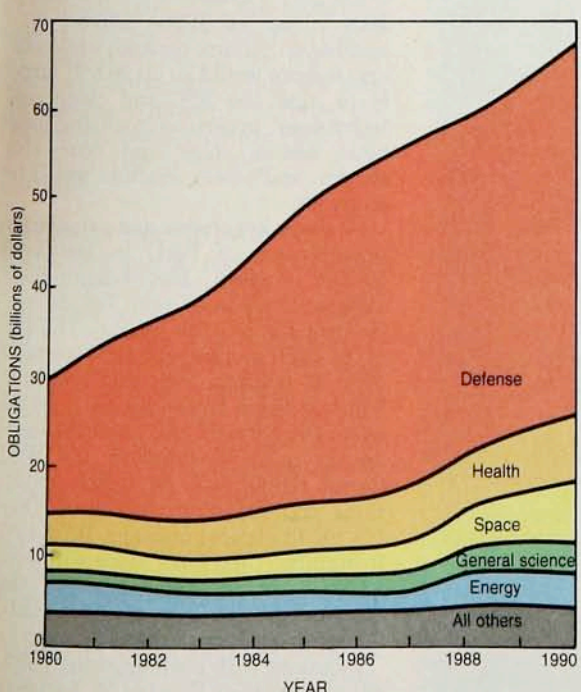
NUMBERS GAME: BUSH'S 1990 R&D BUDGET USES REAGAN'S FIGURES IN MAKING DEALS

The $1.16 trillion budget for fiscal 1990 that President Reagan left behind last January included his last hurrah for American R&D. Convinced by his California business cronies that science is probably the best way to improve the nation's economic condition, Reagan proposed that Federal spending for R&D would increase by 7% next year over current spending estimates and, accordingly, would reach $67.3 billion, with an additional $2.4 billion for starting a few large research projects—notably, the space station Freedom and the Superconducting Super Collider. Indeed, the infamous Function 250, a budget category that customarily pits the National Science Foundation, the space programs at NASA and all general science research in the Department of Energy against one another for appropriations each year, would rise under Reagan by 19.8% or, in dollar amounts, by $2.6 billion, to a grand total of $15.5 billion in fiscal 1990, which begins next 1 October.

President Bush's budget, submitted to Congress on 9 February, just three weeks after Inauguration Day, adopts the R&D requests by Reagan for his own. Even the list of priorities remains the same. Thus, the Reagan–Bush budget for all R&D programs would rise by $5.9 billion above fiscal 1989, with defense R&D increasing by $3.6 billion (up 8.7% in current dollars and 4.9% in constant or non-inflationary value) and civilian programs by $2.3 billion (a 10.1% boost in current dollars and 6.3% allowing for inflation). Even though Defense Department programs would get the lion's share of the proposed R&D budget, the military proportion of the total 1990 budget would continue to be 65%, the same as the current year but slightly less than 1988.

Among non-defense R&D components, space and general science would get 85% of the new funds next year. Funding for space programs would go up by 40% over the current budget, mainly because NASA would get almost 29% more, with outlays for the space station more than doubling from $900 million this year to some $2.1 billion in fiscal 1990. As it happened, the White House Office of Management and Budget cut back NASA's first 1990 request by almost $500 million, causing R&D cuts for the National Aerospace Plane, astronomy and life sciences, as well as the cancellation of one major new start, Gravity Probe–B.



R&D funding trends in past decade, depicted in this graph in each year's current dollars, show rapid ascent of defense spending, while nonmilitary funding remains fairly constant. Among civilian R&D fields increasing most is space, rising from $4.3 billion in fiscal 1988 to an estimated $6.9 billion for 1990. General science, including basic research at NSF and DOE, goes up to $3.3 billion in 1990. "All others" area includes funds for the environment, agriculture and Commerce agencies.

Commitment to NSF

The new budget would allot 14% more (10% in constant dollars) to the National Science Foundation so that almost every directorate would get similar increases. But some NSF programs would prosper. Computer and information sciences would receive a 26% rise to support machine upgrades at the national supercomputing centers and to advance computer networking and related research. The budget seeks a total of $2.15 billion, which reflects the Reagan–Bush commitment to doubling the foundation's operating funds by 1993. Of this, $47.5 million would end up in science and technology centers, with 10 or 11 new ones created to augment the 11 existing S&T centers,

and possibly 8 to 10 new Industry/University Cooperative Centers would be established in fiscal 1990 if Congress approves the full budget request. This year's NSF budget, lest it be forgotten, called for a 19% increase and finished the Congressional season with 9.4%.

