

merce, Defense and Energy departments. Sources in Washington's science policy circles say that Bromley's position may already be weakened by his late arrival within the Administration's power structure.

He will be expected to cross another minefield in September. Gore ex-

tracted a promise from Bromley to make another appearance at the confirmation hearing for the associate directors of OSTP. That hearing, Gore asserted, will begin a series of public sessions on science and technology issues.

—IRWIN GOODWIN

## REMOVING CONTROLS ON PCs REVIVES WORRIES ON EXPORTS

In relaxing the government's export controls on personal and laptop computers to Soviet bloc countries, the Commerce Department acknowledged that the technology is now both technically unexceptional and widely available. The Defense Department's publicized pique with the decision came as no surprise. Only last March, DOD and the State Department agreed to share authority with Commerce in approving technology transfers to US allies and adversaries, but the Pentagon is adamant about holding onto technologies with even a modicum of military usefulness lest it fall into the hands of Soviet armed forces. The decision on computers, which went into effect on 15 August, highlights the turf wars between the departments over technologies with dual commercial and military uses. It has led to the publication of various lists of militarily critical technologies and to embargoes of products to the Soviet bloc.

Commerce's decision contradicts the policies of the Reagan years, when the White House and Pentagon were mainly protectionist and xenophobic about major new technologies. Actually, export controls on computers and other high-technology equipment were tightened by the Carter Administration after the Soviet invasion of Afghanistan in 1979, when Congress passed the Export Administration Act. But with the Soviet withdrawal from Afghanistan, the easing of tensions brought about by Mikhail Gorbachev's *glasnost* and *perestroika* policies, the economic reforms sweeping across Eastern Europe and the drive by America's allies to reduce trade barriers, the Bush Administration had second thoughts about technology sales. When Bush visited Poland and Hungary in June, he pledged to open up trade relations in high technology. One week later came Commerce Secretary Robert A. Mosbacher's announcement on personal computers.

The next day Defense Secretary Richard Cheney called in reporters to voice his dismay. The decision, ar-

gued Cheney, is likely to jeopardize national security. The revised policy, warned Cheney, would give the Soviet military "significant capabilities they do not now possess."

To Mosbacher such fears seem groundless, however, because the Soviet bloc has obtained personal computers made in Taiwan, India, Brazil and China, which are not part of the 17-nation group that, since 1949, has been restricting sales of advanced dual-use technologies to Communist countries through the Coordinating Committee on Multilateral Export Controls. cocom has been more or less successful in keeping what Mosbacher calls "middle-level dual-use high-tech" out of Soviet hands, but that hasn't prevented Soviet scientists and engineers from producing high performance computers or kept spies and greedy businessmen from smuggling computers into the USSR.

### 'Foreign availability finding'

By issuing a "foreign availability finding" in the *Federal Register*, Mosbacher has admitted that embargoed models of Apple Macintosh Plus, for instance, or IBM PS-2 and their clones have been finding their way into Warsaw Pact nations. Mosbacher stated that computers of this type are available in 11 countries and from 70 vendors outside of cocom nations. He lends force to his argument by noting that some desktop computers are already assembled in two Soviet bloc countries—Czechoslovakia and Hungary.

The fuss over personal computers appears to symbolize the Bush era so far: avoid confrontations at home and abroad and emphasize widely popular and practical goals. The new policy on computers satisfies those aims. It allows US microcomputer makers to enter new markets when sales are slowing to older markets; it sends a message to America's allies that the US intends to loosen its trade restrictions; it recognizes that the Soviet bloc is getting dual use technologies despite Washington's embargoes; it sets certain standards for computers

licensed for export and maintains restrictions of computers considered truly strategic.

