Defense R&D grows to become 67% of all Federal R&D

While funds for all Federal R&D are increased $6.9 billion in President Reagan's FY 1984 budget request, 97% of this growth represents an increase in support for R&D in the Department of Defense. Since 1980 there has been a dramatic shift of Federal funds into defense-based research. In FY 1980 the Federal investment in R&D was split approximately evenly—48% for defense and 52% for all other R&D. The FY 1984 request of $31.8 billion for defense R&D, including weapons research conducted by the Department of Energy, is up 110% over FY 1980 appropriations, while support for all other R&D programs is 15% lower than FY 1980 levels. Physics research and basic research in general are not scheduled to reap large harvests from this increased budget.

Funding for basic physics research (approximately $76 million for all three armed services), which represents a very small fraction of the total DOD research budget of $29.9 billion, is now slated to increase an average of 10% in FY 1984. A five-year initiative to improve research instrumentation at universities, begun in FY 1983 with $30 million, will continue as planned in FY 1984 with $30 million, despite the unexpectedly large number of requests for these funds (see box for details). In addition, the Defense Advanced Research Projects Agency budget, up 18% over FY 1983 appropriations in the request, includes more support for some physics-research programs.

Even these increases, however, are tentative pending Congressional action, according to Leo Young, director of research and technical information for DOD. Young told us that if the basic-research budget could retain the approximately 4½% of real growth in the submitted budget (considering inflation as 5%) most programs would be in good shape. "In the past," he said, "the requested amount has usually been higher than what was appropriated. The biggest danger is that Congress often makes undistributed cuts which have a larger impact on research projects than on weapons programs." In fact, sources in the Defense Department said, "For a number of years basic research has been a victim of the budget process because the Appropriations Committees in Congress favor hardware and systems acquisitions over research. When Congress reduces the President's request, DOD has less to spend on basic research because Congress protects certain programs from any reductions. In the competition for DOD research funds, higher priority and greater emphasis are given to more applied and short-term militarily relevant research, resulting in further diminution of support for long-term basic research. This paradoxical situation—of reduced funds available for long-term basic research while funds for research overall are increasing—has only been heightened in the last few years with the larger Reagan DOD budget requests."

The DARPA budget request for FY 1984 of $867 million is up 18% over FY 1983 appropriations of $729 million. According to Carl Romney, deputy director of DARPA, $108 million of the total requested in FY 1984 is for basic research, up $8 million from FY 1983 appropriations. A new initiative in supercomputing, with the objective of developing ultra-high-speed computational systems for military use, is now slated to receive an additional $50 million in the FY 1984 request. Initially this research will focus on artificial intelligence and on gallium-arsenide technology, including research both on the materials and electronics of VLSI circuits. Some basic research programs are largely done at universities. Romney told us in FY 1984 support for these programs would include $18 million for research in microelectronics and solid-state physics, $14 million for research in materials science, and $38 million for research in computer science, primarily in artificial intelligence and advanced digital structures. In addition, the request supports basic research mainly done by industry or at defense labs. This includes $33 million for R&D on particle-beam technology, $20 million for high-energy, short-wavelength laser research, $7.5 million for research on large optics for laser-beam control, and $5 million for R&D on space nuclear power.

The FY 1984 budget request for physics research in the Office of Naval Research is $36.9 million, up $6.5 million from $33.4 million appropriated in FY 1983. Included in this funding are a number of what the Navy terms "special-focus programs," which are specifically targeted five-year research programs. New among these programs in FY 1984 is a research initiative on ultra-low-loss glass fibers; $1.08 million is requested to support research on the purification and drawing of high-transparency materials suitable for use in optical fibers for secure long-distance data links. Another new initiative on electro-optical countermeasures is funded with $600 000 in the FY 1984 request. Priority is also given to some special programs already under way. In FY 1984 $1.5 million is requested to support continuing research on the Kilojoule Advanced Research Laser; this program involves the design and construction of a high-energy gas laser to be used for experiments in strategical laser communication and directed-energy weaponry. Support for two

DOD swamped with requests for instrumentation funds

DOD began a program to improve instrumentation for defense-related research at universities with $30 million in FY 1983 funds. This initiative is to continue for five years with $30 million budgeted in each fiscal year, $10 million for each of the armed services. DOD administrators of the program were surprised, however, by the response elicited by the offer of much-needed funds for instrumentation. The Office of Naval Research, which coordinates the program for DOD, confirmed that 2499 proposals were received; this represents approximately $750 million in requests received for $30 million of FY 1983 funds. Such a large response underlines the need to replace and upgrade obsolete university instrumentation indicated by studies conducted at NSF and the Association of American Universities, among others (PHYSICS TODAY, July 1982, page 55).

DOD had originally planned to emphasize support for larger instruments, in the $100 000 to $1 million price range. The proposals received ranged from $50 000 to $1 million, but, due to the large number of proposals, no million-dollar grants were given. DOD is preparing statistics about this program to help with plans for using FY 1984 funds. These figures should be available soon. Information about submitting proposals for FY 1984 funds will also be available in May from DOD–University Research Instrumentation Program, Air Force Office of Scientific Research, Bolling AFB, Washington, DC 20332.

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directed-energy programs also increases in the FY 1984 request: Funding for research on using high-power microwaves to destroy oncoming missiles increases from $700 000 appropriated in FY 1983 to $940 000 in the FY 1984 request, and support for research on the use of charged-particle beams to destroy targets increases from $650 000 to $1.43 million in FY 1984. A program on energetic materials synthesis, which explores the fundamental physics of explosive materials, also receives increased support in the FY 1984 request, up from $1.29 million appropriated in FY 1983 to $1.83 million in FY 1984.

