Federal Science and Technology Budget Priorities: New Perspectives and Procedures, a Report in Response to the Conference Report on the Concurrent Resolution on the Budget for Fiscal Year 1989 (H. Con. Res. 268) (1988)

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Federal Science and Technology Budget Priorities

New Perspectives and Procedures

A Report in Response to the Conference Report
on the Concurrent Resolution on the Budget
for Fiscal Year 1989 (H. Con. Res. 268)

NATIONAL ACADEMY OF SCIENCES
NATIONAL ACADEMY OF ENGINEERING
INSTITUTE OF MEDICINE

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INTRODUCTION AND SUMMARY

This report is in response to a request of Congress contained in the Conference Report on the Concurrent Resolution on the Budget for FY 1989, adopted on June 6, 1988. The Conference Report asked the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine to provide

> ... advice on developing an appropriate institutional framework and information base for conducting cross-program development and review of the nation's research and development programs. This should be structured in such a way that it can be used by both the Executive Branch and Congress as a method for reviewing program contents and strategies and in determining funding and organizational priorities for science and technology (House Report 100-658 on H. Con. Res. 268).

The request originated with the Senate Committee on the Budget, whose report on the Senate version of the FY 1989 Budget Resolution expressed dissatisfaction with the lack of a "coordinated national research and development budget" and suitable categories and criteria for judging the allocation of resources to and among science and technology (S&T) activities. In asking the help of the Academies and the IOM, the Senate Budget Committee emphasized the importance of a scientific and technical perspective in developing a framework for setting priorities in federal research and development (see Appendix 1).

This report has been prepared by a committee composed of the Presidents of the two Academies and the Institute of Medicine and members of their respective institutional councils. A group of Academy staff members, many with federal budget experience in various settings, provided support for the project. In addition to the committee's deliberations, the study process included consultation with members of Congress; staff of congressional budget, appropriations, and authorization committees and support agencies; officials of the Executive Branch; and other people knowledgeable about the federal budget process and policymaking for science and technology.

In interpreting its charge, the committee at the outset drew two conclusions that determined the scope and focus of its review:

> First, the analysis was to include all science and technology activities directly supported by the federal government, including the education of scientists and engineers and the financing and operation of specialized facilities as well as the conduct of research—basic and applied—and development. "Research and development" is the category conventionally used in budget submissions and analyses of expenditures, but the commit-

tee judged it important to encompass activities that are instrumental to but not necessarily counted as part of R&D, such as education.

Second, the analysis was to consider how public officials think about, prepare, and review science and technology budgets year in and year out. During the most recent budget cycle especially there has been a great deal of discussion about priorities among current federal S&T programs and projects; but it was not feasible for, nor was it expected of, this committee to recommend what resource allocations ought to be made this year or next. Rather, we suggest an analytical perspective and changes in the budget process that will aid decisions about resources for science and technology over the long term.

We have two concerns: Are we investing adequately for the long term to sustain the enabling S&T infrastructure and are we deciding priorities among S&T opportunities in a way that will best advance the national interest?

We recommend that S&T budget priorities be considered in four non-mutually exclusive categories:

- the S&T activities of individual agencies in relation to each agency's mission;
- the aggregate contribution of several agencies to the science and technology base of the nation, including fundamental research, its supporting infrastructure, and its continued production of scientists and engineers;
- the contribution of S&T activities, frequently supported by several agencies, to national objectives that are given priority by the President and/or Congress (e.g., industrial competitiveness, environmental protection, and prevention and treatment of AIDS);
- a set of major S&T initiatives, with different purposes and character, that attract attention in any budget year primarily because of their cost and budgetary consequences for other S&T activities across agencies.

For science and technology activities in direct support of agency missions there is an established process of budget development and review, beginning with agency proposals taking into account any initial administration guidance, running through the Office of Management and Budget (OMB) examination and any agency appeals, and culminating in congressional authorizations and appropriations. In this process responsibilities are reasonably well defined and the results generally serve agency objectives. We do not propose that this process be changed.

With regard to activities in the three categories that cut across several agencies, however, the process is unsystematic and sometimes haphazard be-

cause responsibility is dispersed. Without proposing major changes in the basic budget process, we recommend additional steps in current Executive Branch and congressional procedures to ensure that S&T budgets are more reflective of demonstrated needs and national priorities in these cross-cutting areas.

- The President's objectives in the cross-cutting S&T areas should be included in initial OMB instructions to the agencies for the preparation of their budgets, and these priorities should guide the formulation of the President's final budget proposal to Congress.
- The President's budget submission to Congress should contain a statement of his priorities for the S&T base, S&T activities serving national objectives, and major S&T initiatives as well as a summary of agencies' mission-related S&T activities.
- The congressional budget and appropriations committees should conduct reviews of cross-cutting S&T activities and incorporate their judgments into recommendations for agency budget allocations.
- Following the enactment of necessary authorizations and appropriations, the Executive Office of the President should work with agency heads to see that S&T programs are carried out in accordance with the President's priorities as modified by Congress.

We believe that these recommendations will serve the nation well in a period of pressing resource constraints and growing expectations that science and technology will yield significant material benefits.

