NATIONAL WORKSHOP ON SPACE EDUCATION
THE GEORGE WASHINGTON UNIVERSITY

WHITE PAPER REPORT

(Final Report)

May 2, 2003

NEEDS IN SPACE EDUCATION FOR THE 21st CENTURY: RESEARCH, HIGHER EDUCATION, TRAINING, AND PUBLIC POLICY

Major Workshop Sponsors:
NASA, Arthur C. Clarke Foundation, Arthur C. Clarke Institute for Telecommunications and Information(CITI), Space Systems/Loral-Loral Skynet, International Launch Services, Embry Riddle Aeronautical University, George Washington University

Workshop Participants: Air Force Institute of Technology, Air Force Space and Missile Center, Air Force Research Laboratory, American Astronautical Society, American Institute of Aeronautics and Astronautics, Arianespace, Federal Aviation Administration, Florida Space Research Institute, General Dynamics, Howard University, International Space University, MIT, National Space Society, National Institute of Aerospace, Office of Management and Budget, The White House, Ohio University, PBI Media, Society of Satellite Professionals, Intelsat, Raytheon, Satellite Industry Association, Society of Satellite Professionals International, Space Foundation, Universities Space Research Association, and Washington Space Business Roundtable, World Bank-IBRD

A FORUM SEEKING INNOVATIVE ANSWERS

- **New Approaches to Higher Education and Training**
- **Distance Learning, Tele-education and the Internet**
- **Shared Research Facilities and New Approaches to Research**
- **Joint University Projects**
- **Multidisciplinary Needs and International Perspectives and Languages**
- **Space and Security Issues Related to Education,**
- **How to Attract More Students to Higher Education in the Space Field**
- **How to Prepare Incoming Students More Effectively for College**
- **Wide Spread Survey on Space Education to Find Concerns and New Solutions**

White Paper Prepared by Steering Committee Members:

Randall Johnson, Embry-Riddle Aeronautical University; Joseph Pelton, George Washington University; Henry Hertzfeld, GW; Don Flournoy, Ohio University; and Hussein J. Hussein, Universities Space Research Association

EDUCATION, RESEARCH AND PUBLIC POLICY WORKING IN SPACE IN THE 21st CENTURY

"The breakdown of America's intellectual and industrial capacity is a threat to national security and our capability to continue as a world leader."
Commission on the Future of the U.S. Aerospace Industry[1]

Introduction and Historical Perspective

The issues that we face today in the United States and around the world in the arena of space education are not new, but the contexts and the needs are different—the difficulties in some ways more severe. Every generation must face new challenges with the chance to move forward or to slip back. In the wake of the latest tragedy represented by the Columbia accident, we can not give in to defeatist thinking, but must respond by looking to the courage and optimism represented by the seven astronauts and chose to carry their torch forward into a bright new Millennium.

World War I proved the efficacy of the aeroplane. Before the ink had dried on the Treaty of Versailles, Europe was employing flight in the advancement of communication and commerce. Prior to and during the "war to end all wars," European nations invested in aeronautical and communications research and the development of new technologies. Their achievements were rooted in discovery and learning, sustained by education. Remarkable gains were made under adverse circumstances.

While the National Advisory Committee on Aeronautics (NACA) was created in the United States in 1915 to foster aeronautical research, the United States would wait until 1926 before launching its commercial aviation service. This was in part due to technological gaps, but the key to this timing was that commercial aviation interests needed to attract political attention to develop a viable and technologically based aeronautical system—the forerunner of the aerospace industry. It was only then that the research and educational foundation upon which such an industry could be launched began to fall into place.

The Air Commerce Act of 1926 empowered the U.S. Department of Commerce to become the nexus for aeronautical and communication research. Then Secretary of Commerce Herbert Hoover saw a relationship between basic and applied research and public policy. Pure scientific research, as he saw it, was the "raw material of applied science." As chairman of the National Academy of Sciences, Hoover sought between $10 million and $20 million for the purpose of funding American research universities over a ten-year period.[2]

Hoover charged the National Bureau of Standards to conduct "industrial" research including investigations into radio interference, propagation of radio waves and radio direction finding for aerial navigation. Although the United States had entered the commercial aviation "race" well behind Europe, Hoover, in the mid twenties, fashioned an alliance between government, industry and academe that became a significant national competitive force for the advancement of flight and aeronautical communication. By the time Hoover left the Presidency in 1935 he had, as Secretary of Commerce and as President, overseen the growth of an aviation industry whose telecommunications infrastructure was a model for the world.

---

1 Commission on the Future of the United States Aerospace Industry, Final Report, November, 2002, 8-1

2 Herbert Hoover, The Memoirs of Herbert Hoover: The Cabinet and the Presidency 1920-1933 (New York: The MacMillan Company, 195), 74-76.

Over time, in the United States and elsewhere, governments got behind the establishment of national aviation industries. Key to their success was the role universities and schools played in providing pilots, scientists, engineers and those educated in business, communication and related applications.

In 1957, the launch of Sputnik, the Cold War competition between the U.S. and the U.S.S.R., the perceived "missile gap" highlighted in the U.S. Presidential race of 1960, and John F. Kennedy's challenge for an American Moon mission created not only a new surge toward the development of new space technology and science, but also a new emphasis on technical education in the United States and around the world. One of the most significant impacts of Sputnik was the passage of the National Defense Education Act. This period marked what might be considered a second stage ignition in twentieth century higher education.

Space flight found its origins in aeronautics, and is its natural extension. The forebearer of the
National Aeronautical and Space Administration (NASA) was the NACA organization charged with aeronautics research for the United States. In Russia, Europe, Japan and elsewhere this evolution was also the same. As the frontiers of flight continue to extend beyond earth's atmosphere, space emerged as a platform for science, communication and commerce as well as national defense. Such applications required involvement of the educational community for manpower, for innovation, and for perspective. Without a robust research agenda and close linkages to universities, the space sector cannot and will not prosper. There is concern today in the U.S. and other parts of the world that this robust linkage and partnership is faltering and is in need of renaissance and renewal.

