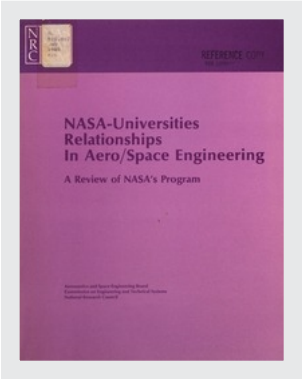

NASA-Universities Relationships in Aero/Space Engineering: A Review of NASA's Program

DETAILS

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NASA-Universities Relationships In Aero/Space Engineering

A Review of NASA's Program

A Report of the ad hoc Committee on
NASA-Universities Relationships in
Aero/Space Engineering

Aeronautics and Space Engineering Board

Commission on Engineering and Technical Systems

National Research Council

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This report has been reviewed by a group other than the authors according to procedures approved by a Report Review Committee consisting of members of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine.

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SUMMARY

The National Aeronautics and Space Administration (NASA) looks to the nation's universities for an important part of its overall program in space and aeronautics. NASA provides funding support for university educational and training programs and for research and test equipment and facilities to enable universities to conduct research. The universities produce basic research results and provide innovative ideas and trained professionals.

NASA's University Program is managed in two major parts: (1) the Engineering Research and Technology Development Program, managed and sponsored by the Office of Aeronautics and Space Technology (OAST) and (2) the Science Program, managed and sponsored by the Office of Space Science and Applications (OSSA). This report documents the results of a review of the NASA University Program in Aerospace Engineering Research and Technology Development sponsored by OAST.

OAST invests typically about $50M/year in university-performed aeronautics and space research activities. The majority of these funds are disbursed by NASA's Research Centers (Langley, Lewis, and Ames) as grants for work in areas correlated with their research programs. Some funds are used for such purposes as Joint Institutes, graduate student support, and Centers of Excellence.*

NASA is concerned about the health of aerospace engineering departments at U.S. universities. The number of advanced degrees in aerospace engineering has declined. There is concern that universities' facilities, research equipment, and instrumentation may be aging or outmoded and therefore affect the quality of research and education. NASA requested that the National Research Council's Aeronautics and Space Engineering Board (ASEB) review NASA's support of universities and make recommendations to improve the program's effectiveness.

* The term "Center of Excellence" as used here is defined in Appendix C.

To accomplish the task, the ad hoc Committee on NASA-Universities Relationships in Aero/Space Engineering was appointed. In two two-day meetings, the committee reviewed NASA-university relationships and programs. Also, briefings and discussions were held with representatives of the Department of Defense, National Science Foundation, the American Association of Engineering Societies, and the National Research Council's Committee on Education and Utilization of the Engineer.

Based on its review of the NASA/OAST University Program, the committee concludes that the program does not fully capitalize on the universities' major strength--independent, long-term, basic research. The specific recommendations of the committee are intended to help correct this situation and increase the universities' value to NASA and the nation's aeronautics and space programs and simultaneously help the universities provide the trained manpower to maintain U.S. leadership in the future.

The principal recommendations are to: (1) improve support of independent, long-term, basic research, (2) institute a system of peer review, and (3) provide a focal point for the program at NASA headquarters. The ad hoc committee's specific conclusions and recommendations follow.

1. Conclusion

Basic research is crucial to OAST's mission, and basic research at universities is uniquely important because of its close relationship to the quality of the schools' primary product, educated manpower. Academic Centers of Excellence established by OAST in critical areas of technology have clearly enhanced both graduate education and research. Approximately 80% of the University Program funding is coupled to ongoing NASA research programs. Such funding is necessary and desirable, but it does not support academic investigators who would like to pursue independent research. Further, the short-term funding cycles are not conducive to long-term, fundamental, independent research.

Recommendation

- That OAST increase funding for independent university research that addresses long-term, fundamental problems whose solutions are likely to have lasting impact and that OAST extend its funding cycles in a manner consistent with such a policy.

- That OAST make fuller use of universities' capabilities by expanding its support of Centers of Excellence, especially in areas of important emerging technologies.

2. Conclusion

OAST's University Research Program would benefit from peer review of research proposals by individuals from industry, academe, other government agencies, and NASA.

Recommendation

- That OAST institute a system of peer review of research proposals; the system should involve academic, industry, and government personnel.

3. Conclusion

The visibility of the OAST University Program is less than adequate, and some action to correct this is warranted. Further, university programs in research and technology development in aeronautics and space engineering are not well coordinated among federal agencies and among government, industry, and academe.

Recommendation

- That NASA establish a position responsible for advocacy and coordination of university research programs within the Office of the Associate Administrator for Aeronautics and Space Technology. The recommended position, at the minimum, would serve as a focal point and advocate and provide overall coordination for the OAST university program.

- That NASA take steps to make the OAST University Program more visible to the technical community and the Congress and to coordinate the program with similar programs in other federal agencies, such as the National Science Foundation (NSF) and Department of Defense (DoD).

4. Conclusion

The number of doctorates awarded annually in aerospace engineering fell 50% in the decade ending with 1983, while the number of bachelor degrees increased 70% during the same period. The shortage of doctorates makes it difficult for universities to augment or expand their faculties in aeronautics and space disciplines. A shortage of operating and maintenance funds for facilities inhibits research and contributes to the departments' difficulty in attracting doctoral candidates. Interest in space-related disciplines is burgeoning among undergraduates, but the universities are ill-prepared to capitalize on the opportunity.

Recommendation

- That OAST establish aeronautics and space engineering fellowships/traineeships for education at the Ph.D. level, with associated funding for supervisory faculty, research equipment, and staff for operational support and maintenance of facilities.

- That OAST encourage the universities to expand their space curricula while still strengthening their aeronautics programs.

