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CIRCUITS

Taking Aim at an Enemy's Chips

By SETH SCHIESEL (NYT) 2145 words

AS the United States readies for a possible conflict in Iraq, many of the star weapons from the Persian Gulf war of 1991 are back and deadlier than ever. The smart bombs are smarter. The stealth planes are sneakier. Even the ground troops are better equipped than they were a dozen years ago.

Yet according to military experts, the biggest technical revelation of another war in the region may not be improvements to old systems but rather a new category of firepower known as directed-energy weapons.

Think invisible lasers, using high-powered microwaves and other sorts of radiation rather than the pulses of visible light common in science fiction. These new systems, which have been under development in countries including Britain, China, Russia and the United States for at least a decade, are not designed to kill people. Conventional bombs, guns and artillery can take care of that.

Rather, most of the directed-energy systems are meant to kill electronics, to disrupt or destroy the digital devices that control the information lifeblood of modern societies and modern military forces. By contrast, traditional jamming equipment blocks communications gear from functioning but does not actually damage the device.

"If there is a war in Iraq, there is no question in my mind that we will see the use of both directed-energy and radio-frequency weaponry," said John Arquilla, a professor of defense analysis at the Naval Postgraduate School in Monterey, Calif., referring to both the new sorts of weapons and traditional jamming technology. "Over the last several years, a great deal of research has been undertaken in this area both by the United States but also by other countries, not all of them allied with us."

That is why, like the genie escaping its bottle, directed energy may harbor danger for the United States itself, not just for its adversaries. With its increasing reliance on digital communications and information systems, the United States is perhaps the most vulnerable potential target for directed-energy devices, military experts say.

But for the moment, most directed-energy specialists are concentrating on the possible uses of the

technology against Iraq.

For instance, military experts say that the United States or Britain could use cruise missiles or commando units to deliver a directed-energy weapon within a few thousand feet of an Iraqi control bunker that happened to be close to a large civilian population. If the weapon functioned properly, it would disable or destroy the electronics inside the bunker without the risks associated with a conventional missile attack or bombing.

As the government works on new battlefield and continental missile-defense systems, directed-energy research is also helping to develop energy beams to be used to shoot down missiles.

And while directed-energy weapons are not generally meant to kill people, there are certainly antipersonnel applications. In addition to the anti-electronics weapons, other directed-energy systems under development are meant to use microwaves to make people feel pain in the outer layer of the skin without generally causing physical damage. That pain is intended to inspire an instinct to flee.

In describing the use of such systems, which are meant to be mounted on a truck or perhaps on an all-wheel-drive Hummer vehicle, weapons experts constantly evoke "Black Hawk Down," the book and film that describe the chaotic 1993 United States military intervention in Somalia. In Somalia, United States soldiers had little way to disperse angry groups of civilians without firing.

"I can see something like this being especially effective someplace like downtown Baghdad," said Christopher Hellman, a senior research analyst at the Center for Defense Information, a think tank in Washington. "If one of Saddam Hussein's tactics is going to be to flood Baghdad with civilians, this could be really nice to have."

"I think that one is pretty close," to operational deployment, Mr. Hellman added. "If it's even remotely close, I'd bet they're working 24-7 to get it ready."

Mr. Hellman estimated that the government has recently been spending "tens or maybe hundreds of millions of dollars annually" on directed-energy systems. "As long as you're not talking billions," he added, "it's not statistically significant."

What is significant is determining the ability of potential foes to develop such devices themselves. For now, military experts generally appear to believe that directed-energy weapons are beyond the technical reach of terrorist groups.

"Considering that the United States has struggled with this and has taken a long time to get it to the verge of operational use, I think it would be tough for terrorists to get something they could use in this area," said David A. Fulghum, senior military editor for Aviation Week & Space Technology, a leading industry magazine. "I think it would probably be easier for them to develop a nuclear weapon and try to employ the electromagnetic pulse produced by that than to try to develop high-power microwave weapons."

Nonetheless, as the nation's civilian society and especially its military apparatus come to depend ever more on electronic communication and information systems, the development of such systems by potentially unfriendly nations with significant industrial and technological abilities could become a military quandary.

"Over the last generation, digital technology has infused every facet of American life," said Loren B. Thompson, chief operating officer of the Lexington Institute, a nonprofit national security think tank in Virginia, and co-author of a directed-energy study that the group released this month. "There is a tendency to think of the Information Age threat as consisting of software worms or viruses or a shutdown of electrical power, but there is a middle ground where energy is used to erase or disrupt or destroy digital systems without cutting off power and without introducing contaminating software."

Mr. Arquilla of the Naval Postgraduate School said, "This is one of the major Achilles' heels of the increasing use of technology in the United States military."

"Most of what we have today is not hardened against this kind of capability and we are extremely vulnerable, so it makes sense for other militaries to be exploring these sorts of capabilities," Mr. Arquilla added. Referring to the Chinese army, he said, "We have seen increasing experiments in this area by the People's Liberation Army and other militaries."