Robert Lontz (director of physics programs for the Army) told us that the FY 1984 request for basic physics research of $6.8 million is essentially the same as last year's appropriation of $6.7 million. Program priorities are also much the same, according to Lontz, with emphasis on optics, optical-processing research and physics relating to millimeter-wave technology. Research associated with high-current switching, mostly atomic and molecular physics research, will also be given some priority.

According to Colonel Hayes Bryan (director of physical and geophysical sciences programs in the Air Force), the total $26.5 million requested in FY 1984 for his directorate includes $18.8 million for physics, $2.3 million for terrestrial geophysics and $5.4 million for space physics. Bryan said plans now call for greater emphasis on short-wavelength-laser research programs, with a $3.0-million increase in funding over FY 1983. These programs include research on chemical and plasma-based lasers with a wavelength shorter than one micron, and more support for research on free-electron lasers. A new initiative begun in FY 1983, now slated to receive $1.8 million in FY 1984, is "space prime power," a program for producing high power in space. Bryan told us the basic research program will investigate the physics barriers to extending generators from kilowatts to megawatts of power for use by space systems.

The heads of the physics programs in the three services and at DARPA all cautioned us about the estimates they gave us for the budgets of specific programs because there is still a large uncertainty about the total FY 1984 DOD budget. As Young told us, "Who knows what Congress will do? I've heard just about everything." They are right to be cautious about Congressional action. As Representative George E. Brown Jr told the House Committee on Science and Technology at 3 February hearings on the defense budget, "The military R&D program has increased a staggering 80% since 1981 and comprises a whopping 70% of the entire Federal R&D budget. I don't want to be a spoiler, but we have to put the Administration's proposals into perspective and take a critical look at overall trends and priorities." On 23 March the House of Representatives voted to reduce the total DOD budget request by 6%. As of this writing the Senate has not yet acted on the DOD budget. —JC

Who owns software?

In a university setting, determining who owns intellectual property can be a difficult and abrasive process, as a recent example involving Caltech and particle theorist Steven Wolfram reveals. While working on the research faculty in the high-energy physics program at Caltech, Wolfram (now at the Institute for Advanced Study at Princeton) was one of the principal authors of a computer software package called Symbolic Manipulation Program. Described by Murray Gell-Mann (Caltech) as "revolutionary," SMP is designed to manipulate very complicated algebraic expressions to perform calculations that would be tedious or impractical without it. Because of its speed, elegance and portability, SMP is believed to have commercial as well as scientific applications.

But who owns what a scientist creates? Assigning proprietary rights for computer software is particularly tricky now because the legal basis for these rights is unclear. The law distinguishes between two types of intellectual property—patents and copyrights. Patents rely on originality and novelty, whereas for copyrights the idea itself doesn't have to be original, only the rendition or expression of the idea. In 1979 the US Supreme Court ruled that software was not patentable; it has not yet ruled on exactly how software *should* be treated. University policies also make a distinction between copyrights and patents, but have found computer software particularly thorny to deal with as copyrightable material. Accustomed to dealing with copyrights primarily in terms of authors of books, universities have been beset with problems trying to use the same policies to deal with software.

In 1979 Wolfram and Chris Cole were both working in physics at Caltech. Cole told us he was working as a graduate student on problems in supergravity and wanted to do calculations with complicated algebraic expressions. At first Cole tried using two existing programs capable of dealing with algebraic expressions—MACSYMA, developed by the Lab for Computer Science at MIT and REDUCE, written by Tony Hearn at Stanford and the University of Utah in the late 1960s. These programs bogged down, according to Cole, in part because of the particular computer hardware system being used. Simultaneously, Wolfram was having similar problems with his attempts to use these programs for his work in quantum chromodynamics. The problems they encountered were that the programs didn't run fast enough and that the size of the algebraic expression they could handle was severely limited. These earlier symbolic manipulation programs are written in LISP. According to Cole, they chose to work with C, a language developed at Bell Labs, because they believed its flexibility would lead to faster-running programs.

At the time Wolfram began this computer project he was 20 years old. He came to Caltech following an unusual series of educational leaps. Having started writing theoretical physics papers at the age of 15 while still in secondary school (Eton), Wolfram attended Oxford University and at 18 went to Caltech as a graduate student. He received his PhD in elementary-particle theory from Caltech a year and a half later. At the age of 21 he became the youngest person to win the MacArthur Foundation fellowship (PHYSICS TODAY, July 1981, page 73).

Cole and Wolfram got together in 1979 to write a new program that would both be very fast and be able to deal with very complicated algebraic expressions and many different types of mathematical operations. Cole and Wolfram received advice and support from the high-energy physics group at Caltech, including access to the Caltech computer for the project; they noted that such help is not unusual for a large project at a university. Various students also worked on the program, including Tony Terrano (now at Columbia University), Tim Shaw and Jeffrey Greif. Fox funded some of the students under his grant, and Gell-Mann took over support for some students under his grant in 1981. Particle theorist Marvin Goldberger (President of Caltech) told us, "Graduate students and others working on this project were funded from many sources, including Caltech monies and DOE, NASA, NSF, the Fleischmann Foundation, and the John A. MacArthur Foundation."

By the end of 1981, 90 000 lines of code for SMP had been written.

In early 1981, while still writing the program, Wolfram told us he approached Rochus Vogt (chairman of the physics department at Caltech) for advice and was sent to Lee Stam, who was Caltech Patent Officer working under