

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

Georgia Centers for Advanced Telecommunications Technology  
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**Pete Aldridge**

Well, good afternoon. I'm Pete Aldridge, I'm the Chairman of the President's Commission on the Implementation of the U.S. Space Exploration Policy, or as I have shortened it, the "President's Commission on the Moon, Mars, and Beyond." I was delighted when I learned that Monica Scarbrough, the Director of Development, invited us here. The Georgia Institute of Technology is in fact my alma mater, and it's generally great to be back on campus. I'm looking forward to looking around at some of the old haunts that I spent many hours on.

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, we've talked to experts at two previous hearings—in Washington, D.C., and in Dayton, Ohio. We've talked among ourselves and we realized 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 and academia.

As you can see from our agenda, we are 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.

And begin on the audience's right, Carly Fiorina. Carly 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 at AT&T and Lucent Technologies.

Michael Jackson is the 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 Agency.

Dr. Laurie Leshin, who will join us a little later, is the Director of Arizona State University Center of Meteorite Studies and the Dee and John Whiteman Dean Distinguished Professor of Geological Science at the University of Arizona.

General Les Lyles—General 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 commander of the Air Force Materiel Command. In that pre-retirement position, General Lyles was responsible for the U.S. Air Force research and development community and an expert at space, I would say.

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

Dr. Neil deGrasse Tyson—Neil 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—Bob 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. While in Congress he was a Chairman of the House Science and Technology Committee with NASA oversight. He also served on the recent Aerospace Commission as its chair.

Dr. Maria Zuber—Maria Zuber is the E. A. Griswold Professor of Geophysics and Planetary Science 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.

Steve Schmidt—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. We've been appointed by the President to make recommendations on how to implement the space vision set up 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 or more presidential terms are covered by this vision. We are listening to experts and the public along with drawing upon our own expertise to generate this plan. I envision that we will select maybe 8 to 10 key strategies to recommend what we believe will lead to putting us back on the Moon, on to Mars and beyond. In addition to experts, we are listening to the American public, the ultimate customer for this vision. Through our website we are accepting comments from people around the world who want to be heard on this subject, and lots of folks want to be heard. We've already received 4,700 written responses through our feedback opportunity on the Web. And literally millions more people are accessing the web page. As of early today we've received more than 3 million hits on our web page from 60 countries. Now, I want you to know that every input is being read. We're listening. You may be interested to know that about 75 percent of those contacting us through the Web are in favor of our sustained journey. I am delighted with those findings. Many of those who expressed their concerns about the process do so because of cost.

As we approach this task as a Commission, we're looking at it through four themes or approaches. We see that we must make recommendations that are affordable and therefore sustainable over several decades. I emphasize this not a—this a journey, this is not a race.

Management of such a large project and maintaining its affordability are crucial elements of our endeavor. Also, we recognize the need to inspire our nation's young people and encourage literacy in science and math and engineering. We need those skills to maintain our leadership position in the world. We've been chartered to lay out the science agenda for the next several decades. What should we be pursuing? What makes the best use of our investment? Finally, we're looking at the strategies that will ensure our nation's competitiveness and promote prosperity. After Atlanta, the Commission will hold hearings in San Francisco and then in New York City. Then we will write our report and give it to the President, just 120 days after our first meeting, as he directed.

We had many a distinguished guest, some of whom come to testify today, and you will meet each of them in turn. On behalf of the Commission I want to acknowledge our Atlanta host, Monica Scarbrough. Monica, where are you? Way in the back. Thanks for inviting us. I'm delighted to be here. Dr. Wayne Clough, President of Georgia Tech. Wayne, thanks very much for providing the facilities for us here. Nikil Jayant, Executive Director of the GCATT, I guess you would call it. The Georgia Communications, yeah, there you go ... [laughs] GCATT [Georgia Centers for Advanced Telecommunications Technology] [laughs], I can't remember all of the names. We appreciate the use of the facilities and all the support of your excellent staff, and thanks to all for the Southern hospitality shown by everyone here; it's very typical of Atlanta, Georgia. Thank you very much.

Our first panel today is made up of space entrepreneurs and purveyors of technology. Here in this communications capital we will be talking to Mr. Elon Musk via videoconference of Los Angeles. I don't think he's on yet, so we'll go back to him in a few minutes. Joining Mr. Musk at the Atlanta witness table is Dr. Peter Diamandis, Chairman and CEO of the XPrize Foundation, which is offering a \$10 million prize for private space flight innovation.

Dr. Diamandis is also the CEO of ZeroGravity, a commercial space company in Fort Lauderdale, Florida, that is developing FAA-certified parabolic flights. Jeff Greason is the CEO of XCOR Aerospace, also joins us today. Mr. Greason will share his experience as a space entrepreneur in the area of long-life highly reusable rocket engines. He was named one of the inventors of the year in 2001 by *Time* magazine, and we're eager to hear about the XCOR EZ-Rocket, and welcome, Jeff, to have you here. We are going to have an audible change here because of the time constraints. We are going to start off with Dr. Peter Diamandis first, and then we'll go on to Mr. Musk when he comes on at about 1:15. Peter, welcome, and the floor is yours.

### **Peter Diamandis**

I'm glad to be here, Mr. Chairman. Can you guys hear me okay? It's my pleasure to be here. I want to speak on three subjects: XPrize itself, space entrepreneurship, and risk. There is a large and vibrant marketplace for space, public space flight, and space tourism. Consistently over 60% of the U.S. public surveyed said they want to go. Recent studies done by Futron say there's a billion-plus-dollar market per year over the next 20 years for people getting a chance to fly into space. The difficulty has been that the ships to privately carry these people don't exist. You have to go Russia right now. To counter that, myself, my colleagues have put together something

called the X Prize. We announced it with then-administrator Dan Goldin, the Associate Administrator of the FAA, 20 astronauts under the Arch of Saint Louis back in '96. Offering up a \$10 million cash prize for the first private team that can build a ship that carries three adults up to 100 kilometers, come back down, and do it again within two weeks. (Next slide, please. Go to one more slide if we could. Next slide, please. Thank you.)

The X Prize itself has been successful; we've attracted 27 teams from seven countries who are building these ships. They have spent over \$50 million in pursuit of this \$10 million prize, and unlike a typical government procurement, where you might see a few paper designs after \$10 million, we are seeing the majority of these teams building and flying hardware. We're not going to have winners selected by a panel of judges. We are going to have the winners selected by those who go and fly and make it happen. Best of all, we are not going to pay out a single dollar till someone pulls off this flight, and we expect the winner of the X Prize in the next four to six months, this coming summer. We hope that that will cause much of a major shift the way the Orteig Prize that Lindbergh won in 1927 did. (Next slide, please.)

And here we see the 27 teams and some of the designs that they have. (Next slide, please.)

We also had a role in playing in the creation of the NASA Centennial Challenges, which were just announced. NASA is going to be offering \$25 million in prizes starting this next year, and it's something that we're very proud to have been a part of. My hope and goal would be that be that will climb in numbers to the point where NASA might serve up half a billion dollars in prizes, 2½ percent of the market. Prizes are a way for us to look at achieving fixed-price science, even fixed-price engineering, and a way to really incentivize and get people excited about participating. Having a chance to go and do something. It's a way that the government can in fact capture the passion of the entrepreneur mind you can't do any other way. We're programmed to compete. (Next slide, please.)

In the pages of *Investor's Business Daily*, the *Wall Street Journal*, *Wired*, *Popular Science*, people are starting to talk about a new generation of space entrepreneurs. Call them astropreneurs if you want. These are the X Prize teams, companies like XCOR and Space X and ZeroG and Space Adventures. And these companies are in fact the entrepreneurial spirit of America in space, the early days of HP or Apple or Microsoft or Netscape. And I encourage and urge this Commission and the U.S. Government to embrace and support these companies. Most of these companies, like my own, are focused on the public spaceflight, space tourism marketplace. It's quite frankly the only market that we see in the early days that really has a mass market. And the importance of this (next slide, please) is that today, the market for launches is pathetically small. There are only 15 to 25 commercial launches of satellites per year. That's not a marketplace. There's 15 commercial launch vehicles out there. That's an average of one per company. What we need is a vibrant, real marketplace. I call them self-loading carbon payloads. You know, they come with their own money, millions of people who want a chance to fly. (Next slide.)

I know that these suborbital vehicles that the X Prize and XCOR and others are creating are 1/30th the size of the Deltas and the Atlases and the Shuttles, but that's okay. They are 1/30th of

the size, but what the problem is, the reason the Shuttle costs so much, is not the fuel, it's the standing army of people watching people watching people to try and ensure safety. We can't get safety that way. We need experience. We need thousands, millions of flights, not a dozen flights. The reason a 737 costs so little, it can be turned around with six people in 20 minutes, is the 50 years of millions of flights we have under our belts. We know operational robustness. We are not going to get to operational robustness with a dozen flights of a Crew Exploration Vehicle or Shuttle. We need something to learn how to do a flight, three, four or five flights a day. Aviation today started with 10-minute hops and it grew incrementally to transatlantic flights. We skipped in the space program these 10-minute hops and went straight to orbital shots. We need that small incremental step. And so I urge the Commission to support the public spaceflight marketplace if for no other reason than to allow for a large increase of thousands of flights per year paid for by the public who want to go. Let's learn from that. Let the DoD and NASA buy these flights. Learn how do you turn a rocket engine on and off, on and off, like XCOR is doing. The final thing I want to address is the issue of risk. Not reducing risk ... (Next slide, please.)

But increasing risk. I am seriously concerned that today, we have become so risk averse we are forgetting how to innovate. When something is truly a breakthrough, the day before it's a breakthrough it is a crazy idea. It's an irrational idea. If it weren't a crazy and irrational idea, it wouldn't be a breakthrough. It would be a small, incremental improvement. But when you utter those immortal words "Failure is not option," when you are not allowed to fail, you can't have breakthroughs either. I urge the Commission to recognize the need for risk, and in fact I ask you to help educate the American people that space is risky. But it's a risk worth taking. As Americans, we are here because thousands of people risked their lives and crossed the Atlantic and the Plains, and we owe them our debt of gratitude. And, for our children and their children we must take risk, and allow risk, and embrace risk. Thank you very much.

### **Aldridge**

Is Elon on the monitor now? Elon Musk? Ah, it looks like you're on. Elon, you're from Los Angeles?

### **Elon Musk**

Yes. Can you hear me okay?

### **Pete Aldridge**

Yes, we're pleased that you can join us today, and let me just explain to the audience you are not only the father of the Zip2 and PayPal, one of the largest web-based electronic payment systems, but he's also about to become father of twins.

### **Elon Musk**

Yes, exactly.

## **Pete Aldridge**

Things are going well. Elon, the floor is yours.

## **Elon Musk**

Thank you very much and I appreciate the committee having me by videoconference because of the impending twins. As the members of the Commission are aware, the cost and reliability of access to space have barely changed since the Apollo era three decades ago. Yet in virtually every other field of technology we have made great strides in reducing cost and increasing capability, often in ways we did not dream existed. We've improved computing cost by a factor of 10,000 or more, decoded the human genome, and built the Internet. The exception to this wave of development has been space launch, but why?

My best guess at the origin of the problem relates to a breakdown of what the economist Schumpeter called "creative destruction." He postulated that the way that an industry improves is that new companies enter the market with a lower price or a superior product; this forces the whole market to improve. But yet with all the launch vehicles, we see a situation where there has been no successful new entrant in four decades, apart from one firm established in the 80s. Moreover, there has never actually been a truly commercial development anywhere in the world that has reached orbit. To address this problem, we must create a fertile environment for new space-access companies that brings to bear the same free-market forces that have made our country the greatest economy in the world. If we can create such an environment, I expect that progress in space launch costs and capability will be no less dramatic than in other technology sectors.

If you doubt that we can possibly see such progress in space access, please reflect for a moment that the Internet, originally a DARPA-funded project, showed negligible growth for over two decades until a private enterprise entered the picture and made it accessible to the general public. At that point, growth accelerated by more than a factor of 10. We saw Internet traffic grow by more in a few years than the sum of all growth previously.

We are in a crucial turning point today. The vision outlined by the President is absolutely achievable. We've got a current NASA budget and schedule, and in fact I think it can be done quite a bit sooner, but only by making use of new entrepreneurial companies along with the incumbents. It cannot be achieved at all if we simply follow the old paths, which have led us to one canceled program after another following the Space Shuttle. So what strategies are key to achieving the President's vision? And, here I think you'll see a common theme between myself and some of the other panel members, particularly Dr. Diamandis, because I would say first and foremost it is increase and extend the use of prizes. Offering substantial prizes for achievement in space could pay enormous dividends. We are beginning to see how popular it can be by seeing the observing the recent DARPA Grand Challenge on the DoD side as well as the X Prize. History is replete with examples of prizes bearing great achievements. As Dr. Diamandis mentioned, there is the Orteig Prize, which is where the crossing of the Atlantic by Charles Lindbergh. There's also the—another great example is the Longitude Prize, which was solved in

a way that nobody expected and that was for ocean navigation. So, few things stoke the fires of creativity and ingenuity more than competing for a prize in a fair and open competition. The result is an efficient goal-winning exercise with the subjectivity and error of proposal evaluation removed. The best means of solving the problem will be found and that solution may be in a way in a poor company that no one ever expected. One interesting option might be to parallel every NASA contract award with a prize valued at 1/10th of the contract amount. We should strongly support and extend the proposed Centennial Prizes put forward in the recent NASA budget. I firmly believe that no dollar spent on space research will yield greater value to the American people than those prizes.

My second point—and I only have two primary recommendations—is that the U.S. Government and NASA and the DoD support new entrants in space launch. The most fundamental barrier to human exploration beyond Earth orbit is not any technology, it is simply cost. And, it should be noted that the cost of access to space also drives the cost of spacecraft; the two are tightly related. If you are paying \$5,000 a pound to put something in space, you will naturally pay up to \$5,000 a pound to save weight if you are being rational, and this creates a vicious cycle of cost inflation. But this problem of affordability walks all over us if we do not set ourselves in the track of solving it with a constantly improving price per unit mass to orbit instead of a constantly increasing price. In fact what we need really is, is sort of a Moore's Law of space. We need to create the system that will enable a constant improvement in that cost per unit mass. If we don't do that, neither the average American nor their great-great-grandchildren will ever see another planet. We will be forever confined to Earth.

It was precisely for this reason that I established Space X and set as our goal improving the cost to us as well as the reliability of access to space. Certainly after selling my first company for \$300 million and my second for \$1½ billion, I'm not doing this to improve my standard of living. You know our first offering called Falcon will be the only semi-reusable rocket in the world apart from the Space Shuttle. Initially we will deliver cargo to orbit in the form of satellites, even though it is a small market, as Dr. Diamandis pointed out, although, I think, larger than people think. But we want to predicate our business on something which we know to be true and then extend it from there to other arenas.

We believe very strongly in the market for commercial human transportation, and that is ultimately our goal. As the starting point for improving the affordability problem, our Falcon rocket is only 1/5th the NASA list price of our U.S. competitors. Moreover, we expect to decrease our prices in real if not absolute terms every year, and in fact we will be shortly announcing a price decrease to make this point on our Falcon 1 launch vehicle. New comings might also, my reliability level is more comparable to airline transportation. In the case of Space X, we believe that our second-generation vehicle, in particular the Falcon 5, so called, because it has five engines, not because we skipped two, three and four, will provide a factor-of-10 improvement in propulsion reliability. That will be the first launch vehicle since the Saturn V to have engine-out capability and be able to complete its mission even if an engine fails, just like almost all commercial aircraft. So, that's really, I think just those two are the primary

recommendations that I have. Thank you very much for inviting me to come here before you today and present my thoughts.

**Pete Aldridge**

Elon, thanks very much. Are you going to stay on board the monitor so if questions come up, you can respond?

**Elon Musk**

Absolutely, yes.

**Pete Aldridge**

Okay, good. Thank you. Mr. Jeff Greason. Jeff, you're up.

**Jeff Greason**

Mr. Chairman, members of the Commission, thank you for inviting me today. XCOR Aerospace was founded with the belief that dramatic reductions in the cost of space transportation are possible. Because of the lower cost of entry, we have chosen to focus initially on suborbital vehicles. For those of you unfamiliar with XCOR, I have a short video clip that shows some of the work we've been doing the last few years. If you could play the clip please? [A video clip is shown.] That's enough of that. The vehicle we've been flying that you just saw, the EZ-Rocket, was intended as an operations demonstrator for our reusable rocket technology. It flies at an incremental cost per flight of about \$1,000.

I was inspired to choose an engineering career in large part by the accomplishments of Apollo and Skylab, and I would love to see the nation move forward again in the bold spirit of exploration. In spite of this, when I heard about the new initiative, I was very cynical. I believed that no matter what direction was set, that the NASA *Challenger* and *Columbia* could not and would not follow it. I am here today because I've seen some signs of hope and awareness that we cannot succeed by recreating Apollo, and an awareness within NASA that this may indeed be their last chance to revitalize and reform the agency.

When President Kennedy set America on a course for the Moon, the nation had launched one human being on a suborbital trajectory for 15 minutes. Eight and a quarter years later, the first men landed on the Moon. It is very likely that before this year is out one or more private companies will launch human beings on suborbital flights for about 15 minutes. I would not be so bold as to predict that in 8¼ years private companies will be landing on the Moon, but I wouldn't rule it out. What is certain is that this is a time of great dynamism and risk taking by the private sector in space—a time which may yet see the emergence of commercial passenger space travel by companies such as XCOR. Surely, at such a time, predicting what any of us will be able to do by 2014 would be foolhardy. Private entrants are developing vehicles on roughly a three-

year time scale. Therefore, by 2014, systems three generations beyond those that are now being fielded should be flying. It is very possible that reusable orbital space transportation systems operating at a small fraction of today's cost will be available by then.

NASA and the exploration initiative cannot count on those capabilities, because they aren't here yet. But they must plan these missions in a way that they can exploit those capabilities as they arise. How do they do that?

