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BEFORE THE
SUBCOMMITTEE ON HIGHER EDUCATION, LIFELONG LEARNING, AND COMPETITIVENESS
COMMITTEE ON EDUCATION AND LABOR
U.S. HOUSE OF REPRESENTATIVES

Hearing on
"Examining Competitiveness in Science, Technology, Engineering and Math"

SEPTEMBER 21, 2007

Chairman Hinojosa, Ranking Member Keller and Members of the Subcommittee,

Thank you for this opportunity to appear before the Subcommittee on Higher Education, Lifelong Learning and Competitiveness of the House Education and Labor Committee. It is my pleasure to testify today on a topic that is so important to all of us – American competitiveness in the science, technology, engineering and mathematics disciplines.

My remarks draw from my experience as the President and CEO of the Universities Space Research Association (USRA), a non-profit association of 101 major space science and technology research universities.[1] As a long-term partner with the federal government on a variety of initiatives that extend the boundaries of our scientific expertise, USRA provides a mechanism through which universities can cooperate effectively with one another, with the government, and with other organizations to further space science and technology, and to promote education in these areas.

To give you a context for my passion for this subject, I would like to share with you a bit about my background. While with the U.S. Army, I served in a variety of space power research and program management assignments. I later served as Defense Liaison in the White House Office of Science and Technology Policy, and as Executive Assistant to the National Security Council Senior Director for Science and Technology. In the private sector, I was the President and General Manager of Bechtel Nevada Corporation, responsible for management and operations of the Nevada Test Site, and as the Principal Associate Director at Los Alamos National Laboratory with responsibility for managing the laboratory's science-based weapons stewardship program.

[1] USRA was incorporated in 1969 in the District of Columbia as a private, nonprofit corporation under the auspices of the National Academy of Sciences (NAS). Institutional membership in the Association has grown from 48 colleges and universities when it was founded, to the current 101 institutions. All member institutions have graduate programs in space sciences or technology.

Through my experiences in the government, private sector and a non-profit university research association, I have gained an appreciation for the importance of education and research in the science and technology fields.

Today, I would like to discuss three topics that are essential to our national education and workforce development initiatives. First, the critical workforce need of the 21st century in space sciences and technology. Second, the importance of strengthening our nation's education and public outreach programs, and finally, the need for federal reinvestments in university research programs.

As is well known, the status of American competitiveness in the important areas of math and science is declining. In 2005, the National Academies of Sciences report titled "*Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future*" recommended: (1) improving K-12 math and science education, (2) sustaining and strengthening basic research, (3) enhancing higher education in science and engineering, and (4) creating economic incentives for innovation.[2]

USRA's member institutions have spent considerable time reviewing these findings and, in turn, USRA has developed four recommendations for improving American competitiveness in the science and engineering fields. First, we must increase funding for Education and Public Outreach programs at the university level. Second, Congress must appropriate sufficient funding for the various elements of the Congressional *Innovation Agenda* and the President's *American Competitive Initiative*. Third, Congress must include adequate funding for NASA in its *Innovation Agenda* and *American Competitiveness Initiative* plans. Finally, Congress must double in five years federal spending on research and training opportunities for undergraduate and graduate students in the mathematics, the physical sciences and engineering disciplines.

Workforce Needs of the 21st Century

Today, the technical workforce in the aerospace and space science industry is facing two key issues: (1) the need to replace an aging workforce, and (2) the need to provide highly technical training at the university level to develop the future leaders of U.S. space research. Statistics highlighting the aging American aerospace workforce are well documented:[3]

- The U.S. aerospace industry employed an average of about 630,000 workers in 2006, and 75,000 of these workers are in space-related jobs (31,400 military and 43,600 civilian).
- 27% of the aerospace engineering workforce will be eligible for retirement by 2008.

Similarly, institutions of higher education are not producing a sufficient number of students to fill the workforce needs of the aerospace industry.

- Of the 70,000 engineers graduating annually, only about 40,000 are qualified to work for the U.S. aerospace industry.

