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S P A C E  S C I E N C E  B O A R D

# Report of the ad hoc Committee on NASA/University Relationships

July 11, 1962

National Academy of Sciences -
National Research Council

# PREFACE

The Space Science Board of the National Academy of Sciences, throughout the four years of its existence, has paid particular attention to the scientific manpower requirements of our national space effort. Mindful not only of the needs of the program to explore space, but also of the unprecedented opportunities which it afforded for scientific study, the Board some time ago (Science, Vol. 130, No. 3369, July 24, 1959) addressed itself to individual scientists encouraging them to take part in space research programs. Although the response to the efforts of the Board and others has been encouraging, it has become increasingly clear that the manpower situation facing this country's space program is critical: the needs of the National Aeronautics and Space Administration alone for skilled manpower at all levels of scientific and technical capabilities are nearly overwhelming. However, the rate of increase of talented engineers and scientists at present is growing only slowly while the demand for them is growing at an incredible rate.

In the course of Space Science Board discussion of this problem, the urgency for a study of the relationship of our universities and colleges to the space science program was clearly apparent. Accordingly, and in response to a request from representatives of NASA that such a study be conducted, Space Science Board Chairman L. V. Berkner appointed an ad hoc Committee on NASA/University Relationships with the following membership: James A. Van Allen, chairman (State University of Iowa), Edward B. Espenshade, Jr. (Northwestern University), Lloyd V. Berkner (Graduate Research Center of the Southwest), James Gilluly (U. S. Geological Survey), James G. Harlow (University of Oklahoma), Joseph C. Morris (Tulane University), and Colin S. Pittendrigh (Princeton University). The Committee met in Washington, D. C., on February 13 and 14, 1962, with Homer E. Newell, Jr., J. T. Holloway, and T. L. K. Smull (all of NASA), M. H. Trytten (National Academy of Sciences), and Hugh Odishaw (Space Science Board) also in attendance. John Truesdale, of the Space Science Board staff, was Secretary to the Committee.

From an examination of pertinent excerpts (see Appendix I to this Report) from the National Aeronautics and Space Act of 1958, as amended in 1961, the Committee concluded not only that NASA possesses adequate authority to develop a program of university participation in space science and technology which is of broad scope and substantial magnitude, but, indeed, that it is directed to do so. The ad hoc Committee, regarding its mission as one of advising NASA how best to meet this objective, reviewed several aspects of NASA's space science program: nature and scope of space science research in universities, graduate and undergraduate training in space science, and facilities for research in the universities and colleges. The report which follows is a brief assessment of the current status and short term trends in these areas.

## I. Introduction

In August 1961 several working groups organized by NASA met to consider the role of the universities and colleges (hereafter called universities) in the nation's space program, and NASA's relationship to them. It was concluded that NASA must turn to the universities not only for the trained manpower it needs but also for the basic research undergirding NASA's activities. For these reasons, it seemed clear, the universities are vital -- probably decisive -- for the future of space science and exploration.

The institutions of higher learning in this country have within their educational custody some 3,000,000 young men and women. It is from these educational ranks that future staffing of the national effort in space science and technology will come. Accordingly, although the quality of education at all levels (but more particularly at the collegiate and post-graduate levels) is of fundamental importance to the national competence, the Committee has restricted its attention to the level of graduate education as the one most crucial to the next decade in space science and technology.

From the standpoint of actual effort and expenditures, the NASA program is dominantly a technological one and is concentrated in industry and in the federal establishment. Yet, the present and projected demand for persons of high scientific, technical, and scholarly competence is so great that the impact on higher education is potentially enormous. Moreover, the opportunities for developing new fundamental knowledge and technical applications may very well equal or exceed those which have existed in the atomic and nuclear physics field during the past thirty years.

It is for the above reasons that a vigorous academic program in all appropriate aspects of the space endeavor must be developed. Such a program must enjoy a viable relationship to that of the federal establishment itself; but it is of utmost importance that it preserve the essential virtues of universities, viz., a devotion to scholarly and scientific inquiry for its own sake, a primary concern for the guidance and education of students, full freedom of discussion and publication, and essential autonomy in the formulation of research objectives and of programs of work directed toward such objectives.

## II. Current NASA-Universities Program

The existing relationship of NASA to the academic community consists of a diversity of research contracts and grants and of pilot programs, just being initiated, of training grants for graduate students and of facility grants to universities engaged in space science research. Also there are many persons from university staffs who act as consultants on special matters.