INTRODUCTION

NASA's responsibilities in aeronautics and space are delineated in the National Aeronautics and Space Act of 1958. The act states that aeronautical and space activities, except those peculiar to or primarily associated with weapons systems, shall be the responsibility of NASA in order to contribute to, among other objectives, "the expansion of human knowledge of phenomena of the atmosphere and space," "the preservation of the role of the United States as a leader in aeronautical and space science and technology," and "the effective utilization of the scientific and engineering resources of the United States." Therefore, basic research is one of NASA's fundamental responsibilities and an important element of its program.

National expenditures for research and development for fiscal year 1983 were about $86 billion. The federal government provides about 45% of R&D funding and industry about 51%. Other sources of funding provide 4%. It is estimated that about 9% of the total R&D performed in the U.S. was performed by universities. However, nearly 25% of all research and nearly 50% of the basic research was carried out by universities.* The nation's higher education system is an important contributor to the flow of research ideas and the generation of new knowledge, as well as to the training of scientific and technical personnel.

University research, in part because of its close coupling with graduate education, tends to be long-term, frequently original, and relatively inexpensive. In addition, the diverse nature of the university fosters greater cross-fertilization of ideas than normally occurs in either industrial or governmental laboratories. The quality of university research often reaches its zenith when a critical number of excellent faculty, postdoctoral fellows, and graduate students

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* National Science Board, Science Indicators 1982. Washington, D.C. National Science Foundation, 1983.

focuses on a narrow range of topics to form a center of excellence, whether so named or not.

NASA looks to the nation's universities as an important source of technical expertise, new concepts and ideas, and trained personnel for aerospace research and technology and has long provided support for universities in various forms. These programs generally fall in the realm of aerospace engineering as contrasted with space and earth sciences. Essentially all such support is supplied through NASA's Office of Aeronautics and Space Technology, which is responsible for the agency's research and technology development (R&T) programs for aeronautics and space applications.

NASA-university relationships in aerospace engineering historically have exemplified early involvement of academic investigators in problems of national purpose, security, and economic concern without risk to academic freedoms. The two-way flow of ideas between the universities and NASA and its research centers has been mutually beneficial.

In recognition of the importance of these relationships to its mission, NASA is concerned about the health of aerospace engineering departments at U.S. universities. The number of advanced degrees in aerospace engineering has been declining. Aging laboratory facilities and outmoded research equipment and instrumentation are said to be contributing to the decline. Because of its concern, NASA concluded that an outside group should assess the effectiveness of OAST's program of support to universities.

Following discussions with NASA's Office of the Chief Scientist and with OAST, the Aeronautics and Space Engineering Board (ASEB) of the National Research Council (NRC) was asked to review OAST-university relationships and to make recommendations to improve the effectiveness of OAST's University Program. ASEB accepted the assignment in March 1984, and the ad hoc Committee on NASA-Universities Relationships in Aero/Space Engineering was appointed in May 1984.

The committee held two two-day meetings, in June and October 1984, at the NRC's quarters in Washington, D.C. The first meeting was devoted to gathering information by means of briefings and discussions involving representatives of NASA, the Department of Defense, the National Science Foundation, the Engineering Manpower Commission, and the NRC Committee on Education and Utilization of the Engineer. At the second meeting, following further briefings by NASA, the committee developed its preliminary conclusions and recommendations and the structure of its report.

The committee relied on its collective experience and judgment in assessing OAST's University Program. It does not contend that this report represents a complete study of all the facets of OAST's support of universities.

BACKGROUND

NASA always has recognized that the nation's universities are an important source of expertise, new knowledge and ideas, and newly trained scientists and engineers for its programs. Consequently, NASA funds academic research and equipment and supports graduate students; faculty members serve on advisory committees for agency programs and often conduct research in collaboration with NASA personnel. These forms of agency-academe interchange comprise a significant mechanism for information transfer and provide direction for academic research.

NASA's funding of university research in aerospace engineering in fiscal 1983 totaled $46.1 million (fiscal 1984 estimate, $52.2 million). In addition to funding university work in aerospace engineering, which is done through OAST, the agency funds university research in earth and space science (about $150 million) through its Office of Space Science and Applications. NASA also funds two agency-wide programs through its Office of External Affairs and another program is administered by the National Research Council. In addition, NASA contributes to five federal programs. Funding for these programs amounts to $13 million, resulting in a grand total of approximately $209.8 million for the agency for fiscal year 1983 (fiscal year 1984 estimate, $230 million).

NASA also provides funds for Independent Research and Development (IR&D) by its industrial contractors on a formula basis (see also Appendix B), but IR&D funds are discretionary and, while the utilization of such funds in university-allied programs is encouraged, it is not mandatory. IR&D funds, including NASA's contribution, are administered by DoD, and industry is required to report on all IR&D-university interactions. Such interactions aid in the negotiation of the industry recovery rates (ceiling) with the tri-services.

