

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

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Pete Aldridge

Well, good afternoon, ladies and gentlemen, and welcome to the fifth and final public hearing of the President's Commission on Moon, Mars, and Beyond.

I think I can speak for everyone here when I say that the time period since this Commission was appointed and asked to produce a report has elapsed at the speed of light. At least it seems that way. Since February, we've heard testimonies from a broad range of space experts, the Mars rovers have won an expanded audience of space enthusiasts, and a renewed interest in space science has surfaced, calling for a new generation of space educators.

In less than a month, we will present our findings to the White House. The Commission is here to explore ways to achieve the President's vision of going back to the Moon and on to Mars and beyond.

We have listened and talked to experts at four previous hearings—in Washington, D.C.; Dayton, Ohio; Atlanta, Georgia; and San Francisco, California—and talked among ourselves and we realize that this vision produces a focus not just for NASA but a focus that can revitalize US space capability and have a significant impact on our nation's industrial base, and academia, and the quality of life for all Americans. As you can see from our agenda, we're talking with those experts from many, many disciplines, including those outside the traditional aerospace arena.

And before I go any further, let me introduce my fellow Commissioners, and I'll begin on the audience's right. I think that's right. Audience's left, my right.

Carly Fiorina serves as the Chairwoman and she's Chief Executive Officer of Hewlett-Packard, which she joined in July of 1999. Her roots are deep in technology and she's served in senior executive leadership positions at AT&T and Lucent technologies.

Michael Jackson is a senior vice president for AECOM Technology Corporation. He is a former U.S. Department of Transportation Deputy Secretary, and was instrumental in the early formation of the Transportation Safety Administration.

Dr. Laurie Leshin is the Director of Arizona State University's Center for Meteorite Studies and the Dee and John Whiteman Dean's Distinguished Professor of Geological Sciences at the University of Arizona.

General Les Lyles was in the Air Force for more than 35 years, rising from the Air Force ROTC program to become a four-star general and the commander of Air Force Materiel Command; in

that preretirement position, General Lyles was responsible for the U.S. Air Force research and development community.

Dr. Paul Spudis is a planetary scientist at the Johns Hopkins University Applied Physics Laboratory outside of Baltimore, Maryland. His specialty is the geology of the Moon. He has also studied the geology of Mars, Mercury, and many other worlds.

Dr. Neil deGrasse Tyson is an astrophysicist and the Frederick P. Rose director of the Hayden Planetarium in New York City. He recently served on the President's Aerospace Commission, which made recommendations to Congress and related government agencies on how to improve the health and future of this industry in the interest of the American economy and national security.

Retired Congressman Robert Walker is the chairman and chief executive officer of the Wexler and Walker Public Policy Associates, a firm specializing in telecommunications and technology issues. Bob served in the U.S. Congress from 1977 to 1997, representing his home state of Pennsylvania. And while in Congress, he was chairman of the House Science and Technology Committee with NASA oversight. He, too, served on the recent Aerospace Commission as its chair.

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

Next to Maria is Steve Schmidt, our Commission's executive director. Steve is a special assistant to the NASA administrator and our federally designated official for this advisory committee.

It is important, I think, to review the process this Commission will follow and has been following. We've been appointed by the President to make recommendations on how to implement the space vision set out on January 14th of this year. It is our job now to recommend the most important strategies or steps to accomplish this vision. This is a sustained journey; more than 10 presidential terms are covered by this vision. We're listening to experts in public along with drawing upon our own expertise to generate the plan. I envision that we will select maybe 10 strategies to recommend what we believe will lead to putting us back on to the Moon and on to Mars. In addition to experts, we're listening to the American public, the ultimate customer for this vision. Through our website, we're accepting comments from people around the world who want to be heard on this subject.

This final hearing is noteworthy because it's the first to focus on one of the significant missions within the vision, namely, the building of international partnerships in space.

For our first panel, we're pleased to welcome three members of the international space community.

Daniel Sacotte is the director of the European Space Agency and is responsible for space exploration. Since November, he's served as director of human spaceflight, microgravity and exploration programs. Mr. Sacotte is also a member of the board of trustees of the International Academy of Astronautics and a chevalier of the Legion of Honor.

We're pleased to welcome Mr. Kyoshi Higuchi, executive director of JAXA, the non-acronym brand-new name of the Japanese Space Agencies. Prior to his post, Mr. Higuchi was the director of the Space Shuttle Utilization Office and the Space Station Program Office. We look forward to his wide-ranging perspective.

Philippe Berterottière is Senior Vice President–Sales/Marketing and Customer Programs for Arianespace as well as being a member of the executive committee. His 30-year perspective on the international space business will be much appreciated. Mr. Sacotte, I believe you're going to be first. Welcome. Welcome you all.

Daniel Sacotte

Mr. Chairman, members of the committee, it is a distinct honor for the European Space Agency to appear before this Commission today. We appreciate this opportunity to contribute to your reflection about the way forward for the U.S. space exploration vision. ESA would like in particular to congratulate our American colleagues for innovating space exploration as a rank at the highest level in your country. This vision and the subsequent implementation by NASA will have a very positive influence for all the world's future space activities.

My testimony today will be made up of four parts. First one will be a brief description of ESA. Second one, what are our ongoing and planned activities in space exploration? Then our international cooperation. And at the end our European vision for international space exploration.

Starting by a brief description of ESA, probably you know that it's a little bit emphatic but we consider that ESA is European space. We have developed an agreement with the European Union and we have now a framework agreement with the European Union that recognizes our role and the role we will have to play together between European Space Agency and European Union. European Space Agency is an intergovernmental organization with a special agreement with European Union. We have 17 member states. That means a lot of difficulties because playing with 17 presidents is far more difficult than to play with only one. So, it will be one of our difficulties. Our budget is on the order of \$3 billion every year. And the difference of NASA, ESA is active and is the [body and shadow?] space in all the field of activities, being launcher, being telecommunication, being Earth observation, and also human spaceflight and exploration.

What are our ongoing activities in the field of space exploration? We have in the field of exploration huge and important and comprehensive program for robotic exploration, mainly devoted to scientific goals and also for technology. We have Mars Express, Europe's first mission to Mars, that was launched by a Soyuz vehicle and injected into an Earth orbit with the help of the JPL Deep Space Network, a good example of cooperation. This mission has

produced a lot of very interesting and basic results in terms of identifying the waterized zones, the carbon dioxide on the Mars south pole and also the presence of methane together with very precise imagery of the surface of the planet. We have also Smart-1, a lunar probe that has been launched in 2003, which is testing a series of interesting technological developments like unique propulsion and very miniaturized experiments for—Smart-1 will be close to the Moon in the coming months. And we'll be able to make a detailed inventory of chemical elements of the lunar surface. We have Rosetta, which is an interesting mission carrying a series of instruments [?] being developed by—provided by NASA and developed by American laboratories. It has been launched in March 2004. It will reach the comet—I've never been able to say the name—but it is Churyumov-Gerasimenko. And it will be done in 2014—that's not so far. Of course, we have also the international Cassini-Huygens spacecraft to study Saturn.

ESA and NASA are looking forward to the very spectacular images of Saturn that will be coming soon and still we have some view of that. And the Huygens probe that is part of this mission will be ejected and will reach the surface of and the atmosphere of Titan, which is for us one of the most exciting places, I would say, in the solar system if not in the universe, so we are very proud to do this mission. We have also smaller missions like Venus Express that is to be launched in 2005 to study the atmosphere of Venus. We will have the mission BepiColombo that is developed in cooperation with our friend from Japan that will study Mercury to be close to Mercury in 2012. So, a lot of scientific robotic developments that are made, most of them in cooperation because we consider that space, the solar system is the right place for cooperation.

Besides those robotic activities, of course you know that we are in Europe and ESA is one of the keepers now of the Space Station. Our contribution to the Space Station is on the order of five billion Euros, that's more or less \$5 billion. The main development we are making for our ISS participation is the Columbus laboratory, is what we call the ATV, automated transfer vehicle, which will help, will be a successor that we have better capabilities than the present rover system of the Russians. Also, we have developed a series of activity for that management system and robotics. I think we will come later with the Space Station during the question-and-answer.

We are also, and it is a subset part of what we do with exploration, a roadmap, including Mars as a goal and Moon as an interim step, called Aurora, which is in a preparatory phase in which we will build our cooperation in the exploration of space. International cooperation of ESA: we have a huge series of cooperation in ESA, and the most difficult and most important one is that we cooperate inside Europe between 17 member states. That is a huge and interesting exercise of common understanding. We have countries as different the U.K. and France, as Germany and Luxembourg, so different in size, different in courtesies, different in technical and industrial developments, so we have to find a common way of working together, and that's a challenge for which we are for certain experience to show. Another type of cooperation we are under we'll be pleased to express here is our fantastic cooperation with NASA. NASA is our first, in terms of time and in terms of content, is our first partner.

An example, early February this year, we have demonstrated with Mars Express orbiter, by way of special cooperation, we used Mars Express to transfer command from NASA to *Spirit*, your

rover on the [world?] of Mars, and it was more or less the first international communication network that has been established around Mars and it was a common experiment between us. We have also huge cooperation with Russia but not in the same type of—I would say direct and eye level. That’s a political point of view as we added with the United States. We are also partners everywhere in the world with all the nations that are doing something in space. Japan, of course, but China also.

We have this experiment about Double Star, which was a way for us to restart work on the space mission, the development that we have made for the Cluster mission, the one that was involved with the first flight of [Ariane?] when it failed. Concerning International Space Station, it is also one of the huge examples of cooperation and what I can say at this stage is that ESA has been and is still a very loyal partner. When I say “loyal,” it’s more than that.

You must know—I’m not sure that it has been understood so well—but during the very dramatic and difficult period that came after the dramatic accident of the Space Shuttle, we have to keep Russia involved, and to keep Russia involved, we have developed certain activities that we have called a “taxi flight” that was, that is still, remains to keep Russia on board by paying flight using Soyuz to the Space Station. We pay for having a European astronaut on board, and it gives the money needed by the Russians to keep the activities. It is not so well known and not so well recognized, and it is an opportunity for me to say it again.

Now, what is our vision for international exploration? What we consider is that in the future, the program for space exploration, we’ll have to go beyond scientific properties we have to develop something a little bit different, and the goals we can assign for Europe in having a stronger program for exploration can be seen as in creating the general knowledge of the universe, of the solar system is not a problem, it can be and it is to develop the competitiveness of industry by the way of developing innovation. That is something that we will try to do. It will be also something a little bit different from your vision to try to enhance the European identity, and space is a way of developing European identity. It is a challenge for Europe to have identity and proven identity with now 25 members of the European Union. And the common goals are not so easy to find. So, space can be one and space exploration in particular.

We can have also—and it is something that is more and more important in our countries—we have less and less young people that are interested by science, mathematics, technology, etc., and we consider that a robust and interesting space exploration program will help give inspiration to the young generation. So, it is a goal we are trying to have. And the last one is related to security. That is yours also, but maybe the way we see security is more environmental security.

So, those are the five goals for our program for exploration. The way it will be implemented depends on the way our 17 member states [feel?], and that’s their opinion. We’ll give weight to those five objectives. And the result will be our participation in exploration program. What we consider—and the way we will group the goals and derive the different activity is first that space exploration is a global undertaking. We are not considering that it is possible for one country, being the United States, to make it for the only interest of United States. It has to be for the interest of mankind, and we consider that Europe can play a role in this view. We consider also

that Europe will probably not be in the driving seat for this program. So, we are ready to find the way of being a partner.

Second point is that the contribution of Europe must be robust. When I say “robust,” it is not exactly affordable and sustainable. It means that it has to be, of course, affordable. It has to fit with the money our government will put in these activities. But it does [upset?] to resist to all the difficulties that are normally coming in the development of the program. That means that we will have to find our way in the global network or in the global picture for space exploration. But we have to keep a certain number of key decisions deciding value [other?] for the large part of what has to be developed in Europe. And it is something on which we can also have a discussion about the fact that it was not the case for Space Station.

Last point is that it has to be flexible because we know that during a program that will extend more than 10 years, maybe 30 years, things will move, things will evolve, and we have to have these flexibilities in order to fit the different developments that will exist in the future.

So, Mr. Chairman, members of the Commission, what we have in mind is that we will play an important role in this exploration program. The schedule we have is that we plan to have a decision, a real decision for starting a program for exploration, let’s say one year from now, the occasion of conference of our ministers that has been fixed now in June 2005. It’s been that during this period that starts now to go to this meeting of our ministers in June 2005, there is a lot of work to do, and we have started. I’m in charge of this program since three weeks, and I’ve—it has been—well, whatever it is, it has moved a lot. We plan to have for this program not only a program for exploration with robots and scientific activities, but we have also in mind to try to see how Space Station can be an asset for the future. So, it’s where we are, and of course we are looking for what to be a good partner and interesting partner for the future of global space exploration programs. Thank you.

Pete Aldridge

Thank you very much.

Mr. Higuchi.

Kyoshi Higuchi

Chairman Aldridge, other distinguished members of the Commission, it’s my great pleasure to have this opportunity to testify before the Commission. I’m Kiyoshi Higuchi, [?] JAXA, and JAXA means Japan Aerospace Exploration Agency. I am executive director of the JAXA, responsible for the strategies, plans, and international relations. I’d like to tell you the view on President Bush’s vision for space exploration on the following points based on how I experience that as an International Space Station partner.

In five minutes, I condense five points. So, I save the time to advise of JAXA. The first one—can I have the slide? OK. Too busy.

First one, the vision is very attractive and challenging. We express our respects for the frontier spirit of the United States.

The second one, JAXA is also currently conducting projects for unmanned lunar and solar system exploration, and we are very much interested in how the vision will evolve to a plan. And this time I skip to the—the project name, I save the time, just say that we have a lot of projects related to space exploration.

The third one is space is a common heritage of mankind and is also international in nature. JAXA has numerous cooperation projects with the United States and also with ESA and all over the world in the fields of space science, Earth observation, and space environment utilization with many beneficial results.

And fourth one, this is the heart of my message. Among these, the International Space Station program is a completely new type of international cooperation in terms of contents and scale. Due to the numerous scale and the complexity of the enormous—due to the enormous scale and the complexity of the ISS program as well as its extensive duration, many difficulties have occurred such as the numerous program changes.

The international partners have worked hard to overcome these problems with mutual understanding and cooperation. One of the serious impacts to Japan is the launch day of the Japan Experiments Module, we call JEM, which in time impacts the budget and delays JEM utilization. However, through its participation, JAXA has accumulated precious experience in areas such as execution of international cooperation projects and manned space technology, including the flight of Japanese astronauts.

The ISS partners must continue to cooperate together so that the ISS can be completed and operated indefinitely in a mutually acceptable way, thereby gaining many valuable results, the experience of success would be important and essential for promoting a new international project. Fifth, JAXA is interested in how the U.S. vision will be evolved into a plan. The plan that fundamentally matches with Japan's policy—space policy—would have possibilities for cooperation. We'd like to see the details of plan to be developed and consider in which area we could potentially cooperate. For that purpose, we believe that information exchange on the specific plans is important.

Finally, I am very proud that JAXA has established very close and good relationship with NASA by mutual efforts. Mr. Chairman and other members of the Commission, I thank you for the chance to share our view with you.

OK.

Pete Aldridge

Thank you very much.

Mr. Berterottière.

Philippe Berterottière

Thank you, Mr. Chairman, members of the Commission, good afternoon and thank you for this opportunity to share with you the capabilities and experience of Arianespace. First slide, please.

Let me start by giving you a brief overview of Arianespace. Arianespace was founded in 1980 as the world's first commercial launch services provider. Since that time, we have signed more than 250 contracts, and have launched the majority of the world's commercial satellites in geostationary orbit. We have a longstanding relationship with the U.S. commercial market playing an instrumental role in its development, growth, and future through support of U.S. satellite manufacturers and operators. Arianespace is a privately held European company with 44 shareholders representing 13 European countries. We are the prime contractor to ESA for marketing, sales, integration, and launch of Europe's family of launch vehicles. Europe is committed to optimizing resources to address all market segments, and thus has chosen to operate three vehicles from French Guiana: the heavy-lift Ariane 5, the medium-lift Soyuz, and the light Vega.

Through this family of vehicles, we have the ability to launch any size payload from the smallest science missions to the largest GEO birds to any orbit. Arianespace is proud to be in charge of operating this robust family of vehicles for ESA. Next slide, please.

Our workhorse vehicle is the Ariane 5. It currently launches in two configurations for service to low Earth and geotransfer orbit. We are currently evaluating a more powerful upper stage and have studied alternative configurations to create a super-heavy version should the need arise. Next slide, please.

All Arianespace launches are from the Guiana Space Center, Europe's spaceport in Kourou, French Guiana. This dedicated commercial facility provides state-of-the-art satellite clean rooms and processing facilities. The space Guiana center meets or exceeds all Western safety standards and is ISO 9000 certified, located within NATO-allied territories, security is at the same levels used to protect the French strategic nuclear forces. Next slide, please.

Arianespace brings a wealth of capabilities to the table. From the outset, the Ariane 5 was developed as a man-rated launch system to carry Europe's Hermes space plane. On our third launch, Europe's atmospheric reentry demonstrator, or ARD, was successfully tested. Use of ARD could be explored for additional downmass capability for scientific experiments from the International Space Station.

In the near future, once the Columbus model is deployed, the Ariane 5 will be used to launch the European Automated Transfer Vehicle (ATV) for vital supply and reboost of the International Space Station. The first ATV should be tested late next year, with an additional six to eight already under contract for launch with fewer Shuttle missions now expected, additional ATV's may be needed for servicing and maintaining the ISS Building on our current experience with Soyuz through our sister company Starsem starting in 2006, the Arianespace family of Vegas grows to include the Soyuz ST from French Guiana.

This is an improved version of this venerable system that has launched more than 1,685 times. And it is another well-proven cargo option for servicing the station. For the time being, the current plan for Soyuz in Guiana does not include human spaceflight. However, they also do not preclude it. In fact, there is an ongoing ESA study to ensure that the new facilities will be designed such that human spaceflight could be added in the future. Upgrading these facilities for human spaceflight could be an alternative for filling the gap between Shuttle and the activation of the Crew Exploration Vehicle in servicing the ISS. Next slide, please.

Arianespace has a history of success in launching complicated science missions along the lines of those that could be precursors to human exploration beyond the Moon. In 2002, we launched the enormous Envisat Earth observation satellite. Last fall we launched the Smart-1 lunar mission, and just this March we launched the Rosetta comet probe. All of these missions required extensive engineering, collaboration, and unique uses of the vehicles, and all were outstanding successes. In fact, the Rosetta trajectory was so accurate that ESA has been able to add additional science missions observing asteroids along the path to the comet. As we look forward, soon we will be launching the Jules Verne ATV, and in 2007 the Herschel and Planck missions to L2. We are as committed to providing outstanding service to the science community as we are to the commercial world. Next slide, please.

Although a European company, Arianespace is truly an international partner. We have launched 23 government payloads for five NATO countries with 100% success. We serve the civil and defense needs of Australia, Japan, India, Turkey, Great Britain, France, Germany, Spain, and Italy. Additionally, we have launched several satellites for intergovernmental organizations, including Intelsat, Inmarsat, Eutelsat, and Eumetsat. We have worked with NASA through the joint CNES [Center National D'Etudes Spatiales] Topex/Poseidon ocean science probe and are working with them now through ESA on future ISS supply and reboost with the ATV. Next slide, please.

Finally today, I would like to bring to your attention the innovative launch services alliance that we formed with Boeing Launch Services and Mitsubishi Heavy Industries in July 2003. Arianespace, BLS, and MHI have agreed to work together to provide mission assurance to our commercial customers using the Ariane 5, the H-IIA, and the Sea Launch vehicles. Basically, the program works like an airline co-chair agreement. We each still separately compete for contracts, thus assuring that our customers receive the best prices. Once the primary vehicle is chosen, the customer can then also choose to add the mission assurance clause, activating the alliance system. Then, if a problem occurs with the primary vehicle, the customer does not lose his launch opportunity as an alternative is all ready to go. The first example of a launch enabled by the alliance is the DirecTV 7S satellite, alternately contracted with Arianespace; satellite delivery delays led to complications on the manifest. Through our alliance relationship, we were able to secure an earlier launch date for DirecTV and in fact the satellite will be launched by Sea Launch early tomorrow morning. While designed for the commercial marketplace, our close cooperation with Boeing Launch Services and Mitsubishi Heavy Industries could be expanded into the civil and space arena.

In fact, Arianespace is already working with MHI to provide backup for Japanese and European government missions. Arianespace and Boeing are also exploring opportunities for cooperation on civil programs. I hope that this short explanation of Arianespace, our history and our capabilities, has provided insight to this Commission on the [?] possibilities for cooperation and collaboration as you look to recommend ways to implement and system this nation's new vision for space exploration.

Our reputation for being a willing and able partner, combined with our unique experience and capabilities in performing complicated scientific missions, could play a critical role in meeting the near- and long-term requirements for space exploration.

The Commission should actively consider the capabilities of European companies and their ability to partner with U.S. firms to achieve exploration goals as you formulate your recommendations. We stand ready to discuss any of these issues with you, the Administration, and NASA at any time. Thank you for your time and consideration. I look forward to your questions.

Pete Aldridge

Thank you very much. I thank all of you for your testimony today. I have a question for each of you individually. While it's still fairly early in the development of the architecture for the space exploration initiative, it is clear that the development of the architecture must take into account international participation early in the planning process. Have there been any discussions ongoing in each of your organizations with NASA on what role you might play in the development of the architecture? Mr. Sacotte, can I start with you?

Daniel Sacotte

Well, it's—well, it's an interesting question. The first—the first part of the answer will be that what we see is that the approach we will take in Europe is more or less, I guess, the same as the one you take in the United States, is to try to work on the idea of building blocks, so we will have several building blocks that we will assemble following a certain architecture or maybe several architectures.

For the moment, what we have been doing and what we have been discussing with NASA is participating in such-and-such building blocks, being part of scientific mission, being part of evolution of the Space Station [?].

For the architecture itself, as far as I know, but I am a little bit new in the system, I didn't hear about it. And it is for us a clear goal we have, because we need early—sufficiently early in the process—to see together what will be the architecture. What we have in mind is in order to have it done as efficiently as possible, we have to share to certain points very high-level requirement we are fixing to each and every of the blocks just to see how we can fit with what we consider as our possible scenario. So, architecture in my own plan I have to develop in the coming months would be a key subject, I would say, starting during summer.

Just a small parentheses, I'm a little bit sorry because I cannot go in many details, because I didn't explain to my member states it would be done this week, at the end of the week, what we want to do, so I have no backing from the member states in the role approach I am presenting today, so maybe I can just be sort of—I can be saved by the member states that it is the right way, but I do not think so.

What we think is that for this development of the architecture, we would need to have a certain and different and see on the way of developing it, but we have to share the same eye-level requirement, and it is a place on which we are trying to have cooperation or at least open discussion with NASA, but it's not yet done as far as I know.

Pete Aldridge

Mr. Higuchi?

Kyoshi Higuchi

I will use interpreter....[speaking Japanese]

Interpreter

To answer your question, as I said earlier, JAXA as an organization is very interested in this US vision. However, we at JAXA have not started considering officially any specific way of cooperating, including, for example, architecture.

Kyoshi Higuchi

[speaking Japanese]

Interpreter

However, we do have our own unmanned lunar exploration program, and so, one of our organizational units in JAXA has begun on just a kind of—well, exploratory basis, started the—some resemblances, if any, between our unmanned lunar exploration program and the—this most recent American vision.

Kyoshi Higuchi

It is very similar, American vision.... [then speaking Japanese]

Interpreter

At any rate, we are keeping a close eye on and also being very interested in how this US vision will be translated into real plans.

Kyoshi Higuchi

Thank you.

Interpreter

Thank you.

Pete Aldridge

Thank you.

Comment, please?

Philippe Berterottière

Well, we have not discussed with NASA on any schemes for the vision. But as I mentioned, we are exploring with Boeing a recruit setup collaboration, in other terms, to civil needs. One of these—one of the perspectives we are discussing is, of course, what we should do in order to provide the adequate access to space for the—for the vision. That's really something currently discussed.

Pete Aldridge

Just a question. I had forgotten that Ariane 5 was planned to fly the Hermes manned mission and forgotten that it was, therefore, man rated. I assume that in your definition of man-rating is certain redundancies in the vehicle as well as the—a smooth interface between the human capsule module and the rocket itself. Is that kind of the way it was defined?

Philippe Berterottière

Yes. I have to say that the original plan four and five was exactly to launch the Hermes plane, so it was man-rated. That has been—it would be the basic plan in 1988. That has been stopped when Europe decided to stop the Hermes plane in 1992. And then the—I would say that we put more constraints on—more constraints on having an affordable launch vehicle than on aiding a man-rated launch vehicle. So, many of the redundancies which we are planned originally have been dropped or during the rest of the development of Ariane 5.

Pete Aldridge

Les?

Les Lyles

Thank you, Mr. Chairman. I thank all the three of you for being here. I think this is a very important element of this vision. Mr. Berterottière, I was very happy to hear about the launch services alliance with Boeing. That kind of cooperation, I think, is going to be very important in the future. In the normal circumstance, you would think of an Ariane 5 and a Boeing EELV as an example of being competitors. In the alliance, is the heavy-lift component of the activities and contracts just to be provided by Ariane 5 or is there flexibility to your alliance to allow another heavy-lift vehicle from the EELV family type to participate?

Philippe Berterottière

Well, in the alliance, it's an alliance in order to provide backup services. But otherwise on the primary market, so to speak, each of us—Boeing, Mitsubishi Heavy Industries, and Ariane—are there to compete. So, none of us have the plan to segment the market in a way where a particular vehicle would otherwise have specific needs. That is not leading to that. It's an open competition. But then, we can provide through this alliance some kind of guarantee of being launched on time, which is, I think quite well appreciated by users.

Les Lyles

Well, along those lines, your ATV as an example, which you stated, could be an important element in the future of getting to the International Space Station. Is the ATV potentially adaptable to any EELV family of vehicles?

Philippe Berterottière

Well, that's something which is currently discussed, which could be envisaged if the capabilities of the ATV versions of the EELV's loads, in fact, to launch the ATV, and then it's fairly—it's fairly doable.

Les Lyles

Thank you.

Pete Aldridge

Paul.

Paul Spudis

Yes. Mr. Berterottière, I have a question about Ariane. Are there any plans to develop a larger lift capacity for Ariane 5? Right now it does 23 metric tons to LEO [low Earth orbit]. Are there any plans to expand that into a heavier-lift vehicle or develop a new heavy-lift vehicle?

Philippe Berterottière

Well, there is currently no plan to develop heavier launch vehicles than that. There is a plan to— a plan to develop an upgraded or new upper stage of Ariane 5, which could improve the restart capabilities and so which could address specific needs. But there are no current planning for an heavier version of the current Ariane 5.

Pete Aldridge

Neil?

Neil Tyson

This question is for both Mr. Sacotte and Mr. Higuchi. I'm curious. We heard from you and in your testimony what the annual budget is for the European Space Agency, and I'm curious, what sets that budget level? A question to both of you. How much—do you poll the member states, the poll the people to find out, or if it's \$3 billion, why isn't it \$30 billion? What accounts for that, and for increased collaboration into this vision, do you expect to fold that collaboration into your pre-existing budget, or might there be prospects for having it topped off?

Daniel Sacotte

OK, so I start. Yes, the present level of budget is \$3 billion. It is the \$3 billion are paid by the 15 or the 17 member states, it's part of the government budget of each and every member state. The budget goes in two directions: first one is what we call monetary activity, which is mainly science and technology, and that is supposed to be mandatory activity as it is science. That means the member states are participating following the national gross product. So, I would say this level of activity for science and innovation and the [?] is of the order—same order every year, it's discussed every five years, and more or less it is one of the cost-plus/minus inflation, depending on the general status of the political appealness of space at this time. So, let's call it constant and the order of magnitude for that is 500 to 600 million Euro.

For the rest, it is voluntary contributions going to special programs like Ariane with a special share of the key contributor, like France, Germany, Italy, because industry of those three countries are leading in those activities. So, it is a mix of political willingness and industry participation, I will say. What we see is that the development program, is if we run those [tax?] to between seven and 10 years and see that as we have something like 15 ongoing programs, some are ending, and it gives room to others to stop. What we have made in our internal

[prognostication?] is to consider that at the next big round of discussion and decision, it has to be—that will take place next June 2005, we plan to have three decisions for big programs, I would say, one being in the field of Earth observation. It will be an improved activity in terms of environment and security together with the European Union. Another one will be in the field of telecommunication. In order to have a [?] activity—we call it reducing the digital divide, we call it, inside Europe, that is a huge problem with newcomers to the European Union and the last one is exploration. That means that exploration will be one of the three programs to start. The level of budget for such activity would be, I would say, on the same order of the decreasing of our activities on the Space Station. So, we consider that we are putting in the field of Space Station and man in space on the order of 600 million per year. We consider that the following activities of Space Station will be, let's say—it's just a rude way of making budget, I'm sorry for that—but let's say half of that in 2010, we'll still be with operating the Space Station if we have the chance to have this possibility. That means that we will release an amount for starting our exploration activity, I would say, of several (that amount) million euros—several million dollars—up to 2050. That's not so much as you are planning to do, but giving us the role of a real partner.

Kyoshi Higuchi

[Speaking Japanese]

Interpreter

First of all, our—JAXA's—current annual budget is about 180 billion yen or approximately \$1.6 billion.

Kyoshi Higuchi

[Speaking Japanese]

Interpreter

And right now approximately one-quarter of this budget is earmarked for ISS programs.

Kyoshi Higuchi

[Speaking Japanese]

Interpreter

Let me just briefly explain how we set the budget in Japan. We have a forum that is called CSTP or Council for Science and Technology Policy, at the cabinet office, which sets forth science and technology policy. So, they make certain plans.

Kyoshi Higuchi

[Speaking Japanese]

Interpreter

In accordance with the policy set forth by this council, then we would come up with our long-term space development program or plans.

Kyoshi Higuchi

[Speaking Japanese]

Interpreter

And unfortunately only the Japanese version of that plan is with me, but if necessary, I don't mind sharing that Japanese version with you. At any rate, in accordance with the policy, from time to time, that long-term plan is reviewed and if they find it worthwhile to start a new plan or program, then they would allocate a certain budget for that.

Kyoshi Higuchi

[Speaking Japanese]

Interpreter

And if we were to participate in the U.S. initiative under this new U.S. vision, and if you are interested in knowing if Japan is willing to increase the budget because of that potential participation, or if our total budget will stay the same or not, at this moment, I don't know either way.

Kyoshi Higuchi

[Speaking Japanese]

Interpreter

But if I would take the liberty of just generalizing the Japanese budgetary trend, the Japanese government has been suffering huge fiscal deficit, and so overall, budgets in general are in a very tough direction or situation.

Kyoshi Higuchi

[Speaking Japanese]

Interpreter

And I hope you would not question me any further beyond this point [laughing].

Pete Aldridge

Bob.

Robert Walker

In each of your testimonies, you hinted at capabilities that either your agency or your company brings to the space business. I want to get to specific. As you look at this space vision and you think about the fact that we have to do this in an affordable way over a long period of time, is there some special capability that you now are looking at that you possess that you think we should include as a part of our thinking, as we make recommendations to the President, that you could bring to the table for this space vision? I would have to ask it of each of you.

Daniel Sacotte

So I will start again? I think what Europe can bring—well, at least the first thing we can bring—is, I will say the competences we have demonstrated with our program concerning science, and with what we have developed for the Space Station, so we are able to bring (and with Ariane, of course) very important building blocks in implementing your vision. So it is something we have to find in the cooperation. The second point, I will say, is what I would call the stability.

European Space Agency is an international organization. That means that, of course, all our member states are bound by budgetary constraint, and we are the reflect of our member states, but once a decision is taken by the European Space Agency, the value of the decision is very high.

Each and every of our program has a legal frame that is something like an international agreement. That means that, once signed, the government of states participating in a program are bound to go up to the—not exactly to the end of the program, but we have a special internal liability system that forces governments to go up to 120 percent of the initial budget.

That means that we are probably the most reliable partners everywhere in the world, so you can use it as you can consider it as a weakness because of your government, but it is something that is important.

We have also a fantastic network of cooperation that could be interesting for you. In order to set up—I would say—a new way of cooperating, because I'm still convinced that, with exploration program, we have to improve and we have to invent more than we did in the past, and in particular in the way of having cooperation organized. So we have to find a certain diversity in the way we will and you will set up cooperation. Part of the cooperation will be government to government, I have no doubt, because some of the goals are at government to government.

Part of the program will be industry to industry, because in some cases, mainly when innovation or further commercial activities are at stake, we will have to develop those type of activity. Part of the program will be scientific area, science oriented, and in this case it is scientist to scientist. It is defining together the broad view, [?] agency to agency.

So I think what ESA can bring is a certain flavor of diversity and a certain way because we're used to cooperate with many people—I will say—excuse me to be a little bit direct—but in a more equal partner view than you have been using to do in many programs in the past. So I think we can help opening a little bit the way of cooperating, and it will be an added value.

Kyoshi Higuchi

[Speaking Japanese]

Interpreter

Well, partly because we don't know the details of the American vision at this moment and partly because the JAXA internally has not made its own formal decision as to what we should do about U.S. vision, the question you posed was a very difficult question to answer in terms of which technology areas we are capable of in participating.

Kyoshi Higuchi

[Speaking Japanese]

Interpreter

However, if, again, I am allowed to offer my general feeling about this...

Kyoshi Higuchi

[Speaking Japanese]

Interpreter

I believe that Japan has the technological capabilities in all the areas except for the technology which would take human beings to the space and bring them back.

Kyoshi Higuchi

[Speaking Japanese]

Interpreter

We already launched a satellite in order to take the samples and bring them back to Earth by doing rendezvous—docking—with an asteroid.

Kyoshi Higuchi

[Speaking Japanese]

Interpreter

We also have different project called the Selene, in which we will sample the lunar surface rocks.

Kyoshi Higuchi

[Speaking Japanese]

Interpreter

As the transportation technology, we have the H-IIA capability and also the HTV, in which we can send various materials and supplies to the Space Station.

Kyoshi Higuchi

[Speaking Japanese]

Interpreter

In addition, Japanese industry is—has a great potential to make a contribution using their state-of-the-art technologies.

Kyoshi Higuchi

[Speaking Japanese]

Interpreter

And just one caveat: All the comments I just made in responding to this question are just general remarks.

Pete Aldridge

Unfortunately, we've run out of time. I would like to get some more questions but we're 10 minutes over our time limit already. I would like to thank the panelists for sharing with us your

testimony. We appreciate your contributions and we look forward to continuous cooperation in the future. Thank you very much.

We have another panel moving up. We'll take just a second to change the name tags.

Our next panel is titled "Lunar and Other Space Science." There is a very big definition behind "other," so—and we'll hear about, I'm sure. The first speaker is Dr. Tony Tether; he is the director of DARPA, the Defense Advanced Research Projects Agency, the same place the Internet came from, I'm sure he has noted many times. As the director of DARPA he's responsible for the management of the agency's projects for high-payoff innovative research and development. I had the pleasure of working with Tony during my stint in the Pentagon, and basically told him if he wasn't failing at least 50% of the time he wasn't doing his job proper, so we do really have high-pay-off, high-return activities in DARPA.

John Delano of SUNY-Albany (this is the State University of New York in Albany) is the Distinguished Teaching Professor in the Department of Earth, Atmospheric Sciences, and the Department of Chemistry. He is also associate director of the New York Center for Studies on the Origin of Life, a NASA specialized center of research and training.

Rounding out the panel is Professor Ariel Anbar of the University of Rochester. He is a biochemist interested in the co-evolution of the environment and life through time. I'd be interested to hear what co-evolution means. I'm sure we'll hear that. He is also helping NASA Astrobiology Institute develop a white paper that considers how some fundamental astrobiology science goals can be addressed via lunar exploration. And, Tony, we'll start with you. Welcome.

Tony Tether

Well, thank you very much, and yes, Mr. Chairman, you are responsible for me being here—on both counts, I guess. First of all, I have some slides, you know, from the Department of Defense. We can't talk without slides, so I do have a few slides. But because we are from the Department of Defense, our interest in space really kind of limits itself out of the geosynchronous belt, maybe a little bit further, but for the most part we're unmanned—our interest is unmanned and doesn't really go much past geosynchrony.

However, DARPA is a place where we have many, many projects, and a lot of these projects obviously apply to other parts of the domain other than that, so I'm going to talk about a few of those. Next slide, please.

I have listed on this slide four areas. I'll start from the bottom one and work up. The bottom one is long-endurance spaceflight. And we have talked with NASA about what we're doing and we have had meetings with them. There is a problem, as most of you know, in space, just having people there, not that that's necessarily a worry of the Department of Defense, but there's a

calcium loss, there's radiation, and so forth and so on, so we have some programs in DARPA that may apply.

We also have programs in just plain logistics. It's going to take a lot of power and water to have people make that distance and get there and back. It's a little bit longer than those on the ground but the problem is still the same.

We have an exoskeleton program. This is not—this would allow somebody to—who perhaps whose muscles have atrophied—to still have strength to move things around, although of course obviously the weight is not the same as on Earth but they may be someplace where the weight does get that way, and finally robotics—major programs in robotics which obviously apply.

The second part on the list, moving up from the bottom, is extremely large deployable antennas. These are programs that we have mainly for looking back down at the Earth and getting resolution, but on the other hand, if you're going a long distance and you know you're going to go a long distance, there is no reason why you couldn't put [WAPOs?] up, and these would necessarily be very, very large apertures for communicating and that technology would apply. And the technology here is actually taking something small into space and having it expand into a very large aperture or even having it perhaps manufactured or deployed in space, so that applies.

Second, we do have programs on advanced communication protocols, where the nodes are very far apart. Mr. Chairman is right, we did do the Internet and the one thing about the Internet with the protocols is that it takes an acknowledgment for a packet. Well, if that packet has to go millions and millions of miles, you don't get much of a data rate if you're always waiting for an acknowledgment on each packet, so we have been looking at protocols not for the distances that we're talking about here, but even forward from here the geosynchronous or network in space, that still becomes a concern.

And then finally, GPS is what we do. The GPS system in space, the satellite system in space, is what we use for on the ground for locating objects, we also like to use that in space for satellite systems to know where they are, but that causes a problem if you do get up outside of the orbit that they are located in.

And so we've looked at an effort, which is—I'll have the next slide—which is pictured on this slide. It basically is using pulsars. It turns out that pulsars are a very nice source. The timing is nice. And we believe that we might be able to use these X-ray sources in space as we do today use a GPS satellite to do a time/distance-of-arrival type of measurement in order to figure out where we are. Clearly this can be used anywhere.

On the ground, we have something we call GDOP, which is a geometric dilution of precision; I guess in this case it will be galactic dilution of precision if you're traveling around the solar system and trying to use these pulsars as your way to know exactly where you are.

And that's about it. It's about what, you know—since you called me, Mr. Chairman, I did look around and that was about what we came up with that was obvious usage for this journey.

Pete Aldridge

OK. Mr. Delano?

John Delano

Yes, thank you, Mr. Chairman. Can I have my first slide, please?

NASA's Apollo program was legendary in its scientific and technical dimensions and epochal in its historical durability. As long as objective history is written, that will forever be a part of America's national legacy and a colossal achievement for the human race. The lunar rocks and soils returned by the Apollo astronauts changed—and fundamentally changed—our scientific understanding of the solar system, not only the Earth and Moon but of the other planets. Next, please.

I would like to give you some sense of some of the important scientific questions that remain that could be addressed by the President's initiative. The Moon is a colossal celestial treasure trove of information for addressing important geochemical questions in astrobiology, but let me point out that astrobiology is itself an important bold initiative on the part of NASA for addressing some of the most profound questions in human history, such as "Is life common or rare?"

Addressing this and other related questions has engaged the imagination of many different fields in science in the last 10 years. Important questions remain that can be addressed by robotic sample returns, human expeditions, and orbital science. Next, please.

The Moon preserves an impressive geochemical memory of the intense early bombardment that threatened the sustainability of life. Next, please.

That challenged and threatened the sustainability of life on Earth as well as any other place in the solar system where life may have tried to get started. Next, please.

In addition, the permanently shaded polar regions of the Moon may contain a memory of the volatiles and perhaps even of some of the prebiotic building blocks of organic molecules that were important for the origin of life. Next slide, please.

The Moon may also—next—the Moon may also contain pieces of other planets. Next slide, please.

That can serve as Rosetta stones for our better understanding of the geochemical origin and evolution of planets throughout our solar system. Could these samples also have transported—next, please—could they also have transported microbial life forms from planet to planet? Next.

Geochemists have also defined global biogeochemical cycles for elements such as carbon, sulfur, and oxygen on the Earth and have been important for better understanding the climate history and all of the other major processes in the Earth's environment. Next, please. And next.

Could some of these chemical and isotopic measurements in Mars' atmosphere, if done on a prolonged period of time, also provide us with deep insights into the global, geochemical and perhaps even biogeochemical processes operating on Mars today? Next, please.

As Carl Sagan pointed out, human beings have dipped their toes into the cosmic sea. Apollo 11 was one such example of that bold approach. The central theme in astrobiology—next, please—seeks, has one of the most important questions in human history, and that is our place in the universe has been addressed by many people such as shown here in this historical slide starting at Plato, and others. All have taken stands over the last many millennia as to whether life exists elsewhere in the universe. Those names that are shown in orange tended to have a dim view of whether life occurred elsewhere, and those in the lighter colors tended to entertain the possibility that life could have existed elsewhere. You can see that this question is a very important one and historically durable. However, all of these people here shown on this list, as bright as they were, were bogged down in a debilitating ambiguity. There was no important information available to them at the time. We will be the generation that will have that information. Next slide, please.

It seems to me—as I conclude, it seems likely that children from 20 years forward in time, and beyond, will look up at the sky differently than I did, and that all of us have. I have been told, “Look at the Big Dipper.” I don’t care.

I would like to look up at the stars and imagine that there are planets there and perhaps there is life on such planets. That is quite a different way of looking at the sky, and it will be because of NASA’s boldness one of the ways that humanity will.

Just as early—next, please—just as early explorers and their host nations are remembered for their courage in defining and accomplishing deeds that history has recorded as being great—next, please—American astronauts deserve epic programs that are worthy of their skill and their courage, and that will be historically durable. Next, please.

The epic journeys proposed in the President’s initiative could become a lasting source of inspiration and epiphanies for future generations of humanity and I end with the following quotation as I speak from the heart, here. Next.

And next time step, please. From T. S. Eliot’s “Four Quartets”: “We shall not cease from exploration, and the end of all our exploring will be to arrive where we started and know that place for the first time.” Thank you.

Pete Aldridge

Thank you.

Mr. Anbar.

Ariel Anbar

Thank you, Mr. Chairman, members of the Commission, for giving me the opportunity to speak with you today. It’s a real honor. As a university professor, I tell my students that important insights come from asking—answering and asking—asking and answering, simple questions, so I would like to begin by asking a simple question: What am I doing here on a lunar science panel?

After all, I'm not a lunar scientist. I'm a biogeochemist. Most of my research is about the history of the environment and life on this planet. So what perspective can I offer you as you try to chart a course for NASA's return to the Moon and exploration of Mars?

This simple question has a simple answer. I'm here to point out that a return to the Moon could help answer scientific questions with implications beyond lunar science. In the next few minutes I'll try to walk you through one of those questions, a question so fundamental to our understanding of life's history that it even brings a biogeochemist to this table. But this is only a single example of compelling science that could be done on the Moon as part of a broader exploration program. Some other topics were touched on in John's testimony. More details are in a NASA Astrobiology Institute white paper included as written testimony and in other reports being developed on connections between lunar exploration and other science goals, including Mars exploration. These reports represent the views of groups of scientists. My presentation is at best an imperfect summary of some of those views, so I hope the Commission will carefully seek out and consider these documents.

To explain how a biogeochemist ends up fascinated by the Moon, let's begin with the fact that I can also be called an astrobiologist. This may at first seem like no answer at all, because astrobiology is often taken to mean the search for life beyond Earth, but of course we do not expect to find life on the Moon so you need to understand that astrobiology is about more than looking for microbes on other worlds, it is really the quest to understand how habitable planets form and how inhabited worlds evolve as well as the prospects for life beyond Earth. And if you understand that, then you understand that for a geoscientist like me, astrobiology actually begins right here on Earth when we study the rocks beneath our feet, the four-billion-year geological record of the Earth, the only world that we are certain is habitable.

First slide, please. What you see here is a depiction of the geological time scale, the geologic record, from today at the top of this chart back to the origin of the Earth at the bottom. And when we look at this geological record, we are confronted with the challenge that eventually takes us to the Moon. We know a great deal about life and environment during the most recent half-billion years, at the top of that figure, because rocks from this time are plentiful, well preserved and easy to get to.

However, life existed long before this time, perhaps as early as four billion years ago, so to understand the origin of life on a planet like Earth, we need to study a much older part of the record. The challenge, the problem, is that rocks are increasingly rare and poorly preserved when we look further back in time. When it comes to the period before 3.5 billion years ago, near the bottom of that figure, before the earliest unambiguous evidence of life on Earth, we struggle to figure out even very basic things, such as when oceans first formed. Next slide, please.

One thing we do know about this early era is that the Earth was bombarded by massive objects left over from the formation of the solar system. The collision with one of the largest and earliest probably led to the formation of the Moon itself.

Afterwards, for hundreds of millions of years, the Earth was struck by objects large enough to melt large parts of the crust, vaporize the oceans, and sterilize the planet. These events dwarf anything since, including the impact that led to the extinction of the dinosaurs.

Obviously this early bombardment had a profound effect on the habitability of the Earth's surface and on the origin and early evolution of life. Next slide, please.

Because the record of this time is almost nonexistent on Earth, most of our knowledge comes from studying the Moon.

As the Earth's nearest neighbor, the Moon suffered similar bombardment to the Earth, and the largest craters on the Moon, as you can see in this figure, are from this time. but unlike the Earth, the Moon lacks plate tectonics, wind, and rain, and so this ancient record sits there, exquisitely preserved, waiting to be read.

