The Honorable Sherwood Boehlert  
Chairman 
Committee on Science 
U.S. House of Representatives 
Washington D.C. 20502

Dear Chairman Boehlert:

For more than a year, the Association of American Universities (AAU) and the National Association of State Universities and Land-Grant Colleges (NASULGC) have been concerned about the scientific workforce pipeline. In late April, Congressional staff and NASA officials asked the Space Science Working Group, a group of space scientists and government relations officers from our member universities, to develop a white paper presenting some ideas for closer NASA-university cooperation on this issue. That white paper is attached.

As Congress has previously noted, too few of our students are electing to pursue careers in math and science. This is creating a severe shortage of scientists in both industry and government. In addition, many university scientists will reach retirement age in the next five years.

We are aware that two bills, HR 1085 and S 610, have already been introduced in Congress to address NASA workforce issues, and we applaud Congressional attention to this issue. The Scholarship for Service provision contained in the Senate bill and the President's FY2004 budget request is of particular interest to universities. Both HR 1085 and S 610, however, primarily address only one aspect of the problem – retention of the NASA workforce. We believe it is also important to address pipeline development and the role universities play in educating the future workforce.

The attached white paper presents a number of proposals, but two merit special emphasis. First, we propose that NASA establish university-based research centers, modeled on the National Science Foundation’s Engineering Research Centers. Such Centers can develop real partnerships between a federal agency and universities, and provide flexibility and opportunities to engage students in a variety of ways.

Second, we urge that NASA renew its commitment to Research & Analysis (R&A) programs. R&A programs are the heart of university involvement with NASA missions. These programs represent the primary source of NASA funding to university researchers, and their students. Although often overlooked, R&A programs are the key to actually deriving scientific discoveries from the NASA missions and ensuring the maximum return on our investment in a
particular mission. It is also almost the only way that individual graduate students participate in space related research. Unfortunately, R&A programs are often treated as an afterthought by NASA’s mission-oriented culture. This has led to diminished funding for R&A programs, which in turn limits the number of graduate students able to participate in any given mission. The end result has been a migration of the best and brightest graduate students away from the physical sciences. Making matters worse, these poor funding support levels for R&A have severely restricted the ability to recruit undergraduates to the sciences, thus losing even more of the future pipeline. It is therefore imperative that NASA both increase the funding levels for R&A within each mission, and create more general R&A funding programs for cross-cutting research analysis.

Finally, we have enclosed a paper prepared by the Space Policy Institute at George Washington University in June 1990 that describes the Sustaining University Program supported by NASA during the Apollo era. We believe that some new variation on this program might also be worthy of consideration.

We hope that you will carefully consider the above suggestions. Both AAU and NASULGC remain eager and willing to work with NASA, OSTP, and Congress to identify ways that we can partner together to meet future workforce needs. Please contact Kathie Bailey at AAU at 202-408-7500 if you have any questions.

Cordially,

Nils Hasselmo  
President, AAU

C. Peter Magrath  
President, NASULGC

Enclosure

cc: Dr. John Marburger  
Dr. Kathie Olsen
Background

NASA has a long history of productive collaborations with universities, supporting research that has given the United States the undisputed leadership role in the study of space and the earth's environment. One of the keys to this success has been scientific, engineering, and technical workforce development efforts supported by NASA and carried out by research universities through programs in undergraduate and graduate education.

Recruiting and developing the scientific, engineering, and technical workforce necessary to accomplish NASA's current and future missions are a significant concern of NASA and the research university community. Our nation's security depends on an aggressive space program for satellite intelligence and surveillance superiority. Our nation's economy increasing relies upon space-based communication networks. The U.S. can not afford to lose its lead in space, but current and future workforce needs threaten this.

The Association of American Universities (AAU) and the National Association of State Universities and Land-Grant Colleges (NASULGC) seek to work with NASA to build upon existing efforts and to identify and implement new collaborations to meet workforce needs necessary to maintain our nation's preeminence in space and space and earth sciences.

