President's Commission on Implementation of United States Space Exploration Policy

Dayton, Ohio
March 3-4, 2004

PUBLIC MEETING MINUTES

Approved:

Steven G. Schmidt
Executive Director

Approved:

The Honorable E.C. "Pete" Aldridge, Jr.
Chairman

President's Commission on Implementation of United States Space Exploration Policy
Air Force Museum, Space Gallery
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Welcome and Introductions

Mr. Pete Aldridge, Chairman of the President's Commission on Implementation of U.S. Space Exploration Policy, welcomed attendees to the Commission's second Public Hearing and expressed his delight in holding the first hearing outside of Washington here in the Dayton area. He introduced his fellow Commissioners:

- Ms. Carly Fiorina, chairperson and chief executive officer of Hewlett Packard, which she joined in July 1999. Her roots are deep in technology, having served in senior executive leadership positions at AT&T and Lucent Technologies.

- Mr. Michael Jackson, senior vice president for AECOM Technology Corporation. He is a former U.S. Department of Transportation Deputy Secretary.

- Dr. Laurie Leshin, Director of the Arizona State University Center for Meteorite Studies and the Dee and John Whiteman Dean's Distinguished Professor of geological sciences at the University. Her research is focuses on understanding the formation and evolution of our solar system and its planets. She currently leads a team that is designing a potential mission to Mars for collection of Mars soil samples.

- General Les Lyles, former commander of the Air Force Materiel Command. He was in the Air Force for more than 35 years, rising from the Air Force ROTC program to become a four star general. He has been involved in space throughout his career.

- Dr. Paul Spudis, planetary scientist at the Johns Hopkins University Applied Physics Laboratory. His specialty is the geology of the moon, and he has studied the geology of Mars, Mercury, and many other worlds.

- Dr. Neil Tyson, astrophysicist and the Frederick P. Rose Director of the Hayden Planetarium in New York City. His professional research interests include star formation, exploding stars, dwarf galaxies, and the structure of The Milky Way.

- The Honorable Robert Walker, chairman and chief executive officer of The Wexler & Walker Public Policy Associates, a firm specializing in telecommunications and technology issues. He served in the Congress of the United States from 1977 to 1997, representing his home state of Pennsylvania. While in Congress he served as the Chairman of the House Science and Technology Committee.

- Dr. Maria Zuber, E. A. Griswold Professor of Geophysics and Planetary Sciences at the Massachusetts Institute of Technology and leader of the Department of Earth, Atmospheric and Planetary Sciences. Dr. Zuber has been involved in more than half a dozen NASA planetary missions aimed at mapping the moon, Mars, Mercury, and several asteroids.

- Executive Director of the Commission, Mr. Steven Schmidt. He serves as special assistant to the NASA administrator and is the Federally Designated Official for this Presidential advisory committee.

Mr. Aldridge reviewed the process of the Commission. It has been appointed by the President to make recommendations on how to implement the space vision (referred to as the Vision), which he set out on January 14, 2004. The Commission has been given firm direction, and its job is to recommend the most important strategies to accomplish the Vision. It will be a sustained journey, spanning many presidential terms. The Commission will draw on its expertise, as well as listen to experts and the public, to generate this plan. Through its Web site—www.moontomars.org—it will be accepting comments from people around the world. More than 4,700 responses have been received on the website to date. Every input is being read. About 75 percent of those contacting the Commission have been in favor of this sustained journey. Many of those who express concerns, was also because of cost. The Commission must make recommendations that are affordable and sustainable over several decades. It is looking at its task through four themes or approaches: management structure for such a large project; inspiration of the nation's young people; the science agenda for the next several decades; and strategies to ensure the nation's competitiveness and maintain its prosperity. In addition to Dayton, the Commission plans to visit three additional cities: Atlanta, Georgia, San Francisco, California, and New York City, New York. It will prepare its report and present it to the President and the NASA Administrator, 120 days after its first meeting (June 7, 2004).

Mr. Aldridge acknowledged the support and effort of the many people in Dayton who made it possible for the Commission to be there, including the Air Force Materiel Command under General Gary Martin, General Metcalf, formerly with the U.S. Air Force Research Lab (AFRL), and the U.S. Air Force Space Museum, the host of the Hearing. He also acknowledged the presence of the students from the Hadley E. Watts Middle School in Centerville, Ohio, who have been studying space exploration as part of their curriculum.

Mr. Aldridge introduce the members of the first panel on "Inspiring Youth and Improving Science/Math Literacy": Dr. Patricia Arnold, vice president of education at the U.S. Space foundation; Ms. Margaret Finarelli, vice president of the North American operations of the International Space University (ISU) in Strasbourg, France; Dr. June Scobee Rodgers, founding chairperson of the Challenger Center for Space Science Education, and Mr. Brett Williams, a teacher from the Fredericksburg High School Aeroscience Program, Fredericksburg, Texas.

Dr. Arnold testified on the importance of education and the role the NASA and the U.S. space exploration plan might play in the renaissance of education. The reinvention of education must start with the very youngest student, beginning in preschool and building through the graduate school programs. Dr. Arnold proposed an approach and structure through which NASA could

have the greatest impact on education—consolidation of all NASA education-related activities into a lean and professional Office of Education Outreach. She explored the differences between the current NASA education program and her suggested Office. This Office would be small and highly focused, rather than a large bureaucracy. It would serve as an effective liaison with education, educators, and information multiplier organizations, with oversight and guidance provided by a NASA-funded but independent national board of advisors who would recommend how best to deploy NASA resources through outside suppliers to excite and support educators and students in science, technology, engineering, and mathematics (STEM) content proficiency and to best prepare the next generation for participation in space exploration. NASA human resources should be used in assisting with developing the most valuable partnerships and collaborations with museums, science centers, and libraries in a non-bureaucratic way to better support student learning. Dr. Arnold's written testimony explained the essential responsibilities of the advisory board as well as the management and organization of the proposed Office of Education Outreach. She emphasized that project and program managers must act as a support team for education programs rather than being non-participants, and must be willing to be an active advocate for student learning. The U.S. space exploration vision can also be a catalyst for teacher professional development, which is necessary to ensure that students receive quality STEM instruction.

Ms. Finarelli talked about the special roles that the ISU might play in implementing the President's space exploration initiative. ISU has a unique academic program for developing skills for working in international, intercultural environments and produces some of the most enthusiastic young people in the space business today. The skills of ISU graduates will help space agencies and aerospace companies in the U.S. and around the world as the space exploration initiative is implemented. ISU does not focus in in-depth discipline training—its emphasis is on how all of the various pieces—science, technology, engineering, management, legal, etc., contribute to the successes of the space program. The curriculum is an interdisciplinary graduate level one that addresses all aspects of space endeavors—space science, space engineering, systems engineering, business management, space policy, space law, and space and society. It also provides a variety of opportunities for students to learn to work effectively and efficiently in international teams. Ms. Finarelli highlighted some of the programs research projects, including one last year that looked at lunar exploration missions utilizing International Space Station (ISS) capabilities. Students come from 25 to 30 different countries, with about 20 percent of them coming from the U.S. Since the late 1980s, ISU has produced more than 2,000 alumni from 85 countries. Ms. Finarelli stated that the ISU "network" is one of its most important products. The network enables alumni to share communications and promotes and facilitates international cooperation. These graduates also have the drive and enthusiasm to help with the Commission's goal of sustaining public interest in exploration.

Dr. Rodgers discussed the 52 Challenger learning centers that are located in the U.S., Canada, and England. Each of these Centers reaches 200 to 300 schools. Children at the learning centers participate in mission simulation. They problem solve and find solutions, working collaboratively with team members. For the past 17 years, these students have been voyaging to Mars and returning to the Moon many times over. These national standards-based missions, always relevant, have now become very timely. Dr. Rodgers recounted how inspiring the Challenger learning centers have been for countless students. The Challenger Center is at the

forefront of space science education for elementary and middle school students through its partnership with NASA, the Smithsonian Institution, and Harvard University. Its programs are found in major urban areas and in rural communities with little access to science resources. Through its work in distance learning, children in even the most remote parts of Alaska are able to venture to distant planets. Students may leave from different locations, different backgrounds and different circumstances, but they all arrive at the same place of discovery and adventure—on a career path of excitement, helping the nation. There is much more work to be done to fulfill the President's Vision. Dr. Rodgers offered the resources and education programs of the Challenger Center as a critical first step to inspire and teach students science technology, engineering and mathematics.

Mr. Williams introduced his testimony with a brief video capturing some highlights of his high school's suborbital aeroscience studies program—500-pound hyper-propelled sounding rockets, capable of achieving twice the speed of sound and lofting 35-pound research packages to altitudes between 88,000 and 100,000 feet. The 60-foot launch tower was loaned to the program from the AFRL; the launch facility was provided through an educational agreement with the U.S. Army's White Sands Missile Range. Everything was done entirely by the students, including the design of the vehicles.

The Fredericksburg aeroscience program teaches the basics of physics and engineering through hands-on research design and development. The main foundation of the program is to develop research-capable vehicles to loft university research packages at a cost difference of pennies to the dollar. Universities become involved in collaborative research projects, thereby introducing the Fredericksburg students to pathways from university's research to industry. In addition, the program develops life skills like critical thinking, problem solving, design and development, communication skills, teamwork, grant report writing, budgets and acquisition, and industry specialties. In addition, the program develops life-long learners. Students are able to apply what they have learned, problem solve, and learn to teach themselves. Today, Fredericksburg High School is the only high school in the United States capable of putting a 35-pound package to research altitudes for universities. Eighty percent of the students in the program go into engineering with about 10 to 20 percent of those going into aerospace specifically. Mr. Williams described some of the current partnerships with industry and the military. Data is showing that the average student SAT score at Fredericksburg High School has increased by over 150 points since the start of this program. By becoming a state program in two years, Texas has the ability to produce hundreds, if not thousands of engineers by the year 2010. The program can be replicated and disseminated. Mr. Williams stated that his recommendation for the Moon to Mars initiative, besides his program, is to develop the needed aerospace workforce by supporting public education through the promotion of hands-on problem-based application of core curriculums to support relevant core classes. He also recommended that high school academia and vocational courses be brought together to produce the project leaders and engineers needed for the President's Vision.

Mr. Aldridge opened the questions with one related to the Vision as a national program. He asked the panelists if there is some aspect of the educational outreach program that should take on a more national perspective as opposed to a NASA perspective. Dr. Arnold indicated that she had targeted NASA because NASA already has some education outreach programs and would

have the ability to partner with different federal departments and agencies, institutions, and businesses. It already has an infrastructure. She noted that the kinds of programs discussed today are those that should be replicated and broadened so that they are of a national base. The Office she proposes would be aligned very closely with educators and education across the country and have the ability to do the kind of partnering that was discussed. NASA has the capability of doing that, but it will require a more intimate and attached kind of relationship, not a bureaucratic one that just looks at the paperwork. Project managers need to be actively engaged and be a supporter and an advocate in order for the programs to really take off.