The new rule seeks to eliminate doubts about computer exports. Last year, for instance, a British engineering firm, Simon-Carves Ltd, signed a \$450 million contract to build a plant to manufacture factory automation machinery in Yerevan, the capital of Soviet Armenia. The plant, scheduled to be completed in 1991, will make industrial microcomputers of a type used to control assembly-line robots. At full capacity, the Yerevan factory may be capable of turning out 25 000 microcomputers each year. When US officials objected to the Simon-Carves deal and suggested the computers might be downgraded in quality, the British rejected the proposal. US negotiators then asked the British to seek permission for the deal from cocom, which would examine the technology for military implications. But the British government refused to do so, insisting that the technology was so innocuous it did not require cocom's purview. Some angry US officials say Prime Minister Margaret Thatcher herself made the decision, rejecting Washington's rigidity and circumventing cocom's review. A British Embassy spokesman in Washington simply said: "You may rest assured that we shall not export to the Soviet Union any equipment that gives rise to security concerns."

Microcomputers have also entered the Soviet Union by back doors. One case occurred in 1986 when a vendor to West Germany's automobile industry shipped 40 computer workstations made by Tektronix Inc of Beaverton, Oregon, complete with disk drives produced by Control Data Corp, to a Belgian distributor who moved the machines to Vienna en route to a Soviet bloc country. Apparently alerted by a tip, US officials broke up the scheme, stranding some equipment in a Vienna warehouse, but not before most of it slipped through. The Pentagon claimed at the time that with the right software, augmented Tektronix 4125s can be used to design nuclear weapons.

### National interests served

Mosbacher asserts that the new policy actually serves the national interest in two ways: It encourages exports by one of the country's most competitive industries and, less obviously, it strengthens the export control system by removing restrictions that many scientists and businessmen regard as futile and foolish.

Personal computers have been among the great growth industries of



## Pentagon's Critical Technologies Agenda

The departments of Defense and Energy, in a report to Congress last May, identified 22 "critical technologies" as essential to "the long-term qualitative superiority of US weapons systems." The technologies were not ranked in order of importance; military officials say the subjects were grouped by related fields.

The list is not considered final. Other technologies may appear on future lists. "Surprises in technology are not unknown," observes a Pentagon source. "The first Sputnik radically changed our strategic thinking over here." To be on the list a technology must meet four criteria: It must significantly enhance the performance of proven weapons systems; it must have a potential for allowing new capabilities or systems to be created; it could result in improved reliability, availability and maintainability of weapons systems; and it must be affordable.

The list of technologies and their objectives follow:

**Microelectronic circuits.** Production of ultrasmall integrated electronic devices, such as microprocessor chips, for high-speed computers, sensitive receivers, automatic controls and other sensitive circuitry.

**Gallium arsenide and compound semiconductors.** Preparation of high-purity GaAs and other compound semiconductor substrates and thin films for microelectronic substrates.

**Software producibility.** Generation of reliable and affordable software.

**Parallel computer architectures.** Ultrahigh-speed computing by parallel processing in the next generation of computers.

**Machine intelligence and robotics.** Incorporation of human "intelligence" and actions into mechanical devices.

**Simulation and modeling.** Formulation and testing of concepts and designs entirely by computer.

**Integrated optics.** Development of optical memories and optical signal and data processing.

**Fiber optics.** Ultralow-loss fibers and such optical components as switches, couplers and multiplexers for communications, navigation and other purposes.

**Sensitive radars.** Development of radar sensors capable of detecting low-observable targets, or capable of target classification, recognition, or identification.

**Passive sensors.** Creation of sensors that monitor their surroundings, including the condition of nearby equipment, without emitting signals that might reveal their presence.

**Automatic target recognition.** Development of machines combining computer architectures and algorithms with signal processing to detect, identify and track targets in real time.

**Phased arrays.** Formation of spatial beams by controlling the phase and amplitude of radiofrequency signals at sensor elements distributed along an array.

**Data fusion.** Creation of machines that process, integrate and interpret large amounts of raw data and present the data simply and conveniently.

**Signature control.** Making signatures of weapons and vehicles less visible to radar, optical and acoustic and other identification.

**Computational fluid dynamics.** Computer simulation and modeling of complex fluid flows, such as those across the surfaces of aircraft, rockets and spacecraft.

**Air breathing propulsion.** Improvement in weight-to-power ratios in engines that use ordinary air, to achieve more efficient combustion.