Within the next five years, one third of NASA's workforce will be eligible for retirement. Both the current and former NASA Administrators have publicly expressed concern about NASA's ability to attract and retain qualified scientists and engineers. Many university space science teams are facing similar problems. As key investigators age and retire, strong teams are weakening. In some fields the problem is acute, with the major scientists all in their sixties coupled with low enrollments of graduate students to follow them. In other areas, there are major new initiatives to be undertaken and yet no certainty that the required educated workforce will be available. The nation's security depends on an aggressive space program for surveillance and active defense, and economic impacts of space communications and remote sensing are large. We must not lose our lead in space research because we lack educated workers.

At the same time, US students are not studying and choosing careers in science, mathematics, engineering, and technology (SMET) in sufficient numbers. The problem has been concealed to some extent by foreign student enrollments in these areas. Foreign students and scientists make significant and important contributions to the U.S. science and technology enterprise, but they are an undependable workforce supply. First, foreign students come primarily to the U.S. on nonimmigrant visas and are obligated to return to their home country. Second, some countries have developed economies that include a strong or growing science and technology enterprise, and increasingly foreign students are not interested in switching from nonimmigrant status to immigrant status. There are also national security concerns related to national dependence on foreign students in these areas.
The House and Senate VA-HUD-Independent Agencies Appropriations Subcommittees recognized the seriousness of this problem last year and included report language in their FY2003 reports asking NASA and the Office of Science and Technology Policy (OSTP) to develop in cooperation with the nation's leading research universities a comprehensive plan and implementation strategy that will result in the number of students pursuing advanced degrees. AAU and NASULGC are eager to work with both agencies on this issue.

The House Science Committee and the Senate Commerce, Science and Transportation Committee have also become heavily involved with this issue. HR 1085 is currently under consideration by the House Science Committee, and S. 610 has been introduced in the Senate. Both are positive moves. The Scholarship for Service program contained in the Senate bill and President’s budget, in particular, is a step in the right direction, but there is much more that can be done.

Since improving the workforce situation will require action at several points along the training pipeline, this legislation needs to be broadened. Both HR 1085 and S 610 focus primarily on NASA recruitment and retention issues. These are important areas to address, but the bills should address talent development as well, since universities as well as NASA have a role to play in addressing the workforce problem. The sections below present several talent development options that should be considered for inclusion in both of these bills.

- First, we propose that NASA establish university-based research centers, modeled on the National Science Foundation’s Engineering Research Centers.
- Second, we urge that NASA renew its commitment to Research & Analysis (R&A) programs since R&A programs are the heart of university involvement with NASA missions.
- Third, we urge that NASA renew its commitment to education programs at the undergraduate and graduate levels.

Programs are needed at all levels – K-12, undergraduate, and graduate levels – to address the pipeline issue. Accordingly, we offer the following suggestions:

I. University-Based Research Centers

NASA should sponsor university centers, similar in structure to the Engineering Research Centers (ERCs) sponsored by the National Science Foundation. The goal of the ERC Program is to educate a globally competitive engineering workforce in an integrated, interdisciplinary research environment where academe and industry join in partnership to advance fundamental engineering knowledge and engineered systems.

The structure envisioned for NASA-supported university centers is one that would give both graduate and undergraduate students an opportunity to get hands-on experience in NASA-oriented skills. NASA and university advisors would work together to adopt criteria that would be unique to NASA, and that would make the model responsive to NASA’s needs. These features might include:

- Research programs conducted by a committed, cross-disciplinary faculty team to: i) investigate fundamental scientific problems relevant to NASA’s strategic goals and flight
projects, and ii) integrate fundamental and technology research with proof-of-concept test-beds designed to test theory in functioning systems;

- Leadership, faculty, and student teams diverse in gender, race, and ethnicity;
- Education programs which team undergraduate and graduate students and integrate research results into curricula for pre-college and college students and practitioners;
- Outreach to involve college and pre-college students, their faculty and teachers in the Center;
- Experimental, computational, and other equipment, facilities, and laboratory space required to perform the proposed research and enable a robust learning environment; and
- Solid evidence of university commitment to facilitate and foster the culture of the Center. This could include facilities, faculty, staff, and in-kind support as well as development of appropriate private-sector industry and non-profit partners and other sources to substantially enhance NASA’s support.