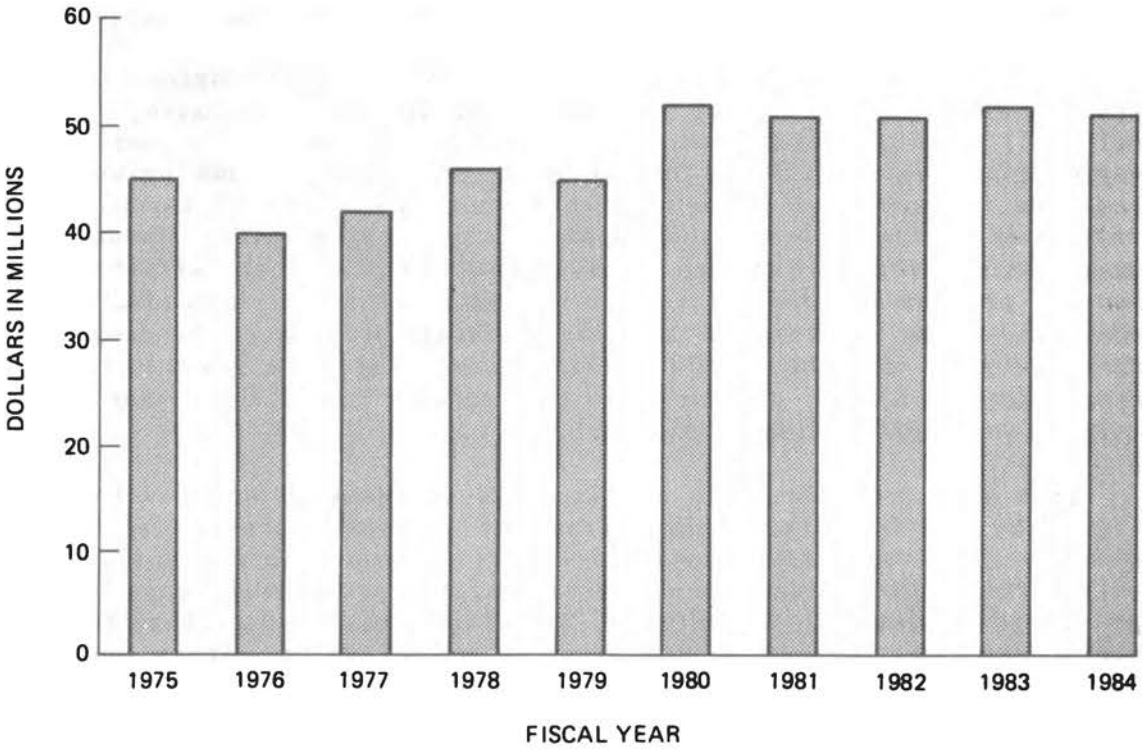
NASA's programs in support of universities, with particular emphasis on the OAST program, are outlined in the following subsections. For completeness, brief descriptions of analogous programs at the National Science Foundation and the Department of Defense are contained in Appendixes A and B, respectively.

The OAST University Program--Aeronautics and Space Engineering

The OAST University Program has four broad goals:

- To conduct long-range, high-risk research
- To develop innovative, creative approaches and ideas
- To apply university expertise to solve problems of mutual interest, and
- To produce trained professionals.

The program in fiscal 1983 (the latest year for which detailed information was available) was budgeted at $46.1 million, 11.5% of OAST's R&D budget of $401.5 million, or 6.1% of OAST's total budget of $760.2 million.* OAST's University Program budget in 1984 dollars has kept pace with inflation, having been essentially level since fiscal 1980 (Figure 1).

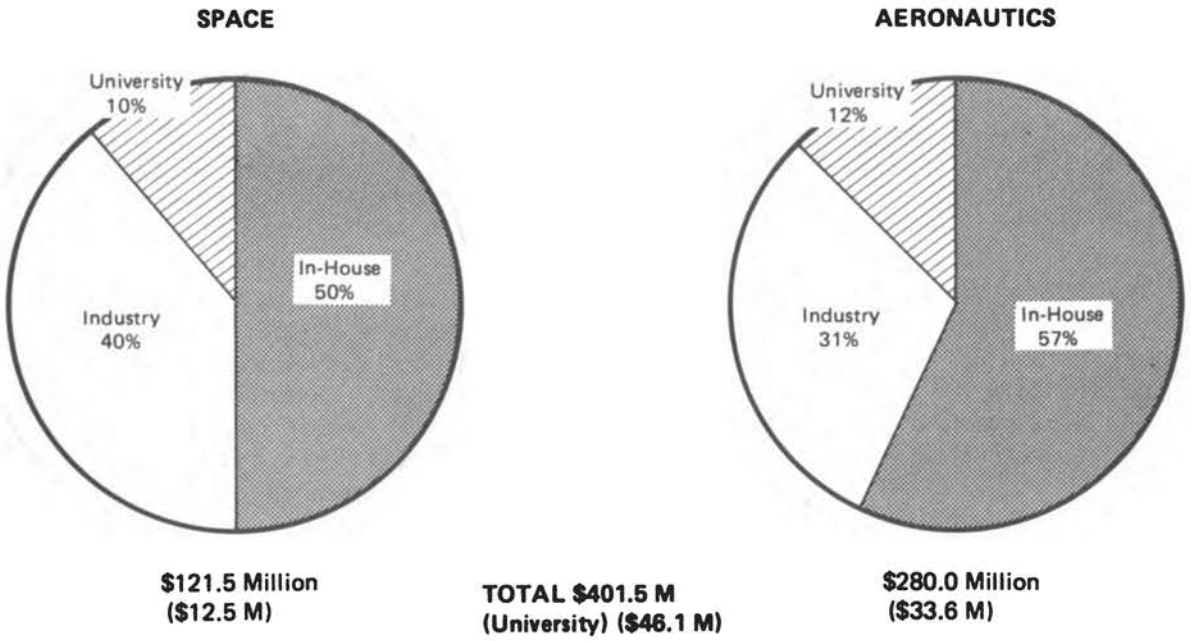


SOURCE: NASA

FIGURE 1 Funding History in 1984 Dollars--NASA's University Program in Aero/Space Engineering

* Does not include $20.1 million for construction of facilities (CofF) in FY 1983

About $33.6 million, or 72.9%, of OAST's 1983 budget for universities was earmarked for aeronautics research and $12.5 million, or 27.1%, for space. In other terms, of OAST's research and development funding for aeronautics in fiscal 1983 ($280.0 million), universities were budgeted for 12%. Of OAST's research and development funding for space in 1983 ($121.5 million), 10% was for universities (Figure 2).