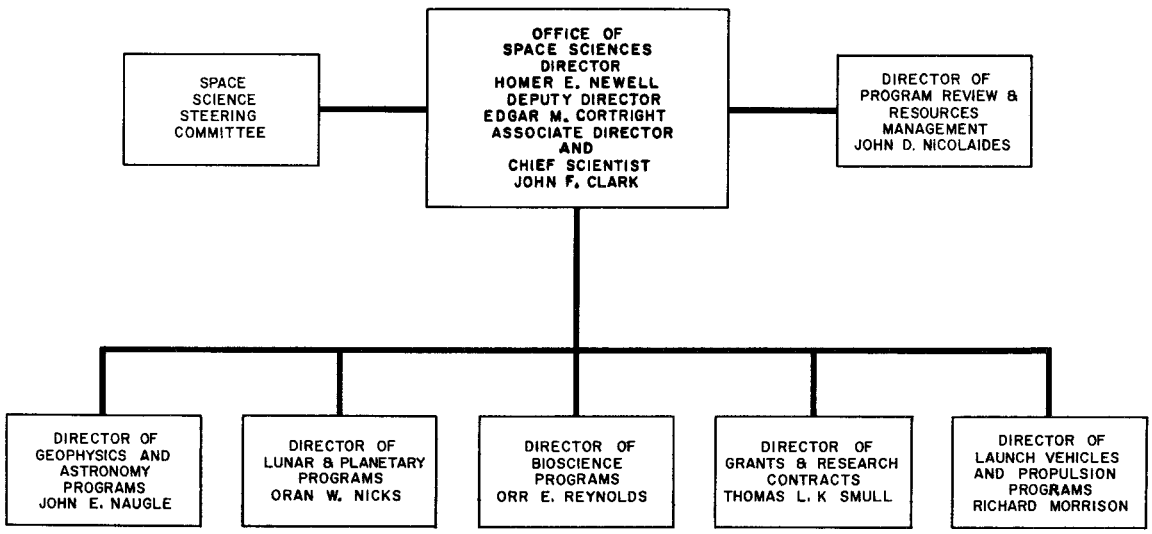
Much of the present program in universities is traceable directly to their pre-NASA activities, especially those supported by the National Science Foundation, and by the Office of Naval Research and other agencies of the Department of Defense during the International Geophysical Year.

The primary initiative for the existing program for space science in universities has rested with the universities themselves, though the NASA administration has reacted with sympathetic attention to the representations of university scientists and administrators. The August 1961 conference of consultants on NASA/university relationships was a significant milestone in the direction of broader planning.

On September 24, 1961, NASA announced major organizational changes keyed to the nation's accelerated civilian space program, and to its three specific national objectives: (1) scientific study of the space environment and celestial bodies to gain new scientific knowledge; (2) early application of earth satellites and of space research and technology to immediate use for human benefit; and (3) the exploration of space by man. Four major offices were established: the Office of Space Sciences, the Office of Applications, the Office of Manned Space Flight Programs, and the Office of Advanced Research and Technology.

Of these four offices, it is the Office of Space Sciences whose needs and interests are most intimately interwoven with those of the universities. The Office of Grants and Research Contracts, which has been the unit that serves as a focal point for NASA relationships with educational institutions, was placed in the Office of Space Sciences under this new organization. Although located in this particular office, it coordinates the NASA-university relationships of all the NASA Program Offices.

The Office of Space Sciences is organized around four major programs, in all of which there is strong university participation: Biosciences, Geophysics and Astronomy, Lunar and Planetary Programs, and Launch Vehicles and Propulsion. Other details of this Office are shown in the following organization chart:



Responding in part to recommendations made by the working groups mentioned above, and in part to views expressed by their individual members, NASA is endeavoring to enhance the university contribution to its program by support of research, training and facilities. $40 million of FY 62 funds, and something in the neighborhood of $100 million of FY 63 funds, will be devoted to such activities. These figures are small in the context of NASA's total budget. Moreover, a fraction of category 1 funds, though administered by universities, is not expended on university campuses but is committed by purchase and subcontract for the development of flight equipment, etc. It should further be understood that for those university programs which involve flight experiments, NASA must provide, within its own budget, substantial sums of money for the purchase of vehicles, conduct of flight operations, operation of telemetry and tracking stations, etc. The payload development costs are typically about 10% of the overall costs of satellite and space probe missions and about 25% of the overall costs of sounding rocket missions.

