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BEFORE THE
SUBCOMMITTEE ON SPACE, AERONAUTICS, AND RELATED SCIENCES
COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION
UNITED STATES SENATE

Hearing on
"Reauthorizing the Vision for Space Exploration"

May 7, 2008

Chairman Nelson, Ranking Member Vitter, and members of the subcommittee,

Thank you for inviting me to testify before you on the reauthorization of NASA and the Vision for Space Exploration. I appreciate the opportunity to provide the subcommittee with this university perspective.

I serve as CEO and President of the Universities Space Research Association (USRA), a consortium of universities deeply involved in our Nation's space program. USRA was formed by the National Academy of Sciences in 1969, at the height of the Apollo program. We were given the mission of advancing space-related sciences and technology for the benefit of humankind. We are now entering our 40th anniversary year, as NASA completes its 50th.

A strong space agency is critically important for our nation. At their annual meeting on March 20, USRA member university representatives called for NASA to be reauthorized as the leader of the civil space program for the United States and provided with significantly increased funding adequate to meet its responsibility to carry out a balanced space program, including advancing knowledge in the scientific and technology disciplines related to space and aeronautics, as well as carrying out the enterprise of space exploration itself. They added that the NASA reauthorization should specifically acknowledge NASA's support of universities as partners who generate new knowledge, make new discoveries in disciplines related to space and aeronautics, and train the specialized workforce needed to accomplish NASA's missions.

Citing a decades long decline of small space missions that allow hands-on training, our member universities unanimously adopted a resolution at their annual meeting urging that at least 1% of NASA's total budget be devoted to funding competitive opportunities for university-led hands-on training provided by university missions on sounding rockets, high altitude balloons, remotely piloted vehicles, emerging commercial suborbital flights, and university class space flight missions.

The 2007 and 2008 resolutions of USRA member university representatives are attached as Exhibit A.

I will focus my testimony on five key recommendations for the subcommittee to consider in its reauthorization of NASA:

- First, that the Vision for Space Exploration be continued, in concert with an assured balanced science program
- Second, that the importance of universities to our space program be recognized and university research be made a part of all NASA programs;
- Third, that workforce development providing tomorrow's scientific and engineering leaders be made a part of NASA's mission;
- Fourth, that adequate funding be devoted to suborbital missions that provide hands-on training; and
- Fifth, that NASA be reimbursed, through supplemental funding, the cost of returning the Space Shuttle to flight.

Reauthorize the Vision for Space Exploration, in concert with a balanced space science program.

U.S. space exploration is awe inspiring to Americans and to people of other countries. A renewed focus by the U.S. on exploration beyond low-Earth orbit, both human and robotic, unfastens our space agency to carry out new great achievements for our Nation, bring new scientific investigation of our solar system, and draw young people into science and engineering studies.

Space is strategic for many nations, and we are in the midst of a massive internationalization of it. In 2005, China became the third nation to fly a human in space. European Space Agency nations, Japan, China, Russia, and India are all resourcing and planning major long-range space science programs, including lunar and planetary missions. China is developing a robotic nuclear-powered lunar rover as the second phase of their lunar program. Japan and China sent probes (Kaguya and Chang'e-1) to the moon in 2007, and India's launch of Chadrayaan-1 is scheduled for 2008. While the U.S. scientific community is restricted in its foreign collaborations under International Traffic in Arms Regulations (ITAR), ESA is collaborating extensively with China, India, and Japan in their lunar explorations. A hesitant approach to exploration will cede U.S. supremacy in space to other nations.

Scientific investigation is central to space exploration, and technological innovation is key. The Vision for Space Exploration calls for sustained human and robotic exploration. Beginning this year, the U.S. is undertaking a series of robotic missions to the Moon that are designed to answer important scientific questions and prepare for and support future human exploration activities. The Vision calls for the conduct of robotic exploration of Mars to search for evidence of life, to understand the history of the solar system, and to prepare for future human exploration of that body. The Vision also calls for the conduct of robotic exploration across the solar system, such as, exploration of Jupiter's moons, asteroids and other bodies, and includes advanced telescope searches for planets around other stars.

The Roman poet Ennius wrote, "No one regards what is before his feet; we all gaze at the stars." Exploration of wondrous worlds beyond our planet fascinate and challenge young people in a unique way. Apollo drew a generation into careers in science, technology, and engineering. Today, middle schools all over the country have programs building robots modeled after the MER rovers, and Hubble images adorn classrooms and bedroom walls. Exploration of the Moon, Mars, and other planets is a magnet that attracts young people. A sustained exploration program can and will help our country reverse the decline of students pursuing science and engineering careers.