Space Education for the 21st Century

"The people must insist upon a redirection of emphasis; they should willingly accept their just measure of responsibility for the execution of our educational programs. To all who ask: 'What can I do to help?' my answer is: 'Take active interest in what is being taught, how it is being taught, and by whom'."[3] —Werhner von Braun

Government and industry have historically turned to universities for basic and applied research and for training young people for productive careers. Academia working in tandem with Governmental agencies serves as the bedrock upon which our aerospace industries are built. This symbiotic relationship has not only provided our nation with the best-educated workforce, but some of the most advanced research and development laboratories in the world. As the U.S. National Science Foundation reported in its *Science and Engineering Indicators 2002*, "The United States has managed to turn its R&D strengths to its economic and commercial benefit."[4]

The number and quality of research PhDs is essential to the R&D effort. Unfortunately, the United States has recently experienced a downturn in the total number of doctorates awarded— and more so in science and engineering (S&E)[5] where totals have declined to pre-1994 levels. (See Fig. 1) The recent slight increase in the number of enrolling graduate

---

[3] Stuglinger and Ordway, *Wernher von Braun*, 146.

[4] *Science and Engineering Indicators 2002*, National Science Foundation, 2002 (NSB-02-1) O-2.

[5] Science and Engineering is comprised of four broad disciplines: Physical Sciences, Life Sciences, Social Sciences and Engineering; National Science Foundation, Division of Science Resources Statistics, *Science and Engineering Doctorate Awards: 2001*, NSF 03-300, Susan T. Hill, Project Officer (Arlington, VA 2002).

students may help mitigate this downward trend.[6]

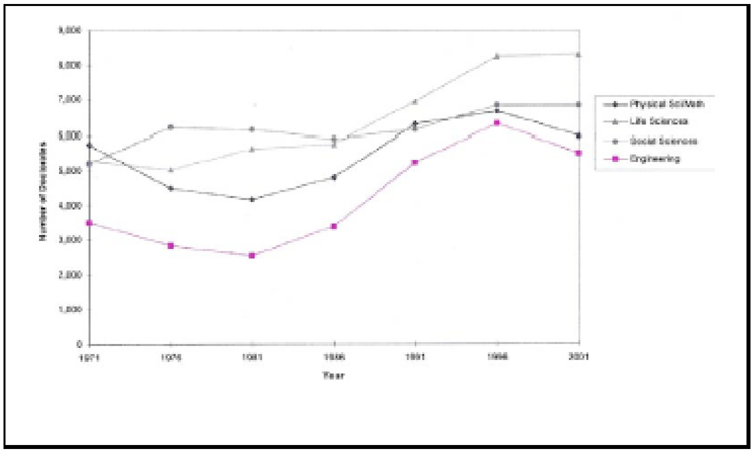

Fig 1—Science and engineering doctorates awarded by broad field, 1971*2001[7]
(Chart from *Science and Engineering Indicators—2002*)

Continued industrial growth is dependent upon a well-educated and highly skilled workforce. As the NSF points out it its report, S&E and its subset natural sciences and engineering (NS&E) is indispensable to the national R&D effort.

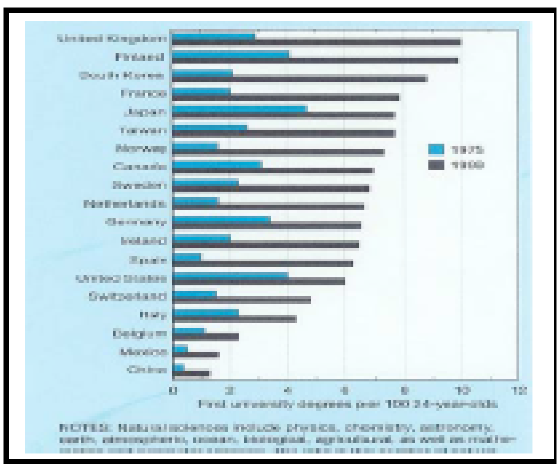

Fig 2—Ratio of natural science and engineering first university degrees awarded to 24-year-old population, by country/economy[8] (Chart from *Science and Engineering Indicators—2002*)

While the percentage of students entering such academic disciplines has remained relatively constant over the past forty years, other nations have out-paced the United States in percentage of baccalaureate graduates in the NS&E programs (Fig 2).[9]
From 1994 through 2000, the United States experienced an annual growth rate of 5.8 percent in R&D. But it was industry-sponsored R&D that was increasing while federally supported R&D was declining. Between 2000 and 2001, R&D growth slowed to 4.0 percent. As industry took on more of the research effort, R&D became more vulnerable to the cyclical

[6] NSF Press release, NSF PR 03-04, January 6, 2003.

[7] *Science and Engineering Doctorate Awards: 2001*, 9, fig 4.

[8] Ibid.

[9] *Science and Engineering Indicators—2002*, O-3, fig 4.

nature of the economy.

Based on current economic conditions, the NSF was predicting that R&D growth for 2002 would decline to 2.4 percent. Increases in defense and federally funded health R&D are presumed to have helped offset the market-sensitive private sector R&D support.[10]

The NSF cautions that the United States "may face increased international competition" as other countries continue to make large investments in education, R&D and centers of excellence forscience, engineering and technology.[11]

These troubling trends in science and engineering education, and in research and development, are underscored in the *report of* the Commission on the Future of the United States Aerospace Industry. The health of the aerospace industry has been closely tied historically to government spending, especially to the Department of Defense where spending fell approximately 53 percent between 1987 to 2000. Military R&D fell 20 percent during the same period. This, together with a 37 percent decrease in aerospace industry R&D and a host of mergers, buy-outs and bankruptcies, has devastated the aerospace workforce (Fig 3).