**High-power microwaves.** Development of offensive weapons that use microwave radiation to disable sensors and to damage structures.

**Pulsed power.** Generation of power in the field with relatively lightweight, low-volume devices.

**Hypervelocity vehicles.** Development of devices, such as electromagnetic guns, with high-velocity kinetic-kill projectiles that can penetrate hardened targets at great distances.

**Composite materials.** Development of substances that possess high-temperature, high-strength and lightweight characteristics for aerospace and weapons applications.

**Superconductivity.** Fabrication of superconducting materials.

**Biotechnology materials and processing.** Alteration of bacteria and other living organisms to produce new substances.

the 1980s. Eight years ago, when IBM introduced its first PC, Compaq Computer wasn't even in business, Lotus Development was just getting going and Apple Computer had barely emerged from Steve Jobs's garage. At the end of last year, by contrast, nearly 100 million personal computers were in use around the world, sales of hardware alone were approaching \$40 billion and scores of companies in a dozen countries were developing machines at a dizzying pace and hundreds more were supplying semiconductors, peripherals and software.

Under the new ruling, computers with a connected main storage capacity not exceeding 39 megabits and a total capacity no greater than 1320 megabits may be exported to the Soviet bloc. They are to be the kind of stand-alone machines used in normal office or home environments and not the type that includes a central processing unit with more than two microprocessors or microcomputer microcircuits.

### Restrictions on supercomputers

A panel appointed by the National Research Council urged the government last December to eliminate export controls on most computers and related systems and to retain restrictions on supercomputers "of compelling military importance," which might conceivably enable Warsaw Pact countries to make substantial gains in their military technology base. Commerce Department sources say the Research Council report influenced Mosbacher's decision.

Last March, responding to Congressional worries that the US is losing its technological edge, the Pentagon released a list of 22 technologies it considers critical to the nation's defense. The list, prepared in conjunction with the Department of Energy, includes such dual-use equipment as high-speed semiconductors and microwave and millimeter-wave integrated circuits (see box).

The report holds that Warsaw Pact nations have "significant" leads in only two critical technologies—high-power microwaves and pulsed power—and that Japan excels the US in a half-dozen other fields—namely, microelectronic circuits, GaAs and other compound semiconductors, machine intelligence, photonics, superconductivity and biotechnology materials and processes. The Pentagon's assessment, submitted to both House and Senate armed services committees, argues that Europe's fear of industrial competition from the US and Japan has fostered large, multina-



tional, centrally directed collaborations of industry, universities and government, such as ESPRIT, EUREKA, BRIT and the Joint European Submicron Silicon program, known as JESSI. The centerpieces of these projects are such generic technologies as semiconductors, sensors, optics, computer software and composite materials. Not only is the US losing its lead in those technologies to Japan and Western Europe, the report asserts, but such other countries as South Korea, Sweden, Switzerland and Israel are closing in rapidly.

Hearings on critical technologies took place last May before the Senate armed services subcommittee on defense industry and technology, headed by Jeff Bingaman, a New Mexico Democrat. One witness, Alan Shaw of Congress's Office of Technology Assessment, asserted forcefully that "by itself, the list is of limited practical use... What is important is... putting programs in place to ensure that these technologies are adequately explored and developed." Shaw often referred to OTA's 187-page report, "Holding the Edge: Maintaining the Defense Technology Base." Some 12 to 14 of the 22 technologies in the DOD list, says the report, bear applications well beyond defense and ought to be pursued as "hot" enough to set fire in the civilian consumer market.

The implication of the OTA report, said Shaw, is that defense and commercial R&D need to be integrated and coordinated much better than they are today. In the best of all possible worlds, "DOD would pursue high-risk, far-future technologies, while exploiting the private sector's talents for rapid innovation and transition into products," said Shaw. The trouble is that DOD puts no more than \$9 billion per year into its own science and technology base programs, of which less than 10% of the sum is spent on basic research. Even then, DOD's budget for R&D is so miserly it cannot hope to influence the direction of commercial technologies.