[2] Committee on Prospering in the Global Economy of the 21st Century: An Agenda for American Science and Technology, Norman R. Augustine (Chair).
[3] John W. Douglass, AIA Update June/July 2007, Volume 11, No. 8.

These problems are occurring for two key reasons: (1) competition for America's best minds has shifted much of the resources and talent towards scientific pursuits in other areas such as computer programming and related next-generation high-tech specialties, and (2) there are fewer opportunities than ever for the next generation of students to gain the training and experience they need to succeed in tomorrow's aerospace specialties. A review of the annual number of flight opportunities where graduate students can be involved in building hardware and analyzing the space data returned from it shows a steady decline over the last two decades. In fact, over the last 40 years, U.S. suborbital experimental launches have decreased 80% - from 270 per year to just 50 planned launches in 2007. Decreases in suborbital launches have resulted in a corresponding drop in the hands-on training opportunities our universities provide to undergraduate, masters and doctoral students in hard sciences, and have limited our universities' ability to recruit high quality students into space studies. Without these hands-on research opportunities at the university level, it is not possible to train a highly specialized technical workforce that will keep America competitive in the future global economy.

This issue is of critical important to USRA's member universities. Last year, we canvassed our members on their most pressing interests and concerns that needed to be addressed at the national level. The response was surprising for its uniformity and unanimity. Across the country, faculty representatives from our member universities cited the shortfall of student space-flight opportunities providing graduate student involvement as the single most important need.

In response, USRA began working to address this issue. At USRA's annual meeting in March of 2007, our 101 member university body unanimously passed a resolution (attached to this report) urging federal support for increased student opportunities to get hands-on experience in space tests. Given the graduate program structure, these opportunities are most often found on sounding rocket, balloon, and small spacecraft flights.

To help maintain American competitiveness in critical areas to national economics and security, USRA is asking Congress to double in five years federal spending on research and training opportunities for graduate students in mathematics, sciences and engineering disciplines.

Strengthening Education and Public Outreach Programs

Ever since the 1983 Department of Education (DOEd) report, *A Nation at Risk*, pointed out significant shortcomings within the American public school systems, the national education reform effort has been building. As part of its mission, the National Science Foundation (NSF) has compiled reports on the health of the nation's educational system. Two interrelated reports, supplying data on U.S. mathematics and science education, indicate results of national and local level reform efforts are generally positive, but mixed.[4] The average amount of classroom time devoted to science and math for grades one through six rose substantially since the late 1970s.

[4] Division of Research, Evaluation, and Communication, Directorate For Education and Human Resources, *Indicators of Science and Mathematics Education 1995 & The Learning Curve: What We are Discovering about US Science and Mathematics Education*. Edited by Larry E. Suter. Arlington, VA & Washington, DC: National Science Foundation, 1996 (NSF 96-52 & 53).

Schools are imposing stricter science and mathematics high school graduation requirements, and are increasing availability of advanced science and mathematics courses nationwide.[5] On the other hand, the report documents great disparities in proficiency gains from state to state scores for white students remain significantly higher than for black and Hispanic students; and the U.S. still fares poorly in comparison to other developed countries. The NSF, as well as the Department of Education, has been working toward the "systemic" reform of grades K-12. This refers to the need for fundamental changes in science, mathematics, and technological literacy by stimulating reforms in school policy, financing and management, as well as reforms in course conduct and content.

USRA strives to complement the systemic reforms being undertaken in the U.S. by enabling students and teachers to share in our nation's space research experiences. We have considerable success in bringing students into the NASA research environment, and in bringing NASA research into the classroom, either in the form of properly configured teaching materials or by coordinating the in-person/hands-on presence of NASA engineers and researchers.

As an example of our efforts to connect students and teachers with leading space research initiatives, let me briefly describe one of our major activities and how USRA relies on its institutes and programs to take the lead on educational initiatives related to space science disciplines. USRA is the prime contractor to NASA for the development and operation of the Stratospheric Observatory for Infrared Astronomy (SOFIA). Managed out of California at NASA's Dryden and Ames Research Centers, SOFIA is a well-known world-class astronomical observatory, with a 2.5-meter telescope designed to provide infrared and sub-millimeter scientific observations into the next century.

