"There is much to learn" in psychopharmacology as well as psychotherapy "independent of any immediate application," he says.

One reassuring factor is that the Initial Review Groups will, contrary to early reports, stay as they are: one for psychosocial and biobehavioral treatments; the other for pharmacological and somatic treatments. However, Knapp and others say this is not enough and stress the need to have a critical mass of expertise at administrative levels to evaluate and guide the design of treatment research. "There will be no unified leadership in Washington," laments University of Pennsylvania psychologist Lester Luborsky.

Luborsky says he and many of his colleagues are afraid that, with the emphasis on major mental illnesses, therapy for disorders that do not require drugs or hospitalization will get short shrift. Families of schizophrenics are developing a substantial political presence, he notes. But there is no lobby for neurotics, and it is hard to make a case for the treatment of lesser disorders on the basis of economics, since the costs—in terms of physical illness, social strife, loss of productivity, and drug abuse—are difficult to trace and quantify.

A decrease in emphasis on nonbiological research is also apparent in the NIMH intramural research program. Melvin Kohn, head of the Laboratory of Socio-Environmental Studies, recently announced plans to move to Johns Hopkins University after he failed to get funds sufficient to continue the lab's pathbreaking studies on the relationship of employment to values and intellectual functioning. The lab's future is in doubt, says Kohn's assistant, psychologist Carmi Schooler, even though "this is basic research" that is "definitely connected to mental illness."

Everyone agrees that explosive advances in the neurosciences inevitably mean that NIMH tilts more toward biology these days; nonetheless, many behavioral scientists feel that Frazier's approach, while politically astute, goes too far. As one lab director told the Consortium for Social Science Associations, "I don't care how much good lab science gets done, mental illness isn't going to be cured by a vaccine or gene splicing."

—CONSTANCE HOLDEN

# New Doubts About Star Wars Feasibility

## Some critics charge that a comprehensive missile defense is doomed to failure because the computing requirements cannot be met

The resignation of a highly regarded consultant to the Pentagon's "Star Wars" program has brought to light a controversy within the computer science community over the program's feasibility. Charging that the goal of the program is unattainable because of inherent limitations in software reliability, David Parnas, a professor of computer science at the University of Victoria in British Columbia, has resigned from an advisory panel on battle management.

"In March 1983 the President asked us, as members of the scientific community, to provide the means of rendering nuclear weapons impotent and obsolete," Parnas noted in a lengthy letter to program officials dated 28 June. "I believe that it is our duty, as scientists and engineers, to reply that we have no technological magic that will accomplish that."

Parnas, who served as head of the Software Engineering Research Section at the Naval Research Laboratory in Washington from 1979 to 1982, notes that unlike some other academic critics of the program he does not object to it on political grounds, nor does he have any reservations about defense-related work. "My conclusions are based on more than 20 years of research on software engineering, including more than 8 years of work on real-time software used in military aircraft."

Specifically, he says, the computing demands of a comprehensive missile defense system are such that no existing technology or innovation on the horizon is capable of ensuring its reliability. New developments in highly touted tools of the trade, such as artificial intelligence, automatic programming, and program verification, will be incapable of appreciably altering this situation.

Parnas, who has also been a consultant to TRW and Bell Labs, explains that one problem is ineradicable uncertainty about the exact nature of the enemy threat. Another is uncertainty about the survivability of various computing hardware. "We have no techniques for proving the correctness of programs in the presence of unknown hardware failures and errors in input data," he says. But the biggest problem is that an elaborate missile defense can never be realistically tested. "In operational software for military aircraft, even minor modifications require extensive ground testing followed by flight testing in which battle conditions can be closely approximated. Even with these tests, bugs can and do show up in battle conditions," he explains.

Similar criticism had previously come from Anthony Ralston, a professor of computer science at SUNY-Buffalo and a former president of the Association for Computing Machinery. "Quite aside from any other technical, political or economic objections which might be raised about the Star Wars system, its computer software problems doom it to failure," he told Science in a recent letter. "In no foreseeable future . . . is there any valid prospect of writing 10 million or 100 million or anything approaching this number of correct lines of code."

And on the day that Parnas's remarks first garnered attention in the United States, Larry Smarr, director of the National Center for Supercomputing Applications at the University of Illinois, also denounced the program as unrealistic. At a press conference organized by a group of 47 physicists at the school who have pledged not to "apply for or accept" research grants from the "Star Wars" program because of political and technical concerns, Smarr said that the software will inevitably be subject to two flaws: "it will not do what it was meant to do, and it will not anticipate everything that the enemy might throw at it."

Officials of the program, formally known as the Strategic Defense Initiative (SDI), counter that they are optimistic about creating a network of space-based computers capable of choreographing an elaborate missile defense. At a recent forum organized to enlist academic participation, Edward Wegman of the Office of Naval Research acknowledged that

"if any portion of the SDI is vulnerable because of the available technology, then this is probably it." But, along with others, he appealed for "unconstrained brainstorming" to develop innovative ideas.