USRA asks the subcommittee to reauthorize the Vision for Space Exploration, in all of its aspects, human and robotic, guided by compelling questions of scientific importance, and in concert with a balanced science program across all the disciplines encompassed by our space program.

Include Universities in all Facets of Our Space Program

Universities have benefitted greatly from our Nation's space program. Research funding to universities by NASA over the past five decades spurred development of entire academic departments and brought about the creation of new institutes and laboratories at universities in every region of the country. This is made apparent by the growth in USRA membership. USRA expanded from its original 47 members at its founding; to the 102 universities today that have qualified for membership.

But our universities are more than beneficiaries. They are enablers. Without our universities, we would not have the engineering and scientific workforce that powers every aspect of our space program. Without our universities, we would not have the innovation that brings about the technological breakthroughs that enabled our space agency to land an American on the Moon and drive robots across the Martian surface. And without our universities, we would not have the scientific leaders and visionaries that put us at the front of the space race and kept America as the leader in space, through to this day.

Without our research universities, we would not be here today. There would be no NASA to reauthorize. Universities are a central pillar standing up our space agency, and this needs to be recognized. USRA requests the subcommittee include in its reauthorization of NASA direction that our Nation's research universities be included as essential partners in every NASA program and undertaking. This has been the history of the agency, it is its only future, and it must be affirmed and preserved.

Universities need to be embedded, not only in every NASA science program, but also throughout NASA's technology development programs and operations. Innovation born from our universities can contribute to efficiencies and breakthroughs across the agency; and NASA engagement can strengthen our universities, prepare our students for the future, and foster American innovation. The mission of our space agency and the mission of our research universities form more than an intersection, they form a shared dependency.

Given the importance of university research to the space agency, both in terms of basic scientific research, and breakthrough technology innovations, USRA also asks the subcommittee to consider in the reauthorization of NASA, inclusion of the agency in the America Competes Act. As a comprehensive strategy to foster American innovation, NASA must be included. The goals of the Act, strengthening scientific research, improving technological enterprise, attracting the world's best and brightest workers, and providing 21st century job training, are consistent with work of NASA and the university community that is a part of our space program.

Make Workforce Development of Tomorrow's Space Leaders a NASA Duty

Should education and workforce development be part of NASA's mission? These numbers answer the question for us: The U.S. aerospace and defense industry is losing an estimated 27,000 employees per year, and the average age of NASA's workforce of engineers and scientists is now 46. Twelve percent of NASA's engineers and 21% of its scientists are now eligible to retire. Estimates show there will be a need for more than 1,000 new doctoral and masters graduates each year to replace key positions in the retiring NASA aerospace workforce. Without a supply of younger workers to assume future leadership roles as older workers retire, NASA is facing a looming workforce crisis.

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;"

In the international commercial sector, new European and Asian hybrid spectrum geostationary communication satellites are emerging. These feature new L- and S-band broadcasting with increased terrestrial bandwidth and allow mobile service everywhere—including indoors—thus avoiding a flaw that helped drive the first generation of commercial satellite services into bankruptcy. A half-dozen European nations have sophisticated space work forces that compete with American firms for satellite contracts like the one recently let by S2M, a Dubai-based startup that will provide mobile television/audio service across the Mideast and Africa. Japan, China, and India are also cultivating large, highly capable space workforces. Three indigenous South Korean satellites are now in polar orbit and relaying images. Even Iran plans to put its own satellites in orbit, using indigenous launch capability now under development that unfortunately also serves as technology for long-range missiles.

The National Research Council's Committee on Prospering in the Global Economy of the 21st Century: An Agenda for American Science and Technology wrote in their report, *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future*, "We fear the abruptness with which a lead in science and technology can be lost—and the difficulty of recovering a lead once lost, if indeed it can be regained at all."

As President Dan Mote of the University of Maryland, a member of the NRC *Gathering Storm* Committee, said at USRA's annual meeting in March of this year, "The USRA can speak to what is needed to attract the best and brightest young space scientists and engineers, such as the hands-on training provided by sounding rockets, balloons, and other small missions. These space professionals are going to be an ever more crucial component of the U.S. workforce, security and prosperity going forward."