Dr. Rodgers added that she would like to see the U.S. Department of Education very much involved, rather than mandating certain kinds of reading advantages; that they provide the leadership in inspiring professional development for teachers and exciting curriculum and lessons that can be provided for the classroom, and that they work to influence textbook writers who now are cutting out a lot of the science laboratory, hands-on work to focus on test taking.

Mr. Aldridge asked Ms. Finarelli if there is something about the model of the ISU that might be directly applicable to supporting the President's Vision, e.g., a university dedicated to this type of objective that would be US-only. Ms. Finarelli commented that one of the great powers of the education at ISU is the international dimension. It would not be necessary to replicate the ISU model for US only; in fact, it would lose something. The university as it stands is excellent. Perhaps there could be additional programs that promote international activities. Probably the biggest limiter is the number of students that can all interact effectively. In the summer program, that is about 100 and the students are divided into two and more recently three design projects. It is in those design projects that the students are having really intense interaction.

Gen. Lyles asked about any ties between the Space Foundation and the ISU, and the Challenger Center and the Fredericksburg High School aeroscience program. Dr. Arnold noted that the Space Foundation and The Challenger Center partner and do many things to reinforce, sustain, and promote each other. Ms. Finarelli commented that one of the advantages of pulling together panels like this is to hear about one another's programs, discuss ideas, and perhaps have some impact down the road. In response to a question about the One-NASA program and current outreach activities as a step along the way, Dr. Arnold indicated that her proposal is radically different. NASA education has become huge and there are so many different programs going on the even NASA doesn't always know. The most critical point is the spiraling curriculum idea. Space can be a catalyst for learning in literacy, math, science, and should happen every year from the time children are in pre-school through post graduate school.

Mr. Walker asked the panelists how the Moon to Mars and Beyond mission could contribute to the evolution of lifetime education that would inspire interest in moving outside of traditional jobs into the higher tech jobs that the country wants to be competitive in for the future.
Dr. Rodgers cited the Challenger learning center simulators, where there could be opportunities for new career paths with youngsters. Dr. Arnold noted that the NASA educator resource center at the Foundation's headquarters in Colorado Springs, Colorado, has received many calls since the President spoke, and people who have no connection with education have come in to check out materials. In addition, the space college career fair has seen people in mid-life interested in

learning more. People are showing interest in making career changes and are asking for help about the kind of support that they can get to do so.

Dr. Zuber asked Mr. Williams to comment on how math, chemistry, and physics are mixed into his curriculum so that the students are taught in a way that enables them to apply and get into good engineering colleges. He acknowledged that his program is going across the current right now when it comes to public education. Because of the need for students to be taught certain things within a certain amount of time, there really is no opportunity to attempt unique endeavors with student or to try to stimulate them in terms of finding a passion or developing an interest in any type of career pathway. Mr. Williams stated that he puts a great deal of emphasis on students being able to teach themselves in the future, understanding research as a way to solve problems. His students learn project management skills. This approach does not fit education right now in terms of what the US education agency wants to see. When it comes to chemistry, physics, biology, etc., there is a need for ancillary support classes. There is no reason why these classes cannot be there to support the core classes.

In response to a question from Dr. Spudis, Dr. Rodgers indicated that the funding for the Challenger Center is largely private, but some public. There is a small amount of NASA money, and a request has been made for more. The biggest problem is not having enough money. For several years, the Center was able to get $1 million a year from congress to work through the national operations. Aerospace industry has also worked with the Center. No one has dictated what the curriculum must be. The Center was allowed to work along the lines of the national-base standards.

Dr. Tyson asked Mr. Williams if he thought that the Vision would be sufficient to stimulate intense interest in going into space, or whether these programs must be relied upon to get the pipeline filled. Mr. Williams noted that he did not have a degree in engineering or physics. When it comes to the teachers capable of replicating this program, any one of them could do it, but it takes a teacher that has a strong interest in the future of the student. Dr. Arnold agreed. She commented that over the last 20 years, the Space Foundation has trained over 30,000 teachers. Through about seventh grade, teachers have not had good training in science and math and they lack skill training and context knowledge. However, teachers want to learn and will do that if the opportunity is provided for them. It would be good if there were additional funding so teachers could get the training that they need. It is not hard to excite students. If a teacher is knowledgeable and interesting, the kids will love it.

In response to a question from Dr. Leshin regarding where the students in the ISU go to work, Ms. Finarelli stated that most of the people from ISU stay in the space field because that is their passion. She noted that in this society, everybody's got to have some level of technological literacy so that they can form opinions on the issues of the day, whether they're environmental issues or whether they're issues about supporting the space initiative, energy issues, etc. There is an opportunity to impact society in a broader way. ISU recruits about two-thirds of its students from science and engineering fields, but it also has people who want to go into public advocacy, and may have other backgrounds, e.g., legal, journalism, etc. Mr. Williams indicated that in his program, the students go into everything from ordinance officers on naval vessels to private aerospace industry. Two students now look like they are heading into the astronaut program.

With respect to a national consortium, Mr. Williams noted that he had spoken to Mr. Jim Pruett at MSFC, who heads up the education division there. There is a need for some type of national avenue or path where people could find out what is in their area, what is available to them in terms of private or public careers. Mr. Williams added that an annual conference is something that he is looking into in Fredericksburg. The business plan has been finished, and the next step is to present some local funding opportunities.

Dr. Tyson brought up the question of the relatively low throughput for the programs described by Dr. Rodgers and Mr. Williams, noting that New York City school system has a million children. He observed that perhaps not all programs are scalable into the needed regimes. Perhaps there needs to be another level of creative thinking. Mr. Williams responded that the Fredericksburg program is three-tiered. Some schools may not want to go to the third level (rocket launch). One of the things in progress now is the promotion of a spaceport proposal from every state.

After a brief break, Mr. Aldridge introduced the members of the second panel, "Creating Prosperity and Fostering a Competitive Environment." Dr. Daniel Curran, President of the University of Dayton; Mr. Mike Cross, a project manager at Ball Aerospace; Mr. Richard Omlor, President and Chief Executive Officer of YSI, Inc.; and Dr. Vincent Russo, former Executive Director of the Aeronautical Systems Center at Wright-Patterson Air Force Base.

Dr. Curran briefly described some of the work at the University of Dayton's Research Institute (UDRI)—research on space debris impacts, microgravity heat transfer, spacecraft batteries, nanomaterials applicable to space platforms. The UDRI is a research partner with Wright-Patterson Air Force Base. Researchers are also helping the AFRL develop concepts for a rapidly reusable space vehicle. Dr. Curran noted that the UDRI has a long history of working with NASA, the AFRL, and other major aerospace companies in the areas of advanced material, power, and propulsion research. He noted that while scientific and educational communities strongly support the President's proposed space policy, they do so with a reservation that they also want to maintain the current level of aeronautical research funding, and insure that Wright-Patterson Air Force Base is included in any renewed space exploration efforts. The AFRL has enjoyed a long-standing successful partnership with NASA and aerospace research and space science and technology. Dr. Curran cited some examples of successful partnerships, including recent assistance with the Columbia accident investigation and development of microprocessor and lithium ion batters for use in the Mars rovers. The Air Force and NASA needs a number of fundamental and common aeronautical and space technologies, such as hypersonics, air and space vehicle structures, high temperature material, rocket propulsion, solar arrays, computer processes and the like. Future partnerships between the AFRL and NASA include reusable metallic and ceramic propellant tankage, ground operations, rocket propulsion, thermal protection systems, and power generation management and application. The Air Force considers these critical to the next generation of military and civil space operations. Dr. Curran stated that the prosperity and continuing economic growth in Dayton are tied to continued support by NASA of these areas of research that are also very important to the Air Force. It is the hope of the community that as the President implements his space initiatives that the partnerships between NASA and the Air Force will be increased in this area. The collaborations between government, academia, and industry will build strong world-class capacities that will support future space exploration. It will also lead to thousands of high-paying science jobs and

technology jobs in southwest Ohio. That is the kind of prosperity that Dayton hopes will result from an ambitious space program. A revitalized space program will fuel the growth of the high-tech jobs that are not only based in Ohio but across the nation. The new technology that results from this investment has tremendous potential for commercialization both by the military and by the private sector. Dr. Curran concluded by stating that the University of Dayton and its regional partners have educational programs in place to support the education and training of the new workforce that will be required to respond to the new directions in space.

Mr. Cross testified on the increased opportunities for growth at Wright-Patterson Air Force Base in the areas of science, technology, and research that would be afforded by the President's Moon, Mars, and Beyond policy. He asserted that this policy would lead to innovation in the areas that aerospace currently works in such as materials, propulsion, sensors, information technologies, human effectiveness concepts and aerospace technologies, and will lead directly to the success of a renewed vision for space as well as increased competitiveness and prosperity in the Dayton area. The Ball Aerospace-Dayton operation supports both the AFRL and the National Space and Intelligence Center. One other area of expected growth is in the area of information technologies modeling in simulation applications and collaborative enterprises. Mr. Cross discussed some of the innovative tools that the Dayton operations can offer, and noted that the space program could benefit from these technologies and concepts. In addition, many spin-off applications from investments are anticipated.

Mr. Cross expressed concern over the possible reallocation of research funds from NASA's earth and space science research programs and the Air Force's aeronautical research. He stated that such reallocations have the potential to have adverse impact on Wright Patterson Air Force Base and the adjoining Dayton technology communities. Mr. Cross concluded his remarks by asserting that Ball Aerospace-Dayton stands ready to support the President's space initiatives.

Mr. Omlor addressed the Commission on behalf of the 350 employee-owners YSI, which has been making technological contributions to the aerospace industry for six decades. He stated that his testimony, as well as others at this Hearing, would verify that the leaders in industry, academia, and the military in the Dayton region and elsewhere fully support a revitalized space program. Mr. Omlor highlighted some of the work that YSI has done for NASA space missions and noted work that is currently being done or is planned. YSI's work in aerospace has helped it expand into the medical technology and environmental science markets. Mr. Omlor noted that YSI maintains 100 percent of its critical manufacturing in the US, providing jobs, revenue, and a secure supply chain. He stated that the country's economy and quality of life would continue to improve directly and indirectly from a revitalized space program. Mr. Omlor observed that the people testifying on this panel had all working together, some of them for decades. With respect to what a renewed space program look like, he opined that it would have to include a closer collaboration between NASA and the Air Force, among others, for economic reasons as well as strategic purposes. The goals should include not only how the achievement would advance the understanding and use of space, but also how and where the goals could contribute to life on Earth. Mr. Omlor concluded by noting YSI's corporate directive, "who is minding the planet," which speaks to its ongoing commitment to making life better.