The NASA representatives affirmed their intention to encourage and support broad interdisciplinary approaches to space problems. The initial program has been concentrated in major universities of demonstrated research achievement. A deliberate attempt will be made in the future to broaden the program to include other universities which are of lesser eminence but which have good growth potential.

The various categories of NASA's university-program are described in somewhat more detail as follows:

1. Research

This category includes grants and research contracts for specific, mutually-agreed objectives, often for the development of observational equipment on a specified schedule for scheduled flights, e.g., development and construction of a magnetometer for Explorer XII. It is planned to continue and expand this program.

Also included in this category are grants for the support or assistance of fundamental research in a scientific or technical area, often an interdisciplinary one, which is related to NASA's mission as interpreted broadly. The arrangements for such grants are adapted to a wide variety of needs in many institutional settings.

In this category, NASA is dealing with about 70 universities at present; it expects to increase this number to about 200 in coming years. All grants and contracts must be for work related to NASA's legal mission. But this mission is one of great breadth and even includes social, economic, political, legal, and international implications of peaceful space activities for human affairs. A listing of "Active Grants and Contracts" is issued periodically by the Office of Grants and Research Contracts of NASA and is available on request.

2. Training

NASA has selected ten universities (University of Chicago, Georgia Institute of Technology, University of Maryland, University of Michigan, University of Minnesota, Rensselaer Polytechnic Institute, Rice University, State University of Iowa, Agricultural and Mechanical College of Texas, and University of California in Los Angeles) at which to begin a traineeship program in the fall of 1962. The criteria employed in the selection of the initial list were: currently active space science programs, geographical distribution, and/or nearness to NASA research centers. The budgeted $2 million for FY 62 will support ten traineeships at each of the ten universities for three years. The basic stipend is $2400 for 12 months, given directly to the student, and $1000 given to the university to be administered by it as it deems necessary for dependency allowance, escalation, etc. In addition, a sum of money is to be given to the university for its out-of-pocket expenses; the amount of this sum has not been determined yet and will depend on experience in the early stages of the program. As a matter of NASA policy, the program is restricted to U. S. citizens except in unusual cases. There are no oath or affidavit requirements.

The traineeships are for pre-doctoral study in space-related fields in the physical, engineering, and life sciences. Responsibility for selection of the trainees is placed in the hands of the Dean of the Graduate School at each university. Since NASA recognizes the need for continuing support until the degree work is completed, the money is made available in three-year blocks (in exceptional cases, a fourth year would be approved), to be paid to the student on a year-to-year basis if his progress is satisfactory. NASA does not require that trainees commit themselves to NASA.

Rather it views this program as its contribution to the national pool of scientific talent, from which it expects to draw its share of manpower if it maintains an attractive and creative space science program. The traineeships are the equivalent of graduate fellowships in the usual meaning of the latter term.

In FY 63, it is planned to increase the program to 700 to 1000 pre-doctoral traineeships in a much expanded list of universities. An undergraduate-support program is also being considered though its nature and scope have not yet been determined.

NASA also has a program of post-doctoral associateships, which first began with a sum of about $650,000 to support about 50 resident research associateships. Originally these associateships were tenable only at Goddard Space Flight Center; now the program has been broadened to include the Marshall, Ames, Lewis, Langley, and Edwards centers, and the Jet Propulsion Laboratory. NASA expects to extend the program still further to include tenure at universities as well. Residence is normally for one year.

3. Facilities

Since August 1961, NASA has been authorized to make facilities grants to universities. Since this authorization came too late to permit proper budgeting for FY 62, only a small pilot program has been possible. A substantial expansion in FY 63 is planned. NASA's facility legislation is broader than that of other federal agencies in that matching contributions by the grantee are not required. In lieu thereof, a substantial long-term commitment to space research is required. However, if a NASA facilities grant is to be combined with grants from one or more other federal agencies whose legislation does require matching funds, then the grantee institution must match the sum of the federal grants with funds from non-federal sources (state or private).

NASA can, and does, when the Administrator has made a determination that it is in the best interests of the government, transfer title of facilities constructed with its grants to the grantee.