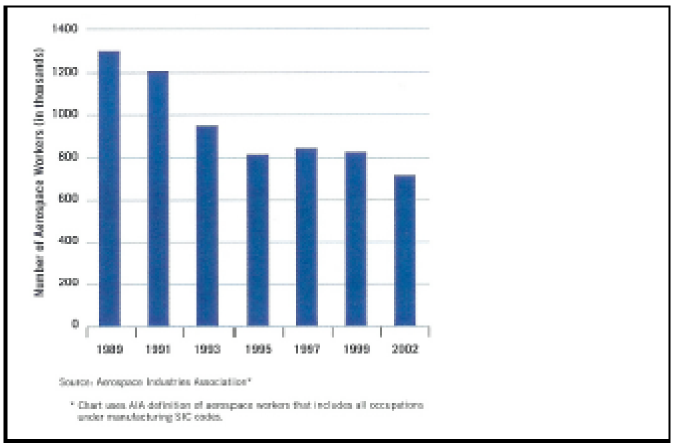

Fig 3—Total Employment in the Aerospace Industry (1989-2002)[12] (Chart from *Final Report*)

"Clearly, there is a major workforce crisis in the aerospace industry," reports the Commission.[13] Not only has the industry seen the exodus of 600,000 "scientific and technical aerospace jobs in the past 13 years," approximately 27 percent of the current aerospace workforce will be eligible to retire by 2008. Replacing researchers, engineers, technicians and support personnel is difficult because the cyclical nature of the industry inhibits new entrants who look for long-term stability and professional growth. "A consequence of this environment has been an overall aging of the aerospace workforce, which risks the loss of intellectual capital."[14]

Many of those joining the ranks of the aerospace industry may not be adequately prepared.

---

[10] National Science Foundation, Directorate for Social, Behavioral, and Economic Sciences, *InfoBrief*, "Slowing R&D Growth Expected in 2002", Brandon Shackelford, NSF 03-307, December 2002.

[11] *Science and Engineering Indicators-2002, O-3, fig 4.*

[12] Commission on the Future of the United States Aerospace Industry, *Final Report*, November, 2002, 8-2, fig 8-1.

[13] Ibid.

[14] Ibid, 8-3.

The Commission expressed alarm at declines in the quality of math, science and technology education in grades K-12 (Fig 4) and worried that our "system is doing an abysmal job of educating our children."[15] Clearly, any nation wishing to exercise leadership in space, no less to participate as a technologically based society, must invest in education stressing mathematics, science and technology.

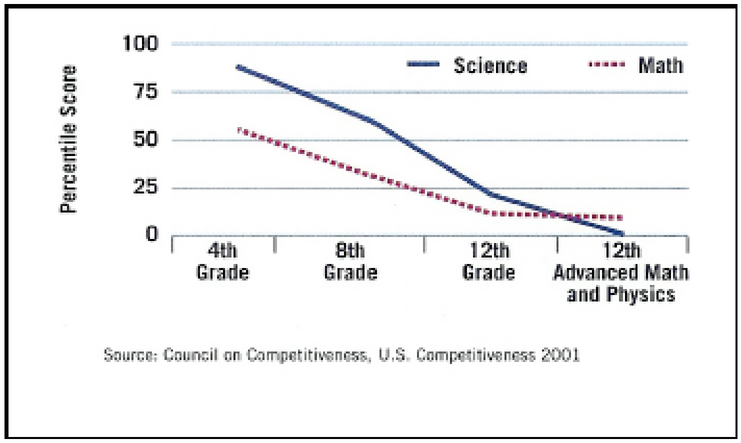

Fig 4—U.S. Students Science & Math Performance Relative to Other Countries.[16]
(Chart from *Final Report*)

In the mid-1980s, the U.S. aerospace industry could boast that it dominated the aerospace market. This is no longer the case. Europe, Russia, Canada, Japan, China and Brazil are successfully challenging that position. These nations understand the importance of a workforce educated in engineering and technology. "Our policymakers," the Commission warns, "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."[17]

Looking Forward: Innovative Thoughts About the Future of Space Education

"We must make these careers more attractive to induce more young people to select them."—von Braun[18]

Wall Street Journal staff writers in a February 2003 article on the plight of NASA speculated that, "Many young people today with a technical bent are more entranced with the Internet or biotechnology than space exploration. Space travel, after all, was a fascination of their parents' generation." The reporters noted that NASA administrator Sean O'Keefe in testimony to the U.S. Congress in the Summer 2002 acknowledged the agency faced a critical skills shortage in space-shuttle and international space-station programs despite "active recruitment."[19]

The current plight of the aerospace industry is in no way unique among U.S. high technology enterprises. Enrollments in science and engineering courses in U.S. colleges and universities

---

[15] Ibid, 8-6.

[16] Ibid, 8-7, fig 8-3.

[17] Ibid. 8-1.

[18] Stuglinger and Ordway, *Wernher von Braun*, 147.

[19] Kemba J. Dunham and Kris Maher, "NASA Struggles to fill Openings for Personnel," The Wall Street Journal

peaked at nearly 450,000 in 1982 and have declined to around 350,000 as of the academic year 2002/2003. During the last decade and a half, the number of scientific and engineering jobs in the United States has increased by some 15 percent and the demand for technical personnel with at least some specialized skill has increased even more rapidly. The net result has been a shortage of people to fill skilled scientific, engineering and technical positions. A pattern has emerged of recruiting overseas by U.S. aerospace, engineering, scientific and high technology industries. The National Science Board of the National Science Foundation in its Science and Engineering Indicators 2002 Report noted a broad spectrum of problems and adverse trends in science and technology education that have been on-going for years.