Dr. Russo stated that his testimony was based on a 41-year career in science, technology, and acquisition of aerospace systems, including leading the team that created the AFRL. His testimony covered three main points: how to get off the Earth's surface in order to explore the Moon, Mars, and Beyond; a national program that benefits both NASA and the Air Force; and where the leadership of a national program should be centered. Dr. Russo noted that he was a member of a joint Air Force-NASA study on access to space. He personally felt that there did not seem to be a balanced look at the two major alternate ways to get to space: with rockets, or with airplane-like two-stage systems. He noted that at that time, both NASA and the Air Force appeared to prefer a rocket-based approach. Dr. Russo presented his argument for a two-stage system. He stated that the technology for such a system is now at hand, and these technologies are the same ones the USAF could use for a future strike system. Dr. Russo clarified what he meant by airplane-like access to space—a first stage of a two-stage system, highly reliable with very short turn-around times, launched on demand versus on schedule, easily maintained, and able to use multiple existing runways. Dr. Russo felt that this system could be built within a timeframe of interest to the Commission. With respect to his second point, Dr. Russo stated his belief that the country cannot afford a parallel development of both a new access to space vehicle and a strong defense program aimed at future strike. Since the technologies for both applications are so similar, close cooperation is mandatory. Dr. Russo recommended that NASA and the Air Force undertake a joint program, with shared leadership by both NASA and the USAF.
Dr. Russo felt that the leadership of such a national program should be centered in the Dayton area. He stated that this area is where all of the military and many of the commercial innovations in aeronautics have occurred. All of the air force's airplane programs and high-speed programs from Dynasoar to the National Aerospace Plane were led from here. The people who have the detailed knowledge of how to do systems engineering, technology development, and technology transition are here. The people who know how to manage the complex systems development are here. The people who provide contracted-for technical and managerial support are here. The educational systems to continue developing the critical intellectual property, including the highly innovative Wright Brothers Institutes, are here. The facilities and infrastructure are here. The community support is here, and of extreme importance and maybe most important, the desire is here.

Mr. Aldridge asked the panelists what they would tell a taxpayer if they had only two minutes to explain why we are doing this program (i.e., the "elevator" speech).

Dr. Curran indicated that he would point to the future and look at the global economy. He would also talk about the commercialization of technology. It is an issue of standard of living. He would point to education, tech transfers, and talk about the partnerships between aerospace, corporations, and higher education. This synergy works for the nation.

Mr. Cross commented that he would address it from the perspective of what it takes as a leader of the operations here in Dayton to inspire people. One of the greatest inspirations is innovation—the ability to innovate, to create, to think outside the box, to come up with new ideas. One of the elements of selling the program in the "elevator speech" would be innovation. This vision offers that kind of inspiration for people. The second element would be the level of spin-off technologies and spin-off systems and ideas that have affected and benefited our culture, such as health programs, automobile industries, etc.

Mr. Omlor responded that in addition to what Dr. Curran and Mr. Cross said, he would note that the program helps the economy, gives the U.S. a sustainable competitive advantage globally. This story needs to be played out more. However, the single biggest thing is the technological advantages and how they will benefit mankind on the planet—new energy sources, cleaning up the environment, etc. That is the real selling point. Keeping the communications flowing across a number of administrations is another critical piece. A third piece is getting the commercial partners to really play their part—to communicate effectively as jobs and technologies are created.

Dr. Russo reminded the Commission that they have an audacious goal—to specify what the vision means to the individual taxpayers in this country. In addition to what has been said, it is not going to be enough to have a loose confederation of government agencies leading this vision. There needs to be a single point for the initiative—some organization must take the responsibility to make it happen.

In response to a question from Dr. Tyson regarding the return on investment message, Dr. Curran agreed that people have to know the return and that there's been a failure to adequately articulate the technology transfer and commercialization opportunity and collaboration messages. We have to articulate what the future will bring. Dayton is a prime example of the collaboration between corporations, the Air Force, and academia.

Dr. Spudis observed that NASA has tried to use the spin-off argument for years and it has not been very successful for two reasons—it has been trivialized, e.g., Tang or Velcro, and the counter arguments that the technology would have been achieved anyway through other means. He asked he panelists to comment on these problems. Mr. Cross indicated that there has not been good communication on the spin-offs that are near and dear to the culture—the technology itself is discussed, but the utility part is sometimes missed. Dr. Russo observed that NASA could learn some lessons from its commercial counterparts—NASA should do some advertising. Mr. Omlor added that there is a significant opportunity to take what the military partners and commercial partners have to offer and pool that research in developing new technologies.

In response to a question from Mr. Walker regarding the near-term feasibility of airplane-like access to space, Dr. Russo indicated that he has spent considerable time over the past five years studying this issue. In his opinion, the technology is not 10 to 15 to 20 years away, as some people claim. The real story is not being heard because of the interest and the bias towards rocket approaches. The vehicle could be built out of today's conventional materials and today's structural concepts.

Mr. Walker asked Mr. Cross to comment on the possible reallocation of monies inside of NASA in order to have a new program. Mr. Cross replied that there would be opportunities where aerospace and the technologies needed to implement the Vision could be complementary. The technologies could be leveraged from aerospace for implementation of the Vision. For example, where an air vehicle is used to get to space, aerospace research technologies could be used for this initiative. Dr. Russo added that it would be very hard to afford both a rocket and an airplane-like program. It depends on how we want to get to Mars and beyond—with one big

push from Earth, or through smaller steps. The disadvantage of aircraft is not as much boost at one event. There would have to be stages to get to the ultimate destination. There will still be a need for rockets, particularly in the second stage. The programs need to be coupled closely—what is done on the second stage dictates what should be done on the first stage. There are not enough resources to build both a new rocket program and a new single staged vehicle.

Dr. Fiorina asked the panelists to comment on whether the Commission should be considering a potentially different role for the private sector, given the issue with sustainability over multiple presidents and multiple budget cycles. Dr. Curran felt that his research organization could take a leadership role as a commercial entity. It has a unique perspective and position and could do that without political boundaries.

Mr. Aldridge introduced the last panel of the day on aerospace medicine: Dr. Stanley Mohler, professor of aerospace medicine and vice-chair of community health at the Wright State University School of Medicine, and Dr. Mary Ann Frey, professor emeritus at the school of aerospace medicine.

Dr. Mohler gave a brief history of the school of aerospace medicine. The role of the program is to look at the limits on what humans can expect to do in space. Dr. Mohler referred to his written testimony for key data archive references that supply information on successfully going to the Moon. Many aspects are already understood. He noted that from the medical standpoint, there is further research to be done, but he did not see any "show-stoppers" to going back to the Moon. Dr. Mohler provided some comments on a late development Mars habitation.

Dr. Frey agreed that the Vision could be an inspiration and a unifier for the people of the U.S. and the world. However, exploration has risks, and she discussed some of the specific risks associated with the vision to send men and women to the Moon and Mars. The risks come from at least four sources: the reduced gravity environment (fluid shifts in the body, loss of normal stress on the bones and muscles, changes in stimuli to the nervous system); the environment inside the vehicle or habitat (floating particles, toxic wastes, poor illumination, loud noise, thermal control); the environment outside the vehicle or habitat (radiation, meteorites or other debris); and psychological and psychosocial stresses. Two risk factors that will rise to major importance for long distance long-duration journeys are the psychological and psychosocial challenges and radiation. Interpersonal and group dynamics for intercultural and intergender groups must be understood and appropriate countermeasures developed. We must learn more about radiation, about its effects on humans, including cancers and genetic problems and cataracts and how to provide effective shielding and other protective countermeasures. Other risks of space flight, which have been of concern in the short-duration missions of the past and present, will be much great in the exploratory missions of the future. A related daunting challenge that is critical to astronaut health on a mission to Mars is the necessity for advanced life support capability. This includes a closed system for oxygen, water and food, and an effective waste management system. There is also the very important challenge of providing medical care on an exploration mission. The ISS will be of major importance for testing counter measures and for some of the research required to understand the threats and to develop countermeasures. However, the ISS will not be a useful platform unless it has a crew of at least seven, allowing at least four to five crewmembers to be researchers and subjects. It must also

have necessary laboratory facilities. The Moon could be a valuable laboratory for some research, and for some countermeasure testing for Mars. A much greater level of commitment and of funding for biomedical research and countermeasure research and development must be made than has ever existed before.

In response to a question from Mr. Aldridge, Dr. Frey noted that the ISS was planned to have seven member crews, with two members to keep things running and the rest devoted to research. To obtain enough information to learn about risks and develop countermeasures, we need to do this kind of research on the ISS. NASA is doing something on closed cycle life support systems, radiation protection, etc., and is developing a plan for what needs to be done. However, funding in life sciences has always been minimal because it has never been a major concern. This research is very important if we are going to achieve the Vision.

In response to a question from Dr. Zuber regarding the Moon as a stepping-stone for preparing for Mars, Dr. Frey observed that there are things that can be done on the Moon. For example, the radiation environment would be more like the radiation environment on Mars, so some question can be answered on the Moon. For other questions, it is important to find the appropriate and most cost-effective platform for each type of research. The ISS is best for some areas. Some things can be done on the ground.

Dr. Leshin asked about the level to which bioastronautical researchers are partnering with private industry to look at some of the best new diagnostic sensors or the best treatments and incorporate those into NASA's plans. Dr. Frey indicated that there is a lot of working back and forth. The Ames Research Center has been working on development of sensors and sensor technology, and they work with other groups. The Neurolab Spacelab mission was a close cooperation between NASA and the NIH, the NSF, and the ONR. Programs like that have high payoff.

In response to a question from Dr. Tyson regarding protection from solar flares or cosmic rays, Dr. Mohler noted that research into the biological effects of ionizing radiation are continuing at Oakridge, the University of California, Livermore, and other centers. He acknowledged that there is more to learn and more to develop from a shielding standpoint. Solar flares can be partially predicted and the astronauts on the Moon could go into a shielded environment until the storm passes over. A human Mars mission is about 30 years off, and with the evolution of technology and increase in information we should be able to address the issues. The Moon is not going to be a tremendous challenge.

Mr. Aldridge thanked the panel members and adjourned the hearing for the day.

Thursday, March 4, 2004

Mr. Aldridge welcomed the hearing participants and attendees and reviewed the task of the Commission. He briefly introduced all of the Commission members.

The first panel consisted of many people from the Air Force. Mr. Aldridge introduced the panel members: Gen. Greg Martin, Commander of the Air Force Materiel Command;

Lt. Gen. Dan Newton, Vice Commander of the Air Force Space Command from Colorado Springs; and MGen. Paul Nielsen, Commander of the Air Force Research Laboratory.

Gen. Martin discussed the Air Force's past partnership with NASA and commented on three areas where space is absolutely pivotal to the Air Force: the communications network, the ability to achieve persistent surveillance and reconnaissance, and the ability to achieve discriminate effect in near real-time. The Air Force Space Command and the Air Force Materiel Command (AFMC) are the two commands that are responsible for acquiring Air Force systems. The AFRL, which is responsible for all research and technology used in the Air Force, is under the AFMC. Gen. Martin described the AFRL organization and facilities. Many of the technologies developed in conjunction with industry and other national partners are dual use—they can serve both civilian and military purposes. Gen. Martin stated that the Air Force would benefit from the President's national vision for space. At this point, Gen. Martin introduced Gen. Leaf, vice commander of the Air Force Space Command.