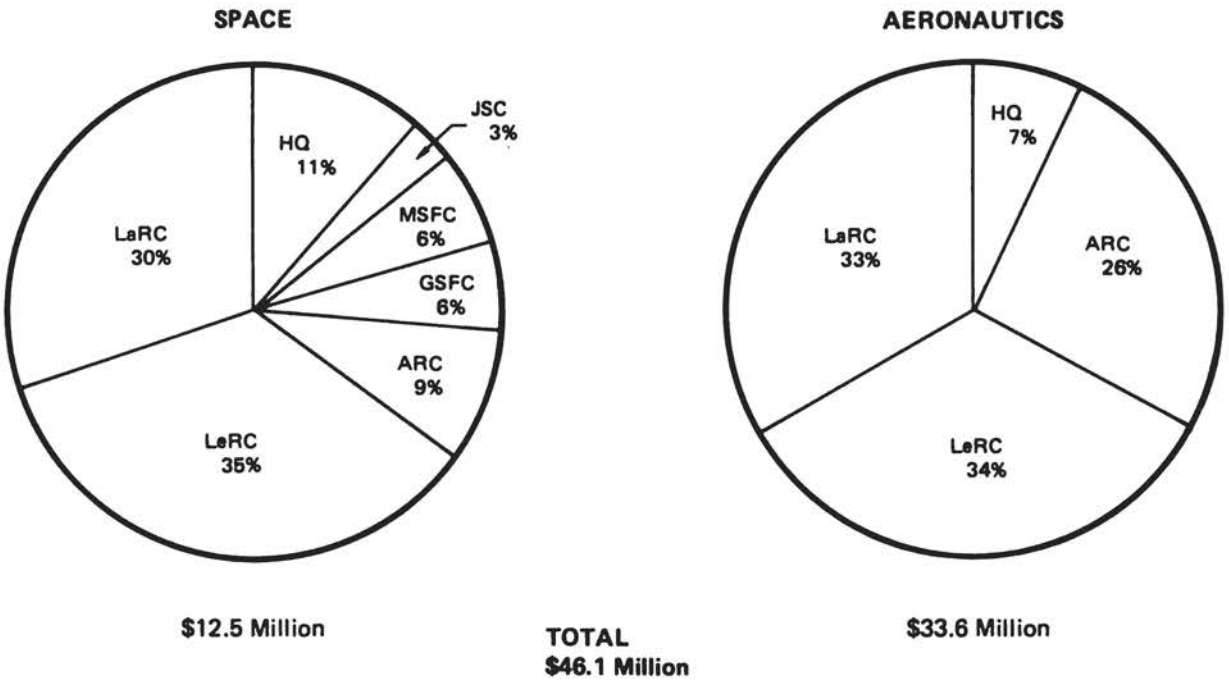


SOURCE: NASA

FIGURE 2 NASA/OAST Research and Development Program Funding by Performer--FY 1983

The majority of OAST's university funding for fiscal 1983 supported work directly related to OAST research programs--82% in aeronautics and 89% in space. The remainder supports other university activities, including independent research, that are independent of specific NASA programs (non-program).

OAST's University Program is managed largely through NASA's field centers. In fiscal year 1983, NASA headquarters managed about 11% of its total space research at universities and 7% of the aeronautics work (Figure 3). Research proposals from academic investigators are evaluated and accepted or rejected by the technical staff at NASA centers; outside-NASA peer review processes are not employed.



SOURCE: NASA

FIGURE 3 NASA's University Program Funding in Aero/Space Engineering Distribution by NASA Center--FY 1983

Program-Related Funding

Program-related work at universities accounted for 84% of OAST's university funding in fiscal 1983. The funds were divided among four areas of endeavor:

- Basic Research Grants ($35 million)
- Research Institutes ($1.4 million)
- Centers of Excellence ($2 million)
- Joint University Program (controls)($0.2 million).

Basic Research Grants in fiscal 1983 totaled $35 million, or 76% of OAST's university funding. These grants fund informally solicited and unsolicited proposals; 600 to 700 grants are awarded annually to 160 to 170 institutions. The grants are designed mainly to support long-range basic research and to extend mainstream research projects.

OAST supports two Research Institutes: (1) the Institute for Computer Applications in Science and Engineering (ICASE), co-located at the Langley Research Center, and (2) the Research Institute for Advanced Computer Science (RIACS), co-located at the Ames Research Center. The institutes are supported by a core contract from NASA and by joint research projects (tasks) with NASA in-house research groups. In 1983, these institutes together were funded at $1.4 million, or 3% of OAST's university funding. There were additional funds ($0.78 million) provided through Basic Research Grants for specific tasks to be accomplished by the institutes.

The core research program is long-term by nature and is supervised by the permanent institute staff. The task research program tends to be short-term and is monitored by sponsoring Ames researchers. This research is carried out by visiting university scientists, postdoctoral students, and graduate students during appointments ranging from two months to two years. Both institutes are managed by the Universities Space Research Association (USRA), a consortium of 52 universities under contract to NASA.

OAST has established five Centers of Excellence, one each at Rensselaer Polytechnic Institute (Mechanical Behavior and Processing of Composite Materials), Massachusetts Institute of Technology (High Performance Computing for Aerospace Applications), Virginia Polytechnic Institute and State University (Chemistry, Mechanics of Composite Materials), the University of Washington (Mechanics and Processing of Brittle Materials), and Stanford University (High Volume Space Information Management). Two of the centers work in computer science and three in materials. Total funding in 1983 was about $2 million, or 4.3% of OAST's university budget. The centers are intended to assure a critical mass of research in selected fields of interest to NASA and to foster interdisciplinary work in these fields.

A Joint University Program in controls involves Princeton University, Massachusetts Institute of Technology, and Ohio University. OAST funding for this activity in 1983 was approximately $0.2 million.

Funding for Independent University Activities

Funding for research into subjects selected by the universities themselves and other activities that are independent of OAST's research programs accounted for about 16% of OAST's university funding in 1983. Of the total funding of $7.4 million for independent research and other activities, 82% went to aeronautical programs and

18% to space-related programs. The funds were divided among four components:

- o Joint Institutes ($0.7 million)
- o Graduate Program in Aeronautics ($2 million)
- o Centers in Computational Fluid Dynamics Training ($0.75 million), and
- o Fund for Independent Research ($4 million).