Physics currently does not fare this well nor does it in the new budget proposal. It is now operating with a 4% increase and is marked in the 1990 budget for an additional 6.1%. Materials research, badly treated last year through miscalculations and mishandling of research grants, would receive a charitable 17.6% more, though such physics-related fields as condensed matter theory and solid-state and low-temperature physics would get only 8.7% more. NSF's astronomy program, which is entirely ground-based, is in the new budget for a 5% rise, about 1% above the current funding level. Within this, construction of the Very Long Baseline Array would get $12.4 million to keep installation of radiotelescopes on schedule for completion in 1993. But the new technology mirror development for the National Optical Astronomy Observatory has been dismantled, a victim of NSF budget pressures. What's more, replacing the 300-foot Green Bank radiotelescope is not in the 1990 budget—though Congressional pressure may change the agency's decision.

NSF is a primary source for academic research in the geosciences, providing more than 50% of funding for basic atmospheric studies, 70% of the basic programs in Earth sciences, ocean sciences and Arctic research. Increases in the 1990 budget would range from 10.9% for atmospheric sciences to 24.2% for Arctic studies. The Global Geosciences Program at NSF would go up from $33.2 million this year to $45.7 million next year.

Department of Energy physics-related research

	FY 88 actual	FY 89 request	FY 89 current	FY 90 request
		(millions of dollars)		
High-energy physics				
Physics research	114.4	123.8	121.8	133.1
Technology research, including detectors	63.7	66.2	65.1	82.0
Facilities operations	230.1	256.6	252.4	277.7
University research grants (included in lines above)	(75.2)	NA	(84.2)	(95.5)
Total research and facilities operations	408.2	446.6	439.3	492.8
Capital equipment, including research instrumentation	76.7	77.8	79.8	85.5
Construction, principally at national laboratories				
Accelerator improvement projects	11.2	11.7	11.7	14.9
General plant projects	10.7	11.1	11.1	13.4
Brookhaven AGS accumulator-booster	8.3	14.0	14.0	5.0
Fermilab computer center	11.0	3.6	3.6	—
Fermilab linac upgrade	—	—	—	4.7
Total construction projects	41.2	40.4	40.4	38.0
Total high-energy physics program	526.2	566.8	559.4	616.2
Major facilities (sums included in lines above)				
Fermilab				
Operations	115.5	125.7	122.8	134.5
All research	24.4	24.7	23.0	28.3
Capital equipment and construction	45.8	43.9	41.8	46.4
SLAC				
Operations	73.4	85.7	80.2	92.4
All research	24.6	24.5	25.5	29.9
Capital equipment and construction	23.3	28.0	26.3	30.3
Brookhaven				
Operations	39.3	40.6	41.6	44.0
All research	22.2	22.5	20.3	22.0
Capital equipment and construction	24.6	21.8	25.6	23.9
Other national laboratories and university programs				
Operations	1.9	4.6	7.8	6.8
All research, including theory	106.9	119.7	118.2	135.0
Capital equipment and instrumentation	23.4	20.8	20.8	22.8
Superconducting Super Collider				
Operations R&D	33.0	64.8	82.6	69.0
Capital equipment and instrumentation	—	16.0	16.0	21.0
Construction	—	283.0	—	160.0
Total SSC	33.0	363.0	98.6	250.0
Nuclear physics				
Low energy				
Operations	3.1	3.1	3.1	3.2
Research	10.7	11.8	11.6	12.5
Nuclear data programs at national laboratories	10.9	11.4	11.2	11.6
(National laboratories only, included in lines above)	(16.2)	(16.0)	(15.7)	(16.5)
Medium energy, including LAMPF, Bates and CEBAF				
Operations	50.2	52.5	51.2	56.0
Research	33.3	34.6	34.5	37.7
(National laboratories only, included in lines above)	(73.3)	(74.8)	(74.5)	(82.2)
Heavy ion, including Texas A&M, Yale and U. of Washington				
Operations	35.3	35.4	35.5	36.7
Research	29.6	33.3	32.0	34.8
(National laboratories only, included in lines above)	(55.9)	(58.8)	(57.1)	(61.9)
Nuclear theory				
National laboratories	4.7	4.8	4.8	5.1
Universities	5.8	6.2	6.0	7.6
(Total universities grants, included in lines above)	(40.4)	(NA)	(41.2)	(43.8)
Total research and facilities operations	183.6	193.1	189.9	205.3
Capital equipment, including research instrumentation	17.7	18.5	18.5	20.0
Construction				
Accelerator improvement projects	4.4	4.3	4.0	4.6
General plant projects	3.6	3.7	4.0	4.4
CEBAF	33.5	44.5	44.5	65.0
Total construction projects	41.5	52.5	52.5	74.0

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Energy on hit list

At first glance, the Department of Energy's R&D program would appear to get only a modest 4.2% increase to $6.5 billion in 1990. But it is a misshapen picture because while general science would go up 26.8%, largely to fund the SSC and clean coal technology, programs involving magnetic fusion, solar and renewable energy, and power reactors would be badly hit.

So there are cheers and catcalls for practitioners of R&D in the 1990 budget. Indeed, the Reagan–Bush budget needs to be seen not as rosy rhetoric but as grim reality. The size of the R&D increase for 1990 seems to defy all political logic and economic logistics these days—during a period when the political and financial agendas in most Washington and Wall Street circles call for deficit reductions and spending restraints. During his inaugural message, Bush said it plainly: "We have more will than wallet." In the circumstances, the Reagan legacy of largess for R&D, accepted by Bush, seems chimerical.

