impose controls on all "fermenters, especially vessels having a self-sterilizing capability," and all "high efficiency particulate filters." Fifty "precursor" compounds useful in making weapons may be regulated, as may a long list of living organisms, including the lowly *Salmonella* and *E. coli* bacteria. One clause extends licensing to "process control instrumentation or computer systems especially designed for use in highly automated facilities, for the purpose of remote plant operations...." The manufacturers claim that most new plants use sophisticated controls of this kind, so the rules would have a broad impact. Says Robert Stevenson, chairman of an advisory group on biological export controls and director of the American Type Culture Collection, "It's true that [items such as fine filters] are needed for the manufacture of biological weapons, but on the other hand, they are so readily available from so many sources that controlling them is a virtual impossibility."

It is not yet clear how the Administration will sort out the conflicting demands of the arms controllers and the business chiefs. But the present hiatus in trade with the Persian Gulf may provide a good opportunity for establishing a new system of export controls. For as Gary Milhollin says, the embargo against Iraq has "put everything on hold for the moment; once it ends, we will be back in the soup again."

■ ELIOT MARSHALL

U.S. Bio-Defenses Faulted by GAO

The Defense Department's program to develop vaccines and drugs to protect U.S. troops from biological weapons could get its first real test in the Persian Gulf this year, but it is already under attack on the domestic front. A General Accounting Office (GAO) report released on 28 January by Senator John Glenn (D–OH) says that the Pentagon may have paid for many less-than-critical projects, and it may be duplicating work already being done at civilian centers like the National Institutes of Health and the Centers for Disease Control.

Since 1984, the U.S. military has spent about $370 million preparing for biological warfare. The budget for these efforts has grown more than 120% in this time, leveling off at around $66 million last year. But GAO found that at least 20% of the expenditures ($47 million) went to projects directed at organisms that were "not validated" by intelligence authorities as true military threats. Another 20% went to projects for which not enough information is available to make a judgment, the GAO says. To Glenn, this is strong evidence of "mismanagement."

Moreover, Glenn argued, military researchers apparently did not make adequate plans to supply troops in the Persian Gulf with a vaccine against predictable threats such as anthrax, a bacterium that infects cattle and sheep and can kill humans in a matter of days. Iraq has reportedly investigated using it in weapons. The government placed "rush" orders for production of anthrax vaccine late last year, according to experts on chemical warfare outside the government, such as Elisa Harris of the Brookings Institution.

Officials in the Pentagon's press office and an assistant to the Army's surgeon general declined to comment, saying they had not had time to study the GAO report.

In the past, some members of Congress, including Representative Wayne Owens (D–UT), have proposed moving civilian aspects of this research out of the Pentagon and into the Public Health Service. Pentagon officials resisted the move, saying military-funded research is focused strictly on defense against weapons. In response to a question from the Glenn committee in 1989, Robert Barker, an assistant to the secretary of defense, wrote: "There are no 'non-military' portions of the [Biological Defense Research Program]. The biomedical research...is focused on militarily relevant problems, with the goal of developing products and information for use in medical defense of U.S. troops against biological warfare attack." If the GAO report is correct, however, military research was not so tightly focused.

When GAO's auditors asked military officials why they had not limited themselves to biological-warfare threats "validated" by the Armed Forces Medical Intelligence Center, they responded that they believed "the intelligence center's interpretation of threat agents was too narrow." GAO points out that unless military officials accept some well-defined limits, they will be able to justify doing research "on virtually all biological agents."

As for overlap with other agencies, GAO noted that the Pentagon's efforts included projects on dengue fever, which has been targeted by the Centers for Disease Control and NIH, and Venezuelan equine encephalitis, which is being studied by the Department of Agriculture. GAO comments that because the Army "does not coordinate its research with federal civilian agencies, [it] cannot ensure that its research is not unnecessarily duplicating" other agencies' investigation of the same organisms. ■ ELIOT MARSHALL

Methanol-Powered

With the war in the oil-rich Middle East raising new concerns about possible gasoline shortages, it may come as a welcome surprise that U.S. automobile makers are about to take a historic step: They are revving up for the first commercial production of cars designed to run on a fuel other than gasoline, in this case methanol. In October, the Environmental Protection Agency (EPA) gave General Motors permission to start making its methanol-powered model, a modified Chevrolet Lumina, the company will begin selling in California in the 1992 model year. Meanwhile, the Ford Motor Company is well along in developing methanol-powered versions of its compact Escort, mid-size Taurus, and full-size Crown Victoria. And Chrysler also has a methanol model in an advanced stage of development, as do most of the major foreign car manufacturers.

Gasoline conservation wasn't the main reason that the U.S. automobile companies began developing cars powered by alternate fuels, however. They were more concerned about meeting air pollution standards, and there methanol has an advantage over gasoline. It burns more cleanly than gasoline, releasing less of the smog-causing hydrocarbons and nitrogen oxides. That's why the first methanol-powered vehicles will be marketed in California, the state with the most stringent emission control standards in the country.

Methanol has other advantages as well. it has an octane rating of 100, compared with 93 to 97 for gasoline. That allows engines to run at higher compression and therefore more efficiently, says Roberta Nichols, who manages Ford's alternative fuels program. Methanol also helps vehicles perform more efficiently because it has a better "flame speed" than gasoline, which speeds burning in the cylinders. And methanol has a high heat of evaporation, which helps to pull heat away from the engine. So it may be possible to reduce the weight of methanol-powered cars by using air-cooling radiator systems, instead of the heavier water-cooling systems.

