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

San Francisco, California
April 15-16, 2004

PUBLIC MEETING MINUTES

Approved

Steven G. Schmidt
Executive Director

Approved

The Honorable E.C. "Pete" Aldridge
Chairman

President's Commission on Implementation of United States Space Exploration Policy
Galileo Academy of Science and Technology
San Francisco, California
April 15-16, 2004

Thursday, April 15

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 fourth Public Hearing. He thanked Ms. Margaret Chiu, Principal and Mr. Anthony Hailey, Vice Principal, of the Galileo Academy of Science and Engineering for hosting the hearing at their school. He also introduced Dr. Frank Tom, Superintendent of San Francisco School District, who attended the meeting. Mr. Aldridge 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.

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

- Dr. Laurie Leshin, Director of the Arizona State University Center for Meteorite Studies. She uses spacecraft and sophisticated laboratory instruments to trace the history of water and possibility of life in our solar system.

- 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 also 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. He recently served on the Aerospace Community which made recommendations to Congress and related government agencies on how tin improve the health and future of this industry in the interest of the American economized National Security.

- 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. He too served on the recent Aerospace Commission, as the chair.

- 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 Designated Federal Official (DFO) for this Presidential Commission.

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 website—www.moontomars.org—it has been accepting comments from people around the world. Almost 5,000 responses have been received on the website to date. Every input is being read. About 87 percent of those contacting the Commission with a pro or con stand have been in favor of this sustained journey. Many of those who express concerns do so 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. The Commission plans to visit one more city—New York—in early May. 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 noted that there will be a press release today on the Commission website regarding the public comments received to date.

Mr. Aldridge introduced the first panel, "Entertainment and Space Exploration:" Mr. Ray Bradbury, well-know writer; Mr. John Bernardoni, Executive Producer of Ancient Mariner Media; and Mr. Lawrence Holland, from Totally Games.

Mr. Ray Bradbury joined the hearing via satellite from Los Angeles. He cited a title that is relevant to the Exploration Vision: "Too Soon from the Cave, Too Far from the Stars"—a journey to Alpha Centauri with a way stop at the Moon and Mars. Mr. Bradbury stated that he has thought a lot about the generation of life on Earth and what we are doing here. We are the audience for the universe. To put his comments in context, he talked about the discovery and exploration of the New World. Four hundred

years later, the Wright brothers took off at Kitty Hawk. The kings, politicians, and population at that time could not have predicted what would happen in this period of time. We are called upon to guess ahead 500 years, and it is an almost impossible task. Mr. Bradbury predicted that we would move outward sometime to Alpha Centauri – life wants to be free of politics and conflicts and we will move outward and onward. We are spending about $1 billion a day for war and conflicts. If we take one day of the amount expended each month on these efforts and spend the money on space travel, we can realize that dream.

Mr. Aldridge noted that one of the issues that the Commission has been wrestling with is how to ensure that the program is sustainable during the decades that it will take to be achieved. He asked Mr. Bradbury to share any thoughts he might have on how to "sell" this to be sustainable. Mr. Bradbury advised letting the people see their destiny—their children, and children's children. It has to be sold on an aesthetic level—the entire human race looking to the sky, an antidote to war, a gift to the future generation, a new freedom, a movement away from politics and the terror of Earth. Tell people to take a vote of the children—they will look at the sky and say, "yes—do it." The children of the world will give us the answer. They will point up and say, "there."

Dr. Tyson noted that the non-supporters of the Exploration Vision have a rebuttal—they say that discretionary money should be spent here on Earth to improve our life on Earth. In addition, why should we believe that if we go to Mars, there wouldn't be the same problems there? Mr. Bradbury asked the Commission to consider the social situation in England at the time of Henry VIII. There were many problems that were not yet solved, e.g. a true democracy. If everyone had stayed there and worked on that, there wouldn't be an America. The same with France and Verrazano; the same in Spain. All over Europe, there were problems, wars, plague, invasions, etc. We say now, "Thank God they sent voyagers out to invent America." We will always have problems, and we will solve them. We must move ahead on all the fronts at once. We will take the good things forward into space. The first people that land on Mars will be responsible citizens. We will not take our problems with us. Mr. Bradbury suggested sending three Italians on the first manned expedition to Mars.

Dr. Spudis observed that Americans are very pragmatic -- we embrace engineering and hard facts. Traditionally, appreciation of aesthetics has never gathered much political support. How do we appeal to the practical side? Space is a source of wealth—this might appeal to the public much more than aesthetic appreciation. Mr. Bradbury observed that there would be wealth of love and well being, the freedom to express joy instead of melancholy. Children will not demand gold or silver; they want the joy of going to space. Children can give us a gift on this higher level. If we stay here to solve problems, we will stay forever and Earth will be a mausoleum.

Dr. Zuber raised the issue of failures. She asked Mr. Bradbury what he thought would happen if the Martian Conquest played out and there were failures in the first few years.

Mr. Bradbury noted that in the history of sea travel, thousands of people had to die to come to America. Millions have sacrificed to make America what it is. No matter what, we will prevail, move ahead and succeed.

Mr. Bernardoni talked about his objectives regarding the Exploration Vision: to use his 30 years of experience as a producer to rally the industry to the space initiative; to re-ignite the excitement of the space program in children; to promote the use of musicians, agents, managers, comedians to reinforce the idea that space is a unifying symbol; and to support the President's new space initiative using the media, arts, and entertainment industries to get the message out. The entertainment industry will do the right thing, when it comes time. Entertainment and advertising need to come together to back the Vision in a very tangible way. All of us are facing a great challenge. There are two generations that don't know what Mercury, Gemini, and Apollo stood for, or why those astronauts risked their lives. The kids today don't have the shot that we did. That is tragic; it is the greatest story of the 20th century. You cannot go into the future until you know the past. One of the jobs is to tell the story of what happened at the start. We need to have a national archive of their stories. What is the message that we need to get out? It is that everything we have has been positively affected from what we have gotten from space flight. Technology is project driven and there is no project like Mercury, Gemini, etc. It unifies people behind a quest. Space is something that everyone can relate to. Space is a unifying symbol. What is the prime goal of the Vision? Will the Congress support the initiative over the long haul? Will it make a difference? The entertainment industry can help. It can make it "cool" for kids. Kids are pumped up through their senses—MTV, video games, music/concerts, radio and TV, and celebrities. We need cable and TV Specials that are not dry and boring. We need advertisers who use space in the theme of their ads. Kids love space movies. Electronic information can be manipulated to increase interest. We need compelling education packages that will allow kids to go on-line and plan their own mission to Mars. What is important is that it be something that is entertaining and gets across the message. The problem has been that it has been too dry. Get the kids to back you up. Sustainability is a definite concern. Mr. Bernardoni indicated that he is not sure what the answer is. Somebody has to coordinate the entertainment and media. Three things are important: to re-ignite the excitement, use the entertainment industry, and make sure Congress delivers. The Committee and NASA should think about the timetable—we could lose a whole generation unless the Vision "delivers." It is the children who will take us there, and we have to deliver.

Mr. Holland discussed the issue of broad public support. He noted that he was excited and had a deep sense of pride and achievement at the Apollo lunar landing, and he has supported space exploration every since. Now, over half of our population was not alive when these steps were taken. They ask "why?" There may be many challenges to overcome, but the greatest challenge is gaining broad public support that will last over decades. The mandate needs to inspire the entire nation to explore space—the current generation as well as the next. We must attack people's emotions—use the power and drama of entertainment; get people fired up. Use it to demonstrate the power of possibilities of space exploration, and create a personal connection with the people in space. There are new forms of entertainment that are hugely popular—computer and

video games. They have become front and center in the entertainment section. The male population between the ages of 18 and 34 spend more time surfing the Internet and playing games than they do watching television. Games do something new, involving, and fun. Players are interactive (not just observers). Games immerse one in rich worlds of variety and create a suspension of disbelief. Games are incredibly deep. Good games engage on multiple levels—physically, intellectually, emotionally, and psychologically. They can create challenges, like building and managing a city. Some games play out on line where game players congregate and socialize. Games can be the key to galvanizing support for the space program—they can make it alive and real and force a bond with space exploration and people who explore. The possibilities are endless; they involve human situations with challenges and trade-offs. This Commission can help by utilizing entertainment and games as a primary means of promoting space exploration. Games greatly add to education, challenging players to solve problems. We have to inspire our entire nation through active promotion, and the best way of doing that is through entertainment, especially games.

Mr. Aldridge asked Mr. Bernardoni to comment on NASA's structure on its ability to market. Mr. Bernardoni noted that his company ran into that several years ago at the Johnson Space Center (JSC). When NASA was asked why "outreach" was so flat and dry, he was told that there was a statute prohibiting NASA from marketing and promoting itself. That needs to be challenged. Where did it come from? NASA has as much right to advertise and market as the Department of Defense (DoD). If there is a statute, it should be repealed. NASA should be able to recruit and do innovative things beyond the website. Mr. Holland agreed, and stated hat it sounds silly not to be able to promote the space program. Mr. Aldridge commented that the Commission questions the ability to sustain this program without promotion.