Senators with such opposing political ideologies as Edward M. Kennedy

of Massachusetts and Alan Simpson of Wyoming agree that higher budgets for R&D are necessary to maintain US leadership in world science and restore US dominance in world markets. But both are at a loss to understand how the 1990 budget can withstand a surge of megabuck megascience projects.

Still, unlike most of Reagan's budgets in previous years, the 1990 request was not declared "dead on arrival" when it reached Capitol Hill last 8 January. "The budget of a lame-duck President isn't taken very seriously," said a senior staff member of the House appropriations committee. This ho-hum attitude derives from the tradition that incoming Presidents invariably redesign the budget to their own liking. This year Presidential history is wrong. The Bush budget package, delivered on 9 February in the form of an amiable message to a joint session of Congress and a readable 193-page document, "Building a Better America," was both long on election campaign homilies and short on government spending details.

Budgets are the best way of putting money where a President's mouth is. That Bush made few modifications to his predecessor's budget came as no great surprise. Throughout his campaign Bush offered continuity, not change. Where many members of Congress as well as the press and the public desperately sought substance in Bush's budget, there was little more than symbolism. House Budget Committee Chairman Leon Panetta, a California Democrat, demanded details and feared that Congress might get trapped into being the bad guys this year—either by cutting the budget requests on its own or allowing the Gramm–Rudman–Hollings deficit reduction process to work its will automatically.

Congress's double whammy

The 101st Congress began in despair because of the double whammy of an apparently excessive budget request and an obviously intractable budget deficit. The situation fell into disarray with the abortive nomination of John Tower as Defense Secretary and the rancorous charges against House Speaker Jim Wright—both issues distracting members of Congress from the budget. Panetta and Jim Sasser, the Tennessee Democrat who heads the Senate Budget Committee, argued that the new President had listed many "urgent priorities," including shoring up an eroding educational system, rejuvenating decaying urban slums and declining rural areas, extending the space frontiers, expanding scientific research and cleaning up the air, water and contaminated defense nuclear plants, but had been purposefully vague on how to fund the programs—many of them neglected during the Reagan years. Nevertheless, Bush and Budget Director Richard Darman met with House and Senate budget leaders to "do deals," as Bush had put it to New Hampshire businessmen, "in good faith."

Among the specific differences between the Bush and Reagan budgets are the funding specifics for science and mathematics education and for environmental protection. Having campaigned as "the education President," Bush clearly needs more money to carry out an ambitious program. In his budget and again on 5 April at a White House ceremony, Bush proposed adding $441 million to the Department of Education to promote and reward academic excellence. His initiative includes a new $5 million program (increasing to $20 million in 1993) to fund 570 four-year scholarships to outstanding high school science and math students (one nominated by each member of the House and Senate as well as 30 by the President); $250 million for cash awards (rising to $500 million in fiscal 1991) to public and private elementary and secondary schools that make substantial progress in raising achievement levels and reducing dropout rates; $100 million for local education agencies to establish magnet schools in science, math and other special subjects; $7.6 million to provide $5000 each to individual teachers judged exceptional in statewide competitions; $25 million for states to place uncertified but gifted teachers, such as retired scientists and engineers, in classrooms; $25 million for antidrug programs; and $10 million to assist historically black colleges and universities. These programs would come from Reagan's request for a