The environment is changing before us, and there is urgency to act now. A failure to invest in today's students and young professionals will seal a crisis when that generation is expected to assume the mantle of leadership within the U.S. aerospace community. USRA asks the subcommittee to make clear in its reauthorization of NASA that education, and, in particular, preparing tomorrow's leaders in science and technology, is a crucial duty of the agency.

Assure Adequate Funding for Hands-On Training Opportunities

The space workforce in the United States is the best in the world, largely because it is led by individuals who benefited from hands-on training with actual space projects during their university years. 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.

Today, there are fewer opportunities at our nation's research universities for the next-generation of scientists and engineers to gain the hands-on training they will need to succeed in aerospace fields. In fact, the number of flight opportunities through which university students can build hardware and analyze related space data has declined steadily over the last two decades. Since 1970, suborbital experimental launches have decreased eighty percent – from 270 launches per year to just 50 planned launches this year.

The Commission on Implementation of United States Space Exploration Policy (Moon, Mars and Beyond Commission) 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;"

This is a problem that impacts all space enterprise, large or small, civilian or military, government or commercial. It affects our ability to design and deploy systems for space science missions, 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.

The decline in hands-on training opportunities for undergraduate, masters and doctoral students at universities must be reversed, if the United States is to retain its leadership position in space. NASA must address this problem by increasing its investment in proven programs such as sounding rocket launches, aircraft-based research, and high-altitude balloon campaigns, which provide opportunities for hands-on flight experience at a relatively low cost of failure. While U.S. investments in suborbital experimental launches are declining, China and other countries are increasing their investments in research and development of similar projects to provide future generations of scientists the critical training skills that will serve as a foundation for future research.

Opportunities for tomorrow's scientists and engineers can be provided at a relatively low cost. The average research payload for sounding rocket projects range from $200,000 to $2.5 million. The average cost of recent sounding rocket payloads was just over $1 million, while balloon launch payloads range in cost from just $50,000 to $1 million. Launch, labor and infrastructure costs involved with each payload launch adds additional costs that average $2 million.

Airborne research programs, such as the Stratospheric Observatory for Infrared Astronomy (SOFIA), also provide a platform on which instruments can be carried that enable hands-on training. As the Nobel Laureate Professor Charles Townes wrote in 2006, "The [SOFIA] project is particularly good for hands-on training of students and young scientists. They can fly, operate the system, go to the ground to modify and improve the instrumentation, and then fly with it again."

USRA asks the subcommittee to include in the NASA reauthorization a requirement that NASA spend at least one percent of its overall budget on university-led hands-on programs such as sounding rockets, high-altitude balloon campaigns, and airborne research. From our estimates, we believe this represents a doubling of current funding levels for programs that provide hands-on research and training opportunities for our nation's undergraduate and graduate students in space-related disciplines. By increasing NASA's investment in flight opportunities for university experiments, we will double the number of students engaged in this research and entering the space and engineering disciplines.

A white paper on *Educating the Next Generation of Space Scientists and Engineers*, drafted by the Issues and Program Committee of USRA's member universities, is attached as Exhibit B.

The National Research Council 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." And on October 16 of 2007, Senator Ben Cardin of Maryland, in a colloquy with Senator Barbara Mikulski of Maryland, cited the NRC report, and stated, "We know that some of NASA's programs involving sounding rockets, weather balloons, and small satellite launches are outstanding examples of worthy Federal investment that not only produces usable scientific data but provides outstanding hands-on learning opportunities

for the next generations of scientists and engineers. Our investment in these programs has not kept pace with demand, and that is a problem we may want to address in future years as we consider the NASA budget."

I also want to bring to the subcommittee's attention an exciting new way in which university-led experiments with hands-on training could be boosted by NASA involvement. Within the next few years, suborbital commercial vehicles being developed by such companies as Virgin Galactic, XCOR Aerospace, Armadillo Aerospace, and Blue Origin, will provide a unique way to engage scientists and researchers. NASA has already taken the first step by issuing a request for information to help in the formulation of a Suborbital Scientist Participant Pilot Program.

By providing the opportunity for researchers and even undergraduate students to fly into space along with their experiments, not only can new experiments be conducted, but the opportunity can inspire students to engage in the math, science, and engineering. The participatory approach of the personal spaceflight industry means each suborbital launch can be experienced by thousands of people, with young people able to tune in and watch live video from space as their professors and fellow students conduct experiments in real time and experience weightlessness and the life-changing view of the earth from space. The hands-on experience will create a new generation of Principal Investigators who will be prepared to lead the flagship science and human exploration missions, later in their careers.