The panel from which Parnas resigned was established to help guide the software research. "Given the current state of software technology, he may be right," says James Offutt, an SDI assistant director for battle management. "I don't think this area is as mature as weapons and sensors, for example. But we're not concerned with the current technology; we're concerned with where we'll be in 5 or 10 years." He is particularly optimistic about using "a hybrid of artificial intelligence and numerical algorithmic programming" as well as about potential improvements in hardware that might ease the requirements somewhat.

Daniel Cohen, director of the systems division at the USC Information Sciences Institute and codirector of the battle management advisory panel, says that he agrees with many of Parnas's conclusions, but also remains optimistic. "Parnas is absolutely right that it can't be tested; that artificial intelligence probably will not help; that program verification techniques are still in their infancy; and that automatic programming also will not solve this problem. Yet there is a very good chance that this code can be written in less than 5 years. It is, after all, not more complicated than the Apollo moon shot, by much."

But others, such as Herbert Lin, a research fellow at MIT who has written an extensive report on battle management, offer less flattering analogies to suggest that systems which cannot be tested and debugged are likely to fail. "Gemini V missed its landing point by 100 miles because its guidance program implicitly ignored the motion of the earth around the sun," Lin says. A more contemporary example was provided several weeks ago when the space shuttle flubbed a "Star Wars" laser experiment because its computer was given instructions in feet rather than nautical miles.

In his letter, Parnas criticizes the battle management panel because it "contains not one person who has built actual battle management software . . . and no experts on trajectory computations, pattern recognition, or other areas critical to this problem. All of its members stand to profit from continuation of the program." Copies of his letter have been sent to members of the Senate Armed Services Committee and to presidential science adviser George A. Keyworth, II.—R. JEFFREY SMITH

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## U.S. Wants to Keep Eye on Biotech Exports

For the past couple of years, the Departments of Defense and Commerce have hinted that they might place export restrictions on some areas of biotechnology. Now there appears to be some slight movement on the issue.

The Defense Department, worried that the Soviet bloc may be trying to exploit the technology for biological warfare, said recently that it will ask the nation's allies to begin tracking biotechnology exports. At a meeting this fall in Paris of COCOM, the Coordinating Committee for Multilateral Export Controls, the Defense Department will propose that certain exports related to genetic engineering be placed on a watch list and monitored by its members, which include Japan and members of the North Atlantic Treaty Organization, except Iceland and Spain. The department has not yet decided what exports it wants monitored.

This disclosure immediately aroused fears among scientists and administrators in industry and academia that the Defense Department would restrict the flow of research information. But Stephen D. Bryen, deputy assistant secretary of defense, who heads the Pentagon's efforts to regulate strategically important technologies, says that the Defense Department "is not talking about restricting basic research. It's been blown out of proportion that we'll clamp down on information flow. We simply want to conduct monitoring to see where the technology is going," he said. "The premise is that it's possible that the Soviets are engaged in developing biological weapons."

Bernadine Healy, deputy director of the Office of Science and Technology Policy, said after a Cabinet council meeting on 12 July, at which biotechnology was the subject, that "there is no talk about restricting scientific communication." Healy, who is coordinating the development of federal regulation in biotechnology, said, "The issue is whether the watch list will have specific products on it."

Bryen stressed that discussions about what should go on the watch list are still at a very preliminary stage.

(Some biological materials and equipment are already restricted under Commerce Department rules.) A list will be drawn up internally and then presented to COCOM. Industry will be consulted at a later date, Bryen said.

Industry representatives, however, may get some input through the Commerce Department. The department is forming a committee of outside experts to advise officials how to modify the existing export restrictions to enhance U.S. trade while balancing national security concerns. The chairman of the committee is Michael G. Hanna, Jr., director of Litton Institute of Applied Biotechnology, but the rest of the committee has not yet been fully constituted. Hanna said, "It is my understanding that we will be participating in the Defense Department's discussion as they develop the watch list."

The Commerce Department "is simply discussing whether export control is needed, but nothing much is going on right now," said Alfred Hellman, who is a technical adviser at Commerce and was formerly a cell biologist at the National Cancer Institute. Hellman noted that the department recently approved funding for two scientists to monitor trade in biotechnology while based in London and Tokyo. "We want to find out what other countries are selling in terms of biotechnology. It would be ludicrous for our companies to be restricted from selling abroad if comparable products by foreign producers are on the market," Hellman said.

Joseph Perpich, vice president of Meloy Laboratories, which develops biotechnology products, says the review of export laws is a legitimate exercise because some of the restrictions are outdated. But "it's essential that Defense and Commerce don't create rules rapidly and get into an adversarial relationship with the industry as they have done with the computer industry."—MARJORIE SUN

## Creationists Lose Again

Fundamentalist religious groups have lost another legal battle in their attempts to require the teaching of so-called creation science in public schools. On 8 June, a federal appeals court in New Orleans ruled that Louisi-