The urgency of these problems is heightened by the fact that organizations such as NASA, NIST and the Defense Department and many high technology industries are facing a situation where a sizeable percentage of their critical skills personnel will retire in the next five years. Further, women and minorities are underrepresented among college enrollments and college graduates in science and technology. Meanwhile the cost of college education continues to rise and new educational methods and on-line systems are being employed with varying results. For these reasons the National Space Education Workshop was held in March 2003. The goal of the Workshop sponsors and participants, which represented a very broad spectrum of professional organizations and institutes, universities, government agencies and industry groups, was to identify new directions, new solutions and new initiatives that could address the need for improved space education programs for coming decades.

The Workshop accordingly addressed a number of issues and possible new initiatives, including the following:

- Distance Learning, Tele-education and Innovative Uses of the Internet
- Shared Research Facilities and New Approaches to Research
- Joint University Projects and Partnerships
- Multidisciplinary Needs and International Perspectives and Languages
- Space and Security Issues Related to Education and Training
- How to Attract More Students to the Space and Technical Disciplines at the Primary and
- Secondary Educational Levels as well as at the College Level
- How to Prepare Incoming Students More Effectively for College and How to Strengthen
- Science, Technology, Engineering, and Math Programs

Report on the Results of the National Space Education Workshop Held on March 27, 2003

Some 120 people from over 40 space related organizations from around the United States and abroad convened at the George Washington University Jack Morton Auditorium on Thursday March 27, 2003 to critically examine the issues faced by educators and students in space related fields for coming decades. The all day session included keynote addresses by well-known space personalities and six breakout discussion groups.

The keynote speakers for the day and session chairs included:

- *Dr. Clifford Houston, NASA, Deputy Associate Administrator for Education, Washington, D.C*
- *Dr. George Ebbs, President Embry Riddle Aeronautical University, Daytona, Florida*
- *Elliot Pulham, President, The Space Foundation, Colorado Springs, Colorado*

- *Terry Hart, President of Loral Skynet, Princeton, New Jersey and former astronaut*
- *Dr. Mark J. Albrecht, President, International Launch Services*
- *Dr. Jeffrey Hoffman, Professor of Aerospace Programs, MIT, and former astronaut and NASA executive*
- *Rear Admiral Ran dFisher, The National ReconnaisanceOffice*
- *Lyn D. Wigbels, Deputy Director and Director of International Program, the GLOBE Program.*
- *Dr. Donald Lehman, Executive V. P. of Academic Affairs, George Washington University*
- *And Session Chairs: Dr. John Logsdon, Director of the Space Policy Institute and Dr. Joseph N. Pelton Director, Space & Advanced Communications Research Institute, George Washington U.*

The keynote speakers and the breakout discussion groups sought and found areas of agreement as to both the problems now faced in space education and possible solutions. While there were many issues and opportunities related to college level space and technical education identified, the consensus was that the greatest needs for reform and improvement were at the primary and secondary educational level. Also, the fact that employment in aerospace had declined precipitously over the last 15 years was found to be of serious concern as was the fact that the number of graduates in technical disciplines had declined in the last 15 years from 450,000 to 350,000. Many voiced the view that the "educational programs" cannot be "fixed" until the future direction and new national vision for the aerospace industry was defined and given a new sense of urgency.

Workshop participants arrived at a number of innovative suggestions for recruiting students to meet the needs of a "graying workforce" that now exists in the aerospace field. One of the many ideas of the day was the proposal that future government contracts require that bidders provide a 1% or 2% set aside in major contracts for training and education that could be carried out in cooperation with schools, universities, museums and others on the basis of "in-kind" programs such as internships, scholarships and coop programs. The workshop also endorsed and put its weight behind the ideas generated in the national questionnaire survey, reported in a following section to this report.

Associate Administrator of NASA for Education, Dr. Clifford Houston noted that 27% of the NASA engineering and scientific workforce and over 50% of all employees will retire in the next five to seven years. He outlined a number of new initiatives that the space agency is undertaking (in cooperation with the NSF and the Dept. of Education) under an expanded budget to interest young people, train educators, and streamline and improve its educational offerings. Particular emphasis is being placed by NASA on so-called STEM programs that emphasis education and training in "Science, Technology, Engineering and Math." He also outlined NASA's mechanisms to bolster science and education through its explorer schools, its explorer institutions, its NASA educator program and NASA's scholarship program.

Space Foundation President Elliot Pulham was of the opinion that revitalizing the space industry in terms of space transportation, space tourism and "going where no man or woman has gone before" has to be a part of the solution. Scott Chase of PBI Media, on behalf of the breakout session on Space Applications underscored Elliot Pulham's message at the end of the day with a simple characterization. “We’ve got to put more “sizzle” back into the space industry.” Suggestions for innovative programs of this nature (ideas that would inspire young people) included a manned mission to Mars, a lunar colony, large-scale solar power systems, space tourism and space planes and a space elevator.

Dr. George Ebbs, President of Embry Riddle Aeronautical University, explained that by maintaining a clear focus on space and aviation technologies and developing student-centric programs, his university was able to sustain a student population of over 25,000 at its two campuses and 100 satellite facilities around the world. Ebbs added that space applications in telecommunications, remote sensing, space navigation and related disciplines were the heart of space-based economics and among the biggest job opportunities. He added quite frankly that NASA had missed opportunities to strengthen these crucial parts of the space industry.

Professor Joseph Pelton, of George Washington University and the Arthur C. Clarke Foundation (who coordinated the Space Education Workshop along with Randy Johnson of Embry Riddle Aeronautical University and Don Flournoy of Ohio University, on behalf of the SSPI Academic Council) added that NASA officials might reflect on the thoughts of bank robber Willie Sutton when he said he “robbed banks because that was where the money was.” Pelton noted that NASA spent less than one percent of its budget on space applications when forward looking space agencies of other nations spent 10% to 40% on R&D to stimulate new space applications. Terry Hart, President of Loral Skynet and former astronaut, indicated that more U.S. Government attention to space applications did not necessarily mean that government funding would increase government regulatory control. He suggested that, in fact, less demanding regulation of the space telecommunications industry was probably the most important thing that government could do to stimulate satellite telecommunications growth and prosperity.