SOFIA provides a unique educational resource that will unite teachers and practicing scientists in meaningful, long-term relationships. As a modified Boeing 747, SOFIA is designed with a special educator seating section that will enable thousands of teachers to fly aboard the observatory during its lifetime, and directly contribute to the recommendation of the *Rising Above the Gathering Storm* report to "train ten thousand teachers, ten million minds." SOFIA is the only major ground- or space-based observatory designed from the start, both physically and administratively, to foster partnerships between educators and scientists in a research environment. Over 600 teachers and other education professionals, such as museum and planetarium workers involved in science education, have already indicated their interest in the SOFIA educational program.

The Need for Reinvestments in University Research Programs

America's leadership in science and technology markets has helped secure the standards of living we have enjoyed for decades. Currently, the U.S. employs close to one-third of the world's researchers in science and engineering, and accounts for 40% of all R&D spending, though it possesses only 5% of the world population. Yet at the dawn of the 21st century, our nation faces an unprecedented level of global competition in emerging science and technology

[5] *The Learning Curve: What We are Discovering about US Science and Mathematics Education*. Edited by Larry E. Suter. Arlington, VA & Washington, DC: National Science Foundation, 1996 (NSF 96-53), p 2.

markets. These technical and scientific achievements are directly linked to the unparalleled quality of American universities since World War II. There is competition from universities in China, India and other countries in both research and investments in infrastructure. We cannot afford to lose this edge, and investments in research are an important component of this race. We commend your support of the Congressional *Innovation Agenda* and the President's *American Competitiveness Initiative* which increase federal investments in research and development (R&D) at our universities and serve as the key platforms for maintaining our nation's leadership in the technology and science areas.

While our universities still lead the rest of the world in both undergraduate and graduate research and education, they face serious challenges. One of these challenges is the need to strengthen the research funding that has been essential in attracting the best and brightest students to the engineering and scientific fields. Since the early 1990s, federal and state funding has been flat or declining in real terms.[6] This has challenged the universities in continuing to develop a workforce that will ensure our nation's ability to compete effectively in an increasingly global and technologically-oriented economy.

One key recommendation from the 2007 National Research Council report entitled "*Building a Better NASA Workforce: Meeting the Workforce Needs for the National Vision for Space Exploration*" is that NASA should make workforce-related programs, such as the Graduate Student Researchers Program and co-op programs, a high priority within its education budget. NASA should also invest in the future aerospace workforce by partnering with universities to provide hands-on experiences for students and opportunities for fundamental scientific and engineering research specific to NASA's needs. These experiences should include significant numbers of opportunities to participate in all aspects of suborbital and Explorer-class flight programs and in research fellowships and co-op student assignments. USRA urges Congress to provide increased federal funding for critical hands-on training opportunities at the university level.

In closing, I would like to commend the Subcommittee for its commitment to our universities and for support of funding higher education programs. In addition to other government agencies, NASA continues to play an important role in educating our nation's technical workforce. Much of the exciting space research conducted at our member universities is funded by Research and Education programs from NASA, and we appreciate your continued support of these programs.

We at USRA believe that strengthening our higher education institutions is essential to our national security and to maintaining our competitive edge in the global marketplace.

Thank you for this opportunity to appear before you today. I look forward to working with you and I would be happy to answer any questions.

[6] Harnessing Science and Technology for America's Economic Future: National and Regional Priorities, the National Academies, (1999).