NASA can position itself to grow with the private sector very simply by buying space transportation services on the commercial market. That is a simple rule with profound implications. For I mean that NASA should use commercial means as their *sole* means of transportation to Earth orbit. That means if they can't find a commercial provider that has a given capability, they must do without it, just as anyone else would in other fields of operation. Off-the-shelf transportation settled the New World, explored the American West and built the Antarctic station; surely it can do more. Almost every bridge and building in the world was built with parts that come in trucks on 10- to 20-ton pieces. The Space Station is built from 25-ton pieces. The South Pole station is built from 20-ton pieces, and there are launchers out there today with payloads in the 10- to 25-ton range. We can go to the Moon and Mars this way, and if we are going we have no choice. NASA will never see the limitless budgets of the Apollo program; we must work with the budget we have. And the inescapable truth is that current funding will not support a NASA-unique launch vehicle infrastructure and the payloads to put on top of it at the same time. Another NASA-unique launch vehicle will never pay for its own development costs.

We don't have to select the launcher today; in fact, we need never select a launcher, we just put the launches out for bid and take the ones that are cheap. By purchasing commercial launch services, NASA will stimulate the development of the launch industry. The surest path to greater reliability is not man-rating but greater traffic volume, as my predecessors have said. The more frequent the launches, the faster the providers will learn and the cheaper they will get. The path to greater safety is not man-rating either but a robust escape system. New launch technologies from new companies will start small before they grow, but even small vehicles can launch propellant, which will make up the bulk of the mass of any exploration mission architecture. And surely we can risk small companies with risky technologies launching hydrogen and oxygen or for even, say, water. In the interim, companies such as XCOR have the capability to develop components such as engines, pumps, and tanks, cheaply and quickly. Some new companies will succeed and many will fail, but how is that different from our current programs? If their exploration initiative founders, we at companies like us, we'll have no new business to compete for. That's why I'm here, and if NASA continues business as usual, that's exactly where we are headed. America can afford to dare and do great things, but we have to do it as exploration has been done throughout history. We have to use what we have, live off the land where possible, and build expensive custom equipment only when nothing else can possibly do the job. That is the true spirit of exploration and an effort that XCOR would proud to be a part of.

### **Pete Aldridge**

Yes, thank you very much. Very intriguing. A couple of questions. Peter, you talked about the, I think you were using numbers like about \$50 million are being used to go after this \$10 million prize. Where does that money come from? What's the incentive provided?

### **Peter Diamandis**

The incentive for prizes—a year ago we went to NASA with the idea of prizes and they embraced it and we did a study for them and said that if the prize is got high enough visibility. If you look at the Orteig prize offered by Raymond Orteig in 1919, won in 1927, it was \$25,000, \$400,000 was spent to win it, 16 times. If you look at the America's Cup, Barry Ellison will spend \$70 million for a zero cash prize. It's the glory of it. But the real effort is the prize credentials: the idea as being something that people should go after. And it makes it so exciting that people will invest, and they invest a different type of money. When these X Prize vehicles, people are not going to venture capital firms, they are going to companies like HP or Microsoft and saying, "Sponsor me for the advertising purpose." That's where the money comes from. It comes from advertisers, it comes from wealthy individuals, ego capital if you would, and that's great money. There's \$20 billion a year spent in sponsorship dollars today. Very little bit goes to space, but it could.

### **Pete Aldridge**

That's interesting, because we are trying to see, what we are looking for, the model by which the private sector would invest in this. And what you are saying is that maybe there isn't a model that—other than just the prestige of it all.

### **Peter Diamandis**

There—exactly. In 2000 I was involved in a company that Paul knows about called Blastoff. It was one of the companies in Idea Lab, which had done E Toys, had raised a billion dollars, and was kept under wraps, but we were building a private mission to the Moon to land three robots. It was a \$60 million budget and I thought we had, and Paul can verify that, an excellent chance of succeeding, and it was basically going to be done on a advertising, television rights, sponsorship model basis and return investment on the dollar. There are private companies that can go to the Moon today in three years for well under a hundred million dollars if they had the opportunity. I have no question about that. It can be done, just unleash the capitalist spirit.

### **Pete Aldridge**

Okay, Bob?

## **Robert Walker**

Thank you, Mr. Chairman. A question for any of you who would like to answer: If we were to put a request for proposal or a request for information on the street within the next few months asking for companies to give us a plan for filling the gap after the Shuttle has been retired and there is the Crew Exploration Vehicle available, what do you think the response of the smaller commercial vendors would be to that? In other words, it would be a request for NASA to actually purchase flights from the commercial community, and it would go out probably on an international scale. Do you think we would get the kind of response that would give us some confidence that that gap could be filled by the commercial community?

## **Jeff Greason**

Let me take a whack at that. I'm going to say that that brings up a couple of very interesting points. Okay, first off let me address your last point about confidence. I mean, I don't know whether it would bring you to a situation where you have confidence, but I think that is a myth. I think if you look at the history of traditional procurement programs, you could not look at them and say that you have confidence, that when you start down that road you're going to get the desired product. In fact, recent history would give you some lack of confidence. As to whether or not private companies are interested in going out for something, the answer is not uniquely different, because it is faced in any other arena: Before a private company decides whether they want to pursue it, they want to know if there is going to be a market there. And so when you talk about replacing the Space Shuttle, I mean the Space Shuttle's market right now is negligible. I much—the prizes that my colleagues have spoken about are very exciting and very interesting, but even more exciting and interesting are markets. And you know it's not clear that privatizing the current trouble missions or Space Station resupply is itself an interesting market because it's not obvious that the Space Station is an interesting market. More interesting would be if NASA has a core ongoing budget wedge to do something like an exploration mission is to take the large portion of that mass that anyone can launch and just put it out for bid. And, if you put it out for bid every year and spread your risk around, don't buy more than 20 or 25% from one provider—well, that's hundreds of billions of dollars of propellant lift going on every year, that's a real market.

## **Elon Musk**

I can also answer that.

## **Pete Aldridge**

Excuse me. Elon?

**Elon Musk**

Oh, yes. Can you hear me okay?

**Pete Aldridge**

Yes. Go ahead.

**Elon Musk**

To answer that question, I would say, I think—it's hard for me to speak for other companies, but I can say that certainly Space X would respond to such a request. We have a strong interest in servicing the Space Station and doing what we can to help our country's space program in that arena.

**Robert Walker**

Just to follow up if I could: Clearly the working model on this is that for human transportation to the station after Shuttle's gone that we would rely upon Russian Soyuz, based upon what we now know. Do you think that anybody would come in and suggest that they could provide human transportation?

**Jeff Greason**

If the money is there, absolutely. Sorry, Elon.

**Elon Musk**

Yes. Yes, in fact I can say again, we would propose to do that.

**Pete Aldridge**

Peter, go ahead.

**Peter Diamandis**

The airmail model is an excellent one—what the government can easily do. The NASA Shuttle budget now is—let's call it \$4 billion a year—offer out a contract for \$10 million per seat to orbit, fixed price, for whoever provides it. You get 100 people to orbit for a billion dollars and put \$3 billion in science budget.

**Pete Aldridge**

Thank you. Neil?

## **Neil Tyson**

I want to thank the three of you for your testimony, and we are trying to grapple with just these very issues, so this will be very useful for our subsequent deliberation. Let me just ask—first, the example was given for the Longitude Prize in the UK, but of course that was a govern—if I remember my history, that was a government-established prize as distinct from most of the prizes in the early history of American aviation that were privately established. And therein is an important distinction, because I believe that in principle nobody's been stopping you from running these efforts. I might ask why haven't, why didn't you succeed 10 years ago or 20 years ago? Why is it just on the cusp now—is it something about the technology that is enabling it? And the flip side of that is, the model of the aviation prizes in the early part of the 20th century—you cited the one that Lindbergh had won, a prize that had been sitting there for more than a decade. The NASA vision as it has been put forth is not a vision that has the luxury of waiting around for somebody to invent something new. Sure, it will take advantage of something that shows up, but to say that we should have a vision and wait the time that it might take to win the prizes that are established, I worry about the mismatch between the winning of prizes for these various achievements and the actual execution of a vision that has a timetable and expectations and a budget based on that fact. So, I don't know who to direct that question to, but you can fight over who's going to answer it.

## **Peter Diamandis**

I'll take part of it. First of all, the reason this wasn't done 10 years ago, the difficulty in all of these launch attempts and all of these is the availability of capital. Mr. Musk has done an amazing job building his capabilities and wealth, and he's now putting his money where his vision is, which is unique in this country right now in the space arena. And we are all very thankful that he's doing that. But before, if you went to a VC [venture capitalist] and said, "I want to build a rocket ship," they would look at you cross-eyed and say, "There is regulatory risk, and market risk, and technical risk, and I'll put my money under my mattress and lose less of it." So, what the prize has done is credentialed the concept, which has brought capital of different flavors and that's why it's doable now. I mean, that's what I think the most valuable part of the X Prize has done. In the early aviation world, the prizes were put up by newspapers to create good news and create, you know, sell their papers. The media giants were doing that, as well as a few wealthy individuals who had a vision, instead of building a hospital or an art wing, they'd put up a prize to help push men forward. And I think government—don't—it's the cheapest way for government to get it, and I think, Jeff, you said it best, it's not one or the other. When given a choice, take both.

## **Pete Aldridge**

Carly? I'm sorry. Jeff?

## **Jeff Greason**

The second half of that: It wasn't done 20 years ago because if you may remember at that time, space launch was a nationalized enterprise in the United States. It wasn't until after *Challenger* that it was even opened for private entrants. And it's taken many years, fundamentally a generation, for the memory of that to pass on. Even today, most people that you approach for sources of capital are under the impression that NASA is the nation's space transportation agency and meets all of its needs. There are many other factors in play—that technology is improving, the regulatory risk is declining—but I think fundamentally it's the perception, rightly or wrongly, that private efforts are in competition with the government for space transportation.

## **Pete Aldridge**

Carly?

## **Carly Fiorina**

First, I want to thank all of you for testimony today, and I must say, on a personal level, I've been sitting here smiling for the last 45 minutes because I have believed for some time that the only way we are going to be successful in this mission is to capitalize on both entrepreneurial spirit and capability in a very different way than we have in the past. And I want to come back and ask, actually, each of you to talk a little bit about the subject of risk and as well to talk a little bit about the subject of other sources of capital. On the issue of risk, I would certainly agree, Peter, with you that I also share your concern that we are becoming a risk-averse nation as opposed to a risk-taking nation, and that that represents a vulnerability and a moving away from the true American spirit. But nevertheless I think it is true that this issue of risk potentially can make this mission difficult. So, I'd like your thinking about how we speak to the American people about the subject of risk. And do you believe that the American people have a fundamentally different tolerance for risk when entrepreneurs are involved in a mission as opposed to their government? (question one). Question two would be, Do you believe there are opportunities to include venture capital or more traditional forms of capital beyond the government RFP [request for proposals] process, the prize process? Have you thought about five or ten years down the road if there were a robust and healthy opportunity for venture capitalists to participate or even Wall Street to participate?

## **Elon Musk**

I'll take the last part of your question first if I could. I think it's quite true that we need to have some sort of a positive example of one company that has started up and done well in space, and we really don't have any example like that today. There have been numerous startup attempts before in space launch. I'm talking orbital space launch. All of them have failed. So you've got a big graveyard, you know, a perception that there are some freshly dug graves waiting to be filled. And we need to at least have something other than zero in the success column. That's what I'm

hoping will be the case for Space X. Certainly I agree with the rest of the panel that, although, I know many of the top venture capital people in Silicon Valley, they were pretty surprised when I told them I was going to try to do something in space. So our goal is to get our first launch successful, which will be just only in a few months, launching a Navy communications satellite, and with that successful launch hopefully that will break the dam. If people remember, the Internet was not initially seen as a commercial arena, as something where venture capitalists could make money. When I first went around asking venture capitalists to invest in my first company, a lot of them weren't sure what the Internet was, and if it did exist it wasn't going to make money. And then with the advent of Netscape going public and doing very well, that whole perception changed, and I think we can see something similar in space.

### **Pete Aldridge**

Peter?

### **Peter Diamandis**

On the issue of risk, again, I think that we have to embrace risk, and that means changing the way people view it. You know, we have 50,000 deaths per year in automobile accidents, and we have huge—thousands in skiing accidents, but yet when *Challenger* went down, everything stopped. We stopped the Space Shuttle program and we take actions, which the public then says, “You know, this is risky,” and we don't shut down roads when a car crashes. And we did it again with *Columbia*, and I understand the issues of losing the vehicles, but there needs to be an active effort done to let the public know that this is risky business, that all of these heroes, these astronauts who should be asked to discuss publicly the issue of risk. “Yes, I'm risking my life and I accept it because it's worthwhile.” And allow them to be heroes again. You know, we used to know—how many people here know who is on the Space Station today? Name the people in the Space Station? Can any of the people in the audience? We don't know who these heroes are. We've made them, you know, unnamed individuals. We need to turn them back into heroes, accept the fact that they are taking risks. On the VC involvement issue, we need—we have zero successes to point at, and VCs will not invest until there are successes. We also need the government to play the [?] role a little more actively. You know, my company, ZeroGravity Corporation, is going to be—if they approve parabolic flight. But the idea of getting NASA to give up its KC-135 is important to them, even though we can do it cheaper than they can. Or maybe because. But it has to be a letting go.

### **Pete Aldridge**

Jeff, do you have a comment?

## **Jeff Greason**

Yeah. On the issue of risk, about 20 percent of my time is spent working the regulatory issues associated with commercial human spaceflight, so it's a discussion that comes up a lot. The thing that's hard to understand but it's at the root of this discussion is that the only way to get safer is to allow risk. If you try to prevent all risk, the only way to do that is to sort of freeze the current state of the art in. You put safety standards in place to embody current best practices, and you can sustain what you are doing that way but you can't get any better. And when it comes to space transportation, what we've got right now is awful—a 1-in-50 chance of catastrophic accident on a vehicle is totally unacceptable on any other form of transportation and should be in space. But the only way to get better is to allow technological change, which means allowing risk. On the capital markets, I completely agree with the example of success being something we need. I think, fundamentally, economics doesn't change. If you want a sustainable vision for anything, it has to make money. You know, we don't have a national auto commission or a national airplane commission that is in charge of making sure that people still fly airplanes or drive cars. If you want the government to facilitate that market, they have to have a market there. And a market has to be something that can be predicted by entrants that they will be able to win on the basis of performance, not because of who they know or what their connections are or what their history is. In the longer term, if you are talking about venture capital involvement not for transportation but for actual exploration missions, you are talking about the next great regulatory frontier of the next decade, which is private property rights in space. That's a very important issue but I don't think it's an issue for today.

## **Pete Aldridge**

Paul.

## **Paul Spudis**

Well, it's interesting that you say that, because that actually feeds exactly into my next question, because I do think it is an issue. One of the interesting things that the President said in his speech was specifically one of the things we want to do in our new initiative is to learn how to use off-planet resources. And my question is really for any one of you who wants to address this: How would you see a transition period? How would you see that strategically planned such that the initial efforts to extract resources off-planet would be transitioned over to the private sector? Are there any particular pitfalls to avoid? Do you have any opinions on how it's best set up to be done? Do you think the prize environment is the way to go about this? Or another option that wasn't mentioned early in the testimonies, things like data purchase, where you contract to deliver a certain set of data or a certain set of commodities? Do any of you have any opinions on that? Looking further downstream, you sort of talked about transportation; what are your opinions on the private-sector involvement in this aspect of it?

## **Jeff Greason**

Well, I'll just amplify that previous remark before I turn it over to the others that clearly *in situ* resource utilization of some kind is a critical component of doing planetary presence, whether on the Moon or Mars, in a way that anybody, even nation-states, can afford. Clearly because that's necessary to support the government's position, the government is going to be in developing some technologies there. At some point, when it's politically achievable to do so, there is going to have to be some discussion of a property rights or mining or something like that regime in space so that you can turn over the, you know, you can start thinking about buying aluminum by the pound or buying hydrogen by the pound or something like that on the Moon. I think that's going to happen, but the legal challenges involved in figuring out what the property rights regime are comparable to what they were, figuring it out for the law of the sea, sea-bed mining and that didn't work out so well because the resulting regime was very burdensome, so there's a lot of challenges ahead.

## **Pete Aldridge**

Anybody else?

## **Peter Diamandis**

The argument that I used that works well, is that everything we hold of value on this planet, everything we fight wars over—minerals, and metals and real estate and energy—are infinite quantities in space. We are fighting over crumbs here. There is a supermarket filled with resources. And I think what is needed first and foremost is any kind of a clear government regulatory structure that says, "You can own this, you can have the rights to this." Once that is definable under any kind of a law, you know, the capital will flow. There is long-term capital that will make 50-year investments in wealthy families and large corporations but right now without any kind of legal structure ...

## **Pete Aldridge**

Les?

## **Les Lyles**

Yes, let me also thank all three of the panel members for being here. I really appreciate what each of you are trying to do and certainly the entrepreneurial spirit that you are bringing to this very, very important question. Having said that, I am, however, going to play a little devil's advocate, if you don't mind. Having sat in the seat Elon is sitting in right now, as a commander out at Los Angeles Space Center and having been involved in space launch development particularly, most of my career, I'm often intrigued by entrepreneurial companies who claim that they can do space launch cheaper, quicker, faster, better than some of the best minds in the

launch business in the history of this country. Sometimes space launch ends up being an art as opposed to a science. I have plenty of scars on my back from other engineers, from government agencies, from Congress, etc., of failures where we failed to stick to the formula, if you will, in getting things done. I'm intrigued as to how Elon and Peter and Jeff—what formulas are you going to bring or your companies going to bring to give success in this very important area of space launch that have not been able to be achieved by other companies in the past?