Department of Energy physics-related research, continued

	FY 88 actual	FY 89 request	FY 89 current	FY 90 request
		(millions of dollars)		
Basic energy sciences				
Materials science research, including solid state physics	126.0	134.6	136.6	140.5
Chemical sciences	88.2	93.1	91.8	97.6
Advanced energy projects	14.3	14.6	14.5	14.9
Applied mathematical sciences	42.5	43.0	42.7	44.9
Energy biosciences	20.3	20.8	20.6	21.2
Engineering and geosciences	31.4	33.4	33.2	34.1
Total research	327.1	339.6	344.3	358.7
Facilities operations				
National Synchrotron Light Source, Brookhaven	19.6	20.3	19.3	23.0
High Flux Beam Reactor, Brookhaven	10.9	11.5	10.9	15.3
Intense Pulsed Neutron Source, Argonne	5.0	5.4	5.1	6.5
High Flux Isotope Reactor, Oak Ridge	22.8	23.7	23.5	28.4
Stanford Synchrotron Radiation Laboratory	10.3	10.5	10.2	13.4
Los Alamos Neutron Scattering Center	3.0	3.1	4.8	4.5
Combustion Research Facility, Sandia-Livermore	3.5	3.6	3.5	4.5
1–2 GeV Synchrotron Light Source, Berkeley	2.0	2.0	1.9	6.0
6–7 GeV Synchrotron Radiation Source, Argonne	10.0	6.2	5.8	10.5
Total operations	87.1	86.3	85.0	112.0
Capital equipment and instrumentation	31.7	31.7	31.7	37.6
Construction				
Accelerator improvements, general plant projects	7.2	7.2	7.2	10.2
Center for Advanced Materials, Berkeley	7.6	—	—	—
3 GeV SPEAR injector, SLAC	3.0	6.5	6.5	4.5
Los Alamos neutron scattering guide hall	8.5	4.0	4.0	—
1–2 GeV Synchrotron Light Source, Berkeley	18.0	30.0	25.0	26.0
6–7 GeV Synchrotron Radiation Source, Argonne	—	6.0	6.0	40.0
Congressional "pork" other projects	72.6	—	39.6	—
University research support, including coop centers	18.2	15.8	21.7	16.1
University research instrumentation	4.9	5.0	5.0	5.0
Multiprogram laboratories facilities support	53.6	65.9	55.7	53.0
Magnetic fusion				
Confinement systems	159.6	175.6	174.8	168.2
Applied plasma physics	74.8	78.2	78.2	73.2
Development and technology	55.9	54.1	54.1	56.7
Planning, projects and program direction	5.5	9.6	9.6	9.9
Capital equipment	18.7	21.6	21.6	13.2
Construction, including Compact Ignition Tokomak	16.9	20.9	12.4	28.1
Inertial fusion	159.0	163.8	163.8	168.9
Nuclear directed-energy weapons (for SDI)	152.9	154.3	137.0	145.1
New defense production reactors	20.0	NA	60.0	303.5
Nuclear warhead complex cleanup and modification	578.5	NA	2588.0	3663.0

National Science Foundation physics-related research

	FY 88 actual	FY 89 request	FY 89 current	FY 90 request
		(millions of dollars)		
Mathematical and physical sciences				
Physics				
Elementary particles	44.7	40.4	41.0	43.4
Intermediate energy (nuclear)	17.8	21.3	19.7	20.8
Nuclear	21.0	23.6	22.7	23.9
Atomic, molecular and optical	13.3	14.3	13.5	14.4
Theoretical	15.2	16.6	15.9	17.1
Gravitational	8.9	9.7	9.8	10.4
Total physics	117.9	126.0	122.6	130.0
Materials research				
Solid state physics	11.6	12.2	12.0	12.9
Solid state chemistry	8.8	9.2	8.8	9.4
Low-temperature physics	8.2	8.8	8.7	9.3
Condensed matter theory	8.8	9.3	9.3	10.4
Metallurgy	9.0	9.4	9.3	10.0
Ceramics and electronics materials	7.7	8.2	8.3	9.1
Polymers	8.1	8.7	8.2	8.7
Instrumentation	4.0	4.5	4.0	4.7
Materials Research Laboratories	26.2	26.9	26.2	27.1
Materials Research Groups	7.4	8.9	8.1	9.1
National facilities	10.6	12.1	12.1	24.6
Total materials research	110.6	118.2	115.0	135.2
Mathematical sciences	63.8	67.6	65.9	76.0
Chemistry, including physical chemistry	94.0	98.6	96.6	103.4
Astronomical sciences				
Solar-system, stellar evolution and galactic studies	28.3	29.0	29.0	31.2
National Astronomy and Ionospheric Center	5.8	6.2	6.1	6.3
National Optical Astronomy Observatories, including Kitt Peak and Cerro Tololo	23.1	24.2	24.2	25.2
National Radio Astronomy Observatory	16.9	18.0	18.1	18.8
VLBA construction	11.6	12.0	12.0	12.4
Total astronomical sciences	85.8	89.5	89.5	94.0
Math and physical sciences and technology centers	—	—	13.7	14.8
Total mathematical and physical sciences	472.0	500.0	503.3	553.5
Geosciences				
Atmospheric sciences	48.7	52.5	49.6	55.2
National Center for Atmospheric Research	42.8	46.1	44.1	48.3
Upper atmospheric facilities	4.7	5.4	5.0	6.0
Earth sciences, including geophysics, lithospheric studies and instrumentation	51.3	59.1	54.2	65.2
Ocean-sciences research	67.2	72.9	71.2	74.7
Oceanographic centers and facilities	37.2	41.2	43.6	45.3
Ocean drilling program	30.6	32.0	31.4	32.9
Arctic research program	8.3	10.8	10.3	12.8
Geosciences science and technology centers	—	—	0.9	1.0
Total geosciences	290.7	320.0	310.3	341.3
Antarctic research program	124.7	141.0	131.2	156.0
Computer and information science and engineering				
Computer and computation research	19.8	22.2	21.1	23.7
Information, robotics and intelligent systems	17.7	19.7	19.1	21.6
Microelectronic information and processing systems	13.3	15.9	15.0	19.0
Advanced computing/Supercomputing Centers	44.7	55.8	55.8	71.7
Networking and communications research	11.5	17.7	17.7	27.1
Cross-disciplinary activities	16.9	17.4	17.4	21.4
Computer science and technology centers	—	—	5.9	6.7
Total computer and information science and engineering	123.9	148.7	152.1	191.2
Science and Technology Research Centers	—	30.0	0.3*	20.0
Engineering Research Centers	33.3	39.9	38.0	45.7
Industry-University Research Centers	3.1	3.4	3.6	5.0
Science and engineering education				
Teacher preparation and enhancement	45.5	53.5	63.5	68.5
Learning materials and informal education	37.8	43.5	44.0	49.0
Undergraduate science, engineering and math	19.0	23.5	28.0	30.0
Research career development	34.0	31.0	31.0	38.0
Studies and program assessment	3.2	4.5	4.5	4.5
Total science and engineering education	139.6	156.0	171.0	190.0