This situation troubled the Pentagon's own Defense Science Board last year when it reported that military research and production in the US are in decline and urged DOD to support collaborations of research universities, commercial firms and government laboratories to explore the frontiers of science and technology (PHYSICS TODAY, December 1988, page 87). The board expressed doubts about the decisions of DOD and Congress in neglecting to make long-term investments in the defense technology base. Worse yet, said the board, persistent deterioration of the nation's technol-

ogy and dependence on foreign suppliers for such critical components as semiconductors, machine tools and precision optics have "diminished the credibility of our deterrent."

Before the Senate subcommittee in May, Shaw observed that "marketing opportunities, not DOD planners, determine the overall direction of development in an increasing number of important technologies." In today's fiercely competitive global market, DOD is unlikely to direct or dominate R&D of new technologies, as it did in the 1950s and 1960s when US companies dominated most high technologies. Though DOD's technology base is not in imminent danger of collapse, Shaw told the senators, the Pentagon is "increasingly unable to drive the general direction of technology."

Companies making dual-use products cannot rely on sales to DOD to keep them profitable. "And creating captive companies that exist only on assured DOD business will almost certainly guarantee that technology falls behind the state of the art," the OTA report declares. Another problem for DOD as well as for the US generally is that much dual-use technology comes from abroad. Dependence on foreign technology causes a dilemma: While the US benefits by having the products, the fact that the goods are made elsewhere weakens US industry.

OTA suggests that Congress could easily pull some levers to improve the technology base for DOD and the nation. "In most cases, simply controlling defense procurement will not be enough to influence the industry. It may ultimately lead to an inefficient, backward, protected industry that is incapable of competing on the world market. Such an industry might only be capable of providing DOD with obsolete technology or overpriced products," the report states. "The government has the option of getting more deeply involved in stimulating the development of technology for commercial ends, including making government R&D facilities available and providing greater incentives for corporate investment. Yet another option is to formulate a strategy—as Japan and other nations have done—for controlling access to critical US commercial markets in order to preserve and support domestic industrial capabilities. A third policy lever that can be manipulated, but not totally controlled, is the cost and availability of capital for R&D... European and Japanese companies pay less to borrow money than do US companies... This allows them to carry on more projects simultaneously and to sell the

resultant products at lower prices than those of their US competitors, putting US companies at a competitive disadvantage."

At the May hearing, Siegfried S. Hecker described how Los Alamos National Laboratory, which he heads, set up an advanced computing center and is collaborating with IBM and other manufacturers in developing parallel processors. Los Alamos also is one of three DOE high- $T_c$  superconductivity pilot centers (the others are Oak Ridge and Argonne) and is forming a consortium with DuPont and Hewlett-Packard to produce thin-film high-temperature superconductors (see PHYSICS TODAY, August, page 55).

Senator John Glenn, the Ohio Democrat, said he planned to introduce a bill establishing a civilian DARPA. Glenn failed in his attempt to pass a similar bill in the last Congress, but he believes US technology will benefit from such an organization within a department of science and technology. Glenn argued that members of Congress have no right to complain about problems of technological competitiveness "if we don't adequately fund our national labs, DARPA and basic research."

### 'Spin-on' technologies for DOD

In his testimony Lewis M. Branscomb, IBM's former chief scientist who is now at Harvard's John F. Kennedy School of Government, emphasized that the Pentagon had a "pathological fear" of DOD contractors marketing an advanced defense technology that might reach an adversary. That might have been true in the past, he said, but in recent years "spin-ons" of commercial technology for military applications are more commonplace than "spin-offs" from DOD into the marketplace. To illustrate his point he cited the case of Digital Equipment, which shared its VAX minicomputer designs with Raytheon in developing machines to military specifications. Now, whenever Digital upgrades its VAXes, Raytheon is able to spin-on improvements in the DOD machines.

Branscomb noted that the instinct for government to "do something" about the transfer of technology to other countries and the loss of international competitiveness were understandable but often mistaken. Protectionism often results in reducing competition at home and losing out on better products from abroad. Restrictions on technology transfer leads to reducing scientific and technical exchanges. "It is important to keep open the market in products and ideas," he said.

—IRWIN GOODWIN ■