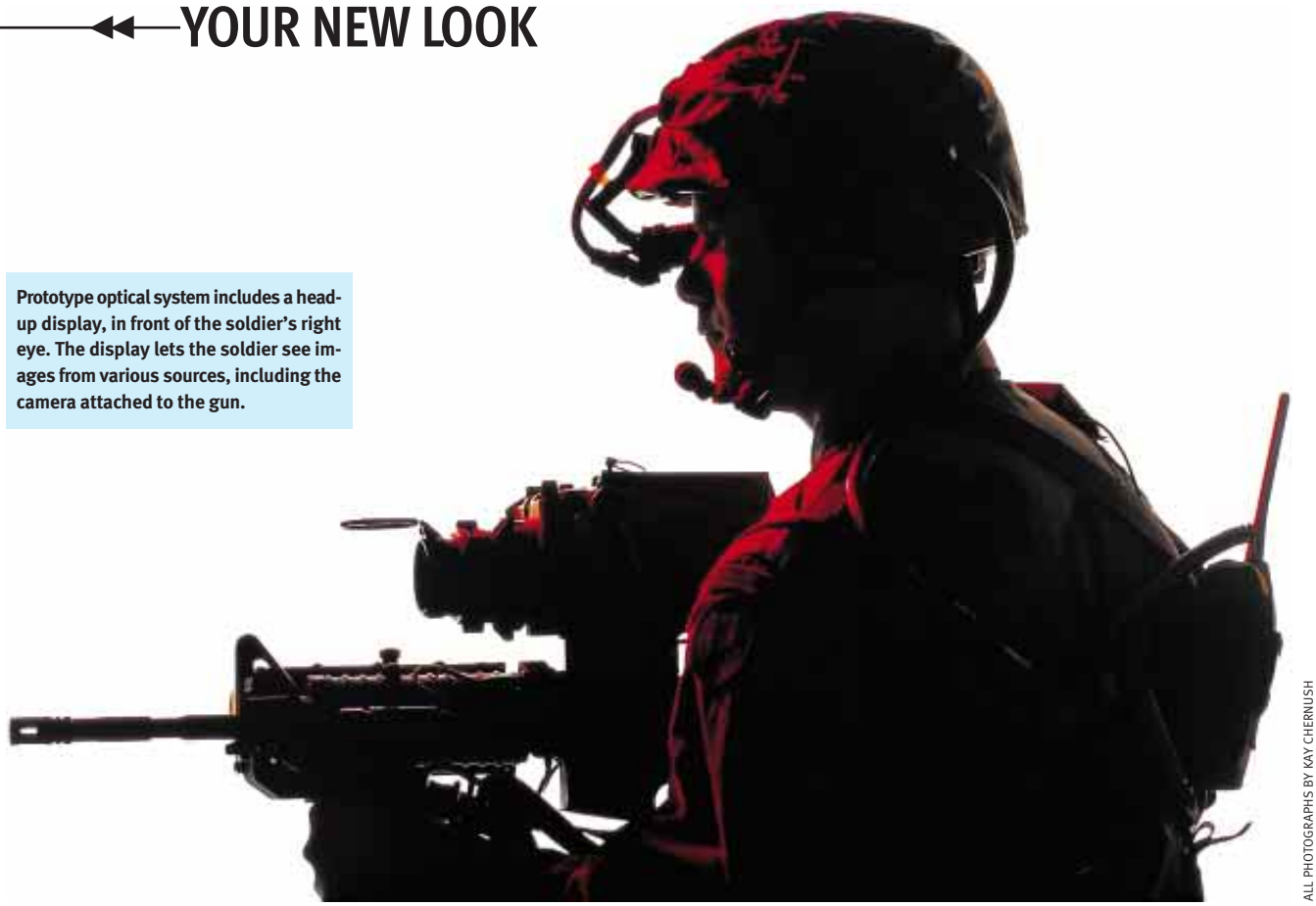

Prototype optical system includes a head-up display, in front of the soldier's right eye. The display lets the soldier see images from various sources, including the camera attached to the gun.

ALL PHOTOGRAPHS BY KAY CHERNUSH

WHAT THE WELL-DRESSED WARRIOR WILL WEAR

Power-generating, chameleonic clothes, food made from bugs and leaves, and tiny robotic scouts may assist the soldier of the next century. **By Steve Nadis**

YOU'RE ALONE, trapped behind enemy lines. You've got your wits to rely on—plus more gadgets than James Bond ever dreamed of. First you unleash a squadron of insect-size robots with tiny cameras to survey the area for hidden threats. Your chameleonic outfit automatically blends in with the surroundings, and its interactive textiles employ "stealth" technology to make you invisible to enemy sensors. And if all else fails, you've still got holographic decoys to confuse the enemy and viruses to disrupt its computers.

Sound far-fetched? Not to the U.S. Army Soldier Systems Center (SSCEN) in Natick, Mass. The center's 550 engineers, technicians and scientists are working on an array of technologies to feed and clothe soldiers, to make them more lethal and mobile, and to help them survive serious injury.