Mark Albrecht, President of International Launch Services, was of the opinion that the success of the space industry in the years ahead would be closely tied to how “transparent” the technology and the services were to the public in terms of being linked to space technology. He suggested that satellite radio, broadband satellite services, satellite entertainment and other space applications had not only to be upgraded and improved but tied to the public’s appreciation that space technology brought people a better and more entertaining life. The combined message of both Hart and Albrecht was that stimulus to growth of the space industry would go a long way to curing the decline in student interest in space related educational disciplines.

Rear Admiral Rand Fisher, Director of Communications Systems for the National Reconnaissance Office explained that satellite data, communications and sensing not only made modern warfare more efficient and globally available, but that it could and did save lives. He suggested that a strong and vigorous space education program was critical to the future security of the United States and that space applications that provided for the national defense would actually promote longer-term prospects for peace. The breakout session on international cooperation and interdisciplinary studies built on this theme of “peace and international cooperation through space” by suggesting that educational programs that allowed for large-scale international space programs (i.e international program management, international team design projects and promotion of international languages) were considered prime candidates for promoting world peace and international collaboration in space.

MIT Professor and former Astronaut Jeff Hoffman explained why the Columbia disaster must not slow human exploration and exploitation of space for scientific and industrial reasons. He set forth the many scientific and economic reasons why the international space station was a key building block to space development. He argued that reactivation of the shuttle fleet was critical to realizing the full deployment of the ISS and continuing our longer term goals toward understanding the evolution of the solar system and the mysteries of the universe.

Following the keynote sessions six breakout sessions explored current problems and challenges related to space education, participants asked what new approaches might be tried to re-invigorate space educational programs. Despite the fact that these issues were addressed from the perspectives of very diverse groups representing aeronautical engineering, space sciences, space law, space applications, regulation, economics and social sciences, international cooperation and new educational technologies and systems, the general conclusion across all the breakout groups was that the focus of new programs and needs should be on K-12 much more so than on college programs. There was a consistent view among the groups as well as from the national Delphi survey results (reported in the following section) that there was a need for schools and educational institutions to work more closely with governmental agencies, museums, industry training programs and professional associations to strengthen the appeal, interest, currency and substance of STEM related programs. Improvements with regard to on-line and tele-education offerings, internships, coop programs, scholarships, hands-on training projects, design activities that strengthened “critical thinking skills” received consistent support. There was agreement that, unless intellectual, economic and industrial incentives were given to pursue careers in space-related disciplines, that educational reforms and innovations alone would not be sufficient. In all the reports was a consistent expression of concerns for the future of space education and the need to take into account the exploding nature of scientific and technical information, the need for life-long learning, new electronic forms of education and training, and conscious adaptation to a world that is changing at an ever more rapid pace and is ever more interconnected, interdisciplinary, and international.

In addition to the eight prime sponsors of the National Space Education Workshop there were over 40 participant organizations involved in the workshop. These included:

- Air Force Institute of Technology
- American Astronautical Society
- American Institute of Aeronautics and Astronautics
- Arianespace
- The Boeing Corporation
- The Civil Air Patrol
- Coudert Brothers
- Federal Aviation Administration
- Florida Space Research Institute

- General Dynamics
- Global Telecom.Tech
- The GLOBE Program
- Howard University
- The International Space University
- Irwin Communications
- Jones Day International
- Massachusetts Institute of Technology
- National Defense University
- National Space Society
- National Institute of Aerospace
- The National Reconnaissance Organization
- Ohio University
- Office of Management and Budget, The White House
- PBI Media
- Prince George Community College
- Society of Satellite Professionals international (Robert Bell, Event Treasurer)
- The SOFIA Project of the USRA
- Intelsat
- Raytheon,
- Satellite Industry Association
- The Society of Satellite Professionals International
- The Space Foundation
- Tek Ventures
- Universities Space Research Association,
- The US Missile Defense Agency
- Washington Space Business Roundtable
- The World Bank (IBRD)

Next Steps

Clearly reforms in space education will take time. Finding the right path and the proper steps to be taken will take great effort. In August 2003, the Society of Satellite Professionals International (SSPI) will cooperate with the CeBit show in California to put together a panel on space education. Discussions are underway to give Society of Satellite Professionals International (SSPI) support to an American Institute for Aerospace and Aviation (AIAA) Conference on September 26th in Long Beach California examining needs and initiatives to be taken in space education. A prime objective at this time is to see that a large number of key people in leadership positions in the U.S. Congress, the U.S. Government Executive Branch, professional associations, industry, and academia have an opportunity to review this White Paper and its findings.

Key findings and recommendations from the Workshop can be summarized as the following:

- More clarity and vision is needed in framing national space goals and objectives in terms of space exploration and sciences, space and national security, space applications, and future manned space missions.