SCIENCE AND ENGINEERING IN FEDERAL BUDGETS

Recent federal budgets for S&T demonstrate that Congress and the Administration recognize the growing opportunities in S&T and their contribution to important national objectives. At the same time, policymakers in both branches are faced with a persistent large federal deficit and a statutory requirement to eliminate it. These conflicting pressures give rise to concerns about the federal budget process for S&T.

The unusual circumstances of the FY 1989 budget cycle in particular drew attention to S&T in the federal budget. The Bipartisan Budget Summit Agreement concluded in November 1987 permitted only a 2 percent increase (on the order of $3 billion) above the FY 1988 level of the nondefense discretionary portion of the federal budget that finances all civilian S&T programs along with housing, health, and other domestic programs apart from entitlements such as Social Security and Medicare. In his proposed FY 1989 budget, President Reagan asked Congress to allocate the equivalent of that increase to S&T,

including initiatives certain to entail large expenditures over several years—a Superconducting Super Collider (SSC) and a civilian manned Space Station. A doubling of the budget of the National Science Foundation over five years and a project to map and sequence the human genome also were proposed.

The widely anticipated crunch in funding for civilian programs did not occur in the FY 1989 appropriations to the degree many feared. Because of a change in the FY 1988 base, Congress was able to raise the $3 billion ceiling somewhat. It approved all the President's S&T initiatives, albeit at lower spending levels or with conditions intended to postpone some decisions for the incoming Administration. Overall, Congress approved $2 billion of the requested $3 billion increase for NASA, NSF, and research programs of DOE.

As for FY 1990 and beyond, there are signs that fiscal constraints will tighten further. The deficit reduction required to meet mandated levels continues to increase. Resistance to raising taxes, curbing entitlements, and cutting defense spending is strong. Interest payments on the federal debt continue to grow. And demands to address domestic social needs will be hard to deny.

The fact remains that in recent years, under growing pressure, the Administration and Congress have quite consistently supported S&T. Witness not only the FY 1989 appropriations but also the total federal investment in research and development, now exceeding $60 billion annually by the government's accounting. [For reasons enumerated in Appendix 2, we recommend for further study the current classification of Defense Department R&D that represents a major share of the total.]

This support for S&T is based on recognition that

- Investments in S&T are essential to address a growing list of national needs and objectives, including economic development, international competitiveness, and environmental protection as well as military security and public health.
- Expanding opportunities and breakthroughs in many areas of science and engineering are likely to yield significant economic and other benefits. Examples range from biotechnology to high-temperature superconductivity.
- Certain national emergencies require support for S&T investments aimed at solutions. The most obvious current example is the AIDS epidemic; others are the *Challenger* accident and its effect on the nation's space launch capacity and the precipitous loss of market share by the U.S. semiconductor industry.
- Investments in fundamental research and the advanced training of scientists and engineers are a precondition for reaping the practical benefits of S&T, and the federal government should make a major contribution to these investments.

These views will not necessarily prevail if fiscal constraints become much tighter, but budget outcomes to date are a measure of the strength of the political support for S&T. The federal budget process has not shortchanged S&T, nor has it failed to make choices when necessary.

Nevertheless, there are two issues: First, are we investing adequately for the long term to sustain the enabling S&T infrastructure? Second, are we deciding priorities among S&T opportunities in a way that will best advance the national interest? These would be compelling issues even if the budget climate were better. In a period of limited resources, there is an even greater premium on making the best-informed budget allocations possible.

In our review, we identified three types of S&T activities that should receive increased attention in the budget process in order to address these concerns. The activities are:

- *Investments in the S&T base—training, research, and its infrastructure.* These are required to sustain all scientific and engineering research and applications. The nation's scientific productivity, technological advancement, and commercialization capacity are directly dependent on the breadth and vigor of this base. These functions are supported through the budgets of several agencies.
- *S&T activities that contribute significantly to national economic, social, and political objectives pursued by the President or Congress or both.* Examples are industrial development and competitiveness, improvement in environmental quality, prevention and treatment of disease, and enhancement of national prestige. Typically, these objectives and the supporting S&T activities are shared responsibilities of several agencies.
- *New S&T initiatives, some but not all of them capital projects, that entail large expenditures.* These are often justified in terms of multiple benefits—new knowledge, jobs, national prestige, future economic growth, social welfare, and/or security. In a tight fiscal climate, such sharp step increases in the budget are difficult to accommodate except at the expense of other programs, including ongoing S&T activities.

The current budget process, which is designed primarily to consider how each agency's S&T programs contribute to its mission, will often inadequately address needs and define S&T objectives in these cross-cutting areas.

A FRAMEWORK FOR ASSESSING S&T BUDGETS

Overview

We propose a framework for guiding federal S&T budget preparation and assessment that provides a perspective on policy objectives and activities across as well as within agencies. The framework includes four nonmutually exclusive categories (see Table 1):

- S&T in the context of agency missions
- The S&T base
- S&T in relation to national objectives
- Major S&T initiatives

The framework will provide a basis for administration officials and congressional committees to sort out and make more explicit the characteristics of federal S&T programs and their contributions to the nation's goals and objectives. It will help identify what S&T opportunities and deficiencies need special attention, what fields or activities are not as productive or important as they once were, and what programs could be strengthened by collaboration and less duplication among the relevant agencies.

