tagon recently included Midgetman on a list of programs that might be delayed for a year if the President's overall defense budget is not approved, and reductions are needed to constrain the deficit.

Senator John Warner (R–VA), chairman of the Senate Armed Services Committee, predicted recently Congress is likely to authorize most of the $1.37 billion needed to start full-scale development of the Midgetman, but then block the expenditure of some of the funds until it has an opportunity to review the Pentagon's final recommendations early next year. ■ **R. JEFFREY SMITH**

Second of three articles. Next: The impact of mobile missiles on strategic targeting and future arms control agreements.

Oil Industry R&D Takes a Fall

Exxon's corporate research operation cut in half as oil companies "downsize" to adjust to market

CUTBACKS in budget and work force by major U.S. oil companies to compensate for the decline in oil prices have brought sharp reductions in R&D activities. In the case of the Exxon Corporation, the largest oil company in the world, retrenchment includes a recent decision to scale back corporate research by half.

Details are hard to come by. Oil companies are reluctant to discuss budgets, manpower, or research strategy lest they provide clues to their competitors. But industry observers agree that changed conditions dating back to the beginning of the decade have shaped new attitudes toward R&D. Edward E. David, Jr., former president of Exxon Research and Engineering Company, where corporate research is lodged, estimates that the level of effort on research, development, and engineering within the petroleum industry has been cut by at least 30 to 40% in the last 3 years.

At Exxon, the pruning of corporate research ends a boom period for the operation that began in the late 1970's. Corporate research, which, as the name implies, serves the whole company, moved into a new $200-million facility at Clinton, New Jersey, 3 years ago (*Science*, 7 September 1984, p. 1001). Basic research is a principal element of corporate research and the new research center was assumed to mark Exxon's firm commitment to such research.

Exxon officials confirm that staff at Clinton will be reduced on the order of 50%. Peak employment at the center was about 900, including 300-plus Ph.D.'s and a technical support staff of over 200. Lab staff is now apparently down near the levels projected under the cuts. Since April, Exxon has been going through a corporation-wide voluntary separation program aimed at reducing its total U.S. work force by 15%.

While current cuts in corporate research look disproportionately large, Exxon vice president for corporate research Frank B. Sprow notes that the division was insulated from earlier reductions in R&D activities. He says that many of Exxon's other technology units were "downsized" beginning in 1982, but corporate research was protected. Now that major cuts are being imposed across the board, corporate research's turn has come.

Exxon is "reverting to type as a natural resource company," says Edward David.

Exxon's total spending on R&D throughout the corporation declined from $736 million in 1984 to $681 million in 1985. Spending on basic research was put at over $100 million in 1984. Later figures are not available, and it appears that decisions on research budgets for the immediate future are not yet firm.

The expansion and contraction of R&D activities at Exxon generally followed oil industry patterns, although Exxon's investment in corporate research seems to have been relatively greater than its smaller rivals. Sprow says the expansion was fueled by two main factors. Exxon wanted research support for its 1970's diversification into business areas such as office systems and electronics. And the corporation also invested heavily in R&D on synthetic fuels when high energy prices encouraged expectations that synfuels from coal and oil shale would be marketed profitably by the early 1990's.

In the early 1980's, the outlook changed. Exxon's experience with diversification proved disappointing and caused a cooling of corporate ardor on that score. Then trends in oil supplies and prices quashed early prospects for synfuels and negatively affected Exxon's base business. Exxon and other oil companies cut back drastically on expensive synfuels commercialization projects. At that point, Exxon and the other majors also began the downsizing process that still dominates industry strategy.

Sprow says that management personnel at Clinton are being cut with the objective of reducing central direction of research and relying more on researchers to set scientific priorities. Increased contact with other technology units of the company is also planned. Sprow says the aim is to "walk the edge between having the people who use the science produced be more involved, but at the same time not becoming an applied science lab."

Corporate research in the 1970's cultivated increased contact with universities by supporting research there and promoting the interchange of researchers between Exxon and university labs. The biggest program has been a collaboration with MIT that focuses on high-temperature chemistry. Now in the last third of a 10-year agreement, with support running at about $900,000 a year, Exxon says it intends to abide by the terms of that and other cooperative arrangements in academe. Sprow says that for the smaller Exxon research effort to retain its effectiveness it is viewed as necessary to maintain contacts outside. He says that future initiatives are likely to have a "closer fit with internal programs" and be "more tactical, less philanthropic."