- There is a need for greater "sizzle" and "intellectual interest" in space by the general public to obtain broadbased support for space research and exploration and to attract young people to this field.
- Space education goals and objectives require longer range vision to address such issues as the information explosion, modern electronic information systems, tele-education, life-long learning, and ways educational institutions can work more effectively with government agencies, professional organizations, museums, and industry.
- Innovative approaches to STEM education and training are needed, especially at the primary and secondary educational level. (All relevant U.S., State and Local Government agencies need to coordinate their efforts and work together toward this end.)
- The fact that the world of space will become increasingly interdisciplinary, international, intercultural and involve private/public partnerships gives rise to new educational and training needs that are not now being fully met.
- Current educational programs in the U.S., at virtual all levels, are in need of sharpening "critical thinking skills and analytic capabilities." (Perhaps too often they focus only on presentation of factual content without placing the challenges in a problem solving or "creative engineering" context.
- A significant factor in declining U.S. educational performance in the science, technology, engineering and math fields is the lack of qualified teachers at all educational levels. (As many as a third of all math and science teachers in the U.S. possess inadequate training. Thus efforts to upgrade teacher skills, educational backgrounds and general capabilities should be considered a high priority.)
- New approaches such as the 1% to 2% set aside for scientific and engineering related education and training that should be included in new governmental contracts for space and defense related activities. Other similar approaches should be considered for urgent implementation.
- Continuing efforts to address the challenges of future space educational needs and STEM related disciplines through mechanisms such as workshops, surveys, cooperative programs, interships, coops, scholarships and new forms of cooperative relationships among potential interest groups should be encouraged within the U.S. Government and all sponsors and participants of the National Space Education Workshop.

National Dephi Survey Results

A questionnaire was prepared by the Workshop Steering Committee and widely circulated via sponsor organizations and participating industry press and web sites. Approximately one-hundred responses were received from a wide range of academic, professional, governmental and industry sources. Responses were tallied from nearly 50 institutions including the Air Force Institute of Technology, the American Astronautical Society, Arianespace, the Arthur C. Clarke Institute of Telecommunications and Information (CITI), The Arthur C. Clarke Foundation, Booz Allen, Hamilton, Coudert Brothers, DTT Consulting, Embry Riddle Aeronautical University, the European Space Agency, F.A.A., Futron, General Dynamics, George Washington University, Howard University, Hughes Networks Systems, Intelsat, Jones Day International, International Launch Services, Lockheed Martin, the International Space University, Space Systems/Loral and Loral Skynet, M.I.T., NASA, the National Space Society, Northrop Grumman, Ohio University, the National Space Society, PBI Media, Raytheon, the Satellite Industry Association, the Smithsonian Institution National Air and Space Museum, the Society of Satellite Professionals International, the Space Foundation, the University of Mexico, the University of North Carolina, University Space Research Association, the U.S. Department of Defense, and the Washington Space Business Roundtable.

The key findings derived from this questionnaire were of sufficient interest that the results are summarized below and explained in more detail in the annex to this Report.

Results of Questionnaire on the Future of the Space Industry and Space Education

The tally of results of the questionnaire are shown in the form of distribution charts that indicate the level of support for various possible future approaches to space education, the areas of projected greatest needs and current perceptions of problems to be faced. This section seeks to identify those areas of particular interest or emphasis and highlight particular responses of respondents. Not surprisingly, industry and government respondents were inconsistent in projecting academic areas of future need and only a few areas showed strong consensus views. There were, nevertheless, seven initiatives that received a "high level" of support from persons and institutions replying to the survey.

Initiatives in Higher Education

Proposals with the greatest amount of support at the university level included:

- Incentives to encourage university faculty to upgrade skills (62 of 94 rated this as a "high priority")
- Scholarships in technical fields (59 of 94 rated this as a "high priority")
- Government, industry, academic and professional partnerships to strengthen technical curriculum and joint educational/research opportunities (55 out of 94 rated this as a "high priority")
- Professional societies and industry associations to increase educational programming, including sponsorship of internship programs and other joint undertakings with universities with regard to recruitment and curriculum development (53 out of 94 rated this as a "high priority")
- Counseling and other support for science and technology students at universities and colleges (76 out of 94 giving "medium" or "high" priority)

Initiatives in Secondary Education

Proposals involving secondary education and its role as a feeder of quality students into colleges and universities receiving "high priority" votes included the following:

- Counseling and support systems for science and technology programs in secondary education drawing on school, industry and professional association resources (61 out of 94 rated this as “high priority”)
- New mechanisms to allow universities, colleges, professional associations, government agencies, science museums and industry to work together to enhance interest among secondary school students in science and technology and recruit students to the field, such as Space Day at the NASM (58 our of 92 rated this as a “high priority”)
- Upgrade and expand databases that identify universities and colleges offering space education and science and technology programs and scholarships, such as those of the Society of Satellite Professionals International (51 out of 94 rated this as a “high priority”)

Initiatives in Tele-Education

Tele-education, distance learning, web-based learning, and sharing of virtual labs among universities were of interest and several fresh ideas were expressed, but none of the initiatives mentioned in the survey received “high priority” ratings. Nevertheless, all but 14 of 92 respondents gave a medium to high priority rating to the suggestion that there be more creative use of web sites and Internet based educational systems to offer training to professionals in the field and to re-certify professional knowledge in the field.

Projected Future Needs in Space Education

Projections of future training and educational needs showed clearly that the space sector requires academic programs in a very broad spectrum of disciplines. Strong support was given for interdisciplinary training and research as well as education in areas such as policy and law and international relations, as well as technical and engineering management and risk assessment.
The areas that projected need at the BS/BA and the MS/MA/PhD levels were as follows:

- Electrical and Computer Engineering
- Computer Science and IT
- Satellite Applications
- Physical Sciences and Math
- Engineering and Technical Management
- Life Sciences-BioTechnology
- Risk Assessment

Those that came out lowest were:

- Astrophysics
- Business, Marketing, MIS
- Operations Research
- Architecture and Systems Design
- Chemical and Materials Engineering

The skill areas rated as most desirable for the space sector were:

- Nano-technology and MEMS (57 out of 88 responses were “important” or “highest”)
- Artificial Intelligence and expert systems (53 out of 88 responses were “important or “highest”)
- Risk assessment (43 out of 90 responses were “important or “highest”)
- Robotics and “smart systems” network design (42 out of 88 responses were “important” or “highest”)
- International Engineering/Project Management Skills (37 out of 87 responses were “important or “highest”)