Agency Budgets and Missions

The starting point for assessing federal S&T budgets is a judgment about the mix, level, and quality of S&T in relation to other activities that will best advance the mission of a particular agency or department. The President's budget submission to Congress, including the "Special Analysis of Research and Development," is based on agency proposals as adjusted by OMB or the President. Congress, too, is organized to consider S&T in the context of an agency's entire portfolio of activities. With a few notable exceptions (e.g., the Department of Energy and the Environmental Protection Agency), one authorization committee and one appropriations subcommittee in each House has legislative and funding responsibility for an agency's operations.

The process by which the contributions of S&T programs to agency missions are judged and resources allocated works quite well to meet mission objectives ranging from advances in weapon system capabilities and health care to technical standards development and agricultural productivity. This is attributable in part to the fact that roles and responsibilities are well defined. It is also generally agreed that this pluralistic approach to S&T budgeting has contributed to the strength of the U.S. S&T system overall. Countries with highly

TABLE 1 Framework for Assessing S&T Budgets (Categories Are Not Mutually Exclusive)

Category	Characteristics	Examples
Agency budgets and missions	Agency S&T activities viewed in term of their contributions to individual agency goals and objectives	Nuclear and alternative energy R&D in DOE Submarine acoustics in DOD Cell biology in HHS Influence on learning in DOED Plant disease resistance in USDA Fundamental research in chemistry in NSF Standards development in NIST Aeronautical research in NASA
S&T base	Activities that provide the people knowledge, and infrastructure to carry out S&T Activities supported across many agencies and under the jurisdiction of several congressional committees	Basic and applied research programs in NSF, HHS, DOD, DOE, NASA, USDA, EPA, etc. Student fellowships in DOED, NSF, HHS, DOD, DOE, NASA, etc. Equipment and instrumentation programs in HHS, DOE, NSF, USDA, NASA, DOD, etc. Facilities for research, animal care, and growing and using special materials supported by NSF, DOD, HHS, DOE, NASA, etc. K-12 materials development in NSF, DOED, NASA, etc. Student internships in federal laboratories in DOE, NIH, etc.
S&T applied to national objectives (presidential and congressional priorities)	Stated priorities of President and Congress with major S&T components Frequently supported by several agencies and within the purview of several congressional committees	Understanding and ameliorating global change in EPA, DOE, NSF, NASA, USDA, NOAA, etc. Industrial development in biotechnology, superconductivity, manufacturing technologies in HHS, DOD, Commerce, NASA, NSF, DOE, USDA, etc. Alternative sources of energy in DOE, NSF, DOD, USDA, etc. AIDS in HHS, DOED, DOD, State Dept., etc. Creation of nuclear defense (Strategic Defense Initiative [SDI] in DOD) Increase capacity for exploration of space (Space Station in NASA)
Major S&T initiatives	Significant increase (and sometimes decreases) in budgets over several years Budgetary consequences across agencies Fall in one or more of above three categories	Superconducting Super Collider (SSC) Mapping and sequencing the human genome Space Station

centralized research systems have shown growing interest in emulating our coupling of S&T support and agency missions.

Science and Technology Base

The nation's commitment to sustaining a world class S&T capacity requires investment in the S&T base, which includes undergraduate training in science and engineering; the graduate education of scientists and engineers in a research setting; the conduct of fundamental and generic applied research on the frontiers of science and engineering, primarily in universities but also in federal, nonprofit, and corporate laboratories; and procurement and maintenance of equipment and facilities required for education and academic and federal laboratory research.

These activities are supported through the budgets of several agencies that are subject to review by different parts of OMB and various congressional committees. Support of the S&T base is central to the missions of NSF and HHS, but DOD, DOE, USDA, NASA, and other agencies make significant contributions.

Any scheme for examining federal S&T budgets must recognize that the S&T base is the bedrock of the nation's ability to use science and technology in the national interest and that it requires continual replenishment.

Continuity does not imply steady funding of the same activities and institutions through the same programs and agencies year after year. On the contrary, the enterprise ought to be highly dynamic. Policymakers must be able to respond flexibly to scientific breakthroughs that suddenly transform an area of research (e.g., high-temperature superconductivity), the invention of a powerful new instrument (e.g., gene-sequencing machine) or conceptions of new facilities that would aid research and training (e.g., supercomputer centers and networks), unexpected shortages of science and engineering personnel, or changing institutional relationships (e.g., the emergence of university-industry research partnerships). And as if that were not a sufficient challenge, budget makers and analysts must be attuned to differences among a wide range of fields. Some changes affect many disciplines, others only a part of a single discipline.

Sustained attention to the S&T base should be a part of the budget process in both the Executive and Legislative Branches of government. There need not be an annual review of every aspect of the base in every field, but each aspect should be reviewed periodically and there should be a capacity for considering a few key issues in any budget year.