In general NASA regards facilities grants as for "bricks and mortar," not for research equipment. (Research equipment may be provided by project-research contracts and area-research grants.) Its policy is to provide facility grants only to such universities as have active research programs whose further development is significantly retarded by lack of working space. NASA has turned down numerous proposals for the creation of new national or regional research centers, principally because of its wish to strengthen degree-granting, student-training universities rather than to weaken them by drawing away their personnel. It is felt that the existing system of major research centers is already adequate for the activities appropriate to such organizations.

Presently under consideration are facilities grants to the following: University of Chicago, University of California in Berkeley, University of Minnesota, Rensselaer Polytechnic Institute, Stanford University, State University of Iowa, and University of California in Los Angeles.

Within the Office of Space Sciences, the Office of Research Grants and Contracts is responsible for the processing of all unsolicited proposals submitted to NASA, regardless of subject matter and for policies, procedures, and business and working relationships vis-a-vis the universities. Ninety percent of all NASA grants are made by this office. Review of proposals, although not carried out by this office, is almost entirely an in-house function, the biosciences being the principal exception. Generally speaking, NASA's research centers review the proposals, although they do not have the power of final decision; part of NASA's decision-making process necessarily involves evaluation of the evaluators.

The problem of personnel for management of NASA's university programs is considered to be a severe one, although at present the problem is principally one of lack of billets. There is now an Office of Programs, in the Office of Research Grants and Contracts; so far it has a staff of two, but a trained staff is being recruited to handle these programs, with the assistance of a cadre of university people rotating in and out of this office from the academic scene.

## III. Committee Comment and Evaluation

The studies of the August 1961 conference as well as the discussions of the present Committee emphasize the following: A marked expansion of the existing university program in space science must be achieved if the program is to meet its objectives of providing an adequate training ground for the large number of persons of high competence required by the national aspirations in space science and technology. At some point in this expansion there may arise complex questions of a social and economic nature as well as of an educational nature. The central problem in achieving any national objective of this sort seems to be the great chasm between the simultaneous national devotion to highly technological objectives on the one hand and to a completely permissive attitude toward choice of educational field and personal career objectives on the other hand. It is clear that the reconciliation of these totally divergent views is a matter of great difficulty and scope. It must be done in such a way that the essential virtues of universities are maintained, viz., the devotion to scholarly inquiry, to the development of students, and to the dissemination of knowledge. Imperfect as the functioning of universities may be, there is no other segment of our culture which performs these functions nearly as well, or is likely to.

The Committee was unanimous in its favorable general impression of the NASA program as outlined by Drs. Newell, Smull, and Holloway. It was particularly impressed by NASA's full awareness of the impact of its mission on the manpower resources of the country, and of its responsibility to replenish those resources commensurately. It was similarly impressed by NASA's intention to perform its mission in such a manner as to strengthen existing universities rather than to undermine them by creating a system of research institutes, isolated from the educational enterprise.

Nonetheless, the Committee feels that the establishment of a few institutes of modest size ($\sim$ 10 professional persons) might properly be done in special instances in order to bolster neglected fields -- if a purely university approach seems unworkable.

The Committee also commends NASA on the breadth of its view in regarding not only the natural sciences but also the social sciences and the humanities as areas of learning that impinge one way or another on its ultimately very broad mission.

Turning now to more specific matters, the Committee feels that the procedures for the review and assessment of proposals are matters requiring the continual attention of responsible persons both within and outside NASA in order to assure that the resulting program of grants and contracts is one of high quality and vigor. NASA probably does well to avoid dependence on a ponderous procedure for the review of all proposals by outside panels. But the Committee is concerned that, under a dominantly in-house review procedure, proposals for broad and imaginative undertakings may suffer in comparison with those offering quick results related to a recognized technical or operational problem.

A Committee review of the full list of active research grants and contracts by title, institution, principal investigator, and funding led to the following impressions:

First, much of the work appears to be of an ad hoc, technological nature. It may be hoped that the corresponding list a year from now will reflect a policy of greater emphasis on a broad spectrum of basic sciences.

Second, there emerged the impression that many university departments are in real danger--by their own initiative-- of becoming deeply involved with problems that are not so much fundamental science as complex development tasks that properly belong in the nation's industrial laboratories. It may or may not be possible for industry to handle such problems better but the Committee feels strongly that universities are in danger of being deflected from their proper role when they undertake projects of this kind. There is also the strikingly evident converse problem, viz., many industrial laboratories

are seeking and receiving NASA support for what is really basic research of the type which can be done so much better under university circumstances, which by-and-large offer much more durable and substantial resources for the long term pursuit of fundamental research. It is difficult to know whether NASA should attempt an omniscient view of these difficult questions of policy or should content itself with passing on the specific merits of each proposal as submitted.