OAST supports three Joint Institutes: Ames' Joint Institute for Aeronautics and Acoustics, which involves a basic research program at Stanford University; Langley's Joint Institute for Advancement of Flight Sciences, an on-site continuing education program at Langley funded through George Washington University; and Lewis' Joint Institute for Aeronautical Propulsion and Power that involves Akron, Cleveland State, Toledo, and Case Western Reserve Universities. Total funding of these Joint Institutes in 1983 was $0.7 million. As in the case of the funding for the Research Institutes discussed earlier under Program-Related Funding, an additional $2.1 million is funded through the Basic Research Grants program for specific tasks conducted at the Joint Institutes.

The Graduate Program in Aeronautics supports graduate research by U.S. citizens through grants to roughly 100 students annually at 45 institutions. Students spend about half of their time at a NASA research center. Funding in 1983 totalled about $2 million, or 4.3% of OAST's university budget.

The Computational Fluid Dynamics Training Program supports a total of 30 graduate students at six universities: Arizona, Stanford, Iowa State, Cincinnati, Penn State, New York, and the Massachusetts Institute of Technology. Funding is about $0.75 million per year.

The objective of the Fund for Independent Research is to support novel, long-range, high-risk research. Unsolicited proposals are reviewed and managed by a basic research council under the chief scientist at each NASA research center. Some 100 grants are awarded annually, for periods of one to three years. Total funding was about $4.0 million annually, or 8.7% of OAST's university funding in 1983.

The OSSA University Programs--Space Science

To assure the completeness of the ad hoc committee's review of OAST's program in aerospace engineering and technology, the committee requested and received a briefing on the Office of Space Science and Applications (OSSA) University Program in Space Science.

OSSA's budget plan for fiscal 1985 is about $1.4 billion, much of it for the design and construction of spacecraft and payloads (e.g., Space Telescope and Galileo). OSSA research programs of the type that correspond generally to the OAST programs account for some $325 million annually. About $150 million is for university-based activities.

In science, NASA relates to universities in a fundamentally different way than it does in engineering and technology. From the beginning, NASA's policy has been that most of the basic research in space science would be conducted by university groups. Therefore, NASA's role in science is that of manager of a national effort as well as a participant, an effort that involves the nation's universities, industry and the NASA centers and in which the universities have a dominant role. NASA's role in aerospace engineering, on the other hand, is one in which NASA is a dominant participant where the NASA centers possess the facilities and the competence to predominate in research and technology development.

OSSA manages its University Program at NASA headquarters. All proposals for research projects are subjected to outside-NASA peer review, and this applies to research by agency personnel at the NASA centers as well as to agency-funded research in industry, other government locations, and academe.

Within OSSA's five main discipline divisions are a total of about 25 discipline-oriented branch offices, each headed by a discipline chief. The discipline chiefs and their staffs handle the peer-review process and also are OSSA's primary day-to-day contact with the scientific community. The discipline chiefs may handle peer review in different ways--such as by mail or by panels--but all reviews are in writing. All decisions concerning funding are made at NASA Headquarters.

In its relations with NASA field centers, OSSA works on the principle that ideas in research originate at the working level and move upward. Thus, the discipline chiefs work with their counterparts at the branch level and with the working scientists in the centers.

Agency and Federal Programs

NASA supports three programs as an agency, as contrasted to the previously described programs that are supported by NASA program offices. Two of the three are administered by other organizations.

- The Summer Faculty Fellowship Program, administered by the American Society for Engineering Education, provides 10 weeks at NASA Research Centers for about 210 faculty members per

year. The program is funded through the agency's Office of External Affairs at $1.8 million in 1983.

- The Resident Research Associate Program is funded by the NASA program offices and administered by the National Research Council. The program supports postdoctoral scientists and engineers of unusual promise and ability for work in residence at the NASA centers. Approximately 175 awards are made per year (235 authorized by contract), something under half of them to non-U.S. citizens; funding in fiscal 1983 totalled about $6.7 million. Of this total for the agency 51 awards were made under the auspices of OAST with OAST funding of $1.9 million in fiscal 1983.

- The Graduate Student Research Program supports thesis-dissertation research on topics of interest to NASA. About 40 students are started each year; the maximum number in the program is 120. Funds are supplied through NASA's Office of External Affairs and totalled $1.3 million in 1983.

In addition to these agency programs, NASA contributes to five federal programs:

- Summer Employment Program for University Faculty and Students
- Historically Black College and University Program
- Baccalaureate Degree Co-op Program
- Employee Graduate Study Program, and
- Intergovernmental Mobility Program.

NASA funding for these programs totalled $8.4 million in 1983. The agency hires about 72% of the graduates of the Baccalaureate Degree Co-op Program. The Employee Graduate Study Program and the Intergovernmental Mobility Program cannot be classified as University Programs.

D I S C U S S I O N

Suitability of OAST University Program

OAST puts special emphasis on close collaboration between university faculty and student researchers and NASA personnel. About 68%, or $36 million, of OAST's support of academic research in 1984 was funded directly from NASA center program budgets.

The $52.2 million budget for OAST's University Program in fiscal year 1984 was almost half that of the National Science Foundation's (NSF) total support of engineering research and is many times the NSF funding of $1.0 million for aerospace engineering (Appendix A). Given this level of funding, the committee believes that the OAST University Program is not as visible as it ought to be, especially in view of the burgeoning student interest in space-related disciplines and the general interest in industry-university cooperation.

Several industry members of the committee, each with about 10 years of service on NASA advisory committees, were surprised and impressed with the size of the program. The OAST University Program, in terms of impact in the aerospace community, should rank well above the NSF and OSSA programs. This is not now the case the committee believes because the OAST program does not have a central focus.