S&T Applied to National Objectives (Presidential and Congressional Priorities)

At any time a limited number of national issues will be on the agendas of the President and Congress. Recent experience suggests that an increasing share of them will have prominent S&T components. Current and emerging examples are industrial development and international competitiveness, dependent on advancing S&T in such fields as superconductivity, microelectronics, materials, manufacturing technologies, and biotechnology; amelioration of global environmental changes; and prevention and treatment of AIDS.

Because these are broad issues, analysis, policy formulation, program implementation, *and* the support of relevant S&T frequently are dispersed among several agencies, as illustrated in part in Table 1. In theory the formulation of S&T budgets in these areas should entail review and judgments about the respective roles of the interested agencies, the relative contribution of S&T activities in each case, and the questions to be addressed by science and engineering. Although some reviews of this kind do take place, they are not done systematically. Congress recently expressed its desire to have such reviews carried out. In the 1988 Omnibus Trade and Competitiveness Act, the President is directed to submit with his FY 1990 budget cross-cutting analyses of federal efforts to advance four industrial technologies of major competitive significance—superconducting materials, semiconductor design and manufacturing, optoelectronics, and advanced manufacturing technologies.

Major S&T Initiatives

Finally, there are S&T activities or changes in programs that entail significant increases (or, less commonly, reductions) in agency S&T budgets. Recent examples include proposals to construct a SSC, deploy a manned Space Station, and map and sequence the human genome.

Projects of this sort will fall in one or more of the above three categories and should be evaluated accordingly. Because of their size and cost, however, they also impinge upon other activities in these categories, including activities beyond their sponsoring agencies, and therefore merit additional analysis as described in the next section. It is increasingly important that future outlays for all large projects receive systematic review.

Applying the Framework

The analysis of S&T budgets in terms of their contributions to *agency missions i*s reasonably thorough. It is in the three categories of activities that cut across agency boundaries that greater attention needs to be brought to bear and

new information developed in the course of the budget process. The framework described above helps to construct a set of questions or tests, the answers to which can help allocate S&T resources. The questions can be used in the initial development of presidential budget priorities conveyed to departments and agencies, and they can be applied to budget proposals from their inception in agencies through their review by OMB and the President and their consideration in Congress.

S&T Base

Analyses of activities cutting across agencies that contribute to the advancement of the S&T base usually should be carried out for a discipline or broad field (e.g., physical sciences, biomedical sciences, biological sciences, engineering, social and behavioral sciences). In a coordinated process, agency budgets and programs would be examined to determine their impact on needs for

- educating science and engineering personnel
- modernizing equipment and facilities
- supporting a mix of basic and applied research
- capitalizing on promising new research opportunities
- promoting interactions between related fields of science and engineering research
- distributing research support by geographic region and type of institution
- maintaining a mix of research modes: e.g., individual investigators, large groups, centers, university-industry partnerships
- balancing competitiveness and cooperation with research programs in other countries

S&T Applied to National Objectives

Analyses of cross-agency S&T activities as they contribute to presidential and congressional programs aimed at meeting social, economic, and other objectives need to be formulated in ways that relate to specific objectives, as shown in Table 1. In general, analyses should seek to determine the adequacy of S&T budgets with respect to

- achieving specific social, economic, or other objectives
- addressing the principal unresolved S&T questions related to the objectives
- achieving the necessary coordination across agencies
- providing for both near-term and long-term results

- complementing and capitalizing on nonfederal efforts, e.g., state and private company programs

Major S&T Initiatives

The analyses of special initiatives with large budget consequences should identify how the proposed program contributes to the three previous purposes, viz., mission agency objectives; the S&T base; and social, economic, and other objectives. The analyses also should consider impacts of the program on other S&T activities. In addition, analyses might document the extent to which special initiatives will

- pursue technical breakthroughs, e.g., biotechnology and superconductivity, or important new knowledge, e.g., the SSC and mapping and sequencing the human genome;
- entail large capital investments, e.g., the SSC and the Space Station, or a collection of many, smaller-scale projects, e.g., mapping and sequencing the human genome, or other arrangements;
- provide benefits such as development of new technologies (commercial, defense, areas related to other agency missions), education of scientists and engineers, creation of jobs, and contributions to U.S. scientific and technological leadership and other global interests.

Finally, for each initiative it is necessary to specify the institutions, individuals, and organizations that will be served; the costs; the opportunities for international cooperation and cost sharing; the management structure; and the timeliness of the program (why now rather than later?).

MODIFICATIONS OF THE EXECUTIVE AND CONGRESSIONAL BUDGET PROCESSES

Putting into practice the analytical framework outlined above requires adjustments in the Executive Branch process of preparing S&T budget proposals and in the congressional process of reviewing Administration requests and appropriating funds. We do not recommend radical changes in either context. We believe, however, that current processes can be modified to yield better results.

Executive Branch

The purpose of our recommendations is to ensure that Administration budget proposals reflect reviews not only of agency needs but also of the needs

of the S&T base, the requirements of presidential and congressional policy initiatives that depend on S&T activities, and the objectives and impacts of major S&T initiatives. We propose that the Administration's development of the budget include two new features.