### **Elon Musk**

Well, first of all I should say we that are approaching this task with a great deal of humility. We recognize it is replete with failure, that there are no successes. And before starting this company, I put together a group of, in fact, the greatest minds in the country as far as rocket engineering was concerned, or at least the best I could find. These were engineers that have been involved with every major launch vehicle development over the past three decades. We met over a series of Saturdays, and the idea was in building a new launch vehicle to make sure that we drew from every lesson we had learned in the past to make something which was truly a significant improvement and to make sure we weren't kidding ourselves. And it was the reason I moved from Palo Alto, from Silicone Valley, down to LA was because this is where the talent is—the greatest concentration of aerospace resources, it is where the great minds in space likely are and that's why we are here. It's to obtain our talent, and we've also solicited as much advice as possible from—particularly from the DoD, who is our first customer for our first launch—and continue to do so. We are actually dedicated to building something better. We are not taking any shortcuts, although we've progressed quite quickly. We'll be launching from Vandenberg, passing a complete range safety the same as Boeing or Lockheed would do, you know, so that is the approach that we are taking. I would ask, that I think, while we've received a lot of support from the DoD and the commercial sector, in fact we've signed—just recently signed our first commercial launch contract and taken a deposit on that. There seems to be a much greater reluctance at NASA, particularly in the Launch Vehicle Procurement Office, to even engage with any new company. Although we've had almost all of Air Force Space Command from General Lance Lord on down, General Arnold, visit Space X, we've never had—in two years, we've never had a single visit from one person from the NASA Launch Vehicle Procurement Office, which I think doesn't make sense. Can you hear me OK?

### **Jeff Greason**

Yes, thank you. In the case of XCOR, we know how much we don't know, so we're starting very, very small and working up, and it's going to take many, many years of patient effort to get to the point where we have capabilities for orbital space transportation. I actually find that we have, when I talk to people in various government procurement, we often have more knowledge of the state of the art, understand that long history than is current, as many of the great experts have died off in the last 10 years. But it's going to take a long time. It's going to take a lot of effort. The real point—the reason I focused so much on existing capabilities during my initial presentation was that, you know, you don't have to speculate on what's available in the future.

You can get than the Shuttle by going out and procuring on the market right now. And while I certainly believe very strongly that over the next 10 years those capabilities in the private sector will emerge and be much cheaper, you don't have to gamble on that. And if you start by buying on the commercial market, with open procurement, you know, just bring your launch vehicle and we'll take the payload—that opens it up and provides market stimulus that will accelerate the pace of development of new entrants. And if they don't emerge, you're still better off than you would have been if you went off and did a NASA-unique vehicle.

### **Peter Diamandis**

If I might add one thing that, it's an important question. Why can entrepreneurs possibly do it better than the government? And I think it goes back to the issue of the willingness to take risks in areas that the government could not. You would literally be shut down and pulled before congressional testimony if you took a risk and failed. And private companies do that all the time. They take high fliers because that's the way they need to succeed. I'll give two very quick examples, of really extreme examples, both of them from Burt Rutan, who is building one of the X Prize contenders. In 1986, he built the Voyager airplane that flew nonstop around the world, and that Voyager airplane was built in about \$250,000 in cash and a half million dollars of in-kind donations. After it made that flight for 10 days and 25,000 miles, one of the aerospace companies who will remain unnamed, but their initials are TRW, put it through their pricing model and it came out at if they were asked to do a non-refueled, non-stop ten-day airplane it would cost them 200 million vs. cash outlay of \$250,000. The American SpaceShipOne team competing for the X Prize right now in a way is comparable to the X-15 that back in the 1960s Phil Walker took twice to 62 miles. But different in the following ways. It's about, probably 1/50th the cost, weighs one tenth the weight, and carries three times the people. So there is the opportunity.

### **Les Lyles**

Please do not misunderstand; I was not saying that the government could do it better. You really, all three of you, have addressed my real concern that you're not just cutting corners. Burt Rutan and the Rutan family and the Scaled Composites always cover and do everything technically perfect. They do it cheaper and quicker, but they don't cut any steps, and I was afraid that you were talking about cutting steps. So I'm happy to hear that you understand the complexity.

### **Pete Aldridge**

Maria?

### **Maria Zuber**

Yeah, first of all, thank you, all three of you, because a lot of the ideas here are really refreshing. This is for Dr. Diamandis: Tell me, what happens after the X Prize is awarded this summer? You

know, somebody—you said there are several contenders who could potentially win it. Someone will win. What happens after that, and how does that bridge into a potential commercial market?

### **Peter Diamandis**

Great question. Thank you. And by the way, I spent 10 years at MIT and loved the place. We have a great mission afterwards. We call it the XPrize Cup. We're going to have one winner and the last thing we want is a monopoly again. We're inviting all of the teams to come together at one location every year and fly during the same two weeks as many times as they can. Set time-to-climb records, altitude records, turnaround times, and XCOR will be one of the teams competing in that and probably the dozen or so XPrize teams that actually bring hard work to fruition. And so during that two weeks, we may see 100 launches to space. We'll bring a half a million people down flying from around the world to be part of that, to give the public a chance to touch and feel these ships. And what we'll see is, again, continued as Elon said, Darwinian evolution, where these ships, some will become the ones that can fly the highest. Some will have the quickest turnaround time. And we'll see them move in different directions. And the technology will continue to progress in those areas. So there is a follow-on plan: we'll do what auto racing has done but in the rocket business.

### **Pete Aldridge**

Neil?

### **Neil Tyson**

I'm just wondering whether I just had some different understanding of risk than everybody else assembled here. I never viewed the American space program as risk-averse when you consider what risk is. What you don't want to have happen is for people to put their lives at risk for something that had been done 111 times before. The risk is not doing something routine. You don't want that to be risky. The risk that we're prepared to accept and I think have always been prepared to accept is the act of moving a frontier beyond where it had been before. Then [there's] a whole different kind of equation there, and we all know people who are ready to jump to the front of that line to risk life, limb, wealth, whatever, so that they can have the distinction of having been the first and having set a record. So, I'm not as—I don't have that same skepticism that others do about the American risk paradigm, because I'm sure people—we just haven't done anything worthy of a risk to have—to measure that fact for the past thirty or so years. That's just a comment. Now I have a question. The business model that you describe—we all agree that given how much money we spend on amusement parks, people will be lined up to ride your X vehicles into low Earth, into suborbital trajectories, but not everything NASA will do going forward will have an easy business model counterpart. The launch vehicle systems are the kind of obvious best example, but the rest not necessarily. We're prepared as a commission to try to ensure that going forward, if you're putting things into orbit every four hours, that NASA is going to jump all over it. I don't see anything necessarily to stop that. So are you—what is your

worry? Are we—is something in your way? As you know, the DoD buys stuff that looks good and is cheap and it's on the shelf; what is it that we can do to try to smooth this going into the future? Because if you succeed we'll all be impressed.

### **Peter Diamandis**

NASA has a big difficulty with risk. First of all, there's big risk issues in procurement. NASA's not going to easily jump on Elon's vehicle or on ZeroG airplane because there's an issue there. Second thing is there's something called these test readiness levels that some of you know about where new technology has been developed and it goes through TRL 1, 2, 3, and it stalls, and in fact, you know "We can't fly that because it's never flown before" is the mindset. And once you get to that, you know, you can't get there from here and you're stuck. And that is an issue throughout the entire organization.

### **Neil Tyson**

If you demonstrate that something works, you know, a thousand times in a row—

### **Peter Diamandis**

There is technology, Dr. Tyson, sitting in NASA labs that will never see the light of day because it is too risky to fly it because it hasn't flown before. I've heard this from hundreds if not thousands of engineers and scientists.

### **Pete Aldridge**

Jeff?

### **Jeff Greason**

I don't share your optimism that if we flew a thousand times NASA would be jumping all lining up to buy things. If they were, we'd have a much better agency. There's always a reason not to buy. If you decided not to buy, there's always a reason not to buy. The risk is too high, the size is too low, I don't like the plug interface, I'm concerned about the risk of proximity operations to our expensive on-orbit asset—there's always a reason not to buy, and the last 30 years are replete with a lot of creative reasons not to buy. But you're fundamentally right. NASA is not in the way. And if they disappeared tomorrow, we'd be proceeding at about the same pace we are right now. I don't think the question is how to get NASA out of the way. The question is "Is there a way that NASA and the new exploration mission that's before our nation can be used to accelerate our progress?" And I think, you know, there are opportunities to do that and we've talked about some of them today. But no, NASA is not stopping us.

## **Elon Musk**

As I mentioned just a moment ago, we've had great experiences with the DoD. In fact, I'm sitting at LA Air Force Base right now. Our first launch is actually funded by—not the development, but just the payment for the launch itself—is funded by the Secretary of Defense. We expect to do probably three, maybe four DoD launches next year. In fact, we expect to do probably over half a dozen launches next year based on our current manifest. And we're actually quite optimistic about making this business model work as far as launch of satellites is concerned, which is kind of a foundation for going further. I wish I could say something positive about the Launch Vehicle Procurement Office of NASA. I really do. I have no positive data points whatsoever. We're incredibly disappointed that in the course of two years there's not been one individual from the Launch Vehicle Procurement Office to visit Space X at any point, when we've have had virtually the entire senior officer corps of Air Force Space Command visit Space X, and many other senior people from the DoD. It's an issue that befuddles us. And this is despite support from the administrator and from senior executives at NASA.

## **Neil Tyson**

So, are you suggesting that NASA might benefit if it had an arm similar or parallel to DARPA's role in DoD?

## **Elon Musk**

Absolutely. Actually, that's a great suggestion. You know, that's an excellent—I hadn't heard that before. That's a really good idea. Although I should point out that actually our personal interest is not a DARPA mission, it's an OSD [Office of the Secretary of Defense] mission. And then our second launch will be an Air Force mission. Our third launch actually will be a DARPA mission most likely, as far as DoD launches are concerned. But yes, that would actually be an excellent, excellent thing for NASA to have—a group which like DARPA is expected to take risks. That is a base expectation. It would be normal. [?]

## **Pete Aldridge**

It's interesting that DARPA was set up exactly for that reason. They will accept 50% failure. And it's because that's the other agencies within the Department of Defense, the military services, can't accept failure rates that high. If DARPA gets 50% they probably are pushing the state of the art, and that's what they were set up to do. Michael.

## **Michael Jackson**

Thank you, all three of you, for being here today. I find it very intriguing to have this conversation. Peter, I'm impressed with the idea that you have about taking crazy ideas and turning them into breakthroughs. I think that's a core part of the success model that we have to

embrace to get the President's vision implemented. But, Jeff, you also talk about hard, cold, fast commercial motives have to be found to stimulate this innovation. So my question really is, if you could start with an organization, you can call it NASA or you can call it whatever you want, that is solely tasked with supporting the President's mission to have the thing happen, which is to have man go to the Moon, to Mars and beyond, and so let's just assume for a minute we could create whatever right organization is necessary to support that. I'm really trying to drill down into whether there is some fundamentally and inextricably governmental function as a part of implementing this vision that is not going to be met by commercial interest, or are you really saying, "Privatize the whole thing, make it a prize to get to Mars on a competition and on a prize basis," or are we really trying to talk about in what manner and to what extent can you sync the private interest and innovation and entrepreneurial spirit to a very high-level public mission which is supported in the right way and integrates private participation? I mean, I really think that it's easy to talk in the principle of getting private-sector investment innovation, and I just love that idea, but I'm curious about whether you're saying, "Privatize the President's vision," and if not, where's the dividing line and how do you make these two sync up?

### **Jeff Greason**

Great question. Yeah, I've often—it's a fun game when space entrepreneurs get together. There's a conference every year that we can all mostly get together at and we'll be sitting around over drinks and play the "If I Were King" game: how would we do it? And this notional organization's even got a name. It's the National Advisory Committee on Aeronautics and Astronautics. Yeah. No.

### **Pete Aldridge**

[laughing] You just gave us yes and no.

### **Jeff Greason**

In my opinion, there is an inextricably government role. It is very difficult, not impossible perhaps, but very difficult in practical reality to envision true exploration missions being done for profit. Prizes are a way that you can do some of that when the time scale for the [Earth?] return is indefinite, but if you need to know something on a fixed schedule, and data purchase is another way, there are ways you can do it around the edges, but I think it's unlikely that private interests for profit are going to build 100% of everything you would need to implement this vision. However, that being said, if you look at successful explorations in the past, the fraction—the whole mindset is different than the one that we fell into with Apollo and beyond. I wouldn't have had to sit here 40 years ago and propose the idea that maybe we should mostly use existing transportation systems. That would have been a given. No one would have even dreamed of putting enough budget into it to do everything any other way. I think if you want propellant on orbit, which is something you're going to need an awful lot of, there's no reason you can't just put out a contract for it. I think that the myth of Apollo viewed through history is different than

the reality of it was. In 1962—you say, “Does NASA need a DARPA arm?”—in 1962 that’s all NASA was. And in some sense, NASA didn’t go to the Moon. Rockwell and McDonnell and Boeing and Chrysler went to the Moon, and NASA waved the baton, provided the key research, had the central facilities that didn’t make sense for companies to operate and coordinated that project. I think that’s a successful model. I think that can work.

### **Peter Diamandis**

That notion where NASA is the sole customer, that’s perhaps the area that is exploration. Where we can identify a multitude of customers, especially in volume, then NASA should be the facilitator and allow the markets to develop there. And what I’m speaking about here is, in fact, quite frankly, you know, it should be fixed price like you buy anything these days. There’s not an Air NASA carrying us between Washington and Houston. You go and you buy tickets. The same thing should be for all orbital flights. We are paying a fixed price of \$2,000 per pound to orbit and \$10 million a person. And when we find out we’re making too much profit on that, we’ll reduce that later down the line. And if in fact going and capturing asteroids or going and processing lunar oxygen becomes a market that is useful, then stopping exploration and start be commercially provided, period. End of sentence. When the capital is there to make the investments, that’s who is missing around the table here, is the VCs who say, “When you do this, I’ll invest.” It’s solved.

### **Pete Aldridge**

OK. Let me summarize this for a few minutes. We’re running near the end of our session here. I gather there’s really two things that might be messages that you are leaving with us. I’m going to try to summarize it. Maybe we’ll all discuss it. But first message is that there are values of prizes: of getting people thinking, motivated. There’s not an economic value of prizes perhaps other than the prestige that comes from them, but it does have something of value to the entrepreneurial spirit, and maybe some stimulus to the space program itself. There’s a second part of it, which is commercialize those things which can be commercial that perhaps are outside of the inherently government role. You talked about NASA having a role of exploration. Commercial value of exploration, like you said, it’s probably not it, but things that support exploration might. Communication satellites, lunar mapping, Mars mapping—there’s probably a lot of things of that nature that are support functions that could be just on out for bid, and a market is there for it because it’s a long-term sustainable marketplace. So I think the message I would take away is that two vectors in this new approach to private sector is prizes for stimulation and excitement and commercialization for those things which are outside of inherently government functions. Am I close? Carly, go ahead.

### **Carly Fiorina**

If I could add a third item, which I think is also inherent in the testimony we’ve heard and very important, less quantifiable, perhaps, but I do think there also is a message about the difference

in approach, mentality, culture, value of risk taking that is fundamentally different in an entrepreneurial community than in a government community. And I think that is a vital message and a vital reality as well.

### **Pete Aldridge**

Any other burning follow-up questions? Elon, thank you very much. Good luck over the next few days with the new family. I'd like to thank Jeff and Peter for being here today. It's been stimulating. And hopefully we as a commission will have something to say about it. Thank you very much. We're going to take about a fifteen-minute break for the time being.

[Break]

### **Pete Aldridge**

Okay, I guess we can get started now. Before we get started, I'd like to welcome Laurie Leshin. Laurie I introduced earlier. And glad to have you join us this afternoon. The second panel is from our host community here in Atlanta. Joining us today from Georgia Tech we have two distinguished faculty members and a student leader. We welcome Dr. Narayanan Komerath—I hope I got that pronounced right—professor in the School of Aerospace Engineering. He brings to us an informed perspective of establishing a space-based economy. Mr. Daniel Hegeman is a Georgia Tech student in aerospace engineering; he's also a student government representative and a research member of the Mars Desert Research Station Project. Mr. Hegeman, we're glad to have you here. You picked a great school and a good department to go to, by the way. And our third panelist, Dr. Paul Ohme, is a director of Georgia Tech Center for Education, Integrating Science, Mathematics and Computing, also known as CEISMC. Dr. Ohme and his colleagues see scientific and mathematical understanding as a way of enriching human experience in today's world. We welcome you all here, and I think, Dr. Komerath, I believe, are you going to go first? OK?

### **Narayanan Komerath**

Can we have the first slide, please? Mr. Chairman and members of the Commission, my students and I are honored to have this opportunity to present our views and our dreams. The President has asked us all to work together. The mandate to use lunar resources to launch to Mars is exciting. To sustain support through this endeavor we must provide an inspiring, credible, and reliable answer to the question "What happens beyond Mars exploration?" Next slide, please.

### **Pete Aldridge**

Dr. Komerath, could you put the microphone just a little closer, please? Yeah, that would be good. You were starting to break up.

## **Narayanan Komerath**

In the 1970s, visionaries such as Gerald O’Neil planned to build cities in the sky. They saw economic payoff as the correct motivator, but they ran into formidable obstacles. Today I submit that there is at least one technical solution to each of those obstacles. The trouble is, these solutions need a strong economic rationale and framework. Next slide, please.

That framework is the space-based economy. Imagine hundreds of businesses, perhaps thousands of businesses, with facilities located away from Earth, trading mostly with each other. This means reduced dependence, greatly reduced dependence, on Earth for supplies and markets. Wealth being generated away from Earth. And government doing what only government can do: investing in infrastructure, supporting knowledge generation, exploration, enabling international cooperation, and, of course, collecting taxes. How would such an economy evolve? If I could have the next slide, please.

Today there is limited synergy between the large projects. Already commercial projects account for more space business, more space spending, than government. As refueling and repair become common and lunar resources enter the market, synergy will really begin to pay off. Next slide, please.

And in time, the space yellow pages will become something messy like that. Hundreds, perhaps thousands, of businesses that exist because others exist, not just to compete with them. We would like to help speed up this process. To make it occur in a thoughtful manner in our lifetimes. Next slide, please.

Today’s space entrepreneurs, as you have heard, people who spoke before me, have to freeze their designs in most cases and go deep into debt for ten years or more before they see any revenue at all. But that by itself is not unusual in a technology company. They may make money if their business model and technology have not become obsolete. Although launch itself may be only three percent of the total cost of a satellite business. Everything depends so critically on that first launch working, and there’s no help beyond that. That’s what makes it unique. Infrastructure beyond that would lower those barriers and lower those risks. Next slide, please.