*Also see line items for S&T Centers under mathematical and physical sciences, geosciences and computer science.

$21.9 billion education budget, which is virtually identical to the fiscal 1989 appropriation—and, hence, in effect would mean that some education programs would be slashed to provide money for Bush's initiatives. "It amounts to robbing Peter to pay Paul," says Panetta.

In environmental matters, Bush promised to reinstate the five-year time frame for reducing SO_2 and NO_x emissions that contribute to acid rain. In his commitment "to ending the long debate on acid rain," Bush differs with his predecessor's policy of slowing down DOE's clean coal R&D. Arguing that the "time for action has come," Bush says he would honor the US agreement with Canada to spend $2.5 billion over five years for the Clean Coal Technology Program, with at least an equal amount to come from industrial sources. In 1990 Bush would spend $710 million, an increase of 274% above 1989 for this program. Reagan had asked for $325 million for the program in his 1990 budget request. It is uncertain whether Bush's increase would come at the expense of other DOE R&D programs. Conservation, fossil fuel research and renewable energy programs were all cut in Reagan's budget—though Congress has always restored funds for these in the past.

Another significant departure from the Reagan budget was submitted to Congress on 20 March as an amendment to his February message. In the current year, DOE is spending $2.59 billion to protect the safety and environment of its nuclear warhead complex of reactors, laboratories and manufacturing plants. The Reagan budget request had sought $3.24 billion for 1990 and Bush asked to increase DOE's request by another $360 million for a total of $3.66 billion in the new budget.

Bush's 'flexible freeze'

The increases in Bush's revisions to Reagan's budget come to about $30 billion—mostly for drug control, Social Security, some entitlement programs and even a bit for R&D. To offset these, he proposes restraints on several programs, including defense, and a "flexible freeze" on others in non-defense discretionary spending. Bush's flexible freeze assumes that economic growth, inflation and unemployment will either continue at the same levels as in the past few years or actually fall. Inflation, for example, is forecast to moderate to 3.7% this year and drop steadily to 3% in 1991 and 1.5% by 1994. The Administration also takes for granted that interest rates will plunge rapidly, with the

average rate of 3-month T-bills dropping from 7.4% in 1989 to 5.5% in 1990. The predictions are uncertain. All the figures headed in the opposite direction between the election and the start of budget deals, but in April interest rates began falling slowly.

All things considered, states the House budget committee, without changes in current spending programs, the deficit when fiscal 1990 begins on 1 October will be $131 billion—almost $40 billion more than the Bush economic mavens figure. So, if the White House and Congress intend to comply with G-R-H targets for the 1990 budget, they will need to reach agreement by late summer. The G-R-H schedule requires OMB to estimate the Federal deficit on 25 August and, if the new budget cannot meet that sum, to impose what is known by the peculiar word "sequestration," an old Scottish legal term for the process of seizing cash and property from a ne'er-do-well and dividing it up among creditors.

If sequestration were to happen, as it did in 1986, appropriations for both defense and domestic discretionary accounts, such as public housing, health care and R&D, would suffer. Even if Congress avoided G-R-H and made the necessary reductions by itself, as happens so often when the executive and legislative branches disagree on where to spend, R&D programs would seem to be more vulnerable to cuts than others. NSF's proposed $2.15 billion budget, some Washington observers say, could drop by somewhat more than $200 million. Bush and OMB do not think that dire scenario will be played out. Like Reagan's true believers, they prophesy that the economy will grow its way out of the deficit. Many economists and Congressional Democrats argue that this is unlikely with a national debt of some $2.5 trillion and interest payments of about $155 billion that must be paid each year. Of course, the feared shortfall in the Bush budget could be made up by new revenues, but Bush's "read-my-lips" campaign pledge of "no new taxes" seems sacrosanct—this year at least.

That has been the sticking point in budget negotiations so far, and the accord worked out in mid-April didn't resolve all the differences. The Administration and Congress provided for fiscal-1990 outlays of $181.3 billion for domestic discretionary programs—that is, those that require annual approval by Congress, such as R&D, agriculture, housing and so forth. Social security, Medicare and other so-called entitlement programs don't require approval. Congressional budget analysts claim the agreement includes enough money to cover current levels of service for the various discretionary programs. What's more, the negotiators agreed to $157.5 billion in budget authority for such programs, which is $3.6 billion more than enough to compensate for inflation. The additional funds would be spent on programs like the space station, SSC and low-income housing that don't cost the government much initially, but possess implications for future outlays.

