SHARON WEINBERGER

Just Over the Horizon

Someday the U.S. military could drive a trailer to a spot just beyond insurgent fighting and, within minutes, reconfigure part of the atmosphere, blocking an enemy's ability to receive satellite signals, even as U.S. troops are able to see into the area with radar.

This scenario may not be far away. An engineer with Research Support Instruments in Princeton, N.J., recently completed the first phase of work for a U.S. Air Force-sponsored project called Microwave Ionosphere Reconfiguration Ground-based Emitter, or Mirage.

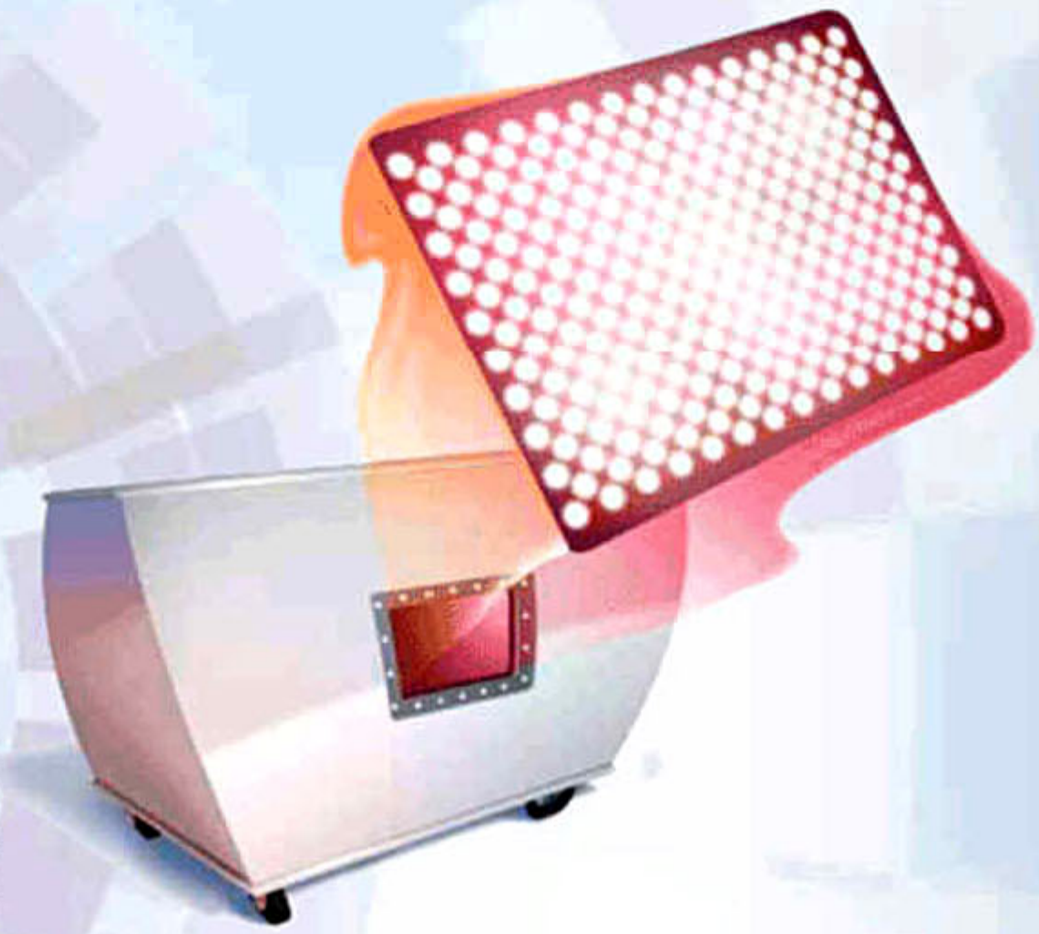
The work involves using plasma—an ionized gas—to reconfigure the ionosphere. Mirage would employ a microwave transmitter on the ground and a small rocket that shoots chaff into the air to produce about a liter of plasma at 60-100 km. (36-60 mi.) in altitude, changing the number of electrons in a select area of the ionosphere to create a virtual barrier. Ionosphere reconfiguration offers two major applications of interest to the military: bouncing radars off the ionosphere, also known as over-the-horizon radar, and the ability to jam signals from the Global Positioning Satellite system, according to John Kline, the lead investigator for Mirage. This work is only the latest effort in Kline's more extensive investigations of atmospheric plasmas.

Work on atmospheric-pressure plasmas, or air plasmas, has been around for some time, but researchers have faced a dilemma: At atmospheric pressures, it typically takes a large amount of power to form plasmas. Kline's work has focused on overcoming that problem. Using commercial microwave ovens, Kline and his colleagues have generated plasmas of close to a liter in volume with just a kilowatt of power.

Kline's work builds on earlier research funded by the Air Force Office of Scientific Research for "air plasma ramparts," a university initiative that ran from 1997-2002. The goal, says Robert Barker, the Air Force program manager for plasma physics, was to find new approaches "to reduce the amount of power necessary to generate and maintain substantial volumes of air plasma (ionized air) in the open atmosphere."

One of the immediate applications to emerge was the use of air plasma to destroy biological warfare agents, says Barker. That was by no means the only possibility, and Barker notes that researchers, like Kline, are investigating other applications.

Before Mirage, Kline had another contract for a project called Plasma Point Defense, which explored the possibility of using a plasma weapon on board a U.S. Navy surface vessel to protect against threats ranging from surface-to-surface missiles to mortars and rocket-propelled grenades. "The intention was to create a plasma cannon, as it were, to deflect or destroy incoming kinetic threats," Kline explains.



NICK ROTONDO

Illustration of a scaled-up 45-kw. experiment that produced a 20-liter plasma.

The Navy contract led Kline to a mixed conclusion: While a theoretical plasma cannon would be effective against some threats, ultimately, it would also have limitations. The Navy chose not to continue with the plasma cannon concept, but RSI went on to receive an Air Force contract for Mirage.

It may be tricky to move the plasma to the open air. "During the Plasma Ramparts program, we briefly experimented with open-air operation and saw that with sufficient power levels, you could get the plasmas 'out of the oven,'" Kline says.

Other researchers share Kline's optimism about plasmas. Richard Miles, a professor of aerospace enginering at Princeton University, who has worked with Kline, also points to the plasma ramparts research, noting that it demonstrated "an efficient way of making volumetric plasmas in air." Miles also notes other possible applications for air plasmas, like providing stealth capability.

"If you look at a standard 1958 Buick with lots of chrome on it, you see there are certain places where sunlight is very bright because of corners that reflect," Miles says. Similarly, plasmas could be used on an aircraft's reflecting corners to make them less visible, he explains; the Russians already claim to have done this.

Air plasmas could also replace actuators and other external moving parts on aircraft. Thomas Corke, a professor of aeronautics and mechanical engineering at Notre Dame University, has been working on creating plasma actuators, using an electrode exposed to the air to help generate the microwave field necessary for the plasma. "They use very little power," Corke says.

One of the difficulties Kline and others face is that the exact workings of the plasma are not well understood. "There are people who would tell you this is standard physics and the various geometries of the plasma make sense. There are also people who will tell you it needs better theory to explain it."

No one is sure whether there is really new physics behind these complex plasmas. "I don't get paid to do [theory]," he jokes.

How far away is RSI's vision of a deployable trailer able to reconfigure the ionosphere with bright shots of plasma? For a very limited system, it could be quite soon. "Generally, we're looking at a five-year window," Kline says. ■