In response to a question from Gen. Lester Lyles on how the interest of the media and entertainment industry could be sustained to carry the message, Mr. Bernardoni indicated that it would have to be rolled out little by little. Currently, the media is rather negative toward NASA. That has to be dealt with. We have to hit a real core on people's hearts as we roll out a campaign to back the initiative. That is where sustainability starts. NASA and the aerospace industry have to provide grist for the mill, and must have the right spokesperson to talk to the media and entertainment industry. Something has to be coming down the pipeline all the time. Mr. Bernardoni expressed concern about the 15 to 20 years issue. We have to be somewhat reasonable and realistic. The only things that will capture the worlds' imagination is sending man to Mars or finding life elsewhere. The campaign has to be well orchestrated as to what happens when. Mr. Bernardoni advised having some good milestones that get people's attention. In response to a question about whether NASA should have a media office in various locations around the country, Mr. Bernardoni indicated that he was not sure what the structure should be.

With respect to the length of the program, Dr. Paul Spudis observed that it is long because our society is not willing to invest resources beyond a certain level. Video games play to our sense of instant gratification. How can we bridge the disconnect between fiction and reality? Mr. Holland agreed that games and entertainment cut out the

"boring parts" and involve ways to collapse time; however, that is a positive thing. The goal of a game is to involve one in complex and interesting choices and challenges. Many types of games (life simulation games, e.g., Sim City) offer unlimited game-playing approaches. If you build a game based on the space program, it could offer people the same sense of interesting possibilities. People play games they enjoy for hundreds and thousands of hours.

With respect to promotion, Mr. Walker observed that the problem is that NASA has been promoted by scientists and engineers. To achieve sustainability, you have to have a connection with the American people. Long term programs either have a constituency, or there is a large block of Americans that commit to what the government doing. How can entertainment help get that connection? Mr. Bernardoni agreed that people are motivated by money, or something that is compelling. He noted that the entire world is fixated on entertainment. Technology industry has spent a great deal of time and money on a new pipeline to deliver content. The reason that people will stay with this Vision is from a national patriotic duty, and understanding that it is something that they should be honored to be a part of. You will start to see a rise in this subject matter. We need to marshal the country for this initiative like the country was marshaled in World War II. Why do we do it? What do we get? Why should we keep doing it? We need to answer those questions for the American people.

In response to a question from Dr. Zuber on what the game entertainment industry is doing to capture girls' interest, Mr. Holland agreed that video games are mostly played by boys; however computer games see a lot greater diversity. Many types of games on computers appeal highly to women, e.g., the Sims games. Games about creating and building things appeal to women. He agreed that the industry could do more along those lines.

Dr. Tyson observed that there is not a dearth of space movies and programs, e.g., Apollo 13 and From Earth to the Moon were very successful. Is there room for more in spite of the fact that there has been a healthy flux? Mr. Bernardoni answered that entertainment covers movies, TV, radio, DVD, everything, not just film. For example, there could be public services announcements for different audiences. Industry can do more. The film industry has done good things and some good work has come out. However, what the special effects people in the entertainment industry can do makes Shuttle activities pale by comparison. This is a problem, similar to instant gratification; however, something expansive, across the entire media, can be done. Mr. Bernardoni cautioned that the "product" should not be "out-hyped"—it has to deliver. If the media sees that this subject is rising on the radar screen of young people, entertainment will start addressing it.

The second panel, "Educating Tomorrow's Astronauts," included the following: Ms. Barbara Morgan, Educator Astronaut; Dr. Jerry Wheeler, Executive Director, National Science Teachers Association (NSTA); Mr. Jim McMurtray, Executive Director, National Alliance State Science and Mathematics Coalitions; and Mr. Dominic Farrar, teacher at Royal Oak Intermediate and co-founder of the Odyssey Program.

Ms. Morgan opened her testimony by stating that this bold, new vision of exploration is the best thing to happen to education in a long time. She emphasized the initiative's connection with America's classroom teachers. So much depends on how the teacher chooses to teach and how enthusiastic the teacher is. None of the other elements can match the effects of a good classroom teacher who is teaching a subject for which he or she has a real passion. This initiative offers a tremendous opportunity to inspire and encourage teachers—if we make sure that teachers see themselves as fully involved. With the Moon and Mars, there will be real people. The undertaking will attract many more students to science and engineering. We need the pipeline to produce an educated citizenry. She asked that the Commission not forget the challenge we have of getting people to go into the teaching profession. An adventure like Moon, Mars and Beyond gives teachers a good perspective from which to teach risk. Children can have something to compare their own life risks to and take their own bold steps. Kids learn by example. Going to the Moon and Mars is an undertaking that has many challenges. The thrill of adventure and the lessons of example are enormous values to education. Make America's teachers our partners and we will get their students as well.

Dr. Wheeler first provided some background on the National Science Teachers Association (NSTA). It is the largest science teachers' organization in the world, reaching over a quarter of a million teachers each month. Science education reform is crucial to the Moon/Mars initiative. Reform depends on three strategic actions: engage more teachers of science; enhance professional development; and increase the support for science. The new initiative can have an impact on all three strategies. Mr. Wheeler reviewed some disheartening statistics on where we are now in terms of science proficiency. He presented six recommendations: (1) Establish science, technology, engineering, and mathematics (STEM) education as a core component of the Vision for space exploration; (2) develop a unifying vision to guide all education contributions of exploration activities; (3) significantly increase the number of teachers engaged in high-quality professional development through space exploration; (4) enhance the content knowledge of educators through their intellectual engagement; (5) create a compelling national understanding of the importance of STEM using the space vision; and (6) explicitly include the science-teaching workforce into all workforce considerations and discussions.

Mr. McMurtray discussed the need for reform of the science education system. He stated that this could be done with the existing infrastructure and could be initiated while the current system continues to function. Mr. McMurtray noted that NASA has designed and undertaken its missions and programs through a technique involving development of a "critical path." The critical path system should be applied to the design and development of a different education system. We must immediately begin to design a replacement to the present system. Higher education is part of the system and is part of the problem. The education system we have now was not designed—it evolved. There are people in the country who are ready to take on the design of a new education system. We must build a system that share our scientific legacy and leaves no child behind. Not all of the students will become scientists, engineers, or astronauts, but they will share the journey back to the Moon and on to Mars and beyond if it is also their own.

Mr. Farrar stated that he was here to represent the advocacy of young people. He shared his experience in the Odyssey program and school reform. Middle school reform is continually changing at the state and local levels. Recently, academic growth and achievement have become the focus of established middle schools. The challenge is that throughout this change, no one can afford to neglect the whole child. A foundation and structure must be put in place to address the intellectual, physical, social, and emotional growth while at the same time accomplishing mastery in standards-based education. Schools must be reorganized in a form that allows for high-quality, human relationships. At many schools, standards have dictated the direction in the classroom, e.g., teaching to the test. The vision of Odyssey has been a turning point. Middle schools should consider alternative structure. The philosophy of the Odyssey program is in the Odyssey poem. The program aspirations are to educate the whole child, with required grade level english, math, and science curriculum. In addition, hands-on projects are incorporated. The program focuses on a secure sense of self. The teacher and the class are kept together for three years—a component called "looping." Flexible scheduling is also a key factor. One of the most prominent philosophies is interdisciplinary team teaching. The program draws content from two or more subjects. Teachers and students have close relationships and engage in cooperative learning opportunities. Mr. Farrar showed several Odyssey activities: creation of an Odyssey film and an archeological dig in the sixth grade; a Rube Goldberg project in the seventh grade; and a literacy project and engineering and construction of a roller coast in the eight grade. Math, science, and technology are critical in the hope we have as a nation to realize history.

In response to a question from Mr. Aldridge on whether we are doing enough in teaching the teachers, Ms. Morgan noted that we are doing a lot, but could do a lot more. With respect to an integrated role, Dr. Wheeler stated that we need more of a shared, common vision where education fits into the President's Vision. There are a huge number of stakeholders—we need to have a vision of what we need for science and education in this mission. If we do not solve the STEM problem, we will not succeed in this endeavor.

Mr. Aldridge asked Mr. McMurtray where we start with the education system. He didn't have an answer, but noted that a lot of people are concerned about the education system failure. The system is too large and too big to fix. Systems resist change. Reform may happen at the state or national level. Dr. Wheeler added that the private sector has been reticent about talking about particular projects. Industry has to help at the local level to get the spotlight on successes, like the Odyssey project. It needs to be vocal within its own community.

In response to a question from Dr. Laurie Leshin on whether changes are needed in the way that NASA works with the education community, Mr. McMurtray indicated that NASA should continue to do what it has been doing. The states control education. NASA should continue to work with the states in whatever they are trying to do to improve science and math education. Mr. Farrar added that we need to get at their level and speak their language. Kids need mentoring and guidance. A large part of what is needed is teaching teachers how to teach so that they can teach kids how to prepare for

the future. Ms. Morgan commented that NASA is doing a good job. NASA has taken some bold steps and worked some partnerships with experts and education organizations to support what these organization want to do. We should use the NASA content to help teach the standards. Explorer schools and explorer institutes are very good programs. Teachers must be brought in from the very beginning. NASA has opened its doors to the astronaut corps twice—the first time for scientists, the second time for educators.