Identification of Key Problems

The respondents agreed there were a number of problems going forward. Three problems emerged as large concerns:

Continued reliance on an international pool of talent. This is perceived to be a key problem for the space sector in light of heightened security concerns. (50 out of 94 respondents indicated significant concerns)
High cost of education in the skilled areas required for work in the space sector. (48 of 92 respondents indicated large concerns)

Recruiting new blood into highly skilled positions in government, industry and academia. (46 of 92 respondents indicated major concerns)

Key Suggestions from Survey Respondents

Almost half of the survey respondents indicated a need for greater cooperation in recruiting young people. Common programs among professional associations, museums, industry, government and the space industry as well as strong academic programs, internships, professional training and re-certification were cited as potential solutions. Strong support was given for distance education, cooperative and intern programs, interdisciplinary projects and multi-disciplinary team activities. The inclusion of topics and materials related to the space sector in National and State competency tests, creation and certification of a new graduate level multi-disciplinary space engineering and management studies program, and creation of new government level space research and education programs or institutes at universities were concrete suggestions offered.

Other suggestions were broader. One respondent thought that the space sector would continue to contract in scope and would only expand again when there was a “new and widely held public vision” of space and what it means to saving the earth’s environment, helping the global economy, giving access to new resources and realizing a mission for humankind’s future role in the solar system and beyond. Another respondent agreed that the space sector would continue to shrink until there was a clear cut demand for new jobs in this area but that educational needs and student enrollment would “take care of themselves” when there was a clear-cut demand for employment and true economic growth in this arena. Most responses were positive. The majority view seemed to be that a higher level of concern together with targeted action with regard to space and related technical education could meet future needs. Respondents seemed to focus on educational programs at the earliest stages and the need for specific improvements at the secondary level in terms of stronger teacher capabilities and training, more counseling, and more internships and specific programs aimed at the 12 to 17 year olds.

PRELIMINARY SURVEY RESULTS

Survey on the Future of Space Education for the
March 2003 Workshop on the Future of Space Education, Washington, DC

Enrollments in science and engineering courses in U.S. colleges and universities peaked at nearly 450,000 in 1982 and have declined to around 350,000 today. During this same period, the number of scientific and engineering jobs in the United States has increased by some 15% and the demand for technical personnel with at least some specialized skill has increased even more rapidly. The net result has been a shortage of people to fill skilled scientific, engineering and technical positions as well as a new pattern of increased overseas recruiting by U.S. aerospace, engineering, scientific and high technology industries. Further, organizations such as NASA, NIST, and other government agencies and some industries are facing a situation where a sizeable percentage of its personnel will retire in the next five years. Further, women and minorities are underrepresented in both enrollment and college graduates in science and technology. Meanwhile the cost of college education continues to rise and many new educational methods and on-line systems are being employed with varying results. Which program initiatives do you support? Please check below those ideas to which you give a low, medium or high rating and also provide us other suggestions.

THE NUMBER IN EACH BOX INDICATES THE NUMBER OF REPLIES RECEIVED TO DATE
(Note: Not all 94 respondents replied to all questions)

MEANS OF IMPROVING HIGHER ED PROGRAMS & ENROLLMENT	LOW	MEDIUM	HIGH
More college scholarships in technical fields	**12**	**23**	**59**
Development of broadly shared computer simulation and modeling tools to allow cost sharing and eliminate duplication in new educational system development	**34**	**45**	**23**
Expand university level interdisciplinary programs and expand undergraduate research opportunities in technical fields	**13**	**51**	**29**
More universities offering technical courses at overseas campuses	**66**	**23**	**5**
More incentives to encourage university faculty to upgrade their skills	**8**	**24**	**62**
More accelerated and special format university educational programs to allow full time employees to upgrade their skills and take advanced degrees more easily	**18**	**35**	**40**
A nationally coordinated program to recruit retirees (via AIAA, AAS, IEEE, etc.) to teach technical courses at universities or community colleges or to help recruit students for science and technology degree programs	**16**	**45**	**32**
Increase government, industry, academic & professional org. partnerships to strengthen technical curriculum, joint educational & research opportunities	**9**	**29**	**55**
Encourage professional societies and industry associations to increase the size and scope of their educational programs and have more joint undertakings with colleges and universities in terms of recruitment & new curriculum development	**11**	**30**	**55**
Increase counseling and support systems for science and technology students in colleges and universities	**18**	**33**	**43**
IMPROVEMENTS AT THE SECONDARY EDUCATION LEVEL			

Upgrade and expand data bases identifying colleges and universities offering space education and science and technology programs as well as scholarships	**20**	**23**	**51**
Increase counseling and support systems for science and technology programs in secondary education (using school, industry, & prof. association resources)	**14**	**18**	**61**
Create new mechanisms to allow universities, colleges, professional associations, government agencies, science museums and industry to work together to enhance interest of secondary school students in science and technology and to recruit good students for colleges and universities (e.g. Space Day at NASM)	**6**	**28**	**58**
New types of incentive programs for summer research projects, museum activities, contests, group projects, etc. to attractive high school students into science & technology fields in college	**7**	**45**	**42**
IMPROVEMENTS IN TRAINING AND DISTANCE EDUCATION			
More distance education programs in technical fields in partnership with NASA, NSF or other Government programs or with AIAA, AAS, IEEE, SSPI	**22**	**48**	**22**
More certificate programs that provide the very latest updates in specific fields, and in-effect, offer just-in-time instruction on state-of-the-art developments	**23**	**49**	**20**
More creative use of web sites and Internet based education to offer training to professionals in the field as well as re-certification of current professional knowledge	**14**	**50**	**28**

**Workshop Sponsors*: A broad coalition of over twenty different governmental agencies, universities, professional organizations, aerospace and media companies are supporting this space education workshop and research project. One can visit the PBI Media web site for more details about the sponsors and the Workshop event to be held in March 2002 in Washington, D.C.