The committee believes that both NASA and the universities would benefit if a larger portion of the program funding were directed to independent university research. Approximately 80% of the work that OAST funds at universities is in support of NASA's ongoing programs. This work is competently done at relatively low cost and is cost-effective. It supports graduate work, creates a NASA presence in the academic community, and builds cooperation between academe and NASA. It should continue to be supported. However, given the universities' unique ability to contribute new talent to the total program and the fundamental and long-term nature of their research capabilities, the committee believes that more of the funding should be allocated to independent academic research.

A major concern in the universities is the stability of funding for research programs. The short duration of grants (one year, year to year) presents a problem to universities in recruiting top-rated

graduate students. There is an implied commitment of longer term funding, but the uncertainty of the continuity of funding tends to cause researchers to seek other sources of support.

One way to improve matters would be to provide multi-year grants that would be reviewed annually and extended each year as warranted. Funding dedicated for this purpose, would be taken from the top of the budget and allocated to the NASA centers and reserved for support of fundamental, independent academic research. Alternatively, support for this work could be allocated by program managers directly from NASA headquarters.

NASA's Needs and University Research

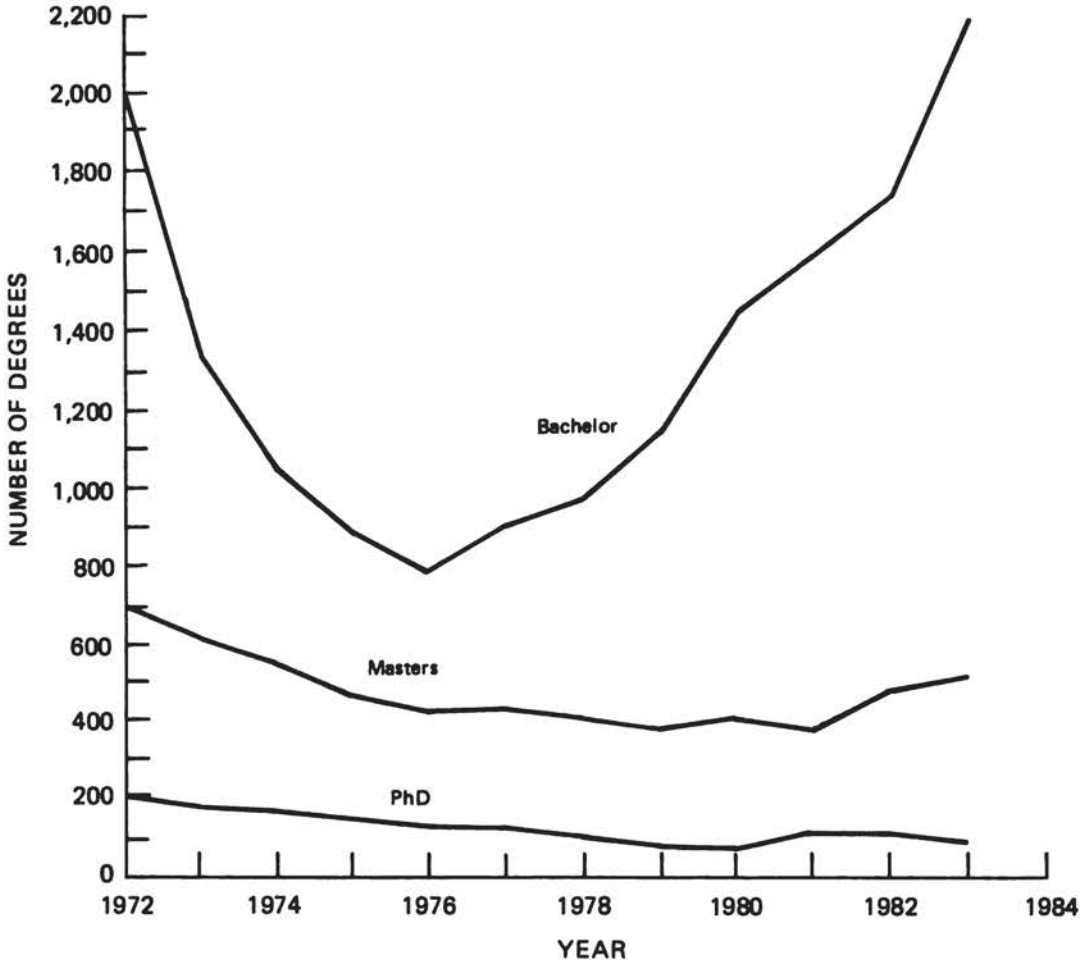
Some funding related to NASA's University Program, while important, should be distinguished from support of university research. For example, funding of George Washington University to provide continuing education at NASA Langley does not represent support of academic research although it is an important attribute for Langley. Also, the funding of the Research Institutes at NASA Ames and Langley does not support independent academic research although the institutes do provide an interface between NASA university scientists, faculty, and graduate students engaged in computer science and applications research.

Other examples include efforts that encourage development of graduate programs through the support of researchers, and faculty-improvement programs such as the ASEE Summer Faculty Fellowship Program. The NRC Research Associate Program is valuable but it cannot be classified as a university program; it is, in effect, a way for new and able doctorate graduates to conduct basic research at NASA centers.

Decline in Doctorates Awarded

The universities, government, and industry are concerned about the decline in the number of doctorate degrees awarded annually in aerospace engineering. The number of bachelor's degrees awarded increased from the most recent minimum of about 800 in 1976 to 2,200 in 1983 according to the Engineering Manpower Commission, an increase of 175%. The number of doctorates awarded, meanwhile, declined from about 150 in 1976 to 100 in 1983, a decrease of 33% (Figure 4). The shortfall of doctorates in aerospace engineering has made it difficult for universities to expand their faculties, especially in astronautics, which in turn could lead to shortages of people with advanced degrees for work in industry.