By example, when we learn to refuel and reuse upper stage engines, extremely expensive things that we now throw away—and we can use lunar fuel or other resources for this—awe will slash Earth launch costs as well. The business plan of a single entity—which is too costly and risky in isolation—becomes viable when it’s plugged into such a space-based economy. I’ve given a couple of examples in the detailed written testimony there. But we will involve a vast cross section of business interest—that is the strategy to generate the support needed to justify admittedly massive spending on investment that will be needed for infrastructure projects. Next slide, please.

Today’s children all over the world still look up to the sky the same way as we did. But they also expect to go after the vast natural resources beyond Earth. We must lead them or they will leave us behind. Next slide, please.

How do we gather support for such an endeavor? First, we must reach out to industries and professions beyond the aerospace community, beyond science and engineering. We must let people see that they stand to participate and benefit, not just to pay taxes and watch TV. NASA's leadership is vital if entrepreneurs are to commit their faith and money. Slide, please.

That's my last slide. My students would like to convey these answers to these questions. We have inspiring answers to all of these questions. But they need to be communicated to the American people and we hope we can do that through you. And I would like to summarize my recommendations. First is please think long-term infrastructure and synergy when you plan exploration projects and, second, show people that they have an active role in the space-based economy of our future and, no, they don't have to like calculus or science to participate. And thank you very much for this opportunity again.

### **Pete Aldridge**

Thank you, Dr. Komerath. Daniel? You're next.

### **Daniel Hegeman**

Chairman Aldridge, distinguished members of the Commission, I would like to thank you for having me here today. I consider it a distinct honor, and I hope that I will represent myself and my peers accurately and honestly. To give the board a brief background of myself: I'm a sophomore in aerospace engineering here at Georgia Tech. But I am originally from Lexington, Kentucky. I'm actively involved on campus, and just this year I decided to participate in real hands-on experience, including working on an experiment that would fly aboard the NASA KC-135, participating in a graduate rocket design team, and most recently participating in the Mars Desert Research Station in Utah, where the emphasis is placed on designing and analyzing human-factors engineering related to the first manned mission to Mars.

Along with these newfound responsibilities of being an adult comes the obligation to challenge myself and my country to accomplish daring and unprecedented goals. The drive has brought me before you today. My generation likes to believe that the basic principles which made this country great still exist and flourish. These include free-market capitalism, competition, opportunity, and most importantly, freedom. The United States was made great by attracting the best and brightest minds to tackle challenges and benefit from the opportunities of the frontier. The President's new call for a focused and economically viable space program is a tremendous step in the right direction, but I believe that unexpected obstacles present in all levels of the government will impede progress. Although this is the land of opportunity, we must not be blinded by these complications that will no doubt arise. The support of many might prove to be the best solution. I believe that the United States must work to cooperate with other nations to increase its knowledge pool and build worldwide support for the endeavor. If the U.S. opens its doors to international and multi-cultural cooperation, all disciplines will flourish because of the increased interfaces. Why should one single nation work toward a goal when the contributions of others can help so much? It might take the effort of the collective whole or at least those most

promising to reach Mars most efficiently and quickly. Let me give you an example of an international perspective. While at the Mars Desert Research Station, I had the pleasure of meeting another space activist and entrepreneur who I would like to remain nameless. They completed international studies and also run several of their own businesses. This person confided in me that they eventually, possibly within the next year, hope to return to their home country. When I asked her about the reason for this she said that, they said, that working in Europe, their home country, enabled them more opportunities that weren't present in our country. The talents of this individual and others like them can be exactly what this nation needs to achieve its long-term goal of sustainable manned presence on Mars. We cannot allow this to happen on a large scale.

How is my generation to take this news that greater opportunity exists overseas? That the country we've always believed in doesn't offer us the ability to achieve our best? The United States needs to set up a framework that embraces private enterprise and thus encourages individuals to realize their creative potentials. The United States must decentralize or at least enact deregulation of its space efforts so that many future minds and spirits can actively contribute to the President's plan. The whole is greater than the sum of its parts, and the result the new space plan calls for is no different. My generation supports the grassroots framework that holds our country together, but additional glue would act to strengthen it. With contributors such as space tours and scientific discovery partly fueling the greater fire, a united effort must be recognized and promoted. I certainly believe we can't do it alone.

One of the major challenges facing your Commission is coming up with a plan to eliminate tasks and programs that are nonessential to the ultimate goal of landing a crew on Mars. NASA must become result oriented. By this I mean that once it is known what the ultimate goal is, they must decide on the most efficient steps to be taken to get there. As any good engineer will tell you, it's not just about getting it done. It's about getting it done efficiently, quickly, and right. As an example, some see the cup half full, others see it half empty. I personally see the cup as extremely over-engineered and a terrible waste of valuable time and limited resources.

Time is truly of the essence when it comes to inspiring and motivating performance. My generation feels that we are unacceptably selling ourselves short to say that as a country we will retrace the footsteps of our parents and take twice as long at that instead of paving the way for our children. With the timeframe as large as two decades, it is extremely easy to get bogged down in details. One system may end up requiring more time than originally planned, and eventually the whole team loses clarity on what the final goal was. A shorter time span needs to be implemented so that things can get done.

Humankind wants to go. We're just being held back by details. Without sufficient pressure, the task just won't get done. It's important to make sure things get done right, but to say that this will take two decades is discouraging. Our nation must have a quick, concise mission to ensure that the job gets done right first time.

I would like to address the needs and concerns of my generation, the group of students who will be among the next von Brauns and Armstrongs. It is no surprise that many of the scientists and

leaders who worked on the Apollo program have already or will shortly retire from the aerospace industry, leaving a huge gap of experience and passion which will ultimately be filled by my peers and myself. We expect to see a swift return to the Moon, a series of missions to Mars, and a plan for further manned exploration of the solar system, all before we die. One of the greatest gifts that this Commission can give to my generation is sustainability in the space field. When we graduate into the real world there needs to be long-term funding and planning security so that we will want to stick with space-related jobs. If there is a focus on the technologies related directly to space exploration, that's where we will be. However, the government is the only customer, and Congress can cancel out the whole space program on a yearly basis. We will seek a more secure profession to support our families and an entire generation will miss out.

I support the planning and implementation of the President's vision that opens space to true private competition. My generation knows that we are the best and will continue to be because the contributions of our parents' generation made to the nation and the cause. But your role is not yet over. Lead us like you were led. And prove that you've still got the eternal fire to and—I'm being bold here—to get to the Moon by the end of this decade.

Let me address one more important precursor to the engineering success: prototypes and simulation. I advocate that more emphasis should be placed on facilities which allow a crew to operate a fully simulated mission, complete, with isolation and simulated and real risks and problems. The Mars society is the only entity now demonstrating such a high degree of integration across all important sectors, such as hab layout, exploration, operational procedures, crew dynamics, and some related technologies. As I understand, this is because NASA has been under explicit orders not to engage in any activities preparing humans beyond low Earth orbit. The successful engineering and scientific research on board the station such as MDRS has been enabled solely by strong vision, funding by private donors, and sustainability provided by highly qualified volunteers who design, build, and operate the stations. This is a great example of what the private sector can do if not held immobile by regulation and restrictions. Additionally, the crew's discussions while I was there on how national greatness in space can be achieved resulted in the identification of possible solutions recognizing and rectifying past obstacles: Abolishing federal regulations which hinder commercial participation in space exploration. Fostering competition and rewarding efficient designs. Awarding contingency contracts to winners of steppingstone projects, such as the XPrize or NASA's new Centennial Challenge budget. And realizing that motivated people can turn visions into reality if allowed to do so. The government must be willing to invest in the future.

I hope that I won't be construed as naïveté, but I truly believe that my generation's multidisciplinary talents, well-based optimism, and desire will be our greatest strengths. We believe in thinking outside of the box, pushing the envelope, and making our parents and nation proud by continuing in their footsteps. I hope that the Commission will agree. Thank you.

**Pete Aldridge**

Thank you, Daniel. Paul.

## **Paul Ohme**

Commissioner Aldridge, members of the President's Commission on Moon, Mars and Beyond, and other citizens present, thank you for the opportunity to appear before you to address how elementary and secondary mathematics, science and technology education is critical to innovative scientific research into a high-tech economy. Next slide, please.

The role of the center, which I direct at Georgia Tech CEISMC, is to enable faculty, staff, and students at Tech to optimally impact the quality of science, mathematics, and technology in the K-12 schools of Georgia. I have provided a detailed description of many of our varied and comprehensive programs in my written testimony, but I do want to mention one program, GIIFT (Georgia Industrial Intern Fellowships for Teachers), that annually places over 80 teachers in 6- to 8-week paid internships in university science labs and corporate organizations. This program, now in its 14th year, is having a powerful impact on classrooms throughout the state of Georgia. Next slide, please.

This afternoon, I would like to focus my oral testimony on NASA-sponsored K-12 programs, their role, their history, and their future. Next slide.

In September of 1962, following the announcement of his new space initiatives, President John F. Kennedy presented an address on the campus of a Southern research university. In that brief presentation, he emphasized the rapid changes occurring in the field of science, man's continual quest for knowledge and progress, the importance of designating funds for space exploration in spite of competing budgetary priorities, and the role of universities in the space effort. Now in 2004, as we begin to develop a space program for the future, these same characteristics as described by Kennedy are still present. However, we have the benefit of being able to review the results of policy and programs of the past 40 years. Studying these lessons learned, we can begin to chart our course for the future.

A large part of any NASA mission has always been to include an educational component for the K-12 student population that will raise the scientific knowledge level of students as well as increase enthusiasm for scientific careers. This was done by developing curriculum material, which was created independent of state efforts, offering student enrichment programs, student internships, and professional development opportunities for teachers. In the past, NASA's K-12 educational programmatic funding has been tied to the various NASA missions. Consequently, as missions have been created and terminated, K-12 educational programs have been continually recreated. NASA's programs traditionally have reached out to individual teachers and students, assuming that by enhancing the content of knowledge of a collection of individuals, the collective goals will be achieved.

NASA currently is employing a team approach, which requires participation by building principal, and a team of teachers and students. In addressing K-12 education, there's always been two distinct goals that may be addressed. One may choose to select the goal of assuring that every child completes high school with a strong competency in mathematics, science, and technology and/or the goal to creating a science, mathematics, engineering technology workforce

that represents a cross section of our population. The achievement of these goals require a distinctive programmatic effort. Next slide.

The educational research community has identified several factors characteristic of good programs that are essential if substantial and sustainable improved student learning is to occur. The instructional process must be content rich, which implies that the classroom teacher is knowledgeable and current in his or her field. Enrichment activities for teachers, students must be in line with community and school expectations, the required accountability instruments, state and local curricular requirements, and existing classroom resources such as textbooks.

Enhancement activities for a teacher must be presented as part of the local school improvement plan. There must be local and partner support for follow-up of the enrichment activity to assure that it's effective transfer to the classroom. Next slide.

Future programs should be designed as a partnership with a specific state in one or more designated school districts. NASA, the state, and the district must agree to implement a program with joint goals, joint financial commitment, and a shared sense of purpose. Involvement of NASA's scientists with teachers is an imperative. With the field of science changing so rapidly, those who are on the cutting edge must continually dialog with those that are in the classroom. Local officials and NASA must understand that a successful classroom implementation of an enriching experience does not occur without a sustained follow-up. Next slide.

To illustrate the type of program that I am attempting to describe, I will tell you about a partnership that is currently under way in Georgia involving the State Department of Education, Georgia Tech's College of Computing, and corporate partners. The goal of this project is to increase the number, diversity, and quality of the students completing high school in Georgia with computing skills. These partners are working together to strengthen the curriculum content of several high school computing courses, offer a summer professional development program for all current advanced-placement computer science teachers in the state, begin preparing 30 additional teachers to be able to offer AP computer science at their schools in the future, and develop a plan for follow-up during the next academic year. This partnership has joint goals, joint funding, and a shared sense of developing a strong diverse workforce. An essential component of a long-term space exploration program is the creation of a scientifically literate electorate as well as the creation of a professional science/math/engineering/technology workforce. To achieve this, NASA needs to implement a K-12 agenda that is based off of knowledge gained from experience and research. Thank you.

### **Pete Aldridge**

Okay, thank you, Paul. Several comments you've made during your presentation, Paul, it's the first question. It's something we've read about, that we have a lot of activities in the K through 12 looking at the students, but there's a sense that maybe—there may be some deficiencies in the ability of teachers to teach some of these very high-quality students, and I detected—you mentioned that there was a lot of effort to try to balance both the teachers and the students and try to improving quality. Did I detect that right?

**Paul Ohme**

Yes, that's correct. In some sense the teachers are a good cost investment because they will work with multiple teachers over a long period of time.

**Pete Aldridge**

Right—and multiple students over a long period of time too. Daniel, did you prepare your testimony yourself?

**Daniel Hegeman**

Yes, I did.

**Pete Aldridge**

It was very good. Does your testimony reflect, say, a majority of your peers and their views?

**Daniel Hegeman**

The more motivated of my peers.

**Pete Aldridge**

That was particularly good. Okay. Yes, Neil?

**Neil Tyson**

A quick question to Daniel. How did you get interested to become this—to take on this major?

**Daniel Hegeman**

OK.

**Neil Tyson**

How old were you and what happened?

**Daniel Hegeman**

Well, when I was younger there was never one incident that occurred that made me want to be an aerospace engineer, an astronaut. It was more the promises held by many opportunities. When I was little I wanted to be an astronaut because the experience of floating—I bought my own trampoline when I was 13, began jumping around on that, and that kind of simulated it. But—

**Neil Tyson**

It also simulates the risk. Because you can get hurt on trampolines, I'm told.

**Daniel Hegeman**

OK. But then when it came down to actually starting getting serious about what I wanted to focus on, I decided if I couldn't be an astronaut, due to the high medical exams placed on people and the high physical requirements of an individual, I decided, if I can't fly, then maybe I can build a Space Shuttle or something. So in looking at colleges, I considered all the top schools, and Georgia Tech was second in aerospace engineering and also offered me the lowest costs. So it was the best, I guess, bang for the buck.

**Neil Tyson**

So at the time, you were not either aware or you were aware but it didn't matter that the aerospace industry was losing half a million jobs over all these years that you're describing?

**Daniel Hegeman**

Right.

**Neil Tyson**

That didn't play into it at all?

**Daniel Hegeman**

Well, the market is very cyclical, so I assumed that by the time I graduated in four or five years, it might be on the upswing.

**Neil Tyson**

Now, let me go to Dr. Komerath. Did your department—what is the reaction of an aerospace department, yours in particular, to what goes on in the private sector with regard to the availability of jobs? Do you see a drop-off in people who want to major in it? Do you foresee that a vision such as this will—regardless of the success of Dr. Ohme's educational efforts—will somehow trigger a wave of students into the industry? Could you just give us some insight into the life's history of this? The life cycle of this?

**Narayanan Komerath**

Let's talk about the numbers. I don't quite understand the numbers. Right now we are at an all-time high—the highest number of freshmen coming into any school at Georgia Tech entering

aerospace engineering. They are among the very best. Entering a studies course so high that I'm glad I'm not applying for admission. Why is this happening? I think it is optimism. I ask this question to the freshmen class: Why do you come in here? And they say, "Space," has gone up substantially. I think it's over 50% at this point. They are much more optimistic than perhaps—I won't comment on myself, but the rest of the people I see, they're much more optimistic about our future in space. What relation this has to present realities—I'm sure they read the newspapers just as much as I do. They are perhaps like me, optimist. So we don't see any drop-off in numbers; on the contrary we see a rise in numbers.

### **Neil Tyson**

In this polling, this informal polling that you did, were you able to distinguish whether large fractions were not attracted in particular by the science results of NASA compared with the manned missions from NASA in contrast with Dan's earlier dreams?

### **Narayanan Komerath**

At that age, a lot of it is dreams. Science results don't make a lot of—they don't have a lot of impact as I see. But they pick what they want. I don't think that has changed since the days when I was applying to college. What do you want to be? Aerospace engineer. Why? Because I want to be an aerospace engineer. And that's still true.

### **Pete Aldridge**

Bob.

### **Robert Walker**

Dr. Komerath, let me preface by saying I generally agree with what you're attempting to say about building an economy based upon space. But let me ask a contrarian question: If all of that is true, and that is what we're able to get, why don't we have an Antarctic economy?

### **Narayanan Komerath**

That's a good question. I would add a more dangerous question: Why don't we have an undersea-based economy?

### **Robert Walker**

Same kind of question.

### **Narayanan Komerath**

I think for the undersea economy the reason must be that it will have not in the immediate economic need for that. And it's something that's progressing slowly. Antarctic, I assume it's because people haven't convinced themselves that there are any resources there, that you cannot find without much difficulty elsewhere or not. Why would space be a lot different? I don't agree with this notion that you can go and drag a platinum asteroid and make big bucks. But I believe as time progresses there will be opportunities to generate services first for entities already there, and then it will become more—it will make more sense to extract the resources. And once it becomes common to extract those resources, the infrastructure has been built. The rest of the interest will come up. And at that point, you're not trying to sell solely to Earth-based customers. You're not depending on Earth for all your supplies. I turn the question around and ask, "Why do people live in Atlanta?" Must be the traffic. And the only answer I can come up with is that because there are excellent opportunities to do business because other people live here and so it's something that builds upon itself. The question I have is "How do we get to that steady state? How do you plan out the next Atlanta?" And make it happen in some—not a controlled communist-type fashion, but in some sensible fashion instead of waiting another 200 years for it to happen through Darwinian evolution.

### **Pete Aldridge**

One might argue that the—you will not get to a space-based economy until one understands and solves many of the problems associated with exploration to find out what's there. And so the step those space-based economy is a vision that says, "Let's go back to the Moon and Mars and beyond," the next step is a space-based economy.

### **Narayanan Komerath**

I fully agree with that. But what I would add to that is that in articulating why exploration is important, we should add this thing: exploration is key to developing an economy where we all make money and become very rich.

### **Pete Aldridge**

That's a very good point. Maria?