- Early in the budget cycle, the President should provide the agencies and departments with specific guidance on his S&T priorities in cross-cutting areas and on major S&T initiatives.
- Agency budget submissions should be developed, analyzed and adjusted in terms of this initial guidance and the questions posed in the preceding discussion of the framework.

We believe that the President's science and technology adviser, working closely with the director and professional staff of OMB, is best suited to coordinate both phases of this process. The additional procedures would not alter the traditional prerogatives of department secretaries and agency heads in formulating S&T programs and budgets in the context of agency missions, nor would they detract from the role of OMB in managing the preparation of the President's budget. On the other hand, our proposals would take advantage of the considerable scientific and technical expertise in both the agencies and OMB. They might require new coordinating mechanisms, although one already available under law is the Federal Coordinating Council for Science, Engineering, and Technology.

More specifically, the process might work as follows:

Being familiar with the President's general policy objectives and having consulted regularly with senior S&T and budget officials of the government, industrial officers, academic scientists and engineers, and professional societies, the science and technology adviser would develop recommendations on cross-cutting S&T priorities for the forthcoming fiscal year budget. With the President's modifications and endorsement, the recommendations would become part of OMB's initial instructions to the agencies. Examples of priorities that might be stated in these instructions are support of graduate training in the physical sciences and engineering, advancement of generic manufacturing technologies, research and monitoring to narrow the uncertainties regarding global climate change, and initial exploration of long-range applications of high-temperature superconductors. The President's statement of priorities would then become part of the criteria for evaluating agency budget submissions.

We also propose that the Administration submit to Congress with its budget recommendations a policy statement presenting the President's cross-cutting priorities for S&T that guided the preparation of his budget. It would include a summary of agencies' mission-related S&T activities as currently presented in the "Special Analysis of the Budget for R&D." The statement

would also emphasize the Administration's proposals dealing with the S&T base, social, economic or other national objectives, or major new S&T initiatives.

Following enactment of necessary authorizations and appropriations, the President's science and technology adviser, director of OMB, and agency heads would work together to see that programs are carried out in accordance with the President's priorities as modified by Congress.

Table 2 shows the additional steps that we recommend alongside the sequence of steps now followed in the formulation of the President's budget.

Congress

If the President's budget presentation conforms to the recommendations above, Congress will have more information than it currently receives to evaluate the President's S&T priorities and budget allocations across agencies. Complementary adjustments in the congressional budget process could facilitate consideration of cross-cutting S&T programs and initiatives in the same manner as the recommended changes on the executive branch side. We make two procedural recommendations. We describe other options, suggested by members of Congress, that would affect consideration of S&T but arise from broad concerns about the effectiveness of Congress.

- Congress, no less than the administration, should consider programs and budgets in relation to the S&T base, national policy objectives, and major S&T budget initiatives as well as in the context of individual agency missions. This review should begin before the budget is disaggregated for consideration agency by agency and program by program. It is therefore an appropriate function of the budget committees of the Senate and House and of the authorizing committees with broad S&T oversight jurisdiction—the Senate Committee on Commerce, Science, and Transportation and the House Committee on Science, Space, and Technology.

  In each house a full committee or its special task force on S&T should examine the President's S&T budget submission; request whatever staff or support agency studies are needed to supplement analysis available from the Executive Branch; and take testimony from the President's science and technology adviser, agency officials, and knowledgeable people in the academic and industrial communities. We note that in recent years the Senate Budget Committee has conducted annual overview hearings on S&T in the federal budget. In the House, the Science, Space, and Technology Committee conducts annual S&T "posture" hearings.

TABLE 2 Current Practice and Proposed Additions to the Executive Branch Process for Preparing S&T Budgets

Current Practice	Proposed Additions
1. Focus is on how S&T activities meet the requirements of the missions of individual agencies	1. Add perspective of major initiatives and S&T activities that have impacts across several agencies
2. OMB manages preparation of President's budget	2. None
3. Cabinet secretaries and agency heads play key roles in formulating S&T programs and budgets to meet agency requirements	3. In addition, President's science and technology adviser, working with OMB, coordinates process to bring the cross-cutting perspective of S&T activities and major initiatives into the budget preparation by agency heads
4. OMB initiates process by sending agencies instructions for preparing their budgets	4. In addition to the types of instructions issued currently, the initial guidance includes the President's cross-cutting S&T priorities
5. OMB reviews and adjusts agency budget submissions and recommends final budgets to the President, with opportunities for agency appeals	5. The President's cross-cutting S&T priorities are used, along with other criteria, in reviewing agency budget submissions and recommending final decisions
6. President submits budget proposal to Congress; a special analysis on R&D is included that presents a summary of agency R&D budgets	6. The President's budget submission includes a statement of the S&T priorities that guided budget preparation, the rationale underlying them, and the resulting budget proposals

Whatever method of review is chosen, the budget committees should, in connection with the Budget Resolution, report their judgments on the President's priorities and recommend changes. The committees' recommendations would not dictate subsequent decisions in the congressional budget process; but they could influence allocations made within the appropriations committees, especially if the budget committees were to track the appropriations and report periodically on how they compare with the President's request and their own recommended adjustments.