By determining the ages of materials brought back from the Moon 30-odd years ago, we began to understand the timing of the Earth's early bombardment. This knowledge is one of the most profound scientific legacies of the Apollo program, so you can see why astrobiologists see lunar exploration as more than a steppingstone on the way to Mars. Next slide, please.

Unraveling the bombardment history of the Moon is important not only to understanding the early environment of the Earth, but also the early environment of Mars; this is because Mars went through a similar experience, so much so that some terrains on Mars, such as that shown here, resemble those of the Moon.

Until we are able to directly measure the ages of rocks on Mars, much of our understanding of earliest Mars, during the time when life might have started there as well, must be inferred from the Moon. Next slide. Next slide, please?

We learned a great deal about the bombardment era from the Apollo program, but we are still pretty ignorant. For example, it is still not clear how bombardment ended. There are competing theories. One theory holds that the rate of bombardment declined smoothly with time. An alternative idea, also consistent with the available data, is that the bombardment died away much more rapidly but finished off with a late spike, a terminal cataclysm. Such a cataclysm might have wiped out life after it began, forcing a second origin of life, or we may be descendants of hardy microbes that survived such a disaster.

Did bombardment end in a whimper? Or in a bang? We don't know. But the answer is critical to knowing when the inner solar system was first hospitable for life and the challenges faced by the earliest organisms. Next slide.

If we return to the Moon, I hope we will return with the intent of tackling such compelling questions.

This need not be a distraction from the ultimate goal of human exploration of Mars. On the contrary, if we aim for a day when humans will pursue important scientific questions on Mars, won't the best training come from pursuing important scientific questions on the Moon?

And if we want enthusiastic public support of this effort over the many decades it will take, shouldn't we find ways to honestly connect even lunar steppingstone activities to grand questions that touch every person, to questions that explain not only why I am here today but that help us understand why any of us are here today at all. Thank you.

Pete Aldridge

Thank you very much. Let me start off with Tony. I think that also you were doing some work on really high-capability materials—very lightweight, high-strength materials? Aren't you doing work in that area that might be applicable? One of the things that came up in one of our testimonies earlier was why doesn't NASA have a DARPA-like organization? And we couldn't find an answer of why not. Do you have any views on that topic?

Tony Tether

Well, if you go back to the beginning, which was roughly 1958, with Sputnik, and that's why DARPA was formed. In response to Sputnik—President Eisenhower did not ever want that to happen again—both NASA's roots, to some extent, and the National Reconnaissance Office to a large extent were really offspring of DARPA. I don't know why NASA doesn't have a DARPA and I don't know why anybody else doesn't have a DARPA. I think that the one thing that makes DARPA different than any other organization is that the people are there for only a short period of time. They're there for the six years. Nobody comes to DARPA for a career because there are no careers.

It's also not like a organization where you just go spend for the six years in a division of a company and then go back to the company—I mean, people really come from other places and really go other places. I mean, there is no guarantee where you are going after DARPA. Consequently that means that the program managers who come in are very strange people. Even the people who are career civil servants, when they come to DARPA they have to give up that career status and they get a term status.

So, I mean, these are people who are different. These are people who are coming because they have an idea and they want to get something done. And they know the clock is ticking when they come in the door. All of this contradicts our “long view” look at things but it seems to still work. So when a person comes in to DARPA, even though it is a long-view, high-risk, high-payoff from the very git-go, we're off getting it done, and getting it done is not just doing the technology but finding out who the customer is. And as Mr. Chairman will tell you, he never let us spend a lot of money without knowing who might want to have it, even if that “might want to have it” would be way, way in the future, but that's a hard—you know, I have had many, many people come to me, Mr. Chairman, other countries, and say, “We want to have a DARPA.” When I tell them the first thing you do is you have an organization where nobody is there for more than for the six years, they don't know how to implement that.

And we got there quite accidentally. We got there because in 1960 the organization almost went away, when the NRO was created. I mean, it really—space was taken out of DARPA, and we went off and did ICBMs, ballistic missile defense; 1970 half the agency was taken away again to form another organization and we went off and sooner or later got back into space again with SDI, and by 1984 half the organization again was taken away to form SDI, and so I think it's just because of the way we started that we happened to end up with an organization that allows change to occur. There's nobody at DARPA who would say, "Aw, we tried that 10 years ago and it didn't work." 'Cause it's a built-in Alzheimer's. Nobody remembers. And so we consequently are a little bit like "Groundhog Day."

We do it over and over and over again until eventually we do get it right. I don't know if that answers the question, but I have been asked that many times and that's the best explanation I have as to why NASA or anyplace else doesn't have a DARPA.

Neil Tyson

Just to clarify: our interest in the model for DARPA for NASA flowed primarily from our concerns about the perception, or reality, that, NASA is risk averse and a place such as DARPA that engages in projects knowing that some high percent of those attempts will fail, you're only succeeding in your mission if more than half of your projects fail, because only then can you know that you are on the frontier of anything.

Tony Tether

Correct.

Neil Tyson

And so one of our concerns, going forward, is the urge to do that which is tested for 10 or 20 years and you feel comfortable and safe and you get a prescribed job done, but it greatly limits how far you can get. And so what might be the implementation of a DARPA-like element of NASA is, can you comment on whether it's a culture change within NASA? Is it a culture change within the public to recognize that we need something like that? Where—based on your experience, running such an agency, what first steps could you recommend?

Tony Tether

Well, even within the Department of Defense, the science and technology organization—the other part of the science and technology organization—is very risk averse. It really comes down to, no matter how hard we tell people, "Hey, don't worry about it, you're supposed to fail," if you had a failure earlier in your career, no matter how hard you try, people remember that failure, so you almost have to be someplace where there isn't a career attached to it.

And I don't know how you do that. You know, maybe it's an agency that is separate from NASA. Quite frankly, it probably has to be—something separate, where people truly are just brought in from someplace and then tossed back out into that someplace with no guarantees, you know, either way.

I don't know how else to do it, but it really gets back down to that career, and if you're at someplace for a career, the worst thing that can happen to you is that you transition it—whatever you are doing—to somebody else, because then you have got to find something else to do. But when you're somewhere where you're not going to be there very long, transitioning it is fine, you know, because you're not going to be around anyways. I think it really comes down to that, and that really is the element, and whether you can create it inside an organization that already doesn't have that, I don't think so, I think you have to probably do it outside. If the Department of Defense didn't already have a DARPA, we probably couldn't create one today, because there are too many antibodies that would stop it from happening.

Pete Aldridge

It's also one of the reasons it's not operated by a particular military department, because—

Tony Tether

Right.

Pete Aldridge

That's—the department is risk averse. They can't afford failures there, so we moved it away from the military departments, and so it may be a different organizational structure that could make it—

Tony Tether

That may be, and it also put people who were in charge of it like yourself, who were also weren't going to be around for a long time. I mean, you know, you knew when you came in that you weren't going to be—it was just the structure, I think, that—

Neil Tyson

A mixture of old and young blood?

Tony Tether

Well, there's a lot of old people there, but none of them are going to be there very long.

Pete Aldridge

Les?

Les Lyles

Tony, the last time I visited with you and out at DARPA, we talked about this huge increase in your space budget, a sort of resurgency in space activity, I think it was close to a billion dollars or something in that neighborhood, and I'm very happy to see that, but the focus was primarily on DoD missions, space surveillance, situation awareness, engagement, protection and those type of things.

If you were to look at NASA's vision, the vision that we're exploring here, I think some of those same space technologies that you are working on for DoD could be applicable in some form or another to helping to accomplish this vision. Do you think there is a way that you, within DARPA, could sort of open your requirements aperture a little bit and look at the exploration needs and see how some of the things that you are working on for DoD might have a natural carry-over to what needs to be done for this vision?

Tony Tether

Well, D does stand for Defense, and you know, it would—it would take somebody besides me to open that aperture. You know, we are there for the Department of Defense and the Department of Defense's missions really do stop around the geosynchronous belt.

You know, the projects I listed for you are really those that I went through and thought might have a dual purpose, and there probably are more—I mean, I'm not saying I thought of them all, and I'm sure I didn't think of them all, but there may be others that definitely have a—have a dual purpose. But even on that last slide I showed, I mean if you looked on it you will see that it says new missions, cislunar, deep space, you know, I mean, Mr. Chairman said that I ran DARPA. Well, nobody runs these program managers. I mean, I keep telling them, "Take that off. We only go to the geosynchronous base." But they still put cislunar and deep space on these slides, so there's people with those thoughts.

Pete Aldridge

Paul.

Paul Spudis

Let me follow up on that for a minute, and then I have a question for our lunar scientist. It seems that now, isn't one of DARPA's roles to look sort of beyond the now into the future? And if indeed we are going to the Moon, and other nations are going to the Moon, and there will be an infrastructure to sort of transport people and machines throughout that volume of space, I would

think that DARPA would certainly take an interest in that—I mean, as an example of how right now cislunar is relevant; I mean, it's possible to get to GEO [geosynchronous Earth orbit] by lunar swing-bys, and what's more, you approach GEO from a direction that nobody's looking at. You're coming in from the backdoor, as it were, so doesn't that mere fact make cislunar relevant to DARPA's mission?

Tony Tether

No. You know, no. We are, again, the Department of Defense, and I'm trying hard to think of a reason why a Army, Navy, Air Force person would care. For the missions that they have to carry out, which is protecting the national security of the country.

Paul Spudis

All right. Let me ask a question for Dr. Delano and Dr. Anbar. You emphasize in your testimony that—about the early bombardment history and its relevance to the origin of life. Of course, the last few billion years are recorded in the regolith of the Moon and in quite detailed manner. Would both of you comment on the relevance of that to both lunar history and to general planetary science?

John Delano

The clearest record, as you know, Dr. Spudis, is in the last two to three billion years lying right on the surface of the Moon. In terms of the better understanding of the bombardment history during the last two to three billion years and the prospects for the future, it's waiting for us to explore. The record is clear. It will be unambiguous. It will be easy to read.

Ariel Anbar

I would agree with that, the astrobiology and the Moon white paper that you have a copy of actually has that specifically laid out as another topic. My focus on the early bombardment for lack of time couldn't go into everything.

Paul Spudis

How would you study that? Just as an example, using, let's say—how would you approach that study? What would you want to do? Would you want to trench it? Would you want to core it? How would you approach studying and unraveling that record?

Ariel Anbar

You would want a multilayered approach. You could do some things from orbit in terms of identifying stratigraphy and that sort of thing and then you want to get on the ground—you need

to work out the stratigraphy on the ground, you need to core, you need to trench, you need to get samples and get ages on them. There is a range of things that need to be done.

John Delano

Also, one of the most common kinds of samples in the lunar dirt, known as the regolith, is 100- to 200-microns spherules of impact-produced glass. A typical kilogram of lunar regolith consists of hundreds of such spherules, each of which has a memory of an impact event, so the technology to be able to extract the memory from microgram samples is ongoing, and that's where the memory exists in plenitude.

Pete Aldridge

Maria.

Maria Zuber

It's a question for the scientists, and it follows up a little bit on Paul's question. You both comment very eloquently on the idea of going after big and grand questions. OK, and now I try to think back and what we would have learned about the Moon even if we took sort of today's technology if we hadn't brought samples back from the Moon, so when we're thinking in the future about the value that planetary sample analysis could have in the exploration vision, there are sort of two paths that we can go down in terms of technology development, and one is *in situ* analysis of samples on the surface, and I'm not being specific to the Moon, we could be talking about the Moon, asteroids, Mars, wherever in the solar system, versus the technology development that is required to bring those samples back to Earth, and could each of you comment on whether you have given any thought to sort of—you know, obviously, you know, you might say something about a balanced program, but in terms of going after the big questions, what's the path? What's the more productive path to go down?

John Delano

In my opinion, the big questions will be answered by the best analyses, the highest-precision, highest-accuracy analyses. Robotic—robotic missions as currently so beautifully represented by the Mars exploration rovers wet our whistle. They are magnificent achievements. But is there a record of life, for example, in the jarosite, hematite outcrops at *Opportunity* landing site? Is there? I would like to know that. Everyone on this panel would like to know that. The only way we will know that in any reasonable length of time is through a robotic sample return for analysis on Earth using the highest-capability instruments, which cannot be reasonably produced, in my opinion, robotically.

Ariel Anbar

I think I would agree with most of that, but I would pick up on one thing John said: he put in the element of time—in a reasonable amount of time. And I think the answer to your question scales depending on what sort of technology you envision as being possible to do *in situ*, and so if you are envisioning this with a 10-, 20-, 30-, 40-, 50-year time horizon, the answer to that question would change. You would still say you could do your best work here but you might be able to do much better work on the ground 50 years from now than you could envision doing today, and so I think if you are thinking about a program with that kind of time scale, you need to have a program that envisions the technological developments that might come along and can scale them that way.

Pete Aldridge

Laurie.

Laura Leshin

Thanks. Mr. Chairman, I have a question for the two educators on the panel, Dr. Delano and Dr. Anbar, and I wanted to ask you about working with students, and you both work with them every day, and they are the people who are going to actually go out and do this program for us in the next 20 to 30 years. I'm curious to hear, in your specific fields, the astrobiology-related fields but also more generally with the vision the President has laid out, are you getting any reaction from them? Are they excited about it? Are they energized by it? Do they see the same kind of possibility in it that you have expressed to us today? Can you relate some feeling about that to us?

John Delano

Yes. I give approximately 35 invited talks per academic year, and most of the time the topics are on astrobiology as related to geochemistry. I am a product of Sputnik. That is not something that galvanizes the interest of students who I look at and talk to, of course, but it is—it was an epiphany for me. As a distinguished teaching professor at my university, I have, as one of my goals, to be in the epiphany business. Where, as I look at every student, in every class, my challenge is to light the wick, see the sparkle, and I am disappointed to say that it does not happen all the time, but it does happen more than half the time. So that, at the end of many of my most recent lectures dealing with astrobiology and the excitement of being able to look at the night sky in a way that is so different than we look at it now, I have been getting many requests for the PowerPoint CD, for example, and that represents with the current generation a most remarkable commitment.

Ariel Anbar

There is certainly a lot of excitement about astrobiology—I mean, I get that all the time. I’m the astrobiologist on campus. And what’s interesting is excitement and interest from outside of traditional science students. I mean, it’s been really a magnet for social sciences majors of different types, humanities majors, which has been really intriguing. At Rochester we have a program called “Take Five” where students can take a fifth year tuition-free to study something different from their undergraduate program, and we have had several astrobiology Take Five students coming out of nonscience majors, and in my experience with that program the only case where we have had nonscience majors doing science Take Fives. I’m sure there have been a few others but it’s been quite striking. So there has been a tremendous interest in these big-picture questions. At the same time, I think that in terms of the vision specifically, I think there is a bit of hesitation just as perhaps there is by large parts of the academic community. People are waiting to see, well what is this? There is a certain amount of cynicism in general about these sort of things, and I think that’s a real challenge that the Commission faces. How do you combat the cynicism? I think the basic science questions have an important role to play there. I think that’s one of the ways you get past the sort of hesitation and cynicism, by engaging in the exciting questions.

Tony Tether

I would actually like to—

Laurie Leshin

Please, please.

Tony Tether

Because I—in some ways I do feel like an educator in keeping the science and technology people interested in science and technology, and I too was a Sputnik. I did tune my ham radio to 21 megacycles to hear that thing beep. And during the 60s I was at that age where, you know, it was really a thrilling time. You know, the first astronauts were truly remarkable people—in fact, Buzz Aldrin is here today, and it doesn’t take too long talking to him when you realize that mentally and physically this is a guy who is not an average person, but on the other hand, what NASA seemed to forget was that we all wanted to go. We all wanted to go and somehow, we lost that. That we all wanted to go, and it was almost taken away. How many people believe that they can go? And until we get that excitement back, nothing much is going to change. How many people would want to go to the Moon and colonize the Moon while the rest went on to Mars—while the new breed went on to the next world? You know, we all wanted to go, and that, I think, is somehow you all need to figure out a way that it isn’t exclusive. That we all, at least, get to go the baby step, which is to the Moon or just into space, and if you can do that, this will have a constituency that it doesn’t have today, because space, NASA, there is no state

associated with it, right?—a state as in United States, but that, to me, is the problem. We all wanted to go and we were forgotten about. Those who wanted to go were forgotten.

Laurie Leshin

Let me make one comment to follow that up. I couldn't agree more with that perspective. And just this past Friday night we had an event at my university, at Arizona State, the Space Forum, broad discussion with the public, there were a thousand people there including probably one-third kids, and I asked the question of well, "Who thinks they're going to be flying in space, you know, during their lifetime?" Every kid in the audience raised their hand. They think that way already. They're already there. We've just got to capture that and keep it going.

Pete Aldridge

I would like to thank the panel. Again, we've run out of time. Tony, John, Ariel, we appreciate your testimony and your time in coming to speak before us and thank you very much. Before we break, I did—I was going to introduce Buzz but Tony did it for me. The man who really did bring back some rocks from the Moon, Buzz Aldrin, would you just stand up and wave your hand around to the audience there. We will take a 10-minute break and be back here in 10 minutes. Thank you.

Pete Aldridge

OK. Let's get started this afternoon.

OK, let's get started this afternoon. Welcome back, everybody. Now in another first for these proceedings, we'll be hearing from leaders of various organizations that represent the people, those non-space professionals who care about space exploration and the promise it holds.

George Whitesides is executive director of the National Space Society, a grassroots nonprofit organization dedicated to the creation of a space-faring civilization. Founded in 1974 by Wernher von Braun, NSS has more than 20,000 supporters and over 50 chapters around the world.

Nicholas Eftimiades is the originator of the Federation of Galaxy Explorers, a nonprofit educational organization to capture youth interest and teach space-related science and technology. He's a graduate of the George Washington University and the Joint Military Intelligence Center—Intelligence College. Mr. Eftimiades has undergraduate and graduate work on Taiwan and mainland China and is a lifelong student of mass movements in society.

Astronaut Rick Hauck is with us representing the Association of Space Explorers. Although membership is limited to people who have actually been in space, the significant outreach activities and popular appeal of ASE makes it an important organization to hear from regarding public support. And, Rick, this is your second time to testify before this group. I don't know whether that's good or bad.

Rick Hauck

I don't either.

Pete Aldridge

Dr. Louis Friedman, executive director of the Planetary Society, represents the largest space-interest membership organization. He also initiated the Red Rover Goes to Mars Project, the first educational experiment on a planetary mission. It is now on Mars with the Mars exploration rovers, and he is currently the project director of Cosmos One, the first solar-sail spacecraft. Gentlemen, we'll look forward to your testimony. Mr. Whitesides, I guess you'll go first, right?

George Whitesides

Thank you, Mr. Chairman.

Pete Aldridge

OK.

George Whitesides

"Space to the people!" What a fantastic call to include in this final hearing of the Commission. What a perceptive title, as well, to bring into these last conversations, before you as a commission leave the public eye to craft your recommendations. For it is indeed people, broadly speaking, the American public, who will determine the ultimate success of this vision.

If you can establish an individual connection with the American people, in Bob Walker's words, then your recommendations will sustain through both administrations and guide generations of explorers. My name is George Whitesides and I am the executive director of the National Space Society. Today I want to speak with you about our thoughts on the most crucial question facing the Commission, the question that Commission members have returned to time and again over the past four hearings.

That question is "How can we shape the initiative to engender sustained and robust public support for space exploration?" Let me make clear at the outset that the National Space Society and its 20,000 supporters strongly support the space exploration vision.

We are marshaling our resources to support the plan and will be part of a major announcement at the end of this week that the space advocacy and association groups of our nation are joining together in a coordinated campaign to support the vision.

So, to the question at hand—how can we shape the initiative to engender sustained public support? I want to stress four key points that are built into and on our 30 years of experience at the grassroots level. First, we must do real exploration with real heroes taking real risks for a

real cause. Second, we must build the capacity of and infrastructure of the private sector. We must directly involve the public, and we must evangelize an exploration society that is predicated on the principle of settlement. That is to say, the underlying goal of exploration must ultimately be to create a space-faring civilization. Let me quickly expand on these four points.

First, the public will passionately connect to real exploration if it involves real heroes, real risks, and a real cause. Whenever this combination has been present in the past, it has attracted massive public interest. If we do not dare enough, the public will not engage and without such engagement, the path of exploration will continue to be subject to the inevitable swings of both public and political sentiment. I must note that if our members are any indication, the public does not want us to risk less, they simply yearn for us to risk for worthy goals.

Second, we must enter this initiative with full recognition that the only path to long-term sustainability is through the private sector. This is, in fact, the deepest form of public engagement: doing space exploration with the public rather than simply in their name. The degree to which this initiative stimulates and establishes private enterprise throughout the solar system will be the central indicator of whether it will have a lasting impact on our society. Previous testimony has addressed the subject of buying services from private companies.

I would emphasize that this is only half of the picture—the other half being that this initiative must consciously build infrastructure that can be used by the private sector.

Third, we must directly involve the public in the near , mid , and far term. And I want to make a point, which is, we do this not just to get their enthusiastic support, which I think will be a result of working with the public; we do this also because it may be the only way to achieve our shared goals. One of the central questions that you, as a commission, need to judge is whether NASA will be allowed to take the risks necessary to pursue worthy space exploration goals. As I mentioned, we believe that the public does, in fact, support such risks as long as they are oriented towards worthy objectives. But if other constituencies limit such risk for NASA, it may be that the only group that can take such risks is, in fact, the public, in the form of the private sector.

Fourth and finally, we must all evangelize an exploration society predicated on settlement. This ultimately is the real cause of the exploration we seek. To create a space-faring civilization, a civilization of vibrant communities living and working beyond Earth. This is the crucial link which ties together space exploration, private enterprise, and public participation. Settlement is the destination for exploration's efforts. Without it, exploration is a dead end.

In the President's own language, we must advance our ability to live and work safely in space, and you, as a commission, have the critical responsibility to make clear that this means settlement, for you are the only ones who can make such a thematic amplification.

To conclude, exploration is a truly noble goal. It is worthy of society's strong support, worthy, indeed, of weaving into the very fabric of our civilization. It expands the perspective of us all at a moment in history when such perspective may be the key to solving our most intractable problems. It is critical for these and other reasons that the U.S. continue exploring, and thus it is critical that this nascent vision blossom into a rich and growing reality. Your work is critical to

the success of that expansion and the National Space Society pledges to do everything it can to help you in your mission. Thank you.

Pete Aldridge

Thank you. Next.

Nicholas Eftimiades

Well, that's—following up to that one is going to be tough. I thought I would take two minutes of your time, sir, and explain to you a little about the Federation of Galaxy Explorers—because, by anyone's standards, we are the new kids on the block; we are about 22 months old—and then tell you how this organization fits into what I believe should be a vision for people's space. The Federation of Galaxy Explorers—actually, we started a year ago July, rather, two years ago, this July will be two years, with a summer camp in Prince William County, Virginia, for 150 kids. Since that time, we've put upwards of about 2,000 kids through our program. We have summer camps in four states this coming summer, eight summer camps; we have an after-school program with a sustained membership of 700 kids.

We have an additional four other states which are currently starting pilot programs, the schools in these states, where organizations, companies, analytical graphics, a few other companies, are starting pilot programs in various states, and it basically exists as once a month, an after-school program with occasional field trips rolled in. And the kids have certain activities that they cover: Earth science, space science, rocketry, engineering.

We're very focused on inspiration, as well as education and sometimes the problem with our community is that we tend to mix the two as if they're the same word. They're not. And we very much focus on trying to passionately inflame kids, visions for the future, where they can be in space, what they dream—where they can dream—space can take them and because those are the things that will really push things forward.

I went to PS 178 in Queens, and much as it was a great educational experience, it's not one I remember as inspiration. And it is important that we distinguish and that we inflame, you know, the dreams for kids for tomorrow. And that's what Galaxy Explorers attempts to do. In that time, as I said, we have put in over 2,000 kids. We have developed lesson plans, over 80, 90 lesson plans for the program. We have educational videotapes that go in support of this, we have developed an infrastructure, websites, everything else, and all this has been done by volunteers. There's not a fulltime person amongst them.

So, when I tell you that we have upwards of 300 volunteers who signed up, you know, in the course of the first year, and most of those, you know, bear in mind, there are different levels how people work, most of them for the belief in space, they've absolutely worked themselves into the ground.

And you know, when Galaxy Explorers appear, volunteer and look up, you get more work to do. So everyone kind of stays focused, keeps their heads down and work. But they work passionately for something that they believe in. And that kind of leads to something about space and the people's view of space. If we take a look at space, and I see it kind of in the context of a mass movement. Mass movements have existed in society since the history of history. And there have been various types of mass movements from social, religious, political, but they all have certain things that guide them. They all have certain tenets, and a key challenge for this Commission—what you're ultimately going to face—you know, we can, play around as we have for the last 30 years and everyone tries to justify the case for space, and, you know, look, you invest billions into space and you get Tang soft drink or you get, you know, advances in technology and the medical industry; all those are true and all those are noble, but it's not the driving reason why anyone goes to space, and it's not the driving reason why America supports space.

One of the things that space offers—a vision of space offers—and it's something we need to capitalize on, and I say *capitalize* in the most positive of senses and something we need to push, is a vision of hope for the future. It is hope for the future. And you can't be embarrassed to say that. We need to step up to the plate and say, "If we look at expanding our society into the solar system, if we look at expanding outward, that offers us hope, it offers hope to every person who looks at it," and that's what we need to foster and push forward. Every aspect of how the American public supports it and how much money and the congressmen that will come and go and some will stand in the way and say, "No, we shouldn't spend this," and some others will say, "Yes, yes," ultimately is going to be driven by the will of the people of this great democratic nation, and we've got to ask them to push forward for a hope for the future.

If they buy that concept, and we need to get away from trying to sell things, if they say, "Yes, I believe in that hope," and I believe they do, then everything else is going to flow pretty easily. That's what mass movements are built on: it's either built on hope or fear. And in this case, hope is on our side because that is exactly what space offers.

I'll tell you that I deal very much on a grassroots level. I deal with hundreds of parents and hundreds and hundreds and hundreds of kids and school districts and, you know, now in eight states. And the one unifying factor that you find in all these people who are not, by and large, in the space community is that they understand, they recognize—sometimes even at intuitive level—how much that this means for their kids and for the future. And, you know, they often say, "I wish I had gotten into it when I was a kid. I wish I'd have been able to do it when I was a kid. I'm not. Now, you know, I'm a printer, or I'm a butcher, a baker, a candlestick maker, but it's something that I really think we need to do." I think the technology of the day, I think everyone's cell phones, the Internet, helps to encourage people in the belief that nothing is impossible. And I think that our focus as America and hope of space for the future is something we can advocate and push and focus and make a focal point of our vision in implementing it.

Pete Aldridge

Thank you.

Rick?

Rick Hauck

Thank you for giving me the opportunity to represent the Association of Space Explorers U.S.A. as you deliberate the implementation of the President's vision of a renewed era of discovery.

Our group is unique in that the only criterion for membership is to have flown in space. Founded in 1985, ASE's mission is to provide a forum for professional dialogue amongst individuals who have flown in space, to promote the benefits of space science and exploration, to promote education and science and engineering and inspire students at all levels, to foster environmental awareness, and to encourage international cooperation in the peaceful uses of outer space. We meet and exchange views with our international colleagues regularly.

Although we do not represent every astronaut, our roster is composed of 60 percent of all living U.S. space fliers. In fact, next month, in July, actually, there will be a congress amongst the members of ASE worldwide in Russia. As you can imagine, we are a strongly focused group of men and women.

Our members have realized their dreams of venturing out into space by questioning, challenging, and acting. We strongly support the view that exploration is an investment in our country's—indeed, the world's—economic future at the same time that it lifts the human spirit.

The members of ASE applaud the President's commitment to a long-term human and robotic exploration program. You'll find differing views expressed by our members as to the "how" of space travel, but not as regards to the "why" and the "when."

One common thread surely weaves its way through every member's thoughts: the belief in the importance of ever-expanding exploration and the willingness to risk our lives in pursuit of that imperative. I'd like to reflect briefly on the cold statistics that highlight the risks taken by those who've already flown in space.

As of March, 2003, just after the *Columbia* tragedy, there had been 430 men and women from 31 different countries who had launched into space since Yuri Gagarin first flew in 1961; 271 of those were U.S. citizens.

Of those 271, 13 died in the *Challenger* and *Columbia* accidents. Of course, Ilan Ramon of Israel was the 14th to die in U.S. accidents in space. That's about 5 percent of those who have flown. On a per-flight basis, 2 out of 113 Shuttle flights have failed, just under 2 percent. The statistics for Russian spaceflight are unnervingly similar.

Of 99 cosmonauts on Russian missions, four died as a result of in-flight failures, but it is significant that none have died since 1971. And that's just about 4 percent. I cannot speak for my colleagues regarding their tolerance for risk, but I can tell you that an overriding

consideration in risking one's life is confidence that everything reasonable, reasonably possible, has been done to minimize the likelihood of failure.

We do not expect guarantees of success, only that we be offered a fighting chance at surviving. Would I have volunteered to fly the first flight after the *Challenger* accident if I knew *a priori* that I had a 1 in 25 chance in dying? Perhaps not.

But I knew that this wasn't the risk that I was taking. When I was strapped into my seat aboard *Discovery*, I was convinced that this, the 26th flight of the Space Shuttle, would be the safest ever. I had confidence in the hardware. I had confidence in NASA management. I had confidence in NASA's contractor team. And I had confidence in my crew.

When Eileen Collins and her crew launch on the next flight of the Space Shuttle, they must have the same level of confidence, and I'm certain that they will. When a future crew launches on the mission to return to the Moon or to fly to Mars, they will do it taking an unmeasurable risk only if they have confidence that everything reasonably possible has been done to minimize the likelihood of failure.

This would include providing a means of escape from a critically incapacitated vehicle up to the point in the mission when it would be impractical.

Undertaking this adventure will take a commitment from the American people that must be sustained for decades. It clearly cannot be done within the time constraints of the budget cycles that govern traditional research, development, manufacturing, and testing. But it will be worth the effort in cost.

Some of our members have expressed concern that committing to undertake this enormous task without marshaling the appropriate resources and the will to sustain the program could result in the end of our human spaceflight program as we know it. And that would be an outcome that our nation can ill afford.

It's widely accepted that the biggest barrier to the birth of a new commercially driven space age is the cost per pound of placing cargo into low Earth orbit. The rocket equation rules and cannot be repealed, but the government could and should provide incentives to entrepreneurs and venture capitalists who are willing to take some of the financial risk of developing innovative approaches to spaceflight. The X Prize, funded by private capital contributed by visionaries, has already stimulated significant progress.

The concept of Centennial Challenges sponsored by the NASA Office of Exploration Systems is a welcome initial step by the government directed at providing additional incentives.

There are a number of educational programs such as the *Challenger* Centers for Space Science Education and Sally Ride Science Festivals, and the programs of the Federation of Galaxy Explorers that merit recognition and support as they stimulate our youth to pursue lives of scientific inquiry. The President has outlined a breathtaking vision, one that excites our imagination and points the way to a goal that humans have dreamed of and fantasized about for decades—if not centuries: the human exploration of Mars. For our part, the members of ASE

look forward to collectively and individually continuing to champion the cause of extending our reach into space. Undoubtedly, some of our members will risk all to take the journey back to the Moon and on to Mars. Thank you.

Pete Aldridge

Rick, thank you. Louis?

Louis Friedman

Thank you. First, let me thank you all as Commissioners. I know you've given a lot of your time, and I know many of you personally, and I'm very impressed with how much time you've given this subject. It's an important one as it decides the future of space exploration not just in this country but, I believe, the world.

I'm very pleased to be here to testify from my particular vantage point as a public—as representative of a public-interest group. I'm not sure I'm happy about the designation of a non-space professional, but I will continue anyway. Our group is the largest membership-based space-interest organization; we're completely privately funded, and we don't seek or take government funds. We're deeply involved in many aspects of the space program, both by expertise with whom we associate and connections we make with other organizations, and in our projects.

You mentioned the Red Rover Goes to Mars educational project, which is now on Mars and which we brought Lego into a worldwide outreach program. We tried to put a microphone on the Mars polar lander in 1999 and we have our own flight project now, the Solar Sail. We also are a nongovernmental organization with standing in international organizations, and this month, we are holding a basic space science workshop special session on lunar exploration in China as part of the UN-ESA activity, and we are very involved in advocacy, including this week we've launched our Aim for Mars grassroots campaign, which we had been doing with our membership, we've now launched it publicly in support of this national space policy.

I've also mentioned that we are conducting some technical studies in support of this policy, one led by Owen Garriott and Mike Griffin, one on Russian space interest in humans going to Mars, and these results I hope will be available by the time—before the Commission completes its work. You'll notice that all of our recommendations and positions always have a mix of technical and public component. We believe that's the important part that we bring to the—from our particular vantage point: deep involvement but public participation.

We're very, very strongly supportive of the new national space policy, this change in direction to make it an exploration policy, and we intend to do several of the advocacy activities that I mentioned in our statement. I've given you a written statement. It addresses three major things which we are doing in support of the national space policy. These are subjects which you've been hearing about at this hearing, the public interest of which I just spoke; international cooperation, which we believe to be valuable technically but also it's especially important for

political and popular support; and there are several inhibitions to international cooperation, which we've dealt with in recommendations in our statement.

And finally, we have some specific ideas for advancing the program, including we've advocated, for several years, the concept of Mars Outpost to bring together both the robotic and human programs in a goal that keeps the public involved, setting up a place on Mars that will be explored and this idea of going to Mars to be learning about ourselves that had been previously expressed, learning the questions of life, the origins of life and human destiny, is really what does keep the public involved, and setting up of a Mars outpost has a chance to both be a focus in the robotic program, and setting up the infrastructure for humans to work on Mars.

An interim goal which we have been skeptical of for, quite frankly, has been what to do on the Moon, if anything, that would help on the way to Mars. We have expressed a great deal of skepticism about it. There is a great danger in a lunar detour or a stalling on the Moon as we have been stalled in Earth orbit for many years. But there are valuable engineering milestones that could be done and we are specifically recommending a lunar way station approach that will help set up the Mars outpost. I like to call it the "Mars Outpost on the Moon" to emphasize that the idea is to really prepare for doing things on the surface of Mars but to take advantage of the way station at the Moon to do them in.

And the condition, if this was an international venture, Europe has a mission to the Moon on its way, as you heard this morning, Japan has two missions in preparation, India is doing a mission to the Moon, and China has two missions in preparation. So the Moon is an international area to work in. We want to harness that energy to move this initiative forward.

In summary, as again is pointed out in your statement, the essential attributes of this new policy that is the basis of our strong support, it's a change to exploration. After 30 years, it's a welcome change in the human space program. It's a vision and focus beyond low Earth orbit.

It commits to the retirement of the Shuttle. This is a clear step that is now needed. It has a willingness to accept a gap in U.S. human launch capability and to launch on foreign vehicles. That gap will be necessary if we are going to implement this space program—sorry—new space policy. It has a redirection of the U.S. role on the International Space Station, again, for long-duration life support for human exploration of other worlds. It puts Mars forward as the goal. It's responsive to the public interest in life and exploration and to the human interest in space exploration. It has strong support for science and the science-exploration mix and the robotic-human mix. Its science even beyond the solar system is strongly supported. And finally, it has international cooperation as a major element of this program, again, necessary for total support.

We have concerns. The package as a whole. There are a lot of people who would like to pick and choose from this package. You could die a death by 1,000 cuts—I've seen it described in some news articles: "It's OK, but let's not have that gap in human space exploration"; "It's OK, but let's do this in low Earth orbit first"; or... if it comes to that kind of thing, it will fail. We—it's tightly interwoven, the budget advantages are great because if we go back to the old way of doing business, we will have a budget that will be wasted. The Commission, I think, could make a better contribution by showing the budgetary advantages of the new policy. But most of all, it

has to engage the public. I heard some great things here today. I think you did, too. This “hope for the future” idea that was expressed by one of the earlier panelists I think is what it is all about, the idea of life in the solar system, and the questions of human life moving outward and the global interest that this has—these are all great things to keep in front of us and great things that we’re proud to support. Thank you.

Pete Aldridge

Thank you very much. Rick, I’m going to ask you a question first, then we’ll open it up for questions. I recall some statistics of people who go to Mt. Everest, that the attrition rate there is about 5 percent. Do you recall that kind of number?

Rick Hauck

I don’t remember that number, Pete, but I did speak with the owner of a high-end adventure travel group, and he said that, in order for him to be able to market successfully high-end adventure travel, he has to be able to assure people as best he can that there’s a less than a percent chance of failure. But I do recall that Mt. Everest claims a higher percentage than 1 percent.

Pete Aldridge

Yeah. That’s what I remember too, and it costs about \$65,000. So, if we’re going to do tourism, I mean, if you’re willing to spend that kind of money to go to Everest, you should be able to afford \$100,000 to go to space, right? Or something like that.

Rick Hauck

Sounds good.

Pete Aldridge

Yes. Neil.

Neil Tyson

When you said “attrition,” do you mean death?

Pete Aldridge

Deaths.

Neil Tyson

OK. I was just wondering. The code for “death.” That’s not my question. I still have a question to ask. I have a question that’s sort amorphically related to all of you, and in the interest of time I just want to tune it. So, let me see if I can tune it on the fly.

I—I’m pretty sure, if I understand correctly, the rolls, the membership rolls in the National Space Society and the Planetary Society are not what they once were—and—whereas Nick describes an interest, a grassroots interest in the roots, where the kids are, as being real. So, what should be our measures of an actual interest in the public for space exploration? When we have this conflicting information. About membership ranks as well as interest expressed in the youth of the day. And so, let me give it to George. You’ve been around since 1974. The organization has, at least.

George Whitesides

I’ve also been around since 1974.

Neil Tyson

You have. By the way, I find it—is it a coincidence, surely not, that your organization was founded in the post-Apollo era? So, was that an attempt to get us back into space, and obviously whatever those attempts have been have failed to go beyond low Earth orbit? So, what gives? What can we look forward to going forward if you guys have the numbers that tell us what the trends are?

Robert Walker

This is the friendly question.

George Whitesides

Well, I’ll give my answer and then maybe you guys can talk. It’s clear there’s interest in space. Space.com’s numbers of unique visitors—well, you had various folks on your panel, I know you had Dan Stone a few weeks ago—increased by at least 50 percent, maybe 100 percent, during the Mars time. I think that what people yearn for is to be directly involved, and what I think Nick offers and the Federation and various educational things is, in fact, opportunities where the kids do feel directly involved with space. And what happens is we maybe aren’t doing such a good job of getting the adults directly involved in space. And I am absolutely confident that, should we create opportunities for adults to be directly involved with space, which goes to your question, that they will. And, in fact, I would argue that the decline in public space advocacy membership numbers, which you accurately perceive, is basically a function of that. I think we’ve moved from a phase in which people were inspired by a national vision to a time when people want to have more direct involvement in whatever it is, whether it’s a national vision or

not. And so, I would respectfully submit that should we be able to create opportunities for direct involvement, then our membership ranks will increase.

Nicholas Eftimiades

Well, first, I'd like to chime in on that because I agree on that 100 percent. The issue is engaging people and getting them involved. You know, everybody talks about the concept of selling space and people say, "OK, yeah, this is great. Now what?" And we leave them hanging. And there hasn't been good means or mechanisms of engaging people because it's technically pretty difficult, I mean, a lot of technical issues in that we're addressing, but engaging people in the adventure of space. You want to look some parameters for the popularity of space? Doctor, how many people come into the Rose Center a year?

Neil Tyson

About 1,000 an hour.

Nicholas Eftimiades

A thousand an hour. Five million a year, three million at the Griffith observatory, almost 10 million at the Air and Space Museum, thousands of science centers all over the country now.

You know, in my—space camps, boy, when I was a kid, you got beat up if you went to Space Camp if they had anything like that. It was baseball, basketball, and if not that, you get whacked. You know, look, even rotten science fiction movies sell well. And, you know, and why? Because people have a passion for this. Same thing with video games and toys.

I mean, right now, kids in the sixth grade, you ask them what a black hole is, and, you know, the kids can give you some rough understanding of taking a look and seeing the black holes in the galaxy and, you know, stars and planetary systems and the works. That wasn't there decades ago. The interest is there; the enthusiasm is there. I think our challenge is galvanizing it and organizing it, engaging them.

People will give tremendous sacrifice, I mean, of themselves, their personal time, their efforts, not their money as much as I'd like, but they definitely will give of themselves if we find the mechanisms to engage them and bring them into the adventure.

Neil Tyson

And, Lou, do you agree with this? And I should report to the public that I serve on the board of the Planetary Society, also as its vice president.

Louis Friedman

So therefore I have to agree with you [laughing]. I don't completely agree that any one of these things will—engaging the public will—immediately boost the membership of organizations, but I'd be very careful about the metrics that we use to measure space interest. And I wouldn't want to use the metric—single metric like that. I remember Dan Golden asking me in 1997 what Pathfinder did for the membership of the Planetary Society, we actually went down in 1997, but, then again, I asked him what it did for the budget of NASA, which also went down that year. So you have to be careful about the use of that, because people also like to cite the four billion hits, the huge number of hits that happen on a website, or the growth of the Internet, which is a much different way of measuring space interest. I think all of these things—I think Nick did a very good job in saying that there's many activities in space that will measure the public interest. I'm not sure that joining an organization is it. It's the total milieu of what we're doing in the industry, in the opportunities that we have, for involving not only young kids but people everywhere and just a great number of activities that we're doing. So, I don't think it's just membership.

Pete Aldridge

Paul?

Paul Spudis

Let me follow up on this point a little bit because I think we're veering near the crux of the matter. It's one thing to engage the public, and as you have eloquently testified, there is a lot of public interest in space. It shows through in the popular culture a lot. I think the challenge that we've had with the space advocacy groups is translating public support into political muscle. And fundamentally this is an issue of not getting the public behind us, but getting the Congress behind us because, fundamentally, the challenge to get a program started is to get it through the political system.

So, I'd like to ask anyone who cares to comment on the following—on this question: Given that we can engage the public or that we have engaged the public, let's assume for a moment that we have—how do you translate that support into political action, and what—do you guys have a game plan, do you have any insight on how we can do that? Because my sense is that to date we haven't been terribly successful at that, and if you guys have some new ideas, I'd love to hear them.

Louis Friedman

Well, let me make one comment, which is I think we have been rather successful. The one recent example we had was the Pluto mission, which NASA actually was going to cancel several times and the administration in the early days opposed.

That mission is in the budget because of public support. The Mars budget in NASA over the last seven years has gone up from the previous year's estimate of what was going to be put in the budget for Mars exploration, again I think is a testimony to public support. Now I used to work in—was a congressional staffer for a year, and I'm leery of claiming credit for anything, but there is I think—there is ample evidence that public support does make a difference in Congress.

Having said that, the average congressperson will—takes the view that he's ahead or she's ahead of the public, that if the public ever knew I was willing to spend \$4 billion on x and y, they would kill me but I'm such a smart person that I'm willing to do it for the betterment of the country. That's a very typical view we get. I think we do have a much harder job, which is to convince the general public. But I don't agree at all that it hasn't been effective. I think we just have to keep at it.

George Whitesides

Can I add—oh, sorry.

Rick Hauck

As we, the very few members of ASE, go out and speak to the various groups that we speak to, I think we all realize it's very important to translate that preaching to the choir. Usually, it's not someone who's not interested in space that comes to hear you talk about space, but we need to encourage that enthusiasm by pressing the question on if you feel that strongly, are you writing your congressperson?

And I've been told, perhaps Congressman Walker can verify this, it seems to me the metric is if one person takes the time to write, there are probably at least 20 other people there that—

Congressman Walker

Forty.

Rick Hauck

Forty that feel the same way but haven't put pen to paper. In a very modest way, we can have an impact, but engaging the Congress is clearly critical.

Pete Aldridge

George, go ahead.

George Whitesides

Just one point. When I was reading the testimony of the past hearings, I was struck by the comments of Bob Walker and Carly in the sense that they were trying to, I felt, go after the point of “How do we move from this group of people who are enthusiastic about space to actually having a constituency of people behind space that will enable the program to navigate through difficult times?”

And I think that that’s a critical point, because that’s really the crux of the issue, is that right now, and I consider myself one of them, we have people who are enthusiasts about space.

How do you move from enthusiast to participant or constituent? And that, I think, is one of the biggest challenges that the Commission faces.

I would say that the more that we can do to frame our program in terms of getting us all out there, which we use the word “settlement” but you can use all kinds of different words in terms of getting we as an American people, as a human species or whatever, out there, so we’re doing this on behalf of you, is one thematic way to try to build such a constituency.

Nicholas Eftimiades

Sorry. I was going to jump in on this for just a moment.

Pete Aldridge

Nick, go ahead.

Nicholas Eftimiades

Just a moment. I think this is an issue in many ways of organization. Galaxy Explorers is obviously focused towards kids, and one area we have space citizenship, for example, where the kids have lessons that they go through, teaches them, you know, the tripartite system of government and Congress and has them doing something related to Congress, so at least by the time they’re 16, they come out of this program, they know they can affect their government and know what the legislative body is and, you know, judicial and executive and they know how governance happens in the United States.

So, I mean, from our perspective, it’s an educational one. However, that said, I think between the Planetary Society and National Space Society and all those others out there, this is an issue of organization more than any.

You know, and coming to this with a China background kind of gives me a little different perspective. When the Chinese Communist Party first came to power and they were actually trying to disrupt Nationalist activities, they had 200,000 people go to Shanghai and join the Nationalist Party.

Well, you know, the Nationalist Party was unable to do anything and the Chinese Communist Party gained a lot of support in those areas, those hardball politics, if you will. But it struck me about the organization necessary to do that, to have a mass number of people between perhaps all our organizations acting with one unified thought, one unified course of action, you know, and select activities on the Hill. And I think if we can—you know, there are going to be wins and losses as we go into the next decade, but I think if we can understand and have not just advocates and not just enthusiasts but good lieutenants who are going to do and move their organizations and spread out into society and move towards some unified political action, I think the gains will be tremendous.

Pete Aldridge

OK. Laurie, I think you're next.

Laurie Leshin

Lou wanted to ask—

Pete Aldridge

Oh, I'm sorry, Lou. Go ahead.