### **Maria Zuber**

Yeah, let me start off with a question for Daniel. You're impatient, and it's a good sign. If you were the administrator of NASA and it was your responsibility to implement the President's vision, how would you accelerate this? Is it a technical problem, is it a political problem, what is it that's really holding us back here? You know, we've gotten the go-ahead to go now, help the country here.

## **Daniel Hegeman**

If I were in that position, I think one of my main interests would be looking out for my own butt. It would be making sure that my job is secure and I don't do something that would get me removed from it. I see our greatest obstacle is—there's a lack of education about the whole process. People don't know about it. There's several organizations that promote knowledge, there's several books about exploring Mars, exploring the solar system, but people widely don't know about it. You know, when you turn on the news, they see, you know, homicides and rap stars and things like that. They don't see that the leaders and heroes of our society are the ones, you know, taking us where we've never been before. On a political front it's hard to gain support for something when there's so many problems at home. But in the spirit of human discovery, I feel that we have to go because we must. We have to plan for future generations, and I'm not just talking about 50 or 100 years down the road. We have to think about what's going to be here in as much as 1,000 years. Eventually, overpopulation is going to occur on the Earth, and I'm kind of blowing this out of proportion, but eventually we're going to have to find some other place for us to go and an opportunity does exist to travel to Mars. To terraform. To turn it into another Earth. You know, something where it has just as much landmass as the Earth and we could live on that. We could double our population, which would increase the opportunities that are available to us. But I see that we need the people with the ideas are also the people that are the ones making the decisions.

## **Maria Zuber**

That's a great answer. If I could just follow up with a question to Dr. Komerath. Going back to the Moon and Mars is a huge undertaking that's going to require modifications in the way that we train engineers. You know, software is becoming more complicated, and systems interactions are becoming more complicated, and how are you factoring into that the way that you're teaching all of these people who are showing up at your doorstep now?

## **Narayanan Komerath**

We have come a long way since the 1980s. We try to remove the discipline barriers as far as possible without making untested changes to the curriculum. We try to convey to people that they can continue to learn beyond what is taught in courses, because that is the only hope of keeping with technology that is changing at such a rapid pace. As you said, we didn't teach Daniel here all these things that he just said. He learned them on his own. And his peers do that pretty routinely. We started—one big change is that we now teach part of what used to be capstone aerospace design from the senior year, we teach that to first-semester freshmen, first weeks in college. It works. so we are learning to teach them how to think the bigger picture and not be told from day one that they have to become super expert before they are able to think about something. That's the best we can do. But we are frightened at the pace at which things are changing.

**Pete Aldridge**

Unfortunately, we've run out of time again. I'd like to thank the panel for your very stimulating comments. Daniel, best of luck to you, you've made my day. Thank you.

**Pete Aldridge**

We'll change, we'll stay on, but the third panel today is the subject of Public-Private Partnerships, and why don't we make a change in the panel makeup?

Okay, let's get started. We have two panelists this afternoon. The first is Captain Winston Scott, U.S. Navy, retired, and Mission Specialist on two Shuttle flights. He's the executive director of the Florida Space Authority. He's responsible for the development of space-related industrial, economic, and educational initiatives and is an outstanding teacher himself. Glad to have you here.

The second panelist is Tim Huddleston; he's the Executive Director of the Aerospace States Association, the nation's premier organization representing states on matters of aerospace policy. Mr. Huddleston has served in the aerospace industry in various roles and looks forward to—we look forward to hearing what he has to say today. Winston, are you going to be first?

**Robert Walker**

Mr. Chairman.

**Pete Aldridge**

Bob?

**Robert Walker**

If I could, because my firm does have a client relationship with the Florida Space Authority, I am going to excuse myself from asking questions of Captain Scott.

**Pete Aldridge**

Thank you, Bob. Captain Scott?

**Winston Scott**

Thank you very much, and good afternoon to the panel. It's a pleasure for me to be here. I know everybody starts off saying that, but I mean it sincerely, otherwise I wouldn't say it. So, I am happy to be here. And I have spent over 30 years—in fact my whole entire adult life has been in the area of aerospace: 27 years on active duty as a naval aviator, aerospace engineering officer, and then had the pleasure of flying in space on *Endeavour* and on *Columbia*. And now, my

career is taking a little bit different turn, because I'm in the more of a commercial side of space now, but it's just as interesting and just as exciting, my new role of executive director of the Florida Space Authority.

I'd like to express my appreciation for the work that this panel is doing. I want to commend our President for appointing this panel. I think the new vision is a good one, a bold, new, right one. I think the nation as we pursue this vision is going off in the right direction. I had the privilege of speaking with Governor Bush and Lt. Governor Jennings yesterday, met again this morning with Lt. Governor Jennings. They know that I'm here. They're fully supportive. In fact I can go so far as to say that they're excited about the new vision also, and the state is certainly gearing up to support that mission. If I can have the first slide, I'll go ahead with my presentation.

The Florida Space Authority has been around for about 15 years. It was created in statute back in 1989 by then Secretary of Commerce Jeb Bush. The mission of the authority deals with improving space transportation, business climate, fostering research and education, and coordinating policy. And what you see before you is just a collection of some of the facilities that the authority has facilitated in partnership with either NASA, the federal government, the Department of Defense and our commercial partners. And I'll get into a little bit of that later on in my next three or four minutes before I'm done. Next slide, please.

We are a subdivision of state government and we're sort of a—we like to think of ourselves as an airport authority for rockets. And we provide facilities and support for new vehicles and missions developed by the commercial sector. Now, like other airports and seaports, we develop facilities like are used by transportation providers. Some of these facilities are dedicated facilities and some are multi-use facilities. Now, the development activity includes bonding and commercial financing. We allow the facilities to be paid off through recurring lease payments instead of as an upfront cost. I mentioned some of the facilities before, and if I can have the next slide I'll talk about some of those, because the key here is the partnerships.

If you take a look at that—I won't get into a lot of detail, but, for example, in the upper left-hand corner, you can't see the detail, but it's not important. It's what we call our reusable launch vehicle or RLV hangar. The RLV hangar was most recently used to house the debris during the *Columbia* investigation. That is a state-owned and -developed facility. Let's see, the next one down, left side again, number two from the top, is the Apollo Saturn V center. It's a visitor center. That was financed by the Florida Space Authority for NASA's Kennedy Space Center and the visitor complex. In the upper right-hand corner is Launch Complex 41. State owned and developed. We financed \$300 million for Lockheed Martin to develop that facility. The next one down is the Boeing Horizontal Integration Facility. Then down is launch complex 20. And the next one down is Launch Complex 46, again state owned and developed. So just some examples of what the partnership between the state of Florida, DoD, NASA Kennedy Space and commercial partners has resulted in.

So we've been deeply involved in constructing and financing every major facility and development at the Kennedy Space Center and Cape Canaveral Air Force Station in the last decade. All together our activities have generated a half billion dollars in capital improvements,

85 percent of which was funded through commercial financing. So in addition to bringing money to the table, the authority also provides construction management through the state's guaranteed maximum-price contracting system and, speaking of construction management, we actually managed the construction of the Space Life Sciences Lab which is on your slide, there, the left one. That's good. The right side there. The Space Life Sciences Lab, a \$30 million facility that we actually facilitated the construction of, a person on my staff worked with the contractors to actually construct that building. For a partner with NASA, the Air Force and other stakeholders in spaceport master planning. As a matter of fact, in the state of Florida, space is officially recognized in all state documents as a mode of transportation. We like to brag that we may be—not sure—may be the only quadri-modal transportation system in the state. I have the privilege of sitting on the Strategic Intermodal Transportation Advisory Council with all of my other counterparts from other modes of transportation in the state. The next slide, please.

In addition to facilitating development and modernization, we bring broader support for the exploration mission, and we're doing that specifically through our partnership with Kennedy Space Center and the establishment of the International Space Research Park. Now, what you see on here is just an outline of where the park is going to be. The Space Life Sciences Lab, which I talked about a little bit earlier, is the anchor that will house the international or attract the International Space Research Park. The park is going to be a 400-acre facility with multiple buildings that will allow us to increase and improve the research part of our mission there in the state of Florida, and thereby hopefully help to realize the President's vision. The new vision obviously refocuses some of the things that we've been doing in our space program—refocuses it towards life sciences. And I can think of no better place to facilitate this than in our International Space Research Park and Space Life Sciences Lab. If I can have the next slide.

I'm really just about done with our—with my part of the presentation. I'd like to again commend the Commission and urge the Commission to examine spaceport range issues and range strategies to fully support exploration mission. Also to support the Department of Defense Operationally Responsive Space Launch Initiative. We are actively pursuing methods to modernize and streamline spaceport strategies and also to facilitate needed changes to launch processes. I had a meeting just last night with General Pavlovich, General Greg Pavlovich, who commands the 45th Space Wing, and General Pavlovich is fully on board with us to streamline in those processes so that, again, we can further and easier and better facilitate the accomplishment or achievement of the new vision.

In addition to the need for infrastructure rehabilitation, new flexible and robust tracking technologies are available. I talked about reforming policies and practices. And I'd like to just say, before I conclude, that Chairman Aldridge's Defense Science Board report of June 2000 and Mr. Walker's Aerospace Commission recommendations provide solid, workable solutions to many of the most critical concerns. This is a topic that needs to be considered by the Commission. Updated space transportation policies are being developed by the administration as we speak, and I commend you and encourage you to be heard. I'm done with my notes here, so I'm just going to say, in closing, before we get to Tim and to the question-and-answer period, how much I appreciate the opportunity to be here. I really think and am thoroughly convinced

that the states can play a critical role in moving our country forward and achieving the vision that's been set before us. So once again, I thank you for these few minutes.

**Pete Aldridge**

Thanks, Winston. Tim?

**Tim Huddleston**

Thank you Mr. Chairman, members of the Commission. I would like to echo what Captain Scott said and that is the states do have a very key role in this process. I think that, through my remarks, hopefully, I'll be able to share the view of the Aerospace States Association relative to that. And I'm going to try to go through my slides pretty fast and try to then bring up some points that we really want to throw out. Let me first tell you that, of course, I'm the executive director of the Aerospace States Association, and the Aerospace States Association or ASA is an organization that is deeply interested in aviation and space issues. If I could have the first slide, please.

This gives you a little bit of background of what ASA does. The key point here is that ASA represents the state itself. Not any entity within the state. The governor of the state appoints delegates to ASA. For the most part, those delegates are in fact are lieutenant governors; in other cases, authority members serve in that role, depending on the state model, but we are a non-political organization, nonpartisan, non—very impartial judge, hopefully, of what the state's interests are relative to aviation and space. This brings us to why we feel very pleased to be here and thank you for the opportunity to talk with you. Next slide, please.

Just quickly to tell you that our delegates, again, usually are led by lieutenant governors. They empanel delegations, delegations who consist of representatives from the state in the area of aeronautics, spaceflight, spaceports, commerce, education, research, workforce. Next slide, please.

ASA focuses across the board, both aviation and space; "aerospace" for us meaning all things aviation and all things space, and we look at the key areas of commerce, education, workforce, research, exploration, and we look at that across all three sectors: commercial, military and civil space. Next slide, please.

The way we reach our mission—and our mission being to articulate the state's interest, to make sure the states are engaged in federal policy making such as this process—is we will conduct hearings and forums. In fact, a number of times a couple of members of this Commission has come before ASA. Congressman Walker, you have honored us several times, and we appreciate your presence and the work that you do. We will formulate white papers on issues; whenever the states are unified behind an issue, we will pass resolutions putting out position papers on issues and various other outreach. In fact, I will mention in my closing about a major outreach project that ASA is about to engage in relative to the Moon and Mars initiative of the President's. Next slide, please.

With respect to spaceports, you have heard from Captain Scott a little bit about—as I mentioned to Tim earlier the Ground Zero Process, you heard how Florida is approaching the spaceports and some things they're doing out of the box which I think is very unique. Using that authority mode that they have, that the state has granted them, they have gone off and done some very unique development work with industry, with academia; it's been very impressive what they do. We think there's a strong model there. We see California and Oklahoma as two other states also coming along with very unique models of how the state interacts into this process. There are three types of spaceports that spaceport states that we are looking at. Operational spaceports states. Next slide, please.

These are the four operational spaceports that we all know of: includes, of course Kodiak, Alaska; Wallops Island, and then of course in California you've got, you know, Vandenberg, and then in Florida you've got the Cape. Next slide.

These are the emerging spaceports: Oklahoma, Texas, New Mexico. These are folks who are actually identified areas, actually planning for next generation kind of facilities. Next slide.

And then these are the states that have said, "We really want to be proactive. We want to see where we are going with respect to the development of space. Is there going to be opportunities to realize vehicles that can fly inland and if so what do we as a state do to be on the cutting edge of being involved in that?" And these are those states. Next slide, please.

And of course our hope and desire is the entire nation to be spaceport states. And you can see Hawaii is out there, kind of hard to see that. Next slide, please.

What I would like to do is spend a little bit of time talking with you about what we envision. We do envision a true national space transportation system—one is that is, of course, reliable, routine, safe, economical, provides true access to space. We envision a true national infrastructure like what Winston is doing and other states are doing. We envision that across the nation as we showed in the slide supporting a true national space transportation system. Next slide, please.

Quickly, just to mention some key organizations that are working with us in this process. Of course, the Aerospace States Association, National Coalition of Spaceport States—that is 15 states that are proactively looking at spaceport development and we expect that to grow. The Patty Grace Smith at FAA AST [Federal Aviation Administration, Office of the Associate Administrator for Commercial Space Transportation], a very key organization, we're very happy with what Patty is trying to do in her operation. We think there's some lessons learned there and we think the direction we're moving forward with them is very positive. There is a major working group called ASTWG, the Advanced Spaceport Technology Working Group, it is a KSC-led working group but it's inter-agency and it reaches outside and actually brings in industry, academia, states. We think they're doing some very tremendous things, and in all fairness I'm vice chair of that working group, so I certainly think it's doing a good job, but it is working with a program that's being developed at KSC that we hold high hopes for called FIRST [Future Interagency Range & Spaceport Technology]. And I hope you have an opportunity, if you have not done so, to get a briefing on the FIRST program at KSC. The FIRST program is

looking at spaceport and future spaceport and range technology and how you create these future opportunities and how we respond to potentially new vehicles and systems. Next slide.

Challenges. We feel like NASA is populated with the most brilliant people. We think they are doing a wonderful job. We just don't think they're given an opportunity to shine as much as they should. Why? Because we feel like NASA, unfortunately, is held to operate within a Cold War kind of mentality. They were founded in the Cold War era and they approach the Moon to Mars—I mean, I'm sorry, we're jumping ahead—they approached the Moon, the mission to the Moon in a way that they had to do but from that point forward we continue to operate in a mode based on that Cold War opportunity and challenge, and it has paralyzed NASA. We think the bureaucracy that has been in place as a result is really causing some problems. Certainly there's some internal strife as well, but we think, you know, Congress needs to get the message that the Cold War is over and that NASA needs to be allowed to function as a very innovative agency as it should be so important, and we think this Commission has the ability to establish that point. Next slide, please. Next slide. There.

Concerns that ASA has: we do not have a true national space transportation system in this country. Let me make this clear to this Commission: When ASA says, when we say, a space transportation system, we don't mean go off and build some new federal vehicles. We're not talking about that. We're talking about the term *system* in the true sense of state government, federal government working to cooperatively with industry, with the private sector, with the consumer, just like we do in all other forms of transportation. Be it the interstate system, air transportation system, you name it. We want to really look at that kind of system, true national space transportation system. The problem is there is a lack, and Congressman Walker's commission identified the key point that there is a lack of basic research going on in this country that supports this kind of concept. It is imperative that NASA be actively involved in the fundamental research necessary to enable industry to go off and build the vehicles that will support this kind of system and enable the states and authorities within the states that want to build the infrastructure to support those vehicles to be able to go do that. We see NASA as being able to enable the process, because it is the role of government to enable, not to go and do, but to enable. Industry needs to go do. Private sector needs to go off and do this stuff. They need to operate the systems. They need to build the systems. The federal government needs to support that by doing the research, doing the education outreach. Doing the—you know, supporting the funding. There's so many—creating the regulatory regime process that allows it to happen. We think that's very significant. Next slide, please.

And to conclude, ASA supports this Commission in what it's doing. This Commission is so important to America's future in space. We truly believe that the American people envision space providing great opportunity to all citizens. Now, when we say that we're looking at things like the air transportation system, the air transportation system is so key, so important to this country, but the fascinating thing about the air transportation system is what it enables. There are thousands, literally thousands, of companies that owe their total existence to Fed Ex, to UPS, to the fact that we can move goods and services throughout this nation and the world. We are saying to this Commission that you have an opportunity to articulate to the President and to

NASA, to Congress, the vision that the American people hope and desire for great opportunity to be realized from space that the American people had expected by this point in time, after we landed on the Moon, that we would be routinely living and working in space. But yet we are here 40 years—more than 40 years—later and I’m reminded of a statement that was made in Washington shortly after one of our hearings. Someone came up and said, you know, if this country can land a man on the Moon, why can it not land a man on the Moon? And that is absolutely the message that we want to deliver—is the American people ask that question.

And when someone says that the American people aren’t engaged or compelled by space, let me tell you what they are engaged and compelled by: the American experience. And that is the experience of great opportunity, of what America is all about, and so they expect any great venture we take—undertake—as a nation, to yield that kind of opportunity. Space can do that. Developing space can do that. You can drive that message home. We think that, honestly, the ability, the thought process and the vision rest in this Commission. We applaud you, we applaud the President for bringing this initiative to the nation, we look forward to going out and selling it.

I want to conclude by saying that the Aerospace States Association is committed to this process. We will shortly release a document that we think articulates the American people’s true vision for space. We will send it to this Commission, we will send it to the President, to the White House, to Congress, and we will go on the road and we will meet with the citizens in all of our states and we will sell what the President is trying to do, what you’re trying to do, and what we believe the true nature of this vision is. With that, thank you so much for this great opportunity. Thank you for all your hard work. And that concludes my remarks.

### **Pete Aldridge**

Thank you, Tim. I was looking at your map of the future spaceports and it showed the U.S., and Alaska, and Hawaii. I’ll just point out that you could probably put the Pacific Ocean on there too because we do have a sea launch.