Faculty positions today are not especially attractive to ambitious young aerospace engineers. The drawbacks include heavy workloads, the difficulty of sustaining a research program in the face of short-term,



SOURCE: American Association of Engineering Societies

FIGURE 4 Aerospace Engineering Degrees

uncertain funding, and a shortage of operational support for facilities. Further, many universities have been slow to recognize the growing need for engineers trained in space technology and space systems.

The committee considered the question of the adequacy of research facilities, instrumentation, and equipment available to the universities. In the judgment of the committee, research facilities are not a critical problem and although funding for research equipment

and instrumentation is a general need,* the situation is not critical for aeronautics and space engineering. Research equipment is obtainable and funding for instrumentation for research tasks can be, and generally is, included in NASA research grants and contracts. The critical need for funding that is difficult for universities to obtain is funding for the operation and maintenance of research facilities.

The aerospace engineering departments of U.S. universities look to NASA and the Air Force for research support and collegial interaction. Able students with potential interest in aerospace engineering can be found throughout the schools of science and engineering. To make it attractive for these students to pursue advanced degrees and careers in aeronautics and space, they must be confident they will be involved in dynamic, competitive research as graduate students and even as undergraduates.

The committee believes that a peer review policy based upon in-house and out-of-house reviewers could provide a means of improving the understanding of the program and potential for involvement in the program among university researchers. A peer review would provide guidance in the selection of proposals for independent university research topics and a means of ensuring the technical quality of NASA's University Research Program.

The committee believes that such a policy, coupled with the allocation of a larger percentage of the university program funding to independent academic research as suggested earlier, would help promote confidence among university researchers that their proposals will receive appropriate consideration. Such peer review would include reviewers from NASA centers, other federal agencies, universities, and industry and could employ formal mechanisms, the NSF approach, or informal mechanisms, the DoD approach.

Coordination

The effectiveness of government-university programs in research is a broad issue,** and the various federal agencies attempt to enhance their relationship with academe in their own ways. One example is the DoD-University Forum (see Appendix B). A similar forum is being set up by the Department of Energy. The committee looked particularly at coordination of programs among OAST, NSF, and DoD.

OAST is concerned with aeronautics and space; NSF is concerned with all sciences and engineering, including cross-disciplinary

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* See Engineering Education and Practice in the United States, Chapter 4, National Academy Press, Washington, D.C. 1985.

** For a comprehensive review of this subject, see Strengthening the Government-University Partnership in Science. National Academy Press 1983, Washington, D.C.

research in engineering; and DoD is concerned with all of these subjects. It appears that if better interagency understanding and coordination of programs with a degree of synergism can be achieved, the end result will be programs that have more meaningful impact on technical concerns of national interest. One effort to improve coordination is the Federal Coordinating Committee on Science, Engineering, and Technology of the Office of Science and Technology Policy. Program coordination would require formal, periodic review of programs by the principals at each agency and would improve the visibility and awareness of the major agency-university programs.

An example of a potential problem can be found in the Engineering Research Centers being established at universities by NSF (see Appendix A). The committee has concern that unless NASA is involved, aerospace engineering will not be much in evidence at these centers. Such a lapse would be avoided, presumably, by a government-wide committee that NSF says may be set up to coordinate the research center program.

Need for a Focal Point

Most of the ways in which the committee sees that the OAST University Program can be improved point to a need for a focus for the program at NASA Headquarters. At a minimum, the duties of a person in such a role would be to serve as an advcocate for the OAST University Program, provide a knowledgeable point of entry to NASA for university researchers seeking support, and to provide coordination.

The committee recognizes that some academic investigators have come to know the program managers in their areas of interest at NASA centers and that common interests and knowledge of programs promote expeditious handling of grant requests. The establishment of a Headquarters' focal point should not interfere with this and other desirable features of the OAST University Program.

APPENDIX A

NSF Programs

The National Science Foundation's total budget for fiscal 1984 was $1.3 billion, of which $120 million was for engineering. The budget for fiscal 1985 is $1.5 billion, including $150 million for engineering. Of the total funding for engineering, approximately $1.0 million can be classified as aerospace engineering for each fiscal year.

A major NSF thrust is to increase access to advanced computers (super computers) for people in educational institutions. Funds for this program came to $10 million in 1984 and is $40 million for fiscal 1985. Access to computers in engineering in 1984 amounted to a total of 1,500 hours available at one industrial site and two university sites. Funding for additional equipment during 1985 and beyond will permit tying super-computers together and establishing three or four supercomputer centers.

A second NSF focus is to increase support for equipment in institutions of higher education. The Engineering Directorate targeted $8 million for equipment in fiscal 1983 and $18 million in 1984; funding is expected to reach $22 million in fiscal 1985. A determined effort is being made to ensure that this funding is provided for equipment that is closely associated with the research projects.

A third agency endeavor is the new Presidential Young Investigators Program, which involves industry-government-university participation and support for five-year awards. NSF supplies the first $25,000 per year and, in addition, matches industry contributions to provide up to $100,000 per year for 200 engineers and scientists. One hundred of the awards will be in engineering. The purpose of this program is to retain in academe young doctorates who might otherwise pursue nonteaching careers.

Just getting started at the beginning of fiscal 1985 was NSF's program of sponsoring and funding Engineering Research Centers to be

established at universities. These centers are to pursue cross-disciplinary research in engineering. The ground rules require the involvement of undergraduates, graduate students, faculty, and industry. NSF expects to fund five or six such centers in the first year and 25 to 30 centers after five years.

All of the foregoing programs are designed to receive proposals that will be reviewed by panels of peers selected from outside NSF.

APPENDIX B

DoD Programs in Support of Universities

The Department of Defense supports research at universities through (1) the DoD's Research, Development, Test, and Evaluation Program (RDT&E) and (2) the Independent Research and Development Program (IR&D). The DoD-University Forum is an Advisory Committee formally established in 1983 to discuss DoD-university interactions such as research, education, indirect costs, and technology export control.