Louis Friedman

This may touch on something you're interested in. I think before we criticize the public representation so strongly, we should reflect on the fact that we really have a very vibrant program of exploration and we're very lucky to live in a time when we can be exploring Mars every opportunity, one or two spacecraft, we're exploring comets, asteroids, planets, missions on their way out to Saturn, missions on their way out to Pluto, as I mentioned earlier, the Kuiper belt.

It's a rich time for exploration. What has been wrong has been the human space program has not had that exploration view. That's what's changed, that's what's essential, and I think you're going to see a great change just as a result of the change policy if you—if we can all successfully implement it.

Pete Aldridge

Laurie.

Laurie Leshin

Thanks. Thank you all for being here. This is extraordinarily interesting and exciting. I'm always so inspired to see the great number of people from all over the country that are so fascinated by what we get to do for a living. It's great.

Sort of building, I think, on where this conversation is going anyway, I was going to ask about coordination and your ideas for how we do it. And I like this idea of creating not just a society of space enthusiasts but a society of space explorers, people who are actually participating in doing it. And the way I sort of think about this whole endeavor is, you know, right now we've got all of us on this blue marble in space and a few of us get to go up here—a few of us just get to barely go up here—and we're sort of going to take these people and we're going to send them out to go far beyond Earth and hopefully also enable some of the rest of us to start getting up here, and I think that would be an extraordinarily exciting thing.

And I am a great believer in grassroots efforts such as yours with the Galaxy Explorers. I think that reaching teachers and kids in this way is a wonderful way to create constituency, but I always am struggling with how to balance that with trying to really create a swell of enthusiasm, so I am curious about the ideas that you have for coordinating your efforts along with, perhaps, other constituencies like industry. They are off coordinating themselves. Are there those kind of partnerships taking place? What could we be doing better? Can NASA help enable some of this? You know, what can we be doing? Do you have ideas about this coordination?

Nicholas Eftimiades

I do, if I can jump in. Yeah. I think what's necessary here is to lay out a strategic plan. And, you know, things—it doesn't happen overnight. It's not going to happen overnight. So we have to consider a long-term strategic plan and we have to bring the stakeholder groups involved. You know, to be frank with you, the aerospace industry can get excited about space and that's one thing. I'm much more excited, you know, when I talk to the Restaurant Owners Association and they're excited about doing something in space, okay, because they have a tremendous reach into the general populace, and if they're excited, if every cab driver is excited that's, you know, that's the type of population we want to shape and move forward and galvanize.

So there are stakeholder groups, which have to be identified, who have interests, you know, across the board, and different levels, and the message has to be probably different to them, government agencies which have to be laid out on a strategic plan, there are congressional activities that have to be laid against a strategic plan, and we have to decide.

If we're going to build a program over a five-year period, for example, what are the milestones that we have to accomplish every year? What are our goals and objectives? We want to have, you know, x amount coming to the Congress, we want to have, you know, certain things done, and, again, as you pointed out, you know, that we live with the Congress, and that's the real function of this, and that's the key in how we're going to move things forward. We lay out a long-term and short-term strategic plan, we identify all our stakeholder groups, we lay out an

organizational structure that takes into account what government agencies can do, what advocacy groups can do, what educational institutions can do, and we basically identify key people, our key lieutenants, if you will, that reach out throughout those organizations to ensure the job gets done within them and then lay it against the strategic plan and decide our actions moving forward. I mean, that's the first step.

Laurie Leshin

Nick, you're hired. George, you were going to mention something about a coordinated effort that's about to be launched?

George Whitesides

Yeah. And one point on that and then another quick point. The Planetary Society and ourselves and a bunch of other groups are going to be coordinating an effort which we'll announce on Friday where, you know, essentially, Lou is doing things, we're doing things, you know, you guys are doing things, and we're going to try to make sure we're doing things in concert as we do our congressional action, and our letter writing, and things like that.

I just wanted to make one quick point, though, which is that it would be useful. I think, for NASA to be open to a wide range of outreach ideas, and they've been really improving on this, and I think it's important to support them in continuing to think outside of the box, so to speak, and who they can partner with so that it's not purely educational groups—that is clearly the main focus and it should continue to be—but we should think about ways we can reach out to young professionals, you know, interesting subgroups, perhaps unconventional partners, because if we continue to stay in this narrow box, we're never going to have the sort of the societal links that we want to.

Laurie Leshin

So, even beyond informal ed to other—

George Whitesides

Yes. Exactly.

Pete Aldridge

Carly?

Carly Fiorina

Thanks so much. And thank you all for being here. I guess we will have to stipulate at least one member of the audience isn't as fascinated as all of us are by space, but nevertheless, we all are.

And I want to continue down this theme of how to take public support and galvanize it, how to extend this to be a grassroots effort as well as a government effort.

And I want to talk specifically about the issue of risk. You laid out some very important statistics.

My own view is that the American public clearly does not tolerate incompetence, does not tolerate dishonesty, but will tolerate risk—honest, competent, risk taking, which obviously, has dangers associated with it—and that, therefore, we should be open and honest about what the risks are.

And I wonder if you could comment on that, because I—my own personal opinion is I worry sometimes that we try and sell programs by underselling the real risks and the real costs. And I wonder if, instead, we ought to galvanize support for this program by being honest and open about what the risks are.

Rick Hauck

I think you're absolutely correct in that. I recall, as I was getting ready for my second Space Shuttle mission, where we were going to go up and retrieve two satellites from space, and it was going to be a very tough job.

And I, myself, thought, "If we got one of them back, it would be incredible, and if we got both of them back, it would be astounding." And the day before we launched, NASA public affairs, very matter-of-factly, said that this crew is going to go up and bring two satellites back. And I had the opportunity to speak with that gentleman just before we launched, and I told him, "You did us a tremendous disservice." We need to—and of course we weren't talking about physical risk then, we were talking about risk of failure of an aspect of a mission—and I think it's been said already, if you don't fail, you're not trying enough new things. And so, I heartily agree with you. I think that we should be very clear to the American people that, yes, we will lose more people, but, as you say, it darn well shouldn't be because of incompetence or because we didn't do the right thing.

Louis Friedman?

So how many did you snag, if any?

Rick Hauck

We brought two of them back.

Louis Friedman

They did a good job. I'd like to add and certainly speak to the human aspect of that and you're quite right. But I'll give you two examples from the robotic part of the program, too, which is

the Mars Polar Lander failure. Great public support for continuing on Mars exploration after that.

And the—and I think the risk that was inherent in the air bag landing this time was part of that drama that made the result so positive afterwards. And a second example which NASA's going to have to face is going to come in the area of nuclear power in space. If the—you're just quite right. If it's not honest about it, and the public won't accept it. I believe if they are honest about it, the advantages to nuclear power in space will be understood and the value will be seen as worth the risk, but there will be risk, so I just say this for basis throughout the space program and I think your analysis is correct. It's certainly true in the human space program, given that example and we've seen it in the robotic program as well.

Pete Aldridge

Bob?

Robert Walker

One thing that has struck me over the years has been how many groups there are that are tied to space in some way, and you represent some of them, and the other thing that struck me is how lousy they have been at organizing politically. They organize well in order to have meetings, and they organize well to, you know, put together newsletters and all this kind of thing, but they've done a pretty lousy job of organizing politically, and I'm just wondering whether or not, as a part of this vision, some of the groups will begin to commit to actually doing real political organization, assuring, for instance, that there is one person in every school district in the country that is committed enough to this to go out to the town meetings that congressmen hold or write letters to the editor. What strikes me is here we have this huge, successful mission on the planet Mars with two rovers doing miraculous things and I'll bet you there are very few congressman at their town meeting that have had somebody stand up and say Congressman, you voted against the NASA budget the last time, or over the last five years. You played no role in that success whatsoever. Why is that?

Nobody feels that they face any political penalty or any political heat whatsoever for opposing what goes on at NASA, and that's a part of the problem that you have got to solve. It's a part of the problem in Congress. It's far easier to vote for the veterans' money inside that appropriation bill than it is to vote for the space money because the veterans are better organized. The AARP is better organized. And my question to you all, after that long explanation, is "Are you prepared at this point to organize the kind of political force that assures that there are people constantly badgering congressmen about their lack of support, or praising them for their support of this vision as it moves forward?"

George Whitesides

Certainly.

Louis Friedman?

The question is—go ahead.

George Whitesides

I was going to say, I think we have a great opportunity in front of us to test us on this issue right now. I mean, you know, yes is the answer. And, you know, what happens over the next six to nine months with the NASA budget is one test of whether we can successfully mobilize our folks, and I for one, am excited to use new ways of reaching out to our membership and other folks. I was involved in some of the presidential campaigns of the past few months, and was amazed at the role of new technology in activating folks, and that's something that the space community hasn't done a particularly good job of yet, but I think it's something that we should. I mean, we're space people. We should be familiar, and use new technology, and—because I think that that can be an effective way to mobilize the troops.

Louis Friedman

I was going to say, your question, besides “Why aren't we doing a better job?” on one level was also a very profound one, because space doesn't touch lives the way health care, environmental issues, veterans' issues, gun control or—gun support. These are issues which do get much better popular representation both in advocacy groups, and then again, in Congress, and for good reason. Because they do touch the daily lives.

Space is one of those things, like education or even, broader, which is generally seen as good but what does it do for me? And so it's a much more diffuse activity that we have to wrestle with, so by way of answer, I support all the points you made, but say that the job is even broader than that because it has to be brought in through all the element of society and communication.

Robert Walker

But if I may just follow up for a second on your point, and on George's, the NASA budget this year is probably not going to get the extra \$800 million. Right now, it's being lost in the Congress as we speak. It's being lost in the budget committees. It's being lost in the appropriations committee. And yet both houses are so evenly divided that if even a handful of people were recruited to stand up and say, “We will not vote for the budget, and we will not vote for the appropriations bill unless it has this money in it,” they can have a very powerful effect in the Congress right now. Twenty people in the House, five people in the Senate, can change the outcome at the present time, and yet I see nothing going on that convinces me that even that handful of people are being recruited to assure that we maintain the figure that's necessary to give this vision its jumpstart.

Nicholas Eftimiades

Congressman, if I can jump for a second, the way we see our organization is to develop and to give these organizations the next generation of organizers and activists, but that said, every one of these people will leave with my home phone number tonight and I'll come with a dozen people to the table to make that happen if anyone wants to give a ring and pull this thing together.

Pete Aldridge

Any other questions? I would like to thank the panel for your testimony today. It's been very provocative and stimulating, and we appreciate your time. Thank you very much. The Commission session is adjourned. We will reconvene tomorrow morning at 9:00 a.m. Thank you.

Tuesday, May 4, 2004

Pete Aldridge

Welcome back to the final public hearing on the President's Commission on Moon, Mars and Beyond. At the end of today's testimony, there will be a special session in which the Commission publicly deliberates the topics that have been presented to us thus far. This is in accordance with the Federal Advisory Committee Act, which governs all such public commissions.

The session—special session, as I said before, will take place at 4:30, and members of the audience are welcome to attend.

The Commission is here to explore ways to achieve the President's vision of going back to the Moon and on to Mars and beyond.

We've listened and talked to experts at four previous hearings—in Washington, DC; Dayton; Atlanta; and San Francisco—and talked among ourselves, and we realize this vision provides a focus, not just for NASA, but a focus that can revitalize U.S. space capability and have a significant impact upon our nation's industrial base, academia, and the quality of life for all Americans.

As you can see from our agenda, we're talking with experts from many, many disciplines, including those outside the traditional aerospace arena. Before I go any further, let me introduce my fellow Commissioners.

Beginning on my left is Carly Fiorina. Carly's not here yet: will be here later today. She serves as the chairwoman and chief executive officer of Hewlett-Packard, which she joined in July of 1999. Her roots are deep in technology, and she has served in senior executive leadership positions in AT&T and Lucent Technologies.

Michael Jackson is a senior vice president for AECOM Technology Corporation. He is a former U.S. Department of Transportation Deputy Secretary and was instrumental in the early formation of the Transportation Security Administration.

Dr. Laurie Leshin is the Director of Arizona State University's Center for Meteorite Studies. She uses cutting-edge laboratory and spacecraft instruments to study the history of water in our solar system and the possibility of life elsewhere.

General Les Lyles was in the Air Force for more than 35 years, rising from Air Force ROTC program to become a four-star general and commander of the Air Force Materiel Command. In that pre-retirement position, General Lyles was responsible for the Air Force research and development community.

Dr. Paul Spudis is the planetary—is a planetary scientist at the Johns Hopkins Applied Physics Laboratory outside Baltimore, Maryland. His specialty is geology of the Moon. He's also studied the geology of the Mars, Mercury, and many other worlds.

Dr. Neil deGrasse Tyson is an astrophysicist and the Frederick P. Rose Director of the Hayden Planetarium here in New York City. He recently served on the President's Aerospace Commission, which made recommendations to Congress and related government agencies of how to improve the health and future of this industry in the interest of the American economy and national security.

Retired Congressman Robert Walker is the chairman and chief executive officer of the Wexler & Walker Public Policy Associates, a firm specializing in telecommunications and technology issues. Bob served in the U.S. Congress from 1977 to 1997, representing his home state of Pennsylvania. While in Congress, he was chairman of the House Science and Technology Committee with NASA oversight. He, too, served on the recent Aerospace Commission as its chair.

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

Steve Schmidt is our Commissioners' executive director. Steve is the special assistant to the NASA administrator and is our federally designated official for this advisory committee. It is important, I think, to review the process by which this Commission will follow. We've been appointed by the President to make recommendations on how to implement the space vision set out on January 14th of this year.

It is our job now to recommend the most important strategies or steps to accomplish the vision. This is a sustained journey. More than 10 presidential terms are covered by this vision. We're listening to experts in the public along with drawing upon our own expertise to generate this plan. I envision that we will select maybe ten key strategies to recommend what we believe will lead to putting us back onto the Moon and on to Mars. In addition to experts, we're listening to the American public: the ultimate customer of this vision.

Through our website we're accepting comments from people around the world who want to be heard on this subject. With respect to space exploration, one of the major themes of the Commission is exploring the idea of sustainability and applying a system-of-systems approach to managing the complex systems involved in space programs. Because the Boeing corporation has done so much work in this area, I'm pleased to welcome Roger Krone, the Senior Vice President of Army Systems from Boeing for the Boeing Integrated Defense Systems, to testify on some of the things that he has been involved with in managing such a complex system of systems. Roger, welcome, and we look forward to your testimony.

Roger Krone

Great. Thank you very much. Can I have the first slide, please? Great. Thanks.

On behalf of the Boeing Company, Mr. Chairman, members of the Commission, we appreciate the opportunity to come and speak to you about the Future Combat Systems Program.

The Future Combat Systems Program is organized within my business unit, which is Army Systems, which is a component of what we call Integrated Defense Systems, which is headed by Jim Alba, which represents about 50 percent of what we do within the Boeing Company. The rest of the Boeing Company is represented by Boeing Commercial Aircraft in Seattle.

Future Combat Systems: In Kosovo, Bosnia, I think the Army came to a transition point where they asked internal questions about their own relevance and whether they were fast enough, agile enough, survivable enough. Under the Chief of Staff of the Army at that time, General Rick Shinseki, I think he viewed the landscape and decided that a whole-scale change in the brigade and the brigade structure was required. The chart in front of you just talks about some of the transformational activities that are occurring within the Army. We see a huge reduction in end strength deployment around the world, which led to what we call the Eisenhower Presentation at the fall AUSA meeting in 1999, where Rick really charted the course of the future of the Army, talked about this thing called the Objective Force, which we now refer to as the Future Force, and really initiated the studies, the concept technology, and development program that led to the current program, which we describe now as FCS.

All right, FCS is thought of as a new way of fighting, one that is network centric, but let me state it is much more than that. It is not just a new way of fighting, the warfighting aside, it is a new way to sustain the fight, and in the Army today, over 65% of the Army TOA is spent in sustaining the Army, in O&M/O&S dollars, mil-personnel, mil-construction. And the unit of action, or the FCS brigade, will change the way we support the Army.

It also changes the way the Army deals with technology. It sets up FCS where we can spiral in or spiral out technology because of the way we build the FCS architecture, the open architecture that we have on FCS. And it also has changed the fundamental way that the Army does business in procuring their weapons systems. Instead of having stovepipe PEOs that buy individual platforms, what FCS does is it designs, integrates, and purchases an entire brigade at a time: you know, approximately 1,000 vehicles and platforms, enough equipment and networks and radios,

essentially, to field 3,000 to 4,000 soldiers—unprecedented in the history of the Army. Let's go to the next chart, please.

All right, program overview: By the way, one of our biggest challenges on FCS is to describe what FCS is. Often people view FCS as a vehicle program or a program that provides a network. The FCS program provides an integrated unit of action, essentially three battalions of brigade-size fighting force. The contract that we are currently executing for the Army, a systems design development contract, is a \$14.78 billion cost-plus incentive-fee contract. It is unique in that it is an OTA, another transaction agreement, and therefore it does not have 100% FAR flowdown, where we've taken a lot of liberties under the OTA structure and only flowed down those requirements in the federal acquisition regs that made sense—again, a revolution in business. The fee structure on the program, I think, is important to note: that we have a 10 percent fixed fee and a 5 percent incentive fee. And the incentive fee is tied to the completion of milestones, all right? So when we complete a systems requirement review and that review is accepted by our customer, then we achieve our incentive fee. And the fee structure was designed to create alignment between the contractor team, which we referred to as the LSI, and the government customer and not to spend a lot of energies discussing award fee issues. In other programs that we have we spend—we're in a continual negotiation on award fee and award fee percentages. We structured this contract so that we are motivated to provide the max customer satisfaction to the U.S. Army and not to spend a lot of energy arguing about fee structure. Other issues around the program: it's about a six-year period of performance. In it are some limited user tests. We had two years in CTD, six-year STD program. There is an LRIP program that we expect to initiate halfway through the program, and the contract will be culminated in the fielding, the first unit equipped in the year 2010. So, we'll go from the Defense Acquisition Board, which happened last June, to first fielding in 2010, about seven years. Let's see. Next chart, please.

All right. FCS is, if you will, the first network-centric approach to warfighting on a large scale. The essence is a warfighting capability provided to the U.S. Army at the brigade or unit-of-action level. Again, integrating, creating a high degree of situation awareness for about 3,000 troops, again a unit-of-action level, about 1,000 platforms which include manned ground vehicles, unmanned ground vehicles, manned aircraft-rotorcraft, unmanned aircraft, remote sensors (both manned and unmanned), a robust broadband network (100 megabytes or larger relative to bandwidth)—all integrated where there is a high degree of situation awareness; it's a publish-and-subscribe network where all of the information is made available on essentially a tactical-like internet and every player on the field—the individual soldier, the team leader, the platoon leader, the company commander, the battalion commander, and the brigade commander—can all access information on the network, can pull down data out of what we call a Common Relevant Operating Picture—all right?—and get the same situational awareness of anyone else in the network and they can also post information into the network as they learn it on the tactical battlefield.

We have been asked to optimize this system of systems around what we call Seven Plus One Key Performance Parameters. And those are shown on the chart. Joint interoperability—that's within the Army and within the other Services—and with our coalition partners. Networked

battle command, all right? Something we call a FBCB2, which is a future battle command system that we're currently using in OEF/OIF. We're going to take that, if you will, to the next level. Network lethality: so how we bring—in the Army will call it steel on tanks. How we destroy a tank. We'll be—we will have a network of offensive capabilities, cannons, rockets, mortars, joint fires that will be networked into the system, and the target weapon pairing will be done automatically through the system of systems, so we'll optimize the class of weapon for the target that we're trying to kill.

Transportability: when we started the program we talked about going from continental United States into theater in 96 hours. We talked about fort-to-fight in 96 hours. The transportability right now is centered around a C-130 box size with a C-130 weight requirement on the manned ground vehicle and, again, the ability to deploy within several days.

Sustainability and reliability: we talked about half the logistics tail versus a conventional brigade and frankly, our goal is to achieve almost an order-of-magnitude increase in reliability and reduce the logistics tail that is such a challenge for the Army today.

Embedded training: one of our KPPs. So, on the way to the battle you can use the same platform, the same system, that you're going to fight in to actually do training and mission rehearsal.

Survivability: because of the requirement for transportability, these vehicles will be lighter than the main battle tank, than the Bradley, than the M113—currently in the Army. So, we have to find another way to achieve the same degree of survivability for the soldier in combat and then the 8th—again, we talk about 7 plus one—is affordability. We need to be able to—and the plan is to field 15 units of actions; at that time it was half of the brigade structure. The Army has since announced—it changed the brigade to go from 33 to 45. But we're still anticipating 15 brigades and, in the end, we have to make a unit of action which is affordable so in the end the Army can buy the full complement of units of action. Next chart, please.

That's a little bit about the program; now I'm going to talk about how we run the program relative to systems of systems, then I've got a couple of charts on how we do systems engineering on the program, and then I'll wrap up and take your questions.

Been in the—in this business as a defense contractor since getting out of college. Been on a lot of different programs, frankly, with some of you on the Commission. I will tell you the success of a program is often known at the time you sign the contract. Setting the program up in the beginning correctly goes a long way to successful execution, and on Future Combat Systems I think we were able to do that. We had a CTD program, essentially an advanced design effort that was run out of DARPA and during that CTD phase we had a contractual requirement to put in place the plan for STD, so, we did that collaboratively with our DARPA and Army customer, defined the critical technologies, created a collaborative environment using some very, very high-order collaborative computer tools—what we call the Advanced Collaborative Environment (ACE)—created a detailed statement of work, WBS structure for the program, the integrated program—plan integrated program, schedule, and, perhaps more importantly, created a joint cost estimate. And, so, early in CTD we attacked the numbers, we attacked affordability, and we

continued to morph the program until we could fit within a reasonable budget given the POM and EPP cycle that the Army had. We also used what was called an alpha contracting approach. Alpha contracting, if you're not familiar with that is, where from the contractor's side, we essentially open our books. We don't go into separate camps and create cost estimates: we build joint cost estimates. We share all of our cost-estimating ratios, our basis of estimate, with the customer. And we do that from the very, very beginning. And where we would have difficulties downstream in negotiations we deal with those early, so that when we arrive at a program cost estimate, it is literally a joint cost estimate that's understood by the customer community.

We also went through numerous independent reviews. I think FCS, relative to standing programs, may be the most reviewed program I've ever been on. The cost analysis independent group at OSD, IDA, the Welsh Panel, which was a OSD-chartered panel to look at the program: we're actually on our third Welsh review. We created a senior advisory group of Army and industry individuals and numerous, numerous Boeing internal reviews so that when we achieved success through the Milestone B process and initiated the STD program, we felt we had an executable program at the day we signed the contract. Next chart, please.

Different about FCS is that we used what is now referred to as the Lead Systems Integrator approach and I want to talk a little bit about how that is different from the conventional prime. My career, essentially aviation programs, F-16, F-18, C-17, we used a prime approach, essentially where we built what we were good at: a lot of content in the conventional prime, and then we subcontracted out subsystems. All right, the Lead Systems Integrator is subtly different than that.

We like to refer to the LSI as being a general contractor, just as you would have a general contractor if you were going to construct a home. Often, the general contractor will build nothing. They will conduct the integration: they will do the trade studies for you. And we recently added onto our house and we had a general contractor. Frankly, the general contractor worked well with my stakeholders—my family, my wife—about picking out cabinets and lighting and working our cost estimate, freed me from having to do that, and then managed the job after we had decided on the design, and then as we got into the construction job and we had to make changes, because of unknown unknowns, that general contractor was able to make those trades. And because the general contractor did not have a lot of work content in the job, we thought of them as being a neutral and really representing our interests. That's what we do for the United States Army. We provide a level of integration across the Army PEO organizations, frankly, across the General Staff, across the various stakeholders in the U.S. Army, including the taxpayer, Congress, the fielded Army, the retired soldiers, the AUSA organization relative to balancing the needs and interests of all the stakeholders in the Army.

Another, I think, very, very important aspect of the LSI concept is our relationship with the rest of industry. Referring back to my general contractor analogy: when we were adding onto our house—and this was in St. Louis—we really didn't have a lot of in-depth knowledge of the building trades in the St. Louis area. I knew a couple contractors, but my ability to pick a carpenter, a plumber, or a brick layer, or someone who would do concrete work was very

minimal. My general contractor was very intimately involved in the trades in St. Louis and was able, with my concurrence, to pick the best-value subcontractors to do the work that was required on my house at the time. The Boeing Company, in its role as LSI, is able to do that for the United States Army. We have terrific relationships with the rest of the defense industry, frankly, in the United States and in some of our coalition partners. We keep abreast of the latest technology, and we were able to, we believe, bring the best of industry to the United States Army in building what we call our One Team. Next chart, please.

This is the One Team on the Future Combat Systems that's shown in the graphic. We show the three concentric circles—essentially the customer, the Army, the Defense Department, DARPA, the Lead Systems Integrator, which is the Boeing Company, and SAIC is our partner in the Lead Systems Integrator role. SAIC has about 15 percent of the content on Future Combat Systems, and then in the red circle is the industry team that we have been able to assemble. A couple really exciting things happened under the LSI concept. All right, so we passed the DAB in June of 2003. We were able to get 23 contracts with 18 subcontractors, went through a evaluation process, conducted awards, entered negotiation, and definitized our entire team between the June and December timeframes. So, by the end of the year 2003, because of our ability to act in a commercial fashion, we were able to put under contract our entire One Team.

Now, if you look at some of the names in the red circle, you will see the world's largest defense contractor in Lockheed Martin, and you will see what is perhaps the world's smallest defense contractor in a company called I-Robot or Austin Information Systems. I-Robot has about 125 employees; they're an MIT spinoff. They make a man-packable robot that we're using on Future Combat Systems, but they're also known for a robotic vacuum cleaner that you can buy in your house that has a price point of about \$200.

The excitement that we've had in building the One Team is our ability to deal, from a Boeing standpoint, both with the large traditional defense primes, but also bring some of the smaller, more entrepreneurial companies in the U.S. onto the program. And then not shown in the One Team is as we launched into what we call our first increment on FCS, we've suddenly started a second increment—part of this technology spiral—and we are working small study contracts with a whole host of second-tier contractors in the United States, looking for that next generation of technology that we could spiral into the program later on. Next chart, please.

So how do you run a \$15 billion, six-year development program? We call it our battle rhythm, and that's essentially an Army term. It is how we run the program. You might recognize the graphic, as it looks like a typical Army sensor-shooter loop. You plan, execute, measure and correct and replan. I just wanted to highlight a couple, I think, of the real essential points in our program management scheme because you need to start out with a good baseline. We spent a lot of time coming up with an integrated baseline where we have integrated costs and schedule down to the level-five team—absolutely important. And today there are IT information products that are available to allow you to have that kind of visibility. We execute through a series of management plans. We have a risk plan, a supplier plan, and a set of integrated schedules. We're adamant about baseline management, and then we continue with the independent reviews.

We measure—we have what we call weekly earned value using this thing called SPICPI, where we measure cost and schedule performance down to the level-five team every week, and we review that cost and schedule performance, as well as the achievement of technical milestones, on a weekly basis every week, whether there is a holiday on Mondays or not. It is absolutely key to knowing how you're doing and how you're progressing on the program.

Corrective action, we're a year into execution of the STD program. We've had, frankly, some success on the program. We were actually ahead of cost. We are 2 percent behind schedule on our schedule performance indicator but we've had some unknown unknowns and we've had to take some corrective action and do some replanning. I can't overstress the importance of rigid change management on a program of this size. We use a series of what we call change boards; again, I think many of you are familiar with that. Our change board meets every week and we actually have a tiered layer of change boards. We have lower-level IPT change boards and then all schedule, cost, or technical changes that impact the program actually flow up to the program change board, which is chaired by the program manager, and the program manager sits at the change board every weeks. Our task is to run this process and to do it well, and to communicate how we're doing, and frankly to execute the contract that we signed, the \$14.78 billion contract. Let's see. Now, I have a couple of charts to talk about systems engineering and then I'll be happy to take questions. Next chart, please.

The core to systems engineering on Future Combat Systems is to have a single unified information architecture on the program, and I apologize for the complication in this chart; it's really here for reference. But, simply to say that we have a unified information architecture reference model, which is shown in the chart, which is by its nature open. It's based on a Unix operating system at the very base. All of our One Team members have bought into this open architecture, which we call the systems-of-systems common operating environment. It's very, very similar to a commercial IT information architecture. Some of you who have a commercial IT background probably recognize that. We have our warfighter machine interface layers; we have application interface layers. We build services into what we call the brick and, if you will, it keeps us integrated, it keeps us coordinated, it helps us to define the APIs, the application interfaces on the program, and we use it with our all suppliers. It is a series of families and services as you would have in an HP environment, an IBM environment. But the fact that this has been promulgated amongst the team, it is open and frankly it is available to all of industry, I think keeps us all coordinated and playing together. Okay, next chart.

I think unique in this program and something that we are excited about and, frankly, somewhat proud of is the way we broke up the tasks on the program: a little bit of a complicated chart. Let me see if I can walk you through it. Typically, what we would do in a program like this is we would contract with a company or a group to build a platform or a major subsystem on the program. And if you recall, this has some manned ground vehicles, it has some unmanned ground vehicles, some air vehicles, some sensors. And typically what we would do is we would go to a company to buy the manned ground vehicle, all right? And that company would be responsible for everything associated with that manned ground vehicle. They would buy the sensors, they would buy the power supplies, they would buy the engine, the gun, the turret, and

they would be responsible for the training and logistics tail that goes with that vehicle. That is not how we disaggregated this program; it is not how we have set up our integrated product teams.

What we have done is essentially taken the functionality in the program and broken it in two different ways. Across the top of this chart we talk about combat systems. Think of that as platforms so there is a command and control vehicle, a non-line-of-sight cannon (think of that as a howitzer), mounted combat systems, an unmanned air vehicle, and we do have some contractors who are building, if you will, the bricks and mortar of those vehicles.

For instance, the C-2 vehicle is either GD or United Defense, and they're responsible for building the chassis in the command and control vehicle. But what's different in this program is we've taken a horizontal slice through all these platform and systems and we've pulled out those elements that are common—all right?—to all of our platforms. So, that there is a separate contractor, Raytheon, who does command and control for Future Combat Systems, and they are responsible for command and control wherever it lies in the systems of systems. So they have an element, shown by that horizontal blue bar in the C-2 vehicle, but they also have an element in the non-line-of-sight cannon, in the mounted combat systems, in the UAV, in the armed robotic vehicle, etc., etc., etc., all the way to the soldier's system. So, wherever command and control lies in our requirements, Raytheon has that responsibility. Same thing with information management, communication, sensing, logistics, training. So, we've taken a whole separate cut. And, typically the Army has been organized in what I would view as a traditional program executive office organization, which is organized logically by the way the Army is organized, so you would find that there is a PEO ground systems in the Army, there is a PEO aviation in the Army, there's a PEO for what's called C3T: command, control, communications, and—I don't remember what the "T" is—tactical. And, typically the Army works within those vertical PEO organizations. What we do within FCS is we have to integrate across those traditional PEO organizations in the Army, and it's this kind of a structure that allows us to cut horizontally through the organization within the Army and redefine the way the acquisition community and the Army works both with industry and within itself. Next chart, please.

This is, I think, a pretty exciting chart. It talks about how you deal with requirements in systems of systems, and I will spend a minute trying to explain the chart. So, we start with an operational requirements document in the upper left, which is the, if you will, the large spec that we use in the program, and we go through a series where we disaggregate large requirements, which is essentially to provide an overmatch warfighting capability, into smaller and smaller requirements. And you can see as you go down there we start with an ORD, go to a systems spec, go to what we're called program item descriptive documents, PCDs, and essentially get down to the very bottom, which might be the design of an alternator at the very, very small system. And the ability to conduct a warfighting action is the summation of all of these requirements and all of these subsystems. So we start with a allocation of requirements and functionality down through our systems engineering process. And then up the right-hand side of this we aggregate those capabilities and we go through a verification and validation phase using modeling and simulation. So, if you can think about it, we talk about a ability to fight a battle, to

fight a war that works its way all the way down to a subcomponent design. We then do the design work on the subcomponent and then we aggregate those subcomponents back into a system and we verify that that system performs as designed as we rebuild the system. And we use constructive modeling and simulation to verify that because it is almost impossible to build and test an entire brigade. And we are heavily, heavily characterized by constructive modeling and simulation on the program. And this is an iterative process, and it's one that occurs at all levels all of the time. So at a time where we're trying to optimize an alternator we are still working some of the high-level key performance parameters at the unit-of-action level. Frankly, we are still working the C-130 transportability relative to weight and capability, we are still making trades across KPPs, but because of the compressed schedule in Future Combat Systems, we literally have activity all the way across this document every day. Okay, my last chart.

Summary: Large systems-of-systems program: got to be executable from day one. I think, Chairman, that funding to the CAIG estimate is clearly one of your battle cries. It's one, I think, at Boeing that we wholly endorse. One of the ways that we got there on this program was through the collaborative cost-estimating process, and frankly, the CAIG was a member of our team as we built our program cost estimates. And when we ran short of funds in the EPP and the POM we were able to make trades within Future Combat Systems so we had a cost-executable program from day one.

I think contract type is important. I think it is very, very doubtful that the industry will ever take a large firm-fixed-price development contract again. We all suffered the pains of that in the '80s. We believe the large fixed fee on Future Combat Systems gets our alignment in the right direction. So, our only purpose as the Lead Systems Integrator is to make our Army customer delighted with the performance that we're doing on the program and to achieve with the 5 percent that we do have on incentive fee those critical milestones on time.

And then the other point I would make about executable from day one is funding stability: always a challenge in the way we fund programs of this size, the kind of public oversight that we have. Funding stability is absolutely paramount, but it never happens, and I would simply suggest in the large endeavor that you're conducting analysis on that you need to understand that there is no such thing as funding stability in these large programs, and you need to take that into account as you make your recommendations on program design.

Managing a systems-of-systems engineering process, we believe having a single contractor who is in charge, call it a Lead Systems Integrator, call them a—the prime of primes, we found that to be very effective on Future Combat Systems. I can tell you that the Boeing Company and SAIC, relative to LSI, our only goal is to meet the requirements of the U.S. Army. That is paramount, it is above profit motivation, it's above work content: it is what we're all about. You need to have a robust process to disaggregate the requirements. How you get a human being from the Earth to Mars has got to be just a whole series of interlocking requirements on propulsion, on energy management: you need to be able to break those down to the point where you literally are designing alternators. A robust process for that is important, and then you need to have a verification and validation process to make sure that, when you put it all together at the end it's

going to work. Again, we use constructive simulation. I believe tools like that would be available in your project as well.

I can't speak enough about baseline management and change management. You know, I think we've learned lessons on Space Station, we've learned lessons on other large programs. It's a lesson we're trying not to relearn on Future Combat Systems.

And last, but not least, it's getting the right team together, having shared values, having a shared vision. And one thing that I didn't spend a lot of time on is that we have driven common processes across our One Team. We're all linked electronically, we use an advanced collaborative system. All of our drawings, all of our data, all of our cost and schedule information is put on this process we call the advanced collaborative environment and is available to all of our team members. There literally are no secrets on Future Combat Systems. Our customer has an ACE account. In fact, I think we have over 4,000 ACE accounts where both our customer and our PA&E/OSD oversight individuals can login to ACE and look at the same data that we use to run the program. So, overall on FCS, we have a single vision, we have a single purpose: we are all aligned. We are about a year into the STD program, three years into the total program. We're essentially on—ahead of cost; we're essentially on schedule. We have our fingers crossed. We have a lot of work to do in the future. At this point, though, I would be pleased to entertain any questions that you have.

Pete Aldridge

Roger, thank you very much. All right, just a comment and then we'll open it up for questions. There is a strange similarity between the tasks that we have of completing, of course, the Space Station and getting back to the Moon and to Mars and beyond because there seems to be—there is manned systems and unmanned systems. There is a tremendous amount of, I guess, communications that go on that have to go on to gather the information, pass information back and forth. And I notice, strangely, we are also weight limited, as you are on the C-130. So, a lot of the applications of the lessons seem to have a direct application to our mission, and I think it's something that all of the Commissioners can clearly see. Les?

Les Lyles

Roger, welcome. It's good to see you again. I couldn't help to think back our first involvement together on the F-16 program when you were at General Dynamics and the attempt at a Lead Systems Integrator, or a Systems Integrator, at that particular program, and then how that has matured to the lead systems integration we do on missile defense, which also just happens to be Boeing, and then where you are today in FCS.

And, I was trying to think of a lesson—major lessons learned. I think you covered most of them in your presentation. But, as you think about it, and going through this whole process and maturing where you are today, are there a couple of key things, that you think, really jump out at you that are very, very paramount in making this successful? And probably the one that hits me

more than anything else is the organization of the structure of the—your primary customer, in this case the Army. Is it a help to you that you're providing the integration across PEOs within the Army structure, or would it be of even greater help if they had a different structure in terms of organization and management for the things that you provide?

Roger Krone

Wow: what a great question. And, General, it's good to see you again. Let's see, I'm not going to make a comment about how I think the Army ought to be organized. I'm not sure that's a contractor role, but I will make some observations about what works and what doesn't and then let me see if I can make a comment about some of our observations on systems engineering and systems of systems.

We have been successful so far on the program because of some key general-level officers in the United States Army who have—who have provided leadership in getting the traditionally stovepipe PEO organizations to work together. Not to put them on the spot, but General Joe Yakavac, General Caldwell, certainly Secretary Claude Bolton, have cut through normal walls in their organization. And, I've been in many meetings with those individuals where they have brought both their PEOs and some of my contractor team and made it absolutely clear what this program was about, how important it was, and that the success of Future Combat Systems was more important than the success of any individual PEO. You know, it would always be easier to have an organization that absolutely paralleled the program that you're running, and because FCS does touch more than one PEO it would—it might make our job less complicated. On the other hand, at the same time that we are running the FCS program the Army is still at war, is still buying conventional equipment, Apaches, they're maintaining their A1/A2 main battle tanks. And they need to have an organization that takes care of the current force as well. And if we were to optimize the acquisition structure within the Army for FCS, we might sub-optimize it for some of the things they have to do today. And frankly we have, as we all know, we've got soldiers over in theater and supporting them is probably job number one within the Army.

However, lessons learned on systems of systems, and we've touched on it today: absolute alignment at the very, very senior level around a common goal. We had the luxury of the Chief of Staff of the Army, General Rick Shinseki, and that has been endorsed by the new Chief of Staff of the Army, General Schoomaker, around the importance of FCS and how it is a transformational—the transformational program for the Army and that has been firmly communicated to all the stakeholders in the U.S. Army, including the contractor team.

The second thing I would say is our ability to create a collaborative environment amongst the Army, DARPA, and industry, and we really have a working-together philosophy. From a Boeing standpoint we really do share everything. There is not a piece of information that we have on Future Combat Systems which is not out on ACE, which is not available online to anyone with an ACE account. The Army sees—the Army is in every IPT, the Army is at all of our program management meetings, the Army will co-locate their program executive office with

our program manager. So, it is an open and honest—so that we talk about problems every day. We talk about them before they become big problems.

And maybe the last is that we maybe over-communicate status and where we are. The trades that we're kind of making we always—we test the assumptions with the Training and Doctrine Command who helps us with requirements and, maybe, the wrapper that goes around all of this and we do it in an environment where we use modeling and simulation to constantly measure the effectiveness of the systems trades that we're making, so we can always go back to the fundamental KPPs and see “How well are we doing against the goal?” And if the goal is to get to Mars, it would seem to me you would want to check progress, does the decision that you make at a fifth-tier IPT move you closer to Mars or further away, relative to your end objective? And, on FCS we have spent, actually a significant amount of money—hundreds of millions of dollars—in constructive simulation so we can answer that question every time we need to make a systems trade.

Pete Aldridge

Maria.

Maria Zuber

Mr. Krone, thanks for that presentation. I was interested in your commentary about your incentive fee being tied to completions of milestones. We've been talking a lot in the Commission about setting milestones and setting metrics for success, and I'm not so interested so much in what those milestones were that you chose, but just the process that you went through to set them and the way that you worked with the Army. Did you bring other subcontractors in? You know, what is the way that you set those?

Roger Krone

Wow, what a great question. Let's see, again, I've been—I've only ever been a defense contractor so I've worked under almost every type of contract known to the department. And I was on some great programs that had a great contract structure and I was on some—I was on the A-12 program, which was a firm-fixed-price development, which, perhaps was not a very, certainly from my standpoint, wasn't a very exciting structure, but I'm not sure it motivated the contractor team to do the right thing.

So, how we arrived at this is we literally sat down with the Tank and Automotive Command and the individuals in the acquisition community within the Army and took out a white sheet of paper and said, “Now, what is it we're trying to achieve?” All right? And we did this with a high degree of trust. All right? So that we have proven to the Army, with our teammate SAIC, is that we really are about achieving the goal of the Army in Future Combat Systems, whatever that may be. Once you've achieved that level of trust, all right, then you say, “How do we—how do we incentivize you to do the right thing, and not disincentivize you to sub-optimize, achieving a

near-term milestone to get an award fee, which may or may not be in concert with the long-term goal of fielding a system?” And we went through numerous different structures—award fee structures, and technical milestones, and on a program that’s systems of systems, I mean, it’s awfully hard to come up with a series of award fee milestones based upon technical performance, all right, that don’t somehow sub-optimize where you’re headed. So, frankly, it was with three-star General Joe Yakavac, we said, “Joe, what do you want us to do?”

And Joe said, “Well, I want you to execute the contract and make any changes I may need to make, because there is a lot of engineering yet to be done on the program, and I don’t want to spend a lot of time renegotiating award fee criteria or spending a lot of time with our administrative folks. I want you to make a change if I tell you to make a change. And, oh, by the way, it’s really important to the Army that this program be fielded on time.” So, relative to the incentive part, again 5 percent is the return on cost, we picked out five interim milestones that are tied to events—in the old vernacular, it would be PDR, CDR, first fielding, and then first unit equipped kind of milestones and we defined what they would be. The customer does determine whether we have met that criteria or not and those are the five milestones. So, they each carry about a one point of fee, and then that point for that milestone is broken down into a couple subcomponents associated with what would happen at a preliminary design review or critical design review, so there is, you know, “Did you get to the review on time? Did you meet your technical milestones that had to be—certainly, technology maturity, you know, systems built? Did you exit the PDR versus the exit criteria for PDR?” The large base fee, frankly, is, as a contractor, we need a fee. That’s how our system works on the industry side. The 10 percent is large enough to keep us focused. But the fact that it’s fixed fee says is that we have really no incentive to do anything to try to accelerate that fee because it’s fixed fee. It will happen as we incur the cost. And, so, it takes us completely out of this negotiation and gamesmanship that you might have on other programs where you’re trying to do, again, subtle things or make near-term decisions that would cause you to achieve your fee, which, again, may not be in the long-term interest of the program. Did I help you with that?

Les Lyles

Yes

Roger Krone

Yeah, I’m sorry, Pete.

Pete Aldridge

We have time for one more question. Mike.

Roger Krone

OK.

Mike Jackson

Mr. Krone, thank you for being here. This testimony is important and very relevant to the—our deliberations, so we appreciate it. I have a little bit of an explanation, quickly, and then a question for you. In the case that you've described of your work with the Army you have a single customer that is consuming the product that you're producing and paying for all of it. In the work that we're talking about with this Commission we've started with a theme that multiple folks have testified to us about, which is the importance of building a space industry, not just a space program. You're building a defense program. So, for us in thinking about how to structure properly the role of the private sector and the LSI type of role to which I think we're very much attracted, we have a more complex matrix within which to operate.

We are going to be presumably procuring systems for NASA to employ in its pursuit of the President's mission. But parallel to that, we're trying to create an industry which can, through subsequent spirals of development, take more of the work that NASA would do and offload it to capabilities which are purely private-sector work. So, in effect we're trying to think our way through a structure in which perhaps there is an integrator's role that looks both to the government's needs and requirements and also tries to help manage all the kids in the sandbox that are trying to create private-sector solutions which will ease the financial burden of the federal government and other international investments to do this work. So it's a more complicated model. Can you talk a little bit about how your lessons learned from this might be stretched to accommodate thinking about this different type of challenge?

Roger Krone

Let's see. I can try. Let's see, a couple of points that I didn't make relative to FCS: we actually manage the GFE on FCS. So, we have a contract for a certain amount of money and then there is an additional amount of funds that essentially reside on the Army side and it's the Army program office which we actually don't do a lot of oversight of. But it's range time and its test assets and things like that. So, our role as an LSI on FCS extends beyond just executing a contract. We haven't been asked, as one of our critical performance parameters, to maintain the industrial base for the Army, which I think is very subtly different, given the task that you've described. I don't want to sound like I'm, you know, an academic, but I am sort of an Adam Smith, you know, student and I don't know how well, you know, a LSI can deal with maintaining industrial base, if the basic premise for maintaining an industrial base are not founded in good business. And I would maybe only comment back is that if you try to deliberately manage the industrial base, you know, the—if you will, the invisible hand, you may sub-optimize. Companies and industries and innovation seems to work well, again in our organization, the capitalist society, when there are appropriate incentives, tends to be profit and, you know, and stock and things like that. And

I would submit that's worked extremely well, with, you know, probably some pockets of inefficiencies, but generally in an efficient way. And you will get innovation and you will get companies that run to the program if the appropriate incentives are there relative to risk and return.

What we have found, and I think we've learned this lesson time and again in DoD, is that, if we try to over-manage, and we create structural inefficiencies in the capital organization of the industry, we can preserve companies that, frankly, probably shouldn't have been preserved and we'll stifle innovation of small companies that otherwise would come in the market.

And maybe my last comment is so your challenge is to create a structure where not only the large companies—the Boeings, the Northrops, the Lockheeds—want to come and participate but that the smaller companies, the Austin Information Systems, the I-Robots, the two individuals in the garage and a good idea, see to the Moon, Mars and Beyond as a place where not only they can fulfill their life ambition of doing exciting technical work, but they can see a reasonable return on their investment and there's a reasonable profit margin. And that's going to be a challenge, given the source of money being the U.S. taxpayer and the kind of oversight that we have in government programs. But I don't think there is any lack of individuals—and I will tell you that my classmates, both in undergrad and graduate, we always talked about creating a new company that could go build a product like Orbital Science and enter the space market and—because of the dream and the vision of going to Mars, I think you'll capture the hearts and minds of a lot of entrepreneurs. But you just have to create a structure where they can make a couple bucks.