### **Tim Huddleston**

Good point.

### **Pete Aldridge**

Because it will go anywhere. It’s a big yellow map, is what it is.

### **Tim Huddleston**

And may I point out that the Alabama Commission on Aerospace Science and Industry actually commissioned the study that created the sea launch concept, so you can tell from my accent that I’m from Alabama and I’m very proud of that point.

**Pete Aldridge**

Captain Scott, yeah. I was noticing the International Space Research Park, and I was intrigued by the first term called *international*. Can you expand on that?

**Winston Scott**

Yes. We are hoping that the research park will not only be a gateway to space for United States researchers but that it will truly serve as an international gateway and attracting researchers from other countries. We'd like to see that—and I'm obviously of Florida Space Authority, so I'm a little biased towards Florida, but we would like to see the Florida International Space Research Park truly become a conduit for researchers all around the world to get their experiments into space, either on the International Space Station or whatever might be a follow-on. That's what we're hoping.

**Pete Aldridge**

What's happening with the Range Standardization and Automation Project? It's been dragging on for too many years. Are we making any progress?

**Winston Scott**

Yes, and to be quite honest with you, I am still kind of the new kid on the block, being in the job for just a few months. And I honestly don't know what—I know what you're talking about, I don't have a good status.

**Pete Aldridge**

This is a modernization program for the range to be able to be more operational—

**Winston Scott**

Yes. I do know, again, I will go back to my conversation with General Pavlovich just last night. General Pavlovich actually pulled me aside and said he would like for us to aggressively begin seeking companies that might provide for us a strap-on flight-termination system as part of an overall range modernization program, because a lot of the incurred cost to our commercial customers have to do with designing and building the range termination system. So where I'm going with this is that General Pavlovich and all of our constituents are very in tune to what needs to be done; so are we. And as I get more caught up on the specifics of what—we can see if we can move that forward.

### **Tim Huddleston**

Could I just add that there's an inter-agency working group called ARTWG, the Advanced Range Technology Working Group; in fact they're working in concert with the group I mentioned earlier, ASTWG, and they have been looking at this issue, and the Air Force has really come up to the plate and began to look at the issue. You know, I'm so proud that our last round of modernization we were able to bring ranges up to 1984 technology standards. We are now to the point where ARTWG is making some very significant recommendations to all the players in NASA and to the Air Force and others. They are participants in this FIRST program I mentioned, as well, so again I would highly recommend that you get a briefing on FIRST.

### **Pete Aldridge**

OK. I think it's about time the Air Force got along with this. One other question is—and I will open it up. We've got a vision now. And although there's a lot of work going on, what specifically is the architecture for all that? We know parts of it include a heavy-lift vehicle of some type and probably a human spaceflight vehicle of another type. Has the Florida Space Authority or the Aerospace States Association looked at specific initiatives that would contribute directly to the vision? We might have to build a heavy-lift launch complex, for example. It may not be that we can use the same crawlers that the Apollo and Shuttle had. But is there something specific ongoing there?

### **Winston Scott**

The Florida Space Authority has put together a draft of a strategy with what we might do to support the vision. The strategy is as specific as it can be made at this point in time, because obviously there is some things that we still don't know yet. The strategy addresses known infrastructure changes that might need to be developed. For example, if we're going to use a Delta IV, an Atlas V, to launch, then we might have to man-rate those vehicles and man-rate the pads, so that kind of, that much detail we know, but beyond that we don't know the specifics. We know as you just said, Mr. Chairman, there probably will be some ground support equipment needs necessary. So we've put together a draft strategy, and the strategy has specifics in it as to what we would ask the state to contribute financially, so we've gotten down to that point. But again, it's a point beyond which we can't go because we don't know specifics beyond.

### **Tim Huddleston**

I would just simply add that the Aerospace States Association has been engaging in the process, particularly with ASPTW and ARTWG; we have representatives on both of those working groups, and we have been making recommendations through that process that allows us to respond in any fashion depending on the architecture, whether we're successful in the XPrize companies, as an example, if they're successful in being able to—and we believe they will be—to realize access to space through smaller lift capabilities, we want to be able to respond to that.

Certainly if we're back to a heavy-lift vehicle, we want to do that as well. Some great recommendations again, in the FIRST program, that we can funnel up. We would recommend highly to look at that.

### **Pete Aldridge**

It would be very useful for the Commission if it's timely to have that input, because certainly the public-private partnerships is going to be a key to this—to the future and if there's some ideas of how we can do that so it's not—NASA doesn't go down a path of irreversibility by making a decision that's inconsistent with what you could provide. It would be helpful for us to know that, and, in fact, in our discussions we are looking for strategies. We may not have specific details, but as long as we have the strategy identified for success, that's good enough maybe for the time being.

Yes, Neil.

### **Neil Tyson**

Thank you for this testimony. I'm especially intrigued, Mr. Huddleston, by the fact that you're sort of—the membership in your organization is predominantly people who hold elective office or appointed by elected representatives, yet it's harmonious and everyone agrees that space is a good thing. One of the things that surprised me and many of us on the Commission was the extent to which this vision has become politicized since it was first announced, and there I was prepared to recognize that there'd be engineering challenges and science challenges and it may be in the end that the biggest challenge is whether this can survive the politics of the moment. So what I ask you is “What makes your organization work politically?” and can you sort of give ground cover for whatever we might be advising or vice versa to have this survive fluctuations in political flavor? Not only that, I wonder because not all of your member states—because it's the whole country, basically, right?—not all have sort of an equal investment in space, and it's very real. I remember my first time staying in a hotel in Florida and just seeing the hotel—TV monitor in the hotel had the NASA cable channel on it, and the newspapers, they announced the launches, and so NASA is just right there—even if you're not otherwise paying attention, it's there and that's not true for all states. So not everyone understands what a mission—a vision like this can bring back to the nation. What advice can you give us as a Commission to solve this problem that apparently you already have?

### **Tim Huddleston**

Well, it is quite unique dealing with that many states and the various political viewpoints. We have three vice chairs and a chair. The chair, Lt. Gov. Mary Fallin of Oklahoma, is a Republican, and we have another Republican vice chair and then two Democratic vice chairs. Now we don't structure the organization so that we are always half and half. It just worked out that way. But we made a commitment early on that aviation and space issues are nonpolitical issues, or bipartisan

issues, however you wish to look at it. I've been often described as a cat herder, and it is a process.

## **Neil Tyson**

Teach us.

## **Tim Huddleston**

Particularly right now, we're in silly season with the elections. Unfortunately the President's initiative has been labeled at times to be more of a political thing or partisan thing. It is not. And you are exactly right in the sense that there are states who obviously space means much more to than other states. Captain Scott is a perfect example. Florida means a lot. My home of Alabama means a lot.

But I can give you examples of—for instance, in Vermont, Lt. Gov. Brian Dubie from Vermont; he's an airline pilot and aviation means a lot to him. And so the common thread of us bringing aviation and space together was very important for us to bring the nation together. But the point that we try to articulate with our members is that ultimately there's this grain between what aviation and space is. At some point in the future, whether it's in my lifetime or on down the road, there will be a total merge of aviation and space. When does a vehicle go from one airport to another? When does it go from one airport to space? When that happens we don't know. But it is, at least, the understanding of these political leaders that that is the case and they need to be in a posture of placing their state in a more of a proactive mode. The problem is elected officials think two years or four years. We understand that. And that's the challenge you're faced with this Commission.

But there is three things that elected officials ultimately owe their constituents that is very important that we speak to: Good economy, good jobs, good education. So we try to look at the message of space. And this initiative is how does it play in Peoria? Or how would the little old lady from Pasadena respond to what we're trying to do? Well, it resonates with her and it resonates with the people in Peoria if you put it in terms that mean something to them around their dinner table. How does it improve the economy? How does it create jobs? How does it improve education and opportunities? NASA, I think, does a good job with the education piece. We're not talking about spinoffs. You can't talk about Tang and Velcro and things like that and get the response. But when you can have your constituents, as an elected official, understand that investing now in an opportunity regardless of what it is, whether it's space or whether it's whatever, it makes no difference. But investing in that opportunity will guarantee that if you directly don't benefit, your children will benefit with a strong economic growth potential. In other words, space being in this case an economic engine driving a part of the economy. If you can make that message resonate, people understand it. What we have to realize is that this initiative is not for NASA, this is for the American people, and that's the way we have to sell it.

## **Pete Aldridge**

Les?

## **Les Lyles**

Well, let me also thank both of you for being here. This is very, very stimulating and very, very exciting to some extent. I recall, Winston, watching and being there as the Florida Space Authority was gearing up and the discussions with the government, particularly the Air Force, and DoD, and NASA, and it's very pleasing to see the progress that you've made and things that have been accomplished. But going back to those days, I know the difficulties we had in even communicating with each other. The sense of trust or mistrust, if you will, between the private sector, state authorities, the government, etc.

And I'm wondering if you could share with us—as a new guy perhaps you don't know, maybe 'cause this is a homework assignment: What do you think has contributed to the success? How have we gotten from those days back in the late 1980s to where we are today with the facilities that have been built up, the partnership arrangements that have obviously been very, very successful? Are there some things that you can look back that you think are the keys to success? And then related to that, are there some policies and regulations—a lot of which were very onerous at the time—that you think either can help stimulate this sort of thing or maybe are still onerous that should be removed to help stimulate growth for the future.

## **Winston Scott**

I have to speculate a little bit because I am kind of the new guy, but I suspect that our closeness and the removal of impediments between the partners has occurred gradually and has taken a new step. I think it's deliberate, and I think it's a result of the leadership we have. I have to be quite honest with that. I think our state government, and Governor Bush, has deliberately attempted to place people in positions where they have parity with each other and has deliberately fostered cooperation with each other. We had Space Day at the Capitol yesterday. This is the fourth or fifth year that we've had Space Day, probably, and my first year of participating completely. I was there as a guest a couple of years ago just doing the astronaut thing, but during Space Day it was highly encouraged for the team to be made up of all of our partners. The person who was designated to lead the team was the CEO—I'm using the term *CEO*, maybe that's the right term, for Boeing. Anyway, he was the Boeing leader. The co-chair was my deputy from the Florida Space Authority. The other members of the team came each from our commercial, military, and federal partners. So here's an example where a team was put together deliberately from all different sides of a partnership there, and by working together I think we fostered those good relations. Now, I said something a little earlier; I need to go back and try and say it properly. I said *parity*. I guess that's a good word, but I suspect that one of the reasons I was hired as the new executive director is because I can sit at the same table and talk the same terms as the CEO of Boeing, as the CEO of Lockheed Martin, as the commanding officer of the 45th Space Wing, because my background allows me to say that I've been there

and done that. And I suspect that that was deliberate. So the long answer to your question, sir, I think it's deliberate on the part of our leadership by fostering—

### **Les Lyles**

I applaud all the partners, going back to where it was in 1989 and where it is today. This is a tremendous, tremendous success.

### **Robert Walker**

Tim, a question for you. Has the Aerospace States Association ever had any discussions about taking over NASA facilities as state economic assets and becoming the managers of, for instance, NASA Centers?

### **Tim Huddleston**

You know, it's interesting you should ask that. In fact that has been discussed at times. We look at models like, again, Florida, as an example where you have a state authority that is empowered by the state government. It is a quasi-state agency but it operates in more of a corporate world and role. So it's sort of breaking down that bureaucratic process. It works really well, I think, not to speak for Captain Scott, but you know he has a board he reports to and that works pretty well. And—so a lot of states have said, “You know, we should look at this model,” and how can we—the states can help. I'm telling you, the states can help in this process. I was once, not under this current administration, but under a previous administration, I was meeting at the White House with the National Security Council, and we were talking about issues relative to spaceports from the very beginning, and I kept hearing how, well, you know, you states, we'll take care of you, we have people up here looking after you, whatever, blah, blah, blah. And I had to finally say, “Do you understand that the states are where the people live? We represent the American people; this is the United States of America. This is not the united federal government of America and we're all here to support that. It's the other way around.” And so I was—it was mentioned to me, okay, fine, we understand who the customer is. Well, let me just say that that is the case. This is the United States of America; the states can play very active roles. Congressman, we have looked at that issue, there are states that really would like to present some constructive dialogue in how to do that kind of thing and look at that as a possibility.

### **Laurie Leshin**

Thanks to you both; this is extremely interesting. I just wanted to pick up on something you said, Tim, and see if I can drag a little more information out of you. You mentioned—you sort of dangled for us that your organization is getting ready to put out a vision document about your view of America's future in space, and I wondered what the time scale for that is and if we might be able to get that during our deliberations. Is it imminent and can you give us some highlights, or is it premature?

**Tim Huddleston**

Well, I would love to give you some highlights, but I'm not sure I'm at liberty to do that at this moment. But I will tell you it is due in short order. In fact, we delayed releasing it. We originally were going to release this vision the beginning of the year, but, out of respect to the President, we did not want to do anything that may interfere with the Moon to Mars initiative and we wanted to make sure that we understood how our vision fit with that initiative and how that initiative fit with our vision, and we've done some analysis and gone back and looked and we find that in fact it fits very well. We are talking about a matter of weeks, not months. And certainly before this Commission is complete and, Mr. Chairman, with your permission we would like to formally submit that to this Commission prior to publicly releasing it. Beyond that I can't give you any details, sorry.

**Robert Walker**

Submit nine copies.

**Tim Huddleston**

Will do so!

**Pete Aldridge**

Any other questions? Yeah, Carly?

**Carly Fiorina**

I want to ask a question about goals and timing, and this question has come up actually a number of times. In the President's vision there is a timetable laid out, and many would say—I among them, but also a previous panelist and our young student—many would say that the timing of the goal is fairly unambitious. And, indeed, in some ways the goal—the timing—has been chosen to ensure that the mission is affordable within current constraints. Reflecting on my own business and my own job, I think I've learned, over the years, that sometimes the only way progress is made is when goals are established that, by their nature, require sacrifice and tradeoff and debate and real commitment. And I'm wondering, from your point of view, and what you're engaged in and the responsibilities and opportunities that you see for the states: does the issue of when and how fast have an impact on your strategies, how you think about your role and if so, what is it?

**Tim Huddleston**

I would have to say it most certainly does and I think I might fall in the same category you do. We don't want to find ourselves rushing to judgment on anything. We want to make sure we do this right, methodically. We are not racing against a foreign adversary at this point, and we

understand that. However, a lot of states operate under the “Let’s just get it done” kind of mentality, and our concern is the longer this thing is drug out, the further the vision, the less the American people become engaged. You know, we are a 60-minute country, you know, football games are 60 minutes long and things of that nature, we—and so, you have to really understand that we need to keep the focus on the mission, so certainly a shorter time frame would be great but not at peril of making a mistake. You know, the great debate between how we would reach the Moon and whether we would use a heavy-lift system or smaller vehicles that would, you know, take us to orbit and transition from orbit to lunar orbit ultimately was answered because of the time line. We think the technology is there, we think there’s some entrepreneurs that are ready to do some flying, we think we can meet it in short order. I would highly encourage us to do this faster, you know. But, anyway—

### **Winston Scott**

I’m not sure if I can say much more. I certainly agree with everything Tim has said. I think the essence of time does play a particular role in whether or not we are going to accomplish the goal. Like you say, if you drag it out too long it becomes diluted, it’s no longer something that we want to do, so I think we ought to—it’s certainly good to have debate. We need to talk about it, we need to discuss it, we need to decide. But once we decide that, yes, this vision is good and we’re going to go forward with it, then, by golly, let’s go forward, let’s get it done. I believe that’s important.

I believe it’s also important not only from the nation’s vision, which I put up in my federal government side, but for developing the overall space transportation system, which, to me, also consists of non-federal government commercial space. I think we ought to be moving posthaste to put procedures in place, to put policies in place, to encourage us to get commercial vendors out there developing spaceflight technology and lowering the cost of access to space for non-federal government personnel and goods and services. Let’s do it. So I could not agree more with the sentiments that were just expressed.

### **Pete Aldridge**

I think there’s also a point that we don’t want to wait around and say, “Okay, we report to the American people when man lands on the Moon again.” We need periodic success stories as we develop and show successes as they occur and report them and continue with incremental steps and positive steps and also those which are affordable. We could probably go a lot faster, but I don’t think the Congress is going to give us the money to do that. So we’ve got to put—balance the time and affordability and the periodic successes as well.

Maria.

## **Maria Zuber**

Yeah, I want to follow up before—and I was really encouraged with the statement about the relatively harmonious existence between all the states feeling like space exploration was good for economy, competitiveness, education. There are thoughts that have been heard that accelerating space exploration is bad for social programs. And so, I'm wondering within some of the states how much push back there is for that argument.

## **Tim Huddleston**

Well, there's always going to be nay-sayers when you talk about new programs and new investments, to say that there are better ways to spend the money, and that's just human nature. It's going to happen in state government. What you have to look at is the consensus of the constituents, and I think constituents, particularly in bringing up my Southern roots, you know, we have a saying in the South that you don't eat the seed corn, you eat the corn that it produces. And so the same would hold true here. We have an investment that we need to make into a whole new opportunity, in this case developing space, and that that investment will, in turn, take care of the social ills as far as providing new opportunities, new dollars.

Someone asked me, "Are you going to ... states love to propose taxes." Well not really, but in this particular case we have some tax structures that exist right now, we just need to float dollars through those tax structures that already exist. So if you are off developing space and you are enabling new opportunities and new industries, you're taking existing federal, state tax dollars—I mean, tax structures—and you're just flowing new dollars through there, so there is now more money for the states and more money for the federal government to be able to go off and do social programs. So the end result is if you want to feed the homeless, if you want to take care of, you know, problems, social problems in this country, you develop new programs, whole new industries like space, so that you empower the economy, which empowers those opportunities.

## **Pete Aldridge**

Okay, we've run out of time again. Winston and Tim, thank you very much for your time. It's been stimulating, as usual. We are going to adjourn this afternoon; we will re-adjourn tomorrow morning at 9:00 a.m. here, and I'd like to remind the audience that tomorrow afternoon about 3:00 p.m. the audience will have a chance to participate by submitting comments, and we will give you the opportunity to say what you think about this program and what you would do to fix it, and we all look forward to that. We'll reconvene tomorrow morning at 9:00 a.m. Thank you.