2. The space and satellite fields are highly interdisciplinary and require many skills. Please indicate by checking below where you foresee over the next ten years a need for college level or graduate degree level personnel.

Desired Discipline Area	BA or BS Low Level Need	BA or BS Medium Level Need	BA or BS High Level Need	MS or PhD Low Level Need	MS or PhD Medium Level Need	MS or PhD High Level Need
Aerospace Engineering.	**13**	**34**	**45**	**9**	**47**	**36**
Chemical & Materials Engineering	**15**	**48**	**28**	**8**	**45**	**28**
Physical Sciences & Math	**8**	**36**	**45**	**17**	**30**	**42**
Astrophysics	**28**	**38**	**22**	**38**	**25**	**24**
Electrical Eng., IT & Telecommunications	**6**	**28**	**58**	**7**	**26**	**57**
Space Applications (Remote Sensing, satcom,etc)	**11**	**23**	**56**	**4**	**32**	**56**
Mechanical & Civil Engineering & Robotics	**13**	**45**	**32**	**9**	**44**	**35**
Computer Science						
Life Sciences and BioTechnology	**6**	**37**	**46**	**3**	**29**	**59**
Engineering or Technology Management	**12**	**30**	**59**	**16**	**39**	**35**
Other Degree Programs of Interest						
Architecture and Systems Design	**24**	**39**	**27**	**25**	**45**	**19**
Operational Research	**29**	**32**	**28**	**36**	**35**	**20**
Business, Marketing, Contract Admin. and MIS/CIS	**33**	**31**	**25**	**38**	**32**	**18**
Contract, Patent, Internat'l & Other Law	**11**	**37**	**40**	**18**	**36**	**34**
Key Skill Areas	Lowest Level Need	Lower Level Need	Moderate Level Need	Higher Level Need	Important Level Need	Highest Level Need
Nano-Technology and MEMS Systems	**--**	**3**	**10**	**19**	**30**	**27**
Robotics & Smart Systems Net Design	**--**	**4**	**18**	**24**	**23**	**19**
Space Mission Design & Micro-gravity	**3**	**8**	**18**	**22**	**22**	**16**

Computer Aided Design	**--**	**8**	**28**	**35**	**9**	**8**
Artificial Intelligence & Expert Systems	**--**	**--**	**13**	**22**	**23**	**30**
Risk Assessment	**--**	**3**	**16**	**28**	**19**	**24**
Computer Prog (C++). & Data Base Mgt	**2**	**9**	**23**	**29**	**18**	**5**
Internet, HTTP & Computer Graphics	**5**	**14**	**24**	**25**	**16**	**2**
Languages (Sp., Fr, Ger. Chinese, etc.)	**3**	**33**	**19**	**17**	**12**	**3**
International & Eng/Project Mgt. Skills	**==**	**17**	**12**	**21**	**23**	**14**
BioInformatics	**4**	**12**	**28**	**20**	**13**	**9**

3. What do you see as the biggest problem or issue to be faced in education and training for the space and satellite industry?

- ❑ Keeping current workforce up to date with new technology and knowledge in the field? (70% of all information in our global society has been created since the start of the Internet and is currently doubling every 3 years. This means 16 times more information than we have today by 2015.) _16_ Minor _53_ Medium_23_Large Problem/Issue
- ❑ Recruiting skill level positions to meet future government, industry or academic needs in the space and satellite industry. _10_ Minor _36_ Medium 46_Large Problem
- ❑ Relying more and more heavily of international pool of talent in spite of problems with security clearances, terrorist concerns, home leave, etc. _20_Minor __24_ Medium _50_Large Problem/Issue
- ❑ Academic and training institutions not being able to provide the range, breadth, depth, specific skills and timeliness of curriculum needed to meet future development and implementation needs. . _11_ Minor _62__ Medium _19__Large Problem/Issue
  - ❑ High and rising cost of education and training. 17- Minor __26_ Medium _48_Large Problem/Issues
  - ❑ Lack of personnel trained to work in interdisciplinary teams, international cultures, and at systems design and management levels. _18_ Minor _48__ Medium _25_Large Problem/Issue

4. If you could make one improvement or create one new mechanism or process to improve space and satellite related education and training what would you do and how could this be best implemented?

1. Develop space educational programs for establishing a Moon and/or Mars colony that includes social sciences, psychology, architecture, etc.
2. Insert space and space science related requirements into State and National Competency Tests
3. More interdisciplinary and team related projects into academic programs (3 times)
4. Create a true space engineering and management degree program that covers electrical, chemical and mechanical engineering, management, economics, etc. (e.g. build on ISU example)
5. More government, school and university emphasis on improving math, science and engineering skills (2)
6. Expose secondary school teachers to space related projects, opportunities, study programs
7. More emphasis on recruiting and training better secondary school teachers especially in math and science (2)
8. Start much earlier, galvanize interest in space among K-6 students and teachers.
9. Rebuild the space industry. Aerospace jobs are "now unattractive" and will remain so until there is real economic growth in the space sector.
10. Increase government support to technical and space education and research (NASA, NSF, NAS, etc.)
11. More collaboration between government, industry, academia and professional groups to increase public awareness of the importance and potential of space.
12. Space sector leaders should speak out more (like Senator Glenn) about the need to improve the quality of technical education in the U.S.
13. More government, industry, professional group, museum, and education collaboration to create internships, scholarship, coop programs, etc. in the space and related fields
14. Expand coop programs (6 months or longer) in aerospace industry (2)
15. Develop a new cadre of teachers in the US with a "vision" of the importance of space to America's future (2).
16. Aerospace jobs and new space programs are needed to rebuild the industry and attract students.
17. People trained in space will continue to switch to other fields if there is not a new vision and new growth in this sector
18. The various parts of the space sector need to work together more to renew space education programs in the U.S.