Pete Aldridge

Roger, we've run out of time. I appreciate your coming—testifying. I think that some of the issues you've raised are quite pertinent to our deliberations, and we appreciate you coming. Thanks very much.

Roger Krone

Thank you very much.

Pete Aldridge

We have another panel coming forth now, which we've titled "Astrophysics for the Beyond." I think maybe Neil Tyson probably thought this title up. This is a rather large subject, obviously. But we welcome three experts in the field, and I'll introduce them as they're coming forth.

Catherine Pilachowski is the president of the American Astronomical Society. She holds the Kirkwood chair in astronomy from Indiana University and has 20 years' experience on the science staff at the National Optical Astronomy Observatory in Tucson.

William Smith is the president of the Association of Universities for Research in Astronomy, known as AURA, and brings over 20 years' experience in science management and policy to the

post. Before his appointment to AURA he served in various capacities with the House Committee on Science and also served with the Federal Aviation Administration.

David Spergel is a professor in the Department of 4 at Princeton University. He's also a member of the Wilkinson microwave anisotropy probe team, which found the oldest existing light in the universe, and he was part of the Space Interferometry Mission Project Office. In his spare time he serves as chair of the NASA Origins Subcommittee and member of the Space Science Advisory Council.

Mrs. Pilachowski, would you start, please?

Catherine Pilachowski

Certainly. If I could have—thank you—the first slide. Chairman Aldridge and members of the Commission, I thank you for the opportunity to speak to you today. I speak on behalf of the American Astronomical Society and the nation's astronomers who carry out research at the forefront of astronomy and astrophysics. We also teach at the nation's colleges and universities, and I and my colleagues are very active as well in K-through-12 outreach through curricular materials and meeting with the public.

For the members—next slide, please—for members of the AAS, scientific research is the most fundamental form of exploration. It's no coincidence that throughout history, exploration and scientific progress have gone hand in hand. The next slide, please.

Throughout NASA's own illustrious history, exploration and research have been closely linked. The list of scientific achievements enabled by our partnership includes some of the most profound questions of the 20th century. When the President first announced his new vision for NASA, most professional astronomers held their breath. NASA's resources are limited, and the relatively small proportion that directly funds astronomy research can be easily swept aside by a major redirection of the agency. We all began to breathe again when Administrator O'Keefe made it clear that scientific research would continue to play a major role in NASA's future, and this has been verified in the President's fiscal year 2005 budget submission. The President's vision of NASA inspires us to think bigger—could I have the next slide, please?—about the future of astronomy and astrophysics.

Only a few years ago we thought we knew something about the structure and origin of the universe, but today we know that less than 5 percent of the universe is visible to us. We have no knowledge of the 95% of the universe dominated by dark matter and dark energy. And many of our most pressing questions require observations from outside Earth's atmosphere, either because of wavelength requirements or the need for low background or the need for very high spatial resolution that can only be achieved from space. Many witnesses at these hearings have testified of the lost vision of Apollo. This time the vision must transcend short-term goals. With the development of new and more robust space infrastructure including new robotic and tele-robotic capabilities, opportunities for exploration naturally beckon. Space infrastructure can be a

tool for exploration, and that exploration naturally leads beyond the Moon and Mars and beyond the solar system. Could I have the next slide, please?

At the same time, we're challenged to sustain the ongoing exploration of the universe that has been one of NASA's most visible and successful programs. Already the redirection of NASA's research efforts has had an impact on research. The Beyond Einstein initiative to test Einstein's theory of relativity has already seen reductions and delays that threaten the existence of these programs. Research to understand the connections between the sun and the Earth and the impact and possible threat of the sun to the Earth—those programs have also been reduced somewhat. How can NASA achieve and retain a healthy balance between space science and human exploration? The National Research Council's report *Issues and Opportunities Regarding the U.S. Space Program* stressed the importance of the interplay between science and exploration and urges NASA to apply the principles of balance and complementarity. Historically, NASA's role in astronomy has been to provide the space tools needed to address the important scientific problems. Could I have the next slide, please?

With this view both science and exploration can thrive to the benefit of each, with creative tension between them rather than conflict. What form will the program of astronomical exploration take? There have been many studies about telescopes on the Moon and many studies and great technical developments for free-floating space observatories. But, I think at the moment we don't know enough to make decisions about what the right directions are for the future, whether that be on the Moon or in space. What are needed are detailed studies of the technologies, costs, and benefits of doing astronomy in these locations. Thus, we recommend that NASA's implementation plan call for an assessment of how best to take advantage of the new space infrastructure to conduct scientific exploration of the universe. This Commission is also right to be concerned with the sustainability of a long-term vision of exploration. Next slide, please.

Superficially NASA's program enjoys broad public appeal. The Mars rover websites see millions of hits per week, and the Hubble Space Telescope website has recorded hundreds of billions of independent visits. We see that NASA produces and space science produced 8 percent of scientific discoveries worldwide in 2003. That's an extraordinary accomplishment.

It's easy to excite kids about planets, black holes, and space travel. Yet, even the huge popularity of HST and the Mars rover program is not sufficient to sustain public support for a broad program of exploration. I teach introductory astronomy at a large Midwestern university, Indiana University. And those kids who were once excited about black holes and space travel come into my classroom with a very different perspective. They find themselves as young adults faced with issues like cancer, AIDS, poverty, racial discord, war, global warming, environmental pollution, and as many of us did at that age, they sense a responsibility to address those problems in some way. They're not persuaded by the manifest destiny of humans in space, and they don't believe that space exploration contributes to economic, social, or technical progress. Could I have the next slide please?

It's easy to excite kids, but it's important to target those skeptical young adults with this new vision to help them understand why it's important. They see space exploration as irrelevant to their lives and to the solution of problems on Earth, and they prefer that their tax dollars be spent solving or at least addressing those problems. To engage the public over the long haul—could I have the next slide, please?—NASA needs to articulate the economic, social, technical, and intellectual value of its exploration program in a way that appeals to young adults. Astronomy has seen much in the universe, and we have much to contribute to this task by providing a constant stream of new discoveries enabled by space exploration. The broader science element of this program really does help to sustain interest in the long haul.

I want to add one additional comment to this long vision, and that is that part of the vision is to search out planets and life on other solar systems. Within the next few decades we will have the capability to send a probe to other stars. That probe may take a hundred years to reach those stars. We really are talking about a long-term program of sustainability to explore the universe. The astronomical community is excited about this vision and appreciates the chance to participate in these hearings. We stand ready to assist the Commission and NASA to make the President's new vision for discovery into reality. Thank you.

Pete Aldridge

Thank you. Dr. Smith?

William Smith

Chairman Aldridge, members of the Commission, I appreciate the opportunity to present a statement on behalf of the Association of Universities for Research in Astronomy. We're an organization that represents most of the large astronomy programs in the university community. As it turns out, our—one of our long-term goals, which we have discussed a great deal internally, resonates very strongly with at least one portion of the vision, and I'll quote, "to conduct advanced telescope searches for earthlike planets and habitable environments around other stars." Therefore, we feel we have a stake in this, and we have spent a considerable amount of time discussing within AURA how we might make this successful, and I will summarize the three or four major outcomes of our discussion.

But before that I would like to acknowledge—I know this is your last hearing—I would like to acknowledge the extraordinary efforts that the Commission has gone to to include a wide spectrum of public viewpoints in the course of your work. This really does recognize that the space program has traditionally had a very strong ownership by the public and touches many segments of our society. The science community and astronomers as a subset are really only a small part of this public representation, and I would not claim that we are the most important group you should listen to, but we do have a special significance that I think you should pay attention to, and that is that—and I want to harken back to the report that Katie mentioned, *Issues and Opportunities in the Space Program*—I think that report made a very good case for the fact

that the science community has a special responsibility for formulating a high-quality and productive program where the goal happens to be science. And ultimately the productivity of this federal investment is going to be a factor in the long-term political support, and therefore the engagement of the science community will be of paramount importance. Given that, then, the question that we asked ourselves is “How can we make this part of the exploration initiative most productive?”

There certainly has been discussion going back to the Apollo era regarding building major telescopes on the Moon, major observatories on the Moon, and I would agree with Catie that this requires much further study. But I would say that the discussion thus far within AURA, and this has been a very active discussion, is that on balance there are probably more disadvantages than advantages. And I wouldn't say that there is a naturally occurring strong support for this idea, partly because of the fact that the advantages of conducting astronomical observations in low Earth orbit and deep space have been proven conclusively wildly beyond what I think the original expectations would be. And increasingly, the advantages of the Earth-sun Lagrangian points are emerging as also very highly desirable, as is evidenced by our planning for the James Webb space telescope. So we are looking at this as our main route towards achieving this part of the vision which is encompassed by the “beyond” part of that statement.

And so what investments do we think might be necessary, and how do they relate to the other parts of the vision? A major opportunity is offered by this new vision for the development of a robust and capable robotics program that can construct and service satellites in low Earth orbit and deep space. Obviously a part of this vision that the President articulated did involve moving humans beyond low Earth orbit, and I think everybody credits that as a very important thing to hold in mind. Science will probably remain in deep space and low Earth orbit, so this is a special consideration you should have. It doesn't appear to me, but perhaps it bears further scrutiny, as to whether this in-space robotics program is a major feature of the current plan. But we all know this plan will evolve, and it could be a major feature of the vision. This could have strong synergies with what the obvious robotics needs are for surface rovers. In fact, there is a strong connection between this concept and the current problem that AURA is very much engaged in, and that is the problem of servicing the Hubble Space Telescope, and we are already beginning to see, through NASA studies, that robotic servicing that can even go to the point of replacing instruments is something that certainly should be pursued. If you look at the studies that are emerging so far, this investment is not small. It is large. But clearly this would be made more valuable if placed in this larger context and this were the beginning of an investment in space robotics, space robotics capability, that has, frankly, long been needed.

The National Academy, as you know, will be conducting a deep and rich study of HSD servicing, and surely this will receive a great deal of attention by them. Finally, I would address a matter if I were to single out one source of discomfort in the science community, it is probably this, and that is that the plan or the vision that has been articulated thus far is something that they would very much need to be involved in in terms of the planning.

The space science community has a very well-developed approach towards strategic planning, and I think this could be a great benefit to implementing this vision. So, I would say there must be consideration of a better way to engage the science community in this planning process and, again, I think this report issues and opportunities made the case that the interaction and creative tension between NASA and the science community has been a very major factor in the success of the space science program so far. So, again, this should be part of the planning process. I will close with that and answer any questions.

Pete Aldridge

Thank you very much. Dr. Spergel?

David Spergel

Could I have the first slide, please? I would like to thank the committee for the opportunity to talk to you about the implications of the President's initiative for astrophysics. The President's initiative not only provides direction for the manned space program and for planetary exploration, but also reinforces NASA's ongoing program to search for life in planets beyond our solar system. The search for extra-solar planets is a quest that excites both the general public and broad scientific community, and it will be an important part of our scientific legacy for future generations.

NASA has already embarked on a long-term program of detecting earthlike planets, characterizing their atmospheres, and searching for signs of extra-solar life. This long-term program will also yield other important astronomical results, as these telescopes are used to study the formation of planets and stars in our own galaxy, as well as look back in time to study the first stars, galaxies, and quasars. Missions now under construction should yield results that I think will stir the public and reinforce support for NASA's program of space exploration.

Sometime in the next decade we will read a headline that says, "We have discovered a planet like Earth around a nearby star." We have a series of missions now under way—Kepler, Simm, among others—that have the capability of detecting these planets if they exist around nearby stars and, from what we know about Jupiter-size planets, they're going to be there. What's, I think, even more exciting, as we look forward to the future—could I have the next slide, please?—is we will have the opportunity not just to detect the planets but to characterize them.

There has been remarkable progress in the laboratory in the last couple of years in the ability to develop the technologies needed to detect earthlike planets. And guided by the new vision and enabled by the rapid advances in technology, NASA's recently decided to take the next big step, to search for life beyond the solar system.

NASA has announced plans to build a pair of telescopes—Terrestrial Planet Finder—that will image planets around nearby stars and characterize their surface temperatures. The first of these telescopes, called TPF-C, is a large optical telescope, four by six meters, that uses a coronagraph to block the light of a star so that it can image planets around that nearby star. The second

mission, called TPF-I, will be a constellation of satellites operating in the infrared and able to cancel the bright light of the stars through interference. TPF-I will be carried out in collaboration with our partners in ESA. The combination of these telescopes will be particularly powerful in characterizing the properties of these extra-solar planets.

TPF-C will detect the starlight directly scattered off the surface of the planet and off of clouds in the atmosphere. TPF-I will detect the heat radiated from the planet's surface. The combination of these two missions may well produce the major scientific discovery of the following decade: the detection of an Earth-size planet around a nearby star with oxygen atmosphere, a water ocean and teeming with life.

For if a nearby planet has oxygen or surface water, these missions will be able to detect it. These telescopes can also yield a host of important astronomical discoveries. TPF-C will have 36 times the sensitivity of the Hubble telescope and three times its angular resolving power. With a small investment of additional instrumentation, it will be able to make important contributions to cosmology, extra-galactic, and galactic astronomy. Could I have the next slide, please?

I think [that?] is a participant in the TPF program. I think it's an interesting model to think about in how to rapidly develop an ambitious technical program. Rather than begin with a point design, what NASA and JPL did is award four contracts to industry-led teams consisting of engineers and scientists from industry, academia, and at NASA centers. I was part of the Ball team. We developed 60 different possibilities—really wide-ranging set of initial ideas—we then presented them, focused in on the eight most interesting ideas. Each team developed their own version.

A lot of novel approaches came out of this—the whole idea of building the coronagraph was not part of NASA's initial plan; this was not how they were going to do it. But this new idea emerged, technology advanced quickly, and as a result we are going to get to where we want to go: the ability to detect earthlike planets much faster and, I think, much cheaper because we were flexible.

We had defined things by asking, "What are the goals are?" and then working together with the science community and industry and NASA and finding the best way to go. Where do we go—could I have the next slide?—where do we go next in the search for life beyond Earth's solar system? Many of us envision a Life Finder mission capable of directly detecting the signs of life itself on extra-solar planets; and a terrestrial planet imager directly able to image continents and oceans on these distant planets. While these futuristic missions are still decades away, they will require our investment in developing several technologies now in their infancy: ultra-lightweight optics, precision formation flying, and a new generation of sensitive detectors. These new technologies will also enable TPF-I and other missions planned for the near term. In the recent past, Code R technology guided NASA's investments in space technology. Working with Code S, Code R had developed a roadmap for investing in these key technologies. With the establishment of Code T, the exploration code, this program has lost much of its initiative and some of its funding.

My colleagues working on developing a number of these key technologies, like lightweight optics and constellation satellite flying, tell me that their funding has been reduced as they feel the need to focus on the Moon program. But these long-term programs are an essential part of the “and beyond,” and if we want to get there, we have to be careful not to eat our seed corn and to continue the investments in the long-term technology needed for the exploration initiative.

And finally, to echo comments of my colleagues, astronomy of course is much more than just the search for extra-solar planets.

Over the past four decades, NASA has made major discoveries that not only deepened our understanding of the universe but stirred our imagination. Among the most notable are the discovery of black holes, small and large, the realization that the dark matter is ubiquitous, composing not only the dominant component of our galaxy, but of all galaxies and galaxy clusters, convincing evidence that our universe is accelerating, and the detection of the echoes of the Big Bang and cosmic microwave background. These discoveries are only possible in the unique environment of space. One of the negative impacts of the Moon Mars initiative has been the delays in the Beyond Einstein program. The Con-X [Constellation X-ray] mission, LISA [Laser Interferometer Space Antenna, a space-based gravitational wave detector], these early NASA experiments have already shown that we only know what makes up 4 percent of the mass of the universe. We don't know what 96 percent of the stuff is. And one of the great forefront problems in science and certainly in physics is figuring this out. And if we are to maintain our leadership—and I know I was really shocked to see the numbers in the *New York Times* yesterday showing the decline in our leadership in physics—we are going to have to stay at the cutting edge of cosmology, which is one of the most exciting and vibrant areas of physics. As a director of our graduate program, I can tell you that when I look at our applications both in the U.S. and abroad, this is the area that attracts a lot of the best physics students. When we look at our undergraduates, the questions—“What are black holes?” “How did the Big Bang start?” “How old is the universe?”—these are questions that will excite and attract the best students to science.

And I think it's important to maintain the diverse program that includes that. You know, I was particularly disappointed by the cuts in the Explorer program, which I view as one of NASA's most successful and effective programs, the model of efficiency and high science return for the dollar. I was part of NASA's Wilkinson microwave [?] anisotropy probe, which imaged the leftover heat from the Big Bang.

Our discoveries yielded measurements of the age of the universe and its composition, and *Discovery* magazine last year picked the—mentioned—it noted the *Columbia* disaster as the number-one science story of the year but picked us as number two, and *Science* magazine hailed our results as science result of the year.

The full cost of this high-profile mission was less than 1 percent of NASA's budget for one year. And despite these successes, the Explorer program has just been cut, and we have eliminated a future mission like that.

To conclude, the new exploration initiative provides important support and direction for the search for life beyond the solar system. NASA has already taken important steps towards realizing this vision.

I think that this search for planets beyond our solar system, the search for life on these planets, will be one of the jewels of the exploration initiative, yet to fully realize the promise of this initiative, we are going to need to continue to make long-term investments and not make the mistake of cutting funding for these long-term needs to get to our short-term goals quickly. I think we also need to support the broad space science program. It has been one of the jewels in NASA's crown and something that I think will be important to our ongoing scientific leadership. Thank you.

Pete Aldridge

Thank you very much. Questions? Yeah, Neil?

Neil Tyson

Thank you for those testimonies. I have a question. Two of you mentioned directly this interplay between science and technology, or science and the frontier of engineering, and that's something that of course will be extremely important as we go forward with an ambitious vision. And I'm just wondering how we actually do that in practice. Because, David, what you described was unusual, although we'd like to believe it is something that can happen routinely.

So might you imagine—let me just invent this off the top of my head—that while we do have these decadal surveys that prioritize science given the needs of the scientific community as well as some projection of what is possible technologically, should the vision have sort of a technology report every five years, laying down where it thinks the technology is going to go, so that the scientific community can see that and try to surf that into the future in ways that are most effective? And, Dave, let me just put that to you. Might you recommend that or some other model?

David Spergel

I think you want a model—there's a very healthy—knowing what is possible helps drive the questions, and the scientific questions help drive the technology. I think you want to have that interplay take place actually not just on kind of a five-year basis but constantly.

There are mechanisms, among the mechanisms that work for this at the NASA level are things like these advisory councils, and I hope that the exploration initiative will have an ongoing fact advisory council that will involve both scientists and engineers, people that information is constantly exchanged.

And I think it's also very good to encourage, in the way the missions are constructed and the visions are developed, participation from the many different communities that can contribute. I

mean, to bring to test situations where you have teams together that bring together people from industry teams, academia, the NASA centers. I think that kind of is a very fertile environment. And good ideas come out of that. And I think one wants to be careful, especially in things that are long-term like this, to avoid a really top-down vision, and that allows—you give the opportunity ideas to bubble up as technology advances and ideas emerge.

Pete Aldridge

Laurie?

Laurie Leshin

Thanks. I add my thanks to you all for being here. You represent a community that has just made spectacular discoveries and has changed really our view of ourselves and how we fit into this vast universe that we live in. And thanks also for the positive outlook generally that you all gave. I appreciate that. And for talking a bit about how your work engages students and the public.

I want to ask a little bit more about the science planning process and about where you think we go from here. The President has articulated a vision for NASA which I think most of us agree that it probably needed—and the nation, actually, exploring space. Meanwhile, we have pretty organized communities of scientists who have been thinking a lot about science goals. And I'm wondering if you can talk a little bit about how broad that community process is, what kind of community we are talking about here, but also about are you hearing inklings of “Hey, let's get back together and start looking again at priorities to get ourselves aligned with this vision” or “How can we contribute to making this happen, how can we take advantage of the great capabilities that are going to be enabled by exploring space in this new way that we are about to embark on?”

Can you talk a bit about how the science planning process works and where it's going to go from here in your view, or where it should go?

William Smith

OK, Katie pointed at me, so I do what she tells me.

Well, I have been a part of the NASA strategic planning process, and it is, really, a very, very important and far-reaching exercise. I believe that NASA attempts to involve the broadest segments of the community. And these issues are debated in depth over a long period of time.

It is a well-developed, well-considered process. It wasn't always in place, but it has been in place long enough for us to understand that this is a very successful way of taking what are very disparate priorities and putting these together in a rational way. And so, the process is actually in place.

I think that what has happened is that the proposal and this new vision is in some sense out of sync with that, because there was a plan, there was a science strategy in place for NASA and, as my colleagues have referenced, this, you know, you look at some of the impacts of the vision and it looks like there was some collateral damage. Now, I do not think that it can't be recovered.

I think the thing that must be recovered, rather than to go and look at specific elements of this Explorer program or Beyond Einstein, I think the thing that must be recovered is this planning process.

I believe the community needs to—I mean, obviously, this is a community that has always been bounded by the budget. We have always been bounded by political realities. So, you know, we know how to do this. And I do think that it can be successful. But we need to go another cycle. I mean, people need to understand if this is real enough, how this can factor into our planning. I think there is a question as to how these technologies might play out. What can we look to as, you know, future ways to do astronomy, and you simply have to give the process a chance to be successful.

Pete Aldridge

Maria.

Maria Zuber

Yes. Thanks, all three of you, for your testimony. It was really enlightening.

And I have a question for, actually based on Professor Pilachowski's commentary that I think I really resonate with that had to do with engaging skeptical young people who might get involved in this.

And maybe you can clarify me if I misinterpreted your words, but you were saying these people don't, you know, they are very worried about social problems and they don't understand the connection between science and what the value is to them and to society in general.

The first thing I would make a note of is, hey, they are taking your class, so there's, you know, there's something there, you know, to reach out to and to touch, OK? And an opportunity there. But the second part of it is you mentioned that NASA needs to articulate what this is, OK? Now, when people say these sorts of things in my class, they get hauled into my office and they don't leave until they are enlightened, OK?

And so I think that the issue here is not to say that this is NASA's space program. This is your space program and this is my space program and that all of us have a role to play in this.

And it shouldn't just be NASA saying what the value is. It should be you people and all your scientific societies who are providing, you know, to this common goal with NASA and the scientific community. Because if you just let NASA to its own devices, you know, you are not going to get where you want to be. You want to be a part of this. So—

Catherine Pilachowski

That's absolutely correct. It is easy for us to excite them about the ideas, about the exploration of the universe, about black holes and dark matter, dark energy.

But the questions that come up in these students' minds, they acknowledge those are important visions. They acknowledge the value of the intellectual activity. But what they want to see is the connection to the lives of people on this planet. They want to be able to understand how these investments will help make the world a better place. They want to understand how it impacts the future of humankind in a dollars-and-cents way. And the vision to them is nice, they appreciate it, they enjoy it, they want to see it happen. But they don't want to pay for it. What they want—they want some concrete reaction. And I think that transcends the astronomical community. I think that transcends what we cover in a basic astronomy class. I think it's a broad societal issue that we need to help the public see the economic value of where we are headed. We need to help them see the social value of where we are headed. We need to see, help them see how it's directly relevant to their lives or their children's lives and what changes this will make in society.

Because they are very broad issues, and astronomers certainly have a captive audience. They take our classes because they have to, they have to take science. But at the same time we can get them there. A huge fraction of undergraduates take astronomy. There are hundreds of thousands of students every year who come into astronomy classes. This is a good vehicle for reaching young adults, particularly young adults at universities and colleges, those who are future leaders of our society. And we can play a role, but I do think it transcends just the astronomy. It really needs a broader message.

Pete Aldridge

Bob?

Robert Walker

Thank you very much. I've done three of these presidential commissions in the last three years, and I have become increasingly frustrated by the stovepipes that we have stuffed ourselves into in terms of government programs.

And my question is directed at that. What you described to us today are extremely important parts of science that this country does, particularly the contributions to the physics community. And I've had some experience with just the kind of basic science that you are talking about. I spent 20 years helping Gravity Probe B survive near-death experiences. And, you know, and this is something we should be doing. But we've got a basic science agency in this country; it's called the National Science Foundation, where the budgets are expanding significantly. Why do we assume that NASA's budget is the only place where we can do a lot of this good work? Why don't we assume that as a part of the expanding role that we think the National Science

Foundation should play in basic science that a lot of the kind of things that you want to do that I think are extremely valuable to the nation can't get done there?

David Spergel

Let me put on my hat as a cosmologist doing experiments looking at the microwave background. So what do we do? There are things where space is the best environment, things like these: making maps of the whole sky; then we turn to NASA, because NASA that has the expertise to put things in space, and it's NASA that we rely on for when space provides a unique environment for doing these explorations. On the other hand, we are going to build an experiment in Chile that will look at the same sky, but now at much higher angular resolution. Where we don't care—the fact that the atmosphere's effects are important on large scales matter less. So we can do everything we need from the ground. So there we go to NSF and rely on their support. DoE is interested in issues like dark energy, so they provide support for some of the research there. But it's the way NSF's mission has been defined is that in such a way that when things can be done from space or must be done—there are things that must be done from space, and it is that part of the science that has become NASA's.

Robert Walker

Yeah, and it—and I guess that is the lack of horizontal integration that I'm concerned about. There is no reason why that artificial wall has to be there. There is no reason why NSF couldn't be funding the experiments and you still take advantage of the NASA expertise or the NASA presence in space in order to do that. I mean, these are artificial kinds of walls that we have built over a period of years that in most cases, given the nature of science, no longer make any sense.

And I guess my plea is to your communities, is to maybe help us break down some of those walls so that basic science can be done ubiquitously within the government in a number of areas rather than simply relying upon NASA budgets, which in this case there are some advantage to having the NASA budget a little more focused to get us some little bit better outcomes.

Thank you.

William Smith

If I could just follow that, I share your frustration. A lot of us in the community do, over this stovepipe syndrome. And there has been a lot of attention focused on trying to look, you know, horizontally how you integrate the NASA and NSF astronomy programs. It is not easy to do.

I believe there is a first step that has been put in place with the creation of an advisory committee, and I know everybody says, "Oh, another advisory committee." But I think this one is actually very important. It merges the advisory apparatus of both the NSF and NASA to look at this very issue. So I think, you know, people are beginning to realize that the stovepipe approach really doesn't serve science very well and indeed it does need to be broken down.

Robert Walker

You and I may need to get back to talk to our old colleagues at the Science Committee a little.

Catherine Pilachowski

Let me add to that as well, since I serve on this advisory committee, that I have been really extraordinarily pleased to see the engagement of both NASA and the National Science Foundation and in fact the Department of Energy to coming to the table. What we do is to look at specific scientific questions, directions that we need to follow, and then look to see at which agency where the best contributions can come. In some—in many of the programs, both NASA and NSF are involved, and they are both funding aspects in areas where they do the best work.

And so, it has been really an exciting process to watch those interagency collaborations develop. There's also just been a report issued by the Office of Budget and Management outlining a process, a more detailed process, for that participation in all agencies in planning these large-scale programs. I think we are seeing a lot of movement in that direction and I'm very pleased to see it.

Pete Aldridge

Thank you very much. We have run out of time again. One question that hit me, and, Dr. Spergel, you may be the one to respond to this. You made a comment in one of your slides about the “We will be able to detect an earthlike planet by the year 2004 to 2014.” That would be something that would excite the American people, I think.

Why wouldn't we make it a goal to say, “We want to be able to detect an earthlike planet by” much like the President has had in his vision, but put a date then so it doesn't just happen by circumstance, it happens by design that we have a program in place by, and I will just pick, by the year 2010 it would be desirable to be able to detect an earthlike planet around an ?

David Spergel

You know, I think that is a realistic goal. It's a—we will be capable of detecting one. The danger in science, of course, is there's always surprises; right now we see planets like Jupiter, around about a 10th of all stars. We can get to probably 150 stars around us. So, I would, you know, I'd put a bet on it. But because of the process of discovery—

Pete Aldridge

OK. I will change my goal. I want to have the capability by the year 2010 to be able to detect an earthlike planet around a nearby star.

David Spergel

I think you will. I think that's a real—that is already in process. If the process continues and the vision continues that has been developed through these advisory councils—

Pete Aldridge

But I'm worried that if we don't put such a date—OK, well, let's slip this to 2012, or let's slip this to—because we have this other incentive in place.

David Spergel

I think it would be very helpful, because I think without that it does slip.

Neil Tyson

Mr. Chairman, I would add that that question, that commandment, "Let us be able to detect one by that date," has the interesting—if that fails that is also interesting science. Because if you can detect an earthlike planet and you do not, that tells you something else about the formation of solar systems.

Pete Aldridge

So you agree with me.

Neil Tyson

I'm agreeing. I'm agreeing. I'm violently agreeing with you.

Pete Aldridge

Again I would like to thank the panelists. It has been very interesting and I appreciate your comments and thank you for coming. Thank you.

Unfortunately we are running somewhat behind schedule but we will take a very short break, say 10 minutes, and we will reconvene after the break. Thank you.

Prosperity and competitiveness is one of the four major themes that we've been addressing. And we are pleased today to have three individuals who will shed some light on how space exploration can contribute to national prosperity and what specific models might be used to stimulate private investment.

First, John Higginbotham is the founder, chairman, and CEO of SpaceVest. He was formerly co-founder, director, and senior vice president of International Technology Underwriters (Intec), a

space and telecommunications insurance underwriting management company, and before that was project manager for Hewlett Packard company's global entry into the microcomputer industry in the early 1980s. Mr. Higginbotham is also the current chairman of the Space Foundation.

Joel Greenberg is president of Princeton Synergetics, with 50 years' experience in a broad range of financial disciplines, including new business planning, financial and cost analysis, market forecasting, systems analysis and technology transfer and commercialization. What else did you do? That is pretty broad. Mr. Greenberg performed financial analysis for a NASA "alternative access to Space Station" contractor as well as regulatory impact analyses relating to space launch and reentry operations. He is the author of numerous publications, including "Economic Principles Applied to Space Industry Decisions."

Myles Walton is a researcher at Morgan Stanley who covers the aerospace and defense sector. He holds a Ph.D. in aerospace engineering from MIT, where he was a researcher in the Lean Aerospace initiative, a consortium of industry, government, and academia aimed at improving the health of the aerospace industry. He is co-author of *Lean Enterprise Value: Insights From the MIT Lean Aerospace Initiatives*.

We will welcome our panel, and I guess, Joel, or John, are you first?

John Higginbotham

First of all, let me thank you, Mr. Chairman and Commissioners, for this opportunity.

I wish to first qualify that the statements that I will make are my own and not necessarily the organizations with which I'm affiliated, unless of course you find them useful, in which case they will want full credit and attribution on a going-forward basis with all right, title, and interest thereto.

I thought first we would start—if I can have the first slide, please—I have supplied for your benefit some notations to these PowerPoint slides which you can read on your own. I thought for today's purpose we could just quickly go through them. I thought it useful to first lay a context of to what in our vernacular we believe this industry to be.

The space industry itself, of course, includes not only the traditional public-sector activities but has built a robust commercial application and technology platform presence in the American economy. There have been many studies done over the last few years that suggest that this industry is well north of \$100 billion a year if you include the commercial side that is roughly half of that number. That has spawned very successful undertakings in areas like satellite broadcasting, telecommunications, information technologies, and many other sectors.

So, I would suggest as you have your deliberations, it would be useful to reflect on the breadth and nature of the industry. I would also point out that, of course, the technologies that are developed historically in a space program and that are clearly forecasted to be developed in this initiative represent potentially very exciting technologies. And if we look historically at what

this program has produced, there's been any number of studies about the value of spinoffs—some suggest in excess of \$1.5 trillion to the American economy.

I would submit to you that on any measure the economic benefits associated with this initiative more than justify the public expenditure that is being discussed to carry this off. And I think there's a robust amount of data that can support that.

That having been said—if we go to the next slide, please—it is important to crystallize the nature of these benefits on a going-forward basis and be able to communicate them clearly to not only the general public but the marketplace as well. This—that communication has been difficult in the past. The stovepipe nature, Commissioner Walker, that you were referencing earlier today, we see that phenomenon occur in the understanding and development of the statistics associated with this industry. So, if you look at the ability to communicate what this industry really means to the average person or the marketplace, we have been somewhat hampered by the lack of a comprehensive perspective of the industry.

Even in our own business, many institutional market investors out there that are not familiar with the industry still perceive what we do in a very narrow context, not realizing that we are impacting essentially every economic sector from an investment perspective.

So, I would suggest one task that be undertaken is to commission a comprehensive model, perhaps under the sponsorship of the Department of Commerce, to give it some focus, that would pull comprehensively and cooperatively among all of the various agencies, utilizing the capabilities of some leading research organizations out there, like Space Foundation, some of the Beltway consultants, what have you, with an objective of trying to get a common perspective on what the real value and real benefits of this undertaking could mean for the American public. From that, we could develop very targeted messages, whether it's to the general public, the capital markets, wherever a message may need to be conveyed that is backed up if you will by a very clear and demonstrable understanding in a lexicon that we all agree we can use for this purpose.

I can't tell you enough how important it is for our purposes and for the general public to have a clear understanding of the breadth of this industry and be able to communicate it clearly. When I say, "Communicate it clearly," I'm saying use the media houses that are out there that are expert in developing communications in a more robust way than we've got. Next slide, please.

In these messages, we need to address some misperceptions and miscommunications. We hear a lot of discussion occur in the public sector and the media that it's essentially government programs and launch vehicles is what this industry is about. We—all of us in this room sitting here—know that is not the case, and we need to be able to communicate much better the real benefits that this is delivering today, as we speak, to every person in this room and every person on this planet. We're just not doing that effectively, and for that reason, people, though they like space, they haven't found the compelling immediacy of getting behind these kinds of initiatives.

That's not their fault, that's our fault in being unable to communicate to them the very important nature and pervasive nature of the capability of this industry in their lives every day. We need to

do a better job of that. That will spill over to the capital markets. Even within the “initiated community,” those of us that have been in this industry our whole lives, there’s a perception the capital markets have been somewhat stand-offish from this industry. Nothing could be further from the truth. And the reason is, let’s look back and see, you know, the funding of the LEO communications ventures—billions of dollars, with disastrous results. There’s no government bailout there. So this industry is willing to take a risk. Flip side is, the industry has underwritten, you know, very successful undertakings, like the broadcast satellite entrants, a number of the remote sensing players, GIS. So you have decades of investment that has gone into this industry from the private capital markets.

On the insurance side, the underpinnings of the capital markets that allows the debt and equity houses to risk this type of hard-earned capital has been there for least two decades. And we are talking literally billions of dollars per year. So a perception that the capital markets are not or have not been investing in this industry is just false—even on the venture side.

We have the privilege of being able to bring focus to the industry and SpaceVest’s second fund, which is a vintage year 99 fund, we have had just under 200 co-investors of other venture capital groups, household names, names that you read about every day in the newspapers, that have co-invested in space-related undertakings with us. And a number of them are even now on their own initiative starting to get involved and really starting to track some of the companies and technologies. So you have a groundswell of capability that has emerged. Now, these investors don’t invest in stunts or projects. They will invest in businesses.

So I think as you look forward, we need to discuss a little bit about “What does it take to create the framework for these investors to invest in businesses in a sustainable way?” Next slide, please.

I’ll take a little bit of liberty here and go beyond perceived expertise, having [laughter] dealt with this industry in many different venues over the last almost 40 years, believe it or not. It seems to me that in order to have a sustainable undertaking, there really needs to be some hard decisions made here. And this is not with respect to any one agency. It’s very easy to look upon just one civilian agency. What we are really talking here is a national undertaking, where we need to take a hard look at the assets and agencies that are all involved in the space industry, and there are many of them, as you know, and really think through the roles and responsibilities, making some hard decisions as to how that will—how that’s going to happen. I was very encouraged by some of the comments I heard earlier this morning that this Commission is looking at that issue.

And I think those of us, you know, you go off public air in our afternoon conversations and, you know, during break, you hear this almost unanimously from the leaders in the industry that a real re-look of how we’ve organized and how we need to reorganize and redefine is necessary to have some confidence that we can pull this off.

I think there is a cultural issue here that we need to examine for this industry. The industry has done a very good job of eating its young. It’s done a very good job of avoiding innovation, in many fronts; it’s done a very good job of, shall we say, keeping things in a somewhat provincial environment. And I think if we really want to embrace the innovation and entrepreneurial spirit

that drives our economy in every other sector, we need to kind of reflect on our culture in this industry, and I don't think that's just a government issue, I think it's an industry issue. Really think more out of the box, less "invented here" kind of arrogance, and, frankly, look into new areas of skill centers that can be brought into this equation.

I was encouraged to hear we have, you know, a perspective from the Army on a traditionally non-Army environment. That's the right approach to start to bring in new ideas, new leadership, new thinking. Integrate that, prioritize the outcome in a comprehensive and collaborative way, and we might just have a chance of rebuilding some confidence, not only in the private capital markets, but the general public, as well.

Looking to the next slide, you know, how do we execute this? We've got to find and motivate the leadership. We spend our lives in the venture capital world, and 90 percentage of our time trying to think through the management talent, the skill sets that we need to execute an undertaking. That know-how is out there. This industry is in competition with that to get that know-how and to get that leadership. We need to start thinking competitively, vis-à-vis the biotech industry or the semiconductor industry or non-U.S. undertakings and really change the game where we are focused on workforce development, we're focused on building the kind of incentives that we heard about this morning to bring the large institutional participation into it, even from the nontraditional players. Attract the innovators and not just attract them, but empower them.

I don't know how many small companies I have seen over the last 25 years have blunted their pick on this process trying bring some innovation into the system just to be dispelled and turned away. Lots of promises of ultimate incorporation and ultimately disappointed. And there's been literally dozens of examples in every sector of this industry, whether it's launch systems, small satellites, new types of programs.

We need to find a way to integrate and empower and protect these innovators. And lastly, I think it's critically important to integrate the nontraditional skill centers. This should be integrated at a programmatic level, not an ad hoc level.

I don't know how many times you will get some kind of program or command stood up, and then, after it's stood up and all the planning's done, "Oh, by the way, we should go talk to somebody in the financial industry or academia." By then it's too late. And, you know, you have set a course and objectives and organizational structure that they cannot change easily at that point to integrate new thinking. So this nontraditional skill center needs to be brought in at the very first step. Next chart, please.

Fostering use of commercial capabilities. This sound likes an easy statement. One that we would all buy into. To execute that takes some hard decisions. It means really looking at core versus non-core functions, spinoff, outsource, privatize the non-core functions. Bring focus back into the equation so that the organizations and agencies that are charged with a mission are focused on that mission and not getting distracted by a lot of ancillary or non-core activity. On the design front, I mean, how many times do we have to reinvent a launch vehicle? I mean, we have done it very efficiently multiple times over the last 40 years. Let's do some performance

tradeoffs, buy commercially, for the noncritical items. Clearly for human flight safety, you have to keep tight controls and requirements. But basically outside of that, you can relax some of the performance requirements, take advantage of commercial capabilities, and speed up the process. What will that do? It will create a market, it will reduce barriers for innovation, and it will allow cost to be more commercially based as opposed to non-commercially based.

Final statement there is develop only that which you can't sell or borrow—you can't buy, sell, or borrow. That's the fundamental launch work. Last chart, please.

Creating and capturing the technology value: We have spent a lot of time and money in this country over the last 20 or 30 years trying to figure out the technology transfer process. It is not a technology transfer process. It's a business-creation process. At the end of the day, the skill sets that are expert in creating businesses from technology platforms are not resident in agencies that are focused on deep space. Their mission is space. It's not business.

Somehow we need to integrate at the same level—and let me say this: The skill sets necessary to take a technology, turn it into a product, take a product and figure out how to sell it to a customer, create the organizations and management teams that can do all that very efficiently and ultimately profitably is just as hard as going to the Moon or Mars. It's a very difficult process. The skill sets required are very different than one finds in the technology or infrastructure development world. We need to access those nontraditional skill centers much more efficiently than we have.

It's essentially been an ad hoc process to date. Integrate it right up front in a programmatic way. If we can do that, we can use business capabilities. Licensing, royalties are a part of business every day. Property rights, assets valuations occur every day in business. Profits, at the end of the day, if they come from this, will do three very interesting things: It will give the resources to train people, build products, and sustain the effort. So, if there's any fundamental message you can take from this, it's that if we can integrate the business development function, programmatically, into this equation, and that is, by definition, outside these agencies, then we have a reasonable chance of capturing these values.

Last point: on a personal note, I feel pretty strongly about this. I watched Dad contribute to the first paragraph and I watch my children thinking about the second paragraph. I feel very strongly that this industry has been a major contributor to the technology underpinning of this country and ultimately its security. This initiative has the opportunity to recapture the imaginations of ourselves and our children. Let's do it right this time. Thank you.

Pete Aldridge

John, thanks. Joel?

Joel Greenberg

Thank you for the opportunity of participating. When one is trying to retire, one normally—

Pete Aldridge

I know this problem.

Joel Greenberg

Has many avenues of getting his voice heard. So I look forward to opportunities like this.

Can I have the next chart, please? Next chart, please. Thank you. First, I would like to say a little bit about Princeton Synergetics, since most people don't know what Princeton Synergetics is, what we do. PSI is a policy research and consulting firm with a very broad client base, some of which are indicated on this chart. We have supported a very wide range of government organizations. We have supported a large range, wide range of aerospace firms and then we have also supported a wide range of non-aerospace firms. PSI has not been active for the past two years, as I said, since I am trying, rather unsuccessfully, though, to retire. Before I go any—well, next chart, please.

This was covered already by our chairman today. But I do have to mention one thing: that I am a member of the AIAA [American Institute of Aeronautics and Astronautics] and I'm a member of the Public Policy Committee, I'm a member of the International Academy of Astronautics and I have co-chaired for, oh, probably nearly two decades until recently the Committee on Economics and Space Operations. And since I am involved with a number of these, I must say that the views I am going to express today are my own and in no way necessarily represent anything that the organizations I am associated with have to say or think. Next chart, please.

I am going—I have just three charts, which cover the details of what I have to say. The first has to do with cost and program planning considerations. The first thing that we should realize is that the Moon Mars mission requires a long-term, multiphase R&D program that continuously buys information as we proceed from phase to phase and adjust our plans accordingly according to the information that we have bought. Now those phases can be annual, or they can be specific, agreed-upon time frames. Annual is nice because that follows the budget cycle. And that, because of the need to utilize new and advanced technology in the Moon Mars mission, planning requires the explicit and quantitative consideration of uncertainty and risk.

Now, the consideration of uncertainty and risk means that we have to, right from the start, admit and plan for the fact that we may have failures along the way. Not all of our technology programs may succeed. We have to set guidelines for when to turn off an R&D program, which is really unheard of these days within most organizations.

But with such an operation as the Moon Mars mission, we are likely to go down paths and spend quite a bit of money if we don't act wisely in determining when a particular project is not going to pay off. We also have to realize that program planning has three interrelated degrees of freedom, these being performance, cost, and schedule. Now, all too frequently, we try to set specific goals for each of these three, even though they are very much interrelated. And when there is uncertainty—and uncertainty really does abound in the Moon Mars mission planning,

when there is uncertainty—it is not possible to specify all three. We can specify performance because we know or we think we know what performance we want to go to the Moon or to Mars. But if we set performance, then we really can't set cost and schedule with any degree of certainty.

And if schedule is also fixed, this is a situation where working to a schedule and not allowing a schedule to slip can really lead to an increase in cost, because you may be trying to achieve unattainable goals with respect to both performance and schedule. So that's why I said at the very start of this that one has to continuously go back and look at what information we have bought in each phase of the program and continuously adjust where we are going, and that means performance, cost, and schedule. We should have goals for schedule, but those goals for schedule should not be fixed.

I have seen this too frequently happen in other programs where costs have skyrocketed because we have been working with high technology where the technology has not been totally in hand when we have started the program and the costs have skyrocketed while trying to maintain schedules. Next chart, please.

A couple of words about potential benefits. High on the list, we have all stated this in various different ways. I stated it as a potential benefit is the pride resulting from success. But if we don't plan properly, we may end up with utter frustration due to unavailability of funds or funds that have been siphoned off for other uses. Also remember that the pride of the nation, and particularly the education process and the young hoping to go into science curriculum, pride can also be enhanced by achieving other goals. For example, energy independence. So, yeah, space is important, but we shouldn't forget that there are other things besides space. Now, as far as the benefits, the other benefits, there are job-creation benefits from additional expenditures. And hopefully those expenditures do not cause inflationary pressures. Job creation, however, is short-term. Job creation lasts as long as funding lasts from a government program. Now there are, true, there are spinoffs that may create other industries and other businesses, but I am not focusing on those right now. When NASA spends \$1, that dollar goes to direct labor. It also goes to indirect labor. And it's about a 2-to-1, approximately 2-to-1, impact of a dollar spent by a government agency such as NASA.

The same impact, however, is achieved if that dollar is spent in the area of housing, welfare, or environment. In other words, it's an expenditure by the government that is important in creating jobs and it's not industry, agency specific.

Talk about technology development and spinoffs for a minute. Technology development can lead to spinoffs, and it has long-term productivity impacts on the U.S. economy, and if there are going to be large benefits from a Moon Mars program, it will be in the productivity, the long-term productivity, area. Now the long-term productivity gains, which can be sizable, there have been all sorts of studies conducted over the years, and I will come back to this in a minute, but let me quote some numbers for a minute and then I will explain why you shouldn't believe these numbers. The numbers range anywheres from a 2-to-1 multiplier to like 40-to-1 multiplier.