Gen. Leaf briefly described some of the military rescues made possible by space capabilities. He concentrated his comments in three areas: the historic partnership between the Air Force and NASA, the operational partnerships that are existing and working today, and how the Air Force and NASA can work together for a future in space as envisioned by the President's Vision. The primary mechanism to formally coordinate between NASA and the department of defense is the Partnership Council. Since 1997, the Partnership Council has been instrumental in facilitating collaborative efforts to streamline operations, to cross utilize facilities and capabilities, to consolidate wherever possible our redundant facilities, to share support services, to leverage science and technology investments, and simply to dialogue with counterparts on other issues like the development of space professionals. Developing space professionals remains the number one priority in Air Force Space Command.

MGen. Nielsen provided a brief overview of the AFRL and how it leads space science for the Air Force, the strong partnerships that the Lab has will all government agencies, especially NASA, and other concerns that the Lab has about the science and engineering workforce. He stated that the Air Force Science Research Lab's science and technology programs have historically been and continue to be a significant source of critical space technology for both the Air Force and the National Reconnaissance Office (NRO). Over the last five years, the AFRL has been moving more money into "unique space technologies." Investments range from basic research to applied research to technical demonstrations. MGen. Nielsen noted some of the technology areas that the AFRL has supported. The Space Technology Alliance is a novel approach where all of the players in the government come together to ensure coordination, collaboration, and planning of research efforts to the best effect for the nation. A joint team currently leads the alliance from the AFRL and the NRO. Not only does AFRL have partnerships direct with NASA Headquarters, but also with many of NASA's Centers. MGen. Nielsen showed the portfolio of space technologies that both the Air Force and NASA need, including hypersonics, structures, high temperature materials, rocket propulsion, solar arrays, computer processors, etc. Many of these technologies will apply to the President's Vision. MGen. Nielsen highlighted some of the existing partnerships with NASA that are at risk right now. These are primarily focused on reusable space access and getting to space at an affordable cost, e.g., propellant tanks, ground operations, rocket propulsion, thermal protection, power generation management and

application. Hypersonics is another area where the AFRL would like NASA to continue its ongoing efforts. With respect to workforce, the senior Air Force leaders are actively and deeply involved in this problem. The AFRL has an innovative personnel demonstration system that has kept the workforce fresh and vital. In addition, the AFRL has a robust science and engineering outreach program that complements the NASA program and spans K-12, undergraduate, graduate and post-graduate education. MGen. Nielsen stated that the AFRL looks forward to continuing its broad partnership with NASA.

In response to a question from Mr. Aldridge regarding something that the Commission could do to help stimulate a different approach, if one is necessary, Gen. Leaf indicated that the strong partnerships that have been forged in the past are a good path for the future. The partnerships can continue to work much more interactively and collaboratively. History has said that a vision like this generally works better through strong leadership in a central office.

As a "take-home" assignment, Gen. Lyles asked for MGen. Nielsen to provide his thoughts on the technologies that he thinks are very important for exploration in space, how the Air Force is developing those technologies today, and how it could play a stronger role in those technologies in the future. MGen. Nielsen accepted this as a take-home assignment. Lt. Gen. Newton indicated that he would like Lt. Gen. Brian Arnold in the Space and Missile System Center in Space Command to participate in that assignment. Lt. Gen. Arnold is the focal point for acquisition and systems development and Lt. Gen. Newton felt that they could partner. As a follow-up question, Gen. Lyles asked whether the Partnership Council could benefit from having Gen. Martin as a member because of the technology areas that have to be addressed. Gen. Martin indicated that this would be advantageous. The technologies that benefit both air and space need to be worked together in a partnered way.

In response to a question from Mr. Walker, Lt. Gen. Newton noted that one of the Space Command's key jobs is to anticipate possible adversary action in, from, and against U.S. space capabilities. He offered to go back and take a look at whether there has been specific work done in that regard, and get back with the Commission. In response to Mr. Walker's second question related to the availability of air breathing first-stage capability, MGen. Nielsen felt that there are some interesting concepts for how an air breathing first stage might change the economic equation and the operations of getting to space, but that we are not there yet. There is a fair amount of work that still needs to be done to develop hypersonic engines that would work in the air. Near-term is over promising at this point.

In response to a question from Ms. Fiorina, Lt. Gen. Newton agreed that there are many who express concern at the mere mention of military and space in the same sentence. However, there is a good solid foundation with treaties and international agreements on what we do in and from space. There is a peaceful place for military participation in space, and we can reassure out nation and our international partners that the civil/military partnership is a healthy one. Gen. Martin added that use of space capability has enabled the U.S. to maintain an edge and prevent mass destruction. What has been done so far has been very constructive to world security and peace.

In response to a question from Dr. Zuber about enhancing activities that are not mentioned with the Vision, MGen. Nielsen indicated that the AFRL continues to support the space physics area very strongly. This is an area where the Air Force has in some ways led the nation from the government side. Beneath a vision, there are a lot of enabling technologies, things that have to be done that might not at first be apparent in the Vision.

With respect to military interest in the further reaches of the Vision, Gen. Martin agreed that interest would want as we get more into exploratory versus the reality of security. However, air and space are a seamless medium and we should make sure that we do not separate them in the way that we construct our systems and conduct our operations. Currently, the U.S. military focuses on terrestrial threat; however, eventually the focus will extend out further as years go on.

Mr. Jackson asked the panelists to share their thoughts on what lessons have been learned on how we can draw the private sector in the Vision and how that can be managed.
Lt. Gen. Newton observed that the most difficult and most important thing to get industry involvement is a stable commitment to pursue the Vision. This would give industry confidence that their investment will not be wasted. Gen. Martin added that it would be useful to understand more about what the opportunities are from an economic and business perspective. This has to be a national vision and everyone must believe that there is something at the other end that will not only benefit the nation, but also benefit our way of living.

Mr. Aldridge suggested that Lt. Gen. Arnold be asked to look at this national vision from a management perspective. If he had to approach the management of a project of the magnitude and complexity and duration, how would he go about setting up the management scheme?
Mr. Aldridge indicated that his ideas would be particularly helpful to the Commission. Systems engineering will be a critical part of this particular endeavor. Lt. Gen. Newton accepted this "homework" assignment on behalf of Lt. Gen. Arnold.

In response to a question from Dr. Leshin, Gen. Martin recounted some of the background on acquisition efforts and some of the past problems, specifically the lack of robust systems engineering up front. He noted that the Air Force has rekindled the systems engineering spirit and has put much more emphasis in the Air Force institute technology. The Air Force Materiel Command is now beginning to recruit those kinds of people who will be systems engineers and ensure that there is robust systems engineering across the different functions of the total program. MGen. Nielsen added that Lt. Gen. Arnold has done a great job in Los Angeles in spearheading systems engineering with some of the universities there.

In response to a question from Dr. Spudis, Lt. Gen. Newton indicated that he was not aware of any specific studies on possible use of logistics from the Moon or other space assets. However, discoveries will lead to more opportunity, more interest, and more requirements to invest.

Dr. Tyson asked about protection of Earth from asteroids and whether that is something that NASA should do or whether it should be part of the portfolio of defense as we go forward.
Lt. Gen. Newton commented that this is a key example of the need for partnership. NASA has the expertise, does the exploration, and is more likely to lead the discovery of a threat. Clearly, it

is the responsibility of the military to defend the nation. Perhaps the primary responsibility for global implications will move to the DOD.

Before moving to the next panel, Mr. Aldridge recognized Greenon High School, another high school group that was attending the hearing:

Mr. Aldridge introduced the next panel on "Science and Technology." Dr. Roger Angel, Professor of Astronomy and Optical Sciences at the University of Arizona; Dr. Andy Cheng, Supervisor of the Planetary Exploration Group at Johns Hopkins Applied Physics Laboratory; and Dr. Michael Duke, Director of the Space Combustion Center at the Colorado School of Mines.

Dr. Angel offered his perspective on what the Moon can and cannot do for astronomy. There is a huge new evolution for big telescopes for astronomy—bigger than the James Webb telescope and telescopes that are close to absolute zero. This is something that we cannot do in near-Earth orbit. For this generation of telescopes, we have to look to the Lagrange points or to the Moon, particularly the poles of the Moon. The model we would like to follow is the Hubble. The instruments must be upgraded as the science and the technology changes, but the glass that is collecting the light never becomes obsolete. We would like to have a big telescope that astronauts can refurbish perhaps every decade. Many astronomers are skeptical about telescopes on the Moon because they wonder if the program will last—it is the issue of stability. This is crucial. Unless there is some real advantage to going to the Moon, e.g., there will be people there to help with refurbishment, it is not a very good place to go because of the energy it takes to get anything down to the surface of the moon. If the mass penalty problem could be solved, astronomy on the Moon would be more attractive. Dr. Angel suggested that this problem might be solved if power capability (oxygen and hydrogen from polar ice) could be harnessed to run a reusable "ferry" to and from lunar orbit. Dr. Angel commented that we need to have a vigorous effort to do remote sensing to understand the resources on the Moon. He suggested that the smartest people in the universities get turned on to think about these problems. He challenged people to think about new technologies and specific challenges.

Dr. Duke focused on the topic of use of lunar resources. The Moon's resources consist of minerals and gasses in its rocks and soil. There may be larger concentrations of hydrogen and perhaps carbon compounds trapped in the permanently shadowed craters near the poles. In addition, solar energy is abundant. These resources will be far less expensive to develop on the Moon than taking things from Earth. A source of propellant in space can qualitatively change our space transportation system. In addition to reducing the size of launch vehicles from Earth, having propellants in space allows us to really consider reusable space transportation systems. You can also fuel spacecraft that are bound for Mars and change the entire way we operate in Earth-Moon space. Dr. Duke discussed how we might get the propellants from lunar soils and volcanic gasses. An early robotic mission should be designed to demonstrate oxygen production. In addition, we need more exploration of hydrogen resources. There are other lunar resources—metals, ceramics, gasses—that can open new opportunities, both on the Moon and in space. We need to develop systems that can operate for long periods and we need to take into account how to do that in the lunar environment. The establishment of a reusable and expandable space infrastructure that is based on lunar resources can be a key to the future viability of space

exploration. There are a number of concepts that could produce at least 10 times its mass of material in a year. The real crux of the matter of using space resources is to have a demonstration of their use anywhere. Dr. Angel commented that the "ferry on the moon" is probably the most useful step we can take towards Mars exploration. In response to a question, Dr. Angel stated that the size of a telescope on the south pole of the Moon should be about 20 meters. Today, there is not a way to reduce the size and weight of the optics to manage the level for launch capabilities. However, there may be another way to do it.