II. Research & Analysis (R&A) Programs

For principal investigators, one of the most important existing programs is the Research and Analysis (R&A) program in the Office of Space Science and the Earth Science Enterprise. R&A grants are the means through which faculty support their research groups, which in turn are the training grounds for graduate students and post-docs. R&A activities support core programs within NASA and provide the scientific underpinnings and key enabling technologies for NASA's missions. These fiercely competed programs fund the bold, new initiatives that can lead to the development of future missions. The R&A line is one of the most efficiently used funding lines in space science research. Each project is generally modest, although the median size of NASA's R&A grants differs across the science offices. The most frequent grant size, however, is between $50,000 and $100,000.

We have three concerns about the current R&A program. First, R&A is no longer listed separately within the NASA budget, making the program extremely hard to track. Second, while it appears that there will be a large increase in R&A in FY2004, this increase is illusory. In both space science and earth science, the apparent increase has been affected by the move to full cost accounting and the moving of program funds into the R&A line. R&A funding has been held constant or to 1 percent growth for a number of years, despite the tremendous growth in the number of missions. Moreover, funding is expected to continue at current levels in the foreseeable future. Increases are needed in the program to address the impact of inflation. We believe that both the size and duration of NASA’s R&A grants program should be increased.

III. Education Programs

Too often, NASA is viewed as being primarily concerned about K-12 education. While creating excitement about science for young people is certainly a laudable goal, students need a place to take this interest at the university level.
• **Expand the Earth Science Enterprise’s New Investigator Awards program to other NASA science offices.** The program was established in FY1996 to encourage integrated environments for research and education for scientists and engineers at the early stage of their professional careers. The program is designed for investigators at academic institutions and non-profit organizations. The NIP proposals are openly solicited approximately every one and a half years. Proposals for the upcoming selection are due July 1, 2003. Awards average $80,000-$120,000 per year for a period of up to three years subject to satisfactory progress and availability of funds.

• **Increase the visibility of and/or consolidate NASA's existing programs that support undergraduate and graduate students.** Most of the existing programs are small, and it is often very hard for students to locate information about them.

• **NASA should support a well-publicized Research Experiences for Undergraduates (REU) program** similar to the one currently offered by the National Science Foundation. REU projects involve students in meaningful ways in ongoing research programs or in research projects specially designed for the purpose. There are two types of REU grants: REU supplements to funded grants and cooperative agreements, and REU sites, which are based on independent proposals to initiate and conduct undergraduate research participation projects for a number of students, primarily not from the host institution. Both are effective models for NASA.

• **Expand the concept of summer academies to universities.** In recent years, summer academies have been offered at Ames, Dryden, Goddard, and Marshall. The summer academies allow students to conduct research in state-of-the-art laboratories as well as to receive broad views into the inner workings of the space program. One of the most valuable parts of these programs is that they expose students to NASA’s greater organization, including aerospace, high-tech, genetic and engineering companies and local, state, and national political decision makers. Students complete the summer with a greater understanding of the variety of space-related careers. Expanding this concept through grants to universities would be a valuable part of the solution to the overall aerospace/NASA workforce pipeline issue.

AAU and NASULGC welcome the attention of Congress and NASA to the workforce issue, and we look forward to continuing to work with NASA in setting up appropriate competitive criteria for initiatives that would maximize the value to NASA, universities, and industry.
Background

As one part of its response to implementing the Apollo program, NASA in 1962 created a Predoctoral Traineeship Program aimed at increasing the production of Ph.D.s by U.S. universities and accelerating the process by which Ph.D.s were obtained. The program lasted for nine years (FY62-FY70), and supported, at least in part, approximately 4,000 Ph.D. recipients from 151 universities.