## **Pete Aldridge**

Good morning again, and welcome to the second day of the third public hearing of the President's Commission on Moon, Mars and Beyond. And we're delighted to be here in Atlanta, and appreciative of the good Southern hospitality we've been enjoying here. I'm Pete Aldridge, Chairman, and I just wanted to note that the heavens seems to be with us as we proceed with the

work of analyzing testimonies in developing the Commission's report. The five planets visible to the naked eye are all in alignment this week. If you look up, you'll see Venus, Mars, Mercury, Saturn, and Jupiter. Perhaps they're lined up to welcome Sedna, the newest planet. In any case, I take this vision as a positive indicator for the space vision that we're now bringing into focus.

The Commission here is to explore new ways to achieve the President's vision by going back to the Moon, on to Mars, and beyond. We've had dialogues with experts at two previous hearings, in Washington, DC, and in Dayton, Ohio; talked among ourselves, and we realized this vision provides a focus that can revitalize space U.S. space capability and have a beneficial impact on our nation's industrial base and educational initiatives.

Again today we'll be talking with experts from diverse disciplines, including some outside the traditional aerospace arena. Before I begin, I'd like to briefly introduce my fellow Commissioners. Beginning at the audience's right, Carly Fiorina 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 served in senior executive positions leadership positions at AT&T and Lucent Technologies.

Michael Jackson is the Senior Vice President for AECOM Technology Corporation. He is the former U.S. Department of Transportation Deputy Secretary and was instrumental in the early formation of the Transportation Safety Agency.

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

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 commander of Air Force Materiel Command. In that pre-retirement position, General Lyles was responsible for the U.S. Air Force research and development community.

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

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 the 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 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. 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 dozen NASA planetary missions aimed at mapping the Moon, Mars, Mercury, and several asteroids.

Last, next to Maria is Steve Schmidt, our Commission's Executive Director. Steve is Special Assistant to the NASA Administrator and our federally designated official for this advisory committee.

We've been appointed by the President to make recommendations of 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; many presidential and congressional terms are covered by this vision. We're listening to experts and the public, along with drawing upon our own expertise to generate this plan. In addition to experts, we're listening to the American public, the ultimate consumer of the vision. Through our website we're accepting comments from people around the world who want to be heard on this subject, and lots of people want to be heard. We've received 4,700 responses to our feedback opportunity on the Web, and literally millions more people are accessing our web page. As of today we've received well over 3 million hits on our website. I want you to know that every input is being read; we're listening. You may be interested to know that about 75 percent of those contacting us through the Web are in favor of our sustained journey. And I'm delighted with those findings. We see that we must make recommendations that are affordable, and therefore sustainable, over several decades.

I emphasize, this is a journey, not a race. The management of such a large project and maintaining its affordability are crucial elements of our endeavor. Also, we recognize the need to inspire our young people and encourage literacy in science and math. We need those skills to maintain our leadership in the world. We've been chartered to lay out the science agenda for the next several decades, a topic reinforced by our presence here, at the campus at Georgia Tech. What should we be pursuing, and what makes the best sense of the use of our resources and investments? Finally, we're looking at the strategies that will ensure our nation's competitiveness and promote prosperity.

After Atlanta, the Commission will hold hearings in San Francisco and New York. We will then write a report and give it to the President, just 120 days after our first meeting. We have many distinguished witnesses and participants, and we'll meet each of them in turn.

Our first panel this morning: we're especially pleased to welcome representatives of organized labor. Gathered together by us, for us, by Dr. Michael Balzano. Dr. Balzano's story is legendary. Right? He dropped out of school at the age of 16 to enter the workforce, then progressed through a series of apprenticeships and schools to earn a Ph.D. from Georgetown. He is now president of Balzano Associates and executive director of the National Industrial Base Workforce Coalition. He has advised five U.S. presidents, numerous cabinet heads and members of Congress, and we're pleased to have him here to advise us.

Joining Dr. Balzano is Mr. Charlie Bofferding, executive director of the Society of Professional Engineering Employees in Aerospace (SPEEA). In addition to position at SPEEA, Mr. Bofferding serves as the executive director of the Council of Engineers and Scientists organization.

Third labor panelist is Jeff Rainey, Business Representative of the District 166 International Association of Machinists and Aerospace Workers, representing employees of Cape Canaveral, Florida. Mr. Rainey is also a driving force in local politics and a member of numerous organizations, including the Space Coast Economic Development Commission and the Spaceport Florida Commerce Park Authority. Welcome you all. Michael, I guess you're going to start off, and we look forward to your presentation.

### **Michael Balzano**

I want to thank the members of the Commission for inviting us here. Yes, I'm the Executive Director of the National Industrial Base, and underline *Industrial Base Workforce Coalition*. The Coalition exists as a group of local unions in about 30 states. We are multi-union, we are multi-company, we are multi-industry. In fact, we are multi-workforce, and many times we've got people to come along with us who they're not unionized industries, like the machine tool people in the West Coast, but they are very much involved in everything we do.

We're unique in two aspects. First of all, we're local unions. Many of our members are affiliated with the AFL-CIO, etc., but we work as union locals, which gives us the dimension of the jobs right where they are. Second, normally we've had coalitions of engineers, we've had coalitions of production workers; this one covers the entire spectrum of the industrial base, everything from engineers, all the way down to the people who put the Coke machines, you know, in the facilities.

We were born really out of the explosion of the *Challenger* in '86. NASA's critics came from all quarters. There were those who said that space exploration was too expensive, we should be—there was no real social value in it. Second, there were those who said that human space travel was too dangerous; it should be left to probes and robots. A third, which was the biggest one that hit us all the time, was billions of dollars were spent in space, and nothing was spent here in terms of human and social needs, so we always were caught between science versus entitlements. At one point it got so bad the manned program was literally, as Dan Goldin once said when he left office, he said, "They were ready to put the lights out on the manned program. If it hadn't been for you guys to come along, it would not have happened." The fact is, they were ready to cancel the manned program, which was, as you know, more than half of the NASA budget. It came at a critical time too. The explosion came at a time when we had just finished the lunar missions. NASA was looking at RFPs for the Space Station, so, there was one major senator, I remember, getting up on the Senate floor and said, "This is the time to kill this program now, because it'll be tens of billions of dollars, we've got a chance to kill it before it starts." Fortunately, he failed. Throughout the battle over the Space Station and following the *Challenger*, unions lobbied, we put together an organization where the unions could lobby the

Congress collectively, rather than his program, his program. We took a generic stance on the thing. The coalition was not simply trying to save the Shuttle, or the Space Station, we were trying to save the entire industrial base that put the thing there.

Third, it included, as I said before, and I remember when we testified before the Augustine Commission, Norm said, "You know, I can't believe it, you've got engineers sitting next to production workers." He said, "How did you do it? They're always fighting with each other." We did it because we had one common theme: we've got to save the industrial base or all of us are gone. In this coalition, not only did we have engineers and scientists and production workers, technical workers, we also had the basic industries. We had steel, the ferrous and non-ferrous, specialty metals, titanium. It was the first workforce coalition that was ever put together, and to my knowledge that exists today that no one else has ever done, is everything from air traffic controllers, all the way up to the scientists and engineers, coal miners, you name it.

The coalition entered the public policy debate at many levels. We met in Washington to talk to members of Congress. We were invited to testify before Congress. We testified before the Augustine Commission. We worked very closely with the President's Space Council; at that time we were in and out of the White House all the time.

Incidentally, you know, during the Clinton years the council was disbanded. We think that was a mistake. We think that it's essential for the President to get as close as possible to the subject, have his own people on staff so that we can work with them, and they can understand what we're trying to do. Because they were local unions, and this is a good one, we were able to lobby Congress at every level there was. I mean, we got them on Memorial Day, Labor Day, 4th of July, Christmas, New Year's, retirement programs, and yes, fundraisers. When they were at fundraisers, we were at fundraisers. And boy, you can get a member of Congress's attention pretty quick when you get a whole delegation in there, across the profile, saying, "Hey, we're worried about this program." The point is the coalition presented a continuous dialogue with public policy makers, so they all knew where we stood, and they took it home with them.

Now, when Kennedy announced the program for going to the Moon, we didn't have the engineers, the scientists, the crawler, all the things that we have today, we didn't even have. What did we have? We had a president committed to a vision. I mean, that's the big one. Secondly, we had a nation that embraced the vision, and third, there was a resounding "Yes, let's do it." President George Bush announces the Moon to Mars initiative, big difference between now and 1960. Take the politics aside. Silence is deafening. I mean, where is the support across the board? Instead, what we're getting is sniped at from all different directions. The governor of Michigan about three weeks ago was on TV talking about arguably being angry that Electrolux Vacuum Cleaners moved out Michigan and gone to Georgia, in which he said was we need jobs in Michigan, not on Mars. There was a protest march, and one of the union guys was carrying a placard saying, "We need jobs on Earth, not on Mars." They don't understand: not a penny was spent in space; it was all spent here. You really want the jobs in Michigan, this is the program that'll do it for you. One thing we do have is all the critics are back. We're hearing it, day one.

A professor from the University of Maryland said we don't have to go back to Mars; we're already there. We've got the probes there, so the President is wrong, we don't need to do this. Secondly, it's too expensive; here we go again, very expensive. And third, once again, the surpassing need for domestic social programs. We would like the Commission to focus on two things in general: number one is what we're talking about here is the need to preserve the industrial base, and don't just look at aerospace workers, look at everything that goes all the way down to the bottom, the titanium tube makers, all the people who contribute. And secondly, we'd like to have you look at the workforce as part of the industrial base. I mean you know, you can have the greatest machines in the world, but if you don't have a trained workforce, which we have, it won't work.

From our perspective there are several suggestions that we would like to make, and, you know, we'd ask you to take them into consideration. First of all there's going to be a need to sell the vision. Okay? The journey of a thousand steps, a thousand miles, begins with the first step. Second, we need to take the heat off the labor unions, because, I mean, when the *Challenger* exploded, the coalition was put together. We had to engage in a ten-year multi-fight—I mean, you name it, we fought for the Space Shuttle, the Station, the appropriations, the authorization—at one point we were actually fighting to keep the *Mir* up. At times we only won the Space Station by three or four votes, I mean it was that close in the House. So the workers that had to build the systems had to also lobby the Congress. I mean, it was a constant night-and-day fight.

The other thing we want to worry about here is the position of NASA in the budget. This is a taboo subject, but I want to raise it. We're constantly juxtaposed with social programs, it's either science or entitlements, and that's because of the position that NASA has in the VA, HUD, and IA Committees. I was a director of a federal agency. I directed the Peace Corps for five years, okay? I know what it's like to fight a budget fight, but I never had to sit down and say, "Okay, it's Peace Corps versus science." And that's what we're going to be dealing with, and this year we're going to have fun.

Last two days in the newspaper, shortfall on Medicare, shortfall on Social Security, we're going to be dealing with that subject right off the bat before we even start, and I think members of Congress are going to be somewhat scared. And I want to see who's going to step up and say we need to save the science programs, in the face of constituents wanting social programs. But we're going to have to win it. If we don't win that fight we're in trouble.

We have unions in our group that are also public employees, and this is another subject nobody wants to talk about. When the President got up and made the speech about we're going to Moon, Mars, I mean, he thought he was talking to happy campers. He wasn't. Because people in that agency were looking at my project. I've got a bird in the hand, we're talking about not doing this and doing something else; what's going to happen to my project? That's dangerous, and it's already happening. We saw it with the Hubble; somebody wants to change the Hubble—wow, they came out of the ground like bees, okay? We've seen it before, NASA employees have got to—somebody's got to get the message to them.

And in 2010, it goes away. The Shuttle is an older program. You know, it's an older technology, it's going to be phased out. So it's not a question of a bird in a hand, it's a question of the food chain. If we don't stop this now, and, see, here's why I'm worried, if the Congress takes the position of "Well, we don't have to do anything on the vision," they're going to accelerate the retrenchment. Because you know the iron triangle between the members of Congress, I mean, they're going to accelerate that retrenchment.

Finally, we have to think about the number of people who are testifying. You know, in a very short time, in a year and a half, I'm going to be 70. Things go pretty quick. People who testified before the Augustine Commission have already retired. The entire Kennedy generation of technicians is retiring. Where are we going to get these people if we don't have a system that says this is a priority? We've got to fire this up because we're doing it with production workers as well.

Sixth, and probably the last one, if the United States leads as the leader in world space exploration, we're not alone any more, we're going to be on the outside looking in. To which we ask, if we're not going to have a vision to pursue, what are the kids going to do? What's the next generation going to do? Are we going to doom them to be hamburger flippers, and working at hotels? No, no, not that that's bad but, my God, this is a nation that went to the Moon! My kids are going to say, they're going to attribute it to witchcraft. We need to do this again. I leave the Commission with those suggestions, and I know that my team witnesses here will have different perspectives on it, but we'd love to answer any of your questions. Thank you.

### **Pete Aldridge**

Michael, thank you very much. I—quite a provocative and interesting set of comments. Charlie?

### **Charlie Bofferding**

To allow some time for answers I'll just touch on some of the high points that we have to do here. But I'm Charlie Bofferding, and I'm the Executive Director of the Council of Engineers and Scientists organization, and as you've heard, we've been involved in this discussion for some time. Our organization spans a number of unions representing high-tech employees in both the public and private sector, so we're not new to this discussion.

I know you've got quite an agenda, and I just want to focus on a couple parts of it. The science technology and also the competitiveness and prosperity for the benefit of Americans and all mankind, and I think that's part of what we have to do here today. We have to underscore not just the vision we have, but also the mechanisms we're going to use, and the requirements in order to achieve that vision.

You know, Marx said all wealth comes from the workers. An engineer like me says all wealth comes from technology, and I believe that, and I think that's what we're talking about today. We're not just talking about going to Mars, we're talking about this nation's commitment to technology and being able to develop an inspiration such that we can realize that. So I have great

confidence in our abilities to do the things we need to do. To get to where we want to be will require that we take everybody along for this ride, not just the people in this room or even the millions that have contacted our web page.

We have got more and more out there that we need to inspire to support us. My concern for science and technology is that while our ambitions are going up, our capabilities, frankly, are going down. Our workforce is atrophying, our supply for the talent for the future is drying up, we are now graduating fewer engineers than we did before, we are also seeing a shift in our universities from U.S. citizens graduating to foreign nationals graduating. And I think that's fine, I love training anyone to be an engineer or scientist worldwide, but I think one of the things that we have to think about is "Where are the capabilities of this nation? What are we doing?"

So our concern is that our technological base indeed is aging, is eroding, and is leaving. The thing I can speak from personal experience, I grew up a Boeing engineer, and today the demographics at the Boeing Company—it just takes once glance at the demographic curves to know that we've got a terrible problem on our hands we need to step up and address. So the question is "Who are we training? Who are we inspiring?" And I think maybe the better question is "Who are our heroes? Who do we look up to as a nation?" I'm sorry to say it really isn't our technological leaders any more. It's now our sports heroes and the people we see on TV.

I also think that dovetails into that discussion is "What do we appreciate, and do we have a holistic view of the systems that we're talking about?" And I'm not speaking about just the delivery systems to put people in space; I'm talking about how our economy works. I was in a number of those discussions with people where we're arguing for NASA, and people were saying, "Why would I put 12 people in space when I have thousands of homeless here in my district?" And the answer was, because by putting people in space we're developing our technological base, we're creating jobs, we're pushing the envelopes of technologies, and those, frankly, are the core and essential elements of a thriving economy, and one that's going to take on the rest of the world.

We are leaders today, but that is not our birthright. If we want to maintain our position, indeed we have to do something positive and conscious about it to maintain that position. So we support the work that's going on here. And let me—I guess one of the things that I'm saying is, before we can reach Mars, we have to reach the general population. A lot of the people I represent, Boeing Company, our commercial airplanes, so I talk about the view from 50,000 feet. I may have to change my terminology here, and I'll speak of the view maybe from three light years, and I think that's the perspective we have to generate: an appreciation that we as the sector of our economy that represents technology is a critical sector, and it is one of the life-giving parts of our economy. It is a source from which we drive the economic engines that allow us to have a service economy.

The bottom line is, we have to create things. And I think this also dovetails into what is at the essence of going to the Moon and Mars and beyond. We're more than just people having a job today. We are part of a larger destiny. We are part of the human race that's moving forward, and I believe indeed it is our destiny to continue to explore, to grow, and to thrive. And our message

today is we have concerns right now about America's technological community. Are we continuing to push the envelope? Are we training ourselves for the future or are we training the rest of the world for the future? And what is our position in the world going to be? I think it's up to us and the things that we do to clearly establish as a priority our rightful place in the world. I think we also have an obligation to the rest of the world to continue to lead, to continue to push the envelope, to bring to bear the unique skills and talents that we've developed over generations.

The thing that scares me the most, particularly when I look at the demographics today, is I see that we're in what I'll call a glide slope to history. We look at—and I have an animated chart I didn't submit in advance, so I can't share with you now, but I will paint it with my hands for you. This is our population, and this will be time, and what's happened is, that slug, it's a snakehead, it's eating a rat, and it's digesting it, and so it's getting smaller and it's moving along. But to go look, very few people under 30, very few people under 30, and the question is (1) how are we going to maintain our technological base and (2) how are we going to capture that wealth of knowledge, experience, and information that is getting ready to retire, and take it out with it?

So I think this program comes at a critical time, I think our effort is worthy, and I think our cause is noble, but the engineer in me says we've also got some spade work to do here to make sure that we've got the foundation required to achieve our dreams and our goals and make the world a better place. So that's what I have to say. Thank you for your time.

### **Pete Aldridge**

Charlie, thank you very much. Jeff?

### **Jeff Rainey**

I'd just like to say thank you very much for having us here. You know I stayed up to about 2 o'clock this morning, and I had all this great plan out here, but listening to what different things have happened today, I realize that, you know, Congress has got a tremendous job. A few years ago I started complaining about the area I live, and I was challenged to run for office, and was elected to office. I've been doing that for six years.