These new vehicles will provide low-cost access to the space environment for scientific experiments and research. The market rate for these services has already been set by the space tourist market at $100,000–$200,000 per seat, a much lower cost than existing sounding rockets.

We believe the commercial potential here could be energized by the participation of our space agency. USRA requests the subcommittee authorize NASA to follow through on the request for information by establishing the Suborbital Scientist Participant Pilot Program and issuing a NASA Research Announcement soliciting investigations. This will create a university research payloads market for these emerging commercial operations, provide a new way for university researchers to conduct experiments with student involvement and hands-on-training, and bring the involvement of NASA, and its imprimatur, to an exciting new U.S. industry.

Reimburse NASA for the Cost of Returning to Flight

NASA has spent more than $2 billion in the past few years implementing space shuttle safety improvements to help restore flight operations after the Columbia accident. The funding for those safety improvements came at the expense of sustaining and expanding other programs for NASA in aeronautics, science, and exploration. Last year, Congress almost provided $1 billion in supplemental NASA appropriations to help the agency recoup those expenses and improve funding for other agency priorities. We hope that Congress will provide this supplemental funding and such other money in FY09, as

needed, to help NASA replenish funding stripped from a number of critical programs, including the Vision for Space Exploration.

Conclusion

The first Space Act was passed in 1958 and signed into law by President Eisenhower, a major legislative act of the 20th century. Today, space touches every aspect of American lives and is growing. Over the last 40 years activities in space have become integral parts of national defense, providing intelligence, early warning, meteorology, communications, protection from missile attack, positioning, navigation and timing services. Business and financial transactions use both space voice and data communications. Space-based commercial sensing is used for land-use planning, emergency response, weather and environmental monitoring. The replacement for our outdated air traffic control system will be space based, and GPS will soon be a part of every modern transportation system. Scientific discoveries in our galaxy, of our solar system and of our own planet's changing climate are exploding. Space also plays a huge part in educating future generations - motivating youth to pursue science and technology careers.

NASA must be reauthorized to make people and innovation one of its highest priorities. American universities are the greatest leverage we have for affecting America's future in space. They are the source of new knowledge and the training ground for the rock-star scientists and engineers that are our future. They are the fuel that powers better achievements in space, done faster and more cost effectively.

I ask the subcommittee to consider these five recommendations, as it deliberates the authorization of NASA's future programs: First, that NASA's new Vision for Space Exploration be authorized to move forward, in concert with an assured and balanced science program across the agency; second, that the importance of universities be recognized and university research be made a part of all NASA programs; third, that workforce development focusing on tomorrow's leaders be made a part of NASA's mission; fourth, that one percent of the NASA budget be devoted to university-led missions to provide hands-on training; and fifth, that NASA be reimbursed, through supplemental funding, the cost of returning the Space Shuttle to flight.

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

EXHIBIT A

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

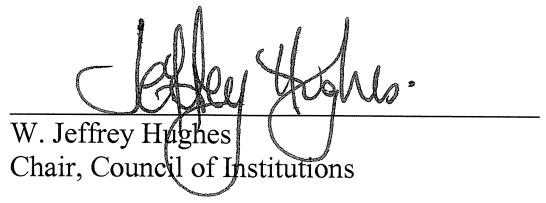
WHEREAS, the National Academies Committee on Meeting the Workforce Needs for the National Vision for Space Exploration found in 2006 that, "NASA should expand and enhance agency-wide training and mentorship programs, including opportunities for developing hands-on experience, for its most vital required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

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 an association of 102 universities, including 8 international universities, 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 a strong and inspiring NASA is critically important for our nation; and

WHEREAS research universities are extremely important engines of technological innovation in the United States and play vital roles in preparing the next generation of space researchers and professionals, as well as in developing and executing the space missions that help shape a positive, peaceful vision for all nations and give our country a competitive edge in a world that is increasingly dependent on space technology; and

WHEREAS the space workforce in the United States has been led by individuals who have had the benefit of hands-on training with actual space projects during their university years, and whereas the number of these crucial hands-on training opportunities at universities has been declining for decades, and that trend must be reversed if the United States is to retain its leadership position in space; and

WHEREAS future space research and exploration will be enhanced by the substantial and growing technological capabilities of nations other than the United States, and whereas for economic, scientific, and foreign policy reasons, it is vital that barriers to international collaborations by U.S. as well as other universities be reduced;