But many members of Congress wonder about the budget scheme. During a House Appropriations Committee hearing for the DOE budget on 22 March, the chairman, Tom Bevill, a Democrat from Alabama, told the department's new secretary, James G. Watkins, that he does not know any member of Congress opposed to the SSC, but many are concerned about its 1990 request for $250 million. Watkins claimed the SSC "so far" had not stolen from other DOE research programs. Indeed, he said, it was time for Congress to make "a bold move" with a

NASA physics-related projects

	FY 88 actual	FY 89 request	FY 89 current	FY 90 request
		(millions of dollars)		
Physics and astronomy				
Hubble Space Telescope	93.1	102.2	95.9	67.0
Gamma Ray Observatory development	53.4	41.9	41.9	26.7
Advanced X-ray Astrophysics Facility development	—	27.0	16.0	44.0
Shuttle-Spacelab payload development	47.8	61.5	69.7	86.1
Payload and instrument development	46.6	77.1	81.7	71.4
Space station planning and payloads	18.9	8.0	8.0	23.0
Explorer development	67.9	82.1	82.1	93.2
Mission operations and data analysis	140.5	156.2	143.2	204.8
Research and analysis	82.9	89.1	85.8	112.5
Suborbital programs				
Sounding rockets (includes Spartan)	27.5	28.7	27.0	30.5
Airborne science and applications	7.3	7.8	9.8	10.9
Balloon program	9.9	8.6	8.6	12.1
Global geospace science	18.6	101.4	64.4	112.3
Total physics and astronomy	614.4	791.6	734.1	894.5
Planetary exploration				
Galileo development	51.9	61.3	73.4	17.4
Magellan	73.0	33.9	43.1	—
Ulysses	7.8	10.3	10.3	14.5
Mars Observer	53.9	102.2	102.2	100.5
Comet rendezvous asteroid flyby/Cassini	—	—	—	30.0
Mission operations and data analysis	73.8	112.7	110.7	155.4
Research and analysis	67.3	83.6	76.9	79.1
Total planetary exploration	327.7	404.0	416.6	396.9
Earth science and applications				
Upper atmosphere research satellite	89.2	103.9	94.2	73.9
Ocean Topography Experiment (TOPEX)	74.5	97.8	83.0	72.8
Scatterometer	22.6	15.8	10.6	13.8
Earth science payload instrument development	27.7	45.0	46.4	66.5
Mission operations and data analysis	14.7	18.5	17.6	24.8
Interdisciplinary research and analysis	1.1	1.2	2.2	2.3
Upper atmosphere research and analysis	32.7	34.0	31.1	38.1
Ocean processes research and analysis	20.1	21.6	20.8	24.5
Atmospheric dynamics research and analysis	31.4	32.8	32.0	37.4
Land processes research and analysis	21.1	22.9	19.9	22.5
Geodynamics	32.3	33.9	32.9	38.0
Airborne science and applications	21.8	23.0	23.0	19.7
Total earth science and applications	389.2	450.4	413.7	434.3
Materials processing in space				
Microgravity shuttle–space station payloads	49.8	59.8	56.4	74.6
Commercial microgravity R&D enhancements	—	—	5.6	5.1
Research and analysis	12.9	13.6	13.6	13.0
Total materials processing	62.7	73.4	75.6	92.7
Other physics-related projects				
Research and technology base				
Fluid and thermal physics research	33.9	38.0	43.7	44.0
Materials and structures research	55.7	57.6	60.1	62.1
Information and computer sciences	26.6	32.0	17.3	19.2
University space research	4.0	16.3	16.3	17.1
Space research and technology				
Pathfinder program	—	100.0	40.0	47.3
Civil space technology initiative	114.2	156.8	121.8	144.5
In-space experiments technology	—	—	—	16.2
Space Station Freedom program	392.3	967.4	900.0	2050.2

Department of Defense basic research funding (6.1 budget category)

	FY 88 actual	FY 89 request	FY 89 current	FY 90 request
	(millions of dollars)			
Army				
Research, including physics and materials	167.6	173.5	172.7	175.9
Army laboratories discretionary research	—	—	—	9.1
Universities research initiative	—	—	—	21.9
Navy				
Research, including physics and materials	316.6	333.0	331.9	342.0
Navy laboratories discretionary research	22.6	23.8	23.4	24.4
Universities research initiative	—	—	—	24.3
Air Force				
Research, including physics and materials	185.2	189.4	189.4	187.6
Air Force laboratories independent research	15.0	10.2	7.0	7.7
Universities research initiative	—	—	—	24.9
Defense Advanced Research Projects Agency				
Research, including materials and computers	79.9	89.5	88.1	85.1
Universities research initiative	—	—	—	25.0
Office of Secretary of Defense				
Universities research instrumentation	24.6	—	—	—
Universities research initiative	85.0	95.0	141.0*	—