The three recently added items on NASA's--area-research grants, training, and facilities-- constitute broadly conceived programs of institutional, as against specific project, support. The Committee endorses these programs full-heartedly and expects them to set the pattern for the future evolution of federal support to higher education.

Nonetheless, the actual operation of such programs during the experimental period must be watched closely to avoid the following developments which are believed to be undesirable:

(a) The creation of large research establishments which do not regard the training of students as their primary role and obligation.

(b) The enhancement of the role of administrative "promoters" and opportunists at the expense of the role of working scientists and scholars whose interests lie in the substantive content of the work to be done.

(c) The creation of serious disbalances and resentments within the university community.

The program of training grants is again good insofar as the funds available will be placed at the discretion of the Dean of the Graduate College. The pilot line program of ten traineeships at each of ten universities may be expected to yield up to 100 space-oriented Ph.D.'s by the end of a three- or four-year period.

It is probably that a program of ten times this magnitude can be assimilated without serious dislocation of other graduate fellowship programs (NSF, NIH, NRC). But there is a finite limit to what can be done in this area. Explicit discussion of this matter is deferred to the following section.

The present program in which post-doctorate fellows must work at NASA facilities has been a useful device in the early development of these centers--profitable alike to the fellows and the centers. However, it is clear that a mature NASA program must include a post-doctoral program to the university community in general.

It is noted that NASA is planning to extend its cultivation of the manpower pool back into the all-important undergraduate and even high school years. Among the ways this can most effectively be done is to provide funds for undergraduate research assistantships both in term and in the summer. Exposure to real investigation is surely one of the strongest tools available for attracting talented students into work at the graduate level.

## IV. Manpower and Recruitment

Although the proposal by NASA to support a large training program is considered desirable, there is a question whether the program will increase the available trained manpower pool. Will 1000 new graduate fellowships attract new students into graduate study or merely shift the financing among the present population? Unless an expansion of the graduate population occurs, NASA's training programs might develop at the expense of teaching-assistant needs. There is a lack of agreement on this point and conflicting evidence; but if the NASA graduate training program does not increase the graduate body of scientists and engineers roughly by the numbers envisaged, the ultimate space manpower needs will be met at the expense of other research needs, the college teaching force, and industry.

Berelson* states that there is an undergraduate reservoir of qualified students who for reasons unknown do not now enter graduate study. Consideration should be given to ways of encouraging individuals in this reservoir to do graduate work.

This shift would solve the immediate short-range problem; but since it depletes the BS-degree work force, an undergraduate program must be developed which will attract additional students who will follow appropriate programs. The order of magnitude of the expansion necessary is suggested by the following estimates. To produce an extra 1,000 Ph.D.'s we need to produce an extra 21,000 BS candidates (present number BS candidates in science fields, 63,600). To produce 21,000 BS candidates, because of attrition, we need to enroll an additional 130,000 students in appropriate areas (current estimated enrollment in needed areas is almost 650,000). Can we attract the needed number of additional qualified high school graduates to enter an appropriate college program?

There is ground to believe that current curricula and ancillary inducements are delivering as large a supply of potential scientists and engineers as can be delivered from the present group of superior, white men in the college population. It also is not unreasonable to assume that most high school graduates who take the necessary mathematics and science to continue engineering and science programs in college are now entering such institutions.

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*Bernard Berelson, Graduate Education in the United States, McGraw-Hill Book Company, Inc., New York, 346 pp., 1960.

Most of the nation's scientific and technical manpower has, in fact, been sequestered in agencies (viz., industrial and governmental laboratories) which bear little or no responsibility for the replenishment of such personnel. One important area of experimentation for NASA might lie in efforts to make such agencies productive of competent technical personnel. Admittedly, the task would be formidable: the academic paraphernalia of degrees, residence requirements, tenure, and the like all would be involved. But the manpower demand is already so severe that all possibilities for meeting it must be actively explored.