So there's little agreement as to what the multiplier should be, but it's general agreement that, yes, there is a productivity gain from investing in R&D. Now the important point is investing in R&D. The productivity benefits that we get are only related to the expenditures on R&D. Not operations, not infrastructure. Now R&D may not be a very large part of the expenditures in the Moon Mars mission. So we have to be very, very careful when we try to judge what the productivity gains might be from this program. The technology development and the productivity gains can, as I said, can be lasting and can have significant economic impacts and as a result of the new technologies that are stimulated by the space program. These contribute to the long-term economic growth and increases in the standard of living that are [of] most interest to the health of the economy and to furthering U.S. economic competitiveness. Unfortunately, the numbers that I created, that I stated before, one cannot say what specific multiplier is correct, because there is a very weak linkage between formal R&D programs and the changes in our productivity and the gross national product. In other words, for example, some of the studies that have been done over the years try to trace through NASA patents and the implications of the NASA patents on new businesses and the growth of existing businesses. So there have been surveys that have been conducted which say that, you know, "You've made arrangements to pay licensing fees for this particular patent. What effect has had that on your business?"

And, well there's a product that has resulted from the use of this patent, and our profitability over the years has been such and such, and cash flow has been such and such. It all sounds very, very great. But, was that patent the only thing that was important in the creation of the new product? Were there other patents? Was there other technology that didn't require patents? How does one make the linkage between the patent and the business?

Very, very weak. I have seen, for example, studies from the FAA which indicate the effect of space transportation on the economy. And they trace it all back to the individual launch vehicles. They say this launch vehicle gets such and such a business. But what led to the launch vehicle? It was the ballistic missile program and it was the achievement of miniaturized gyros in the guidance system. So how can you assign what dollar value industry has achieved and relate it back to a specific program? Very, very difficult. As I say, studies have indicated, though, that there is some form of linkage. It's just that we don't understand what that linkage is, and there is some multiplier, and the multiplier is probably greater than two and probably less than 40, but again it's related only to the R&D content of the program. Next chart, please.

In real estate, it's location, location, location. In the space industry, it's transportation, transportation, transportation. And it's got to be low cost. If we are going to expand the space economy, we have to reduce the cost of space transportation.

Now, I have a concern that the—if not conducted properly, the lunar Mars mission will develop advanced transportation, but will it be the transportation that can satisfy the needs of industry—communications industry, even in the future maybe space tourism? But will it be of a form and of low cost that is useful for those other industries? If the transportation part of the program could be oriented to take into account commercial needs and low cost, that would be a significant impact on the commercial development of space.

Another consideration—or another concern—that I have is the impact of the current planning on the Hubble telescope and other kinds of programs like Hubble. I am very concerned about not being able to either extend the life of Hubble, which I think it would be most desirable, or to bring Hubble back in a controlled environment. Remember: in a controlled manner. In order to bring Hubble back in a controlled manner, there has to be the funding for a, another flight. Either a manned flight or an adequate robotic flight to ensure that Hubble can be brought back so that we have a very safe return to the Earth.

I have some concerns about the ISS program, particularly with respect to impact on partners, and presumably you will hear more about that later on. But my concerns have to do with the—by withdrawing from the ISS, what effect will it have on our partners' viewing us as an unreliable partner? Will they be reticent to participate with the U.S. in the proposed long-term Moon Mars activity?

And I think worldwide participation in that program is absolutely essential. Last, but not least, my concern that NASA budgets—oh-oh, before I leave the Space Station, I also have a concern: if the U.S. withdraws from the Space Station, who will have the responsibility for returning ISS to Earth in a safe manner? I participated in an NRC study where I was responsible for looking at the return of the Space Station in a safe manner. And even with the current NASA plans, I believe that there are some concerns about it being returned in a safe manner. But who will have that responsibility? Last but not least, my concern that NASA budgets not be increased unless alternative uses of the funds have been carefully considered. In particular, can funds be used wisely for increasing our energy independence?

For example, developing infrastructure which is necessary to get people to buy alternative-fueled automobiles. Right now, I believe that infrastructure development is significantly lacking. Those basically are my comments, and I would be very happy to answer questions later on.

Pete Aldridge

Thanks, Joel. Myles?

Myles Walton

Good morning. Chairman Aldridge, other members, distinguished members, of the Commission. I want to thank you for this opportunity, which is very unique, to testify before you today. I am both personally excited and professionally intrigued in the President's vision for renewed spirit of space exploration. Today, I will be talking with you from the context of the Morgan Stanley equity analyst covering aerospace and defense companies and not from my space enthusiast hat with a Ph.D. in aerospace engineering. So it may be a little [silver?]. Before I start, consistent with U.S. regulatory disclosures, I have to say that Morgan Stanley has or intends to have investment banking relationships with all the aerospace companies I may mention, and a complete list of disclosure is provided at the end of the testimony.

There are few phrases which make an aerospace analyst's or heart race or hair turn white like the phrase "commercial space." And so when speaking with members of your staff and hearing that they would like me to suggest business models in which commercial space is a viable, exciting business that sources of capital seek out and look to put their money into, I knew I had my work cut out for me.

Investors' mental models of commercial space of the past 10 years have been imprinted with the difficulties of previous commercial space ventures: Iridium, Globalstar, New Skies, Astrolink, Loral Space, Intelsat, Inmarsat, Teledesic, Ellipso, Skybridge, just the ones I can think of off the top of my head. And large space contractors have had their own problems making a business of commercial space. Boeing in 2003 took charges of \$1.6 billion related to their space investments. Putting that in context, in the years 1998–2002, they were reported a total profit of \$1.2 billion, basically reversing their entire previous history. Likewise, Lockheed took charges relating to its space investments in 2002 and 2001 in amounts of \$940 million and \$728 million respectively. So you can see it's not a difficulty isolated to any single contractor. Therefore, a natural response of investors is one of great skepticism when it comes to investing in commercial space ventures.

But for a minute, let's backtrack and describe fundamentally what investors are really looking for. They are largely indifferent to the investment vehicle they ride to make their money, whether it's software or space. At the very basic level, investors are willing to pay for three things: predictability, visibility, and profitability. Commercial space is unfortunately thus far lacking in most of these three traits. Profitability, a company's ability to exploit capital, make a profit, feed it into other ventures and produce more profit fueling growth. Most of the U.S. contractors have commercial space businesses which are actually drains of profits rather than sources. Predictability in returns goes to the level of risk associated with the investment. For example, the cyclicity of aerospace is one thing that can both play against the investor but also play to their advantage if they can time it accordingly. Although we continue to improve the reliability of space travel, its initial stages of a controlled explosion are not for the faint of heart.

Furthermore, business models in space are notoriously hard to predict—i.e., the commercial global telecommunications business and the closely coupled [tie?] commercial launcher business. And finally, three, visibility—something investors are willing to pay for as it lowers their risk and increases the faith they can see in the future of an ongoing business. It allows the investor to have a long-term horizon and investment perspective. They can see progress all along the way.

I don't mean to classify all investors alike. Some are more aggressive, others more risk averse. Some longer horizons, some shorter. Some even invest in things they know have awful returns but are overly infatuated with the product or the industry. Warren Buffet is one example whose infamous attraction to airlines despite his repeated acknowledgement of it as a poor investment. So that's one thing space has going for it: very, very interesting products. But that's not enough for the long term. By and large, for a large commercial endeavor to succeed, three characteristics must be in place: profitability, predictability, and visibility.

So with regard to larger and some smaller contractor commercial space endeavors, we have yet to see truly profitable growth [story?]. One would think with the limitless expanse of potential opportunities, someone would have found a model, but a completely healthy value stream for commercial space has yet to materialize. Instead, what we have is a commercial satellite supplier base that is having trouble staying break-even with five geosat manufacturers competing for maybe 15 potential contracts a year, a commercial launch market with overcapacity and yet not enough readiness and only a few niche, but arguably profitable, operator models that have gained credibility.

So the financial reports are littered with failed commercial space ventures. And so it's not surprising that the capital markets are hesitant to put money into that area, so it's becoming a harder and harder to convince those investors that allocation to this area is a good investment. Not that it's impossible. But it will be a hard sell. So the question is: What elements of the vision for Moon, Mars and beyond can be leveraged from commercial space funding from the capital markets?

Placing purely commercial endeavors on a critical path would appear to me to be a mistake. We could find ourselves with, rather than an Interstate Highway System connecting the U.S., a series of interspersed toll roads connecting the U.S., which clearly wouldn't be as economically viable as we currently have today. I found myself wondering about the market tolerance versus the government tolerance for failure.

For example, would a commercial endeavor have the capital commitment to endure the first 13 failures of Corona only to get to the eventual 14th successful flight? Sometimes only national imperative is enough to push through such odds. It strikes me in this case, it is the case that only a national imperative will be enough. So government should continue to take the lead in both vision and funding. There are a couple of potential emerging business parallels for use of commercial alongside national assets.

One example is space imagery, where providers of supplementing an existing national asset base serving surge capacity and clearly that's the service that has come into high value as of recently because of the ongoing conflicts and meanwhile allows the commercial entity to continue to form its business case while it has not necessarily fully closed upon itself.

Another positive influence is perhaps the X-Prize. It provides a proving ground for concepts in the Darwinian survival of the fittest with a reasonable reward. Yet clearly ten million is not enough for us to get back to the Moon, and it's not even enough to buy you half a trip to the ISS.

So parallel work is going to have to be going on on a national level at space transportation. But the X-Prize in concurrence allows for valuable lessons learned and innovations to take place, a priority before billions are invested by the national government. So in the end, there are certain areas where commercial-driven models just don't make a whole lot of sense, at least not right now, and space is perhaps one of those. In space, I see commercial following the government's lead, not the other way around. Yet there are technologies and processes that can be adopted from the commercial world, but space travel at this moment is very much a public, not a profitable, commodity. That being said, I think you as Commissioners have the responsibility to

recommend the insertion of policy hooks where it opens the door to future potential commercialization of space.

I think the GPS is a good example where they put in and had the foresight to put in a military band and a civilian band, thus allowing the military capability while still allowing the commercial capability to exist.

So, my final words would be, one, look for commercial to help but don't rely on it. Two, leave the door open for commercial to take up the flag in the future, and, three, continue to encourage those emerging space enterprises with both financial and regulatory relief, as they will likely serve as your source of innovation. Thank you.

Pete Aldridge

Thank you very much.

One of the—there are the discussions that we have had in this particular area center around a view that we must get the private sector more involved in this mission if it is to be sustainable over a long period of time. Somehow, the private sector has got to get more deeply involved. And it may require some cultural shift from the government and NASA to say, “I can do it all,” to being “I'll do those things which are inherently governmental,” I think you used, John, the core, and really open the door for non-core things to be done by the private sector. A model that we have been thinking about is something along the lines of what data purchases can we get from the commercial sector and maybe some launch services in things that are now done fairly routine and getting to low Earth orbit.

Maybe some classes that you can do and classes you can't do. But does that model fall into the same thought pattern as maybe you, John, and Myles, have been discussing? Is that—

John Higginbotham

Yes. And I think it's two things. The last two charts, chart that—purchasing, selling, borrowing assets. Buying data, buying commercial launch services, all of these help create a market and start to address some of the issues that Myles was talking about. But I also think, getting back to this core issue, you've really got to rethink what the agency should be doing.

With the greatest respect, I don't understand why a deep space agency runs a cable channel. I don't get it. OK? And I am sure there's a lot of people at NASA right now that are about ready to strangle me. But—the broadcasting function is important, but the operation of some of these “non-core activities,” one wonders if it couldn't be spun off, spun out. The educational fund—

Robert Walker

The camera just switched off [laughter].

John Higginbotham

I know I am going to get a lot of e-mails off of that. The educational function, we have heard innumerable examples of outside organizations that are doing really groundbreaking stuff. Let's find a way to embrace those activities and maybe offload some of these requirements in the new kinds of skill centers.

Technology transfer/business development is the subject of venture capital. And it's a mystery to me why any agency would think about starting an in-house venture capital activity when you've got an incredible skill set already out there and perhaps a better way to interface is to find out how to interface better with that community. I think InQtel is a very good example of how to do that as opposed to standing up a new command inside of an agency that's going to be a venture capitalist. I mean, so it's not just buying products and services. It's really looking at the core missions, spinning out anything that doesn't exactly directly relate to the greatest extent possible.

Pete Aldridge

Myles, do you have a comment?

Myles Walton

I think that what you recommended is completely consistent with what I would view, but again it's not a completely commercial vision, either. The consumer is still the government, it's still a monopsony, so I think that it's certainly a consistent and proven contracting method.

Pete Aldridge

Paul?

Joel Greenberg

Excuse me, can I respond?

Pete Aldridge

Sure, I am sorry.

Pete Aldridge

Address me.

Joel Greenberg

In the buying or using commercial, there are costs. Still going to cost you something. And the only way that cost will be reduced will be if there is an additional market or demand from the commercial side that would be missed if you built it or did it in house. Otherwise, it will be about the same.

Pete Aldridge

Paul?

Paul Spudis

Yes, my question to two of you, Mr. Higginbotham and Mr. Greenberg, brought up the spinoff issue, and it's something I have been interested in for a long time. And you made a very interesting suggestion about perhaps chartering a commission, maybe the Department of Commerce, to actually look at this and get a comprehensive view of spinoff. And yet Mr. Greenberg talked about how difficult it would be to evaluate that, actually link things.

That's the problem I always had is how do you actually connect spinoff with a specific program or with a specific innovation that the government did for space? And yet you suggested that the problem here was communication, that we have not communicated this. But may I,—let me ask you a different question: Is the problem really communication, or is it analysis?

John Higginbotham

Both.

Paul Spudis

But which is greater? I mean, it's one thing to say, "I am having difficulty communicating this to the public." It's another to say, "I have good, solid analysis that I can communicate." And I think maybe the analysis part is actually more difficult than the communications.

John Higginbotham

It is. And let me be clear, I am recommending a study not just on technology spinoffs, but a comprehensive model of the industry, inclusive of technology spinoffs, inclusive of defense multipliers, inclusive of the proven commercial sectors like satellite broadcasting, remote sensing and others. There are equally important and I have innumerable examples of that you've got to know what the message is you want to convey and then convey it very clearly and very professionally. And I would submit that we have done both very badly in this industry.

Joel Greenberg

I don't think the analysis is really the problem. Yeah, analysis, it would be really great to pin down what the specific number is. But is it worth it? What is it going to tell us if it's a factor of three or five, is it going to make any difference?

I think what is important is that you have to have innovators out there who are interested in trying to develop something new. And that comes in two ways. One, it's created by an agency improving the awareness. You got to advertise. You have to say, "I have this, I have this technology, I have that technology."

And then you have to have the innovator at the other end who says, "Gee, that sounds good. I may be able to use that, combined with x, y, and z., and create a new product." I mean, I have gone through that. I play bridge and we used to have a very active bridge game with people with very diverse backgrounds. And we used to, at the end of the bridge game, we used to talk about what's your problem? This is my problem. Tell me about yours. And well, one of the fellows was in the medical profession and he said complete blood count is a real problem. It's a manual operation and very difficult, very unreliable. Well, within a couple of weeks, we got back to play bridge again, people had been thinking about this. And we came up with solutions that drew upon very, very diverse technologies. I mean, one of the fellows in the group was a programmer, knew how to automate microscopes and microscope stages. Another one was doing research for, at the National Institute of Health, doing work on stains that could be used, like fluorescent stains in particular, and I had a business background, and we all came together and we saw that by putting things together properly, diverse technologies, we were able to solve a real major problem. I think you have to have people who think and can think out of the box for developing new businesses. But you have to communicate to them what the technologies are. What's new that they may be able to draw on and solving problems that they perceive?

Pete Aldridge

OK. Bob?

Robert Walker

John, you mentioned prioritizing outcomes. Joel mentioned that we need to get low-cost transportation, and Myles specifically mentioned the X-Prize. And Myles, in your mention of the X-Prize, you said that \$10 million wouldn't get you to low Earth orbit. You are absolutely right. In an opinion of each of you, what if it was a substantial prize?

What if instead of \$10 million it was \$100 million? \$300 million? A billion dollars? Would that—would that generate—the kind of activity that all of you are talking about?

Myles Walton

Well, what I can initially think of is the prize is at the end of the line and you need the capital to get there. So—

Robert Walker

But we heard from the X-Prize people that \$400 million has been invested in winning the \$10 million X-Prize.

Myles Walton

And so the capital is there to some degree. The question is, Will you have a, an effort that has the longevity to endure failure? We haven't had—we have had pencil to paper. We haven't had rocket to liftoff. And I think that encountering failure will be natural and it will be scary, especially for investors.

John Higginbotham

I think you have to separate angel investors and individual high or mega-net worths that have made a fortune in other markets that can afford a tax write-off, from institutional investors, which is the underpinning of the economy of this country. That is, the day-in, day-out check writer for new businesses, new business formation, and all that sort of thing. You are going to always find angel funds, and I don't—that's a wonderful thing. That's where a lot of the inventiveness of the nation comes from.

If you want sustainable institutional investment, you look for the business. I am not saying that these prize programs are bad things. But they, in and of themselves, in my judgment, are not going to attract institutional investors. Now if part two of that equation is, having done or won an X-Prize or similar kind of thing, you have created a vehicle that is then, whose services are then purchased in an ongoing, you know, operational business to supply NASA or other agencies, I will invest in that.

Pete Aldridge

Neil?

Neil Tyson

Yeah, I'll make this quick. John, you painted a rather compelling story and argument for public support for space—activities in space. However, you didn't distinguish specifically between activities near Earth and activities far from Earth.

John Higginbotham

Right.

Neil Tyson

And this vision will specifically want to take us far from Earth, and that's where we are trying to explore what the investment opportunities might be. Most of the cases you cited were kind of obvious. You want to communicate and you would have satellite positions for that and geosynchronous. An so to an investor, that's an easy sell to; to say we want to go to Mars, now, if no one can think of something to make money off of going to Mars to do, I see it as more bleak than the picture you paint.

John Higginbotham

If it's just painted as underwriting an initiative to Moon Mars, you are absolutely correct. That's the whole point that, is that this is one part of a larger industry.

Neil Tyson

No, I'm trying to think who creatively is thinking about, other than tourism, which is fine in and of itself, but the broader marketplace. I am trying to find—it's not as obvious what to do for market perspective, in the Moon Mars and beyond than it is cislunar.

John Higginbotham

Yeah, we are having trouble getting from zero elevation to low Earth orbit right now. OK? So we got to take this in a series of steps. In the near term, in the short term, by doing this initiative it lays the groundwork for potential non-core activities to be outsourced and privatized and put into a profit-making entity, which is creating a market, buying launch services to accomplish some of the unmanned stuff. In the medium term, you've got potentially a really interesting technology bed emerge from this that can lead to value creation. In the long term, which may not be my or the next generation, we will have, if we actually accomplish this mission, looking 40, 50, 60 years out, you are going to see serious exploitation, capitalistically, of Moon Mars and beyond. But it's that kind of horizon.

Pete Aldridge

Joel, real quick.

Joel Greenberg

I don't see worrying about the long-term commercialization. Because if we are successful, 40, 50, 60 years from now, there are going to be so many other things that have happened and so many other new opportunities that will just open up that we can't predict today—why worry about it at this point? But what you can worry about today is the fallout along the way. Can you plan a program, as I said before, which will develop low-cost transportation or other kinds of technologies that can be used immediately in other businesses that are in the short term?

Pete Aldridge

I would like to thank the panel for your testimony and for spending the time with us today. And we appreciate it. Thank you very much.

We are now going to turn to two more members of the international community. We will take just a second to get reestablished. Our first member is Dr. Marc Garneau; he's the president of the Canadian Space Agency. He became the first Canadian astronaut flying aboard Shuttle 41G in October 1984. Since then he's flown on two other Shuttle missions, and we welcome our, we welcome his out-of-this-world perspective and certainly his Earth-based insights.

Dr. Volker Liebig is a program director of the German space program and is also the German delegate to the council of the European Space Agency. He joined the German Space Agency in 1994 following six years in the space industry and holds a doctoral degree in geophysics from the University of Munich. Gentlemen, welcome. And, Dr. Garneau, I guess you are going to be first. Right? Thank you.

Marc Garneau

Thank you Mr. Chairman, Commissioners, ladies and gentlemen. It give me great pleasure to be here today to represent the Canadian government and its space agency at this very important Commission. Additional documentation, I believe, has been provided to support this presentation and help guide your deliberations.

The Canadian space program is a living example of the power of leveraged partnerships. More than 40 years ago, the United States helped launch Canada as a space-faring nation with the deployment of Alouette, a small scientific satellite designed to study the ionosphere. That collaboration, which continues heavily to this day, propelled Canada to design and deploy its own commercial telecommunications and broadcast satellites in the following years.

The legacy of collaboration in space ventures continues today as we celebrate 25 years as a cooperating member of the European Space Agency and we continue to expand our partnerships with a growing number of agencies around the world. The Canadian Space Agency champions the nation's space priorities, such as Earth observation, space science and exploration, satellite communications, and space awareness and learning. Following the 1984 invitation by the President of the United States to participate in the development, assembly, and operation of the

International Space Station, Canada confirmed its intention to join the program and signed the intergovernmental agreement. Canada's contribution to the ISS program is a specialized robotic system that is critical for the assembly and maintenance of ISS. In exchange for its contribution, Canada has rights to conduct research on the station in accordance with a prescribed allocation formula and also has responsibility to maintain its contribution and of course share in the common operating costs. The primary objective Canada is pursuing in the station program is the use of this unique space laboratory for scientific research in a microgravity environment. Other objectives include technological, industrial and regional development goals to enhance our nation's expertise in space automation and robotics.

Canada's participation in the ISS represents a major challenge for our nation—especially given that our overall investment of \$1.4 billion peaked for a number of years to consume fully 50 percent of our annual budget. Our engineers and technicians achieved a whole new level of excellence as they solved the technological challenges of this complex new robotic system in terms of size, power, flexibility, and reliability. Canadian space industry, small in comparison to that of our partners, managed to pull it off, I believe, with flying colors.

Now, Mr. Chairman, I would like to share the Canadian experience as an International Space Station Partner. We believe that Canada has demonstrated its capability to act as a reliable and trusted partner in the most complex international space program ever conceived. We have learned that it is possible for the most advanced space-faring nations to work together even on a program as complex as ISS. More than eight in 10 Canadians are proud of Canada's achievements in space and believe it is important to participate in international space projects such as the ISS.

In response to this support, the CSA is developing a new long-term strategy for our science, technology, and space exploration programs. Future international missions require that we learn from our experiences on the Space Station program. Ideally an umbrella legal framework signed by all of the partners would allow the cooperating agencies to agree and execute implementing arrangements covering a particular mission or group of missions. Any concerted international space exploration program based on a partnership should take into account individual national programs, which may have complementary plans for space exploration. The incorporation of these national efforts into an international space exploration program could provide for a more robust outcome than any one country's efforts.

National political considerations should not hinder programmatic progress any more than absolutely necessary. The International Space Station program is an example of how political considerations can delay program completion by years, reduce public support, and subsequently drive the cost of the program upward. Export-control mechanisms should also be established to facilitate free flow of technical information between partners.

Stable, multilateral planning and approval mechanisms are required to ensure the smooth advancement of program efforts and the success of the long-term objectives of a space exploration program. We congratulate the administration's boldness in setting a new vision for NASA for the human exploration of the solar system. Canada's long-term plan is to continue to

partner with the world's space-faring nations. Space is too complex and too expensive for a country such as Canada to go it alone; we intend to maintain our role as an important and reliable partner with the aim of advancing our knowledge of the universe, of our own planet Earth, and for the exploration by humans of the solar system. Mr. Chairman and Commissioners, in closing, I would like to thank the Commission for inviting the station partners to address you. At this point, it would be my pleasure to respond to questions, but I guess after Dr. Liebig.

Pete Aldridge

Yes.

Volker Liebig

Yeah, thank you very much, Mr. Chairman, Commissioners, ladies and gentlemen. Let me start to thank you for the opportunity to speak to you today, and at the German Space Agency, we appreciate the invitation and the opportunity to testify here.

Space communities all over the world appreciated the attention that was focused upon exploration of space following the speech by President Bush in January. Also in Europe, astronautics can rely on a strong and robust political mandate. Just this weekend when the European Union was extended by 10 new members now to 25 members, representing 450 million people and 1,000 billion approximately of dollars GDP every year, this support will be broader. And Europe is developing some momentum and also new self-confidence, and we believe this is a point in time to take on other new, challenging tasks. The *White Book on Space* of the European Commission, which was published this year, states what are the priorities of Europe in the next years, and it clearly prioritizes application-oriented programs like investment in the Galileo navigation system, like Earth-observing systems for our global monitoring of the environment, but also for security. And new communication system bridging the digital divide in broadband connectivity in Europe and elsewhere.

Germany is the largest net contributor to the European Commission. Certainly we'll support these new priorities, together with ESA in the new initiatives. The German space agency, DLR, which I represent here, has a 40-year history of cooperation with the U.S. This was, for the most part, a success story based upon mutual trust and contractor agreements. Among the highlights of the German-U.S. cooperation in space, I would like to mention two German-sponsored Shuttle missions with the German-built Spacelab, the Jupiter probe *Galileo*, the Compton gamma ray observatory, and the Shuttle radar topography mission. At this time, DLR is operating two Grace satellites for NASA, small satellites doing research in the geopotential field of the Earth. A number of German astronauts have flown on U.S. Space Shuttles. German-U.S. cooperation in space has been highly complementary and yielding results that no individual nation could have produced on its own, at least not without major additional investments.

Germany is among the prime contributors of the total European space program. In particular, Germany provides more than 40 percent to the European share in the International Space Station

and the biggest share in the European space science program. To put Germans' engagement and commitment into ISS into perspective: we spend about 35% of our yearly space-related budgets into the Space Station. Not only are we leading the development of the European Columbus module, we are also hosting the consolidated European astronaut center on our DLR complex in Cologne and we are fostering a strong and very creative ISS user community. Today, the European Columbus module for the ISS stands ready for launching to the ISS at the NASA Kennedy Space Center. The European-built Automatic Transfer Vehicle will be ready hopefully next year to supplement the progress, the Russian progress for cargo delivery to the ISS soon. Ground infrastructure such as the Columbus control sensor close to Munich and various user support centers in Germany and all over Europe are getting ready for the utilization phase of the Space Station. So the public and the research community is really awaiting a meaningful and multidisciplinary utilization of the biggest investment ever into an international research endeavor. As much as one can admire the vision and the courage behind the Moon Mars initiative, to us, ISS is still the first step to get there.

So let's not abandon our goals halfway through. When partner science international governmental agreements on the ISS, they certainly didn't have in mind to operate ISS in a mere mode, meaning to service it just, but to use and progress having a permanent crew of two to three, possibly in a long-duration stay, having virtually no download capability and very limited means to respond to unforeseen events aboard.

Back in 1998, ISS was a great vision intended for an international crew of six, provided with adequate crew rescue capability for six astronauts and a steady exchange of experiments, supported by adequate up- and download capacity. U.S. plans to retire the Shuttle by the year 2010 will raise some questions in this respect. DLR, as well as ESA offered support on ISS crew rescue in the late 90s; under another DLR MOU [memorandum of understanding], DLR was to deliver on a best-effort basis crucial hardware components for the X-38 CRV [crew return vehicle] demonstrator, while NASA was to flight-demonstrate the hardware on a best-effort basis, as well.

Unfortunately, however, the X-38 hardware, the X-38 project was terminated in the U.S. at a time when DLR was just providing the last hardware delivery. This was the first and only time in the history of DLR NASA cooperation on the MOU was unilaterally terminated. Having clearly expressed that ISS is a priority for the German and the European manned space program and that we are relying on our partners to honor existing agreements, I would like to comment on Moon and Mars.

I am convinced that man will eventually go to Mars. There's nothing that can stop the strive for exploration curiosity of mankind. Germany has a proud history of unmanned planetary research. Many achievements have been reached in cooperation with our U.S. partners. For example, in famous U.S.-led missions to Mars, to mention just some examples, the alpha [?] spectrometer built by Max Planck Institute for Chemistry and our university in Mainz was provided to the Mars Pathfinder mission. Two of these A.P.X.S. centers now together with German-built Mössbauer spectrometers are operational on both rovers, *Spirit* and *Opportunity*, on Mars. That

we have provided prominent contributions to Cassini-Huygens in cooperation with NASA and through ESA. More recently DLR and the German science community participated in the ESA-led Mars Express and the Rosetta comet mission. The Rosetta lander, the first man-made object ever to land on a comet, in 2013, was integrated in DLR and also led by a DLR management team. The DLR-built high-resolution stereo camera on Mars Express is transmitting daily very exciting pictures from the Martian surface, and the demand on the Internet is tremendous. So, another element is the DLR Space Medical Institute which has supported many U.S. Shuttle missions and performed live science experiments aboard the Shuttle for many years. Our medical team is providing support to the European astronauts corps, which is also located in Cologne, as I mentioned before, and is a member also of the U.S.-led Space Biomedical Institute, and there is close cooperation between the U.S. National Institute for Health and our institute in Germany and the Russians. I already mentioned the German expertise in materials, especially in materials for thermal protection systems like carbon-silicone-carbon, which NASA requested us to provide to the X-38 project. This comes with a broad aerothermodynamics expertise, which was also put to use for the former X-38 project; now when X-38 is canceled, you can buy this technology with your latest Porsche cars because it's part of the brakes and also in some elevators, it's now part of the emergency brake system. So there are, of course, still some applications for this material development.

Germany claims the leadership position in various aspects of technology such as laser communication. We are about to demonstrate space-to-ground and space-to-space laser communication with bandwidth of some gigabits per second, providing for high-speed, high-data-rate transfers. We have invited our U.S. partners to participate in our laser communication demonstration and are awaiting their response. Space robotics is another point I would like to mention. We are going to fly two missions with our Russian colleagues to qualify technology necessary for in-orbit robotics, and we are working closely together with Canada, for example, also in software development and with the Japanese who are also active in space robotics.

And the last example I would like to mention is life-support systems, self-sustaining life-support systems. We have been working on a second generation thought to be on the ISS potentially, but of course this can be used also for the space exploration initiative and nowadays it's going into submarines.

In summary, the focus of Germany and the EU in space is, as I said before, application programs. But, Germany's relying on the U.S. to live up to its commitment and legal agreements regarding the ISS; at the same time, we congratulate the President and you for providing the vision of the Moon, Mars, and Beyond program. Germany, by focusing on finishing what we have started, namely the ISS, will be glad to offer support to the Moon Mars initiative, for example, through direct industry-to-industry or also science-to-science cooperations. Currently, however, manned exploration beyond the ISS is not foreseen in the German space program, and I should say also not in the German space budget so far. Thank you very much for the attention and for the opportunity to speak to you.

Pete Aldridge

Thank you very much. One of the elements of the President's vision was a, for the Moon, Mars and Beyond, included international participation. We are in the process of trying to write the final report to the President and hopefully will deliver it to him about the second of June. Do you have some advice as to what we should say about international cooperation and this report that would go to the President?

Dr. Garneau, let me start with you.

Marc Garneau

Thank you. I would certainly say that the international community would like to participate. That is my feeling, and I can certainly speak on behalf of Canada. I think that we must, at the same time, complete our engagement with respect to the International Space Station, to show that we can successfully complete that international undertaking.

And I think that we must learn some lessons from that particular experience. I think that as the President himself said, this isn't a race. This is a long-term program. Nevertheless, even though it is spread out over a long period of time, I think that—and people were talking about communicating before in the previous panel—I think that the one way to maintain public support is to show that this is a serious, scientific technological, and human endeavor, not try to spin it. I think spinning only works for a little while. And that the best way to achieve the support over a very long period of time is to make it happen roughly on schedule, definitely within cost, and to achieve what we say we are going to do. I think that is something where we have failed a little bit in our first undertaking, and it's very important that we complete that task. I think that public support within Canada, if I can judge that support, tends to wane. It tends to wane when there are continuous stories about overruns and schedule slips. So it's particularly important with a 30-year, 30-plus-year vision, that I think we frame this as a very serious undertaking by an international community, not try to over-hype it and take that approach, but do what we say we are going to do.

Pete Aldridge

Dr. Liebig?

Volker Liebig

Yes, first of all, I would like to say that what Marc Garneau expressed is more or less our view. We strongly believe that to be successful with international participation and I feel a mission to Mars or Moon and beyond is something for mankind, not just something for one nation; it's also something for more than one generation of scientists, so it should be done together to a certain extent. But it's important to show reliability and continuity for the first step—how we expressed it before. And I have no doubt that public support is available in Europe, as well. In Germany

public support for space issues is tremendous, especially when we look what happened with Mars exploration and all these things. They are all in the headlines. Politically, support is somewhat more difficult because it's connected to budgets and at least at this time, we have all our budget problems at home. And so I would not expect that a very quick answer is coming. So if you ask for advice, and I would say, "Please keep the possibility to cooperate open also for a longer time period." Everything is on a long time scale. It's a long-time-scale vision. And I am sure there will be many partners who would like to join you.

Pete Aldridge

One of the—a model that's being thought about in this process consists of two different approaches. One approach could be that there are elements of robotic missions that could be done by individual nations, as it contributes to a overall architecture in which you bring your robotic mission and it accomplishes a particular mission. Another model might be that there is a larger component of which nations bring their components to fit into a larger piece, much like the International Space Station. Dr. Garneau may recall there's a model called the Joint Strike Fighter that Canada is participating in, in which the system integrator selects the components on a best-value basis in a competition, and it becomes international by definition through that process in a contractor-to-contractor relationship under an overall umbrella of government agreement. Are those two models consistent with how we might plan an international participation in this particular initiative?

Marc Garneau

I believe that either model may turn out to be the best model, but I think the very first thing that we have to do is to decide amongst ourselves what we want to do. And when we have decided what we want to do, I think that will, in a sense, turn us towards one of the models. I mentioned in my opening notes that we should bear in mind what partners have in terms of their own capabilities and their objectives. They may dovetail very well. On the other hand, where there is duplication, we want to, I think, if we are going to really work as a partnership, avoid that.

I couldn't say at this point which of the models is better. But once we determine what we really want to do, once that roadmap is there, I think that either model could be the best model.

Pete Aldridge

It does clearly depend on getting this architecture down to what we want to do first. And then, of course, I know NASA is working on that now. Dr. Liebig?

Volker Liebig

I personally believe that there's no real contradiction between the two models. And as a matter of fact, I would expect that both will coexist; on the one hand, we will see many missions worldwide which are somehow complementing to the Moon Mars mission.

Even if Europe, for example, does some of the missions independently, as we do it with Mars Express, you see how much cooperation is between the NASA program and the European program, so Mars Express is used as relay for the rovers, you helped to search for our Beagle and so it's, as a matter of fact, it is existing even though the elements were independently driven. And I am not the expert on the Joint Strike Fighter model. I think Admiral Steidle is, and he's in charge of the project, so I am sure his experience will flow in.

Of course one can mention industry-to-industry direct cooperation. I don't believe that in such an endeavor it can come without an umbrella, a governmental umbrella. It's necessary. Also to raise funds. Well, and the rest will have to be seen. For our situation at home, I already said that at the moment we don't plan to have big infrastructure participations like we had it with the Space Station, so we try to reorient a bit. But we have very interesting technologies available.

Pete Aldridge

OK. Bob?

Robert Walker

Dr. Liebig, you pointed out in your remarks that the EU is now consists of 450 million people in reasonably robust economies. Your total GNP is something approximating what the United States has at the present time. We are also under severe budget constraints in our country and yet, of that, we prioritize about \$16 billion a year of money that goes to NASA to support these broad-based programs.

ESA testified here yesterday, they get about \$3 billion a year, and I am not certain just exactly what the individual budgets are of France and Germany and so on, but I don't think it comes close to the, to adding up throughout the European Union to the \$16 billion that the U.S. puts in place. Since ISS is a priority and since there are going to be a number of applications coming off that, I mean, is there any movement at all in Europe to increase the amount of money that the taxpayers there are going to contribute to the overall space effort so that, in fact, we have not only technology sharing but burden sharing?

Volker Liebig

Yes, thank you for the question. As a member of the German Space Agency, of course, we lobby at home with our government, and I know my colleagues from the other European agencies with their governments to increase, exactly with these arguments, our space spendings. But of course we have to see the realities. We spend about \$5 billion in Europe altogether on the

civil space side every year. \$3 billion goes to ESA and the process, which has also been led by Germany in bringing in the European Commission, at least in political responsibility for space is of course one of the answers.

There are, at least we hope so, there will be available additional funds for what we do in space. The Commission believes, or at the moment expresses in the *White Book*, that they feel more responsibility for future infrastructures, for applications, for environment, etc. But this could, if this is taken over, for example, by new budget lines in the Commission, we could free other budget lines in our R&D budgets we get from our national governments. So I am pretty sure we cannot come really close to you with your \$15–\$17 billion per year you give to NASA. That is just a dream for us. We would like to have that in the European Space Agency, as well. But I hope we can close a little bit the gap we have between Europe and the U.S.

Pete Aldridge

OK. Carly?

Carly Fiorina

Good morning, gentlemen. Thank you for coming. I want you to, if you will, suspend reality just for a moment and assume for a moment that the U.S. decides this mission isn't worth it, that we are not wanting to go to Moon and Mars and beyond and that we will stay where we are. What do you suppose the European Union would do? What would the Canadians do?

Volker Liebig

In terms of the manned space exploration?

Carly Fiorina

Yes, in terms of space exploration, in terms of how you would think about your own involvement in space.

Volker Liebig

Well, it's a question of time scale, of course. In short term, I am sure we would concentrate on what we already have decided to do: increase in space applications—Galileo, digital divide, etc. These are the expressions of the new thinking, the paradigm change in the European space programs. This does not keep us from having a space science, space exploration program already programmed until 2013 and beyond.

So we have a couple of very interesting missions coming up, and of course we would follow this path. They go to many different objects—to comets, to Mars, to Venus, to Jupiter moons, etc. So there's very interesting things upcoming. I don't think mankind will stop to explore the solar

system, but it will take longer. And you always need an entrepreneur, and so in this century at least, it was the U.S. who leads these efforts.

Marc Garneau

I don't think I have to suspend my disbelief here. It's going to happen one way or the other. It's just a question of how long it takes if the United States decided it wasn't worth it. If we assume that their exploration program related to searching for water, the Mars missions to go at least to the end of this decade, continue, I think there's probably scope for still working with the United States; Canada is working with the United States in that respect, anyway. And we would work with, as we are at the moment, looking at possibilities with the Aurora program within the European Space Agency. We, as a country, will continue to look for partners who want to accomplish what we would like to do scientifically in terms of space exploration. There's no question that if the United States gets off the boat it's going to take a lot longer and it's going to be a more torturous path to reach that end game, but I think that there's sufficient mobilization across the space agencies of the world that it's going to happen one way or the other.

Pete Aldridge

Paul?

Paul Spudis

I just, point of clarification. You both mentioned that you would like the U.S. to live up to her commitments on ISS, but my understanding of what the President announced is he wants to first return Shuttle to flight consistent with Shuttle crew safety, complete the construction of ISS, continue our participation in ISS research for at least the next decade, although with a slight change in focus. What commitments have we made that we're not living up to under this plan?

Marc Garneau

I am satisfied, personally, that NASA is going to support continuous research after the station is completed in 2010 (the current plan) until 2016, in terms of performing research on that. My concern is in order to do viable research between 2010 and 2016, there has to be a certain amount of, if you like, mass transfer capability between the station and Earth and between Earth and the station. So although the station may be in a form that is called complete, will we be able to pursue the science as vigorously as we would like to between 2010 and 2016?

I am going on word of mouth, if you like, that that will happen. And I think it is important for me as a partner to be able to reassure my country that we will live up to our full expectation, which is to do research on the International Space Station.

Volker Liebig

Well that's more or less the concerns we have. One is crew number, crew size. We need at least more than three, we believe six, to make the utilization we intended to do, and we prepared. We have the user community stand by. And we know from the initiative, from the new initiative here, that the U.S. is going to concentrate on life science only, but we have all the viable material science community waiting. We have facilities prepared. We have concern we will not have download capacity at the moment the Shuttle retires. Because then we have only program—only Soyuz to bring masses back. We ask ourselves what we do if some accident happens or anything unplanned happens. We have seen with *Mir* what can happen. And last but not least, as has already been mentioned in the session before, what are we doing with the ISS if it comes to be deorbited? So you can't just let it come down as big as it is, and the [?] modules are not foreseen to deorbit themselves. So there has to be a planning for that. So these are some questions, I'm sure if you go in more details, you will find some more. But that's a bit of the context. And last but not least, of course, budgets is a question. If this Moon Mars initiative wants to reach something, it needs budgets, and if you can't increase another budget far beyond this \$17 billion ever year, you have of course to take budgets away from other programs. So that's in a nutshell what we are concerned about.

Pete Aldridge

Unfortunately, we have run out of time again. I would like to thank the panel for coming to New York and being with us and presenting your testimony. It's been very nice. Thank you. We are going to break for lunch now. We will return at 1:00 p.m. We don't have a whole lot of time, but 1:00 p.m. to reconvene. Thank you.

Pete Aldridge

I can't believe it, we're all here.

Well, good afternoon. We have a special panel convened today. Three people who will see the, what we call the big picture regarding public awareness of our space program and hopefully will tell us about it. Richard Gelfond is the co-chairman and co-CEO of IMAX corporation. In 1997 Mr. Gelfond and his partner, Bradley J. Wechsler, won an Academy Award for scientific and technical achievement. For the past two decades, IMAX has played a major role in documenting NASA's Space Shuttle program, and Mr. Gelfond is also the chairman of the Columbia Memorial Trust steering committee.

David Levy is one of the most successful comet discoverers in history, having discovered 21 different comets, 8 using his own backyard telescope. It must be a pretty good one, though. He's written 31 books and also writes for *Sky and Telescope* magazine. Perhaps most significantly, Mr. Levy is the science editor of *Parade* magazine, which reaches over 78 million readers each week.

Craig Covault, senior editor of *Aviation Week and Space Technology*, has written about 2,500 major articles on space and aeronautics during his 32 years at the magazine, some of which have been pretty good, I think, Craig.

Craig Covault

Thank you.

Pete Aldridge

There are those other ones, though. He has covered diverse space science programs, as well as Apollo, Skylab, Shuttle, the International Space Station and military space operations and he continues to write extensively on missions to Mars, overall U.S. exploration policy, and international space programs—all of which are of interest to us. I would like to thank the panel for coming. And I guess we start with Mr. Gelfond first.

Rich Gelfond

Thank you, Mr. Chairman. It's my pleasure to be here today. About two years ago we opened our first IMAX theater in China, and we're in about 30 countries throughout the world, and the opening film was called *Space Station 3D*, a film we made documenting the building of the International Space Station. And when I walked out of the theater, you could see the Chinese kids, you couldn't understand them, reaching out and talking about it and just being incredibly engaged by the whole idea of space and space travel. And this was before the Chinese space program had launched its first manned mission last year. And that's really what I want to talk about this afternoon—which is, I think there's this tremendous passion in people in space, and I think largely, the efforts of the industry and others has not really ignited that passion or penetrated that passion in any material way. As part of what I point to, IMAX has made five space films with Lockheed Martin, some with the Smithsonian, they've been seen by over 85 million people in 15 languages, they've grossed—and you have to remember these are shown at museums, typically, for low prices—over \$350 million, making it one of the most successful film franchises of all time, like *Lord of the Rings* and *Matrix*, things like that. These IMAX space films are seen by that number of people.

Several astronauts have told me over the years that seeing an IMAX space film was what inspired them to become astronauts. And they've said when they forget what it's like to go in space they go back to the Imax theater, because that's the closest thing to being there. It reminds them. And I think that IMAX films, along with a lot of other things, inspire viewers to imagine the human possibilities—particularly of space travel and science and to think outside the box. The world isn't just what's on the news today or what's in the newspaper. There's more out there. And there are bigger things to think about. Further evidence I would have for this passion in space is the recent Mars expedition. Where my understanding is, that when the images started coming back from Mars, there were something like three million hits on the Web in the first few

days, and in the first month, there were more hits than were hit all last year on NASA space sites. So obviously, people are interested in the right kind of message. The success of these Imax films when you see space exhibits, when you look at the attendance of the Air and Space Museum in Washington, there clearly seems to be a lot of pent-up public demand for it; the challenge is really how to tap that demand and how to capture the public's imagination and passion for science.

I believe that the space program and its benefits have been greatly under-marketed. One way I think about this is it's one of the best products in the world, with one of the worst marketing plans behind it. One senior aerospace executive told me in the context of talking about an Imax film that the industry's idea of marketing is handing out a fancy pocket pencil holder. And you know, it's a humorous comment, but I think he's right. I certainly apologize to anyone working here today, but I came in and this is the idea of marketing: these pins. Until I got involved with the aerospace industry, making these movies, I didn't even know what these pins were. And now I have baseball caps, pins and mugs. And I think there's got to be more.

During the Mars mission, no Web addresses were collected for follow-up. So those three million people who hit, or the three million hits, maybe they weren't all individuals, there was no way of getting back to them and finding out who they were and marketing to them, going forward. During the filming of *Space Station 3D*, Tom Cruise was the narrator on that film, and he shares a passion for this kind of thing. And at one point it sort of looked like he went off track, because he got on his soap box and he said, "What is it with these Wheaties boxes? There are criminals on the boxes. Where are the astronauts?" And I think he asked a very good question. I certainly don't have many of the answers. But I know we must reshape the message as well as the means of communicating the message if we're really to make any progress in terms of people's psyche. I personally grow up in the 60s and the message for space was not about dollars and cents, it was somewhat about competition with the Russians, but it was also about acting on ideas and attaining human potential. The space program taught us, there were always unanticipated bumps on the road.

Many of you here remember things didn't always go perfectly. But they all taught us that human creativity could overcome those obstacles, and I think those kinds of things helped shape my generation. We knew the names of astronauts. We knew about their families. We related on a personal level to what they were going through. And none of that exists today. So the question, the hard question: How do we reshape the message? I believe the space program is being sold too narrowly today, partly on a dollars-and-cents basis. And I understand that, because if you're a member of Congress or the administration, that's the obstacle you're facing in the media or that's what other constituencies are talking about. And they say, "Gee, if we go to the Moon, we could get a ton of iron ore for"—I'm making these numbers up—" \$18, instead of \$20." You know, boy, doesn't that really catch your imagination? Doesn't that really want to drive you going forward? I don't think so. I mean, what if Queen Isabella had decided not to send Columbus to the United States because she said there were poor people in Spain? I mean, there are always poor people, but the fact is, how many benefits came out of Columbus' expedition?