*Includes $46 million in "pork" projects earmarked by Congress for specific colleges and universities.

commitment to begin building the mammoth particle accelerator. Bevill argued that the $98 million Congress had voted for the SSC in 1989 showed its commitment to the machine, but for 1990 he saw four options: making cuts in other DOE research programs (which he deemed undesirable), raising new revenues (which Bush had ruled out), paying for the accelerator "on a credit card" (which he objected to) and obtaining joint funding from international partners (a tactic he liked). Accordingly, said Bevill, Watkins should enlist the White House and State Department to drum up support from foreign governments. Bevill suggested that Congress be informed about the status of foreign contributions to the SSC. Without such specifics, he cautioned, Congress will "scoff at your spending plans" for the machine.

To be sure, DOE laboratory directors Leon Lederman of Fermilab and Nicholas Samios of Brookhaven, testifying on 23 February before the House energy subcommittee, stated that they are satisfied with the budgets proposed for their facilities (see table on page 44). For his part, NSF Director Erich Bloch told Congress he is pleased with the proposed increase, which would put his agency "on track again" to double the budget by 1993 (even if it is a year later than Reagan had called for three years ago). What's more, Bush's requests seem to affirm Reagan's plan for a 5% reduction at the National Institute of Standards and Technology, even though the recently passed Omnibus Trade and Competitiveness Act not only changed its name from the National Bureau of Standards but, more important, assigned it additional functions to advance US technological competitiveness in world markets. Defense research and technology would rise by 7%, from $41.3 billion to $44 billion—though most of the increase is designated for development and testing of weapons.

The highlights of the Reagan–Bush budget by agency:

National Science Foundation. In his eight years as President, Reagan raised NSF's research budget by 25% and Congress increased the foundation's science and engineering education program by 250%. Bush's budget leaves unchanged the Reagan proposal for $2.15 billion in 1990. Like the last two years, though, physics does not burgeon. It would receive only a 4% increase, which is somewhat below last year's inflation. Support for individual investigators and facilities would continue to account for the lion's share of NSF's budget, increasing from $1.19 billion to $1.32 billion. But funding for research centers and group research would go up at a faster rate, rising from $319 million to $376 million. Within this, another 10 to 12 science and technology centers are likely to be chosen, in addition to the 11 established late last year. During the Reagan years, support for groups and centers has accounted for a growing share of NSF's budget, increasing from about 10% in 1982 to 17% this year. The agency also plans to provide "seed money" for 8 to 12 new Industry–University Cooperative Research Centers in 1990.

Within the physics program, superconductivity research would rise by $2 million to $25 million. Competition for a new High Magnetic Field Laboratory would begin this year so that some $12 million of funds might begin flowing in fiscal 1990. The facility is expected to take five years to construct and equip, at a total cost of $100 million—half put up by NSF, the other half by states, universities, corporations and other sources.

The foundation's science and engineering education programs are slated to increase by 11%, from $171 million to $190 million. While the education directorate concentrates on upgrading teachers and curriculums in precollege schooling, much of the undergraduate and graduate programs are directed by the research directorates, which is a source of contention within the agency and from grant seekers. NSF's education programs have been a perennial favorite of Congress. If the past is prologue, these programs will receive more money, while increases in research will be held down.

Department of Energy. The most conspicuous item in the DOE budget is the SSC, which Bush recognizes as a crown jewel in his R&D program to

Strategic Defense Initiative (6.2 and 6.3 budget categories)

	FY 88 actual	FY 89 request	FY 89 current	FY 90 request
	(millions of dollars)			
Directed-energy weapons	934.2	1029.9	819.8	1116.9
Kinetic-energy weapons	773.2	936.3	773.1	1346.5
Surveillance, acquisition, tracking and kill assessment	934.5	1124.6	1100.7	1281.0
Systems concepts and battle management	461.5	639.9	506.5	780.9
Survivability, lethality and key technology	429.6	790.4	406.3	776.8
Boost surveillance and tracking system	—	—	—	262.0
Total SDI R&D program	3533.0	4521.1	3606.4	5564.1
Construction	59.2	90.5	83.0	12.9
Headquarters management	20.0	24.8	21.0	26.4
Total Defense Department SDI program	3612.2	4636.4	3710.4	5603.4
Department of Energy SDI program	353.8	402.0	336.0	311.0
Total SDI	3966.0	5038.4	4046.4	5914.4

revitalize science and technology as a way of advancing US industrial competitiveness. Other construction projects include two new starts: the 6-7 GeV synchrotron light source at Argonne National Laboratory, for which $40 million is proposed, and the Compact Ignition Tokamak at the Princeton Plasma Physics Laboratory, with some $5.5 million designated for a project that will ultimately cost $445 million upon completion, now anticipated in 1997. DOE planners and OMB have postponed another possible start, the Relativistic Heavy Ion Collider planned for Brookhaven, for at least another year—though some funds would be made available for R&D.