Mr. Bob Walker noted that lifelong learning and individualized instruction are important. We are still teaching people to teach the old way. He asked Mr. McMurtray if there is some way to bring about the change in how we teach teachers to get the enthusiasm in STEM that we have to have. Mr. McMurtray stated that what is really needed is a new system. Mr. Farrar observed that some have been willing to take a risk and do some trailblazing. You have to teach teachers how to teach. We have to decide how to go about the process. Do this through collaboration and teamwork—decide what is in the best interest of the children. There has to be a mandate. What we have been doing is no longer going to be the norm. We have to pull our resources together and go for it. Kids thrive in Odyssey because it is not the norm. Dr. Wheeler noted that NASA is one of the best agencies in terms of having a coherent message and strategic plan and vision. What we are missing is beyond NASA. He suggested that we need to move beyond the individual very rich experience and think about scale. There are 2.1 million kids out there. We need to bring the rich experience to all of them. Undergraduate education is the single biggest problem. The National Science Foundation (NSF) had a collaborative program for a number of years that got departments working together.

Dr. Tyson observed that good teachers have something that the others do not—a passion for a subject that has nothing to do with the formal training as a teacher. What can we do to promote enthusiastic teachers that are experts in a subject? Dr. Wheeler stated that good science teachers have both a passion for science and a passion for teaching children. Mr. Farrar added that teaching as an occupation is not as attractive to people as it should be. We have to educate the whole child. Don't just look for the experts—they have to give the kid everything else they need.

Ms. Fiorina observed that the "journey" to the vision is important—the nation can build capability for children to compete and function successfully in this century. With respect to sustainability of the mission—it must connect to people's lives every day. The teachers, the parents, and the children represent a grassroots community that should stand up and say that this mission is important for the journey it will cause us to take. What would it take to have the communities stand up, go to the Hill, etc., and say "this is important because of the journey we have to take as a nation?" Ms. Morgan answered that teachers must feel they are truly partners. Recognize that these are people who have a challenging job. Bring them on board at the very beginning to be equal players. Mr. McMurtray stated that it is a question of who owns it. If it is owned by all of us, it will not be shut down. If it is owned by one party or another, it will go away when the party shifts.

The next panel was on "Sustainability for the Long Haul, " and included the following panelists: Mr. Reecie Giesecke, President of the UAW Local 848, Texas; Mr. Dean Zvorak, President of the UAW Local 887, California; and Mr. David Goodreau, Chairman and Co-founder of the Small Manufacturers Association of California.

Mr. Giesecke spoke on behalf of the employees at Vought Aircraft Industries and the employees at Lockheed Martin Missiles and Fire Control, a major participant in the current Space Shuttle programs. He indicated that although the workforce is diversified in its efforts, it is unified in support of new space programs. The public needs to witness the long-term, positive benefits of a robust space program. The jobs created by the space program are here on Earth. Creation of jobs is extremely important because every workforce in the industrial base has suffered from downsizing. Jobs in America's space program require years of training, education, and experience. Whenever a program comes to a close, the skilled workforce can easily be lost forever. Mr. Giesecke provided an example of how the loss of skilled workers can affect the future of an industry. America's technological and skilled workforce has earned a place at the table. Mr. Giesecke provided some recommendations: lay out a clear framework and timetable; encourage industry to stand at the forefront for advancing the exploration program; and educate the public and members of Congress about the long term benefits of a space program. Mr. Giesecke stated that he hopes the Commission will make positive recommendations and will encourage further training and education.

Mr. Zvorak represented employees of Rockwell's Space Division. He confirmed the impact that the initiative will have on the next generation of workers. The UAW workforce produces rocket engines and has been a vital participant in the country's space program for decades. During Apollo, the union local had over 70,000 members with 30,000 members working directly on the program. Now, the union is down to 1,200 members. Closed facilities and laid off workers are representative of what has happened to our nation's space programs. Much of the California down turn in manufacturing is due to excessive environmental regulations, and exorbitant business taxes. A national space exploration program must have a supply of eager, highly trained workers. It is essential that current and future policy include assurances that there will be jobs for the next generation of workers. Mr. Zvorak recommended the following: a new initiative should include a detailed study of the skills that will be required for the space exploration initiative; both current and future administrations must provided sustainable, uninterrupted funding; Congress must commit to a national space exploration initiative, no matter which political party is in charge, to assure that the U.S. secures the first outpost on Moon, Mars, and beyond; there must be a national commitment to an educational curriculum from kindergarten through college degree programs to educate and train the next generation of workers; and there must be action and commitment from the administration, Congress, industry, workers, and citizens. American workers could be the allies and defenders of the President's space exploration initiative.

Mr. Goodreau provided some background on the Small Manufacturers Association of California, a statewide organization of 1,000 small companies dedicated to uniting small and mid-sized manufacturers to improve the business environment. Mr. Goodreau

explained the dynamic changes going on in manufacturing and why manufacturing will never be the same again. There has been a severe decline in manufacturing infrastructure resources that serve the space infrastructure. There are roadblocks within the science and technology career ladder that keep students from taking this critical career path, and perpetuates a low awareness of manufacturing science and technology and discriminates against mechanically inclined individuals. There is a crisis in how society perceives manufacturing science and technology careers. There must be leadership from both government and the private sector to rebuild and energize private sector participation in process improvement programs by creating grant opportunities. Funds would be dispersed through the community colleges, adult education programs, or union/association training centers. The small and mid-size manufacturers have a number of suggestions, including helping the mechanical skills program integrate with math and science theory, creating a modernization program for manufacturing science an technology classrooms, increasing funding for programs that integrate manufacturing and science and technology, establishing public/private teams to support the education and training programs, and dedicating funding to encourage retired manufacturers to mentor youth. Mr. Goodreau cited an article that indicated perception of careers in manufacturing science and technology—because of funding, the San Francisco State University president decided to cut the school of engineering. Culture has changed how we view these programs—the leaders don't connect how science and technology fit into the economy. We must address the crisis in America's manufacturing infrastructure. It needs public and private leadership to instill awareness and pride in our manufacturing base. Stop dismantling the infrastructure that gives America the edge.

Mr. Aldridge noted that part of sustainability is ownership of the program by the taxpayer. Sustainability and ownership is key. Labor unions can help us by getting on board, getting information out, and passing that information on to their families and communities. One of the complaints of a small business is that they feel they cannot get a role. There should be a way for small businesses to participate in an aggressive manner. Mr. Aldridge asked the panelists for their comments. Mr. Goodreau noted that NASA has its own supply chain. NASA has to learn to be a servant of those in its supply chain. It has to assure that those at the bottom of the supply chain are successful. The schools are part of that supply chain. Evaluate the way that NASA interacts with suppliers—these people do exist and are important to the mission.

In response to a question from Dr. Tyson on whether it is possible for people to go straight from high school into a career like Mr. Zvorak's, Mr. Zvorak answered that a high school graduate today cannot do what he did. Many kids were able to get in at that time. Because of downsizing, you have to offer more. Training has come from outside. The union is trying to work with the employer to provide this.

Mr. Walker noted that there must be a bipartisan effort on the Vision, or there will be a problem with sustainability. The unions could take advantage of opportunities to make it a bipartisan initiative. He asked Mr. Zvorak if there would be an opportunity for the UAW to make sure that Sen. Kerry speaks favorably about a Moon to Mars mission. Mr. Zvorak stated that if he wants the UAW members' votes, he will.

In response to a question from Dr. Zuber on the importance of science and math in technical training, Mr. Zvorak noted that there is a program that invites kids from technical schools to work with a machinist to see what is required today. In response to a question from Gen. Lyles, Mr. Goodreau noted that there have been some outstanding models where cultural bias against mechanical skills is being addressed. In the San Fernando Valley, where there are many small shops, students have the opportunity to go into a co-op program with those businesses. About 200 graduates have gone into positions this way. During a two-year period, a high school with a high drop out rate only lost 2 out of 30. Fifteen of the 30 took jobs in the valley. There are other models. The problem is models vs. institutional change. We need to take away the thinking that it has to be either work or school. We need to show people the career path.

Mr. Aldridge thanked the panels for their testimony and solicited their support over the decades to come.

He adjourned the day's session at 4:00.

Friday, April 16

Mr. Aldridge welcomed participants and attendees to the second day of the Public Hearing of the President's Commission on Moon, Mars, and Beyond. He briefly reviewed the purpose of the Commission and introduced the Commissioners.

The first panel was "Propulsion Requirements," with the following propulsion experts: Mr. Byron Wood, Vice President and General Manager, Rocketdyne Propulsion and Power, Boeing Rocketdyne; Mr. Michael F. Martin, President of Aerojet; and Mr. James Mosquera, senior government executive with Naval Reactors, U.S. Navy.

