that undergird democracy go by the wayside. This could well mean the end of any idea of democratic peace that supposedly sets our foreign-policy decision making apart.

Such wars without costs could even undermine the morality of "good" wars. When a nation decides to go to war, it is not just deciding to break stuff in some foreign land. As one philosopher put it, the very decision is "a reflection of the moral character of the community who decides." Without public debate and support and without risking troops, the decision to go to war becomes the act of a nation that doesn't give a damn.

Even if the nation sending in its robots acts in a just cause, such as stopping a genocide, war without risk or sacrifice becomes merely an act of somewhat selfish charity. One side has the wealth to afford high technologies, and the other does not. The only message of "moral character" a nation transmits is that it alone gets the right to stop bad things, but only at the time and place of its choosing, and most important, only if the costs are low enough. With robots, the human costs weighed against those lives that might be saved become zero. It doesn't mean the nation shouldn't act. But when it does, it must realize that even the just wars become exercises in playing God from afar, with unmanned weapons substituting for thunderbolts.

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