ATTACHMENTS

USRA White paper on Educating the Next Generation of Space Scientists and Engineers

"Our policymakers need to acknowledge that the nation's apathy toward developing a scientifically and technologically trained workforce is the equivalent of intellectual and industrial disarmament and is a direct threat to our nation's capability to continue as a world leader." (The Report of the Commission on the Future of the U.S. Aerospace Industry, November 2002)

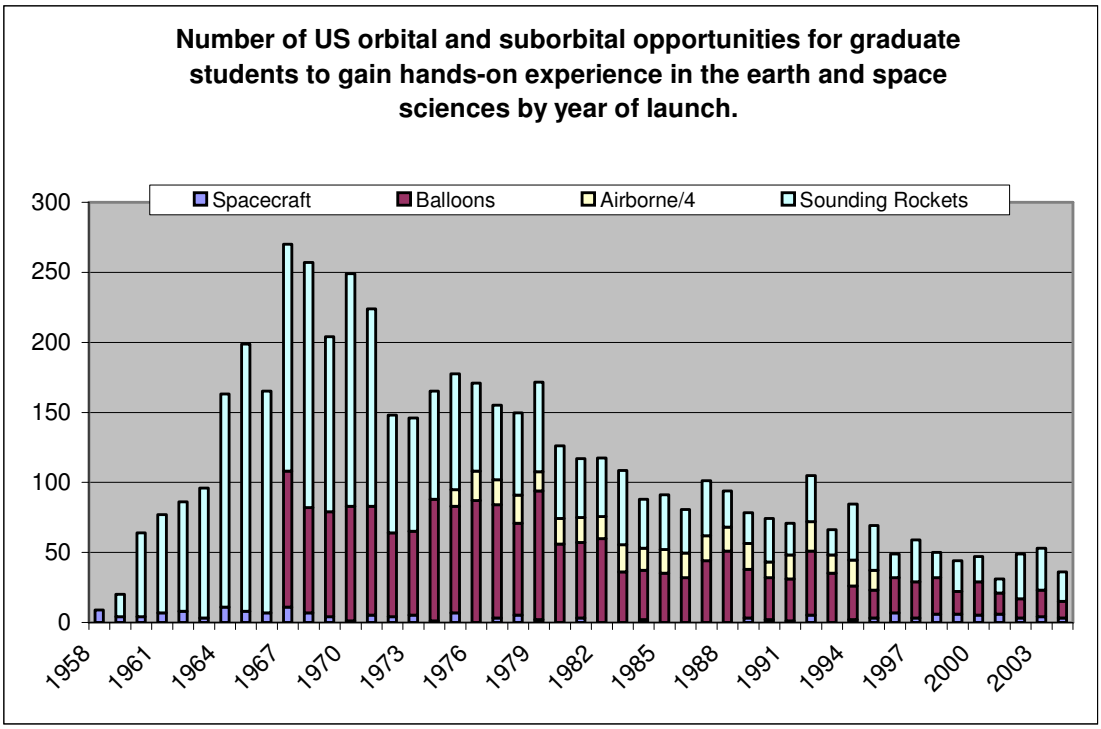
"At present, there are insufficient methods for students to acquire hands-on experience in the scientific and technical disciplines necessary for space commerce and exploration." (Commission on Implementation of United States Space Exploration Policy (the Aldridge Report), June 2004)

There is a significant deficit of scientists and engineers in the United States with meaningful hands-on experience with space instrumentation and space systems, which is jeopardizing the ability of the nation to maintain a vigorous presence in space into the future, regardless of whether we are in space for reasons of commerce, exploration, national defense, or scientific research. This deficit leads not only to a loss of capability, but also to escalating costs of many of the space systems vital to the nation's security and industrial competitiveness.

Space scientists and engineers are trained at universities, particularly in the science and engineering graduate programs of those research universities active in space research. To attract good students into these fields requires sufficient funding for graduate stipends from either research projects or graduate fellowships, and projects or research opportunities that excite students so that they choose space research over other possible areas. These projects or research opportunities must also provide the students with the range of experiences they need to become fully trained scientists and engineers.

The scientists and engineers who learned their trades during the first decades of the space age have reached or are nearing retirement. These were exciting years for a young person to enter space research, and space attracted many of the best young scientists and engineers. These years were marked by frequent launches of smaller missions many of which were led by university-based teams that included graduate students. These students got plenty of hands-on experience, and learned first hand the difficulties of designing and constructing an experiment or engineering system that would operate reliably in space. Many students also learned from designing and building experiments for smaller, suborbital flights on rockets or balloons, or by observing with an airborne telescope.