Not just sort of ephemeral benefits but real dollars-and-cents benefits that was very hard to talk about in advance. We need to create an awareness of exploration on a broader scale.

We don't know what we'll find. We need a leap of faith, based on past exploration. We need to capture people's imaginations. We need to make the case that the desire to explore is in our DNA code. And it's ours to pursue. Administrator O'Keefe at the Space Foundation conference talked about societies and ones that didn't explore and ones that did explore. And the ones that did explore turned out to be much more successful societies and much more outward-looking, and we need to present that message in a very clear way. We need to further talk about all the benefits of the space program, the immeasurable advances to science, engineering, medicine, communications, and education. I think the whole industry has to pound its chest a little bit. Now, I understand there are limits on NASA's ability to say, "We did this." But I think, whether it's the industry or some separate entity that gets formed, but someone needs to go out there and start to tell the story in a much more proactive way.

How do we communicate the message? One hundred twenty five million Americans are under the age of 31, and they were born since the last American set foot on the Moon. They have no knowledge of role models or examples of human potential. I have a 19-year-old daughter, and I asked her about this. And she said, "Dad, I really don't get it, the way you talk about it." And I think that's the point. Half of the country doesn't get it. They didn't live through it. And I think we need to figure out a way to communicate with that half of the country.

So how can we stir the passions? I think film is one obvious way. We have a new Imax 3D space film coming out that was financed by Lockheed Martin. It was developed by Tom Hanks and we're doing it with Playtone, which is Tom's company. And it's called *Magnificent Desolation*, and it's about the men who walked on the Moon. But it's not some technical story of, you know, measuring how many feet from the bottom of the ladder to the top of the lunar surface. It's about what the people thought or what they went through and how it changed their lives and how it changed their views of humanity. And that will be coming out towards the end of 2005. I think we need to enlist the help of passionate celebrities. Some of that has been done. And Tom Hanks is a good example. And Ron Howard's a good example. But there are a lot of celebrities out there who are really passionate about this and I think they need to be reached in some way. Because obviously they're role models for the public.

I think there needs to be commercials. What comes to my mind is the Marines. The Marines used to have one image. But then they came up with a much more aggressive, creative advertising campaign around "Be all that you can be" and great visuals, and I think there's a new image of the Marines in the public. And I think the statistics have shown that out.

This one, I don't really know how I feel about it, but I think it's interesting, and I think we shouldn't limit the ideas. IMG, which is a really well-known sports marketing firm, is pitching a new reality series to some of the networks, where there are eight men and eight women. And they compete and the winner goes into the astronaut training program. Now, whether they succeed in the program, it depends on the standards of the program. But I think something like that, where the public can actually get involved and root and learn and think is a direction we

shouldn't be closed-minded towards going. Interactive medium. Obviously the Web was made for this. A gain the Mars photos, what if we had gathered those three million addresses? Why couldn't someone get to them right now? With different messages, education programs. And start to build some support from the ground up. I think NASA TV has great carriage. But the question is, Should it be limited to the uses it's used for now? Or in addition to its current mandate, should it be showing Discovery films or Imax films or interactive programs? Should it be broadened in some way?

Grassroots, I think, is where we have to get back to. Whether it's schools or clubs, encouraging people's imaginations. And then the only sort of concrete thing I have instead of the general is just my question about whether there needs to be some organization that is in charge of marketing this. Because, obviously there are limitations on NASA's ability. All of the defense contractors and the space contractors have their own agendas and their reasons to compete rather than work in accord. And again, I haven't completely thought this through. But I think maybe there needs to be some independent marketing body put together to make those ideas feasible. Thank you.

Pete Aldridge

Thank you. David?

David Levy

Thank you. The big picture. This is what this session is about. And I think in many ways, this is what the whole presentation, the whole idea of going back to the Moon, going on to Mars, perhaps, is all about. It is about the big picture. My work with *Parade* and my work over the last few months at Arizona State University has allowed me to talk with many, many people and to hear many, many letters—read letters and hear from people—about the whole idea of going back to the Moon. And there have been really two major problems that have come up whenever the idea is asked, “What should we do about the President's space initiative?”

First question, “In our post-9/11 culture, why are we thinking about going to the Moon?” I think in our post-9/11 culture, especially, we need to be thinking about going to the Moon. We are fighting to save our world and our way of life. What are we saving it for? We are saving it because we are explorers. We are a nation of explorers. Every person who has taken a course in American history, all over the world, is excited by the sense of exploration that the United States has had, the Lewis and Clark in all of us.

It's exciting to look up at the night sky, to look up at the Moon and say, “We've been there.” There's someone here in this room right now, Buzz Aldrin, who has walked on the Moon. But there isn't just one person here who's walked on the Moon. Every one of us, who was there that night, who was the sixth of the world's population, who was watching the television that night—we were there, with him. We were there, walking on the Moon, exploring the Moon, seeing the

Moon. And that is the crux of this whole thing. When we go to the Moon, we bring everybody with us.

My big picture really began on September the first, 1960, when I looked through a small telescope and I saw the planet Jupiter and I thought, “That’s a world out there, that’s a place.” Of course, it’s a very large world. And it’s a world that, of course, I had no idea that I would somehow be involved in it 34 years later when a rogue comment happened to collide with it.

But it really brought things home as to our cosmic heritage. The fact that when you look up at Jupiter, and when you imagine that just a few years ago, a comet slammed into Jupiter, that comet was really telling us a little bit about our own heritage. It’s a very basic, a very simple heritage. When you look up at the Moon, you see that, right there. You don’t even need a telescope.

One of my favorite childhood books was *Starlight Nights* by Leslie Peltier. I was reading that as a high school student, and I read what he said: “I followed the advancing sunlight, all the way across the face of the Moon. I descended into craters by the score—Plato, Aristophanes, Copernicus, Tycho, across majestic Clavius and down the blinding wall of Aristarchus. One night I walked across the strange and violent gash of the Alpine Valley and then I climbed a torturous trail from peak to peak, across the sweeping range of the lunar Apennines. I rested briefly in the long black shadows of Pico and Piton, whose towering monuments arise starkly from the level surface of the Sea of Showers.” You don’t need to go there in a spacecraft to see that. You see that in the smallest of small telescopes. And this is why going to the Moon is something that we don’t do just with a lot of money and rocket power. We do it in the hearts and minds of everyone in this country. I think President Bush’s space initiative is a great idea. It’s bold. It represents what is best about the United States as a nation that is founded in the spirit of exploration, a nation that is always looking ahead, even in dark times, to the nearest, to the newest and most exciting frontier. I have a few ideas, though, about how this initiative might best proceed.

The first one is we’ve got to make it inclusive. Let whatever we come up with, let it be augmented with a big push for science education, especially at the elementary levels, high school levels, and the first two years of university levels. This is really what we did the last time we went to the Moon. I remember walking home one day, and hearing, in fourth grade, that Sputnik was up there, and coming home and asking, “Dad, what is a Sputnik?”

And he looked at me with some concern and he said, “The Russians are beating us out there.”

And just a few years later, starting to watch our own program. On the bus to school: “Did you hear? We recovered a capsule, it’s possible.” Faking an asthma attack and mom letting me stay home to watch Alan Shepard’s flight. Sitting in a summer camp and watching a tiny little TV camera, with a group of 150 children, watching that small step, that giant leap. We really, it would be so good, if we had this push with better science education. If we do this, an entire generation is going to come with us on our way to the Moon and to Mars. Not just a few astronauts.

The second problem that we've heard on the television, people come up and they say, "What do you think about the President's space initiative?"

And the answer is "Shouldn't we be spending that money on Earth?" Of course, it is obvious, when we do spend money in space, we do spend it on the Earth. But we can do it more directly. From our base on the Moon, we will explore the heavens, but along with that, I believe we should fund as part of this, as part of our space initiative, the global observing proposal that the National Oceanic and Atmospheric Administration has come up with. I think this is a marvelous proposal. And in my Attachment A that you all have, I've written a little bit more about it. They want to fund a plan that records, much better than we're doing now, the conditions of our oceans, our lands, and our atmosphere.

When its global observation network is complete, NOAA will have accurate weather forecasting up to a week in advance. They will be able to have accurate positioning of major storms, hurricanes, El Niño events. This proposal is one that NASA is playing a big role in. It is nothing less in my mind than a Hubble Space Telescope pointing at the Earth. It goes a long way towards answering the objections that we need to put resources into humanity and into our own world. We bring our own world, we don't just explore the Moon. We don't just explore Mars. We're also exploring ourselves and our own planet as well. Mars is a laudable goal. Especially after all of us, the materials that we've seen, those images that we've seen, as little *Spirit* finally climbed up to that crater and looked down into it.

And Carolyn Shoemaker told me how she, it reminded her of the excitement that her husband, Gene, felt every time we looked at something new—a new crater, to tell us about our cosmic origins. Let's focus on the Moon, though, at the beginning. Let's send people there. Let's build a base there. I think we can do other things. We could immediately expand our efforts to study how lunar resources can be exploited by a lunar base. Let's go visit a near-Earth asteroid. We could actually do that before we go to Mars.

We let them come to us. There are not that difficult to get to, as long as we remember to get off the near-Earth asteroid before it goes too far away from us. These are incredible things. An exciting thing we can do on the Moon, is we can get little small rovers, mini-rovers, that are controlled by children in their schools using the Internet, using the Web. Finally, I think it would be a good idea to keep this Commission, or something like it, in service on an indefinite basis. It could be a steering committee that would oversee not just the ideas on the initiative that we're doing now, but also how it unfolds, a way that the nation can get in touch with its leaders, to say, "We're going to the Moon. We're going to Mars. We're bringing the whole generation with us." Let's keep doing that. I really am excited about the possibilities. I'm more excited today about our nation's future in space than I've been ever since July 20th, 1969.

Let's go back, let's have fun. And let's do what America is all about. Thank you very much.

Pete Aldridge

Thank you, David. Craig?

Craig Covault

Thank you very much, Commissioners, for inviting me to appear before you today. *Aviation Week and Space Technology* is the sister publication to *Business Week* under McGraw-Hill. *Aviation Week* was founded in 1916; we are nearly 90 years old and read in 180 countries. The people involved in exploration have read about it in *Aviation Week* before and after they have made their marks in history. Some guest writers for *Aviation Week* from the past have included Orville Wright and Amelia Earhart. Charles Lindbergh learned about the contest to fly the Atlantic by reading about it in *Aviation Week*, and Lindbergh called our New York office at the time to learn more about entering. “Space” was added to the title about 40 years ago, and we became *Aviation Week and Space Technology*.

Most of the Mercury, Gemini, Apollo, and Shuttle astronauts have been loyal readers years before their space missions, and we are into participatory journalism to get the depth our readers expect. I’ve spent many a day in simulators with astronaut crews, and most recently spent seven weeks at JPL covering the *Spirit* and *Opportunity* rovers, including a very special week specifically embedded with the *Opportunity* science team. Keeping up with rover science and robotics ops is one of the most homework-intensive news stories I’ve ever covered. So we’ve been immersed in both human and robotic space ops for a long time, and we do this thing all over world, especially in Europe, Russia, Japan, and China. We see the benefits and challenges of the space business from the inside out, around the globe. From this vantage point, I can say that it’s not English that is the universal language around the world, it’s space exploration.

About 20 years ago, while tramping around Lhasa, Tibet, I went into an old Tibetan monastery, careful not to step on prostrate worshipers, and headed for the back stairs that would take me to the roof and a magnificent view. I started up and but I found a Tibetan monk in his red toga, blocking the way and it was a bit intimidating. This place was about as far away from anything as you can get on Earth, but, remarkably, behind this monk was a calendar with a picture of astronauts John Young and Bob Crippen, sitting in the Shuttle cockpit. “I know these guys,” I said, pointing to the picture. I have no idea if that monk knew what I said, but he immediately got excited, pointed to Crippen and Young, shook my hand vigorously and cleared the path, proving in a simple little way that space exploration is not only the path to the high ground (that day, the roof) but also to people all over the world.

On another trip to China, I was invited to lecture to a large student class at Northwest Polytechnic University in Xi’an, one of China’s major aerospace universities. I brought along a film of Chinese-American astronaut Taylor Wang floating around in the Shuttle. And every time he’d float into the view, the whole big lecture hall of Chinese kids would break into great cheers. The Chinese don’t have to cheer for Chinese-American astronauts any more. They’ve got a league of their own. I do not believe from what I’ve seen on several trips that there is a serious Chinese manned lunar plan yet, but everything else about their program is very real, including the huge potential of the increasingly large numbers of young Chinese engineers.

Back on the home front, nearly 17 years ago, I did an interview with former astronaut Sally Ride, who was then about to finish a team assessment of “New U.S. Space Goals.” “We do not have a

strategy for human exploration in NASA,” Ride said, “We have the Shuttle and the Station. But they are not a strategy for human exploration.” Ride continued, “The U.S. did not finish the job we started during the Apollo program. Mars is the ultimate goal of human exploration, so the real question is, how do you approach that goal?” That from Sally Ride, 17 years ago in the July 13, 1987, issue of *Aviation Week*. So here we are, pushed under that starting line again, wondering if this time we’ll get the green flag. The implications of all this, especially for U.S. math-science education, are profound and were highlighted yesterday in a front-page story in the *New York Times*. Since *Aviation Week* is part of McGraw-Hill, one of the world’s largest educational-related companies, I will take a minute on that side of the equation. Several weeks before the *Columbia* accident, Sally called to see if we could help them with her educational programs. And I told Sally our parent company, McGraw-Hill, could make such an initiative more of a new foundation for math-science programs.

I rounded up the flag at McGraw-Hill Education, and Dr. Ride went off and worked up about a dozen proposals spanning all grade levels. When we briefed that together to McGraw-Hill Education here last September, a key foundation for the presentation was the expected success of the Mars rovers, Cassini to Saturn, and the anticipated new manned lunar Mars initiative. McGraw-Hill has adopted several of those ideas. Placing Sally Ride and her Imaginary Lines program under formal contract with McGraw-Hill for math-science efforts. And since the success of *Spirit* and *Opportunity*, we have been specifically spending a lot of time in *Aviation Week* looking at what else we can do on both the educational and news-related sides of both robotic and manned exploration. It’s a bit time-consuming but builds for the future and certainly is toward a much younger audience. Exploration is an adventure that has to be shared at the broadest level with the American taxpayer.

The news media is the conduit for that sharing. But there is bad news along with the good. NASA has lost the media on the International Space Station, no matter how spectacular the facility, which it truly is. Once assembly restarts, NASA has a chance to win some media back, but only as long as the spectacular imagery lasts. The worst problem is that the ISS is not defensible on a science-versus-cost basis alone. It is more defensible on the maintenance of a contractor base, a foreign policy base, and as a foothold in space toward the later manned lunar Mars exploration initiative. Those are all viable points, but I don’t believe were articulated that well by NASA.

The new manned lunar Mars exploration initiative must ensure future manned exploration science does not fall into the same trap. That is far less a challenge for fantastic voyages like the rovers to Mars and Cassini to Saturn. I believe the robotic missions are becoming so productive that there’s a very real possibility they will push human exploration somewhat further to the right in the big picture schedule. From covering both the manned and unmanned programs, another big picture area that comes to my mind for added attention with any exploration initiative is a much better assessment of risk than current models and processes seem to provide. In covering both aviation and space programs, we run into risk questions all the time. At JPL recently, Pete Theisinger, the outgoing rover project manager, called my attention to this issue on the success side of the equation. Theisinger noted that risk assessments for both the 1997 *Pathfinder* mini-

rover, as well as both Mars exploration rovers, rated them as extremely risky. Yet all three were tremendously successful. “How can it be that they could have done so well in the face of such high risk?” Theisinger asked. “It’s got to be more than just luck. But how do you quantify it for use by all downstream missions, manned or unmanned?”

And finally, how can NASA pull everything together—the public, the media, the science community, and the Congress, for sustained support to carry forth the renewed manned program back to the Moon and on to Mars? Some of your previous witnesses here today as well said it all boils down to marketing. I’m a journalist, and my genes don’t allow me to go down that path very far. But having said that, I’ve crossed that line just a bit with our own folks by turning the phrase “9 billion web hits” into sort of a chant. And it’s 9 billion, not 3 million from a web hits point of view—10 billion now, maybe. I personally disagree, however, with any unabashed marketing approach that borders on show biz.

Flying in space is not show biz. The content, the quality of the subject matter, and how it is presented is what earns media air time or print space, and that should be NASA’s focus with the media. The agency has a lot more work to do in that arena, and it needs to hurry, because Mars beckons—not only because of its educational and science potential, but also because it’s just plain fun. Up in the JPL headquarters building the other day with center director Charles Elachi discussing things we normally discuss with center directors like robotics on the coming missions, Charles sprung out of his chair to ask, “Have you ever had so much fun in your life?”

And in a quiet moment, up in Steve Squier’s office above the rover control center, and there are not many quiet moments with Steve, he used the same words. “Can you believe how much fun this has all been?” And then Steve asked, “Do you think I’ve been going overboard?”

I not only said no, but I said, “Hell, no.” This was the day after *Opportunity* had climbed out of its home crater and transmitted the stunning Lion King panorama. The scene looks back at the human presence of the lander base sitting alone down in the crater, covered with rover tracks now, coupled with the full expanse of the Meridiani Plains finally revealed.

As the team entered the especially equipped science operations working group room to finalize commands for the next day, the software guys put that extraordinary new panorama up on high-resolution screens across the full 50-foot expanse of the facility, queuing up on the stereo, Holst’s “Mars” from the epic musical composition *The Planets*. We all stood there in complete awe. No administration or Congress should underestimate the public’s desire and enthusiasm to share in that kind of an experience, that level of exploration. You don’t have to bottle it and sell it. It’s already in the water supply. All you have to do is deliver it. Thank you.

Pete Aldridge

Craig, thanks a lot. One of the themes that seems to be coming from our deliberation is that this mission, this vision, is really not just a NASA vision. But it’s a national vision. And yet, most of you talked about what NASA can do to sell the program. I wonder if it might be thoughtful to say, if this is truly a national vision, it must be sold and—I use the term *marketing* but I don’t

mean to—it must be justified, rationalized more from a national perspective in terms of the inspiration it gives and the technical advances and the industrial competitiveness and all the things that benefit the nation as a result of going in this direction. Plus, all the other things that other agencies are bringing to bear in the National Science Foundation, the Department of Defense, Department of Energy and so forth.

Do you think it ought to be marketed, rationalized, at a higher level? Or is NASA sufficient to do it on their own? And I'll start with you, Richard.

Rich Gelfond

I think I kind of plugged into your question briefly by saying I don't think NASA is sufficient to do it on its own. I think some kind of new mechanism has to be created, whether it's a panel or it's a consortium. And I think it needs to include different constituencies. You know, some of the points that came up on the panel: I think you would want an educational constituency to be part of it. I think you'd obviously want NASA to be part of it. And you would want the industry to be part of it. I could see you want some communication components to be part of it. But I think one of the problems until now has been that it's been imposed upon NASA without a lot of the resources to do it. And also, NASA's culture is more of a technical, kind of engineering, culture. And I think you would want to create this organization with a broader cultural aspects that would have the ability to integrate these different parts and to effectively communicate with the population, because, you know, I agree with what Craig said before, I think, I think it's very serious business. But I think if you underestimate your ability to shape the message, you really don't get it on people's radar screens. So, the short answer: I think you need to create a separate mechanism to implement it.

Pete Aldridge

David, do you have a comment?

David Levy

Yes. You know, there has been a lot of talk about "How do we market this?" And while I'm listening to all this, I'm thinking of that night on Christmas Eve, 1968. All three networks—I remember just watching the show, and it was, you just saw the Moon below you on the TV screen and the astronauts reading from Genesis. And, I mean, you can't buy publicity like that, the feeling that that made. And that like that year, 1968, like this one, it was a rough year for the country. And with all the—I guess my point is, that as NASA goes from success to success, with some failures that obviously are going to happen, we've just had a real big one with Mars. But as we go from success to success, I really think that the missions themselves are going to be our publicity. I want to write in *Parade* about NASA's wonderful track record. And I know, I know I'm a tremendous supporter of NASA and what it's accomplished. But if you look back over our lifetimes and what it's accomplished, that we've, for the first time in humanity's history, we've

gone out into the outskirts of the solar system. The missions themselves, as we build from success to success, I think, will be our publicity. We need to emphasize that. We need to emphasize that we are exploring and we will have some rainy days as we explore. But that's the publicity we need.

Pete Aldridge

Any comment, Craig?

Craig Covault

This administration or the next one, and the Congress, has to spend some political capital. And I haven't seen any of it spent, save one speech at NASA, on this initiative. You spend political capital or you're not going to buy much.

Pete Aldridge

OK. Neil?

Neil Tyson

I have a question for David Levy. But, Mr. Chairman, I must disclose, before I ask a question, that the one asteroid in the solar system named after me was discovered by David Levy. But not alone. He discovered it with Carolyn Shoemaker. And the last time they discovered something in the solar system, it slammed into Jupiter. But he assured me that my asteroid is safe from hitting anything. Uh, David—

David Levy

Your asteroid is just fine.

Neil Tyson

David, please just remind me the circulation of *Parade*?

David Levy

The circulation is about 78 million readers.

Neil Tyson

It's insanely high.

David Levy

Yes, it's about a quarter of the population of the country.

Neil Tyson

And that's even without a lot of New York City, because the major papers here don't even carry it.

David Levy

Exactly.

Neil Tyson

I've got a question, then. This is surely one of the largest, loudest, mouthpieces that exist in the nation. And you are among the most articulate of any speakers and the most elegant of writers that I know on this subject. And that is your medium, *Parade* magazine, as well as all else you do. Yet, still, if you poll the public, it's not more than half of the public in support of our space visions now or ever in the actual polls that are taken. And so, if it doesn't work there, if that's not working, what hope do we have to get this to work? Because that's not only urban America, that's middle America, especially middle America. It's states where there's swing votes in Congress. If, so, how do we—I need advice from you. Because I don't know how much more powerful a voice we can have, other than what's wrapped up in you.

David Levy

Thanks, Neil. The first point that I made is that we've got to have a greater push in science education in our schools. It's—even when I'm writing for *Parade*, and *Parade* materials get edited very, very, very tightly—all the other things that they want to and need to cover. So that we have to write a science article so that it will not lose the reader after the first sentence. There's—you know, I can write all I want, but I have one bad sentence or one long sentence fragment that doesn't go anywhere and I've lost half of my readers right there.

Neil Tyson

That's 40 million readers.

David Levy

Yes. Unless those readers have a better background in science. And it's not just to learn Euclid's laws and to learn—teach them how to add and subtract, but the vast panorama of science that's gone from thousands of years ago to Galileo to Newton to all kinds of things is

something that we need to do. And it starts in the hearts and minds of the people. And by putting this right into the schools, I'd like to think that our journey back to the Moon is going to begin in an elementary school. So that the next generation is going to be so much into science, and so much into science as a part of their daily lives, that they're going to say, "Well why shouldn't we explore it?" The Moon is a place. It's one of the only things that I look at in a telescope that is a place. You can walk across the craters and climb the mountains. And you don't need a big telescope to do that. A tiny scope will do that. You look through that telescope and you think, "We've been there and we're going to go there again, this time to stay." That's a very exciting thing. But it's got to go right back to the schools. That's why that's so important a part of this.

Pete Aldridge

Les?

Les Lyles

Well let me thank all three of you also for being here this afternoon. This is very exciting. If nothing else, if we could bottle the enthusiasm and passion that the three of you are showing, it would go a long way to achieving all of our objectives. My question is to Craig. Craig, I applaud the linkage and the connection that McGraw-Hill and *Aviation Week* is going to make with Sally Ride and her activities.

I'm curious, though, as much as I love *Aviation Week and Space Technology*, and salivate every week waiting to see the next edition, I can't imagine that appealing to young kids, the kind of kids that David just talked about that we need to reach out to. Are you envisioning a junior version, if I can use that, of *Aviation Week and Space Technology*? Or another way to tone, not tone down, but certainly get the message across, a little differently to reach out to the young people that we want to touch.

Craig Covault

The fundamental education connection area is through the other part of the company that's called McGraw-Hill Education. It's a division, which is a huge educational division. So we've just acted as kind of a middleman, if you will, to bring those two sides together. Space is kind of the bait on the hook. And from there on, it's math-science.

Les Lyles

If I could ask a second question that relates to getting back to *Aviation Week and Space Technology*, and the first word, *aviation*, one of the things that the Commission has been wrestling with is at least thinking about the idea that the aviation part or aeronautics part, if I can use that term, of NASA's mission, may to some people's minds, interfere with the space vision. I would be interested in your thoughts as an aviator, a pilot, in talking about this vision. Might

we see in the future a *Space Week and Aviation Technology* magazine? Or your thoughts about the aviation piece of this and how it relates to the vision?

Craig Covault

I've used that same line around my own shop. We find, in the aviation side of things, there's certainly a group of engineers and people that gravitate to the space side of the operations. But at the same time, on the marketing side of things, we find they don't. And this, I think, is a problem. That's where you're getting all, well, frankly, my word is old fuds.

You end up with the folks who are stuck in 40-, 50-, 60-year-old land, working in marketing circuits, air shows, and things of this nature. I don't think that's where aerospace ought to be going. I don't think that's where the youth of the country who wants to be in aerospace ought to be going.

Certainly there will always be people very seriously interested in aviation, as just about everyone who got hooked on space has been in some fashion. But I think there has to be a more serious approach on the aviation side, that space is part of that family.

Les Lyles

Thank you.

Pete Aldridge

Maria?

Maria Zuber

Yeah, first of all, thank all three of you and your organizations for your contributions to space exploration. Your contributions have been as significant as many of us who have worked in the field for a long time, and thank you for bringing that home.

One of the things that, that I have found most gratifying about the current Mars rover mission has been not just the total number of Web hits, which everybody quotes now, it's the repeat hits. There's a very, very high percentage of people who go in and they—the first thing they do in the morning is click on that web page and look at, look at what the MER rovers are doing today. And we've talked a lot on the Commission about the sustainability of the space exploration program. And the fact that you get all of these repeats indicates some sustainability on the short term for the MERs. What the Commission has been grappling about this is how do you make this sustainable over a long period? I don't note that there's been the same kind of repeatability of people going in and saying, "What are we doing on the Space Station here?" every day. And is there an untapped potential here for NASA to go in and, as opposed to just putting it in NASA

TV, which not everybody gets? Of doing, you know, having something every day that would motivate people to go and be a part of the human exploration on the Web as well?

Craig Covault

Well, I think they're going to have to rebuild the human spaceflight side of this, brick by brick. I think they will get that interest, the Shuttle returning to flight will naturally bring some. Return ISS and what are truly spectacular assembly flights will bring it some. But the real interest is going to continue with the rovers, and then as Cassini moves in on Saturn.

The good news here is that there's, it's not onesy, twosy, anymore with the Mars program. It's a sustained set of missions every couple of years where you'll have sustained return and sustained products that folk can look at.

David Levy

One thing where I think the Web can really help is not just in deciding what we're going to do in space but how do we observe space. For example, June the 8th is coming up really fast and with it, the transit of Venus. And I know, I'm getting in touch now with science centers, planetariums, museums all over the country. Everybody east of the Mississippi is going to get to see this event for the first time in 112 years. If it weren't for transits of Venus, right now, you could make an argument we would not know the distance between the Earth and the sun and we would not know the distances that go from that to the nearest stars, to the farthest stars, to the galaxies and to the great clusters. It's all happening again. We all go back to our roots on June 8th.

And I think the Web is going to play a tremendous role then for those of us who don't get to the East Coast to see the transit to say where you can see it and to watch it on the Web. I think we need to take advantage of events that come to us, events that we don't have to go to them, but events like the transit to get people interested and use the Web. I hope I answered something of your question there.

Pete Aldridge

Yeah. Bob?

Robert Walker

Yesterday, we had some testimony that fascinated me where Tony Tether said that what NASA forgot somewhere along the line was that in the course of the early years of the space program, we all wanted to go, and that somehow NASA over a period of years has lost that feeling, that now people don't really have the same feeling that it's come down to a select few get to go, and maybe we live vicariously through them, but most people don't.

Is there something in that with those of you who are in the media? IMAX does some of that in the films that it does. It gives people a sense of going. But is there something that NASA should be doing as a part of the missions that we set up that give people more of a sense of going?

Should we put—should we put something in the cockpit of the spaceships as they go so that people can ride along? You know, are there things that go on inside the program that would actually make it more appealing to the public and get back to the idea that we all want to go?

Rich Gelfond

The way we—the term we use in the movie business for that, Bob, is you're talking about do we make this a first-person experience rather than a third-person experience, right?

Because a third person—you're watching the movie, you're watching the other people. And the good news is that technology today has really enabled so much more to become a first-person experience. I think you're on to something. And you know, the comment before, the question about the Web and, with all deference to the panel, I think a lot of the things that are out there are great for people who grew up at one time and one place with a certain passion.

But we're not getting to the people who don't yet have that passion and figuring out how to energize them. And that might be one very good idea is to create websites where you can talk to the explorers on a more regular basis, where you can look at what they're looking at, where you could, you know, direct experiments or maybe get the results of experiments that are going on in the mission. You could download the same data at the same time. So I definitely think you're on to something.

David Levy

There's a small display, at a very tiny out-of-the-way science center called the Discovery Science Center [Discovery Park in Safford] out in southeastern Arizona. You have to drive through an hour of sagebrush get to it. But once you're there, Leonard Wikberg's fantastic Shuttle simulator is there. Children all over the state go. They climb into this thing. You get a Shuttle ride, but at the same time, you get a look at the universe. It takes you on this half-hour tour. I think if NASA could do more of that, working with museums around the country to get people a hands-on experience of what it might like to be in space, I think that would be a great idea to do.

Craig Covault

I think the rovers have really helped us reach a watershed moment in that type of interaction and outreach. No other program that I know has that much public interaction. It's only going to get better as the imagery capabilities get better. It's part of the reasons I think that really high-quality robotics might push human exploration a bit further to the right on the calendar, simply because

the robotics will allow, with high-def TV and things of that nature, a far more personal experience, perhaps sooner.

Pete Aldridge

Anybody else? I would like to thank the panel for your testimony today. We appreciate the time you spent with us and for coming to New York to do so. Thank you very much. Thank you.

We have the NASA administrator coming in about five minutes. So we'll take about a five- or six-minute break while we get the administrator here. Thank you.

We'll resume now. As most of you know, the Administrator of NASA, Sean O'Keefe, leads the team and manages all of NASA's resources. Prior to his appointment at NASA, he served as Deputy Director of the Office of Management and Budget, the Secretary of the Navy, and Comptroller and Chief Financial Officer for the Department of Defense. At NASA, Sean certainly manages a complex system of systems and we're most eager to hear his testimony today. Sean, welcome. Glad to have you here and looking forward to hearing what you have to say.

Sean O'Keefe

Well, thank you, Mr. Chairman, members of the Commission. I appreciate it very much for the opportunity to spend time with you this afternoon on what I understand to be your last of the public sessions that you're planning. And it has been a very thorough examination that you've conducted in a very short period of time. So I want to thank you all for the dedication of public service that you have placed at this in the course of the last four months in what appears to be a very breakneck schedule and more time than, I think, some of you had wanted to invest.

Pete Aldridge

I think you lied to us when [inaudible].

Sean O'Keefe

Well, I was being optimistic, Mr. Chairman. But I had not anticipated the depth and degree of enthusiasm that each of you would take to the task and certainly we are most gratified by that. And I know the administration is very much looking forward to the efforts that you put into this over the course of several public hearings now, as well as several independent investigation efforts that you've conducted to pull together an agenda that we're certainly looking forward to seeing as a moving ahead forward implementation strategy that I think will be most beneficial and helpful in the quest.

I think it's important at this concluding stage to kind of step back a little bit and examine again what brought us all to this occasion. And in so many ways, the most cathartic moment that was a

prompting event, certainly became a searing event and a tragedy that prompted a lot of serious consideration, was the loss of the Shuttle *Columbia*. After the first of February 2003, I think the attempt, from that point forward, was certainly to examine the issues that led to that particular tragedy, to find the cause of the accident, correct it, and resume the activity that they had dedicated themselves to.

But it became apparent in fairly short order when the Columbia Accident Investigation Board conducted its activities that the much broader question was to really seek a clarification of the space policy that, in a way that in their view, as they articulated in their report, is something that had bedeviled us for the past 30-odd years. So since the end of the Apollo program, the definition and degree of clarity of the strategy of the broader space policy objectives had lacked the level of detail, as well as a clear objective in their estimation and the way they articulated it in their report released in August of 2003.

The administration took that very seriously. The President very directly felt that there was an imperative that had been building over the course of their review and the course of their public reviews and testimony on the investigation of the *Columbia* accident to think in terms of the specific interagency activities, the functions we do within the federal government, and affected by space policy and to bring together a coordinated approach in terms of how that should be managed. And in the course of roughly the mid-summer through till December, the objective that he directed us to follow through on is to coordinate all those activities among us in the administration—the State Department, Defense, Commerce, Transportation, the Office of Science and Technology Policy—all of the stakeholders, if you will, and the policy objectives, to bring together a comprehensive set of options for his consideration. His engagement on the development of that set of policies was—in my judgment, having worked through a number of prior public service opportunities and looking at presidential directives and so forth—this is the most extensive I’ve seen any chief executive engaged on a matter of policy of this nature. And as a consequence, his guidance all the way through is what I think lent itself to the clarity of what ultimately emerged in this presidential directive. And the very clear instruction and direction of what was involved was a conscious set of choices that he made.

That said, we also recognized that the difficulties of working through that specific set of objectives would call for a different way of looking at this set of problems. And therefore the opportunity to assemble a group of distinguished Americans, as yourselves, to think through this from a wide range of disciplines, of precisely how we go about implementing such a strategy, was what consciously and as a matter of premeditation led to his conclusion and certainly that of all of us engaged in the administration that a much broader understanding of what those imperatives should be and how we look at that set of challenges beyond the confines of the kind of monolithic environment that the federal government typically can bring to such problems. Instead, step away from it and think about it in a way that is much more extensive.

And so in that spirit of kind of rethinking exactly, or restating exactly how we arrived at this point, what I would like to play, if you’d tolerate, Mr. Chairman, is a very short video that summarizes and drawn from the President speeches, a speech from the 14th of January exactly

how the components of this particular strategy should be assembled and what our objectives are, what we're directed to do, and how we then go about doing it. If we could roll that five-minute piece. I know somebody's got control over that right now?

[NASA video, "A Renewed Spirit of Discovery."]

President Bush

It is time for America to take the next steps. Today I announce a new plan to explore space and extend a human presence across our solar system. We will begin the effort quickly, using existing programs and personnel. We'll make steady progress, one mission, one voyage, one landing at a time.

Our first goal is to complete the International Space Station by 2010. We will finish what we have started. We will meet our obligations to our 15 international partners on this project. We will focus our future research aboard the station on the long-term effects of space travel on human biology. Research on board the station and here on Earth will help us better understand and overcome the obstacles that limit exploration. Through these efforts we will develop the skills and techniques necessary to sustain further space exploration.

To meet this goal, we will return the Space Shuttle to flight as soon as possible, consistent with safety concerns and the recommendations of the Columbia Accident Investigation Board. The Shuttle's chief purpose over the next several years will be to help finish assembly of the International Space Station.

Our second goal is to develop and test a new spacecraft, the Crew Exploration Vehicle, by 2008 and to conduct the first manned mission no later than 2014. The Crew Exploration Vehicle will be capable of ferrying astronauts and scientists to the Space Station after the Shuttle is retired. But the main purpose of this spacecraft will be to carry astronauts beyond our orbit to other worlds.

Our third goal is to return to the Moon by 2020, as the launching point for missions beyond. Beginning no later than 2008, we will send a series of robotic missions to the lunar surface to research and prepare for future human exploration. Using the Crew Exploration Vehicle, we will undertake extended human missions to the Moon as early as 2015 with the goal of living and working there for increasingly extended periods of time. Returning to the Moon is an important step for our space program. Establishing an extended human presence on the Moon could vastly reduce the costs of further space exploration, making possible ever more ambitious missions. Also, the Moon is home to abundant resources. Its soil contains raw materials that might be harvested and processed into rocket fuel or breathable air. We can use our time on the Moon to develop and test new approaches and technologies and systems that will allow us to function in other more challenging environments. The Moon is a logical step toward further progress and achievement.

With the experience and knowledge gained on the Moon, we will then be ready to take the next steps of space exploration: human missions to Mars and to worlds beyond. Robotic missions

will serve as trailblazers: the advance guard to the unknown. Probes, landers, and other vehicles of this kind continue to prove their worth, sending spectacular images and vast amounts of data back to Earth. Yet the human thirst for knowledge ultimately cannot be satisfied by even the most vivid pictures or the most detailed measurements. We need to see and examine and touch for ourselves. And only human beings are capable of adapting to the inevitable uncertainties posed by space travel. As our knowledge improves, we'll develop new power generation, propulsion, life support and other systems that can support more distant travels.

We do not know where this journey will end, yet we know this: human beings are headed into the cosmos. The vision I outlined today is a journey, not a race.

We choose to explore space because doing so improves our lives and lifts our national spirit. So let us continue the journey.

Sean O'Keefe

Given that very clear, concise direction that even the public affairs folks can render into something that is a very direct manifestation of what the clarity is of what the President has charged has really focused our attention in very broad and important ways. The objective—I've got a very brief presentation—I can walk you through it; I will not labor you with each of the charts that are involved here, but just to highlight a couple of points. Hit the next slide, please, if you would.

Again, the objective is to implement a sustained and affordable robotic and human presence in a variety of different approaches towards our exploration agenda. The debate back and forth as to whether or not there should be one versus the other is really clarified to a stage of looking at the broader set of objectives that could be achieved by a steppingstone approach, by advance robotic capabilities and then, as called for, the human characteristics that we bring to exploration objectives on a specific surface—as opposed to a severability between the two. And again, the specific objectives of what he has charged as part of that presidential directive is a promotion of international commercial participation and, indeed, to borrow a term that I think the Commission has used on a number of public hearings that you've engaged in so far, to really develop a space industry, to focus on a much wider range of capabilities, and change our view and typical approach that has been taken in the public sector and certainly from a government contracting standpoint of being the consumer of product or services to being more of a facilitator of entrepreneurial thinking of how we access capabilities in the broader space objectives. I think the trend and [at least?] focus each of you have articulated on that point is very attractive, very consistent with this strategy, and exactly the kind of thing that we seek your advice on how best to implement and to do it in a way that's likely to yield the result that has been spoken about. Next chart, please.

Again, the objectives of what the President has articulated is exploration. And indeed, as the first bullet, the first objective, the first primary focus, this becomes a rather historic directive, if you will, and strategy and policy in its own right because exploration is at its core. And, again, if I had to point to any one aspect of what is clearly embodied in this presidential directive that was

manifest in the President's thinking, in his direction to us from the beginning when we first assembled, to the end, it was this is the point: it is the act of exploration in and of itself that is the goal. And how you achieve those objectives and how you determine exactly where they should be pursued becomes matters of extreme consequence and importance, but nonetheless, it must be the human desire to want to explore that we are essentially responding to with an approach like this. Extension of human presence, again is a range of opportunities that can be presented therein that will, again, follow a broader robotic capability that therefore advances those circumstances.

Innovation, I just touched on a moment ago. And, I think, again, the Commission is way ahead in the thinking in terms of the direction where we need to be thinking innovatively how we do this to the point of changing the roles and relationships that we typically have considered in terms of what is a public-private, you know, sector kind of focusing, and as well as partnering arrangements. There is, again, on this aspect, and I hope that the sense you've gotten from what I understand from the public testimony from our international partners is there's great enthusiasm for wanting to pursue the next stages of exactly how do we specify that. That's what I've heard from them in private discussions. And certainly as a consequence of the very ambitious structure that has been created in the International Space Station program, the infrastructure is there to do this, as well as the relationships, the communication network, the engineering teams, top to bottom. This is a very well-coordinated process now. And in developing the interest from the primary partners who have been engaged in the International Space Station certainly would be the easiest to begin to pursue early. And that, indeed, is where the earliest indication of interest is developing of partnering arrangements as we move forward.

The remarkable difference I think in this one, and again, it's an aspect that seems to dominate some of the current public debate is this is not an Apollo-like program. For some reason, this is not being construed at times as "Why would we need to pursue something at such a breakneck circumstance and a crash program in order respond to what?" Well, it's a question in pursuit of a problem. Because it doesn't exist. That's not the objective that's being articulated here. This is very much a program that is, again, a journey, not a race. It is not driven by an imperative to either win or avoid the consequences of not winning. That's not the point. And that's not what it's about and it's not what it would conceive, this particular objective. As a result, it really focuses on, I think, an issue that the Commission has again opined about as well, that we look to you for various—for advice on how we may achieve this to make it a sustainable kind of effort over extended periods of time.

I think the way the strategy was constructed very specifically, it was designed for the purpose of having a longer-term set of objectives that would be carried out. But at the same time, it also required, I think, an approach of looking at what those elements of sustainment need to be, in the broader effort, that we can begin to sketch out and look at some framework to get some very specific ideas on how to implement that from a strategic standpoint would be extremely valuable. And the second major feature is it must be by definition affordable. And therefore, again, not a crash program that requires massive investments or even large investments. This is more that

should be very much in line with the approach that—and I'll speak to that here in a little more detail in just a moment. And then I think at the core of this is a point that was very evident to, I think, those of us who participated in the assembly of the vision and the strategy and the options that the President ultimately chose from, is that business as usual, if we simply try to overlay this on top of an existing structure, isn't going to work. That's not what we're about doing. There is no way that the present organizational structure and how we do business today will be the most appropriate way to go about doing this.

Could it be achieved? Sure. With a fair amount of coercion, insistence, axle grease, steam, a few other things, it might be possible. But that's not what the intent is here. The objective really has to be to look at a transformative model that facilitates and doesn't force this as a function for the purpose of achieving this strategy. And that's an approach, again, that I've been very, very gratified to hear the kind of discussion that the Commissioners have taken on in this question has been extensive. And really thinking through "What are the specifics of how we would achieve that kind of effort?" and the discussion that we've had that you've offered to us to spend time thinking through what some of those organizational alternatives has been extremely beneficial and we thank you for that. Because it's truly helped us move the ball forward in that direction as well.

So again, in order to achieve it, we must set priorities. And that's clearly what the President's vision does. Fundamentally transform. And, in so many ways, again exploring different approaches with you and your tolerance of hearing those alternatives and offering different viewpoints on how we may pursue that has been helpful, as well as fostering national capabilities that would exist outside of NASA, within the broader federal expanse, as well as through commercial and international options. Next chart, please.

The means by which to go about this particular approach of sustainment, as well as to look at transformation, really calls on, I think, the necessity to look at three basic real simple questions: the *what*, the *who*, and the *how*. How do you define exactly how do you go about doing this? And what is it we're attempting to achieve? Well, the strategy clearly begins with whatever ultimately the Commission produces here in the time that you have to deliver that document in terms of what you think the appropriate strategy of guideposts ought to be as we implement. To look at this I think, Mr. Chairman, as you mentioned in your opening comments, as a system of systems. This is not a production, or a program. And, in fact, in many ways, found that some folks who are in oversight capacities that reside in certain locations in Washington, DC, that happens to reside on a place that's a little elevated from the rest of the city, are frustrated because this is not a program, this is not something that defines itself as a program. And the question is usually posed "What does this cost for this program?" And the answer is "It isn't a program. It is a strategy, a broader focus on how you look at a system of systems." And the systems of systems can also be how you assemble components in different ways to yield entirely different consequences and results than what any element of that set of components could yield on their own.

And this is a point that seems to be challenging as a concept to understand, but it is one that your participation and your adoption of that very phrase has been extraordinarily helpful in moving that process forward—in educating and really enlightening folks to look at what the nature of that issue means and how you go about that approach. It becomes the key that unlocks an awful lot of the focuses on how we would perceive.

The capabilities of systems integration, again, this is something that NASA has always been very, very good at. Indeed, the large-scale systems integration effort has its origins, in many respects, in the Defense Department, as well as in NASA in the 50s and 60s. And certainly taking pages from that historical experience of that process, that strategy, is what we seek to do now. Not to duplicate the technology or to duplicate the same way we did business at the time. But instead to take the notion of how that systems integration approach, which is really what separated us in so many ways from so many of the other challenges we had previously encountered, is part of what we needed to adopt. And again, we spent time on partnering, as well as leveraging, entrepreneurial opportunities. Those are critical ingredients.

The *who*, organizationally, has to be a complete change in the focus of how we look at who we are at NASA. Instead of an organization of research and development centers that number ten across the entire United States, each with their own proficiency, of which there is an occasional opportunity to meet at Bretton Woods and decide exactly how the relationships will be working, as if we were negotiating treaties, this really has to work as a very collaborative, cohesive effort. And it's one that we are fortunately not at the beginning of. We didn't just start this particular process. It's one that has been two years in the making. And working through the challenges of thinking like an organization that is focused towards broader research and development opportunities, technology development, and in turn, the opportunities to participate in what are extended exploration challenges.

So, in that respect, there's dispositionally a mindset that I think is accepting and certainly willing to look at a broader range of approaches on how we do this and we've already headed down that road to great effect. It means being very clear about requirements definition, rather than commissioning elements of our agency to go off on their own, devise the idea, develop a program, produce a product, and then let's see what the results are. No, no. This is one which you have to be very disciplined about defining what the requirements are for we proceed with. This is not—in sharp contrast to the research and development strategy and focus that is employed in some sectors with great effect—this is a very clear effort to migrate away from the philosophy of a thousand flowers blooming and then anticipate which ones may be the most successful and therefore develop from there. No, this is a very targeted approach of developing requirements that requires a much greater degree of discipline than what organizationally we have put to bear so far—or organizationally been structured to do so far. Looking at things in very specific stovepipes is an approach that really isn't requiring a change. And capability management: this is the infrastructure itself. And there are so many ways, that I think from the comments the Commission has offered on this point in your public statements and public commentary and hearings, it will be very helpful in moving forward in terms of how we look at

that infrastructure management in a way that brings those capabilities to bear on the larger challenges we involve.