Mr. Aldridge welcomed Dr. Cheng, who provided testimony on asteroids as an exploration destination. Asteroids tell us about the early solar system and how Earth-like planets formed. There are great resources on asteroids. In addition, the role of humans in exploring asteroids is something that should not be ignored. Humans can respond to unexpected discoveries. Another reason we need to study asteroids is that there is a great natural hazard associated with asteroid impact. We do not know when the next one of these impacts will occur. Currently, we do not know enough about how these asteroids are put together, what materials are in there, how strong they are, etc. An interesting question is: What is the relationship between the bombardment of the Earth and the Moon by asteroids and the development of life. The one ended, the other began.

In response to a question, Dr. Cheng noted that on very small asteroids, human exploration would be somewhat like operating an extravehicular activity (EVA). On a larger asteroid, there is enough gravity to walk around on it. Exploring an asteroid would pre-Mars. It is a way of testing crew support, life support equipment, vehicles, etc. There may be resources on asteroids that do not exist on either the Moon or Mars. In response to a question, Dr. Cheng agreed that there would be a great fuel savings to approach and get very close to an asteroid.

Mr. Aldridge introduced Senator John Glenn, the first American to orbit the Earth in Friendship VII in 1962, and a mission specialist on the Space Shuttle in 1998. Sen. Glenn recounted a short chronology of the manned space program. In the early program, there were two purposes in addition to the Soviet spur—exploration and basic research. The Space Station was conceived as the first permanently orbiting laboratory. Sen. Glenn noted some of the research that has been done on the Shuttle and that planned for the Space Station. Currently, it is manned by only two people instead of the planned crew of six. The new Vision concept says that they only research that the U.S. can do there must be directly applicable to the Moon or Mars. Anything else will be cancelled. This is wrong. It pulls the rug out from under scientists who placed their faith in NASA and devoted years and years of their work. Sen. Glenn also felt that this is breaking our promises to our partners. The Station was sold on the benefits that it would bring to people on Earth. Pride and exploration were factors, but the biggest selling point was on results here on Earth. We should maximize our research return. It should not be taken away for lack of comparatively few dollars. Sen. Glenn talked about education and the state of math and science education in the country. He noted the recent international study that showed that by the time U.S. student get out of high school, they are two or three from the bottom. The movement of jobs and business overseas is not all because of low-cost labor. Other countries are beginning to educate their people above the level of people coming out of our own high schools. This is something that must be reversed. Education and research are two important things. Sen. Glenn also mentioned the Hubble Space Telescope. He felt that we should do everything we can to get

every year's value out of the telescope, including one more launch, to keep it on line. Sen. Glenn questioned whether the Moon would be a good testbed or a step as a launch pad for going to Mars. He stated that exploration and research go hand in hand, and we should be doing both. Shuttle and Station should be stretch out so we can use them repeatedly. Sen. Glenn indicated that he supports the long-term goals. This was needed, but not at the expense of benefits for people here on Earth and for a comparatively small budget. He opined that we could do both—have research on the Station and have an exploration vision. We owe it to the taxpayers to get the maximum research return to benefit them here.

Mr. Aldridge asked Sen. Glenn how he would do the two-minute "elevator speech" to explain to the American people why we are doing it. Sen. Glenn noted that it would be a dual program—to maximize research return for human benefits as well as exploration. In response to a question from Dr. Tyson on whether it would be possible, in the Senate today, to get the budget to do it all, Sen. Glenn noted that to do the research on the Station would not be a huge amount of money. He felt that with the potential for trade, leading the world in research, it could be sold. We have people go in, fight for things far less worthy than this in Congress, and get them. This is crucial for the future.

In response to a question from Mr. Walker on the feasibility of appointing a pool of astronauts now from whom the actual Moon travelers would be chosen, Sen. Glenn noted that the earlier you get the astronauts involved, the better off you are. In terms of focus, Sen. Glenn stated that he has always that the NASA was reasonably focused, and that he did not agree with the CAIB on this point. He stated his view on going to the Moon—if there are worthwhile projects to do on the Moon, then we ought to go there, but he has serious questions about using it as a steppingstone to Mars. One of the biggest problems for the Vision is going to be management of the whole project. It is going to be enormous if it goes through as it is outlined. If we cannot manage a Station right here near Earth and get the best return from it, what does this say about our ability to go out into deeper space? Sen. Glenn declined to comment on whether or not NASA has the right organizational structure to manage a venture like this. He noted that the Agency is currently working on reorganizing and we do not know the results of that yet. In response to a question, Sen. Glenn indicated that he would like to see more funding in aeronautics. Some of these things are key toward developments for the future that are going to be of worldwide importance to us.

Ms. Fiorina asked Sen. Glenn to talk about risks and how to talk to the American people about the risks that are required to accomplish these kinds of objectives. Sen. Glenn noted an old saying in aviation—if you want 100 percent safety, put all the airplanes in the hangar and don't ever let them out. However, he noted that in the three fatal accidents in space, it was not the science, it wasn't the research, and it wasn't the engineering—there were waivers given on things that shouldn't have been given waivers. With respect to the Moon/Mars path, Sen. Glenn expressed concern that there would not be enough money to mount a Mars mission right after going to the Moon.

With respect to outreach, Sen. Glenn opined that NASA has had a very good outreach program to schools—providing a lot of material, lesson plans, etc. He again noted his concern about math and science. One of the problems is the teachers themselves—a large percentage of math and

science teachers are teaching out of field. In addition, the turnover is very high—50 percent are gone within five years.

Mr. Aldridge introduced Mr. Frank Samuels, Aerospace Development Executive for the Governor of Ohio. Mr. Samuels welcomed the Commission to Ohio on behalf of Governor Taft. He noted that aerospace is front and center in many of his concerns. He shared his thoughts on how Ohio might be able to help the Commission reach its mission of advising on affordable and successful space exploration. The key to that are teams of productive people creating a host of new products through collaborations. Ohio is creating some of the new models of collaboration; one example is the Ohio Center for Advanced Power and Propulsion. Mr. Samuels discussed the center and the governor's plan—a 10-year project to build intellectual capital to create jobs and economic growth. It is a public-private institute partnership with five Ohio institutions. A variety of work is going to be conducted at the various institutions, all aided by computational modeling. Collaboration among the various elements is key. Other guidelines are: insist on excellent science; pay attention to the work force issues; and encourage collaborations across sectors and maybe across state boundaries.

After lunch, Mr. Aldridge introduced the first panel in the afternoon, from the Air Force Research Lab, on "Science and Technology." Col. Joseph Boyle, Associate Director of the Propulsion Directorate; Dr. Charles Browning, Director of Materials and Manufacturing; Col. Michael Leahy, Director of Air Vehicles; and Col. Williams McCasland, Director of Space Vehicles.

Dr. Browning focused on three key messages: the pervasive enabling nature of materials; some of the exciting current and future research and development in space materials; and the collaborative nature of virtually everything that is done in his organization. Dr. Browning described his directorate and discussed the importance of materials, which are fundamentally enabling to all systems. He highlighted some of the recent focus areas for applications to spacecraft.

Col. Boyle discussed the science and technology program in the Propulsion Directorate, focusing on those programs that are specifically applicable to the Moon, Mars mission. He noted that his organization has a long history of collaboration with NASA, and that collaboration continues today through the National Rocket Propulsion Test Alliance, which coordinates test infrastructure across the country. Col. Boyle highlighted the technology efforts and plans for advanced reusable booster engines that are currently ongoing and explored the applicability of electric propulsion. He also discussed the power program and how it applies to the space mission. Col Boyle noted that collaborations are key to delivering improved capabilities. The technology derived from the electric aircraft initiatives supplies an array of technology options that can enable the Moon Mars mission.

Col. Leahy discussed the research in his organization that is focused on making an operationally responsive space lift system before 2020, with turn time in hours and weeks and single digit millions in launch costs. This new capability will enable a wide range of Air Force and NASA space missions. He noted that the first spiral in that revolution is only a flight demonstration away. Continued investment along three major fronts—advances in propulsion and power,

leveraging over 50 years of research and experience, and converting new materials into advanced thermal protection systems—will permit an integrated microscale flight demonstration within the decade. Col. Leahy discussed thermal protection systems, which are the focus for his organization's space research thrust. While the microscale demo will have no operational residual value, it will allow maturation of the critical integrated technology suite and provide direct scalability and traceability to full-size hybrid ELV and two staged orbit design.

Col. McCasland highlighted what his organization is currently doing to advance the state of the art in adaptive optics, radiation hard electronics and design hardening, crystal and solar cell efficiency, antenna arrays and deployable optical telescope structures, communications networking, and precision pointing. This research is motivated by making space capabilities more flexible, affordable, and operationally responsive. The AFRL shares NASA's vision that some kind of reusability is the right way to drive down launch costs. It is aggressively advancing the state of the art in all key technologies needed to make the payload mass accomplish more than it ever could. The AFRL has a long history of collaborating with NASA and expects the relationship to grow. The Lab shares NASA's concern with stimulating science and engineering, and sponsors undergraduate and graduate study interns in the Lab, as well as other outreach programs running in the elementary through high school levels. This initiative should generate the intellectual fire for science and engineering study for the next generation of space explorers.

In response to a question from Mr. Aldridge, Col. Boyle and Col. Leahy provided a few examples of collaboration between NASA and the Air Force, e.g., the integrated high payoff rocket propulsion system (IMPRP), use of test facilities. Dr. Browning mentioned the integrated materials working group, which includes industry as well as NASA. Gen. Lyles asked Col. Boyle to take a "homework" assignment—provide the Commission some information on how the IMPRP has actually progressed. Col. Boyle agreed to do this. In response to a question from Gen. Lyles, Dr. Browning commented on ways for all institutions, including HBCU's, to share in the inclusiveness of the Vision. He noted that there are an unlimited opportunities. It takes an infusion of money, but not a lot. This most important thing is sustainment—someone to keep it going.

In response to a question from Mr. Walker, Col. Leahy noted that Space Command has recently completed an analysis of launch alternatives for the different missions in space. That analysis is pointing the Command toward a degree and amount of launches for small and medium payloads that necessitates a reusable kind of paradigm. The timeline target for initial operational capability is in the 2018 to 2020 timeframe. One of the next key steps is to address some of the systems issues. Col. Boyle added that as far as propulsion units are concerned, the timeline rule of thumb is between 5 to 10 years to go from demonstration to an operational kind of engine. With respect to use of facilities, Col. Boyle noted that the test facilities that he showed in his presentation are open to anybody. His organization has commercial test agreements with industry, and is also using the NASA Stennis facility. In response to Gen. Lyle's question, Dr. Browning indicated that educational partnership agreements (EPAs) are easy mechanisms that are used by his organization to allow universities to come in and share facilities, equipment, people, etc. There are many opportunities for sharing. In response to a comment from Dr. Tyson, Col. McCasland observed that if there is commercial spin-off and opportunity for private capitalization and return on investment, there is a whole capital market to tap. His

organization is open-minded in its policy to permit contractors to seek commercial exploitation. The Air Force may ask for unrestricted intellectual property rights because of the investment with defense applications, but those are negotiations that are conducted in any partnership agreement.