- The appropriations committees also should have a procedure for reviewing cross-cutting S&T activities in light of the President's priorities and the budget committees' recommended adjustments. At a minimum, there should be discussions among the committee chairman and ranking minority member and the appropriate subcommittee chairs and their ranking members; and these discussions should begin before the appropriations committees allocate spending authority to their respective subcommittees (the 302b allocations).

Many members of Congress have proposed major changes of congressional budget procedure and committee structure that may receive serious consideration in a future Congress. One such procedural change is for the budget committees to propose, and both houses to approve as part of the Budget Resolution, the 302b allocations, which would then be binding on the appropriations committees. Proposed structural changes include placing on the budget committees more chairmen and ranking members of the appropriations subcommittees and authorization committees, creating a joint budget committee, consolidating the authorization and appropriations committees, and revising the jurisdictions of the appropriations subcommittees to combine similar programs and agencies.

We recognize that changes of this scope will only be adopted, if at all, out of broad concern for improving the performance of Congress in its legislative, budget, and oversight functions and after full consideration of the demands on members' time, their constituency and policy interests, and the distribution of influence among members and committees. But we urge Congress to consider also how procedural or structural changes would affect the review of S&T programs and budgets. In general, we favor a continuous process in which the early cross-cutting reviews of the President's S&T budget priorities would carry weight in the appropriations phase. If either house revises its committees' jurisdictions, we favor combining S&T programs with their parent agencies where possible. The budgets for S&T activities are now too large and their bearing on national affairs too great to be treated in an uncoordinated fashion.

Finally, there appears to be growing support for the government to shift from an annual to a two-year budget cycle. Indeed, the President's FY 1989

budget proposes two-year appropriations for a number of agencies. Although we have not considered how this should be accomplished in practice, we support biennial budgeting in principle. It could benefit longer-term federal investments such as S&T expenditures by enabling program managers to plan their S&T activities over a longer period, by giving S&T performers somewhat greater assurance of stable funding, and by encouraging decisionmakers to be more realistic about out-year spending requirements especially for major projects. A two-year cycle might also make it easier to accomplish the additional steps we propose in the development and review of the President's S&T budgets.

In recent Congresses, there has been a movement toward multiyear authorizations for agencies and programs with S&T components. If Congress decides to experiment with biennial appropriations, we believe that S&T programs should be leading candidates for such a trial.

CONCLUSION

In preparing and evaluating federal budgets for S&T, it is time to institutionalize a cross-agency perspective on three categories of activities: those contributing to the S&T base, those contributing to broader national policy objectives identified by the President and/or Congress, and those representing major new initiatives. These are activities undertaken by several agencies or with budget consequences for several agencies. Political support for such activities continues to grow, but none of the categories receives adequate attention in a budget process designed to consider S&T programs almost exclusively in relation to the mission of the parent agencies.

The Academies and the IOM examined several approaches to conducting cross-agency reviews of S&T programs in the budget process. We recommend an expanded framework for assessing and adjusting S&T programs across all agencies and procedural changes to apply the framework in both the Executive and Legislative Branches. The analytical framework should be useful immediately to officials involved in the budget process. The procedural changes can and should be implemented beginning with the FY 1991 budget cycle.

The National Academies of Sciences and Engineering and the Institute of Medicine hope to remain active participants in efforts to improve federal budgeting for S&T and will continue to promote discussion of these issues within the science and engineering community.

APPENDIX 1

Excerpt from the Report of the Committee on the Budget, U.S. Senate, on S. Con. Res. 113, Concurrent Resolution on the Budget FY 1989 (Sen. Report. 100-311)

Science and technology programs are widely recognized as being key to the nation's response to the challenge of economic competitiveness, as well as other major national priorities, such as health, environment, national defense, and quality of life.

Funding for these programs is spread across more than thirty independent federal agencies, making it difficult to develop a coordinated national research and development budget. Annual analyses performed by the Office of Management and Budget and the National Science Foundation merely compile agency proposals and are retrospective in nature. They generally are not used in the Executive branch decision-making process.

The Committee held hearings this year on science and technology. Much of the discussion centered on the problems and lost opportunities associated with the lack of coordination and the need for a better way to examine funding and organizational priorities in the federal effort in science and technology.

In light of these hearings and other findings, the Committee believes that the nation needs to develop a comprehensive set of mission categories to examine the allocation of resources to science and technology and identify gaps in funding. Any such approach should include substantial involvement from the scientific community in establishing priorities within the federal effort in research and development.

To undertake this effort, the Committee believes that the National Academy of Sciences, acting jointly with the National Academy of Engineering and the Institute of Medicine, should provide advice on developing an appropriate institutional framework and information base for conducting cross-program development and review of the nation's research and development programs. This should be structured in such a way that it can be used by both the Executive branch and Congress as a method for reviewing program contents and strategies and in determining funding and organizational priorities for science and technology. The Academies' advice should be provided to the appropriate Committees of Congress not later than November 15, 1988.