Mr. Wood discussed propulsion's role in the national Exploration Vision. He provided a schematic that illustrated the Vision and how propulsion is an essential component at every step. The challenge is to maximize mission success with payload capacity. Industry and government need to significantly team together to meet the Vision requirements. The launch system must serve for many years after Shuttle retirement. So far, we seem to be limiting ourselves out of fear of the cost of a new engine. Mr. Wood discussed how this could be alleviated. The new Rocketdyne engine could be human rated. The Shuttle main engine could be modified to be adapted to an expendable launch vehicle (ELV). If a new engine is needed, NASA should capitalize on investments already made. However, some investment will be required. The U.S. must lead in the exploration of the ocean of space. Mr. Wood reviewed some propulsion history. Our propulsion development capability is at risk. In the last 20 years, the government has started and stopped a number of propulsion efforts. The U.S. is far behind the rest of the world in engines launched. China and India are working to develop state of the art engine systems. The national Exploration Vision will use bold new propulsion systems and industry stands ready to accept the challenge. The exploration trip must get out of

the Earth-bound "driveway." There must be an experienced workforce. If the capability is lost, can we afford the 10 to 12 years it takes to rebuild? Get the propulsion industry and the workforce significantly involved now. Build a spiral development roadmap and keep competencies engaged. Reassert ourselves in propulsion.

Mr. Martin focused on key propulsion technical and programmatic challenges. He showed the three phases of NASA's exploration roadmap: phase 1 is robotic trailblazers; phase 2 is human missions to the Moon, and phase 3 is beyond, including exploration of Mars. There is a range of propulsion functions needed for this exploration roadmap. Near term can be accomplished with existing ELVs with increased payload lift. The second phase will require human rating of ELVs and a possible new heavy lift launch vehicle; phase 3 will involve nuclear thermal propulsion systems. For in-space propulsion, the near term can use existing technology and hardware. The mid term will take advantage of in-situ propellant production, propulsion systems developed during phase 1, and high power nuclear electric propulsion for outer planet exploration; the far term will involve nuclear thermal orbit transfer propulsion systems. Mr. Martin reviewed the propulsion system challenges: timely and thorough requirements definition; program plans that allow time for risk reduction, development "hiccups" and adequate testing; and refinement of nuclear propulsion qualification strategy. He concluded that the vision is achievable. However, requirement definition and adequate development time are critical.

Mr. Mosquera discussed technical culture and safety. He provided some background on Naval Reactors and compared the unique capability of Naval Reactors and deep space exploration. The safety mentality must be pervasive, ingrained in every action, not the main purview of an oversight group. At the center of the cultural discussion is people—technically capable people who are well trained, tested early, and provided with continued professional development. There must be formality and rigorous discipline—enforced requirements and adherence to formal recommendations and actions. There is no substitute for technical competence; there is no place for generalists who know how to manage, but don't have technical knowledge. Everyone must feel responsible for the whole, not just his or her piece. However, responsibility must be clear—you must be able to point your finger at the person responsible. Truly safety conscious organizations are committed to values and resulting actions that mainstream safety into day to day operations at the level of each individual worker. This lesson is applicable to technical leadership and management of other complex and unforgiving technologies. Mr. Mosquera submitted Admiral Rickover's 1979 testimony (after the Three Mile Island accident) for the record. He noted that it was relevant because it describes many of the same key attributes and core values that he discussed today.

Mr. Aldridge noted that propulsion is the enabling technology to achieve the mission. He asked the following questions: How do we manage a program so important to the success of the nation? Can it be done within the existing organizational structure of NASA or the government? Are there any suggestions?

Mr. Wood stated that it is clear that the way to success is if we are able to combine all the pieces (government, industry, and academia) and make it a total team. Perhaps there has

to be some new organizational structure that embodies that or oversees it. It will take the combined resources of all of the elements. We must enlist the Congress and the public to make it sustainable. Mr. Martin emphasized Adm. Rickover's quote on responsibility: "[responsibility] can only reside and inhere in a single individual. Unless you can point your finder at the person who is responsible when something goes wrong, then you have never had anyone responsible." He noted that he is encouraged by the new Code T within NASA. The key to its success will be clear lines of responsibility and communication. NASA is starting on the right foot. When Mr. Aldridge asked the panelists how they felt about a special office for propulsion that would be the focal point for integration of all of the industry, government, and academia activity, they indicated that they did not feel that this was a wild idea. Mr. Martin noted that a lot of scientific work is being done on nuclear thermal propulsion, but a lot more is required.

Gen. Lyles observed that there has been a loosely formed organization that looks at integrated high performance rocket technology. There is a framework for the types of technology that can address improvement of rocket propulsion. He asked it this was and if it could be the beginning of an integrated propulsion office for exploration. Mr. Wood indicated that the organization is the IPRIP. It has gone on for some time, but has suffered from underfunding and redirection. It needs a bigger scope; however, some exciting and breakthrough technologies have come out of this program. Mr. Wood noted that something more radical than IPRIP is needed, i.e., at the next level up. Mr. Martin agreed that what is needed is a different approach.

Dr. Spudis asked about how to go about setting up a program to develop and test ETR. Mr. Martin referred the question to Mr. Cassidy, the technical expert who attended the meeting with him. Mr. Cassidy indicated that we have to look at the architecture studies before we make a commitment. If the studies lead in that direction, there are plans in place. There are Earth facilities that could do testing, but there would have to be a big facility investment. The first step is to assess the architecture to determine if and when we need the technology.

In response to a question from Mr. Michael Jackson on whether there is any impediment in going to the next step, Mr. Martin responded that there are a number of things to think about—what are the requirements and what are the various ways of meeting those requirements? If requirements can only be met by some form of nuclear power, then it can be done. Fifteen years development time for a qualified nuclear reactor is a tall order. Mr. Jackson noted that the Commission had received testimony encouraging creation of an industrial base that would allow embracement of other commercial missions. He asked the following questions: How to stimulate the development of such a space industry in the early stages of the Moon, Mars propulsion effort? What would maximize the prospect for the private sector? Mr. Wood indicated that the only way to make a firm commitment for Mars is in the context of nuclear thermal. That is a very complex proposition. We must make it a U.S. initiative, not one where we compete. It is the next national commitment to do something, and it is fraught with hazards. We have to do this right; we cannot afford to stumble when we put a nuclear device in space and take astronauts to Mars. What is needed is a completely new structure—a national vision

company made up of members of government and industry. This transcends what we have thought about in the past. The projects are too big and important to be managed in the classical sense. Mr. Martin added the following comments: set requirement properly to begin with; learn more about what's affordable and tailor a program to clearly defined requirements with realistic schedule milestones; and have good measures of success.

In response to a question from Dr. Tyson on the source of the workforce for Apollo and later for the ramp-up for Shuttle, Mr. Wood stated that the initial buildup was a great inspiration for the technical workforce. Many engineers were looking for work. Apollo set the standard for engineering science. When the program ended, there were plenty of jobs for those people to go to. In the build-up for Shuttle, very few came back, so the workforce was built again. We are now in the next cycle. If we build up again, we will have to build up with largely new people. College graduates are more scare now—the content of foreign students has gone up, and we are precluded from hiring them. We will have to pay the price in time to build up the required workforce. Over this time period, stable funding will be needed.

In response to a question from Mr. Walker regarding how far we are from having a program that fits the parameters, Mr. Wood commented that we have to come back and look at the requirements and roadmap of what we want to do. The more things you launch in one package, the less reliable it is. We need to look at the program and see how we can make it more reliable. We have the capability. We need to look and see if we have the reliability and the confidence for a nuclear payload and humans. In response to a follow up question on whether the integration can be done in a way that is affordable and competitive, Mr. Wood noted that in the near term (ELV), there is. We need to carefully consider the foreign capability. We must be careful we don't put ourselves in a national security issue in relying on off shore resources. We can come up with concepts that can serve the needs of the Vision, both near term and long term, within the funding wedge.

Dr. Zuber asked about the pipeline for nuclear engineers and if there is enough capability to run good internship programs and other creative things to get students to go into this area. Mr. Wood observed that the people who come to work in this industry are inspired. As long as there is employment, they tend to stay with the industry. However, the programs tend to be cyclical. Students want to be challenged first, and worry about the security second. We are not training enough engineers and scientists, particularly in the nuclear field; but even if we were, we don't have the jobs for them to go to today. Mr. Martin added that "push systems" are not very effective; a "pull system" is needed. What attracts people is the opportunity to work on an exciting project. We can keep people as long as there are exciting projects and reasonable job security; however, more does need to be done.

In response to a question from Gen. Lyles on reliability and robustness, Mr. Wood indicated that for assembling things in space, the complete analysis of the reliability has not been completed. We have some very reliable vehicles. For multiple missions and assembly, we need to balance that reliability with a bigger vehicle that can put up more,

but with less reliability. We have the capability to put our arms around the near term. To make the ultimate leap for a Saturn V type class of payloads, a lot of study and analysis needs to be done. The International Space Station (ISS) has demonstrated capability for assembly in space. The solution is there. In response to a question from Dr. Tyson regarding the safety of nuclear, Mr. Wood stated that in the work in support of Prometheus, we need to reaffirm all of the lessons learned for safety. We do have safe nuclear protection for launch to space, but we haven't effectively communicated that. There is a lot of work that needs to be done before we make the commitment. We need to be upfront with the public, and let them know about everything that is being done for safety. Mr. Aldridge asked about new technology in propulsion that could enable a major jump from traditional propulsion. Mr. Wood noted that there is a lot of embryonic work going on. Unfortunately, the ideas only work well in the laboratory, because there is a roomful of supporting equipment. However, we should look for those nuggets and put some additional effort behind them. Mr. Martin added that it is possible that some of the new materials and new computing tools will help bridge the gap.