The Space Policy Institute is engaged in a study of the career histories of a large sample (over 1500) of the individuals who received NASA predoctoral traineeships and ultimately earned the doctoral degree. The preliminary data from this study is currently available (the final data and analysis will be available at the end of August). It is based on a statistically valid sample, and thus can be used to project the results from the overall population of 4,000 trainees with a high degree of reliability. In addition, since so little is known about women scientists, the women in this group were oversampled, making it possible to conduct analyses on this sub-population of the trainees. The results of this study are used in the following analysis.

Origins of the Program

As NASA in mid-1961 mobilized to carry out the manned lunar landing program that had been announced by President John F. Kennedy on May 25, the organization's leaders recognized a need to engage the country's universities in research related to space program objectives and in providing some portion of the skilled scientists and engineers that NASA would require to carry out those programs. They also recognized an opportunity to help the country meet an increasing need for technically qualified people at all levels, including Ph.D.s. One estimate made to the White House at the time was that the country would need an additional 20,000 Ph.D.s by 1970 in all areas of science and technology, and NASA wanted to help meet this national need.

The Administrator of NASA at this time was James Webb, who had been interested in issues related to higher education for some time. At an initial July 17, 1961 meeting to discuss NASA-university relationships, Webb stated that it is the desire of NASA to cooperate with universities on a broad educational basis such that "universities are strengthened…in helping to meet the needs of the NASA."

A month later, a group of university consultants responded by suggesting that "NASA initiate a fellowship program as soon as possible.... It is suggested that NASA provide 4,000 of these [the 20,000 Ph.D.s needed by 1970] at a rate of 1,000 per year. In accomplishing this, NASA would make fellowship funds available to a wide base of educational institutions. "This
recommendation, as accepted, and became the basis for the NASA Predoctoral Traineeship program.

The Sustaining University Program

In the spring of 1962, NASA announced it would complement its support of university research related to specific NASA programs with a broader effort, to be called the Sustaining University Program, to support university activities in three areas:

1. predoctoral training;
2. construction of facilities required for space-related activities; and
3. research not related to specific flight programs.

Over the nine-year period FY62-FY70, the Sustaining University Program provided $215.1 million to U.S. universities. Of this amount, available records do not indicate specifically how much was spent on the predoctoral training program, although the amount was almost certainly substantially less than $100 million. The characteristics of the traineeship program included:

--Grants were made to universities, which then selected the individuals who were to receive traineeships.

--The awards were for one year, renewable for up to three years total if trainees met university requirements.

--The recipients were required to be U.S. citizens.

--The university received an allowance for each trainee; that allowance was roughly equal to the trainee's stipend. This was not an overhead reimbursement, but rather support intended to strengthen a recipient university's graduate education program by funding such things as faculty augmentation, library acquisitions, laboratory equipment, or guest lecturers.

In Fall 1962, ten universities were awarded ten traineeships each as the initial beneficiaries of the predoctoral traineeship program. The program increased rapidly in size and scope:

<table>
<thead>
<tr>
<th>Year</th>
<th>Universities</th>
<th>Traineeships</th>
</tr>
</thead>
<tbody>
<tr>
<td>FY62</td>
<td>10</td>
<td>100</td>
</tr>
<tr>
<td>FY63</td>
<td>88</td>
<td>786</td>
</tr>
<tr>
<td>FY64</td>
<td>131</td>
<td>1,075</td>
</tr>
<tr>
<td>FY65</td>
<td>142</td>
<td>275</td>
</tr>
</tbody>
</table>
FY66 151 Universities 1,335 Traineeships

With the downturn in the NASA budget after FY1966 came a decrease in the traineeship program: only 797 new awards were made in September 1967, and the activity disappeared with the rest of the sustaining University Program in 1971.

Universities were selected to participate in the predoctoral traineeship program on the basis of the following criteria:

--accreditation ratings;

--resources already available for graduate training;

--current and planned activity in space research; and

--location of the university and need for additional graduate training in its region.

