craft carriers which need a small fleet of other ships to defend them. But the trouble here is that the aircraft carriers provide targets worth a mere billion dollars apiece, whereas the laser space stations would probably cost at least $10 billion each.

That's only where the serious problems begin. The carbon dioxide lasers are real gas guzzlers. One parked in geosynchronous orbit would need about 100,000 tons of consumables shuttled up there to top up its tank. Three such stations would be required to provide global coverage. Conceivably, the Russians might not sit quietly on the sidelines while this cumbersome armada to make America number one again was slowly being assembled in the wild blue yonder.

Even if the Soviet Union took no steps to interfere during the construction process, there would be ample opportunity for attacking the laser stations by the same stratagem which has defeated all other antiballistic missile systems: money. When the means of attack cost less than the necessary countermeasures, the defense is in a no-win game. The laser stations depend on sensors which can be blinded; they can be attacked by lumps of chicken wire—projectiles in a form that would require inordinate amounts of laser energy to be destroyed; and their prime purpose of shooting down Russian missiles during the boost phase can be defeated by arranging for the missiles to enshroud themselves in a curtain of smoke that dissipates the laser pulse.

These and other problems of laser weapons are described in a study published last month by physicists M. Callaham and Kosta Tsipis of the Massachusetts Institute of Technology*. Although written from the perspective of arms control, the study delineates problems that are less often dwelt upon by the proponents of laser weapons. These problems are so severe, in the MIT physicists' opinion, that a space-based antimissile laser system lies probably 20 years or more in the future, and certainly not within the visible technological horizon. As for uses within the atmosphere, what promise there is for viable weapons probably requires the development of a new generation of lasers.

*M. Callahan and K. Tsipis, *High Energy Laser Weapons—A Technical Assessment*, Department of Physics, Massachusetts Institute of Technology, Cambridge, 1980.

Now that the physics of how laser light interacts with a target are better understood, says the MIT report, "There is little if any doubt that, in principle at least, and in the absence of counter-measures, an appropriately designed and operated laser can inflict lethal damage onto many targets of military significance." The problems come with the operational systems—the tracking, targeting, aiming, defeat of countermeasures, self-protection, and viability under battlefield conditions—into which the laser device must be incorporated. It is at this point that the technological sweetness of a device that reaches its target at lightspeed becomes soured with the realities of battlefield conditions.

The MIT physicists approve the vigorous research programs on carbon dioxide and carbon monoxide lasers, even though they doubt they will make practical airborne weapons. The most useful goal of military laser research, they believe, is to enable the development of defensive countermeasures against any form of laser attack.

French Have Rocket Aimed at NASA's Shuttle

The repeated delays suffered by NASA's shuttle program have enabled the Europeans at last to offer credible competition to the United States' virtual monopoly of space launch vehicles. The Europeans' hopes are pinned on Ariane, a predominantly French rocket which, at its first firing in December 1979, enjoyed a perfect flight.

A second firing, in May last year, was less successful; the rocket disintegrated in flight a few minutes after takeoff from the French launch site of Kourou in French Guiana. Nonetheless, Ariane struck a major blow against her rival the shuttle when Intelsat, the international telecommunications satellite organization, placed orders to launch three of its nine Intelsat-5 global communications satellites aboard the French rocket. The satellites had been intended as shuttle cargo, but NASA lost the order because of the continual delays.

Ariane itself has now fallen behind because the cause of the May 1980 failure, now determined as an instability of combustion, is proving particularly troublesome to fix. The French National Center for Space Studies says that the third flight of Ariane will be delayed several months beyond the scheduled March date.

The European contractors for Ariane had been talking boldly of building some 40 rockets over the next decade. In the view of *Le Monde*, the new delay of Ariane is a "setback with heavy consequences for Europe." Foreign customers, attracted to Ariane, may turn again toward America, the French newspaper warns.

That dire possibility is made more likely by the shuttle's recent progress. After months of engine failures and sloughed tiles, things at last seem to be going right for the vexed program. The main engine passed its certification test, the tiles are being glued back on, and on 29 December Columbia, the first manned shuttle vehicle, was rolled out of its plant to the launch pad. What NASA calls the "pencil date" for launch is 14 March 1981, the same period as had been scheduled for the third Ariane flight. Columbia will be the first shuttle to be launched from ground zero; an experimental vehicle, Enterprise, flew from a Boeing mother ship.

Biologists Need Code on Commercial Behavior

The commercialization of biotechnology has produced new stresses and strains in the fabric of academic life, and scientists should develop a new set of principles governing researchers' behavior in the face of these commercial incentives.

So suggests Stanford University President Donald Kennedy in a recent talk given at the University of Pennsylvania. "Scientists who once shared prepublication information freely and exchanged cell lines without hesitation are now much more reluctant to do so," Kennedy observes. Graduate students may find that their access to a large body of significant work in molecular genetics is seriously reduced, and "the fragile network of informal communication that characterizes every especially active field is liable to rupture," Kennedy warned.

Nicholas Wade