Mr. Aldridge introduced the next panelists on "Prospects for Space Prosperity:" Dr. Stan Rosen, Chairman of the Board of the California Space Authority (CSA) and Director of Strategic Development and Integration, Boeing Satellite Systems; and Mr. James Benson, Founding Chairman and Chief Executive of SpaceDev.

[Mr. Walker recused himself from the discussions with Mr. Benson because he serves in the SpaceDev Board.]

Dr. Rosen described the CSA, a statewide, non-profit organization providing voice, visibility, and edge for the California space enterprise. The CSA provides about 28% of the world's space goods and services. CSA supports the initiative very strongly. A reasonable set of programs, with reasonable milestones, can be affordable. Dr. Rosen discussed his recommendation. A new name should be adopted for the initiative, easily understood by the public and not limited to exploration: "Moon, Mars, and Beyond." This initiative should emphasize four major themes, tailored to different audiences: (1) not limited to exploration—opening up a new frontier for human development, providing many benefits for mankind; (2) inspiration and motivation for the next generation; (3) national leadership and strength; and (4) support global unity, by participation of other countries. The Moon has many, unique characteristics, and constructing large facilities on the lunar surface is a job suited for humans. From the lunar surface, use of recently emerging technologies, e.g., information collecting and processing, high data rate communications, propulsion and transportation, can revolutionize operations in low Earth orbit and open the path to many other capabilities. Only by explaining and pursuing these capabilities will this initiative receive long-term support. The lunar roles can ultimately be assumed by the private sector. Dr. Rosen recommended reconstitution of the National Space Council and re-strengthening the space caucus within Congress. We must identify and understand the long-term potentials. Inspiration and motivation of the next generation will produce a new generation of skilled systems engineers, beyond space endeavors. Dr. Rosen recommended that young people be involved in laying out the plans and strategies for the Vision. Space exploration will keep the U.S. in the lead in

space. The capabilities derived will provide future national strength. Outward expansion should be a strong, unifying global theme. Understanding the four themes will strengthen the initiative, a national imperative, critical to our quality of life, creation of jobs, and new operational capabilities. CSA will continue to be a strong voice in support of this activity. CSA is currently promoting a resolution in the California assembly to support activities in these programs.

Mr. Benson shared some of his ideas for the exploration vision. He described his background and why he was here. SpaceDev's goal is to make space happen profitability and practically in the near term. Space is like the computer industry was 20 years ago. Large corporations are afraid of innovation, believing bigger is better. Doing things smaller and quicker with modern technology revolutionized the computer industry. SpaceDev is successfully implementing the microcomputer way of thinking within the space industry. It has already had successes in the space field since 2000—CHIPSat for University of California, Berkley (UCB) and NASA—the world's first orbiting Internet node, and a safe hybrid rocket motor—a water propulsion system. You can have faster, better, cheaper. Mr. Benson offered his title for the initiative: "Moon, Asteroid, Mars and Beyond to the Stars." Solar thermal and water as propulsion offers many advantages—it is an abundant in situ resource, enabling low cost missions. It is practical to expand SpaceDev's hybrid-based Streaker, an expendable small launch vehicle currently under development with the Air Force, to safe, low-cost manned sub-orbital and orbital space flight. SpaceDev believes that a wide variety of scientifically and economically attractive missions to the Moon, Near Earth Asteroids, and Mars are now possible and affordable if conducted by smaller companies with the "right stuff." Mr. Benson had the following recommendations: the Administration, Congress, and the NASA Administrator should work together cooperatively and aggressively to stop treating NASA and its activities as pork barrel, job maintenance programs; stop treating big company programs as entitlements; staff NASA with A-team players who have successful private sector start-up track records; and recognize and reward the small, innovative companies that give NASA successes by delivering smaller, lower cost, higher performance systems.

In response to a question from Mr. Aldridge, Mr. Benson agreed that what he is recommending is a cultural change and a paradigm shift. New technology is available today. NASA has intimated that nobody can do space but NASA. It needs to embrace commercial practices and innovative companies.

In response to a question from Mr. Aldridge on whether NASA is organized to accomplish the themes, Mr. Rosen stated that if the initiative is treated as a NASA initiative alone, you come up with one set of conclusions. If looked at in the broader sense, there are other management structures. With respect to analyses on return on investment in the space business, Mr. Rosen noted that the community has done those kinds of studies. Direct benefits include the communications satellite industry, e.g., GPS. Secondary or indirect benefits and ancillary industries are even larger. The third level of benefit is all the jobs that come out of these, not just the jobs that come our of space industries. Mr. Benson observed that Heinlein said that at low earth orbit (LEO), we are

halfway to anywhere. For the last few decades, we have been running on empty. Between Earth and Mars is an Asteroid belt that has water, an abundant potential fuel. We could refill on orbit and go anywhere we want to go.

Gen. Lyles asked Mr. Benson how we would we define which companies have the "right stuff," and what that really means. Mr. Benson replied that based on his experience, we would need to look at companies headed by people who have a track record and are willing to start small with successful steps. He advised steering clear of wishful thinkers and daydreamers.

Dr. Spudis asked Mr. Rosen to elaborate on the key role of the Moon—what are the key technologies to get us on the path? Mr. Rosen noted that there are many attributes on the Moon—a large, stable, space-based surface with access to large amounts of energy. There are opportunities to create infrastructure that can influence orbit operations. There are opportunities for information collection (antennas). There is a potential to explore many new exciting ideas, and the potential to contribute to sustainability for going back to the Moon for longer-term paybacks. We need to think about this a lot harder. Start early and begin thinking about how to operate from the Moon in support of the larger opportunities. In response to a question from Dr. Spudis on how to implement robotic missions, Mr. Benson noted that Lunar Prospector was a great mission—low cost, and it created five new data sets. NASA and NSF should get together and decide what they are willing to pay for scientific datasets, and put that out for bid—not till delivery. Cost plus contracting leads to escalating costs and is a bad idea. Missions should be offered up as fixed price products. Let the innovative companies have some profit—don't ask how much it costs.

Ms. Fiorina asked Mr. Benson to share his thinking about the role of scope, scale, and volume in undertaking a mission of this type, recognizing the important role of small firms. In addition, how might a company like SpaceDev do better? Mr. Benson stated that CHIPSat was done for NASA. SpaceDev developed a conceptual design for DoD, and got more and more contracts. There should be another step on the scale to large quantities. It is more difficult when scaling to large things like people to Mars. However, with small steps and innovative pieces, we can probably get there faster, cheaper, with lower risk. In response to a question from Mr. Walker on whether companies would be interested in taking on a billion dollar prize for a permanent station, Mr. Rosen indicated in the affirmative. However, he noted that whether it would be successful or not is another question. There are entrepreneurial people ready to rise to the challenge. There are companies who would go for this. Mr. Benson added that the X Prize is appropriately sized. He suggested that instead of a single prize, map out what you want to do, a step at a time (with prizes), up to the billion-dollar prize.

The next panel on science and technology, "Planetary Science," included the following panel of experts: Dr. David Morrison, Senior Scientist at the NASA Astrobiology Institute; Dr. Michael Carr, astrogeologist in the Astrogeology Department, U.S. Geological Survey; and Dr. Jonathan Lunine, Professor of Planetary Science and Physics, University of Arizona.

Dr. Morrison clarified that he was not speaking for NASA, but as an individual scientist. He discussed astrobiology and how it relates to Mars and asteroids. Astrobiology deals with the big questions: Where did we come from? Are we alone? Where are we going in space? These are the defining terms for astrobiology, but they appear in the NASA vision and mission statement. Mars is the most likely abode of life, and it the likeliest place for human to establish a planetary outpost. We will need to search carefully for life on Mars, and need to do so before we send astronauts there. There are three possibilities: no life; life genetically related to Earth; and life genetically not related to Earth. These three subjects will rank among the most important discoveries. When we send humans, we will send microbes to Mars, so it is very important to carry out a very robust and thorough robotic search over the next 20 years. Asteroids are one of the places where astrobiology really counts. NEAs come closer to us than any other object and should be part of any plan. They are a left over building block of the planetary system and they provide important materials. In addition, we may someday need to defend our planet against impact. The asteroid survey is going very well. Ultimately, we should be able to predict the next impact. In addition to searching for asteroids, we should begin to develop the technology for defending ourselves. One of the three Prometheus missions could go to an asteroid and be used to do a demonstration of technology.

Dr. Carr stated that he is a strong advocate of robotic exploration of Mars, but he is not an advocate of human exploration until after a thorough exploration of Mars is achieved. The real reason we will ultimately go to Mars is that it inspires us and lifts us above the everyday concerns of food and shelter. The spiritual driving force will ultimately take us to Mars. The main interest in going to Mars is the possibility that life may have started there, and there may be extant life on the planet. We have just acquired very strong, compelling evidence that there were once bodies of water on Mars, and that there once were places in which life could have flourished. The likelihood that Mars once had rivers, lakes, and seas makes it an ideal target of exobiology—an exobiological treasure to be carefully preserved and protected. We have to understand this planet before we contaminate it and destroy any evidence. We must have robust, robotic exploration consisting of well-instrumented rovers, and sample returns combined with mobility. A number of sample returns are essential before we send people there.