That is why the Pentagon in recent years has intensified its research on possible defenses and countermeasures against an enemy's directed-energy weapons systems.

In the early 1960's, the United States and the Soviet Union first recognized the potentially destructive effects of the electromagnetic pulse, or EMP, emitted by nuclear weapons detonations. In addition to releasing heat and physical energy, a nuclear detonation releases high amounts of electromagnetic radiation.

That radiation can disrupt the operation of semiconductors, which form the basis of transistors, which in turn form the basis of microchips. Semiconductors essentially operate by regulating a flow of electrons, or current. When a large amount of external radiation is applied to a semiconductor, it can induce more current to flow than the semiconductor was built to handle, potentially destroying the device.

From the 1960's through the end of the cold war, the United States and the Soviet Union spent billions of dollars to protect their electronics systems, or "harden" them, against the effect of a nuclear-generated electromagnetic pulse. Because old-fashioned vacuum tubes are generally impervious to EMP, the Soviet Union also used tubes in some of its sensitive systems.

Put simply, the new generation of directed-energy weapons is meant to emulate the sort of damage that nuclear EMP can inflict upon electronics but at far less range, with more control of the damage and without all of the ancillary physical destruction and radioactivity.

There are important technical differences, however, both in how and in what sort of electromagnetic energy is generated.

The epicenter of most directed-energy weapons research in the United States is Kirtland Air Force Base in Albuquerque. A spokesman at Kirtland said that he could not comment beyond the information on the base's Web site (www.de.afrl.af.mil). Companies including TRW, Raytheon and Lockheed Martin are also engaged in directed-energy research. In addition, the research involves nonclassified work being conducted by civilians such as Edl Schamiloglu, director of the pulsed power, beams and microwave laboratory at the University of New Mexico's department of electrical and computer engineering.

Mr. Schamiloglu said most of the research on directed-energy applications over the last 15 years has focused on the part of the microwave range of the electromagnetic spectrum between 1 gigahertz, or 1 billion cycles per second, and 10 gigahertz.

By contrast, nuclear-generated EMP tends to be at much lower frequency ranges, generally below 1 gigahertz. That means that existing safeguards against nuclear EMP will not protect against the new generation of directed-energy weapons.

Most of the details on directed-energy weapons are classified. But there appear to be some reasons the military is focusing on the microwave band.

First, it bypasses existing protections against nuclear-generated EMP.

Second, microwaves in the 1 gigahertz to 10 gigahertz band appear to be especially efficient at generating excessive current within modern semiconductors.

Third, the physical characteristics of microwaves appear to lend themselves to offensive applications against electronic targets -- even those as simple as a PC. "Look at your computer," Mr. Schamiloglu said. "Look at the disc drive, the CD-ROM drive, the air slots, even the hole for the power cord. The holes are about half an inch. The slots are about 6 inches and there is conducting material all around them." Because those specifications correspond closely to the wavelengths of the directed-energy beams, he said, "those are perfect antennas for microwaves."

There are two main families of anti-electronics directed-energy weapons: ultra-wideband devices and high-power microwave systems. Ultra-wideband weapons, known as UWB, emit energy across a relatively large swath of the electromagnetic spectrum. High-power microwave devices concentrate high amounts of energy in a very narrow frequency band. High-power microwave devices are generally used to destroy electrical components, while UWB devices are more likely to only temporarily disrupt target devices.

One of the main problems in developing all of these sorts of directed-energy systems has been generating the necessary power. Nuclear EMP obviously has a tremendous power source. Initial versions of directed-energy weapons in the United States and particularly in the Soviet Union also focused on chemical explosions as a potential power source.

Over the last decade, however, directed-energy systems have become viable weapons largely because of advances in batteries and capacitors that allow a large amount of electrical energy to be delivered in a very quick pulse. A capacitor is an electrical device that stores and releases power. The use of electrical power allows the use of antennas that can focus the electromagnetic energy into a beam rather than an omnidirectional pattern, as a bomb would produce. Military experts say the range of modern directed-energy weapons could generally be measured in thousands of feet.

"High-power microwaves have been around since the late 60's, early 70's, but they were strictly laboratory equipment," Mr. Schamiloglu said. "It's because of the technology advances in capacitors, switches and batteries that you can now think about making these smaller. And once they are smaller they become of interest to various branches of the military and you can see the applications."

Mr. Fulghum of Aviation Week said cruise missiles were the most likely way that high-power

microwave or ultra-wideband weapons would be delivered in the event of hostilities in Iraq. Cruise missiles appear optimal because even using a beam configuration, a directed-energy weapon is likely to disable the vehicle that delivers it.

"The first step is to put it in a cruise missile that isn't necessarily coming back," Mr. Fulghum said.