The RDT&E provides about $1.1 billion per year for universities. About $450 million is for engineering research. It is intended to increase the rate of real growth for basic research to 8% starting in fiscal year 1987 and to sustain that rate of growth until DoD support for university research is raised to the level of the mid-60's. About 50% of the basic research and most of the applied research is in engineering.

DoD has increased the involvement of university researchers in its R&D programs in general. Annual funding for university research and development--including R&D conducted at off-campus university research centers--has increased 73% over the past four years when budget categories 6.1 through 6.4 are taken into account. This compares favorably with overall DoD funding increases.

To improve relationships with the nation's universities and seek their advice on issues of mutual importance, DoD established the DoD-University Forum as a formal advisory body to the Department of Defense. The forum is co-sponsored by DoD and the Association of American Universities, the National Association of State Universities and Land Grant Colleges, and the American Council on Education; it is composed of DoD officials and university presidents. The forum and its working groups meet periodically to discuss issues of mutual interest to DoD and the academic community, including export control policies, engineering and science education, foreign languages, and area studies.

DoD's University Research Instrumentation Program (URIP) is a five-year, $150 million initiative to upgrade university research instrumentation, funded at $30 million per year through fiscal 1987.

The program is directed at large items of equipment, $50,000 to $500,000, and approximately equals the funding level for equipment items that are routinely included in research contracts with universities. In the first three years, $90 million in over 650 grants to 152 universities in 47 states was awarded. For fiscal years 1984 and 1985, 1870 proposals requesting $370 million were received.

Recognizing that it cannot and should not bear the full burden of improving the nation's research and teaching institutions, DoD can play an important catalytic role in the solution. It has begun to explore ways of maximizing its efforts by helping to strengthen the interaction between universities and private industry.

Industry performs R&D for DoD through technical efforts that industry selects, initiates, and sponsors. This is known as its Independent Research and Development (IR&D) Program. A company selects its program on what it perceives will enhance its competitiveness in future DoD system procurements, while ideas for its programs come from the basic research community, including university research. Key elements of today's operational systems can be traced back to industrial independent research and development efforts, and these efforts in turn can be traced to university research programs. Therefore, it is imperative that efforts be continued to strengthen the university-industry interaction in order to improve the transition of basic research ideas to technological innovation and operational systems.

In this connection, DoD has adopted a plan to encourage greater industry-university interactions. The plan is to reward industry for increased university interaction in IR&D ceiling negotiations. It is hoped that the effect of increased industry-university interaction will be to expose students to industrial problems earlier in their careers; transfer new scientific advances more rapidly to industry; provide new and challenging problems to university faculty; and generally strengthen university research.

Another collaborative project involving universities, industry, and DoD, which DoD is supporting, is the development of the National Technological University. This new university will be made up of a consortium of 24 major engineering schools whose faculty will deliver advanced degree courses via satellite to engineers employed in commercial and DoD laboratories and installations. The first degree offering, computer engineering, was begun in fall 1984 with video-taped delivery. Satellite delivery will commence in the fall of 1985 along with other master's level programs in such areas as manufacturing engineering and engineering management.

In addition to DoD, industry is also heavily supporting the National Technological University. Corporations contributing to the development of the new university include GTE, Hewlett-Packard, IBM, and other major employers of engineers. This new effort will

contribute in several ways. It will maximize the utilization of the abilities of engineering faculty members to reach larger audiences; provide them with additional income, which will hopefully encourage them to continue to teach; and help provide continuing education to larger numbers of engineers throughout the country who currently may not have access to advanced education opportunities.

DoD basic research programs at the nation's universities also support approximately 4,000 graduate assistants each year. In addition, each of the armed services has established graduate fellowship or assistantship programs that will support this year more than 250 students pursuing advanced degrees in disciplines important to the defense mission.

DoD has for many years sponsored summer faculty research opportunities for university researchers in its laboratories. In the summer of 1984, this program involved more than 300 university faculty, as well as some 50 graduate students. An attempt is being made to include high school teachers in the program.

DoD also supports the president's initiative on Historically Black Colleges and Universities (HBCU's). In fiscal year 1983 DoD funding totalling about $20 million went to almost one-third of the nation's HBCU's. Of this $20 million, about $16.5 million went to support ROTC detachments and scholarships and $3.5 million to support basic research at the nation's HBCU's.

DoD is also actively involved in collaborating with other federal agencies on issues related to research and education. The Under Secretary of Defense for Research and Engineering participates as an active member of the newly created National Academy of Sciences Government-University-Industry Research Roundtable.

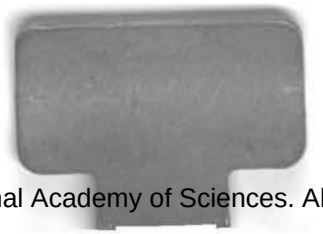
DoD also actively participates in the interagency steering committees on academic research facilities--the so-called "bricks and mortar" element of university research. To establish the magnitude of the facilities problem and to project future needs, the universities are asked to participate in an in-depth survey of adequacy of the present facilities and their anticipated needs. DoD is particularly interested in those new facilities that enable totally new research approaches. Based on analysis of the survey results, DoD (in cooperation with the National Science Foundation, National Institute of Health, and other participating federal agencies) will make recommendations to the Congress on how to improve university research facilities.

APPENDIX C

Centers of Excellence

A Center of Excellence is defined as a NASA-wide activity housed at a field center or supported at a university with responsibilities to the aeronautics and space community at large. For such a center, program continuity must be assured to undertake long-range programs appropriate to a federal laboratory; to provide career development; to assemble the cohesive group of professional skills necessary to maintain a scientific critical mass; to develop the facilities required for advanced research; and to create the institutional prestige that attracts top talent. Such centers should be developed to maintain expert knowledge in a selected disciplinary area and made available to all.

Establishing Centers of Excellence should be a one-at-a-time, controlled operation--not a wholesale implementation.



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