Dr. Lunine addressed the "beyond" element—earth-like planets around other stars. We still don't know whether a planet like the Earth exists around another star, although we know there are 120 planets the size of Jupiter around other stars. The technology for detecting Earth size planets is rapidly maturing. It doesn't require astronauts, but requires putting into space two systems—one that works at optical wavelengths and one the works at infrared. These can detect different clues to the nature of a planet. For the optical, we can do this with a single telescope in space with a coronagraph. The telescope would have to have a diameter of at least 6 meters. The other system (infrared) would be an interferometer—several telescopes along a beam that would combine the light in a precise way in order to reveal an earth size planet. Its technology is less mature. The coronagraph is likely to fly first. We have a solid foundation for a program that would characterize Earth-like planets—Terrestrial Planet Finder (TPF). The coronagraph

would fly around 2014 and the interferometer around 2018. TPF is the gateway to something much grander that could involve programs requiring astronauts—a follow-on, much larger device (life finder), which is at least two decades off. The Commission should not recommend jumping right away to a life finder mission. TPF would provide an incredible boost of interest in sending astronauts to the Moon. Dr. Lunine recommended that the search for other planets and human exploration take separate paths. He gave an example of two versions of programs—one in which TPF flies first, one in which it doesn't.

Dr. Zuber noted that there has been discussion on whether the search for life should be the central scientific reason for exploration. She asked the panelists to comment on how the search for life fits into the broader scheme for exploration. Should this search be the driving factor for the scientific aspect? Dr. Morrison stated that life is certainly the most important scientific drivers, including the moving of our life to other worlds. Dr. Carr agreed that life should be driving the scientific program. Although important, geology is not as strong a driver. Dr. Lunine stated that life is the organizing factor or motivator in exploration, but in the broader sense, we all want to know what our place in the universe is, how life came to be, and whether we are a common outcome of the evolution of the universe or represent a singular anomaly.

Dr. Spudis observed that the surface of Mars is a sterile environment, and any extant life will be at depth. Assume a robotic program with sample returns, and that each one is negative. How many would be required before Mars could be declared devoid of life? Dr. Carr indicated that we have to sample different environments, and have to understand them well enough. We don't know how deep below the surface you would have to go to find conditions for life. Until we explore the environments and where life could survive, we shouldn't send people. Given the range of environments, we need to sample as many as possible that might sustain life. We would have to make a prudent judgment on the chances of finding life. You will never get absolute proof that there is nothing there. Dr. Morrison noted that the problem is initially on the surface. It may be possible to go there without risking contamination on the subsurface. However, we cannot set requirements now for what we will be doing 25 years from now.

In response to a question from Dr. Leshin on how a science program on the Moon could help us on the quest, Dr. Morrison noted that the Moon is very exciting to geologists and biologists—to understand events crucial to when life was forming on Earth. Dr. Lunine added that the first half billion years is lost on Earth, but is there on the Moon, and it is a crucial object to understand that period.

Dr. Tyson asked whether there is anyway to test if life could make DNA other than be related to Earth. How much of the sample return incentive is because people are not thinking more robotically? The Vision is charged with using in situ resources, etc. Can you imagine a remote robotic laboratory? Dr. Morrison replied that it is not just the DNA and RNA; it is the pattern in which they are put together. There is no capability for a

robotic lab—it would take decades. In addition, with sample return, you would always have access to the sample. It could be examined with future technology. Dr. Carr stated that it would be almost impossible to imagine a remote lab as doing what we can do on Earth.

Dr. Leshin noted that the goal of the Vision is to advance the economic and scientific interests of the nation. She asked the panelists to talk about what the incredible discoveries would mean to the public. Dr. Carr noted that the pubic is continually interested in Mars. The interest is astonishing. It reflects back to the awe of the universe and the pride that we have the capability to explore. It resonates with the public. Dr. Morrison added that the Ames Research Center had an open house and over 700 people came to hear about Mars. Great interest was aroused over the "Mars rock." Think how much more interest there would be if we found real life. Mr. Lunine observed that in Europe, about the only non-jaundiced coverage of the U.S. is science and space exploration. We are leaders, but space is something that brings everybody along. Fewer and fewer people are able to actually see the sky and view the universe. We are creating a curtain with the urban environment. Space exploration is the only way to punch through that curtain.

Dr. Morrison noted that defending the planet from asteroid strike is also something the public resonates with, and the public thinks it is reasonable for NASA to assume some responsibility for protecting us from catastrophe. In response to a question from Dr. Zuber regarding how humans could contribute to the asteroid deflection problem, Dr. Morrison noted that robots are not independent; humans are intimately involved in robotic exploration. We may need humans later. If the Vision develops technologies that lead to a robust infrastructure in space, then it could be applicable to asteroid protection.

In response to a question from Ms. Fiorina on why there is such cynicism and mistrust, Dr. Lunine observed that there is a general misconception on how much we actually spend on space endeavors. Most of the public thinks that we are spending much more than we really are. Dr. Carr added that there is enthusiasm for true exploration (robotic science missions). The cynicism with respect to NASA has come from another source—promises that were made and not fulfilled on the Space Station. Mr. Aldridge added that much of the cynicism and questioning seems to come from the human space flight side.

In response to a question from Dr. Tyson on whether there would be the same level of public interest in the Vision if life were a lesser part of it, Dr. Carr admitted that the potential for life is a grabber. However, exploration is of interest to the public, irrespective of the possibility for life. Dr. Lunine commented that ultimately, people are interested in these worlds in terms of whether they do have life, or whether people could eventually go there. Dr. Morrison observed that even if there is no life on Mars now, there could be in the future. We can be the future Martians.

After lunch, the science and technology theme continued with "Robotics," and witness Dr. William L. "Red" Whittaker, Director of the Field Robotics Center, Robotics Institute, Carnegie Mellon University.

Dr. Whittaker introduced some of the great robotic opportunities at the poles. Poles provide a power scenario. For robots to follow the Magellan circumnavigation routes, they follow the daylight. Dr. Whittaker discussed the advantages of Sun-synchrony on the Moon and Mars. At 45 degrees latitude, the rover speed would need to be 3.6 m/s on the Moon. This is achievable. Dr. Whittaker showed some typical evolutionary robots. Each of them has contributory technologies. He showed a rover with science autonomy in the Antarctic Meteorite search. One of the advantages of sun synchrony is three times the productivity than we have now. The terrestrial standard is 1 m/s. Dr. Whittaker showed a film clip of fast navigation of unrehearsed terrain. His point was: skip the landers—go for circumnavigation. On the Moon, there are entire scenarios that could be enabled by this sun-synchronous robot. With respect to beyond Mars, a sun-synchronous robot could spiral the surface of Mercury. Robots are capable of offering many venues at the poles. The poles are unexplored opportunities for science, resources, and habitation that are accessible by solar means. Lunar circumnavigation is the achievable, affordable first step. Growth and technical capability of robots outpace Moore's Law. He encouraged the Commission to prioritize polar exploration.

Dr. Leshin asked Dr. Whittaker to talk about how students interact on these projects and whether scientists are involved. He replied that students who engage in this have the experience of their lifetime. The last imitative was exclusively students. Besides the leap of technology, the relationships with industry were critical. A student with robotics experience has a capability that takes ten years to build. Many of them move from these training grounds straight to missions.

In response to a question from Gen. Lyles on the Defense Advanced Research Projects Agency (DARPA) failure, Dr. Whittaker noted that the project averaged 24 and hit 54 miles. In terms of inspiring a generation, hundreds of thousands of people have enrolled, with not one dollar of government funding. "Red's law" has speed and distance accomplishments. Enabling technologies are also high growth. Dr. Whittaker stated that he is committed to robots at work. A major shift has to occur in the space faring enterprise to get to machines that "work."

In response to a question from Dr. Zuber regarding a robot with an adequate power source, Dr. Whittaker noted that there are cold traps in the shadows of the direct sun areas. There are scenarios of kinetic devices and other means of exploration. He stated that he is an advocate of isotopic power. There are very near term objectives for robots, e.g., at the Moon. The year 2004 is the time for the mission studies, and we should immediately lock into those studies. Next, we must embrace the sense of robotic ambition and boldness. Capabilities will rise through these scenarios. Leverage what the private sector brings to bear.