The *how*, I think, is again still very much a work in progress, but there is some basis to build on there. The process of transformation in and of itself, I am—presume under no circumstances to advise several members of this group of exactly what the challenges are related to that. You know it far better than I, have experienced it, or are currently living through it. Any one of those can certainly be categorized by lots of the members here on the Commission. So the process, you know, is challenging under any circumstances in any venue and in any events. And so therefore we're taking that as a serious charge and not one that is assumed to be of success. It is going to have to require a number of very specific objectives as we move forward.

But what we're building on, is, I think, an element that also I am very pleased and proud to say to you in recalling as part of the history of the President's decision on the strategy and the vision he chose is that we're building on a organizational foundation in many respects that is the best in government. The President came in with a very specific approach in the President's management agenda of outlining five critical areas. They are five areas that have been part of the public administration, public management of the federal-sector fabric for as long as I have ever known. And yet he very consciously went about the business of saying these are five things that we're going to take on, show progress, show results, demonstrate how we're moving forward rather than simply put them on a poster and keep describing how we pledge allegiance to them. And set up a very specific structure for the purpose of implementing that management agenda on the very specific focus of dealing with the fundamentals of what call for credibility and public management.

On two of those five categories, budget integration and performance, as well as the approach that we've taken, you know, across the board in a wide range of areas on human resource management and human capital and the strategic planning thereof—on those two areas, we're designated as the highest-ranked agency of the federal government, in terms of looking at this problem proactively and seriously. First in the case of budget performance and integration, to be the first agency really truly in compliance in our efforts with the Government Performance Results Act, enacted by congress ten years ago. This is the first tangible opportunity to say yes, there is a linkage between budget and performance and how you can see a consistent relationship therein.

And on the broader human resources, strategic management of human capital, the objectives we've laid out have earned and garnered the highest ranking of any federal agency in that particular category as well. And progress on the other three as well for information technology, as well as competitive sourcing and financial management systems. We have finally, as of just about eight months ago, moved to a position where there is one financial system in the NASA. One. That's it. There isn't another. There's one. That was a momentous move all by itself. And we're still working through the challenges of that. Again, looking at lots of folks who are members of this Commission you know precisely the challenges of moving any large organization towards one of anything. Agreeing on the time of day is usually a momentous time.

But getting to one financial system is unbelievable. And it's had its challenges and it still has its consequences. But it nonetheless is an element that has now been accomplished. We're working through the residual growing pains of that effort, and it's one that continues to take some real serious challenge as we move forward as we build on that. But it nonetheless is a foundation we can build on and one that no other federal agency can lay claim to as well. They're all still moving in that direction and very successfully because in so many ways the President's management agenda has helped focus on that objective. And again, continuing success in achieving the implementation milestones: that's again what we seek guidance from the Commission to do. Let me turn very quickly to the affordability question, as I mentioned and I'll make this relatively brief. Next slide, please?

Much has been talked about, written about. How affordable could this be? Well, just to start from a relative context, this is a historical funding chart that reaches back to 10-plus years ago in terms of what the NASA agency funding levels were as appropriated. We are basically climbing out of a trough and have been now for the last three years. And in a way that at this point is very much directed towards an effort to have a more targeted, focused, prioritized set of objectives in the strategy involved. So rather than reach back to 1991 and say, "Let's go ahead and duplicate that same period of time," that wouldn't get us any better off either. That level of resources would not be specifically well spent in the manner in which it was devised at that time to be replicated today. Instead, it requires and therefore the President has not asked for, a massive increase in resources over the course of time. Instead, it is relatively modest and it would do no more than bring us back to slightly less than the amounts we experienced as an actual matter in 1995. So as a consequence, this is not a major investment of up-front capital. Trust us, you know, it's going to work. No, this is a very gradual kind of development that builds on success as we move along. Next chart, please.

The plan is, and I've got one more graphic I want to show you in a minute, but the plan is, in terms of the affordability, is very consistent and exactly in line with the President's objective to cut the deficit in half in five years, to assume long-term projection of only inflationary growth, as soon as that particular level of attainment has arrived and is fully consistent with the plan. Indeed, much of what he was—was part of this direction as we developed the interagency process was that it converged, not be parallel to or separate from, the budget process. So that at the end, upon the conclusion of the vision option he ultimately selected and the approach that he wanted to go with and the strategy he wanted to lay out, wanted to assure that, in doing so, it would meet the affordability test. This was a very rigorous process that put through this particular effort. Not just in the fiscal year 2005, but in the long term, what does this portend? That this not develop or require some massive balloon note at the beginning of the next decade or something else. No, over time, this has to fit within the parameters of where we go and so therefore is dependent of not only of the elements of I think consistent kind of resource base from the Congress, but also that we transform as an agency to accommodate this adjustment and the approach we take to it.

The overall budget itself, again, is less than 1 percent of the federal budget. That is significant in that it is about the historic standard that we've experienced and less than so from 10 years ago.

In sharp contrast to that again crash program era of the 60s and early 70s in which it was five times that number, we are nowhere near that figure and never climbed to that, and at no point based on the calculus that I can see do we see a phase in which the NASA budget would exceed 1 percent of the federal budget, even over the course of the next 10 to 15 years.

The plan provides, you know, again, for an investment in the overall space program. But also, I think, just to borrow a phrase again, should be part of the overall effort to transform to the broader space industry approach that you've outlined. It assumes setting priorities, again retiring completed programs as we move along, as is articulated for the Shuttle program and elsewhere and investing in different content in order to reach those program assumptions. Over time, again, it's a steppingstone at a time and building on successes as they're achieved. Next chart, please.

Building on those successes again require—and again we'll go through great detail here. And as the President articulated as part of his speech on the 14th of January, as embodied in the President's directive of that date, as well as summarized briefly in the commentary we started with this morning, is returning the Shuttle to flight. And so much of the rest of the program is dependent upon that effort in order to complete the International Space Station, garner the research necessary in order to advise and inform broader exploration objectives: that's what we're committed to doing. So, as a consequence, that becomes the paramount priority as we move forward is to achieve that and do it right, to do it in compliance with the Columbia Accident Investigation Board recommendations and to not waver on that charge. To operate again—to conduct the research necessary to understand the broader exploration objectives is what is the primary focus of that. Operating in deeper space condition. Again, our experience with the Mars rovers here in the course of the last four months. And the continuing success, there seems to be no end in sight here. I mean, it's continuing to operate in ways that we never thought imaginable. So building on that understanding and that broader capacity and performance than what we'd seen is an opportunity in the next set of robotic missions here in a couple of years is to build on that capability now, to build that into the revised mission profiles and to do it a way that will be important. As well as, again, the range of other missions that are listed therein—in the President's management agenda I spoke to very specifically. Next chart, please.

Again, this is a chart that has gotten some currency, and it's been analyzed, described, dissected, reviewed, full range. And again, the objective here is only to demonstrate that beyond 2000—I'm sorry, the 09 timeframe, that there isn't a large investment required thereafter to meet the commitments made five years earlier. That's not what's involved here. Each step [video dropout]. There's lots of adjustment that could be made on this scale. Whether or not the International Space Station operates to date x versus date y . It's going to be all driven by when we achieve the research harvest it was built and designed to do, which, in this particular case, is now focused very directly on advising and informing the [video dropout]. Each of those steps along the way, again, is subject to lots of different interpretations, but it is not, again a program. This is a combination and a strategy of ways to go about pursuing this that's dependent upon this transformation objective. And finally, the last chart.

We're exploring ways to move forward. And, again, you've been extremely helpful in forming those kinds of questions that we [video dropout] thought about a fair amount, looking forward to advice and strategies that you will be producing here in the very short time ahead that meet the kind of objectives that we've talked about throughout the course of this particular discussion. Also view the necessity I think to adopt one of the essential tenets and objectives to inspire [video dropout] ... and nail it, you know, very clearly and directly, at this point. The likelihood is that most of the folks who are in grade school and high school right now are the ones who ultimately will carry this out to its ultimate objectives. And so really concentrating on that generation of explorers now is an opportunity that we have really spent a lot of time and effort in working through as well.

And finally, I would just conclude with—in the manner in which I started, so much of what prompted this, I think, very deeper consideration of where our space policy should go, the strategy that we should carry out, what the objectives should be, and indeed the quest for exploration, was tragically as a consequence of the loss of seven really remarkable people. Their legacy, as a consequence of this, is what motivates me every day to be thinking about the imperative that we get this right. And in so many respects, they took the risk of the broader cause of exploration in so many ways that is the manifest of the President's comments just days after the accident: exploration is not an option we choose. It is a desire written in the human heart. And, indeed, so much of what we're about [inaudible—video dropout]

Pete Aldridge

[Video dropout] ...comments made about some of the things that we've heard through three—I guess three—months now of our discussions in terms of business as usual won't work, the national view of things, that we have to go through transformation and so forth. So I'm really encouraged that, one, maybe you're hearing things that are ongoing, which is good, and we're encouraged because you kind of believe they're right. So it's a two-way street, that is very good. I've got one question and we'll open it up. I'm really worried about uncertainty here. I read what is going on in Congress and I get really bothered.

They yelled at you for not having a vision and now you've got one, well, tell us, you know, you're not giving us enough information. And I know there are some things you could be doing in 2004 that could get you steered on this vector, and they're not letting you do that, and it's not even clear that the funding available in 2005 may be there, so that's one uncertainty. The other uncertainty is that suppose we can't get the Shuttle flying as early as we would like and so those—the sand chart, the infamous sand chart, starts delaying the time in which you can get the Space Station finished and the money started funding into really the exploration. Could you address those two concerns of uncertainty?

Sean O'Keefe

Sure. Well, the—in somewhat of a Churchillian twist, you know, this is one of the messiest processes going, but it's the best one that's out there, you know, I mean, it's a variation of that theme. And again, I think your history and recounting of it is precisely right, Mr. Chairman. I still have the ringing in my ears of lots of members of the Accident Investigation Board, members of Congress, lots of committees, all insisting that it was time, necessary, absolutely imperative that there be a direction articulated and not just by anybody, it had to be the President of the United States. They were very specific about this. They didn't even leave room for margin of how it would be delivered. And, you know, lots of interest on how the process shook out and who was involved and lots of alternative and competing views. All of it was had. All of it was engaged in. There was just no end of hearings of different ideas. And some—and the ideas ranged from very interesting to not quite as interesting, but they were all vetted. Everything was on the table, and in the end the President chose this approach. He responded, answered the mail, very directly, in his own words, himself, in person. We're moving forward and put the budget forward to say here is where we're going. This is a moment in which the basic fundamentals of, I guess, the American way of doing business is required to be reviewed at its basic level. The administration and the President, very specifically, is charged to propose and the Congress is requested to dispose. When they act one way or the other, that will be the result of what is involved here. But in the process, let me assure you, we are providing any and every amount of information and detail that anyone has asked for. And in inventorying this on a daily basis is there any residual request out there? I can't find any. All of them are being responded to promptly. And, so, as a consequence we're attempting to move everything and anything we possibly can to anybody who has further information or detail necessary to understand it.

Let me, I guess, comment very briefly on the issue of getting started in 2004. There are only two elements in 2004 that have direct relationship to new elements of the exploration strategy that are included in our 2004 planning. The first is the establishment of a Centennial Challenge program, which is a variant of a theme that several Commissioners have talked about. And we are intent on proceeding with that, and I understand there is a big difference between the kind of number we have in mind and the kind of number you have in mind, but that's OK. At least get the concept started and moving along works. That's one that is very unique or different than what we had proposed in the budget and the second one is the cost to run this Commission. Those are the two things. There isn't anything else related in 2004 to getting ahead of the exploration objectives.

Pete Aldridge

You mean we're not going to get paid?

Sean O'Keefe

I'll be delighted to inquire if the committee is in appropriations on that matter. But both of those have been suggested and that's the only two that fit in the category of any new or different in this fiscal year right now in 2004—different than what had been justified and ultimately acted upon as part of the appropriations measure the Congress acted on earlier this year.

So, as a result, the 2005 issue very much is in doubt. There's no question. That's a—in terms of its progress and process and so forth because no—neither chamber has acted as yet on any appropriation bill, to my knowledge. So this is not uncommon. It certainly isn't targeted toward this agency and isn't towards this policy. It is across the board. There is not a single measure moving anywhere. So as a consequence there is a—certainly a pattern in that that would suggest that there is an effort that we've got to be very attentive to as we move forward. But, for 2004 there is no question: the continuing effort which laces into the second part of your question is imperative, which is to continue to move forward to implement every recommendation of the Columbia Accident Investigation Board. There is no wavering in that. There is no exception to that. We will not interpret it necessary in order to move through that. It's going to be compliance with each of those recommendations before we fly.

When we're fit to fly, that's when we will, and so however long that takes, which is the second part of your commentary, is what it's going to have to be. And, I'm optimistic now. I think the oversight that we have requested of a very, very extraordinary panel of external experts of every discipline that could be assembled, just about—I guess there is probably exceptions—in the form of the task group overseeing the return to flight activities, have now examined and viewed as compliant the approaches we're taking with several of those recommendations, and they meet regularly, early, often and examine everything we're doing. So, if we're stumbling anywhere, we'll know about it in very short order. And, so far, it appears to be on track, and I'm optimistic about our progress in that direction to be looking at an opportunity sometime after the beginning of next year. But that will be dictated, again, by a determination that we'll make as to whether we think we are then fit to fly at that point. When we feel that that's been complied with, that's when we'll go.

Pete Aldridge

Neil?

Neil Tyson

Sean, I spent my life in academia and, and in education—

Sean O'Keefe

And I'm envious—don't try to rub it in!

Neil Tyson

I'm not trying to rub it in, I'm just trying to say that whenever I see something as clear as the information in these NASA brochures, which is clearer than other NASA brochures, I might note—but, the budget, the layout, what gets phased in, what gets phased out, and then I read in the newspapers bipartisan puzzlement over the steps that need—puzzlement over what NASA plans to do, I just don't understand what's wrong. Either there is some cognitive problem on Capitol Hill or maybe—

Bob Walker

Welcome to my world.

Neil Tyson

See, I can say that, but Bob can't because he's from Congress. Or I wonder if there is another thing going on here. Maybe to say, "Well we're not sure, but what you're doing here," is not so much that they don't understand these charts, maybe they just simply don't believe the charts. Maybe NASA's legendary spending past is coming back to haunt what is fundamentally a sound vision, but now we have to sort of empty all that baggage and show that there is no—nothing hidden within it. So I just would like you to comment on that and whether, in retrospect, perhaps the vision should have not been so fiscally responsible.

Maybe it should have said, "Let's double NASA's budget," and then everyone would say, "Well, of course you can get the vision done with that much more money." Then there would be no debate here about whether it could happen for that much money, and no one would think anything was hidden. So, I'm wondering if you could just comment on whether it's just a disbelief, given NASA's historical spending habits.

Sean O'Keefe

Dr. Tyson, I think there's something to that. The credibility of this agency has been tested on several occasions. Indeed, I don't fashion myself as having been a natural pick for this capacity. Indeed, it came around as a consequence of two days after Inauguration Day, the revelation that there was a \$5 billion overrun on the International Space Station just kind of showed up. So within a year thereafter, I was in a position where, having looked at lots of other alternatives, the alternative was no, it's necessary to send someone to NASA with a capacity, or at least some passing background, at understanding what the resource management challenges are of running a large organization. I barely fit that criteria, but that's ultimately why that occurred.

I don't fit the usual pattern of why various selections have been made in the past in terms of the kind of competencies in engineering, and technology, and scientific community: I mean, I fit none of those categories. So it has been as a consequence of that very point and the credibility of this agency has been tested, no question, in the past. That said, I've worked tirelessly for the last

two years to do everything and anything we can think of in order to restore that credibility, and it is, nonetheless, a long, long haul. It's not something that gets done overnight, and it's not something that gets done by the appointment of anyone, or any group of people. It's got to be a sustained effort over time. And the approach that we've taken is to look at, again, things like the International Space Station and a variety of different programs that have certainly, in the course of my tenure there, to have a sense of understanding of what those resource demands are, to be very clear about what you know them to be, and to not make it up when you don't. And so part of what has certainly been a potential contributor to the credibility problem is the propensity on my part to say, "I don't know," when I really don't.

And I think that's a more important approach that we have adopted than trying to say, "Well, what answer would you like?" OK? And that's an approach that we simply have not adhered to in the course of my tenure. So I think there is a fair amount of reputation building that is necessary and, again, I don't want to ascribe it to malice or belligerency on anybody's part or institutionally. It's more, I think, as a consequence of how we've been organized and how we do business. It has primarily been focused on each activity, then soup-to-nuts setting its own requirements, objectives, programs, producing and then carrying them out. And the rest of the agency occasionally wishing them well, if they're aware at all—as opposed to marshalling all the capabilities and resources of an agency toward specific priorities.

That's the direction that I see in this strategy that is so imperative that we do differently. And we've been moving in that direction for the last two years. But, again it's something that takes time. And I can't, under any circumstances, you know, think of any way to instantly grant credibility in cases in which that hasn't occurred. And I think an important caveat to everything I've just said is that we are involved in an inherently risky and very unknown set of activities in which it's hard to estimate because no one has done some of this stuff before. It's very hard to find a benchmark for "How do you put two rovers on Mars?" There isn't any. This is it. We're as surprised and pleased as anyone else is. But at the same time, this is a new benchmark. And the establishment of each of the steps along the way, the things we do, there isn't any way to reach back and say can we find out how that's done? We're usually plowing new ground, and that's why this agency was founded in the first place. So it is by its very nature an agency that always will, I suspect, ride the edge of the credibility curve, as it does the edge of the technology curve, as it runs at the edge of the—what is the edge of the envelope in terms of the kinds of things that can be achieved. We're doing our best, though.

Pete Aldridge

Thank you. Carly?

Carly Fiorina

Mr. Administrator, thanks for being here this afternoon. I was encouraged in your presentation that you used, I think, very consciously, the word *transformation* when you spoke about NASA.

You did not, for example, use the word *reorganization* or *optimization*, you used the term *transformation*. And I think that means something different than *reorganization* or *optimization*. And I wonder if you could just talk a little bit about what the difference in your mind is between *transformation* and mere *reorganization*. Not that reorganization isn't complex, it is very complex, but transformation is more complex and I think it's one of the things that this Commission certainly believes is necessary and it's clear that you do as well.

Sean O'Keefe

Thank you. No, I—indeed, I could take substantial lessons, and therefore copious notes, from many of you who have experienced exactly this kind of adjustment and clearly appreciate, as I know you do, the distinction between each of those points. And it is, I think, as you appropriately say, a reorganization effort would typically be undertaken in order to optimize, be more efficient about carrying out a stated set of objectives that are similar to what they were yesterday but to do it better than what you did yesterday. Or to adopt new approaches that may reveal themselves in terms of manufacturing process, marketing effort, whatever else, in order to achieve those kinds of goals.

But again, fundamentally, the goals and objectives of what's required are not the same, but similar, to what they might have been yesterday. This is an effort to be more efficient and more cost effective or more managerially prudent about how they carried out.

A transformation means adjusting the way you look at the problem—very different ways—and looking at what the issues are, what the imperative is, what the goal is. And, in many respects, what the President has delivered for us here, I think, is a vision that is very expansive, one that is, quite frankly, much broader than what the agency had been dedicated to in the past, and while it may have harbored the desires on the part of lots of folks—lots of very smart folks around the agency who had always hoped for this degree of expansive expression of mission goal and objective—nonetheless we've been organized to do things like we did yesterday. And so in many respects what has occurred over the course of just recent history, I think, is an effort to try to again optimize, to improve the manner in which we attempt to deliver on services, or research, or developmental efforts or whatever else. This is a case where we're really focusing on the broader aspect of—and goals of—the exploration agenda. It calls for looking at this as a much more strategic view, one that is, again, systemic as opposed to program-oriented, and the programs then flow from that set of strategies that are understood. That's a different way of looking at the set of challenges. Because in so many ways the disciplines represented within our community and within our agency are much akin to harking back to a period of my life that I sometimes pine for in a great way, particularly during congressional hearings, is the university life. It is very much like that. Lots of different disciplines, lots of different approaches, lots of different ways of looking at problems, and there is an occasional willingness to exchange on how those different disciplines view those problems, and if it happens occasionally it's considered to be accidental. So—and we can't afford that in this circumstance. This is not something that should happen as a consequence of just good fortune. So, the transformation objective I think we

need to be about is around those strategic goals as opposed to optimizing efficiencies as a management focus.

Pete Aldridge

Maria?

Maria Zuber

Sean, shortly after the President's speech, there were significant parts of the scientific community that felt disenfranchised from the vision and part of it, as we can tell, is that there is now a strategic focus within NASA and some of the complaints we heard had to do with "Well, we've had years and years of committee reports in which we've laid out objectives for the most scientifically important things to do." And now this new vision, if it's going to be implemented in the way the President suggests, is throwing all of that away and starting something else. And as the dust begins to settle and people start to see what's really associated with the vision, it seems to many of us, anyway, that there are great opportunities for the future.

But I'm wondering if maybe the way that we've thought about the process of selecting NASA-based science maybe needs to be re-looked because it's always—and the way we've done it before on all these committees of which all of us here on the panel have served on many of them, have all started saying you have to pick a scientific question, and then you have to figure out how to do it, whereas what is happening with this vision is that it's really creating capabilities to go out and explore in ways that you haven't done before. So maybe all of these scientific advisory committees really need to go press Control-Alt-Delete and go back and start to think about what kind of science you would do if you had capabilities that you didn't have before. And so maybe we need to start thinking strategically about the way that we're doing our science within NASA.

Sean O'Keefe

I couldn't agree more. I think you've just hit the nail on the head. This is the first part of the scientific agenda, and it will not change, should continue to be: Pose the questions. What are the things we really are looking for answers to? What are the issues that should guide the kind of exploration focus that we see and utilize those capabilities and capacity to go seek answers to those enduring questions? That is an invaluable aspect of, I think, what the scientific community has done and, I'm certain, will continue to do, given the right challenge and motivation and interest.

What is different on this, and again I think you've got it exactly right, and I would hope that it would be viewed as liberating, but instead it's been viewed a slightly different, way which I find curious. But I would hope it would be viewed liberating as to then not ask scientists to then assume the role of being program managers. I thought you were scientists, OK, and that the objective was to pose the science questions, lay out the science agenda, but then to say, "OK,

that's it, you have to move over here and conduct the program management effort," is what has led to some of the challenges I think Dr. Tyson referred to. That's a Herculean expectation on the part of anybody to transcend disciplines and to be able to navigate very widely and freely into a range of those kinds of capabilities. So, part of what is being created here, I think, is the capacity, the capability, the talent to look at this as a system-of-systems challenge. A systems integration challenge: how do I assemble pieces and parts to go carry out this objective? To answer those questions and then have a scientist do and focus on what is really an extraordinary contribution, which is: what are the questions, how do I go about answering them, what is the discipline I need to put to gathering information to achieve that? Really becomes quite an efficient way of looking at the challenge.

I'll give you one very narrow example that I found to be—it turns the argument very dramatically, and it's the kind of thing we have to duplicate, I think, across the board. Most—as I understand it—members of the scientific community that have looked at a range of deep space exploration objectives in the past have found that one of the limiting features always has been, fine, pose a science question, tell us what the research model is, tell us what it is you're attempting to understand, what information you have to gather, how do you do it—oh, by the way, you'll be restricted to an amount of power during the course of a flight that will equate to—nothing like this: two, 60-watt light bulbs. That's it; go away, you know, best of luck, and I hope you can work out the package. That's usually been the charge, because that's the limit of the energy draw that we can afford to do given conventional technology capacity that we employ for deep space exploration missions, which have to be in a very, very low-power-generation mode for extended periods of time and then activated years later to then generate the research package necessary in order to garner the scientific information and evidence that the scientist devised in the first place. Well, number one, if you assume that you find anyone with the patience necessary to last that long on most of these missions and, number two, that can design, as a function of this, an exceedingly low power-generation requirement for that span of time you've really defined an extremely difficult problem that most scientists then become finding themselves in the role of being really good engineers of trying to devise.

Well, what if we changed that and said, "Don't worry about the power requirements. We'll give you 100% more. No, I'm sorry, 100 times more than what you're currently dealing with right now. And your challenge is to try to find a means to fit within a very limited mass, volume, spatial distribution, but no other challenge than that. You tell us what you can do and give us the range of options of what you think you could fit within that." Suddenly it's liberating. That's what project Prometheus is all about. That's what that whole effort has been dedicated to do in the last year and a half is to look at power generation and propulsion capabilities that liberate the scientific community from being engineers. And liberates engineers to start looking at those challenges in ways that comply with how you deliver on capability that is demanded as opposed to thinking like "What do I do in order to mollify the scientists who want more data, research, evidence, whatever?" It really puts folks into their expertise wheelhouses much more efficiently by this mode.

Pete Aldridge

Michael.

Michael Jackson

Sean, I join my colleagues in thanking you for being here with us. Also in thanking you and your team that has worked with this Commission so effectively. You've shown an intellectual nimbleness yourself here today. That's no surprise for those of us that know you but your management team has, too, already indicated that they're ready to walk down this road of transformational change, and I think that's a very encouraging thing. So, I want to ask you, really, a question about how you deal with the private sector and how you manage to be nimble over time and changes; the private sector grows in its capacity to answer parts of your core needs. I guess my real question is if you've laid out, as you have, the need to offload to the private sector those things which the private sector can do adequately for you and reserve your core resources for the things that nobody is going to do unless NASA does it well, how do you manage that over time? Have you thought about what type of procurement structures, regulatory authority, budgeting plans or processes, any tools in your toolkit that you need that you could tell us, that we could help you with, to help you manage in spiral development cycles over time, procuring and deploy technology that we know we don't know how to do today but which will, over time, develop and become more rigorous?

Sean O'Keefe

Quite frankly, and thank you, Secretary Jackson, this is one that we really are looking for guidance from this Commission to working with because it is—I wouldn't say counterintuitive to the way we've done business but it's not typical in the way we've done business. So, as a consequence, intellectually, I think folks can look at various models of how to maximize the objectives you just articulated. But then organizationally and as a manner of process—"How do we follow through with it?"—is one that, again, the range of expertise represented here on this Commission is going to be invaluable to thinking through how we do this. But, as a dispositional matter, let me offer this: I don't think there is any desire—I shouldn't say that. Any time you use an absolute phrase you have to wonder. I think there is limited desire, from what I can tell, that there is interest within the agency of maintaining capacity capabilities that even come close to replicating what we could deliver on or acquire from or request of any commercial private-sector capability. It just isn't in the nature and the fabric of what the agency typically wants to do. Are there occasions in which we have duplication? You bet.

Are there circumstances where by necessity you have to because of its unique nature? Yes. There are some aspects that simply, no matter how much time and effort and energy you put into it, a market-generated kind of demand has not emerged, even though lots of forecasting would have suggested otherwise. So it requires—I think the operative term you used is to be *nimble* in those cases. Because if you believed, for example the market forecast for telecom services

requirements of just seven, eight years ago, there would have been this absolutely overwhelming demand for launch services out there that easily could have liberated us from everything we do in that area. There was only one problem with the forecast: It didn't materialize. So as a consequence the market conditions that were motivating in order to develop that kind of deeper capacity, had we moved in that direction precipitously at that time, might have been a very different situation. So we've really—we have limited experience at really understanding how to diagnose these cases or forecast them properly and understand precisely when we should transition best, and that's where the expertise that you all bring to bear can be exceedingly helpful. But as a general proposition, as an intellectual matter, absolutely. There isn't an awful lot of desire within our agency, I think, to wanting to replicate, duplicate, do the same thing that somebody else is already doing. By definition the kinds of things we're engaged in are as part of the mission objectives called for the things that only NASA can do, and there is great pride and exhilaration that comes from that and a lot more interest and excitement. So there is not an awful lot of interest in taking over the business of sausage making with our agency.

Pete Aldridge

Bob.

Bob Walker

Sean, I'm interested in the business of getting this thing off the ground. I'm concerned that, as we complete our deliberations here, that it seemed like an exceedingly short period of time for us but some in the space community are becoming impatient for the idea that we have to have more things on the table. But that before the ink is dry on the report that we'll give to the President that the Congress may, in fact, take the \$900 million out of your 2005 request and thereby leave you without the ability to move ahead, my question really is "What happens at that point?" I mean, is this something where you would recommend the President veto a bill that doesn't give you the sufficient resources to move ahead? Is this something that does debilitate the program in major ways going forward? And if I'm correct, I think it may it debilitate the ability of—to move forward on the Shuttle because most of the money that is in that \$900 million really relates to getting the Shuttle back online.

Sean O'Keefe

That's exactly right. Thank you, Congressman, I really wouldn't want to speculate on what we may or may not do based on some hypothetical set of circumstances. The facts at this time are that the Senate-passed budget resolution supports the President's budget request. The House-passed budget resolution, along with every other domestic discretionary agency and department of the federal government is to be frozen at the discretionary levels of 2004. Those are the two contrasting positions. And, indeed, the report language and so forth that accompanies both measures suggest very strong support for the President's vision, strategy, and objectives, and yet

the House has made the preliminary determination, in its budget resolution position, that the objectives of the broader resolution are more important and more significant priority than what may be contained in any one individual domestic discretionary account. So, those are the facts as it stands now. That's all that Congress has acted on so far. That's it.

Everything else has been public utterances from either the dais or with—of journalists or whatever else. And that's not inconsequential, but it nonetheless is not quite as guiding in that particular case. So, hope springs eternal that there will be an opportunity that the process will move along and move along in a way that is consistent with certainly the Senate budget resolutions position, in which case this becomes a moot debate. To the extent that it's not—again I think your illustration is exactly right—85 percent of the increase is tied up in Shuttle return to flight and International Space Station. Roughly \$140 million worth is related to really moving expeditiously and kick-starting further into Project Constellation—the Crew Exploration Vehicle and the approaches we've taken there. But, again, that's going to assume that a lot of work is going to get done, and I think as you have learned from discussions with Admiral Steidle and the exploration systems approach that we're taking there, broad area announcements are just now coming out in the next couple of months. So there is a lot of work to be done on that front. The immediate challenge is going to be return to flight and maintenance operation of the International Space Station. And there is no skimping on the support requirements that will be focused on that activity. So regardless of what level ultimately is approved and the Congress appropriates, our objectives will be to return to flight and sustain the operations on International Space Station, because there's at least two folks aboard there right now who depend upon that—their—literally their lives literally depend upon it. And we're not going to skimp on that at all. So as a consequence, everything else will then be relatively lower priority than that. And that's the kind of problem that gets compromised, I think, as we go along.

Pete Aldridge

Yes, Les.

Les Lyles

Sean, again, thank you very much for being here this afternoon and thank you for your steady leadership of NASA through these years. It really has been exemplary.

Sean O'Keefe

Thank you.

Les Lyles

As we look at the organization itself and obviously the first A is *aeronautics*, this vision clearly articulates space, and space exploration and everything that that portends. Do you see an

evolving of NASA in the future as the vision becomes more materialized, that NASA will become a space agency alone, or do you still see room for the aeronautics piece of NASA? We talked about this before, but I would be interested in your comments.

Sean O'Keefe

No, thank you, General Lyles. This is a critically important issue, and the more we really parse through as part of the strategy development, and in the inner-agency process examine the approach that we take, there are two factors that really drive us to conclude this is a natural fit that will always be synergistic, for two reasons.

The first one is that there are a range of aerospace technologies that are blind, independent, to the question of exactly how they're applied, whether it be the capabilities for aeronautics, aviation-related, civil aviation kinds of programs, or whether it's deep space exploration. There are just materials research activities, structures, aero-structures, etc., kind of capabilities that all lend themselves to the same kind of skill mixes, expertise, and depth of talent required to do any of the direction. How it's applied and how it's focused is a different question.

Along the way, again, how you apply those synergies is really critical. And what we saw in the *Columbia* tragedy, I think, was a reminder that there are capabilities across the agency that really, really could be utilized more efficiently. And that's what we're laboring to do right now in order to bring that expertise to bear in diagnostic capabilities and looking at trend analysis—a range of different things that are independent, again, of the aeronautics functions or space exploration functions. They're common disciplinary kinds of skills that can become extremely useful.

The second part of the equation, too, I think that's important is that one of the elements that has made the aeronautics piece of NASA over the course of four decades now an extremely successful effort is its long-term focus of looking at breakthrough technologies, that if we didn't do it, they simply wouldn't happen. I mean, it is not an accident that hitting the new, you know, air speed record of 5,000 miles per hour is something that we did and that NASA created as part of the X-43 program—a just recently attained objective. That's well beyond the scope of what anybody would ever dream of. Its relevance could be that, over time, not immediately, not tomorrow, probably not even the day after—it's going to be a while down the road, that ultimately if you can develop that technology, it becomes the liberating means of getting away from what has consistently been a vertical launch dependency. We've got to launch everything by a chemical rocket right now. The only way to get out of Earth's gravitational pull is to put an awful lot of mass and an awful lot of power into something that takes eight and a half exhilarating minutes to get off the ground. And you can only do it at a finite number of locations. Imagine if we could take this kind of technology and develop it over time to ultimately yield a horizontal capacity for launch. That suddenly becomes a whole different way of looking at the problem. Access to loads of different places you could do this. It suddenly makes this a viable set of space access objectives. There's only one problem: It either requires a suspension of the law of physics, or an invention, or a miracle in order to do that today.

Pete Aldridge

Or all three.

Sean O'Keefe

Or all three. And there are some programs that kind of died aborning because neither one of those three or all three of those weren't present conditions. But if we don't do this and the very notion that, you know, there would be anybody who would fly anything at Mach 7 and have it survive the experience, much less, oh, by the way, let's go look at another program that's going to approach more ambitious objectives than that in a few months' time—you wouldn't see it get done. There are a few commercial activities, and no other government agency who has that kind of long-term objective at looking at developmental efforts that in turn could have tremendous synergistic effect—a liberating effect—of technology breakthrough necessary to continue these objectives. So, it's a very, very close synergy that I think has to be carefully attended to but at the same time that we keep in mind exactly where those synergies exist as opposed to moving off in lots of interesting directions that otherwise wouldn't contribute.

Pete Aldridge

Sean, we appreciate your time and your testimony. And we really appreciate your leadership. Thank you for coming, and we look forward to talking with you more when we get close to the end of the report.

Sean O'Keefe

Thank you, Mr. Chairman, members of the Commission. Again, thank you all for your public service: it's invaluable. We look forward to the results of your efforts and we appreciate the time you've invested in this.

Pete Aldridge

Thank you.

It is time to open the floor for public comment from the audience. The process is that I have a bowl here with a bunch of names which have been submitted. I will draw names at random. I'll call two names, the first followed by the second. There's a microphone up here in front for you to raise your comment.

We will not respond to questions, what we would like to hear is your thoughts. And so my first person to come up is Bruce Damer. Bruce, come forward. And following him would be Rob Wilke. And you have two minutes. We have a big hook at the end of two minutes that pulls this way. Please try to keep your remarks to two minutes.

Bruce Damer

Thank you. About three years ago the United States Army, with a general directive, decided to task a team out in California to create something called AmericasArmy.com. You've probably heard about this; Admiral Steidle talks about it. Just for the audience, there's three and a half million people in its service, simulation game. It's sort of like a training game. You go into basic training in the game and you have a squad and come out and go into combat. It's fantastic. A million and a half people have done it. It improved the Army's image and probably the recruitment for the Army. Very, very small investment. And a bunch of us out in California working the NASA Ames, and recently in Houston with Buzz, we did a program with Boeing. Why can't we do an America space program massive multiplayer environment for the youth that are out there now into the teenage and into the 20s that is reality based that uses a lot of our simulation we've done in the agency and just put that out for people to get excited. You know, we're excited about television and Walter Cronkite in the 60s brought people into the program. It's online environments like these that are going to bring people on stream in the 21st century. So, that's just my input to the panel.

Pete Aldridge

Thank you very much. OK. The next one is Rob Wilke. And following him will be Ed Fisher.

Rob Wilke

Thank you, Mr. Chairman, Commissioners, ladies and gentlemen. My name is Rob Wilke. I'm from Long Island. I was captivated by the Apollo explorations and inspired by teachers through my youth. Then I hit physics and calculus and I decided to become a lawyer. But I'm here as a stakeholder today and I want to thank you for your service and if you could please thank the President for articulating really the people's vision.

Briefly, regarding education and youth: If you recall the transforming nature of the 20th century's GI Bill. If you could come up with some way to have a GI Bill for this century, I think that would go a long way to putting scientists and engineers in the silos; it would be very useful not only for this effort but for many others. NASA could be commended for its Explorer Schools Initiative, where it's reaching out to communities in not-as-advantaged parts of the country. And if you could find a way to ask them to continue to expand programs such as those. Also, to look to give grants or materials to some community or grassroots educational organizations to help them, or to help us, reach out to different communities not only defined as students or youth, but there is also other populations that need to hear what is going on with space exploration. And they need to hear it in different ways than in a K-through-2 materials packet or a middle school packet. Science and technology. Recalling Clementine's success from ten years ago. Please try to synergize and capitalize on whatever DARPA can bring to the table and what other federal agencies that are working for various other government groups can bring to help make this vision come to fruition.

Finally, management and sustainability. Stay goal oriented. Don't become destination oriented. Help us to realize that the goal can remind us that we're all stewards of this Earth and that the successes that come each step along the way can show that there are answers through this exploration that can help address environmental issues on Earth and to help improve people's lives.

We've heard about a social conscience. People are concerned about helping their neighbor. People need to be reminded not that only in this country but the developing world has benefited tremendously by space programs: resource utilization, mapping, weather forecasting. Sustainability. Get the word out for us stakeholders that we need to be more than armchair enthusiasts but really public policy influencers, and that will be something that will really help this to be a sustainable vision. Management: please follow the JSF model and not the ISS model.

And I think that will really help the people go a long way. And finally, sustainability: keep the lawyers employed. There is a lot that can go with international treaties, national laws as well as administrative regulations that will go to the next level and make the private sector have room to grow in space. My final hope is that we're all around in about ten years and the first crew that goes to the Moon will carry about ten of these lapel pins with them and, as a tribute to you, will be left behind in the soil. Thank you for your time.

Pete Aldridge

Thank you.

Neil Tyson

Mr. Chairman, I just have a quick question of the gentleman. You grew up on Long Island. Were you aware at the time you were a child of the role of Grumman in building space vehicles for the Apollo program? I just wondered. Were you aware?

Rob Wilke

Very much so. My father was an electrical engineer, he went to school through the GI Bill, he worked at Grumman.

Pete Aldridge

Thank you. Ed Fisher is on his way up. And following him will be Thomas Hamilton.

Ed Fisher

Thank you for this opportunity. I believe strongly that our efforts in space must concentrate on human exploration of Mars with the eventual goal of settlement and creation of a new branch of human civilization.

The best way to achieve this goal is with a mission architecture based on the Mars Direct plan or its descendant, the NASA Design Reference Mission. The emphasis of this mission architecture on *in situ* resource utilization, combined with direct launches to Mars without recourse to any on-orbit assembly or lunar side track produces a robust and highly redundant program which is both economically feasible and highly productive in scientific and exploratory terms.

Whatever the ultimate recommendations of this Commission, and whatever final plan is put forward, however, I believe that the NASA that we've had over the last 30 years cannot implement. In NASA's glory days of Apollo, they had a clear goal and a clear schedule. This forced NASA to devise an efficient and rational plan to achieve the goal, design the hardware that would be required to implement that plan, build that set of hardware, and fly those missions. They did so brilliantly, and the men and women involved, some sitting in this room today, can be justifiably proud of their accomplishments and assured of their place in history.

In the 35 years since the end of Apollo, NASA has spent much more money, and achieved much less, in terms of human space exploration. This is so because they have had neither a clear goal or a certain schedule. As a result, random programs have come and gone justified by the weak reasoning that they might be useful sometime if we ever decide to go somewhere. Now is the time and Mars is the place. Congress and the President, with the able assistance of this Commission, must give NASA the direction which it needs. Thank you.

Pete Aldridge

Thank you. Thomas Hamilton, and following him will be Cary Robyn.

Thomas Hamilton

Yes, sir. Forty years ago I was working on the Apollo project in my second job out of college. I was at Grumman Aircraft doing design work on radar accuracy requirements, fuel requirements, and the characteristics of circumlunar orbits. When the project started to sag, I moved on, started working in planetariums, and became a college teacher for over thirty years. I've retired, turned in my last grades May 8th last year. Because I worked in the planetarium, I did shows teaching astronomy to everything from kindergarten on up. So I've dealt with the public on every possible level teaching astronomy. And I have found that there is a profound interest and also a very profound misunderstanding, lack of knowledge, and one of the things that I believe your group could foster: About 25 years ago JPL had one employee, Ben Casados, who worked with planetariums all over the country to feed them information, slides, posters, everything that they asked for. Not—he tried to develop the program so that it was the things that they could use. Yes, I know NASA has an office now where you can go to them and ask them for a poster or whatever.

I have a former student who works for NASA who would send me their posters. But it is not something where they do a good outreach, where they find out what the groups can use. Now, in New York City, for example, there are over 50 planetariums. I bet that Dr. Tyson's is about the

only one that ever hears from NASA, if they do. However, Congressman Walker said something yesterday which touched me because, in addition to my background as an astronomer, I spent eight years as the county chair of a political party; I'm still on the state committee and the county executive committee. And his comments about the politics of the situation struck me because there are very, very few people in the sciences who are active in politics. I have always been regarded by my colleagues as sort of weird. He's laughing, he knows.

Pete Aldridge

But you're running out of time.

Thomas Hamilton

OK, I want to get to the point.

Pete Aldridge

Yes.

Thomas Hamilton

There are organizations that I'm a member of that their members in every—they have been organized so they get email saying, "Your zip code is such and so; that means this is your congressman. We want you to send your congressman a letter today because otherwise the republic will fall." Well, you know, occasionally I answer it, but the thing is, this should be done by—they were here earlier; anyway, the various space organizations should be doing this and they aren't. I'm going to contact Lou Freedman and see if, you know, we can set up something like that.

Pete Aldridge

Okay. Thank you very much.

Maria Zuber

Mr. Chairman, if I could address one of the comments. JPL has started a museum program and they're expanding it. Just the kind of program you're talking about.

Pete Aldridge

OK, Cary Robyn is coming up, and this will be our last questioner or our last comment, Adam Glass after Cary.

Cary Robyn

To sustain popular support for space endeavors we need to elicit what Larry Harvey, the founder of Burning Man Festival in Nevada, calls social convection forces around the concept of a space-faring civilization. This requires appealing to more than aerospace contractors and astronomy buffs alone. We need to inspire a comprehensive sense of Gaian mission awareness among the institutions of society as a whole. There is a large culture gap evident here between government bureaucracy and the leading edge. The Bush Administration, in particular, has so alienated the creative intelligentsia and the youth audience that there is even a danger of an ad hominem backlash against space simply because this atypically idealistic initiative has come from the same source as the Iraq war, the drug war, the budget deficit, threats to the remaining wilderness, and erosion of civil liberties.

Success requires both style and substance. Twenty-first century space advocacy needs to position itself much like Steve Jobs of Apple Computers and the late Carl Sagan. Space should be approached from new paradigms and integrated with an emerging equitopian vision of a freer, friendlier sustainable culture living in peace much like that articulated by Marshal T. Savage of the Living Universe Foundation, Stewart Brand of *Whole Earth Review*, and many others over the decades, from Terrance McKenna to Robert Anton Wilson, Jean Houstons, Bucky Fuller, most of these ignored by the government. Several presenters spoke of being inspired by news of Sputnik. For younger generations I think it was the image of the whole Earth and extensions of the Gaia hypothesis—the Earth as a living superorganism—that spoke most compellingly to us. Gaia beckons for humanity to take on a noble role as an enlightened technological species, restoring the environmental damage done during the industrial era, shielding the biosphere from asteroid impacts, ending poverty with resources and energy from space, and carrying the seeds of life to birth new worlds above. Thank you.

Adam Glass

Hello.

Pete Aldridge

Hi, Adam. Two minutes.

Adam Glass

I don't represent anyone in particular. I'm just a kid with an interest in space. I guess, in a way, I represent the youth of America. I'll keep this short. I just basically want to repeat two ideas that I feel are the most important that this Commission has discussed.

One being the creation of a space industry instead of a space program. I believe that that can dramatically reduce the cost of getting to low Earth orbit and also stimulate the economy, create

new jobs, and possibly we can even see the space industry grow as quickly as the computer industry has. That's one.

Number two is I think NASA really needs to focus more on advertising and recruitment. Space, in general, is something that is cool and interesting and needs to be presented that way. We need more people that can talk about what NASA is doing in an interesting way and put it more in laymen's terms for the general public people like—Steve Squier, people like Mike Foale, people like Administrator O'Keefe. Recruitment's very important, too. When I went to my high school's career day, there was a guy there from the Navy, there was a guy there from the Army, there was no NASA guy. I think there definitely needs to be. I would have loved to have gotten a job at NASA. I did really good in math and science, but I wouldn't know how to go about getting a job at NASA. It's not something that is that easy.

Finally, you hear all this talk about the graying of NASA and how the NASA workforce is in the process of retirement and how they desperately need young people to come in. I would just like to say there's plenty of young people out there with good math and science skills and an interest in space. You just need to reach us. Thank you.

Pete Aldridge

Thanks very much.

I also see a future astronaut sitting up here on the staircase. We have run out of time. We have to turn it over now to a press conference. We have people calling in from outside and, Susan, would you come up and lead the press conference? Following the press conference, which will be about 30 minutes, we'll have an open deliberation of the Commission to discuss issues that have come to our attention during these five open sessions. Susan, you may proceed.

Pete Aldridge

OK. With that, that ends the press conference. What we have now is, we have to our legal authorities for the Federal Advisory Committee Act is that we will open up discussions among the Commissioners.

We do not anticipate questions from the audience. We'll be talking among ourselves but you're obviously here to listen to some of the thoughts that will be generated and some of our thinking process at this point in time. Yet obviously we'll have—we will take these inputs that are being developed and we'll bring them back and we'll think about how do we write them down in words that are comprehensive and accurate. And the process occurs now. And we will go by a rough—not by alphabetical order but by a logic train. And as soon as I find the logic train we will proceed. Here it is. First on the agenda, it so happens it is by alphabetical order. First, and that is Carly Fiorina, sustainability rationale. Carly, we'd like to hear what you have to say.