NOW THEREFORE BE IT RESOLVED, that NASA should be reauthorized as the leader of the civil space program for the United States and provided with significantly increased funding adequate to meet its responsibility to carry out a balanced space program, including advancing knowledge in the scientific and technology disciplines related to space and aeronautics, as well as carrying out the enterprise of space exploration itself; and

RESOLVED FURTHER, that the NASA reauthorization should specifically acknowledge NASA's support of universities as partners who generate new knowledge, make new discoveries in disciplines related to space and aeronautics, and train the specialized workforce needed to accomplish NASA's missions; and

RESOLVED FURTHER, that NASA budgets should reflect the historical precedent that at least 1% of NASA's total budget be devoted to funding competitive opportunities for hands-on training provided by university missions on sounding rockets, high altitude balloons,

remotely piloted vehicles, emerging commercial suborbital flights, and university class space flight missions; and

RESOLVED FURTHER, that the fundamental research exclusion in the International Traffic in Arms Regulations should be extended to U.S. aerospace firms, Federal laboratories, and non-profit organizations when they are interacting with universities in pursuit of fundamental space research and on university space experiment hardware.

IN WITNESS WHEREOF, the members of the Council have adopted this resolution at their meeting of March 28, 2008.

Edward J. Groth
Chair, Council of Institutions,
Universities Space Research Association

EXHIBIT B

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)

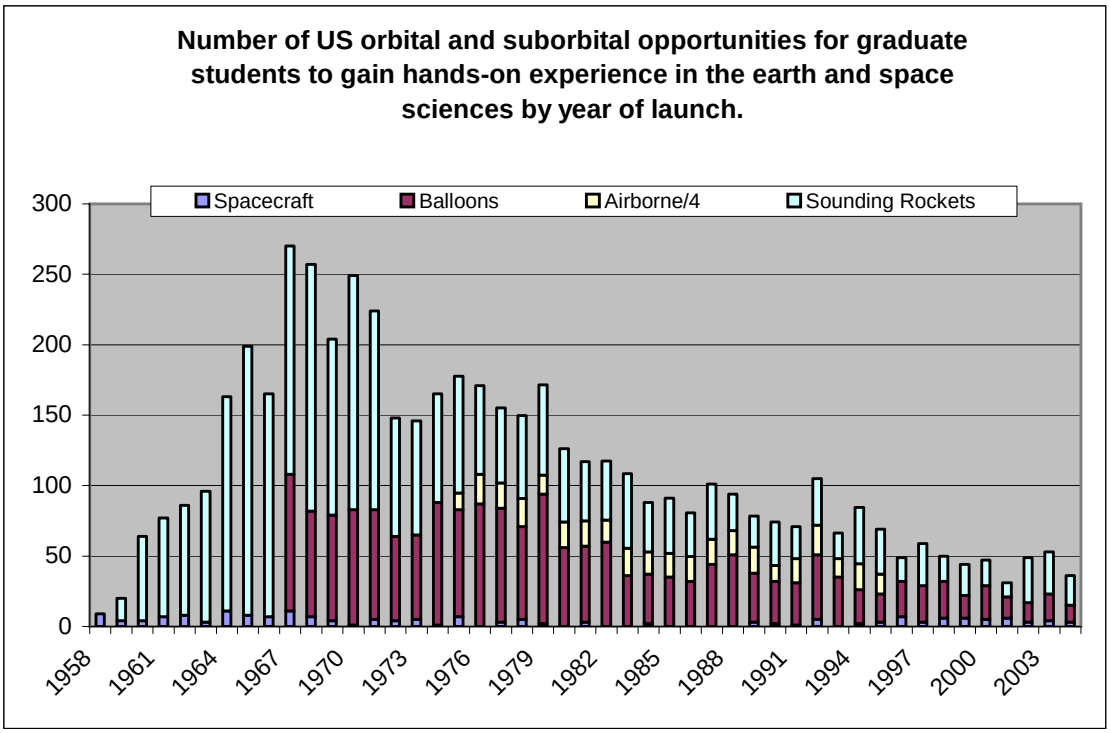
"At present, there are insufficient methods for students to acquire hands-on experience in the scientific and technical disciplines necessary for space commerce and exploration." (Commission on Implementation of United States Space Exploration Policy (the Aldridge Report), June 2004)

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 US 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.