Mr. Rusty Schweikart, Chairman of the Board of the B612 Foundation and former pilot of Apollo 9, shared some of his thoughts with the Commission. He believes that the Commission has the responsibility for the future of humans in space. This is a wonderful vision. It is the new direction, but it is still fairly amorphous in the public mind. The

Commission is being looked to provide the specific exciting, inspiring reality that people can endorse. Mr. Schweikart noted that today, he is wearing the hat of Chairman of B612, a group of astronauts who have come together to address what can be done about near earth orbits (NEAs). There are technologies being developed today to do something about NEAs and see that they don't collide with the Earth. The task has been to convince NASA to place going to NEA into the program. Out of that capability, we will be able to assure that we will not be impacted. Public acceptance of nuclear reactors in space is extremely important. Mr. Schweikart added that he is here to go beyond the basis of the B612 Foundation. The goal is to alter the orbit of an asteroid in a controlled manner by 2015. We must convince NASA to identify this as one of the Prometheus objectives. How do we responsibility protect the future of life on the planet from this type of threat? NEAs are primarily an opportunity. NEAs should come out of "beyond;" the vision should be "Asteroids, Moon, Mars, and Beyond." NEAs are quite easy to get to in terms of energy—much easier than landing on the moon. At the same time, they are a tremendous resource. There is a wealth of scientific data that can be gained by ventures to NEAs. The most important aspect for the Commission's work is the resources that exist on NEAs. They have a much higher quality of resource materials for conversion into oxygen, fuel, etc. Unlike the Moon, they were not blasted out by impact. Many NEAs are rich in water, metals, etc. There are hundreds of thousands of these bodies, the surface area of which is equal to or greater than the surface area of the moon. We have a tremendous resource that we should not by-pass in the President's Vision. If one is looking at opening up deep space to human activity, these resources will become the most favored sites for private development. There are industry potentials that will be very cost effective in the end, if NASA takes the role of enabler. Private enterprise will flourish in this new environment. The way to protect the Earth in the future is by private initiative having an additional job, at the same time providing jobs in space for young people.

Dr. Spudis observed that we have a lot of ignorance about NEAs. The question is: How accessible are they? Before we commit to getting most of the resources from NEAs, we need a series of survey missions, and we need to do that immediately. Mr. Schweikart agreed. The basic proposition to NASA is exactly that—to begin the exploration of the NEAs. There is a great deal that we have to understand about them. Prometheus' ion engine would be suitable for this objective. While not fully funded, it is an accepted program. The NEA mission is a perfect testbed for Prometheus and the future Jupiter Icy Moons Orbiter (JIMO). We have all three major motivating factors: curiosity, commercial potential, and fear.

Ms. Fiorina asked what it would take to have private enterprise working in space. Mr. Schweikart indicated that he had not done a great deal of analysis. From a conceptual point of view, it seems clear that as long as major space activity remains in the hands of the government, it will always be a painful process. While taxpayer money may be available for opening up potential, whenever something goes wrong, there is hell to pay. Part of the government responsibility when there is really large potential for human future is to be an enabler, for industry to follow. You do that by being an anchor customer. If fuel in situ is to be made available, why should the government produce it

without an announcement of opportunity? Government has an opportunity to be an enable for private investment. NEAs are territory in space, similar to the way the American West was in the 19th century. The detection program is the beginning of territorial mapping. For private industry potential, it would be helpful for the government to provide the maps.

The final witness, Dr. M.R.C. Greenwood, Provost of the University of California, talked about the role that the University of California might play in this program. The University of California makes a major contribution to knowledge and economic growth of state. It has a large research university that is the dominant research partner in the state. The intellectual brain trust will have to be multi-decadal. There must be partners that can sustain continual output. Historically, space exploration has been very powerful and productive. The Commission is not only about the Moon, Mars, and Beyond, but also about the structure and partnerships that are important to the nation's security. To accomplish the technological challenges, Dr. Greenwood talked about new leaps in technology that will be necessary—nanotechnology and the convergence with nanobiotechnology. Nanotechnology could accomplish some of the goals of this mission. Along with the California universities, they can provide the future assets to be developed. The San Francisco/San Jose/Oakland area enjoys the highest concentration of biotechnology, biomedical, and nanotechnology areas. As part of the circle, federal and national labs have added major centers that interface with industry. The University of California has pursued new partnership opportunities with NASA—the NASA Research Park. The focus is on developing the next generation technologies for the space endeavors. In California, there are four institutes for innovation. Centers were established with the understanding that with every dollar from the state, there would be two dollars from other partners. This is an example of the type of relationship that can be built between the fed government and universities—Biotechnology, information technology, and nano research. This is a way for the NASA organization to have a powerful brain trust. The University of California has been working with San Jose State University to establish a new approach to provide a powerful pipeline. There is an opportunity to change the way science and math are taught in California. This is a state approach to science and math that will ensure a strong workforce that will be necessary for the future.

In response to a question from Mr. Aldridge, Dr. Greenwood commented that the national shortage of qualified science and math teachers is one problem that we all are concerned about. The biggest problems are the math and physical sciences areas. NASA has always had a role in the use of technology in providing new materials and understanding to keep students who are more advanced. The complication is integrating those materials into the schools. It is hard to change school environments without changing the teacher training. Dr. Greenwood stated that she would start at the high school level to inspire young people to teach who have the potential for becoming good science and math teachers. In the University, we concentrate in the areas and work with math and science departments to bring in bright young people. The University of California can offer the new teacher center—young people are put into a professional environment and mentored. About 90% of the teachers that go through this program stay in the field.

In response to a question from Mr. Aldridge on the declining number of engineers, Dr. Greenwood noted that over the last few years, the program has been built up, although we have seen a decline in very recent years. In the University of California, many of the students are not foreign. There are many domestic students.

Dr. Tyson observed that the Vision should be an easy sell to California (it has the economy, the university, the NASA connections), but not most of the country. How can we convince those that don't share the California equation that they should support the Vision? Dr. Greenwood stated that it would be a challenge for the partnership and how they identify the objectives. There are some good models for partnering. Get the university and the industry to think about 20 to 30 year partnerships, attached to the "seed" assets. On some of the scientific projects, some virtual centers would work well; on other projects, they would have to have a real center. Dr. Greenwood noted that the University of California partnership with NASA is only about six months old, but it is innovative. The partnership is based upon a working relationship with NASA. NASA brings tasks that it needs to get done. The University works for the team that takes on the task. Most of the work being done now is being done at NASA. There are International Traffic in Arms Regulations (ITAR) issues, but so far, there has been a successful route and both partners are satisfied. There are enthusiastic people who want to work on the tasks. Dr. Greenwood offered to provide some specific information on the projects. In response to a question from Ms. Fiorina on what didn't work well, Dr. Greenwood stated that the time invested in getting the contract was the biggest issue. These are not easy bureaucracies to mesh. It is a new venture for NASA and the University of California. There is a culture clash—The University is less used to the federal acquisition process. However, the negotiations have been successfully concluded, the task orders are being issued, and the program is moving forward.

In response to a question from Gen. Lyles on whether there is anything else we should be doing to reach out to minorities and stimulate interest in technical skills, Dr. Greenwood stated that California is the most diverse state in the nation and it has had experienced with underperforming schools. In the wake of Proposition 209, it has focused its efforts. The University of California college preparatory on line brings opportunities to rural schools. It delivers basic courses in physics, math, and biology, and delivers free to any student American College Test (ACT) and Scholastic Aptitude Test (SAT) prep on line. There are about 6000 students enrolled in some of the basic courses. We have to make sure they have access to materials. We are targeting critical path points, e.g., algebra, focusing on getting students and their families to understand why they need algebra. There are summer algebra courses. There is the Cosmos program for students interested in science. We are identifying plenty of smart, young minority students. The question is—where are we losing them? With regard to producing more engineers, we have used funds to increase recruiting and have talked about enlarging the program. We have focused funding on the areas of engineering that were critical to the California economy. Many students have been recruited into businesses in the state. The University of California can provide a constant stream of new young people interested in working in

research areas in the Department of Energy (DoE) objectives. Many of the technologies that were necessary for national security were developed out of the partnership.
In response to a question from Mr. Aldridge on some type of space academy to increase the number of experts for both industry and government, Dr. Greenwood commented that a separate institution could be established, or special types of academy programs could be connection to some of the programs in universities for a semester or two. We need the innovation that the entrepreneurs bring.

Mr. Aldridge opened the public comment period by drawing names and asking the participants to provide short statements.

Ken Winans, the W Foundation. The new challenge in the space horizon is China. Another area of education concerns the involvement of museums. Give the public the museums to go to. What could we find on Mars? Chinese. Take this seriously. We have another nation funded by a military that is moving very quickly.

Michael A. Ayala, student at City College of San Francisco, had four points: (1) Incorporating international cooperation will be an excellent point. The U.S. has been interacting with other countries in a reactive way; this program could provide a more proactive way. (2) Increase student involvement and interact with other schools and at the international level. (3) The program offers an opportunity for the U.S. to get into the venture system. (4) When we go to Mars, remember to laugh at least once a day. Also, print the report on metric paper.

Katie Snyder, the mother of college bound senior who wants to be an astronaut, had some suggestions. At the age of eight, her daughter took a summer school space program. This kind of program is a good bet. She attended the one-week space camp at Ames Research Center at age 9. More programs are needed. There are only two space academies—make more. What will NASA need five years from now? She didn't know how to contact anyone at NASA. NASA needs to set up a place for someone like this to turn. Create a specific office to mentor kids who want to become astronauts. Advice should be age specific, e.g., the college major. Aim publicity at taxpayers over 18 to get funding support. If you want to appeal to kids, ask them for ideas—have them send ideas to a website and select the most creative for a brainstorming panel. Mr. Aldridge asked Ms. Snyder to get her letter to Ms. Susan Flowers.

