tionary fund, which this past year was $1 million and which may be twice that next year. The fund allows SERI to take advantage of attractive targets of opportunity. This year, for example, $150,000 was used to mount a demonstration of passive and active solar technologies by selected metropolitan Denver home builders—a project initiated more or less spontaneously after the president of the Denver Home Builders Association came to SERI seeking advice about how best to take advantage of land he owned on slopes facing south.

Officials at DOE headquarters, notably Robert San Martin and Bennett Miller (who has been DOE's deputy assistant secretary for solar energy but is now leaving), say Hayes is doing an excellent job.

As for complaints of DOE breathing over SERI managers' shoulders, San Martin says that new rules are now in force to prevent such interference. But Hayes claims that the new rules have not worked as well as San Martin suggests, and he hopes to see more improvement. In any case, he has said that gross interference by DOE program officials will not be tolerated.

Hayes seems to enjoy generally good relations with DOE officials. Secretary Charles Duncan gave in gracefully when a congressional committee recently supported Hayes rather than himself in approving a somewhat faster pace of funding for SERI's permanent facility and testing ground.—LUTHER J. CARTER

News and Comment reporter Luther J. Carter has taken a leave of absence to write a book about the politics of radioactive waste management. It will be published under the auspices of Resources for the Future.

Philosophers at the Pentagon

Academicians with a philosophical bent take on billion-dollar problems uncovered during a war game

Two years ago the Pentagon carried out a computerized war game called Nifty Nugget, a massive, secret, government-wide mobilization exercise, the first such exercise to be carried out in this country since World War II. For 1 month, more than 1000 players around the nation waged an all-out conventional war against the attacking forces of the Warsaw Pact in Europe.

Or that was the plan. Nifty Nugget was in fact plagued with computer foul-ups, logistical snarls, and what General Walter T. Kerwin, then vice chief of staff of the Army and official overseer of the game, later called "great gaps" in understanding among various players. "You wonder," he says, "whether they were playing the same exercise."

One very unmilitaristic upshot of this war-game muddle and a long history of such "command and control" breakdowns is that the Pentagon is turning to academia for answers, or, it would seem in some cases, for mind games.

Last year, some 30 academics with a philosophical bent, including microbiologist and Nobel laureate Joshua Lederberg, an expert on the subject of artificial intelligence, met with an equal number of top-ranking people from the Pentagon. These included Robert J. Hermann, then a Deputy Undersecretary of Defense for Research and Engineering, and Robert M. Brookman, Deputy Engineer for the World Wide Military Command and Control System (*Science*, 14 March, page 1183). Computerized and problem-ridden, the more than $1 billion WWMCCS system is relied on by the President and the Joint Chiefs of Staff to coordinate the global forces of the U.S. military.

The Pentagon-generated list of invited academics included anthropologists, control theorists, cyberneticians, mathematicians, psychologists, systems theorists, sociologists, and neurobiologists.

Putting philosophers and systems theorists onto the billion-dollar problems of the U.S. military may seem somewhat laughable on the surface, and indeed, the series of three meetings held around the country in 1979 produced their share of opaque pronouncements. "How we see things," opined one of the participants, quoting an oft-abused statement made by Albert Einstein, "determines much of what we see."

On another level, however, the meetings and the subsequent discussions in the corridors of the Pentagon and the follow-up studies are significant in several respects. For one thing, the meetings themselves were a tacit admission of the severity of the command and control problems facing the U.S. military, an admission not often forthcoming. For another, the meetings showed that segments of the military are actively searching for nontraditional solutions to command-control problems. This in itself is just short of astounding. In the past, the principal preoccupation of the U.S. military has been the acquisition of more and especially more expensive hardware such as computers, satellites, secure transmission circuits and the like. All this miraculous gadgetry and the formidable acronyms that go with it have consistently come up short on performance, however, and the search for a non-hardware integration of the systems is a healthy sign. Finally, the meetings produced a few proposals that have been taken to heart. In one case, a general systems theory derived from biological examples is being tried out on command and control problems at the battalion level in the Army.

> The nub of the command-control problem faced by the philosophers was complexity, and, for the military, complexity's not-so-distant cousin, chaos.