The chart shows that the number of these opportunities peaked in 1968, at the height of the Apollo program. Since then the number of student opportunities provided by spacecraft missions, rocket and balloon fights and airborne observatory sorties has diminished from over 250 per year to consistently less than 50 per year. Most graduate students now never have an opportunity to do hands-on science. Instead the vast majority of science PhD students analyze data obtained from instruments they have never seen and thus have only a vague idea of how they work or how they might malfunction. They certainly don't learn the important skills needed to conceive of, and to help design and construct a space experiment.



The chart hides another phenomenon. As space missions have, necessarily, become more complex, they also take longer to design and construct. The increasing complexity means that fewer universities have the resources and capabilities of managing the complexity, so increasingly missions are being run by non-academic laboratories and research centers. The mission time scale is now significantly longer than a typical graduate student remains in school. Both of these effects significantly decrease the likelihood of graduate student involvement, exacerbating the problem.

This is a national problem. It affects not only space science, but also human space exploration, global climate prediction, commercial ventures in space, and national security uses of space. All these enterprises require space engineers able to design and construct reliable space hardware, and space scientists who understand the space environment and the rigors of conducting any activity, robotic or human, in space.

What needs to be done?

These critical needs are addressed by a proposed hands-on, rapid cycle flight program of moderate risk that focuses on inexpensive system development for suborbital and orbital applications. This program should provide multiple flight opportunities involving graduate and undergraduate students from science and engineering disciplines, and should provide the excitement of discovery to attract those who will become leaders of the future U.S. space enterprise. The program should permit a four-fold increase of hands-on experiences over present levels to return to the peak levels of the 60's and 70's. The proposed level of activity should allow an average of two launches per month or more.

RESOLUTION OF THE
COUNCIL OF INSTITUTIONS OF THE
UNIVERSITIES SPACE RESEARCH ASSOCIATION

We being the members of the Council of Institutions ("Council") of the Universities Space Research Association ("USRA"), a nonprofit corporation organized under the laws of the District of Columbia, hereby adopt the following resolution:

WHEREAS, USRA is a one hundred member university association chartered, "To constitute an entity in and by means of which universities and other research organizations may cooperate with one another, with the Government of the United States, and with other organizations toward the development of knowledge associated with space science and technology;" and

WHEREAS, the research and teaching faculty of the member universities of USRA see first-hand the decline in workforce development for space science and engineering brought on by the diminishment of hands-on, low-cost flight opportunities involving students; and

WHEREAS, the Commission on the Future of the U.S. Aerospace Industry found in 2002 that, "The nation's apathy toward developing a scientifically and technologically trained workforce is the equivalent of intellectual and industrial disarmament and is a direct threat to our nation's capability to continue as a world leader;" and

WHEREAS, the Commission on Implementation of United States Space Exploration Policy found in 2004 that, "At present, there are insufficient methods for students to acquire hands-on experience in the scientific and technical disciplines necessary for space commerce and exploration;" and

WHEREAS, the National Academies Committee on Meeting the Workforce Needs for the National Vision for Space Exploration found in 2006 that, "NASA should expand and enhance agency-wide training and mentorship programs, including opportunities for developing hands-on experience, for its most vital required skill sets, such as systems engineering;"

NOW THEREFORE, BE IT RESOLVED, that the council supports the plan outlined by the USRA Issues and Program Committee to provide multiple flight opportunities involving graduate and undergraduate students; and

RESOLVED FURTHER, that we urge the United States Government and others to implement and facilitate a plan to provide space flight opportunities that enable the hands on training for graduate and undergraduate students.

IN WITNESS WHEREOF, the members of the Council have adopted this resolution at their meeting of March 30, 2007.

UNIVERSITIES SPACE RESEARCH ASSOCIATION

W. Jeffrey Hughes
Chair, Council of Institutions