Before substantial improvement can be expected in size of the scientifically-oriented student manpower pool, new information must be developed and put to use in one form or another. It certainly can no longer be argued, for example, that science and engineering activities do not receive adequate publicity. According to Berelson, everyone who wants to enter a graduate school can be admitted somewhere. Career seminars, NSF institutes for able secondary school students, new curricula in science and mathematics, special guidance efforts and training for counselors-- all these are either operating or moving into operation, and still the enrollments in science and engineering continue to decline.

We need to know much more precisely how young people view science and scientists. We need to know what factors are most powerful in the formation of their career plans. We need to know more accurately when these choices are made. We need to investigate and to map accurately the web of controls which inhibit women's choices of careers in science and engineering. We must find and develop the resources in science and engineering talent among Negroes and other groups which currently are socially disadvantaged. New Federal expenditure to increase the scientifically-oriented student manpower pool certainly cannot be expected to produce substantial results unless these and related informational needs are satisfied.

It is recommended that NASA (i) encourage and support investigation of the problems attached to improvement of the manpower pool; (ii) cooperate vigorously with other agencies seeking to satisfy these informational needs, such as the scientific societies, certain of the educational agencies, and others; and (iii) that limited projects designed to increase the pool be undertaken parallel with these investigations. New activities as suggested under (iii) above could include training grants limited to women, talent search activities specially designed for use in the small colleges, summer fellowships in research and engineering for talented high school juniors, and the like. Innovation is of the essence here, but it is the recommendation of the Committee that major effort await the development of the new information suggested above.

## APPENDIX I

The legal basis for a formal working association between NASA and universities may be found in the following excerpts from the National Aeronautics and Space Act of 1958, as amended in 1961.

"TITLE I - SHORT TITLE, DECLARATION OF POLICY, AND DEFINITIONS

. . .

Declaration of Policy and Purpose

Sec. 102. . . .

(c) The aeronautical and space activities of the United States shall be conducted so as to contribute materially to one or more of the following objectives:

(1) The expansion of human knowledge of phenomena in the atmosphere and space;

(2) The improvement of the usefulness, performance, speed, safety, and efficiency of aeronautical and space vehicles;

(3) The development and operation of vehicles capable of carrying instruments, equipment, supplies, and living organisms through space;

(4) The establishment of long-range studies of the potential benefits to be gained from, the opportunities for, and the problems involved in the utilization of aeronautical and space activities for peaceful and scientific purposes;

(5) The preservation of the role of the United States as a leader in aeronautical and space science and technology and in the application thereof to the conduct of peaceful activities within and outside the atmosphere;

(6) The making available to agencies directly concerned with national defense of discoveries that have military value or significance, and the furnishing by such agencies, to the civilian agency established to direct and control nonmilitary aeronautical and space activities, of information as to discoveries which have value or significance to that agency;

(7) Cooperation by the United States with other nations and groups of nations in work done pursuant to this Act and in the peaceful application of the results thereof; and

(8) The most effective utilization of the scientific and engineering resources of the United States, with close cooperation among all interested agencies of the United States in order to avoid unnecessary duplication of effort, facilities, and equipment.

. . .

Functions of the Administration

Sec. 203. (a) The Administration, in order to carry out the purpose of this Act, shall --

(1) plan, direct, and conduct aeronautical and space activities;

(2) arrange for participation by the scientific community in planning scientific measurements and observations to be made through use of aeronautical and space vehicles, and conduct or arrange for the conduct of such measurements and observations; and

(3) provide for the widest practicable and appropriate dissemination of information concerning its activities and the results thereof.

(b) In the performance of its functions the Administration is authorized --

. . .

(5) without regard to section 3648 of the Revised Statutes, as amended (31 U.S.C. 529), to enter into and perform such contracts, leases, cooperative agreements, or other transactions as may be necessary in the conduct of its work and on such terms as it may deem appropriate, with any agency or instrumentality of the United States, or with any State, Territory, or possession, or with any political subdivision thereof, or with any person, firm, association, corporation, or educational institution. To the maximum extent practicable and consistent with the accomplishment of the purpose of this Act, such contracts, leases, agreements, and other transactions shall be allocated by the Administrator in a manner which will enable small-business concerns to participate equitably and proportionately in the conduct of the work of the Administration;

. . .

(7) to appoint such advisory committees as may be appropriate for purposes of consultation and advice to the Administration in the performance of its functions;

(8) to establish within the Administration such offices and procedures as may be appropriate to provide for the greatest possible coordination of its activities under this Act with related scientific and other activities being carried on by other public and private agencies and organizations;

. . . "