There was no restriction on what disciplines were eligible for traineeships, as long as they could be said to be somehow relevant to the space program; the goal was to support the best students in science and engineering. However, the ultimate distribution of those completing the doctorate who received a NASA traineeship was strongly concentrated in the physical sciences and engineering. Our sample shows that of all the trainees who receive doctorates:

- 54.9% were physical scientists
- 32.0% were engineers
- 10.0% were life scientists
- 2.8% were behavioral scientists
- 0.3% were social scientists

Impact of NASA Trainees on the U.S. Scientific and Technological Enterprise

As mentioned earlier, data from current GWU research are available on 1520 recipients of a NASA predoctoral traineeship, and these 1520 individuals constitute a statistically valid sample of the total population of over 4,000 trainees holding doctorates. Thus the following characteristics of the sample can reasonably be expected to apply to the total:

--Less than half of the trainees (42.9 percent) did dissertations on a space-related topic.

--Approximately 98.5 percent of the trainees are employed full-time.

--Only 6.2 percent have left science and engineering; the other 93.8 percent are working in a position related to science or engineering.

--45.1 percent of the trainees work at a college or university; the majority work at a university that provides degrees at the doctoral level.
--41.0 percent of the trainees work in the private sector, while 13.8 percent work for state, federal, or local government.

--Over one-quarter of the trainees (27.6 percent) have had at least one patent. The average number of patents per trainee is 1.2.

--On the average, each trainee has published 20 papers in peer-reviewed journals; only 10 percent of the trainees had not published at least one refereed paper.

--Almost one in five trainees (18.4 percent) had published at least one book; the average per of books per trainee is 0.4.

--Nearly two-thirds of the trainees (64.1 percent) have produced technical reports on their work. The average number of unpublished technical reports produced by the trainees is 19.

--On the average, each trainee presented 21 talks to professional audiences. Only 16.7 percent of the trainees had never presented such a talk.

--Trainees have also been active in presenting scientific and technical information to the lay public. The average number of scientific presentations to a lay audience is 11.3.

--Almost two-thirds of the trainees (64.0 percent) supervise other technical workers. On the average, trainees supervise 59 other scientists or engineers.

--Almost 40 percent of the working time of trainees is taken up with tasks directly related to conducting research. On average, trainees spend 11.1 percent of their time conducting basic research, 14.6 percent of their time conducting applied research, and 13.9 percent of their time in administrating research.

Extrapolating from the sample, then, the approximately 4,000 NASA predoctoral trainees have contributed to the country's technical base between the mid-1960S and the present:

--over 4800 patents
--over 80,000 refereed scientific or technical papers
--approximately 1600 books
--over 76,000 technical reports
--nearly 84,000 talks directed at professional audiences
--nearly 45,200 scientific talks directed at lay audiences
As the NASA trainees finished their doctorates and emerged on the job market, NASA was winding down from its Apollo mobilization, and new job opportunities in the agency were scarce. This was undoubtedly one factor, but only one, in determining employment patterns for traineeship recipients. A very small percent of the trainees, perhaps as low as one percent, went to work for NASA. Stated more positively, this means that the individuals assisted by NASA traineeships diffused throughout the U.S. science and engineering base, and thus that their contributions were not in relatively narrow areas of specialty. One indication of this is the breadth of response when trainees were asked to identify their most important technical contribution:

"Helped to develop the prototype of the scanning tunneling microscope."

"Qualified advanced fuel element designs for nuclear reactors."

"Pioneering in an application of computer control to real refining processes."

"Personally discovered a 200 million barrel oil field in offshore Norway."

"Inventor/developer of a revolutionary new process of polymer chemical modification."

"Delivered world's best electron-bombarded CCD to NASA/Goddard."

Summary

The NASA Predoctoral Traineeship Program was aimed at helping produce 4,000 new Ph.D.s by 1970; by the end of that year 3,516 trainees had received their doctorates, and the number rose to 4,055 by the end of 1973. Thus the quantitative target of the program was achieved. More significantly, those who received NASA support appear to have made major contributions to the country's scientific and technological base. Moreover, almost all trainees remain active in some aspect of science or engineering; thus their contributions continue. It is hard to avoid the conclusion that the United States got a significant return on its investment in the NASA Predoctoral Traineeship Program.