education until graduate school, the report says, may make their professions "less susceptible to intense swings in supply/demand relationships characteristic of engineering today."

At present, Shull said, industry relies heavily on engineers who hold only a baccalaureate degree, and, as a result, undergraduate engineering courses are overspecialized. If companies and universities could cooperate in bringing about a change, Shull said, the cyclical peaks and valleys in the job market might be smoothed out. In times of high demand for engineers, many young people holding only an undergraduate degree would go straight to work. In times of low demand, they would continue their education. ■ ELIOT MARSHALL

Mathematicians Look to SDI for Research Funds

A briefing organized by the National Academy of Sciences provided an opportunity for mathematicians to make a pitch for SDI money

MATHEMATICIANS came to a recent briefing with directors of the Strategic Defense Initiative program, "with their hands open and their pockets empty," observed Donald Austin of the Department of Energy. The briefing, held at the National Academy of Sciences on 7 October, was billed as an opportunity for mathematicians to hear how the Innovative Science and Technology program of the SDI program could use their talents. Instead, it turned out to be an opportunity for mathematicians to tell SDI administrators why they should receive SDI funds.

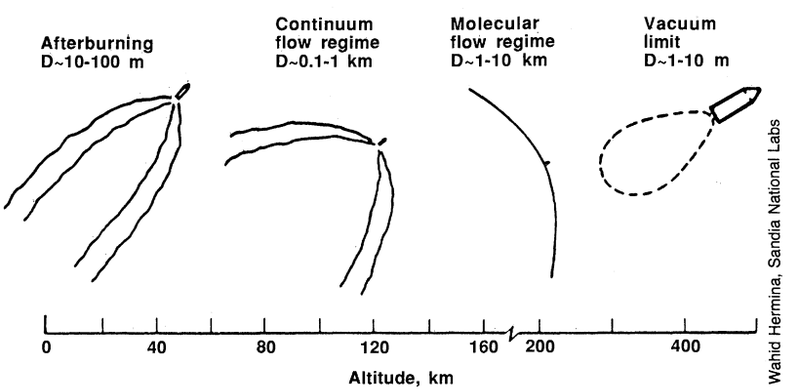
And the SDI responded. James Ionson, director of SDI's Innovative Science and Technology Program, said that "we probably will put a couple of million dollars" in mathematics. The program invests about $1 to $1.5 million on mathematics now; in 1987 that figure most likely will be $2.3 to $3 million, according to Ionson. The National Science Foundation spends about $50 million a year on basic math research.

The briefing was the idea of the Conference Board on Mathematics. It is, says Ionson, the first time the mathematicians have come, as a group, to discuss receiving more SDI funds. Until now, they have filed into the SDI office as individuals and, says Leonard Caveny of the SDI, "they may think they communicated with us, but they really haven't." Only a few are receiving SDI funds. In the past, the mathematicians were not specific enough about how what they do is really SDI work in other guises. Work on fast ways to solve problems on computers, for example, may be directly applied to SDI computer problems. The recent briefing was different.

Ionson said that math research on optimization, or finding best solutions to complex computer problems, and spatial statistics are "high on my list" of projects to fund. Both are areas of mathematics that are crucial for the design of systems meant to work in what the SDI euphemistically calls a "stressful environment," meaning a nuclear attack.

David Shanno of Rutgers University, who spoke on optimization at the briefing, pointed out that the problems the SDI program faces include designing a communications network in which "nodes [communications points] of the system may disappear. How do you establish a communications network? If the missiles are independent, you may end up firing them all. If you have a central communications center, what if it is knocked out? These are really *fascinating* mathematics problems and they are not thoroughly addressed," he remarked. Shanno pointed out that although a number of scientists have said that the computations involved seem impossible—or at least impossible to do quickly enough—mathematicians recently discovered several very fast methods that can quickly cut computer time. In particular, there is the algorithm discovered by Narendra Karmarkar of AT&T Bell Laboratories (*Science*, 21 September 1984, p. 1379) and one discovered by John Reif of Harvard University and Victor Pan of the State University of New York at Albany (*Science*, 14 June 1985, p. 1297). "By looking at the mathematics differently, mathematicians can devise new concepts that can blow away preconceived notions," he said.

Spatial statistics, explained Jerome Friedman of Stanford University, is crucial for surveillance. It is needed "to detect and identify rocket launches and to tell how fast and in what direction the rockets are moving." Statistics also tells "how well we know what we seem to have measured," he continued. "The problems are fascinating and difficult because you are looking for a needle in a haystack—the signal is small above background and you are looking for unusual events. There also will be jamming by natural and deliberate noise in the system and deliberate misinformation, or decoys." The Soviets, or whoever is attacking, will try to slip by our defenses, perhaps by making their missiles invisible to the SDI shield. To Friedman, this makes the statistics problems even more intriguing. "Since the enemy is providing us with the information, they will



Find the target. *As a rocket ascends, its plume changes dramatically, flattening out so that, by the time the rocket is above 200 km in altitude, the plume is as much as 10 km wide. The math problem is to find a way to locate the relatively tiny rocket in the plume.*

try to conceal it—which provides an extra added twist," he remarked. The problems facing the SDI designers "are at the forefront of modern statistics research," Friedman said. "There is a natural marriage there. Both statistics and the SDI can benefit."