APPENDIX 2

Recommendation to Study Classification of DOD Activities in Federal R&D Statistics

Historically, DOD has accounted for a majority of federal R&D spending—currently, nearly two-thirds, or approximately $39 billion. Of this amount, between $4.5 billion and $5.5 billion are for activities similar to civilian agency S&T activities—basic and applied research and exploratory development. More than $30 billion are for advanced technology and military equipment development, testing and evaluation, and the operation of facilities for these specialized purposes—activities that are critical to the DOD but not comparable to other federal S&T activities. In the military budget buildup since the late 1970s, moreover, the latter budget categories have grown more rapidly than the former ones.

Lumping together as R&D the defense and civilian agency activities now classified as such may lead to overstating the national S&T effort overall and in certain research fields. We therefore urge the new Administration to assemble a group of experts to examine what DOD activities are appropriately classified as R&D. The group should include people with experience in OMB, the Office of Science and Technology Policy (OSTP), and DOD R&D management.

COMMITTEE OF COUNCILORS

PURNELL W. CHOPPIN is President of Howard Hughes Medical Institute. Dr. Choppin was a member of the faculty of the Rockefeller University for twenty-eight years, serving as Vice-President, Academic Programs from 1983 to 1985. He has served on numerous advisory committees of the National Institutes of Health.

KAREN DAVIS is Chairman of the Department of Health Policy and Management, School of Hygiene and Public Health, and Professor of Economics, Johns Hopkins University. An economist, Dr. Davis was earlier on the faculty of Rice University. She served for one year as Administrator, Health Resources Administration, Public Health Service, Department of Health and Human Services; and for three years as Deputy Assistant Secretary for Planning and Evaluation. She currently is a member of the Physician Payment Review Commission.

GERALD P. DINNEEN has been Vice-President for Science and Technology, Honeywell, Inc., since 1981 and held Department of Defense positions from 1977 to 1981 as Assistant Secretary of Defense, Communications, Command and Control, and Intelligence, and Principal Deputy Under Secretary of Defense, Research and Engineering. For twenty-five years he held various positions at Lincoln Laboratory, Massachusetts Institute of Technology. Dr. Dinneen is Foreign Secretary of the National Academy of Engineering.

JAMES D. EBERT, Director, Chesapeake Bay Institute, Baltimore, Maryland, is Vice-President of the National Academy of Sciences and immediate Past President of the Carnegie Institution of Washington. Dr. Ebert served on the faculty of the Johns Hopkins University from 1956 to 1978. He has been associated with a number of national laboratories, including the Brookhaven National Laboratory, the Marine Biological Laboratory, and the National Institutes of Health. He currently chairs the Government-University-Industry Research Roundtable.

ALEXANDER H. FLAX, Home Secretary of the National Academy of Engineering, was for six years Assistant Secretary for Research and Development, Department of Air Force and has twenty years experience with the Institute for Defense Analyses, serving as its President from 1969 to 1983 and President Emeritus from 1983 to the present. Dr. Flax's recent affiliations include the NATO Advisory Group for Aerospace Research and Development and the Defense Science Board.

HARRY B. GRAY is Arnold O. Beckman Professor of Chemistry at the California Institute of Technology where he joined the faculty in 1966, chairing the Division of Chemistry and Chemical Engineering from 1978 to 1984. Prior to his current position, he was on the Columbia University faculty for five years. Dr. Gray has served as Chairman of the NSF Advisory Committee on Chemistry and in advisory roles for the Oak Ridge National Laboratory, the Los Alamos National Laboratory and the Solar Energy Research Institute.

JOHN L. McLUCAS, a corporate director, scientist, and government administrator, is currently Chairman of QuesTech, Inc. Dr. McLucas was Executive Vice-President of COMSAT and President of its two major subsidiaries for ten years, and earlier was President and Chief Executive Officer of The Mitre Corporation. In the federal government, Dr. McLucas was Administrator of the Federal Aviation Administration, Secretary and Under Secretary of the U.S. Air Force for six years, Assistant Secretary General for Scientific Affairs, NATO, and Deputy Director of Defense Research and Engineering. He has served on advisory committees for NASA and the General Accounting Office.

RICHARD A. MERRILL, Dean of the University of Virginia School of Law from 1980 to 1988, and Daniel Caplin Professor, is currently on sabbatical as a Visiting Fellow of the National Wildlife Federation. Mr. Merrill was formerly Chief Counsel of the Food and Drug Administration. He has been a consultant to the Office of Technology Assessment, Food and Drug Law Institute, and the Environmental Protection Agency.

FRANK PRESS, President of the National Academy of Sciences since 1981, and President's Science Adviser during the Carter Administration, was reelected by the NAS membership to a second six-year term in 1987. As NAS President, Dr. Press serves concurrently as Chairman of the National Research Council. A geophysicist, he has served on the faculties of Columbia University, California Institute of Technology, and Massachusetts Institute of Technology. He served on the President's Science Advisory Committee during the Kennedy Administration and on the Baker and Ramo Presidential Advisory Committee during the Ford Administration. He was appointed by President Nixon to the National Science Board of the National Science Foundation and also served on the Lunar and Planetary Missions Board of the National Aeronautics and Space Administration.