Carly Fiorina

OK. Thanks, Mr. Chairman. I think it's been clear through all of our deliberations that we are concerned about the sustainability of this mission because it requires a long-term commitment, and a long-term commitment by its nature requires broad-based support and bipartisan support and public support. And I think the requirement for that broad-based support means we have to start by asking a very fundamental question: Why are we bothering at all?

I mean, why are we thinking about going to Moon, Mars and beyond when there are so many problems right here on Earth and so much budget pressure right here on Earth? And I think we have heard a number of compelling rationales.

I think we have heard in very eloquent terms about what I will broadly call the greatness and glory of this mission. We've heard people talk about a great nation such as the United States should embark on great missions, and this is certainly one of them. We've heard from our own President saying that this mission lifts our national spirit; it is glorious in its quest.

And I think we've heard as well from many folks, some of our public comments from citizens, for example, have said this represents an opportunity for the United States to lead the world in a positive way. I think we've heard as well about the scientific value of such a mission, and indeed as administrator O'Keefe commented on many times, the exploration is a primary purpose of this mission. And the scientific value goes to our ability to ask some of the most fundamental questions of all, like "Where did life come from?"

And I certainly would not in any way underestimate the scientific value of the mission. I think we've also heard a category of answers to the question why that I would broadly describe as the inspiration of it all. We've heard people say the human being is an explorer by nature. Our President said it is a desire written in the human heart.

I believe in San Francisco we heard Ray Bradbury say, you know, when the Congress gets bogged down in budget deliberations, ask our children, and they will point ecstatically to the sky and say, "Yes, we must go." So this is a great mission, it's a glorious mission, it's an inspiring mission, and it is a mission of great worth in terms of scientific discovery. But the pragmatist in all of us says, "None of those rationales is sufficient."

And indeed I do not believe they are sufficient, although I believe them strongly individually. I don't believe they are sufficient to compel a broad-based, long-term, bipartisan level of support. And so I think we have to look to, as well, very pragmatic here-on-Earth reasons.

And I'll start perhaps with the most fundamental, which is, if we don't do it, someone will. And while I recognize when I say that that this is not the era of Sputnik, it's pretty clear from the testimony we've heard that China has a very active space program. Russia has a very active space program. India has a very active space program. The Europeans are interested as well. The Japanese are interested. While it may take longer, someone will eventually figure out how to send men and women into space and exploit that discovery and ultimately perhaps commercialize it. And so I think the United States should lead. If we don't, others will. And it's important for us to be the first to protect, candidly, our military, economic, and political

leadership in the world. I think, secondly, even more near-in perhaps than that, is that the 21st century is a century about technology. Leadership in the 21st century depends upon technology leadership. And today our leadership in technology and the industrial base that flows from that is threatened by other nations who are very much focused on gaining technology leadership. We have had a great deal of debate in the press about the exodus of high-tech manufacturing jobs, about the tragedies of outsourcing.

And what's interesting to me is very few people yet have connected up that if we want to stay leaders in high-tech manufacturing, we have to lead in those industries that create high-tech manufacturing jobs. Space is one of those industries. The United States has to lead in those industries that create technology leadership. And those industries include, certainly, computing technology, biotechnology, but they as well include space and aeronautics.

We have heard, I think, quite eloquently from a number of unionized workers who say every dollar spent in space is a dollar spent here on Earth. We represent high-tech manufacturing jobs, and if we do not choose to take this mission, our technology base will erode. I was also interested to see one of our other panelists describe this, but this article in the *New York Times*—"Losing Our Dominance in Science"—unfortunately this article didn't yet connect up with keeping a dominance in science means going after industries that rely upon science and technology. And clearly, space is one of those.

So I think that's the second pragmatic reason here on Earth: Our technology leadership is key to our economic leadership in the 21st century, and economic leadership is key to ongoing prosperity for all Americans.

I think the third reason is, again, referenced in this article: the cold, cruel reality is that the children in the United States, their ability to compete and prosper in the 21st century, is, on a relative basis, in decline. When we look at our preparedness in math and science and engineering in the 21st century, on a relative basis, we are becoming less, not more, competitive. And in order to reverse that trend, we must not only re-engineer our educational system—and I think we've heard from a lot of people that an inspiring mission like space can help do that—but we also have to lead in those industries that create the demand pull for the skilled labor.

So I guess what I'm trying to say perhaps in a too-lengthy a way is that while the destination is grand and glorious and inspiring and worthy scientifically, the journey that we are going to have to take here on Earth in a very pragmatic way is, in the near term, what this is all about and worthy of public support, and I think we have to really help people make that connection.

I guess two other comments I would make before I stop here: First, I think we have heard from so many people that sustainability is going to require grassroots support. And it will require NASA, the administration, all of us, to tap into grassroots support. As you commented earlier, we heard so almost plaintively yesterday from one of our witnesses, "We all wanted to go." And so I think we have to provide recommendations on how to keep this a very broad-based mission with a broad base of support.

And I think that means a couple things. I think that means—some people are offended by the term *marketing*. I don't happen to be one of them. I think marketing, when done well, is speaking to people in language they understand. But I think we are talking about straightforward communication that educates people about the inspiration of all this, the real risks of all of this, but as well, the very pragmatic and necessary rewards of it. I think we are talking about some innovative ways of galvanizing grassroots support. We heard one actually today from the student who said, you know, "Help recruit us." We heard, as well, a great idea about a simulation game that would engage people in a very real-life kind of way and what space exploration could be about. We heard, as well, about an idea of allowing children to operate robots on the Moon, through the Web. All of those are great ways of galvanizing grassroots support. I think it will be important to keep the support going that we, as well, have a set of metrics and milestones so that we are achieving measurable success along the way.

This is a long journey, and people will want to know where are we now and are we achieving the things that we intended to? And finally, as I think has been noted many times, it's very clear that the private sector will have to be engaged in this journey even more deeply than they have been engaged in missions before. And that not only means the big traditional contractors, it means entrepreneurs, it means private capital, venture capital. And I think that will be critically important as well.

Pete Aldridge

We'll hear some more about that in a minute. Les?

Les Lyles

Mr. Chairman, I think that, as Carly just articulated, talking about the sustainability and affordability, particularly sustaining this vision, it brings the notion that hit each one of us, the very first day that we started our deliberations, I recall as we were all sort of introducing ourselves and talking about this particular objective of this Commission, in one way or another, each one of us used a term that this is really a national vision; this exploratory vision is not just a space vision, it's not just a vision for NASA, it really is a national vision. That notion has been reinforced throughout our entire process over these last three and a half months or so. It's been reinforced in each one of us in various ways, and it's sort of shaped in some respects the kinds of thought processes and recommendations that I think ultimately this Commission is going to make. I was glad to see Sean put up a chart in talking about the vision for space exploration, coming out of the President's speech in January. And the statement he used was that the fundamental goal of this vision is to advance U.S. scientific, security, and economic interests through a robust space exploration program.

The vehicle, the journey, is through robust space exploration, but the objectives are far broader than just space and space exploration itself. And that in itself brings into play lots of other agencies in our federal government, lots of other organizations, lots of other private interests.

From the Department of Defense, Department of Energy, Department of Education, the universities, lots of private interests and entrepreneurial ideas that are out there, everybody to some extent is involved in this vision. Hence, our term that it really is a national vision.

And when you think about that, and you think of all the stakeholders, all the other vested interests, the common missions that are out there, that are very much germane to accomplishing this space exploration vision, it makes you look at everything a little bit differently. One, at how we convey the message, how we maintain that sustainability that Carly so articulately defined, how we manage and organize this whole entity and all the things that are involved in it, and how we leverage the resources that are going to be necessary to accomplish this particular goal.

Just looking at the management aspect, when I think about different government organizations alone, federal organizations that could be involved in this, it brings back the notion that perhaps we need to restimulate or revitalize the National Space Council, which was, at one point, chaired by the vice president, to ensure that different government agencies, different federal entities, different organizations that are all involved in a particular mission, in this case space, are coordinating their activities, are working together, have common visions, common goals, and are articulate in trying to achieve these things as one team. We think perhaps that might be one of the recommendations that we make—that we need such a structure.

Even within NASA, as we heard from Sean O’Keefe. He’s looking at a different management structure internally to the organization. And we also are making some recommendations, I think, along those lines to keep a broader perspective than just what you normally would think for NASA. So it brings a different approach in how you look at things, how you organize, the management aspects of things. We’ve talked and we’ve seen today ideas from the Department of Defense about a lead systems integrator. We’ve heard different other management techniques, things like Joint Strike Fighter, missile defense agencies, as examples of ways that you can take on a broad systems-of-systems approach for a very, very complicated mission, which certainly this particular exploratory vision encompasses. So it makes you think about things very, very differently.

And lastly, I think it gives us a different aspect in how we leverage the resources. And when I say *resources*, I’m not necessarily talking about just the dollars and cents that are involved. The intellectual capital, the innovative ideas that are out there. The various management techniques, as I’ve mentioned. There are lots of different things and lots of different people, lots of different organizations that can contribute their resources to helping to accomplish this space exploration vision.

And I think this notion of a national vision forces us to think of these things much differently than we’ve done before. One final example of that: enabling technologies—everywhere we’ve gone so far as we’ve talked to people who have talked to the panel, we’ve made visits to organizations, we’ve talked about the notion of some enabling technologies that are key to making sure we accomplish the broad mission here involved in this space exploration.

I’ve been very, very pleased as we’ve gone around and talked to centers and center directors, at Kennedy Space Center, Marshall Space Flight Center, Johnson Space Flight Center, JPL, and

we've asked each one of them about their ideas of enabling technologies to accomplish the mission. We've also asked some organizations that aren't part of NASA the same questions, and one particular one was the Air Force Research Laboratories that we talked to at Wright-Patterson Air Force Base during our second public hearing. They sent in a list of enabling technologies, their space taxonomy, if you will, and lo and behold, it's very much in sync with what NASA has identified as enabling technologies. Some different mission objectives, but the basic physics, the basic engineering, the basic technologies are very much the same. And again, this broader aspect of a national vision gives us an opportunity to look at things differently, to manage things differently, to bring a lot broader researchers to accomplish this goal of space exploration.

Pete Aldridge

Good. Thanks, Les. Michael?

Michael Jackson

Thank you, Mr. Chairman. I'm going to try to just build off of what we heard from Carly and Les a little bit and zero in on one particular area, which is our relationship with the private sector in making this vision successful. But I think it's a good departure point for, Carly, what you've talked about, with the criteria of sustainability being foremost in our head as we go along. And Les's point that this really is a national objective, so it's not just about NASA and its program. It's about something bigger than that.

When I try to unpack a little bit of the testimony that we've heard around the question about "How do we do this?" there are two big clusters of issues that I think that our folks who have testified before us have been grappling with. One is "What is the right structure for the government to meet this objective for the long haul? How do we organize ourselves to do the job? Who is it that gets organized and how do they get organized?" I'm not going to talk about that part. The second part is "How is the private sector to be organized for success? Who is it, what do they do, how do they relate to the government sector?" That's what I would like to talk about.

Within the question of the private sector, there are a whole series of constituencies that we have to work with right. If we do it wrong with them, almost in any case, we're going to mess it up. So we have to have success with the educational community, with the scientific community, with the public at large.

But a crucial part of this, as you drill down through this—How do you work with the private sector?—is the business community that is going to engage and actually help drive the technology and drive the exploration with NASA, with the government, with the nation as we do this. So my focus is on that business community. And I just want to say at the start I think the question of who is our workforce is something important to just begin with. And it's an obvious point, but one worth stating, that really the workforce at NASA that has brought us this spectacular series of successes in space and the workforce in the private sector that works so

closely together with them is a national treasure. It's a global treasure. The community of men and women that work on these exploration programs, on these scientific programs.

And so our job in thinking about this proper structuring of the private sector's role here has to do with both enabling and supporting and protecting and developing and educating and encouraging and rewarding both our public- and private-sector colleagues in the right ways. So what we've heard is, I think, from administrator O'Keefe, a cornerstone of our conversations among ourselves as well—is that we need to forge for success a new and robust and different relationship between NASA in particular and the private sector.

We need to have, to use the expression which I think darn near everybody has now spit out today, to find a way to nurture a robust space industry, not just a space program. It doesn't mean that NASA doesn't have a programmatic set of objectives that they, too, are going to accomplish. As we heard yesterday, and perhaps it's fair to say that this is a national vision, but it is also a global undertaking. We have to leverage the—particularly, I would like to focus on the private sector's role globally.

So this is about taking private-sector assets, tools, and innovation from the private sector around the globe as well as domestically. Although I think Carly's point about why we as a nation have to do this is just absolutely vital. It is about preserving the industrial base, the innovation technology that's core not only to the success of the space vision but to the success of our nation. So I want to just throw out four terms and then I'll unpack each of them briefly and then I'll stop.

The four terms are *innovation*, *nimble*, *entrepreneurial*, and *spiral development*, that lesson in Defense Department—speak which we've all taken at the hands, Les, of you and the chairman. So those four words.

Innovation: We have to find a way to institutionalize and make normal and make routine the extraordinary ability to change constantly and to think our way through problems which we can't even begin to understand at this date.

It's obvious, but exploration will open up these many new technologies; entrepreneurial work in this sphere is indispensable. NASA is probably more of an exception than any other place in government that I can think about, but by and large, the government doesn't do nimble, innovative work easily. It doesn't come naturally. It takes a lot of hard work. So we need to try to help partner up in the right way with folks in the private sector who can infuse those genes into the public-sector colleagues that they'll be working with.

Nimble relates to this: obvious, we have to be quick, we have to learn through a series of progressive steps how to change and take lessons away from that.

The word *entrepreneurial* we heard from the administrator today, we heard this from just a whole host of people at almost all of our hearings. NASA's charter speaks to the commercialization of space. I believe Bob Walker was responsible in no small measure for making sure that that is part of their charter when he was in Congress. But it speaks to the importance of trying to understand how to find commercial rewards and incentives and utility out of space.

That's just an indispensable part about making this partnership work in the right way. It's a sea change in the way NASA deals with the private sector we're asking for to help think of their role as creating an industry and nurturing an industry and sustaining an industry, but it's a part of what must happen for this to work. This is about large corporations and small corporations. It's about two gals in a garage that have a breakthrough idea that's going to revolutionize some component part of our problem set. But it's also about big organizations who can take the type of skill sets and apply them to these massive problems that will be associated or massive issues that will be associated with the enterprise. NASA should do the things that are indispensably governmental.

And there is in the technology clusters that you talk about a big list of those that are indispensable for NASA to undertake and we'll help unpack some of those. But we should try to rely on the commercial sector to do what it can do and NASA doesn't have to do. And I would give an example of that is I'm persuaded that it won't be long that NASA can rely on in a much more dependable way on the private sector to get launches into low Earth orbit from the private sector without having to do nearly as much as they have done in the past. Spiral development means we have to bite a little bit, chew it, digest it, and think about it before we do the next set of steps. We have to learn lessons in a sequential and routine way and then modify the mission targets or specific tasks to take advantage of what we've learned.

Fortunately, and in conclusion, I would say with only a slight pun intended, this is not rocket science. We have a lot of good management tools and experience on the table that we now must take advantage of, can take advantage of, to make this work. It's not just walking in the dark without any lights. We have procurement tools that are proven in the integrator technology that the Defense Department has used in Joint Strike Fighter, Deepwater at the Coast Guard, and others.

We have this series of lessons learned about how to leverage engineering tools, modeling tools, procurement methodologies that will make these relationships between the private sector and the government work smoothly. And finally, we have, I think, on the Commission, found some degree of attractiveness to the idea of prizes—and not necessarily just small prizes, but trying to create in effect a package of incentives and continuously updating that package of incentives to make that relationship work. So, Mr. Chairman, that would conclude my reflections on one constituent part of what we need to do for the vision, which is to engage in a new and aggressive and fruitful way the skill sets of our private-sector industries in the U.S. and around the globe.

Pete Aldridge

Mike, I'm delighted we have a note taker, here because I think you might have written a chapter in our report.

Pete Aldridge

Lauren. You're up.

Laurie Leshin

All right, well, thank you, Mr. Chairman, and this has been a spectacular experience for me, a fantastic learning experience, and that's really what I want to spend my time talking about here is learning, because that's the perspective I bring here as an educator, and as a scientist, a seeker and disseminator of knowledge, if you will. Because I interact with students every day as an educator and also, if you'll indulge me, because of my position as the most youthful member of the Commission, I will take the opportunity to emphasize the importance of the implementation of this vision for inspiring the youth of today to engage actively in their math, science, and technology education.

We all know that science and math education issue has been identified by reports literally for decades as being a major problem facing our country. And it puts us at risk both economically and from a national security perspective because the workforce we need to prosper as a nation is not being trained adequately. Just one example: in 2001, the Hart-Rudman Commission warned that the failure of math and science education was the second-largest national security threat facing America. This was obviously echoed by Carly and her remarks and also on the front page of the *New York Times* just yesterday.

Here in our hearings we've heard from numerous educators, from Barbara Morgan, educator-astronaut, teachers, informal educators, through museums, even some students. Listening to these experts and from listening to the experts that are my students at home, it's absolutely clear to me that a vibrant space exploration program like the one that's been outlined in the new vision is really going to enable us to reach inside the minds of the youth of America and engage them. This is great news.

And I know that both Maria and I have seen greatly increased interest at the university level in space science just since the vision was announced on January 14. And actually accomplishing this journey will be more engaging than we can imagine if we embrace the opportunity to involve the kids of today, who are really the inventors of the future, in it.

Now NASA has already transformed itself in some ways to address this issue. And it's doing admirable things in this area. And I know it's a clear priority of the administrator, and I applaud him for that. I think that we must seek to redouble our efforts in formal education. Focusing on training the trainers. That is, training the teachers, both in-service active teachers and preservice teachers, those that are still in university and college, being trained as we speak. Through assessment of existing programs and closer coordination of those programs, we need to basically build on our successes here and magnify those.

I think we also need to think about educating the next-generation workforce that's going to create the space industry that we've been discussing here. And as such we need to engage universities in new kinds of partnerships in new ways to help break down both cultural and technical barriers that are currently in place that are—have the potential to keep us from being able to achieve the vision. And we can start doing this at the college level. For example, the

barrier between science and engineering is one that is, I know, of extreme frustration to a lot of people working in space science. And it is a problem that we have to address.

We can do this through relatively inexpensive investment. This is the good news. In university programs where students in integrated science and engineering teams get hands-on exploration experience as part of their education, solving exploration-type problems—actually performing exploration endeavors and they don't have to be in space to learn the skills that they need to learn to get through this issue. We have even discussed the possibility of a virtual space exploration academy, distributed at existing brick-and-mortar universities, working directly with NASA and exploration agencies to help train this next-generation workforce.

Regarding sort of informal education and public outreach, I believe, as has already been mentioned here, we may need to think about a much different model, much more aggressive, involving more grassroots organizations, more cutting edge, more out there perhaps than the government may be capable of. And we heard some of that here today. And I just wanted to quote Roger Gilbertson, who spoke so passionately at our San Francisco public hearing, "We need to knock their socks off."

Carly spoke of the very practical rationales to sustain the vision over the decades it's going to take to make this exciting journey, and I agree wholeheartedly with that sentiment that the endeavor is about more than science and discovery, it's about planting our feet firmly on the path of being the prosperous, competitive innovating nation that we must choose to be. However, this vision also excites me because it represents the most positive thing the government can do. It gives me as a scientist, a great sense of possibility. It encourages us to be entrepreneurial as scientists and to imagine great discoveries and then set out to make them as part of the exploration team. And so as we undertake this exploration guided by science, we will discover things that will stretch our minds to the limit of our imaginations. Indeed, we really for the first time in history have the opportunity to ask and answer some of the most profound scientific questions conceivable: Where did we come from? What does the future hold for our planet and our biosphere? Are we alone?

The answers will help us understand our place in this enormously vast universe. They will engage us and, indeed, the answers will change us, all of us.

I truly believe it will require the focus, undertaking, and capabilities developed through the proposed exploration vision to find the answers we seek. So, Mr. Chairman, it's my hope that we let this journey be remembered by history not only for opening the space frontier to all, but for opening our minds to extraordinary discoveries. And, by doing these two things, we will both be pursuing lofty goals worthy of a great nation and cementing America's future prosperity. Although I know it's about the journey, I also look forward to celebrating the success of when the first person walks on Mars. And as she dusts off that red soil from her boots, I hope we can all remember this time that we all looked into the future together and said, "Let's go." Thanks.

Pete Aldridge

Laurie, you're just going to have to get a little more enthusiastic than that. You're too shy. Neil.

Neil Tyson

All right. Thank you, Mr. Chairman. I can't help but—well first I want to describe how we set a science agenda for this vision. But as a preamble to that, I can't help but reflect on the need expressed multiple times before me, and surely will be expressed again, that the public will need to take ownership of this vision, lest it be wrestled from the national priorities by a disgruntled politician and/or anyone else who has power over national visions. And the act of taking ownership is not something new, of course.

I think the Mercury, Gemini, and Apollo astronauts, they didn't really belong to NASA, they belonged to the public, the profiles written on them in *Life* magazine. They were ours. And they were not NASA's. That was a form of ownership. It was argued earlier that back then, we all wanted to go. Certainly true: and today, that is lost. But it didn't stop people from taking ownership, for example, of the Hubble telescope when announcements were made that we would not repair it; I think the response to that was extraordinary. And I don't think any of us predicted it. We might have grumbled along with others, but I don't think we could predict the extent to which the public took ownership of the Hubble telescope. And wrote letters to the editor. And there's a bill in Congress. And it tells me, gives me great hope, that such ownership of space ventures remains possible. On the one hand, ownership of—and the vicarious thrill of—following people who go into space, but not only that, taking ownership of scientific discoveries.

I don't know that there's a precedent that the public has taken ownership of a scientific laboratory before. Perhaps it's because we all watched Hubble get born and we watched its—you know, it had sort of prenatal problems and we watched the surgery on the prenatal state, and we watched the repair mission triumph over those challenges.

These are the kinds of things that make high drama, as any venture in space does. And so what this vision is is a portal between how we used to do science and how we can do science moving forward. So much of space science is conceived in the limitations of the technology available. And so until now all we could really imagine as astrophysicists, for example, is putting a telescope in low Earth orbit. All the planetary geologists could imagine is a fly-by to another planet, maybe go into orbit, the occasional lander, and that's sort of restricted by budget, the kind of budget that went below the radar, that wouldn't be argued about in Congress and then cut by someone without foresight, but now in the presence of this vision, the palette has grown for the kinds of things we can accomplish.

We now know how to build large structures in space. The International Space Station is evidence of that. But now we're not going to limit ourselves to low Earth orbit to do such a thing. Build large structure on the surfaces of other planets, at Lagrangian points, in free space, in places that are in the service of getting around the solar system, ways that now we only dream of. Not only building large structures, we're going to build hardware, the kinds of hardware that does stuff

like turn carbon dioxide into fuel and oxygen to breathe and search the soils for water, either in the—or hydrogen in the craters of the Moon or on Mars itself. We can now, in the presence of this vision, think of building minifactories to enable these visions.

And so you can now, not only that, you can imagine not only going to planets, but landing there, gathering material, coming back. With that as the new palette, what I think we need to do as a Commission is charge the scientific community with rethinking what this represents now as new forms of opportunity, not simply as opportunity that's different from what happened before and thereby pinches the way we had previously dreamed of doing science, but as a new palette on which to paint new dreams. And the mechanism for that is actually already in place: the decadal surveys—something astrophysicists have done for the past 40 years, out of these surveys has emerged things like the Hubble telescope. The solar system community has joined that bandwagon, now has a decadal survey of their own, inaugurated in the current decade, but it just came out before the presidential vision. So I look forward to sort of revisiting these decadal surveys in the context of this vision in such a way that we can set science priorities on this broader palette.

There's some of my colleagues who are concerned that they don't want the science to follow the technology, they want the technology to lead. That's naive. What happens is they both lead each other. That sentence actually does make sense, because occasionally a new technological breakthrough enables scientific breakthroughs, and then occasionally you have a scientific question never before asked that the technologists run behind and say, "I know how to do that, even if you don't." And so it's that synergy that we need to find new mechanisms to ensure will remain in place going forward, because so much of this vision will rely on the technological enablers that are specified in these early plans. So we need to find ways for the technologists to be in the same room as the scientists, not every 10 years but perhaps daily or weekly.

I see, and I'm almost finished here, Mr. Chairman, I see three channels through which science gets done. One of them is the kind of science that is done simply to expand our horizon of understanding in the cosmos. By the way, that science is not always sexy science; it's not always the kind of science that the reporters run to to get sound bites on.

But it's no less important in the total spectrum of science that must happen if we proceed in a sensible way, advancing the frontiers of chemistry, biology, physics, geophysics, astrophysics. We needn't—we shouldn't lose sight of that. But also, nor should we lose sight of the high-public-interest science. There's a strong overlap between science of high public interest and science of high science interest, like the search for water in the solar system, the search for life that might thrive on that water if that water is liquid. The search for planets. Not only planets, but planets that might harbor life. Doing science of high public interest and science of high scientific interest, you can't get a better marriage than that, and we have to make sure that that's in the palette of science that's conducted. And by the way, it already is, so I'm not trying to wedge something in that isn't already there.

But there's a third kind of science. It's the science of security. Now, I'm not talking about the traditional kind of security where we defend our borders or what. That kind of security is, in

large measures, irrelevant when you're in space because you can't see national boundaries in space. Nor, by the way, will flags wave in space, where there's no air.

There's another kind of security, the security of the whole planet. There are asteroids out there, thousands of them, with orbits that cross Earth's orbit. We call them near-Earth objects. We should really find a more menacing term for them, but that's what we've got, that's what has stuck: near-Earth objects. These things are out there. They need to be characterized, and you can do science along the way, but we ought to have as a goal to protect the human species from the threat that these objects represent. They've hit before. They took out the dinosaurs. And there's an interesting dichotomy there because the duality of these species-killing asteroids because they enabled mammals to aspire to become something more ambitious than a tree shrew from 65 million years ago. Yet it could take us out just as easily as it enabled us. So I have a love-hate relationship with these things. But anyhow, asteroids need to be on the agenda as something that need to be studied for our security. And not only that, we're flanked in the solar system by our nearest neighbors, Venus on—to the left, closest to the sun, closer to the sun than we are, Mars outside of our orbit. And each of them are wholly inhospitable to life as we know it. Venus, 900 degrees Fahrenheit; Mars, once wet, now bone dry. Something went wrong on those planets. Part of this vision in the interest of the security of life on Earth should be to find out what did go wrong on those planets to ensure that we're not turning those same knobs here on Earth. Because, if there is no species there is no other real concerns we'll have if we go extinct. So I really hold those as pretty high priority in this palette of science that gets conducted.

Pete Aldridge

Paul?

Paul Spudis

Thank you, Mr. Chairman. Of a lot of the visionary things that the President outlined in his new vision for space exploration, I think one of the most visionary was his advocacy of using planetary resources to create new capabilities.

Now, what is a space resource? Basically a resource is something that you find in space off-planet that you can use, that you don't have to drag with you out of the deep gravity well of the Earth. So by virtue of its position in space, it has inherent value. It has operational value because you can use it to create new capability, and it has economic value because it doesn't cost you. You're already using something that's there.

And this is, to me—one of the things that Carly mentioned was sustainability. To me, one of the essences of sustainability is to create new capability. It's an enormous amount of leverage. It allows you to do things that you couldn't otherwise do except at great cost, and therefore you probably wouldn't try to do them. So this is a great challenge, and in fact one of the most innovative things, because this is something also that we've never done in space. This is something that's going to be brand new. And we need a new way of thinking about it and a new

way of looking at things. There's a synergy here, too, between science and engineering. Science is required to identify resources and to characterize their physical and chemical states, but engineering is needed to actually make those materials, or energy, useful, to somehow harness that for some productive end.

We've had many presentations on resources during the Commission's lifetime. We had oral testimony from Mike Duke of Colorado School of Mines, Andy Chang from APL, and Dave Morrison, and then we had submitted written testimony from Stu Nozette of NASA, Dave Criswell from the University of Houston, and Klaus Heiss from High Frontier, all of them emphasizing the potential high leverage of the early use of lunar resources. Now, the Moon actually contains the materials and the energy we need to bootstrap a space-faring infrastructure. There's no doubt about this. We know what the Moon is made of. We know what elements are there. The real issues are what physical states these elements are in and how can we get at them. So it's an issue of processing, an issue of collecting and processing, not an issue of their presence or the physical plausibility of it.

I don't minimize the technical difficulty of this; however the payoff is so large that, at a minimum, it should be a fairly significant R&D effort of this new initiative to try to understand "Can we do this?" And fundamentally, I think, that's what this initiative is about, it's about creating new capability and to answer the question "Can we live off-planet?" Well, a key thing about living off-planet is not having to drag everything we need with us when we go there. It's learning how to use what's there already.

So, specifically, let's talk a little bit about the Moon. It's bulk materials, and by this I just mean the rocks and the soil that make up the regolith, the outer part of the Moon, are useful for simple building purposes. For example, when you get to the Moon you're going to want to survive the lethal radiation environment of the Moon. The Moon is above the Van Allen Belts, so it gets cosmic rays and it's susceptible to solar flares. One example of an early use of lunar resources is to cover your habitat module with lunar regolith. A couple of meters of lunar regolith will adequately shield the inhabitants of the Moon from cosmic radiation or solar flares. But more importantly, I think, it's the volatile elements of the Moon that potentially give you the greatest leverage. The Moon by weight is about 40% oxygen. It's bound up in silicates, but we know how to extract that. We know there are simple industrial chemical processes that can extract bound oxygen. So it's something that we know can be done. But more importantly, we found that there's hydrogen on the Moon. There's hydrogen from the solar wind on the lunar dust grains and there's also elevated amounts of hydrogen in the dark areas near the poles, the cold traps on the Moon. Basically what we don't know is what state this hydrogen is in. Is it in some kind of molecular form, implanted by the solar wind, or is it in the form of ice deposited as a result of the steady accumulation of cometary volatiles over time?

I think NASA has developed a nice preliminary architecture to get the first-order answers to these questions that we need. Specifically, is—this was brought up today, the Lunar Reconnaissance Orbiter, which is scheduled to fly in 2008, and there are many other international missions to the Moon. The Europeans are flying the Smart-1 mission. The Indians

plan to fly a mission called Chandrian 1 in 2007. The Japanese plan to fly an orbiter called Selene, which will map the whole Moon. All of these missions will provide critical scientific and engineering data that will allow us to assess where these materials are, what their physical states are, and how we can possibly extract them.

After we map this material from orbit, after we determine where these potential deposits are, the obvious next step is to go down to the surface and measure in detail what their physical and chemical properties are. With those two sets of information, both of which, by the way, are in the NASA architecture for returning to the Moon, we'll be able to actually make intelligent decisions on how we'll go about processing and using this material. I think we need to conduct some ground research to experiment with different kinds of extraction processes and how you would actually gather and store the material that you collect and then also then you could follow up those experiments with actually flight demos where you could land small robotic landers on the Moon and make test amounts of propellant or extract hydrogen or actually produce solar panels on the Moon to generate electrical energy.

One thing that I've been thinking about is that this seems to be a missing hub of expertise at NASA in regard to this. Because it's sort of the nexus between aerospace, classical aerospace, expertise and the expertise that's used in terrestrial mining and manufacturing. So NASA needs to think about setting up something—possibly call it the Office of Planetary Surface Engineering—that would investigate some of these technologies. And you might call it—think of it as Boeing meets Bechtel: two different kinds of industrial centers of expertise and yet they need to merge, because this is a new field that we don't quite know how to operate in yet.

The potential of this is actually quite revolutionary. I think people tend to underestimate it. If we can do this, if we can actually make the resources we need to create new capability, it totally revolutionizes the paradigm of spaceflight. Right now everything, literally everything, that we need in space, we take with us. And it's an enormous penalty as we drag it up out of the gravity well of the Earth.

If we can use this material, it will create new opportunities for three different things. For science it creates new opportunities because you can build, for example, reusable lander spacecraft. You can have a robotic lander that can land repeatedly on the Moon and be refueled in space to make repeated trips. So, you don't have to build a new lander every time you want to land a payload. So you have routine access to the lunar service, in addition to routine throughout cislunar space, which basically relates to two other things: if you can access cislunar space, you can access any orbit between LEO and the Moon. Now, what's the significance of that? Well, simply this—literally all of our commercial and natural strategic space assets occur in this volume of space. Right now we cannot access any of them. We design spacecraft, we launch them on off, we put them in that orbit, they perform or they don't. If they do perform, they have a limited lifetime. When they die, they're written off.

Think of it a different way: think if we had the ability to routinely move from that—from low Earth orbit to any point in cislunar space. It would completely change the way we design, configure and operate spacecraft, which relates to literally everything that space assets provide

us, from resource utilization, to communications, to national surveillance. All of those things are affected.

In that sense, what Les mentioned about the fundamental vision, the fundamental goal, which is to advance scientific security and economic interest to the United States through space exploration, this relates—this is at the very heart of this. Because what this initiative, I think, really is all about is creating new capability. And when we have new capability, it always pays off and always in forms that we couldn't have predicted before.

Finally, one other point I would like to make in this regard is one testimony, one of our witnesses said, "Exploration offers up commercial opportunities." And, in fact, I think nowhere is this better possible than in the area of space resources. NASA's role in this should be to identify the technologies and the techniques needed to produce this material but should not be in the business of manufacturing it. I think this is a classic example of an area that's ripe for transition. Once NASA has pioneered the way, has shown this is how you can get to these things, this is how you can extract them, this is how you can store them, then it will be transitionable to the private sector to actually turn that into a workable business. Thank you.

Pete Aldridge

Bob?

Bob Walker

Mr. Chairman, during our deliberations, we've heard a lot of enthusiasm about the vision that the President has put forward. But we've also heard questions about whether NASA is actually capable of accomplishing the vision. What we've heard is that NASA has a problem. It's cultural, and it's debilitating.

Now, this is nothing new. Congress has heard these kinds of issues raised for a number of years. A number of commissions have heard the same thing, have actually written about them. And now our Commission has also come up against this problem. And it really is a case where the culture and the infrastructure that worked so well during the Apollo era has become a hindrance to future development.

The thing was that Apollo was a very coherent program: it was singularly focused. It did its job well. It built infrastructure to support the program and accomplished a great, great deal. But it was so successful that NASA began to view itself, and many people began to view it, as the only way that America went to space. Now, for 40 more years, NASA achieved a lot of things, did amazing things.

And continued to be something that people looked up to. But also during that period of time, it gradually became unfocused. It became a little bit of everything for everybody. And Congress certainly contributed to that. Because, in each appropriation cycle and in each authorization

cycle, Congress added new little duties for NASA to do and helped to bring about a more unfocused state for the agency.

But the other problem was that NASA also became an agency that was excluding people who had ideas from the outside from coming inside to bring those ideas into the space community. In fact, to some extent it became almost an exclusive club on space. Someone here a minute ago referenced the testimony we heard yesterday: we all wanted to go. Well, the fact is that what NASA became is a few got to go, and the rest of us got to pay the bill. And that became a problem politically for NASA.

If, in fact, this is going to be solved, this problem with the culture there, it's going to have to be inside of a new opportunity to create a broader industry model where NASA serves as a part of going to space, not the exclusive way of going to space.

It becomes a crucial part of the whole that marshals the resources of private enterprise but uses a broader context in which to define the future in space. In other words, it becomes inclusive. You take some of the developments that are now going on in suborbital technology where we heard some testimony here that was pretty exciting stuff, this could lead to technologies that provide orbital resources. The problem is that NASA needs to be able to structurally reach out and get some of that and bring it inside. And those very entrepreneurs that are out there doing it on their own buck at the present time often feel frustrated in their inability to get through the door at NASA.

So what has to take place here is that there has to be a restructuring, or, as the administrator put it today, a transformation. And I must say that I'm encouraged and I think a number of the members of this Commission are encouraged by the kind of thoughtfulness that Sean O'Keefe has brought to this problem. Our discussions with him have certainly indicated that he's prepared to do a substantial transformation.

But I think what we found is that that transformation is going to be absolutely essential to accomplish the mission. It's going to have to bring the kind of focus that will assure that the budget can support this mission. The budget can't support doing everything for everybody and then adding on a new vision beyond that. It has to be a focused presence. And so what does that look like?

Well, I think what we've heard is that it should include a NASA that has clear lines of authority—clear lines of authority both in terms of implementing the programs, but clear lines of authority in carrying out budget details as well. It needs to have some structures that actually promote risk taking. The attitude within NASA ought to be not an attitude of “No, but,” but an attitude of “Yes, if,” so that people are constantly reaching out for a series of new ideas.

And finally, NASA centers need to become economic models, places where there is activity going on that contributes overall to the economy and becomes a place where entrepreneurs feel comfortable coming in, to bring in new ideas, because those new ideas can contribute broadly to this industry that we want to create.

Really, what I think we've heard as a Commission is that there's a choice before us. There's a choice between the NASA that has been or the NASA that can be. The NASA that has been has become inwardly focused, it's become exclusive, it's become unfocused, it's become risk averse, and it's become, in many people's mind, a drag on the budget. The NASA that can be is one that will be forward looking, that will be inclusive, that will be focused, that will be risk taking, and will be economically vibrant. Mr. Chairman, the NASA that can be can do the mission of implementing the President's vision. The NASA that has been cannot.

Pete Aldridge

Bob, thank you.

Maria?

Maria Zuber

OK, Mr. Chairman, I would like to pick up on some of the comments that Bob made and talk more specifically about the role of NASA centers—

Pete Aldridge

He was a little wishy-washy, though, wasn't he?

Maria Zuber

He wasn't tough enough, so let me see if I can amplify. It became very apparent to us early in the process that NASA centers were going to play a central role in implementing the nation's space exploration vision, and so, as a consequence of that, a subset of the Commission did fact-finding trips and we visited five of the NASA centers, and these visits to the NASA centers were extremely illustrative and gave us a great deal of information, and we regret that we couldn't have visited all of the NASA centers because we all learned so much. We learned so much about science. We learned so much about technology, and we learned so much about how to implement the space program.

I want to talk a little bit about the NASA workforce. The civil servants, contractors, university affiliates, all of the people who make up NASA just contain a remarkable world-class expertise. These people have achieved some of the most challenging technical feats of our time that have ever been accomplished, in fact, on this planet. And collectively, they have a great deal to be proud of. Our fact-finding indicated just an immense excitement about the national vision when we visited. And quite frankly, we were a little bit worried about this. Because if you have a job in hand today, how do you feel about the job that you have today compared to some nebulous job that you might have in the future when you don't know what it is?

And, so, actually, we were quite impressed that when we went around at the NASA centers and threw the managers out of the room and talked with the people who were actually doing the work, the level of enthusiasm that everyone that we talked to just saw a brighter future than the future that they had, now since January 14.

And that the excitement and the enthusiasm and the level of commitment at all levels in NASA, from the top, which you saw today with Sean O'Keefe, all the way down the chain is just remarkable, and the NASA workforce is definitely behind the vision. We view centers as important contributors to the state and local economies that provide a highly educated workforce who have high-tech jobs. They attract private-sector involvement in technology-related fields. They're often associated with nearby educational institutions, where they contribute to basic and applied research and also to the educational process and also to educational outreach. One of the things that we've been giving thought to is, as Bob said, we see the centers as local economic engines that could engage the private sector and we would like to see this happen to even a greater extent than it does now. And they could potentially be even more valuable to local and state economies than they are in areas now. And all of these places, they make quite important contributions the way things are currently set up. However, the centers as they're currently organized are arguably not optimally suited to carry out the nation's space exploration vision, and that's not surprising, because they were organized based on a long history.

They are not organized for the mission that NASA and the nation is undertaking right now. In some cases, they have Apollo-era infrastructure that is in major need of modernization. They carry out programs that are not in all cases in alignment with future directions of the agency. They have duplicative capabilities that if you were in industry, you would not maintain duplicative capabilities. You would go to a more shared responsibility model. They contained a skill mix that is not in all cases a good match for what the space program of the future is. And we've heard about this before, the workforce is graying and is in need of revitalization.

So the Commission has studied the composition of the present workforce and have raised the question of whether a new model for the NASA workforce would be of value in helping NASA and the nation implement this vision. And I want to underscore that we looked at a number of models, which I will summarize for you, but the Commission has not at this point made any decisions about what its recommendation will be. But let me share some of those thoughts with you.

First of all, it's very clear that the transition to full-cost accounting in NASA is leading to a structure that puts the centers on a more even playing field with the private sector, and that this is a positive movement in the right direction. There have also been some recent changes in the way NASA can compensate its personnel that is more in line with the way that some parts of the Defense Department can do this. And this is also going to help in the ability to attract and maintain highly qualified workers and try to compensate them in something that approaches the private sector, but probably doesn't quite reach it. Another possibility is to do a transition within NASA from the current situation where you have a lot of career long-term civil servants to more temporary civil service positions.

There's a real need for a greater infusion of younger workers who have new state-of-the-art training and who come with new ideas. And there need to be innovative methods to recruit the workforce of the future.

And we've heard already today from one young man who's ready to sign up. And I don't know if that individual has the right skills to work for NASA or not, but if he does, then NASA needs to figure out how to find him and others like him to compete for those positions in the future.

One of the interesting things that we've found is that the promise of a permanent civil service job is not a requirement for NASA to be able to recruit.

The people graduating today from college who've got great skills are looking for something exciting to do. They want to go out, they want to do something thrilling, they want to change the world. And the promise of a permanent civil service position is not going to be required to get these people on board and get them helping to take us to the Moon, Mars, and beyond.

Another thing that the Commission discussed is whether there would be some benefit for at least some of the NASA centers, those that engage primarily in research, to consider an FFRDC model, which is a federally funded research and development center, examples of which include the Jet Propulsion Lab, MIT-Lincoln Lab, some of the national laboratories. These centers, they do not operate with a civil service workforce. And this model could potentially introduce a flexibility that would facilitate workforce transitions and potentially introduce university partners that will provide a ready source of new, highly educated workers with fresh ideas and something that I think is quite important, and that is a vibrant culture of excellence and innovation. One of the things we noticed in our trip to the Jet Propulsion Lab just how proud the workers there were of their association with Cal Tech, just because of the tradition of excellence that comes associated with Cal Tech. We saw similar things in other places. So this is something that could work.

In the case of operational centers, like the Kennedy Space Center, we found evidence that state and local authorities might be potentially interested in contributing to infrastructure improvements, or you could build these—the needed improvements—in the short term and then capitalize them over in the longer term so that we can get this vision in motion.

And we also—it's in place today and it's going on and it could probably be even better where local and state authorities actually contribute to the running of these centers. Another thing I'll note is that there has been a historical tendency for NASA employees—not all of them, but a preponderance—to spend an entire career at a single center. And this is something that might work well for certain types of work, but arguably it might be a negative in the desire to develop a broadly based leadership pool for the future, where broad perspectives are desirable. And so it's happening already at some NASA centers where workers are being encouraged to do rotations at other NASA centers. And this is something that we're deliberating on the Commission, that could be a positive for NASA.

I guess, in summary, what I would just like to say is that many of the things that we've observed with regard to the NASA centers and their workforce have all followed the common theme of the

workers reaching out and looking outward as opposed to inward. And by reaching out, I mean reaching out to the private sector, reaching out to university students and researchers, reaching out to industrial partners, international partners, the general public. And, so the NASA employees really have the opportunity to help lead all of those, and, in fact, all of humanity, on a grand journey. And I'll close right there.

Pete Aldridge

Maria, having worked for an FFRDC, I think you covered it briefly, but it might be important to recognize it: Once you've created the FFRDC to support the NASA mission, there is an opportunity for that FFRDC to work in other areas and contribute to the economic well being of the locality so long as it does not interfere with the objectivity and independence of the—

Maria Zuber

That's right. It really broadens the potential for engaging other technological opportunities.

Pete Aldridge

Right. I thank the Commission for their comments and I find them all absolutely terrific.

Neil Tyson

Just to clarify something, Maria. So when you say, "Just convert them to FFRDC's," that would involve porting, by whatever administrative means is required, those who are previously civil servants into the employment profile of an FFRDC. Is that right?

Maria Zuber

That's correct.

Pete Aldridge

Let me very briefly, again, we've run out of time. What we've heard, and I will be very brief because we've heard the details from each of the Commissioners. First of all, we are very delighted that we now have a vision. I think we have heard that NASA was a spinning compass on several occasions without any direction. And now we have a vector.

The goal is very important, but, as we've heard, the journey is also going to be very important, and the economic benefits, the inspiration, the technical achievement, jobs, prosperity, and so forth. To achieve the goal and the benefits of the journey will require fundamental changes be made. As you heard many times, we cannot continue business as usual.

We must be managed as a national effort. If it's going to be a national effort, the whole management structure of how this entity is run probably has to be elevated to a higher level in government and must be managed in a way that takes and utilizes the resources and capabilities of multiple federal agencies. It must be sustainable over decades and that means having ownership by the American taxpayer.

We must transition to a space-faring nation, leading to a space-based industry. That will provide that economic strength, the competitiveness, leadership, and sustained commitment to the goal and the journey. It requires more private-sector involvement in which NASA does the hard stuff and the private sector does the rest. And the partnership must exist and a culture must exist to make that happen. International participation is important. We've talked about the model of independent projects or integrated components, and either of which would be appropriate, so long as it's developed in the proper way.

The NASA organization must be more integrated, focused, and aligned with the new mission. We must manage the effort as a system of systems, using the best practices of managing very large systems. And you've heard about systems engineering and spiral development and so forth. Our ability to do this will be declining over time. The skills and the industrial base are declining. We need incentives for math, science, and engineering and a sustained national commitment for the goal and the journey. And we will be making recommendations in this Commission that will address each of those issues. And with that, I adjourn the session as our last open hearing. We thank the audience for attending. We will be in the process of now working on these topics and preparing the final report for the President, hopefully around June the 2nd. And, again, the Commission, I thank you for coming, and we are now adjourned.