Mr. Aldridge introduced Dr. Lennard Fisk, Chairman of the Space Studies Board, National Research Council (NRC), who discussed the NRC's workshop report, "Issues and Opportunities Regarding the U.S. Space Program." The workshop was held last November and the report was written before the President's announcement on space exploration.

Dr. Fisk discussed the workshop, whose purpose was to discuss national space policy. The question was asked: What should be the essential features and how should it be implemented? Dr. Fisk noted that there are many aspects of the workshop that are well embodied in the President's vision for space exploration. He noted that the workshop had some view on implementation that the Commission might want to consider. He also pointed out the there were also some serious departures from what the participants at the workshop thought the correct approach should be. Dr. Fisk provided a complete list of workshop participants and a copy of the report. Some of the key issues that were agreed upon were: NASA's Space and Earth Science program are productive and progressing steadily, and are of continuing importance; human space flight lacked direction and purpose; there are certain factors that have contributed to the success of the science program that should be noted by the human space flight program, e.g., a large external NASA constituency, very clear goals that are established by the science community, an extensive process of strategic planning, and a program conducted through a sequence of successes—a series of individual steps that accumulate success from which progress can be measured and momentum sustain. The workshop participants argued that the goal for human space flight should be exploration, which includes the acquisition of new knowledge—knowledge of space as a place for human activity, knowledge of our solar system, knowledge of the universe beyond our solar system. The participants felt that there did not need to be a dichotomy between space science and human space flight—an exploration properly conducted, in which humans and robots play appropriate roles, would result in synergy in a way that has not existed in a long time. Exploration of the solar system is a long-term endeavor that needs to be accomplished with a series of incremental steps. The purpose of the Space Station should emphasize preparation of humans to live and work in space.

Dr. Fisk noted that the workshop participants were worried about the ability of NASA to accomplish an ambitious exploration program. The question is: Is the current infrastructure configured properly for a bold, new initiative? The work force of NASA is aging, and the attitude seems more risk averse than creative.

Dr. Fisk pointed out some inconsistencies. The President's 2005 budget for NASA, which begins the exploration initiative, has resulted in major collateral damage to certain of NASA's science disciplines, e.g., the Sun Earth Connections program, which has as its goal to understand the sun and its influence on the space environment. It is inconceivable that we would consider sending humans into the solar system without developing an understanding of and ability to predict the space environment. The dividing line between the sciences that are "in" (infrared and visible light astronomy) and those that are "out" (x-ray and gamma ray) make no sense. In

addition, Earth science has been badly cut. We may have a priority to explore, but we still have a responsibility (under the Space Act) to deliver to the policymakers and the public a sufficient knowledge of how to be good steward of our home planet.

Mr. Fisk observed that the proposed exploration initiative has resulted in a fundamental departure from a balanced scientific approach, and he encouraged the Commission to recognize all the science disciplines that will be needed for success, and that true exploration is a broader concept than is currently being defined.

In response to a question from Mr. Aldridge, Dr. Fish noted that the NASA budget declined during the 1990s and the Agency lost a significant piece of what NASA's programs should cost. If the budget had been allowed to keep up with inflation, we would probably not be having a problem now. We should try to restore the level of support that the federal government has put into NASA historically. Dr. Fisk highlighted three points: there are science disciplines that should be supported because they will be needed for exploration; the responsibility of NASA to the home planet and an understanding of the global climates system; and the investment in the long-term future—to learn to use space in the optimum way.

In response to a question from Dr. Leshin, Dr. Fisk indicated that it would be wonderful to have international participation in the exploration initiative. We should do it as part of humankind, with other nations, not on behalf of humankind, which would be arrogant. It should become a demonstration of U.S. goodwill. With respect to partnerships, engaging people early is a very important issue. It should be U.S. led, but there must be sensitivity for the participants' national interests and concerns. In response to a comment from Mr. Walker, Dr. Fisk noted that during the Apollo program, space science as a whole flourished. One of the worries is the aging work force of NASA and the broader science community.

In response to comments and questions from Dr. Tyson, Dr. Fisk noted that without a healthy NASA doing a large program, the science program of NASA is not going to survive and prosper. For much of the history of the space program, when the budget of NASA went up, the science budget went up. In recent years, the science has done better than the Agency as a whole because of the spectacular things it has done. However, the idea of an aggressive science program in NASA standing on its own is probably not going to happen. If you have to sustain the exploration program through multiple administrations and the funding is finite, then the only variable is time, so you need a healthy science program that produces visible results for NASA. The broader science program is what creates in people's minds the sense that good things are happening in NASA.

Mr. Aldridge held a "lottery" and selected the names of people who would be able to make two-minute statements to the Commission later in the afternoon.

Mr. Aldridge welcomed the three participants in the last panel, "Management Techniques for a 'System of Systems':" Mr. Mike Mott, Vice President and General Manager of NASA Systems, Boeing; Mr. Jeff Harris, Vice President of Strategic Planning, Information Systems, and

Solution, Lockheed Martin; and Mr. Craig Staresinich, Vice President Deputy for Programs, Northrop Grumman Space Technologies.

[Mr. Walker recused himself from the discussions because of his relationship with Lockheed Martin]

The panelists address questions that had been provided by the Commission. The first question concerned the challenges associated with managing a large program with a 40-year roadmap that will maximize long-term multiple systems and receive intense public and technical scrutiny.

Mr. Mott noted that the national Vision would offer direction, purpose, rejuvenate our sense of challenge and national pride, and inspire people. It offers an affordable and sustainable path to demonstrate America's commitment to the exploration of space. However, the Vision is only the start of the journey. The issue is a matter of execution—the complexity of developing, integrating, and operating the hundreds of robotic, human, and telerobotic systems to launch, assemble, transfer, land, and build permanent human habitats on the Moon and Mars. Mr. Mott recounted our experiences on the Space Station. The assembly is a real credit to the leadership of NASA, the international partners, and the contractors. There is no question that we can step up and execute the President's challenge. A little over 10 years ago, Gen. Tom Stafford led a group to discuss lessons learned from managing a very large program. Mr. Mott noted five of these lessons as a precursor to the guidelines that will have application in the future: (1) clean lines of management, authority, and responsibility for all elements of the program; (2) realistic program milestones providing clear entry and exit criteria for the decision process and creating useful capabilities at each step; (3) a clear understanding of the technical, programmatic, and realistic cost of the program; (4) develop a system of systems engineering tools; and (5) open architecture.

Mr. Jeff Harris opened his remarks with a story from DOD, with the point that the key to achieving success on a program like this is getting everything to work together well, and that depends on the people, the processes, and the ingenuity to get to a system of systems environment. Mission success must be paramount and everyone on the team must understand that and work toward the same goals. In a system that spans several decades, it is not enough to control the three legs of the stool—cost, schedule, and performance—time is also an element that must be controlled. The spirals and the sub-spirals have to be controlled. Systems integration and system engineering must be done early, often, and continuously. Interfaces bring more complex requirements to the table. If they are not treated with the same emphasis as requirements, the system will have some lack of control. Independent program or project teams must be guarded against carefully. Complex programs must have a process to make timely decisions and communicate those decisions to the far reaches of the program. Mr. Harris presented several models to look at systems of systems integration. Organizational conflict of interest is important. Architects and system engineers should be separated from the industry teams that are doing the hardware and software. Industry and government must be equally engaged, and government must reach out to the breadth and expertise of the industrial team.

Mr. Staresinich focused on the National Polar Orbiting Environmental Satellite (NPOES) program as a good example of systems of systems. In designing systems for Moon and Mars,

NASA will lead the integration of a similar set of system elements, manned and unmanned space vehicles, communication, and routing systems, beginning with today's infrastructure and heavy lift challenge. There will also be a set of users, including scientists, academia, and researchers who have diverse expectations and priorities on how the exploration data and artifacts should be made available. Mr. Staresinich suggested that there are six management factors that are key to effective systems of systems management: (1) clear articulation of system objectives that will govern the system in the way that it is implemented; (2) systems of systems management begins and ends with the users; (3) regardless of the acquisition approaches and user interface selected, key responsible authorities must take their leadership role in managing across and beyond the interfaces, i.e., understand both sides of an interface; (4) all individuals contributing to the system must understand their role and how it affects the rest of the system of systems—strong emphasis on organization, teamwork, and collaboration; (5) technology—managing technology and having "gates" for system of systems; and (6) systems management on a large scale requires broad system level thinkers trained to think in threads.

Mr. Staresinich noted that his colleagues at Northrop Grumman are beginning to see more of a system of systems and mission systems engineering emphasis in college curricula, and this should support NASA's future.

In response to a question from Gen. Lyles regarding stimulating private sector interests in the vision, Mr. Harris indicated that the focus should be on the people—building small teams of dedicated people that know what the mission is and giving them the resources to get the job done.

Ms. Fiorina asked about lessons that could be learned from industry, from a program management approach that could be applied more broadly. Mr. Harris noted that one of the messages in collaboration is getting to a shared set of value. Systems engineers are a very useful "glue" in a program to get everyone to share values. It is important to reach out to the youth of America—to get them excited. Mr. Mott added that one of the great things to come from the Vision would be the generation of skills. This complex program would not only be a research and scientific challenge, but would provide a challenge to engineering and management skills. It would have enormous positive impact for industry.

In response to a question from Mr. Jackson on whether NASA is up to the job to run the project, whether it has the right type of assets, Mr. Staresinich noted that this goes to the earlier question about lessons learned. The larger the system, the more imperative it is to establish good communication ties. Communication becomes a more critical issue. It is also incumbent on the leadership to make sure that everyone is involved and the people at the lowest levels of the organization can be heard. Mr. Staresinich cited the successful Chandra X-ray observatory program. There was an almost badgeless interaction between the government and industry, sitting side by side, working issues as they came up. The larger the system is, the more important it is that all parts are well integrated and the communication gaps are closed. Lessons learned are important, but they must be incorporated into processes so that everybody uses them.

Mr. Jackson asked Mr. Staresinich to take a "homework" assignment to address the following questions: Does NASA have the right people, resources, organization, structure, assets? Are

there impediments? How to you harness the Centers to a single big mission? What sort of procurement technologies and tools have they used and do those need to be changed? Mr. Staresinich agreed to take on the assignment.

Dr. Tyson asked the panelists to comment on the disconnect between the message that we need to attract fresh talent into the aerospace, engineering, scientific pipeline, and the reality that exists in the industry today (consolidation and loss of jobs). Mr. Harris answered with an anecdote. He noted that given the age of the workforce and the way that the last couple of decades have treated the industry; Lockheed Martin is hiring some 50,000 – 60,000 people over the next couple of years. We can talk to these groups and say there is a great opportunity.

In response to a question from Ms. Fiorina on whether we can leverage what we have today into an even broader and more complex realm, Mr. Mott responded that in many ways, we are doing that. We are managing many different systems that we have not managed before. The International Space Station has changed dramatically from the path it started on a number of years ago, and what is being done on-orbit is very impressive. There are many other examples, e.g., in missile defense. The industry focus on how to do these things is much more process oriented than it was many years ago.