The nub of the command-control problem faced by the philosophers was com-

0036-8075/80/1024-0409$00.75/0

plexity, and, for the military, complexity's not-so-distant cousin, chaos. In the past 20 years, the electronic communications links throughout the different levels of the U.S. military establishment, as everywhere else, have grown enormously. In addition, there has been an explosive increase in the amount of computing at every level, including that of individual weapons systems, theater combat commands, and the National Military Command Center in the Pentagon. For the battlefield alone, the Army currently has 150 computerized systems under development. The result has been a vast increase in the available amount of tactical and strategic data. Quality, however, is another question. As one Pentagon official put it at one of the meetings, the systems have "helped us to know a lot of things we don't need to know, but they have not helped to define what we need to know."

Put another way, the question is whether the traditional reductionist approach to understanding can make workable such a "holistic" challenge as a worldwide U.S. military command and control system.

The question may sound theoretical to the point of uselessness, but it is prompted by some very down-to-earth considerations. The Soviets, for a variety of technological and cultural reasons, rely on a much more centralized command structure than the one used by the U.S. military, and the difference has Pentagon officials worried. The sponsor of the meetings with the academics, for instance, was the Pentagon's Office of Net Assessment, which seeks to determine how U.S. forces would compare with those of the Soviet in a variety of potential conflicts. According to Andrew Marshall, director of the office, the key concept behind Soviet command and control is to ensure strict compliance of subordinate combat units with the planned operation. The individual ship, plane, or tank is not expected to fight on its own initiative. In fact, they do not have the full instrumentation to do so. In each case a unit with several assigned weapons systems is directed in action by a commander who has available to himself the control mechanisms which in the U.S. military are on each individual weapons system.

One problem for the U.S. military, according to John J. Ford, a Washington-based consultant who helped organize the meetings between the academicians and the Pentagon, is "to find the means of orchestrating the cacophony now rampant in the U.S. command-control

(Continued on page 412)

Progressive Case Fallout Has a Long Half-Life

A year ago, the government dropped its efforts to prevent publication of a *Progressive* magazine article that allegedly divulged H-bomb secrets (*Science*, 5 October 1979). But repercussions of the conflict lingered on.

In early September the Justice Department informed the *Progressive* that there would be no criminal prosecutions or contempt-of-court proceedings as a result of the case. For at least one government scientist, however, the *Progressive* case is not over. A theoretical physicist at Lawrence Livermore Laboratory, Hugh DeWitt, is still trying to counter sanctions imposed on him by the lab for actions related to his participation in the case.

DeWitt requested a grievance hearing, now scheduled to begin on 29 October, to ask for removal from personnel records of a "notice of warning" which he views as a serious threat to his career. Officials at the nuclear weapons laboratory, after formal investigation, made the decision to issue the notice on grounds that DeWitt disregarded security regulations.

DeWitt became involved in the *Progressive* case when he was asked by the magazine's editors in March 1979 to serve in an expert witness capacity. In subsequent months he provided three affidavits of technical comment.

The laboratory's objections to DeWitt's role center on two incidents involving the affidavits in which the lab contends that DeWitt's actions could have resulted in classified information being divulged to unauthorized persons. In the first case, in March 1979, the allegation is that DeWitt allowed access to such information to three persons who lacked proper security clearance—a typist, a *Progressive* editor, and a person who delivered the document to the court in Madison, Wisconsin. DeWitt says he believed that the information was not classified and was available to the public.

The second incident occurred the following May under circumstances in which DeWitt, under a deadline, was attempting to send an affidavit to Department of Energy (DOE) headquarters in Washington for a decision on its classification status. DeWitt is accused of taking the document to be transmitted by scrambler telex before it had been properly marked as classified, thereby disregarding the instructions of his superior. A report by the lab concluded that no classified information was compromised.

Laboratory officials conducted a formal investigation of the incidents last fall and winter and in March issued the formal notice of warning, a serious administrative action, which specified that another significant violation of the rules by DeWitt could result in his dismissal. Later, DeWitt was given a rating of "marginal and unsatisfactory" in a regular performance evaluation, but the rating was later raised to "satisfactory, second half."

DeWitt was also tangentially involved in a separate incident stemming from a letter written in the spring of 1979 by four scientists at Argonne National Laboratory in which they criticized government actions in the *Progressive* case. A DOE decision that the letter contained classified information coincided with DeWitt's sending a copy to a California man interested in the case. DeWitt's attempt to retrieve the letter was unavailing and material from it was published in a newspaper. This incident led to newspaper reports that the Justice Department was inquiring into allegations that government scientists at Argonne and Livermore were leaking classified information.

This in turn prompted congressmen, including Representative Paul N. McCloskey, Jr. (R-Calif.), to express concern that the government was using threats of criminal prosecution to muzzle scientists.