PETER H. RAVEN is Director, Missouri Botanical Garden, a position he has held since 1971 while concurrently serving as Engelmann Professor of Botany, at Washington University, St. Louis. Dr. Raven has also been associated with the faculties of Stanford University, St. Louis University, and the University of

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H. GUYFORD STEVER, a corporate director, scientist, and engineer, served as White House Science and Technology Adviser to President Ford and Director of the Office of Science and Technology Policy and was Director of the National Science Foundation from 1973 to 1976. Prior to his government service, he was President of Carnegie-Mellon University from 1965 to 1972 and Professor of Aeronautics and Astronautics at the Massachusetts Institute of Technology for twenty years. Dr. Stever has served as NAE Foreign Secretary and as chairman of the National Research Council Committee on Space and the Panel on Technical Evaluation of NASA's Proposed Redesign of the Space Shuttle Solid Rocket Booster.

SAMUEL O. THIER is President of the Institute of Medicine, National Academy of Sciences, appointed to this position in 1985. He also currently is Visiting Professor of Medicine, The Johns Hopkins University School of Medicine, and Clinical Professor of Medicine at George Washington University School of Medicine and Health Sciences. Prior to his election as IOM President, he was Sterling Professor and Chairman of the Department of Internal Medicine, Yale University School of Medicine. Dr. Thier served on the faculties of Harvard and the University of Pennsylvania School of Medicine prior to his appointment at Yale. He did research at the National Institutes of Health from 1962 to 1964, and from 1980 to 1984 he served on the Director's Advisory Committee there.

ROBERT M. WHITE, President of the National Academy of Engineering since 1983, serves concurrently as Vice-Chairman of the National Research Council. Dr. White was the first Administrator of the National Oceanic and Atmospheric Administration. He was appointed Chief of the U.S. Weather Bureau by President Kennedy in 1964 and served under Presidents Kennedy, Johnson, Nixon, and Ford. He was appointed by President Carter to the National Advisory Committee on Oceans and Atmosphere. From 1977 to 1980, Dr. White was President of Joint Oceanographic Institutions, Inc., a consortium of universities engaged in deepsea drilling. From 1980 to 1983, Dr. White was President of the University Corporation for Atmospheric Research, a consortium of 50 universities with research programs in atmospheric sciences and technology.

ACADEMY STAFF GROUP

DAVID L. BODDE is Executive Director of the Commission on Engineering and Technical Systems. Prior to joining the National Research Council, Dr. Bodde was Assistant Director of the Congressional Budget Office and a Deputy Assistant Secretary of the Department of Energy. A graduate of the U.S. Military Academy, his graduate education includes nuclear engineering at MIT and business and economics at the Harvard Business School.

RAPHAEL G. KASPER, Executive Director, Commission on Physical Sciences, Mathematics, and Resources, was trained as a nuclear physicist. Dr. Kasper has served as a senior policy analyst in the Office of Science and Technology Policy, and as director of studies of the Nuclear Safety Oversight Committee in the Executive Office of the President.

LAWRENCE E. McCRAY, Executive Director, Committee on Science, Engineering, and Public Policy, received his doctorate from MIT in the field of science policy studies. In addition to his work on the effects of the Gramm-Rudman-Hollings Act and other assignments in science policy at the National Research Council, Dr. McCray has worked at the Office of Management and Budget and elsewhere in the Executive Office of the President.

STEPHEN A. MERRILL, Associate Project Director, is Director of the Office of Government Affairs of the National Research Council. He has participated in several Academy studies of science policy and technology and international competition. Dr. Merrill has served on various congressional staffs, most recently that of the Senate Committee on Commerce, Science, and Transportation. He was a member of the Senate staff group that developed the Senate committee reorganization plan adopted in 1977.

NORMAN METZGER is Deputy Executive Officer of the National Research Council and has been responsible for a number of examinations of science and its support. These include guidelines for the science and technology centers of the National Science Foundation; a series of reports on the outlook for science and technology; and a workshop on federal research and development support, emphasizing the relative costs and benefits of that support.

DON I. PHILLIPS, Project Director, is Executive Director of the Government-University-Industry Research Roundtable. Dr. Phillips prepared reports on federal and industry R&D budgets at the American Association for the Advancement of Science, served as a special science adviser in the Office of

the Governor of North Carolina, and was the Director of the North Carolina Biotechnology Center.

PHILIP M. SMITH, Executive Officer of the National Research Council and National Academy of Sciences, has had broad science policy experience in the federal government. Former positions include Executive Assistant to the Director, National Science Foundation, and to the Science Adviser to the President; and Associate Director, Office of Science and Technology Policy, Executive Office of the President. He was Chief of the General Science Branch of the Office of Managment and Budget and has directed polar research programs of the National Science Foundation.

AUDREY G. WARD, Associate Director of Government Affairs, National Research Council, has been involved in legislative research and congressional liaison in the science policy area for the past 13 years. Earlier experience includes positions with the Bureau of the Census and as an intelligence analyst with the Central Intelligence Agency.