Mr. Aldridge opened the last half hour to audience comments (selected earlier by lottery).

Lyle Kelly, Procter and Gamble engineering retiree from Cincinnati, currently with The Mars Society, provided the Commission with three thoughts on sustainability: (1) the attention of the public—milestones that can be achieved and touted that give a sense of pace; (2) low cost—a simplified architecture and building off existing technology rather than a huge R&D investment; and (3) private enterprise—involving the public, like space tourism.

Gerald Zakniki, from the Wallace Kettering Science Institute, commented that this is a wonderful opportunity for everyone to learn about this exciting project. What many people are looking for is what new things they can see, the gains that the civilian can predict from the project. The more diverse a group that collaborates on a project, the more innovative the approach and the more surprising the results. There is tremendous opportunity with what will be learned in this process and what can be applied through technology transfer along the way and with the infrastructure we have in place now.

Alan Thompson stated that he supported the ultimate goals of the President's mission. However, the implied strategies to implement this appear to be the same strategies have been used in previous policies. If we wish to motivate and retain this knowledge in the future, we must utilize strategies that can sustain the policy, educate, and create jobs independent of government programs. Implementing the proposed space policy will require all resources within the manned space flight sector, solely dedicated to lunar and Mars exploration. The policy will only be sustained if the American public perceives manned space flight as affordable. The public's perception of affordability would be significantly improved through implementation of strategies that could include the development of a manned space flight sector that is independent of federal funding. Is the Commission looking at these types of strategies? Would the Commission recommend these strategies within the framework of the proposed policy, even it means

adjustments to this policy? Is the Commission suggesting that the U.S. focus solely on science and exploration? Mr. Thompson indicated that his group has formalized a strategy that has been put out on a website. They are being requested from foreign interests to respond and work with them. This is not something that fits into the President's space mission, but it does fit into an independent commercial space sector. Mr. Aldridge asked Mr. Thompson to provide his input to the Commission website.

Ray Symanski, with 31 years experience at Wright-Patterson Air Force Base, thanked the Commission for taking time to show support for a local science fair. He noted that since 1947, the UFO term has been in our jargon, and perhaps after 50-some years we might want to put another set of eyes and ears up there to determine whether or not we are alone.

Steven Solich, a systems engineer from Dayton, educated at Wright State University, co-owner of a small business, Digital Concepts, Inc., expressed his views on the Vision. He indicated that he hopes that the Commission report recommends the involvement and exploitation of small business capabilities to solve the technical issues that need to be solved for the exploration goal. Small businesses have the long-term vision to engage these goals and provide the required creativity to help advance the necessary technology. These small businesses would help sustain the national vision, the critical ingredient. If small business becomes significantly engaged in the space exploration initiative, the positive impact to our economy and the advancement of technology will dwarf even the results of the race to the Moon.

John Berneki, formerly in the aerospace industry and now in the telecom industry, offered two comments: (1) The propulsion systems are the primary system determining factor. Perhaps we should be focusing on propulsion technology and make a crash program out of that and develop the high-thrust, high-ISP engines that are necessary to make this mission occur faster, the flight times lower. (2) To keep costs low, outsource to China and India. Migrate the aerospace industry to China. It can be done. Mr. Berneki expressed concern as a taxpayer—is it all going to go to China? Is that what this systems management and infrastructure is going to allow us to do?

John Livingston, formerly design engineer at Wright-Patterson and now at the Aeronautical Systems Center, indicated that he has been working an access to space since 1979. The three failures (the transatmospheric vehicle program, the NASP program, and Venture Star) all had one thing in common—they had an ill-defined set of requirements, and there were solutions that were ignored because they were not technically challenging enough, i.e., fully reusable two-stage to orbit. There are near-term reusable launch system solutions that could be fielded with initial operational capabilities (IOCs) in the 2012 to 2015 timeframe. These are two-stage, fully reusable, hydrocarbon lock systems with the current state of the art technology. Systems that we could put together in that timeframe would have return times of one to three weeks. With a little bit of technology, that time could probably be dropped down into the one to 5 day timeframe. The answer to why this has not been done yet is that we do not put enough things up on an annual basis to justify a reusable launch system. The ELV systems are adequate for the job, but if we plan to grow out market, we have to get into the RLV arena and solve those problems.

Danny Cooper, recently retired Air Force missile engineer, provided his recommendation: Look at what Senator Glenn provided as far as experience to the team today and perhaps add

somebody like that to the Commission, someone who can test ideas and strategies. John Kennedy said that we do things because they are hard, not easy. We need to be challenged as a society. We need this for this century. We need this for the children. We need to light the children's interest in this goal.

James Brown offered the following comments: Why don't we create a robot/satellite system to go across the out sphere and pick up the junk? Why don't we go to Mercury first instead of going out? Why don't we send a man and a wife to Mars and why don't we land a woman on Mars? Why can't the mission be to find another planet? The President is not standing with the planet and protecting it, finding a way to live with it instead of consuming it.

Monica Ice, with the Mars Society, commented that The Mars Society actually has prototype habitation units that can be used on Mars or adapted for other planets. The Society has been field-testing these for 4 years. It also has Mars rovers that have been built and internationally tested. There is an inflatable greenhouse at the Mars Desert Research Station in Utah, and we are learning how to explore Mars. The Society is looking at the problems we will face when we get there. The basis for the Mars Society is the "Mars direct" plan—five launchings of three missions, two of the manned for less that what we have already spent on the ISS, simply by living off the land. By using in situ resources, we can reduce cost. This is something that can be done in the next 10 years and we can have people on Mars by 2010. The Mars Society has studied lower gravity, and has already addressed medical issues. All of the papers are on the Website at www.marssocity.org. Ms. Ice invited the Commission to use the Society's resources and research.

Mike Snead, aerospace engineer at Wright-Patterson and chair of the IWA Space Logistics Technical Committee, asked the Commission to consider forming a basis for this initiative built around a very robust space logistics infrastructure. We have the industrial capacity to establish that infrastructure built around fully reusable access to space with near-term two-stage to orbit, logistics support for both human and robotics systems, and transportation throughout the central solar system. Those capabilities can be achieved and can provide a different way of looking at how to implement the exploration initiative as well as formulating a strategy for sustainability over a period of 25 to 50 years.

George Campbell, retired manager and former president of the Management Association in Columbus, talked about his interests, which are function versus cost. What is the primary function of this exploration? Is it scientific? If it is, the most efficient way to gather more information and analyze it is to use more robotics. We have it on Mars now, and by expanding that, extending its capabilities, improving communications, it seems that would be the most efficient way to accomplish something that is quite worthy.

Mr. Aldridge thanked the audience participants for their comments. He encouraged input to the Commission's website, www.moontomars.org, and noted that there is a process by which all of the inputs will be read and considered, and acted upon appropriately. Before adjourning to the press conference, Mr. Aldridge also thanked all of the staff who made the hearing at the Air Force Museum possible.

President's Commission on Moon, Mars and Beyond

WITNESS LIST AND TIMELINE FOR DAYTON, OHIO, HEARING

Hearings will take place at the Air Force Museum, Space Gallery
1100 Spaatz Street, Wright-Patterson Air Force Base, OH

Wednesday, March 3, 2004

1:00 p.m.	Welcome and Introductions Chairman Pete Aldridge
1:15 – 2:15 p.m.	**Inspiring Youth and Improving Science/Math Literacy** Dr. Patricia Arnold, Vice President Education US Space Foundation Mrs. Margaret G. Finarelli, Vice President North American Operations International Space University Dr. June Scobee Rodgers, Founding Chairman Challenger Center for Space Science Education Mr. Brett Williams, Teacher Fredericksburg High School Aeroscience Program
2:15 – 2:30 p.m.	BREAK
2:30 – 3:30 p.m.	**Creating Prosperity and Fostering a Competitive Environment** Dr. Daniel J. Curran, President University of Dayton Mike Cross, Project Manager Ball Aerospace Richard J. Omlor, President & CEO YSI, Incorporated Dr. Vincent J. Russo Retired Sr. Exec. in the Military Service
3:30 – 4:00 p.m.	**Human Sustainability for Long Term Spaceflight** Wright State University School of Medicine Dr. Stanley Mohler, Professor of Aerospace Medicine Dr. Mary Ann Frey, Professor Emeritus in Aerospace Medicine
4:00 p.m.	Commission adjourns

Thursday, March 4, 2004

9:00 a.m.	Welcoming Remarks Chairman Pete Aldridge
9:15 – 10:15 a.m.	**Science and Technology** Gen. Lance W. Lord, Commander, Air Force Space Command Gen. Gregory S. Martin, Commander, Air Force Materiel Command MGen. Paul D. Nielsen, Commander, Air Force Research Laboratory
10:15 – 11:00 a.m.	**Science and Technology** Dr. Roger Angel, Professor of Astronomy & Optical Sciences University of Arizona Dr. Andy Cheng, Sr. Staff & Supervisor of the Planetary Exploration Group Johns Hopkins Applied Physics Laboratory Dr. Michael Duke, Director of Space Combustion Center Colorado School of Mines
11:00 – 11:10 a.m.	BREAK
11:10 – 11:55 a.m.	**Management and Sustainability** Senator John Glenn
11:55 a.m. – 12:30 p.m.	BREAK
12:30 – 1:15 p.m.	**Science and Technology** Col. Joseph F. Boyle, Associate Director of the Propulsion Director Dr. Charles E. Browning, Director, Materials & Manufacturing Col. Michael B. Leahy, Jr., Director, Air Vehicles Col. William N. McCasland, Director, Space Vehicles
1:15 – 1:45 p.m.	**Management and Sustainability** ***Issues and Opportunities Regarding the U.S. Space Program*** Lennard A. Fisk, Chairman, Space Studies Board National Research Council

Thursday, March 4, 2004 (con't.)