Aside from such practical benefits, methanol cars could have special appeal for drivers because they are lively. In acceleration tests conducted at the Ford Motor testing grounds near Dearborn, Michigan, the Crown Victorias were able to go from 0 to 60 miles per hour in 11 seconds, a half-second improvement over the gasoline-powered models, according to Ford. The smaller Ford Escort, when powered by methanol, picked up one second in similar trials. These results

Cars Get Ready to Hit the Road

won't surprise A. J. Foyt. Methanol is already the fuel of choice for many drivers of Indianapolis-type race cars.

A key criticism leveled at methanol has been a perceived problem with cold starts, since methanol is less volatile than gasoline. But engineer Bob Larsen of Argonne National Laboratory near Chicago, who has been overseeing the testing of a fleet of 12 methanol cars there, says that problem can be laid to rest. Vehicles using M85, a blend of 85% methanol and 15% unleaded gasoline, turned out to start well in the frigid climes of northern Illinois. All in all, Larsen boasts, the Argonne fleet of security and service vehicles, driven a half-million miles over 4 years, met the lab's standards for fuel efficiency, maintenance costs, and reliability.

Nevertheless, even Larsen agrees that methanol-powered cars still have a few problems. For example, burning methanol releases about half the energy that burning gasoline does. As a result, cars can only go half as far—up to about 300 miles for a mid-size model—on a tank of methanol as they can on a tank of gas. In addition, methanol releases more aldehydes, which exacerbate ozone and smog production and may be carcinogens as well, than does gasoline. And consumers may not appreciate the higher price tag on methanol vehicles, which are likely to cost $300 to $500 more than conventional vehicles. But, Larsen says, "These problems are not show stoppers for the car industry. We have been working on the gas engine for 100 years. It is going to take more than a few years to fine-tune a new system."

This leaves as the major obstacle to the widespread adoption of methanol-powered cars the uncertain availability of the fuel. The methanol plants now in use, says Glyn Short of ICI Americas in Wilmington, Delaware, which makes the technology needed for methanol production, produce methanol for the chemical industry. That has higher purity—and therefore costs more—than the methanol needed for fuel use.

Methanol boosters currently suffer from a chicken-and-egg headache, Short says. Car companies don't want to make a lot of methanol-powered cars until the fuel is widely available; and producers don't want to make a lot of methanol until they know there will be an ample supply of the cars.

Meanwhile, the consumer will have a hedge against the timidity of the producers: to cope with the likelihood that drivers of the first methanol-powered cars won't always be able to find methanol when they need it, the early models will be "flexible fuel vehicles," or FFVs, designed to run on different ratios of methanol and gas. These cars will be equipped with sensors that assess incoming fuel mixtures and then adjust fuel injection, spark plugs, and emissions controls accordingly. They aren't likely to become the cars of the future, however, because they are not as efficient as cars that use a fixed mixture of methanol and unleaded gas. And if the cold start problem can be solved in some way other than by adding gasoline, cars that run on methanol only would be even better.

According to Charles Gray, who as director of EPA's Emission Control Technology Division gave General Motors the go-ahead to make the methanol-powered Lumina, the flexible fuel vehicles have about a 5% efficiency advantage over gasoline-powered cars. But a vehicle designed to run exclusively on methanol could probably achieve 30% better efficiency than an equivalent gasoline model.

In addition, dedicated methanol vehicles have the potential of reducing overall emissions of hydrocarbons and other pollutants by 90%, while flexible fuel vehicles running on methanol-gasoline mixtures will likely achieve 30% to 40% reductions. "The flexible fuel concept will probably be necessary during a transition period," Gray says. "But it is critical to keep the period brief and push quickly on toward vehicles that are designed with one fuel in mind, to take full advantage of the opportunities each fuel offers."

In any event, should the demand for methanol fuel increase, it may be easier to deliver than other alternative fuels, such as natural gas. According to a report issued last August by the Department of Energy, building the infrastructure to distribute enough methanol to replace 1 million barrels of oil daily, about 10% of the oil the United States uses for transportation, would cost about $21 billion. That makes the methanol infrastructure cheaper than those the other fuels would need. The comparable figure for natural gas, for example, is about $37 billion.

Current estimates indicate, Short says, that the cost of methanol will compare favorably with the cost of gasoline. A gallon of methanol could be delivered by supertanker to the United States, he notes, for 35 cents a gallon. Because methanol has about one-half the energy density of ordinary gas, that is equivalent to about 70 cents a gallon for unleaded gas. "Add distribution costs, profit and taxes, and you get a price of $1.20 to $1.30 a gallon," says Short.

It remains to be seen, of course, whether U.S. drivers will accept methanol-powered cars, whatever the cost of the fuel. But there is one precedent for the successful introduction of an alternative fuel car. For some years, Brazil has powered its autos with a related alcoholic compound, ethanol, which is produced from that country's often surplus sugar crop.

And then there is the stimulus provided by the current hostilities in the Middle East. The raw material for making methanol is natural gas. Short envisions that plants for producing methanol will be sited in secure areas with abundant natural gas supplies. These could be in, for example, Canada, Australia, Trinidad, and Venezuela. Now, more than ever, security seems to be a major consideration when it comes to choosing an alternative fuel. ■ ANNE SIMON MOFFAT

Anne Simon Moffat is a free-lance writer based in Chicago.

Argonne National Laboratory

Fill 'er up. *Chicago winters are not a problem for methanol-powered cars.*