The department is asking for a 9.3% increase for high-energy physics research, which would bring this program to $133 million, and a 9.9% rise in nuclear physics to raise it to $97.7 million. The latter increase would enable DOE to enhance support for nuclear theory and for researchers preparing to use the 4-GeV Continuous Electron Beam Accelerator Facility, being built at Newport News, Virginia. Total spending for high-energy physics, which includes operating the national labs, constructing detectors and developing other equipment, but excluding the SSC (which is given its own category in DOE's budget), would go up 10.2% to $616.2 million. Nuclear physics would rise in 1990 by 14.7% to a total of $299.3 million.

But the Basic Energy Sciences program is earmarked for a modest increase of $40.7 million, slightly more than compensating for inflation. This diverse program includes superconductivity research and geoscience investigations that look at the global warming phenomenon.

NASA. The request for the space agency totals a whopping $13.3 billion, up from $10.9 billion this year. A dominant factor in the increase is the $1.1 billion added to the budget for the space station. Congress decreed last year that $550 million in fiscal-1989 funds for the project could not be spent before 15 May of this year, so that the new Administration would have time to review the concept. While a candidate, Bush voiced his enthusiasm for a manned space station, and his statements since indicate that he will proceed with it. But a "white paper" by a committee of the National Academies of Sciences and Engineering asking NASA to look hard at the rationale and scope of the station could raise questions in Congress and make the project vulnerable in a year of fiscal constraints.

Elsewhere in NASA's budget, funds are included for a start on the CRAF/Cassini mission to Saturn and its moon Titan—a project that will be conducted jointly with the European Space Agency.

Department of Defense: Last year, military analysts forecast that the Pentagon's fiscal 1990- budget would have to grow by at least 4% above inflation to pay for new arms programs already in the procurement pipeline, and even bigger increases would be needed in subsequent years. However, in Bush's revision of the Reagan request for 1990 the increase amounts only to the inflationary 4%. Many of the cuts in Reagan's original $309 billion request are in slowdowns to the rate of procurements, which would tend to increase the cost of weapons in the long run. Richard B. Cheney, the new Defense secretary, has said he is making real cuts, which are bound to shape US military policy and spending outlays for years to come.

Of the $44 billion proposed for R&D, most would go to development and testing, with only $930.1 million, or about 0.3% of the department's entire budget, for basic research. Even that sum is suspect, because most of the research is in the 6.2 and 6.3 categories that cover work applicable to DOD's mission. About half of the so-called basic research goes to universities.

The largest increase in R&D would be directed to the Strategic Defense Initiative, which would soar by 54% to a stunning $5.6 billion in 1990. Work on nuclear power systems for space and directed energy weapons is channeled through the DOE budget at $311 million, down $25 million from the current year's program. There is little likelihood that Congress will enact such a massive increase for "Star Wars." In fact, the testimony by Cheney and SDI's new director, Lieutenant General George Monahan, suggest that DOD would be pleased to get as much as it got last year—about $4 billion.

The Universities Research Initiative, a basic research program that supports multidisciplinary studies at universities, would edge up a mere 1% to reach $96.1 million. The Reagan budget showed $299.7 million, a 29.9% increase over 1989, for the NASA-DOD National Aerospace Plane—the proposed ultrasonic "Orient Express," as Reagan refers to it. On the development side, Sematech would receive $100 million, the second installment of the DOD obligation to support semiconductor manufacturing technologies.

—Irwin Goodwin

WATKINS'S DECISION TO RESTART HFIR HERALDS NEW ERA FOR DOE REACTORS

In his first appearances before the Senate Budget Committee last 15 March and, a week later, before the House appropriations subcommittee on energy, Energy Secretary James G. Watkins provided a surprise: DOE plans to restart the High Flux Isotope Reactor at Oak Ridge National Laboratory, which was shut down in 1986 over worries about its safety. The House subcommittee appeared puzzled by Watkins's announcement. The issue of DOE's troubled reactors wasn't on the agenda of the hearing, nor is HFIR a component in the nuclear weapons production troubles that haunt the Bush Administration. Watkins, whose nomination as DOE secretary was confirmed by the Senate only two weeks before the hearing, almost singlehandedly decided to restart HFIR as the first reactor to return to operation since the department's reactor crisis began in January 1987 with the closing of the N-Reactor at the Hanford Reservation. The action on HFIR is perceived as symbolic of Watkins's intention to get the ailing nuclear warhead complex cleaned up and running again after its virtually complete shutdown last year (PHYSICS TODAY, November, page 49).

Watkins's decision is seen by Tom Bevill, a powerful Alabama Democrat who heads the House appropriations subcommittee on energy, as "an important sign that the department is coming to grips with its reactor problems as a top priority." Oak Ridge's new director, Alvin W. Trivelpiece, who had been director of DOE's energy research office in 1981–1987, believes Watkins is already "making a difference."

Watkins has the strongest technical background of any DOE secretary to date and has assured Congress that he will not compromise on safety in