2:15 – 3:00 p.m.	**Management Techniques for a "System of Systems"** Mike Mott, VP and General Manager NASA Systems Jeff Harris, VP Strategic Planning, Information Systems and Soluons, Lockheed Martin Craig Staresinich, VP Deputy for Programs, Northrop Grumman Space Technologies
3:00 – 3:30 p.m.	Audience Comments Through a lottery system, 12-15 individuals will be given an opportunity to present comments to the Commissioners
3:45 - 4:30 p.m.	Press Conference. Accredited media will be invited to call in.
4:30 p.m.	Hearing adjourns

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President's Commission on Implementation of United States Space Exploration Policy
Air Force Museum, Space Gallery
1100 Spaatz Street, Wright-Patterson Air Force Base, OH
March 3-4, 2004

COMMISSIONERS

Edward C. "Pete" Aldridge (Chairman) of Virginia

Carleton S. Fiorina of California

Michael P. Jackson of Virginia

Laurie Ann Leshin of Arizona

Lester L. Lyles of Ohio

Paul Spudis of Maryland

Neil deGrasse Tyson of New York

Robert Smith Walker of Pennsylvania

Maria Zuber of Massachusetts

President's Commission on Implementation of United States Space Exploration Policy
Air Force Museum, Space Gallery
1100 Spaatz Street, Wright-Patterson Air Force Base, OH
March 3-4, 2004

ATTENDEES

Name	Affiliation
Adams, Cheri	Boonshoft Museum of Discovery
Barr, Ann H.	Challenger Learning Center
Bennett, Mike	MCB Consulting (Information Technology Solutions)
Bongiovi, Robert P.	RobbinsGioia
Brown, Mark N.	Computer Sciences Corporation
Close, George	Reynolds & Reynolds
Coffman, James M.	The Distinguished Flying Cross Society USAF Air Force Institute of Technology
Della-Rose, Maj Devin J.	Department of Engineering Physics
Di Biase, Matthew	Boeing
Ackroyd, Scott B.	Pratt & Whitney
Dwyer, William G. PhD	The Greentree Group
Folck, James	Universal Technology Corporation
Harber, Joseph R.	Aeronautical Systems Center
Hellman, Barry M.	Aeronautical Systems Center
Huesman, Neo	Dayton Wright Bros. Airport
Joseph, Matt	City of Dayton, OH
Kaplan, Ron	National Aviation Hall of Fame
King, Thomas D.	Orbital Science Corp
Koyama, Masato	Japan Aerospace Exploration Agency
Lain, Douglas J.	Lockheed Martin
Lake, Stephen P.	Ohio Department of Development
Miller, Charles E.	Constellation Services International, Inc.
Osborne, Wilbur A.	Hewlett-Packard
Pearson, James C., Jr.	Systems Technology Group
Poe, Garrett D.	Systems Technology Group
Price, Laurence A.	Lockheed Martin
Rabe, Douglas C.	Air Force Research Laboratory/AFRL
Ricaurte, Edward M., MD	Wright State University (Deparment of Community Health)
Rose, David E.	Technology Industry Professional
Samuel Jr., Frank E.	Office of Bob Taft Governor
Sheehan, LtCol Mark D.	Air Force Research Laboratory/AFRL
Slavey, James C.	Aeronautical Systems Center
Somers, Betty J.	Wright State University (Deparment of Community Health)
Szymanski, Raymond	Air Force Research Laboratory/AFRL

Thompson, Alan D.	
Trapp, Dick A.	SelectTech Services Corporation
Wehn, Judith A.	United States Air Force Museum
Erbland, Peter J., PhD	Air Force Research Laboratory/AFRL
Martin, Pamela	National Aviation Hall of Fame
Paul, Donald B, PhD	Air Force Research Laboratory/AFRL
Katz, Allan P., Dr.	Air Force Research Laboratory/AFRL
Joseph, Matt	City Commissioner
Havig, Paul R., PhD	Air Force Research Laboratory/AFRL
Ball, Ann H.	Residence Inn Marriott
Stewart, Jennifer	Legislative Assistant - John Boehner Member of Congress
Montgomery, Peter	Aerospace Testing Alliance
Early, Stanley A.	Assistant City Manager
Harris, Jeffrey	Lockheed Martin
Sewell, James S.	Air Force Research Laboratory/AFRL
Ciesa, Mary T.	Marriott
Cogineni, Sivaram P., PhD	Innovative Scientific Solutions, Inc.
Harrison, Steven D.	Northrop Grumman Space Technology
Kelly, Lyle	Mars Society
Ice, Monica	Mars Society
Clapp, William	USAF
Rittinger, Thomas	USAF
Snead, Thomas	AIAA
Spain, John	ASC/HRV
Puhola, Irene	Visitor
Smith, Phillip W.	Retired
Willaims, Brett	FHS/MSO
Quinn, Leland	AFRL
Tollefson, Eric	Rose-Hulman Inst. Of Tech
Whittman, Ben	
Helling, Jim	AFIT/LD
Dostal, Joy	AFIT/ENG
Smith, Bryan	AFIT/ENG
Pannier, Emily	Watts
McClain, Trisha	Watts
Cordonnier	Watts
Shultz, Jason	Watts
Rui, Martain	Watts
Stoltz, Garth	Watts
Winton, Eric	AFIT/ENY
Iddings, Kary	DDC
Winner, Amy	DDC
Verret, Philip M.	AFIT
Gochepaur, John	AFRL
Brinegar, Judy	DDC

Kendig, Kevin	AFRL
LaMonica, Joe	AFRL
Scott, Evan	DDC
Ivanciv, Frank	AFRL
Ivan, Shawn	
Claycamp, Ryan	AFRL
Bayley, Allison	Watts
Corns, Jessica	Watts
Fultz, Justin	Watts
Lawson, Carmella	AF/AFIT
Voevodiu, Audrey	AFRL/MLBT
Eggersee, Bob	
Copas, Tara	ASC/LVM-WPAFB
Hancock, Robert	AFRL/PRTC
Davidson, Kenneth	AFRL/MLLM
Koger, John J.	AFRL/SNZT
Fry, Shawn	AFMC/PA
Rankin, Bob	Volunteer
Turner, Brett	Skywrighton
Zellman, Mary	USAF
Johnson, Peter M.	USAF
Plaga, John A.	USAF
McDaniel, Jay	USAF
Constantine, Roftiel	USAF
Orahood, Katie	Greenon High School
Cevik, Burcin	Greenon High School
Dodson, Jade	Greenon High School
Kolp, Ashley	Greenon High School
Brill, Adam	Greenon High School
York, Shannon	Greenon High School
Jensen, Greg	AFIT/CI
Ifle, Joe	USAFM
Pape, Manuel	USAFM
Underwood, Jeff	USAFM
King, Jerry	WPAFB
Duke, Michael	Colorado School of Mines
Baude, Brien	AFIT
Zainey, Emily	Greenon High School
Riley, Stephanie	Greenon High School
Op, Julie	Greenon High School
Estep, Kathy	Greenon High School
Foster, Shara	Greenon High School
Halloran, Michael	Greenon High School
Hawley, Glenn	USAF
Petrale, Gerald	USAF

Edmonds, Darren	USAF
Bartoli, John	USAF
Baldwin, Rick	BAH
Magee, Sherry	
Cooper, Brian	AFRL/VACC
Sloan, Diane	
Snell, Steve	YSI
Geis, Jack	Retired
Bowers, Steve	AFIT/ENR
Brown, Ivan	
Mathis, Richard	
Bhechwest, Jack	AFRL/XIS
Baker, William	AFIT/CESS
Russo, Vincent J.	Retired
McNabb, Dennis	AFIT/ENG
Jacobs, James E.	
Crossland, Mary	AFIT/MS
Simons, George	AFA
Rockwood, Tom	AFRL/VACC
Wagner, Andrew	AFIT
Fritchman, Guy	AFIT
Myers, Robert G	ASC/MOA
Lehmann, Melissa	Watts Middle School
Patel, Anahli	Watts Middle School
Stoller, Meredith	Watts Middle School
Yellin, Anne	Watts Middle School
Good, Evan	Watts Middle School
Prich, Thomas	Watts Middle School
Sbechi, Ken	Watts Middle School
Beyne, Robert	AMTI to ASL/ORB-J
Cullom, Mark	88CS/SCMLFS
Funge, Alistair	AFIT/ENG
Croop, Harold	AFRL
O'Toole, Wendy	Contractor
Barum, Randy	ASL/6RR
Beers, Kenneth W.	Retired WSUSOM
McKinney, Thomas	Self
Turcotte, Jeff	AFRL/VAO
Johnston, Ralph	Self
Lynch, Dennis J.	HP
Henry, Cynthia	USAFM/MUT
Omlor, Rick	YSI
Henry, Phil	
Tresser, Sally	AFMC
Denham, Dan	AFMC

Rose, Virginia	SCC/Student
Noble, J. R.	885h Security Forces
Radlonski, Phillip	ASL/ENMM
Tucker, James	
Presdorf, Tom	AFRL/VAAI
Jones, W. David	AFRL/SNO
Pengel, Herman	USAFM
Ballard, John	College of Mount St. Joseph
Becker, Eric	AFRL
Browning, Josse	AFL/MUD
McGhee, Mickey	UDRI
Tarser, Gunn Anne	
Johnson, David	AFRL
Matsumoto, Akiko	Aerospace Medicine WSU
Mohler, Ursula	WSU
Robb, Jeff	USAF
Ivy, Jack	USAF
Burn, Wilson	VTL
Snead, Mike	AIAA
Blake, Michael	AFRL
Farmer. Barry	AFRL
Farmer, Sharon	Professor
Allnutt, Rick	AFRL
Johnson, Murray	Professional Engineer
Sanderson, Barbara	AFRL
Mable, Leon	AFIT/LSB
Furkes, Ken	AFIT/LSB
Schrock, John R.	Self/The Moon Society & The Artemis Project
Novack, Rick	Novack & Associates
Blackberry, Jack	AFRL/XPS
Stickle, Brian	USAF - AFRLM
Clegrat, Dan	AFRL
Moore, Ray	AFMC CLV
Ross, Ginny	Greenon High School
Wenner, Ashley	Greenon High School
Whitt, Jake	Greenon High School
Cardora, Carlos	AFRL/PRTE
Joy, Sarla	AFRL/XIP
Woflman, Ben	
MacDonald, Adam	AFIT
Workman, Mark	AFIT/MSF
Jensen, Elizabeth	ASC/FB
Roberts, Reed L.	ASC/YF
Bellamy, Frederick L.	AFIT/RP
Colan-Diaz, Nivia	AFRL/SNRR

Green, Joshua	AFIT/ENG
McCabe, MV	UDRI
Martin, Gen Gregory S	USAF
Hales, Col. Thelma	USAF
Johnson, David H	AFRL/ML
Smith, Lt. Brian	AFRL/ML
Sidor, Matthew J.	Wright State University
Hale, John	Retired
Eggene, Bob	
Arwsa, Lily	ASL/ENFA
Hunt, Sam	USAF
Cluis, Katherine	Green Local Sch
Morris, Wayne	National Aviation Hall of Fame
Camder, Mike	AFRL/VHS
Caldwell, Lt. James	AFIT
Rich, Shelley	AFRL/DROP/UTC Contractor
Levin, George	AFRL/PRPG
Miller, Jason	AFRL/VA
Miller, Vince	AFRL/VA
VanVliet, Brian	AFRA/VA
Carbaugh, Col. Samuel	AFRL/VA
Hansen, 1LT Michael	AFIT/ENY
Bryd, James C.	WASC/ENAS
Johnson, Vincent R	AFRL/MLSC
Hotto, Michael	tour
Shewalter, Richard R. Jr.	tour
Fanell, Mike	WASC
Jackson, Steve	
Doust, Robert	
Cooper, Ernest	Retired AF
Banon, Robert E.	
Campbell, Brucvre	
Learn, Andres	USAF, AFIT/ENG
Noel, Daniel	USAF, ASL/AAAA
Keffer, Jeanne	
LaFantain, Mary Beth	USAF, ASC/YDK
Mohler, Stanley	Wright State University
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Swartz, Katy	Greenon High School
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