Jim Spellman, representative of the National Space Society, stated that he was both encouraged and discouraged. He was encouraged that we have an Administration willing to make space an agenda item. He was discouraged at the relatively empty auditorium (about 40 or 50 people). Ms. Flowers from the public affairs office (PAO) has done her job, but if the gatekeepers in the media don't consider this important, it will not make the paper. The public don't see themselves as stakeholders. They need to be told why this is important. The space program is more important than Social Security. We are giving ourselves a hope for humanity. Look at your history and other reports that have been

written. There is a concern that this report will be treated like other reports—shelved and buried. We have to get beyond the paper rockets, simulated imagery, and paper reports. Leadership must come from both the top down and bottom up

John Reid, past president of the National Space Society. This initiative cannot go the way of the superconducting supercollider. It is a huge project. We need to network with all the universities, science centers, planetarium, and national museums. We have to get public input from sports celebrities—use the Superbowl, the Olympics, to get endorsement for the Vision. Have traveling exhibits. People need to feel and touch examples of the technologies that will have to be created.

Roger G. Gilbertson, child of the Apollo program. The boost of the early Moon missions sent him to engineering. One hundred fifty years ago, we could have seen schooners, ships, and new explorers in San Francisco Bay. Many stayed to carve out a new world. The testimony clearly tells us that the space frontier will be the same. Request to the Commission: do not let your work go to the world as a document that will only gather dust. Distill all the energy and ideas—make it jazz. Make an MTV video; ask Cameron or Spielberg to give the report to the American people. Madison Ave will do it. Give us the results powerful enough to keep the next generation awake at night.

Bruce Pittman, systems engineers and entrepreneur, also a child of the Apollo era, had four suggestions: (1) the Commission has an awesome responsibility—don't be too specific; keep the options open. (2) Allow for the insertion of new technology—there is a tendency to lock things in. In this case, things need to be fuzzy for a while. (3) Keep the door open for the general public to participate. Let one seat on the vehicle to Mars be for the general public. (4) Consider new alternatives. Offer $10 billion to the first company that puts a man on Mars and returns him to earth.

Dave Bengel, independent consultant and inventor. He has developed some new concepts for launch vehicles. Tether fixed wing aircraft, and do a high altitude launch. If you launch from high altitude, there will be less wind buffer. This will allow remanufacturing the tank and the tank becomes part of the payload. Robotics will be needed for manufacturing in orbit, and can be used on Earth. If people are motivated by a reward, they generally rush to a solution, and those solutions are not as good as solutions from people that are motivated by accomplishment. Mr. Bengel indicated that he has proposals on how to incentivize cooperation and communications and will send these ideas to the website.

John Paterson, systems engineer with Lockheed Martin, indicated that he wrote a paper for Ames and will forward it to the Commission. While at Ames, he worked on the first Space Exploration Initiative. He is currently a senior test director at Edwards Air Force Base, California. We will backslide severely is this nation does not pursue the program. During Apollo, this nation enjoyed the highest level of docs and post docs and got a spin-off return of 4 to 1. This effort would provide excellent benefits in terms of quality of life as well as economic return. It would provide change for the better. It is important that the U.S. lead the effort. Three weeks ago, we received notice from the Mars Society

that there is new evidence that there is methane on Mars. We had a false start in the early 1990's. We need to have a successful one this time around.

Phil Lane, microbiologist, formerly at Ames Research Center. The space program is a delicate balance of human activity that provides an inspirational role and a science yield, as well as opening up areas of commercial activity. NASA got the balance right in the lunar program. The science data reoriented our understanding of the Earth-Moon system. The commercial activities from NASA have been relatively limited—weather satellites, GPS, communication satellites. Getting the balance right is hard—it has not been right in the last 20 years—the science yield has been relatively minimal. In trying to redirect the way NASA does business, figure out ways to meld the human and robotic activity to maximize the yield. For Moon and Mars, the Moon base is a terrific idea; sending humans to Mars is way too expensive now, but is good for the ultimate goal.

Mr. Aldridge adjourned the meeting at 3:35 p.m.

President's Commission on Moon, Mars and Beyond

WITNESS LIST AND TIMELINE FOR SAN FRANCISCO, CA, HEARING

Hearings will take place at the Galileo Academy of Science & Technology
1150 Francisco Street, San Francisco, California 94109

Thursday, April 15, 2004

1:00 – 1:15 p.m.	Welcome and Introductions Chairman Pete Aldridge
1:15 – 2:00 p.m.	**Entertainment and Space Exploration** Ray Bradbury, Writer John Bernardoni, TV Producer "Legends of Space" Lawrence Holland, Totally Games
2:00 – 2:15 p.m.	BREAK
2:15 – 3:00 p.m.	**Educating Tomorrow's Astronauts** Barbara Morgan, Educator/Astronaut Dr. Jerry Wheeler, Executive Director, National Science Teacher's Association Jim McMurtray, Executive Director, National Alliance State Science and Mathematics Coalitions Dominic Farrar, Odyssey Program
3:00 – 4:00 p.m.	**Sustainability for the Long Haul** Reecie Giesecke, President UAW Local 848 Dean Zvorak, President UAW Local 887 David Goodreau, Chairman and Co-founder Small Manufacturers Association of California
4:00 p.m.	Commission adjourns

Friday, April 16, 2004

9:00 - 9:15 a.m.	Welcoming Remarks Chairman Pete Aldridge
9:15 – 10:00 a.m.	**Propulsion Requirements** Byron Wood, Boeing Rocketdyne Michael F. Martin, Aerojet James Mosquera, US Navy (Naval Reactors)
10:00 – 10:15 a.m.	BREAK
10:15 – 11:00 a.m.	**Prospects for Space Prosperity** Dr. Stan Rosen, California Space Authority James Benson, SpaceDev
11:00 – 12:00	**Lunar Science** Dave Morrison, NASA Ames Research Center Michael Carr, US Geological Survey, Astrogeology Dept. Jonathan Lunine, University of Arizona
12:00 – 1:00 p.m.	LUNCH
1:00 – 2:00	Robotics and DARPA "Red"Whittaker, Carnegie Mellon Robotics
2:00 – 2:15 p.m.	BREAK
2:15 – 3:00 p.m.	Provost M.R.C. Greenwood, University of California
3:00 – 3:30 p.m.	Audience Comments
3:45 – 4:30 p.m.	Press Conference
4:30 p.m.	Hearing adjourns

###

President's Commission on Implementation of United States Space Exploration Policy
San Francisco, California
April 15-16, 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
Georgia Center for Advanced Telecommunications Technology
Atlanta, Georgia
March 24-25, 2004

ATTENDEES

Name	Affiliation
Hubbard, G. Scott	Director - Ames Research Center/NASA
Winans, Kenneth G.	President, The W Foundation
Wreyford, Deborah	Director, The W Foundation
Spellman, James Jr.	Executive Director, National Space Society, Western Spaceport Chapter
Gilbertson, Robert	President, Mondo-Tronics Inc
Brunnell, Valerie	Rocketman Productions
Pittman, Bruce	Profit Engineering Technologies
Paterson, John	Lockheed Martin
Ayala, Michael A.	Self
West, Glenn	Self
Tanaka, Masaaki	JAXA
Brownlee, Don	Vice President, AEROJET, Washington Operations
Lane, Phil	Lockheed Martin (former)
Morrison, Davis	NASA
Holland, Robin	Totally Games
Kavanaugh, Joe	Kavanaugh & Del Favero
Dianati, Soheila	NASA
Moriaty, Gail	

Lynn, Roger	Odyssey
Reid, John B.	National Space Society
Wiens, Stuart	Lockheed Martin
Dodds, Ned	National Space Society
Seastrand, Andrea	CSA
Warren, Liz	
Litzenberger, Julie	Stanford University
Hanuschak, Gregor	Stanford University
Landfield, Ryan	Stanford University
Walker, Lorraine	
Stainets, Lilly	
Ayala, Michael A.	Self
Southern, Glenn	DOE
Hubbard, G. Scott	Director - Ames Research Center/NASA
Gilbertson, Robert	President, Mondo-Tronics Inc
Schweickart, R. L.	B612 Foundation
Wreyford, Deborah	Director, The W Foundation
Race, Margaret	SETI Inct.
Nany Ann Budden	NASA/NAVY
Scallera, Eric	Netgitbook
Bengel, David	Self
Kavanaugh, Joe	Kavanaugh & Del Favero
Lane, Phil	Lockheed Martin (former)
Spellman, James Jr.	Executive Director, National Space Society, Western Spaceport Chapter

Pittman, Bruce	Profit Engineering Technologies
Lucking, Matt	The Planetary Society
Wiens, Stuart	Lockheed Martin
Seastrand, Andrea	CSA
Alwood, Joshua	Stanford Student
Koening, Jesse	Stanford/Space Dev
Dubord, Luke	Stanford
Sokolik, Cindy	
Walker, Pat	
Snyder, Katherine	
Pelligron, Ralph	NASA
Roach, Anthony Andres	