FUTURE MESS: BUG McNUGGETS

If an army marches on its stomach, as Napoleon Bonaparte is supposed to have said, it is Gerald Darsch's job to come up with the lightest, most advanced fuels. Darsch, a project director in the Combat Feeding Program, dreams of high-density rations the size of a deck of cards that would provide a soldier's nutritional and caloric needs for a full day. He hopes these so-called smart foods, or "nutraceuticals," will not only feed soldiers but also boost their immune systems and alleviate stress. During intense conflicts, when troops would not even have time to eat, they could be sustained by a device known, unappetizingly enough, as a transdermal nutrient delivery system. Its sensors would assess the individual's nutritional status, and a patch would administer through the skin the needed vitamins, minerals, amino acids and sugars.

High-tech vending machines, airlifted to troops in the field and powered by microwaves beamed from satellites, would dispense "mission-appropriate" rations. In addition, groups of soldiers would be equipped with "biodigesters" that could convert available ingredients, such as grass, leaves, bugs and worms, into nutritious, if not exactly sumptuous, meals.

Although none of Darsch's futuristic fare exists today, he thinks some will be available by 2025. "If it took McDonald's 10 years to field Chicken McNuggets," he shrugs, "it could take us even longer to field this."

The army is also taking a long-range view with regard to shielding its warriors from water, heat, cold, bullets, and even chemical and biological agents. Plans call for outfitting soldiers in lightweight, so-called reactive garments whose microscopic fibers will be treated to give them various properties. Using a technique called electrospinning, SSCEN chemist Heidi Schroeder-Gibson has produced a thin polymer shell, which could be fashioned into a body glove that would act as a protective second skin. Though composed of the tiny fibers, the shell has the consistency and texture of a balloon. According to Schroeder-Gibson, "we could put a lot of things in those fibers"—carbon to absorb toxic chemicals, enzymes to break down nerve agents, and environmental sensors—"depositing them in different layers to give the garments the features we want."

Researchers at the center think the polymer shells could form the basis of sensate liners in which a built-in network of sensors, fiber-optic wires and other conductive fibers would ascertain whether a soldier has been wounded and determine the location of the wound, the amount of blood lost and other vital signs. The liner would forward the findings immediately to a command center, where medical evacuation teams would be dispatched.

A helmet-mounted display permits seeing—and aiming—around corners (*above*). The soldier can also call up maps (*right*) that pinpoint the locations of nearby friendly and hostile forces.

In fact, a garment capable of detecting the penetration of the human torso was first demonstrated in 1995, according to Eric Lind, an electrical engineer at the Space and Naval Warfare Systems Center in San Diego. The garment, which has not yet been clinically tested, works by sending light through a closed fiber-optic loop. "If the pulse of light comes back, you know the torso hasn't been penetrated," Lind says. But once the circuit is broken by a bullet, tiny ultrasound microphones embedded in the garment can trace the bullet's path.

A similar approach could lead to garments that change colors, chameleonlike, to match their surroundings: a material's color would be based on the color of light coursing through its fiber-optic threads. "It's possible to do that now," Lind points out, "but we need practical ways of supplying power."

SSCEN specialists are addressing that challenge, too, and not just for the color-changing clothes. They recently started work on a photovoltaic membrane made of conductive polymers that can convert sunlight into electricity. A potential advantage is that the small fibers would give the membrane a surface area some 200 times larger than that of a conventional sheet of comparable size. Others are investigating the possibility of shoes with piezoelectric devices that would generate electricity when their wearer walks.

Lind notes that the nonmilitary market for high-tech clothing could eventually be enormous. Who knows what the fashion world will make of cloth that can change colors on demand? And reactive garments would have obvious applications in law enforcement, firefighting and medicine.

FIRING AROUND CORNERS

In another project with spin-off potential in law enforcement, the army has developed a high-tech protective helmet with a head-up display (no pun intended) that shows the wearer where the friendly and hostile forces are. This display can even be linked to the soldier's weapon, explains SSCEN team leader David Cheney, so that "he could put the weapon around a corner and engage a target without putting himself at risk."

For the longer term, the well-dressed warrior might even sport a "stealth" uniform that alters the wearer's heat emissions and radar-surface signature to blend in with those of the background. Other investigators contemplate in-stride mine detection devices that would instantly alert soldiers to land mines in their midst. Even further out, microrobots that could reliably survey an area and portable devices for creating holographic decoys both await fundamental technological advances.

While no one disputes the tremendous advantages that sophisticated technologies such as these could confer, their high cost could ensure that some, perhaps most, are never issued in large numbers. Estimated costs for outfitting the soldier of 2002 with early versions of a helmet, protective clothing, weapons, and a computer and radio system run about $70,000. Cheney, however, cites $1-million cruise missiles and $100-million tanks in arguing that more money should be spent on the troops themselves.

Political factors will ultimately determine how much of this high technology trickles down to the grunts on the ground. But it is already becoming clear that the next wave in military equipment could very well be personal, literally enveloping the soldiers of the next century in technology.

ABOUT THE AUTHOR

STEVE NADIS is a freelance writer living in Cambridge, Mass. His killer instinct is limited to barbarous games of cribbage.