A number of members of the mathematics community object to the very idea of SDI research and have urged their colleagues not to seek SDI funds. There was a symposium at the meeting in August of the International Congress of Mathematicians to that effect, for example. But these views were not a part of the recent briefing. Nonetheless, some mathematicians did ask questions related to how SDI money would affect basic research. Jagdish Chandra of the Army Research Office asked whether the work would be classified and whether researchers receiving SDI funds would need security clearances. Ionson replied that the math projects would be

Some mathematicians warned that their research might not have quick payoffs.

unclassified, although the investigators "are welcome" to apply for clearances and thus to get closer to the heart of the program. Daniel Mostow of Yale University, who is president-elect of the American Mathematics Society, asked whether these would be new funds or whether the money would be pulled from other programs that currently support mathematicians. Ionson assured him the funds are new.

Some mathematicians also warned that their research might not have the quick payoffs that the SDI administrators want. Ronald Graham of AT&T Bell Laboratories, for example, notes that the SDI administrators are hoping for solutions to very specific problems within a few years, but those solutions frequently rely on as yet unrealized advances in basic research. Graham says, "there are no quick fixes. When you fund math research, especially basic math research, that's a long-term activity. If the research is good, it will find applications in many areas. But it may take 10 or 20 years."

But Graham argues that "this is an opportunity for mathematicians to say what they can and cannot do." Phillip Griffiths of Duke University, who is chair of the National Academy's Board on Mathematical Sciences, agrees. "Mathematicians cannot only solve problems but, perhaps more important, they can tell what can't be solved," he says. ■ GINA KOLATA

Briefing:

Vaccine Compensation Bill Passed

After 4 years of debate, Congress has finally passed legislation to provide compensation for children who are injured after receiving vaccines such as diphtheria-pertussis-tetanus, or DPT, that are mandatory in most states. But the battle isn't over. Whether the President will sign the bill is unclear. Furthermore, a bill to enact the tax to fund the compensation must be introduced by the House Ways and Means Committee. "We don't have a total bill yet," one congressional staffer says.

The bill, which was championed by Representative Henry Waxman (D–CA) and Senator Paula Hawkins (R–FL), has two goals. The first is to compensate injured children; the second is to try and create some stability in the vaccine market. Vaccine manufacturers have been dropping out of the market, and those who stayed have raised their prices—and especially their prices for the risky DPT—claiming that lawsuits by parents of injured children have made their liability costs so high as to be ruinous. Waxman expects the legislation to result in lower vaccine prices when this litigation burden is relieved.

The vaccine compensation system will have two parts. First is the federal vaccine compensation program that requires the families of injured children to seek no-fault relief through the system before deciding to take their case to court. An arbitrator, or "master" will set compensation for children whose injury from a mandatory vaccine occurs within a prescribed period after the vaccination.

The maximum compensation for the death of a child or for pain and suffering is $250,000. There are no limits on the compensation for medical expenses and rehabilitation. Injured children also can receive payments for lost earnings, but not until they are 18 years old. Children whose vaccine injury occurred before the legislation goes into effect can be compensated for their present and future medical expenses.

After learning the amount of the compensation awarded to their child, parents can reject it and go to court. But they cannot recover damages from a vaccine manufacturer on the grounds of negligence if the manufacturer complied with Food and Drug Administration standards. This should make it more difficult for parents to win in court and should protect manufacturers from costly suits.

The parents are free to sue their physician for negligence if, for example, he failed to recognize that their child was at high risk for vaccine-induced damage and to recommend that the child, therefore, be exempt from otherwise mandatory vaccination. Physician negligence is not part of the new legislation.

The Waxman no-fault bill, which is the one passed by the House and Senate, was based in part on a 1985 report from the Institute of Medicine. In particular, notes Roy Widdus at the institute, the compensation scheme in the Waxman bill is "the most favored one in our report."

On the unresolved matter of legislation for the vaccine tax, it is clear that the Administration is vehemently opposed. However, Hill staffers point out that the tax is designed to create a compensation system that is self-sustaining; it should require no federal appropriations past the first 1–3 years, they say. Final resolution of the issue awaits the next Congress. ■

GINA KOLATA

Researchers' Dreams Turn to Paper in U.S.-U.S.S.R. Fusion Plan

Ever since President Reagan and Soviet General Secretary Mikhail Gorbachev met in Geneva last November, Administration officials have struggled over a pledge to expand international cooperation in research on magnetic confinement fusion. While the summit language did not obligate either country to carry out any specific task, American and Soviet scientists have advocated construction of a major new experiment—the Energy Test Reactor (ETR). Seen as the forerunner of a new type of nuclear power reactor, the device would allow researchers to study plasmas burning at more than 100 million degrees Farenheit.

For now, however, it appears that the United States is unwilling to pursue such an ambitious goal with the Soviets. Instead, the Reagan Administration is expected in the near future to propose that American scientists undertake just a design study with the Soviet Union, Japan, and the European Economic Community. While the exact dimensions of the undertaking are "classified" for the moment, Administration officials say it will probably call for determining the design parameters, assessing related engineering and technology problems, establishing a management structure, and refining cost projections for the ETR, which have been estimated at $4 billion.

The proposal clearly falls short of the