The decline in oil prices, particularly the sharp drop that halved prices in a few months earlier this year, is seen as the main cause of recent cutbacks. Chevron on 12 June announced its own 12% reduction in employees. But some observers see expectations of excess capacity and low prices creating a siege mentality in the U.S. oil industry along with a pessimistic view of the value of R&D.

David, who resigned as Exxon's research chief last year before the latest oil price

crunch occurred, suggests that Exxon's actions in respect to technology and research are at least in part a matter of "history, tradition, corporate culture." He notes that Exxon is "reverting to type as a natural resource company," and "the role of research in a natural resource company is indeed minor."

Observers agree that the assumption that Saudi Arabia can raise oil production at will and swamp the market has discouraged U.S. companies' interest in investment in the exploration and production end of the business. Most U.S. companies have deeply cut back research that supports exploration and refining activities.

Another negative influence on oil industry R&D is seen in the restructuring of the industry that began about 1980. In a talk on energy R&D in May, Phillips Petroleum Company vice president for research and development Charles F. Cook noted the effect of corporate takeover bids and mergers. Examining what he called "merger mania," Cook cited "ten acquisitions which resulted in $58 billion transferred or added as debt since 1980. These acquisitions, regardless of the justification, did not add one additional barrel of oil to U.S. reserves. It did, however, take a lot of money out of research and the search for oil.

"In reaction to raids, a number of oil companies have taken on excessive debt and/or have buy-back programs of their own stock. This too has removed cash or added debt to the oil industry."

Taken together, Cook said in an interview, the collapse of prices and restructuring caused "a significant reorientation of thinking. You've got to plan in a fluctuating oil price scenario." In remarks at the AAAS Colloquium on R&D Policy in March, Cook said that "Stability in R&D and exploration budgets is history and rapid changes will be a way of life." He predicted a "down cycle for R&D in the oil patch" for at least the next 5 years, with the date of a turnaround unknown. ■ JOHN WALSH

Federal VDT Study Finally Wins Approval

First proposed in 1982, it was held up by OMB because critics charged that the design was flawed

"It's been a long time coming," says Philip Bierbaum of the National Institute for Occupational Safety and Health (NIOSH). After 4 years of planning, the agency on 6 June finally won approval from the Office of Management and Budget (OMB) to begin a study of the potential reproductive hazards among women who use video display terminals (VDT). The project is one of the first major attempts to determine scientifically if VDT use is linked to spontaneous abortions and birth defects.

In December, the budget office rejected NIOSH's original proposal for the study, but has now approved a revised version. The budget office objected to the study after Brian MacMahon, head of epidemiology at the Harvard School of Public Health, and Sally Zierler, assistant professor of public health at Brown University, criticized its design. The two scientists reviewed the proposal as paid consultants to Bell South, whose employees, along with workers at AT&T, were to be the focus of the study. Supporters of the study, including workers' groups, consequently have charged that Bell South was trying to squelch the study and that OMB was meddling in scientific affairs.

Marjorie Sun

Spontaneous abortions and other reproductive problems have been reported among women VDT users, but the number of women are too small and the problems too varied to draw any conclusions.

The company, MacMahon, and Zierler argued that they were not opposed to the study, but said that its design was badly flawed. Their criticisms, and the lengthy dispute over this research, highlight the complexities of planning a sound epidemiological study of reproductive effects that are likely to be encountered at very low levels, if at all.

From the beginning, the project was difficult to design. NIOSH first proposed the study in 1982 after several widely publicized reports indicated that clusters of women VDT operators in the United States and Canada suffered high rates of spontaneous abortions, birth defects among their children, and other reproductive problems. But the groups were too small and the reproductive problems too varied to draw any scientifically valid conclusions. The likelihood of an association is considered small because VDT's emit trivial amounts of nonionizing and ionizing radiation, according to NIOSH.

Teresa Schnorr, the NIOSH epidemiologist who drafted the study protocol, says that right off the bat, agency scientists had trouble forming a hypothesis to test. "There were no patterns among the clusters," she says.

In general, reproductive studies are more difficult than others in epidemiology because medical records on miscarriages and birth defects are not as reliable or consistent as records pertaining to disease or death. Some doctors, for example, only report miscarriages that occur late in pregnancy. Also, medical records of miscarriages and birth defects often are not included in company personnel records. Although the information may be available through medical insurance files, a comprehensive study would