Along the way, DeWitt has been backed on various points by declarations of interest and support from several members of Congress and organizations such as the American Physical Society and Federation of American Scientists. He also says he has been given a sympathetic hearing by officials of the University of California, which is the contractor for Livermore. In the grievance hearings, which will be held under university rules, legal assistance for DeWitt is being provided by the California State Employees Association with which the professionals' union at Livermore is affiliated.

0036-8075/80/1024-0410$00.50/0

Norden Systems/*Army Magazine* Photo

Help or hindrance?

Battlefield computer calculates and transmits fire-control solutions for artillery.

(Continued from page 410)

domain." Deputy Undersecretary of Defense Hermann mentioned a related issue at the initial gathering. "Our capability to deter world war," he said, "is increasingly inhibited by our inability to cope with the problem."

A feeling of "quiet desperation" pervaded the proceedings, according to one participant, in part because it quickly became clear that there were no simple solutions "out there" in academia that were amenable to easy adoption by the Department of Defense. Contributing to the uneasy feelings was the fact that much command and control information is classified, and the academic participants were thus struggling to help revitalize a system they could not easily visualize.

The sense of desperation may have also been abetted by some of the simplistic solutions put forward. Consider one recorded in the final report on the meetings, written by ESL Incorporated, a defense contractor in Sunnyvale, California. "Much of the expenditure of funds in command and control at present is for the gathering, communicating, processing, storage, and display of information," the report noted and then went on to make what must be one of the all-time great restatements of the obvious. "A better understanding of how the human mind uses information, its power to absorb data could have a major impact on technology requirements."

A more thoughtful proposal, one currently being tested by the Army, was put forward by James G. Miller, president of the University of Louisville and author of the general systems theory outlined in his book, *Living Systems*. In this he states that all biological and social systems, starting with cells and proceeding up the evolutionary ladder, have 19 functional subsystems for energy, matter, and information handling which can be traced regardless of the hierarchical level of the system under investigation, be it a jellyfish or the city of New York. If one learns how the subsystems function in one system, according to this theory, the knowledge can be extrapolated to another. Although the details are classified, this approach as applied to command and control problems is currently being tested by the Army.

Other suggestions involved theories out of the hard sciences. Much emphasis was put on exploring the formulation of Werner Heisenberg's "uncertainty principle" in modern physics, which says an experimenter can determine the position or the velocity of a quantum particle, but not both. As there were no physicists at the meetings, however, the details were not explored in depth. Given the philosophical difficulties of applying the uncertainty principle to realms of human endeavor, it will probably stay that way. At least one suggestion that did result in a follow-up study was a proposal to explore the implications of the theoretical modifications of the Second Law of Thermodynamics, as suggested in the open literature by Ilya Prigogine, to see if such mathematical explorations could result in a "concept for the overall structure of U.S. military command and control." The resulting 87-page study, entitled "The Application of the Maximum Entropy Principle to Models of Military Command and Control Systems," dated July 1980, was carried out by K. E. Woehler at the Naval Postgraduate School in Monterey, California.

A conspicuous omission during the meetings, according to one consultant, Ford, was a "critical examination of the dominant paradigm which condones the expenditure of vast resources without even the semblance of a conceptual rationale for the effort."

To a remarkable degree, this called-for "critical examination" now seems to be unfolding at an increasingly rapid pace in the wake of the theory-rich confrontations between the philosophers and the Pentagon. One sign of this is the unflagging enthusiasm with which officials in the Pentagon's Office of Net Assessment discuss the issues. And the sentiment seems to be spreading. The proceedings from a Pentagon-wide workshop, "Quantitative Assessment of Utility of Command and Control Systems," dated January 1980, have recently been released. Another workshop is slated for later this year.

One reason for all this preoccupation with command and control is undoubtedly the raw memories of Nifty Nugget. Arguments that began in the aftermath of that exercise still echo through the halls of the Pentagon and on Capitol Hill because it suggested that one option the President must consider is the possibility of losing the next conventional war. Despite signs of a critical examination in the wake of Nifty Nugget, Ford is somewhat skeptical about how far-ranging the results of such an inquiry will be. "There is not much chance for the formulation of a command and control concept," he says, "so long as the dominent paradigm persists in emphasizing things over relationships, hardware over the concepts needed to use it effectively. This narrow point of view needs to be shifted if the fatal consequences surfaced by Nifty Nugget are to be avoided if and when our forces get involved in something beyond a war game."—WILLIAM J. BROAD