We have to do what's right, and what's needed for the future. And the community that I live in, freshwater is very, very important; of course we can do without a lot of things, but we can't do without water. And we've had to spend a lot of money and make a lot of tough decisions, because we had to believe in that vision of that water for our future, for our children.

And I believe the space program—I don't believe that most people realize what the space program has given to America, and to the world. And it doesn't matter if you like watching NASCAR on Sunday, the technology that those cars use, the safety, whether it's a football game with the pads, the plastics, whether you're in the hospital in the ICU, the technological advances of that space program has brought to that, the understanding of our wellness, the life science. I've had some personal experience with life science and working with some brilliant people

around the world when I worked for Boeing on the payload side. The things that they have learned, I believe we are just starting to scratch the surface. I believe we do need to have the Space Station.

Most of those experiments stayed in space 15 days, came back, and the advances that we made were just wonderful. And I think it's very important that the space program stays intact. We do have a workforce that's trained, there at the space center. NASA is working with local colleges to even bring up more technicians in this field, because as we look around, I was 20 when I started, and I'm quite a bit older than that now, but you look around, everybody's my age, and it's very important that we train these people. And I understand where Congress and the politicians, they have their issues. But every dollar that's spent on the space program is spent on Earth. The off-spins of that money is felt all across our country. The savings—a year ago I rode a vehicle 3½ times, I don't think I would have walked away from that vehicle 20 years ago, because of the technology that happened that everybody uses today, that we don't realize that came out of the space program. And I think it is very important that we continue the space program.

The workers that I represent are some of the best, and are, in my opinion, second to none. They're trained. They do a wonderful job, a great job, and there's a—you know, I can talk until y'all got tired of listening to me, but one of the things that's very important to me is, I believe that the knowledge that is out there for us to get to the space program. I don't think anyone really can fathom what wonderful things can come out of that.

History has shown that in the 1400s/1500s the countries that dominated the seas, dominated the world. Later when the country that dominated air, which is the United States, I believe where our Air Force and our pilots are second to none, we dominate. I mean, 20 years ago what we've done in Iraq couldn't have happened without the satellites, without the technologies that we have, and the knowledge that we have, the way they do the medical treatment on the battlefields. But I honestly feel the bottom line is space will be explored, and I want it to be the United States that does that. I don't have anything against any other country, but you know, I'm an American, I was born here, raised here, and intend to stay here, and I'm very proud to say that I'm an American, and everything that we do we give it 100%. And I believe that it is America, of course with partners, but America has to take the lead in space, we have to be the dominant force, we need to have the engineering capabilities, the management capabilities, and we also have to have a workforce to make all that happen.

### **Pete Aldridge**

Jeff, thank you very much. I was particularly interested in the comment that while our capability seems to be going down, the problem of providing the technical industrial base, the pipeline for future students, and math, science and engineering is declining. And I know we all talk about the value of the President's vision in space as hopefully providing the incentive to try to turn that around. But the implication is we've got to even do more than just a space vision to turn this around. It's a problem that's bigger than just the vision in space. Am I sensing that as a right—

we've got to do a lot more in stimulating young kids, training teachers, a much broader issue here? Comments?

### **Michael Balzano**

You know, Mr. Chairman, we talked about my being a high school dropout—you know, I really learned English by listening to the radio when I was a kid. And I listened to the *Lone Ranger*, *Terry and the Pirates*, *Jack Armstrong*, you know.

### **Pete Aldridge**

Unfortunately we remember those.

### **Michael Balzano**

Well, we do remember them, but you know what? They were all moralistic portrayals of what's good and what's bad, the difference between good and evil. Now today, you know, TV's been taken over by you know, *Friends*, you know, *Feinsteins*, *Sex and the City*. I mean, where are the kids getting the messages today? They're getting them from the video games. If you look at the video games, I mean, they're high tech, they're games, but there's a moralistic thing in there, admittedly it's violence. We have to find a way to bring this back, I hate to say this, but we got to retrograde, we need to go back to the kind of educational system that we had when we were kids. Because it built—we had a culture then, we had a culture that looked for heroes. Who are the heroes today? Yeah, I mean, when Grissom burned up in that capsule, I mean the whole world was with him, we had heroes. When the Apollo 13 cracked up, I mean, the whole world was watching. We're not focusing on heroes anymore. We're talking about, you know, this comes from our school systems, and again, I would make one more thing. When I was getting a degree at the University of Bridgeport, you could count; you could count the engineers, science, math people on one hand. I mean, everybody was getting a degree in sex education—not sex education, but childhood development, etc., everybody was taking the soft sciences, the hard sciences were pretty, pretty meek. The Kennedy generation put the money in there, we got the engineers, we got the technicians, but it had to be—the pump had to be primed. And that's what we need to do at the educational level.

### **Pete Aldridge**

It was interesting yesterday; we had testimony from professors in aerospace engineering. At Georgia Tech, the fastest-growing engineering school is the aerospace engineering school, which was a first time I got kind of a positive stroke on that one, that something is happening, that they are in fact beginning to be interested in that. Another comment you were talking about, the value of space, we've all heard the jokes, well I don't need space, I have the Weather Channel, I have my DirectTV, and I have my GPS receiver, so why do I need space?

## **Charlie Bofferding**

But the question is “Where did you get all those things?”

## **Pete Aldridge**

Right, I know, but some of the people who don’t realize exactly what the value of space has to their day-to-day lives. Yes, Paul?

## **Paul Spudis**

Yes, Dr. Balzano, I was really intrigued by your comment about the budget authority, which has worried a lot of us for a long time, and you mentioned the fact that the workforce and technical infrastructure issue is really an important—you view the space program primarily as a way to keep that sharp, and at top efficiency. Maybe could you, would you make the argument that perhaps the space program should be in the defense authority on the grounds that fundamentally we’re talking about national security at a very fundamental level, not the military, but national security in the sense that we have the industrial and technical base to defend America? Would that be a good plan? Would you advocate that?

## **Michael Balzano**

Yeah. Let me just say that, when the chairman and I spoke today, the last time I saw him was at DoD. The Secretary of Defense is very concerned, and is very close to the workforce, and he’s trying to keep a link alive there. In the 1980s it was almost taboo to mention defense, because we had a fairly liberal Congress, and the idea was to keep different NASA civil space versus DoD. What happened there was during the campaign, and this is not a political discussion, but during the campaign, our workforce sat down with candidate Clinton and we got him to understand that there was a significant workforce, industrial base implication, and he said, “Don’t worry, if we get in there, space stations, we’re going to move forward.”

Well, they appointed Panetta to be budget director, who Panetta had an axe for the Space Station since he was born, and the first thing he did was he zeroed it out. Well, we were on top of him like somebody knocked over a beehive, okay? We wound up saving the Space Station, but Dan Goldin, literally, I remember that night, he came to my house, I had to assemble a whole bunch of people, he said, “Look, we can’t sell this any other way, we’ve got to have a Russian partnership.” So the thing went more toward the peaceful use of space. Now I know the DoD has parts of—I mean, they’re worried about our capability because they’ve got platforms, and they need to launch things. I think we’re going to have to make it clear that the space program is everybody’s program, including DoD. And I would not shy away from it, but I think there will be those in Congress who may use that as an excuse not to support it because, I mean, it’s supposed to be peaceful use of space. Well, the Chinese are going to be launching things, and I’m not sure that’s going to be peaceful use of space, you know.

## **Pete Aldridge**

Carly?

## **Carly Fiorina**

Well, thank you all coming this morning. And everyone on this Commission, I think, deeply agrees with you that the space mission is about competitiveness and prosperity here at home. And we all struggle with how to appropriately articulate that to the American people. Jeff, I actually think you may have come up with the Sound Bite of the Year award on two counts, because you said two things that I think are really piffy. One was every dollar that's spent on space is spent on Earth, and the other was space will be explored; it should be explored by America. I think those are two really key comments. So you may be famous in this report when it's all over. But bridging off those two comments I want to come back, Dr. Balzano, to the point you made about preservation of the industrial base. And I'd like ask you how do you think we should appropriately quantify the industrial base that exists today, so that when we talk about preserving it, people understand the magnitude of this for our economic prosperity not just today, but 20 years from now, but let's start with today.

## **Michael Balzano**

Unfortunately, the quantification of the industrial base today is depressing, because what is everyone talking about on the Hill? The need to preserve manufacturing jobs. Well, we just have gone through part of the battle over at DoD, over "Buy America," which is a great slogan, but if you really talk about "Buy America" the way it was introduced, it would mean that there would be no tools that were used to make an American defense product if the tools came from another country; well, we would certainly discover that they all come from another country. Well, what happened there? And my job with the Secretary and other people was to try to get the unions to understand that, look, it took us 50 years to get where we are, we do want to reverse it, but it can't be reversed over night. I think the key is we should fight for every manufacturing job we got. We just cannot, and, you know, I'm talking about outsourcing, but I'm talking about people leaving the country and going overseas. I mean, we've got to focus on that, because the manufacturing sector is falling apart now. We're worried about jobs everywhere else in the world, and I know it's pushed by the bottom line for major corporations, everybody's trying to do it, but we're going to have to have some internal sacrifice about what is American here too. I think you can measure that decline today in the impact of what's happened. Now reversing it's another story. We've got a private sector, we've got, you know, a capitalist-driven economy, and that's not bad, but someone is going to have to now set the pace for what do we need to do to turn this around?

## **Carly Fiorina**

And your point, if I can interject, your point is that the space program is an opportunity to preserve and create manufacturing jobs.

## **Michael Balzano**

Absolutely.

## **Carly Fiorina**

And your point I think is that it is also an opportunity to preserve and create technologically driven jobs, which are the future. I would add that one of my own—being a leader of a major corporation that operates in 178 countries around the world—I would add that my concern when I think about skills and jobs, is less cost and more skill. And I think bridging back to your space is going to be explored, it will be explored, it should be explored by America, the more distressing thing to me as a CEO is not where is the least costly worker, but where is the appropriately skilled worker, which I think is to your issue of the feeder [point?].

## **Michael Balzano**

Charlie, that's yours. Go ahead.

## **Charlie Bofferding**

Sure. One of the metrics, I think what we've got is a flux problem, in that we look at what's coming out and we look at what's going in as we monitor the entity itself. So if we're looking at technological capability, let's see the capability we have, retaining what we have, and what we're doing to reinforce it. But the other part of it is—how do we say this?—it's very economist would tell you the only way to increase real wages is in benefits, right, is to increase productivity? And the thing that I have to say is, every technical person I know is all about increased productivity. It makes the job more inspiring, it makes the heart warmer. And I think these are the areas we need to go. I think it feeds back to one of the core things we're talking about, and that is not just statusing where we're at today, but acknowledging that we need to invest in the future. Alright? And part of that investment, I think, is this space effort that we're talking about, so we give that investment, and then generate the capabilities and the increased productivities, because from your perspective you want more of it, and you want it faster and you want it better, right? And these sorts of things. Everybody wants that. You know, that's how we all enjoy life more, and so what we have to do is create a vision that sustains it. Because a lot of my friends, they're really smart people, and they can do the calculus themselves and say, "What does the future hold for me in this industry? And what are the returns, and what do I get back from it, and what's going to happen? I have other choices now." And without somebody else saying, "I'm with you, I'm standing shoulder to shoulder with you, in the commitment to the

future of these technologies,” it’s hard to go alone. And again, our point is, I think, is yours—there’s something in this for everyone, and something that we together need to do.

### **Carly Fiorina**

You had a great sound bite as well, which is “We’re not talking about our nation’s commitment to space, we’re talking about our nation’s commitment to technology.”

### **Pete Aldridge**

That’s good. Laurie?

### **Laurie Leshin**

Thanks. Thank you, this is fascinating, actually, and I study rocks in a lab, so this is something that I don’t really know very much about, but I’m very curious about trying to quantify similar, actually building on what Carly said. I have in my head this idea that we have a wonderful vision for an inspiring space program, which reaches into the 120,000 schools in this country and plucks kids out of classrooms, and gets them excited and gets them into that pipeline early—which then ultimately must save us money, because we don’t have to retrain them later, because that’s the way the economy’s going. And I’d like to be able to close the loop on that argument by understanding a little bit more, and asking you all to educate me a bit about job retraining, and about kind of how much of that we’re doing, how many people are we talking about, how much money are we spending doing that now, how much is anticipated in the future. Can we, if we get them early and often with this program, are we ultimately helping ourselves, and can we quantify that? So can you educate me a little bit with some numbers there, if you’ve got them?

### **Charlie Bofferding**

Oh, I don’t have the numbers, but the reason you see the smile on face is what I’m thinking is what every engineer thinks and that is “I can do anything.” And we believe if you trained your population as engineers, retraining costs would go way down. Now that’s a very egotistical view, but my point really is, when you talk retraining, the first question you have to ask yourself is “How far am I moving those skills?” Right? Because I’m readjusting application of scientific principles and understanding, it’s really very easy, and frankly, it happens every day on the job as people progress through their professions. But if what we’re trying to do is actually shift, right, serve a sector to high technology, that’s heavy lifting, and as you point out, the way to do that is gradual and over time, and put more people into the technological areas. But again, I think at the core of this is getting people to think about that from the start. And I think what we’re saying today, space is really a surrogate for technology, and some of the great work that NASA has done has inspired people, not just about space, but about technology and all its uses. You, know, I’m looking at the laser pointer here, and I’m looking around the room, and I’ve got my

computer over there and my Treo in my pocket, you know, and people develop this appreciation and hope they want to be part of it, rather than just assume it.

### **Pete Aldridge**

OK. Neil.

### **Neil Tyson**

I have a comment and a question. First, Dr. Balzano, I was concerned about how quickly you were prepared to possibly blame TV and other sort of pop culture forces, simply because, you know, in the past decade violent crime in America has actually been dropping at a time when the number of TV stations has been growing exponentially, and of course the two generations immediately preceding the advent of television fought two World Wars, with the slaughter of 70 million people. So human violence wasn't born with the advent of television. This concern about heroes, though, is a very real one, and I think the—I don't quite know what to do about that. "Can a robot be a hero?" is one question or, does that require a human? So I want to sort of put that out, but also we are all sort of in the same business here. We're trying to alert the public of the value of a vision. You three have specific awareness and sensitivity to an investment in a vision, and the consequence of that investment in employment, and in the technological frontier of a nation. Somebody's not getting that story out. Somebody's failing at that because—and, Mr. Rainey, you're in a county where everybody in that county knows it, because it's the Space Coast of Florida. So who's not doing their job, alerting the public about the value of this for our frontier? And I don't have the answer to that. All we can do at the end is write a report, but you guys are in the trenches. Could you tell us what we should do or, what you can continue to do, that hasn't happened already?

### **Charlie Bofferding**

Everybody's not doing their job in this area, and we've all got things to do, and specifically our union—we're beginning to do outreaches, we're beginning to engage ourselves in mentoring our students to bring them along, and I think an awareness needs to be generated. The world is not single variable, it's easy to analyze in that state, but it just doesn't function that way. You've hit the nail on the head, and we need a holistic solution. And I think, again, we underscore that's the wonderful thing about you know, Moon and Mars. This is a big piece of it. This isn't all of it, and I would hope no one would think, "Oh, good, that's happening, so all our technological concerns are taken care of." But this is a big part of it, and this, I think, adds to the nation's focus. Technology is important, we're doing really cool things with it, and we're advancing ourselves as a race and a planet. And we all have, though, our own specific areas to fill, and it's like all politics is local, I think all inspiration is one-on-one.

**Pete Aldridge**

Maria?

**Michael Balzano**

Can I just ask a question? Gee, it seems like a hundred years ago, but when I was at the University of Bridgeport we had a man named Phillip Stern, who was trained by Henry Neely, of the Hayden Planetarium, a long time ago.

**Neil Tyson**

Right. Sure.

**Michael Balzano**

He wound up teaching one course in astronomy, which I [aided?], went to it, and I ended up lecturing at the planetarium, and it was a fantastic thing. And one of the things that Phil Stern said: we need to get this down into the grammar school level where kids understand there's something for them out there. Now, I'm dealing at the other end of that equation. Okay? What I said to you earlier was, it seems terribly unfair for the workers who are building the hardware and the software to have to abandon everything to go back in town and fight the battle to keep it funded. I mean, you're draining off our energy in fighting political battles. We're good at it, but you know, you're taking us away from the mission. I didn't mean to focus on TV as the assailant here, but I want to go back to that. We had heroes on the radio stations. Okay? I literally—I learned English there, okay? We identified with good and evil, and we identified with heroes. I don't know how many radio stations are broadcasting *Terry and the Pirates* or, you know, *Jack Armstrong* and *The All-American Boy*, we'd probably be "something-else boy" now. But the point is, we need to go back to that. And you're a press agent for astronomy, I've seen you on television many times. OK? You're a press agent for it. Like Henry Neely used to say, okay, I never met the man, he died before I met him, but he used to say, "Every time we open a planetarium door, I've got the next generation in my hands." And it's true.

**Neil Tyson**

I feel that every day.

**Michael Balzano**

You do that every day. It's true, it's still true.

**Neil Tyson**

Every day.

## **Michael Balzano**

Absolutely. But there's got to be follow-through. When the planetarium show is done, and the kid walks out of there, what does he do next? I honestly don't think we're stressing this in the grade schools enough, I really don't. I know what subjects are being taught, and some of them are revolting, okay? But they're not focusing on the heroes, the mission, the challenge. And we've got to find a way to do that. We'll do our end, but somebody's got to prime the pump on that end and make it happen. There should be more trips and students with teachers to NASA. They should go to the Space Shuttle, they should go to the launches, I mean, we have to find a way to fire these kids up—OK?—so that they'll take the hard courses. You know, the easiest thing to do is take a course in sociology or some soft science as opposed to the hard ones. And I've got a Ph.D. in philosophy, so I'm not downing soft sciences, but I'm telling you, I spent—I have a Ph.D. in philosophy and I spent the last 30 years working in the industrial base. We need to find a way to link those two.

## **Pete Aldridge**

Good. Maria?

## **Maria Zuber**

I want to follow up a little bit on the question that Laurie asked about retraining. And in the vision that we're talking about implementing here, there's going to be some uncertainty involved, and I guess maybe my question is for Mr. Rainey. You've got a number of workers on the Space Coast who are, say, involved in turning the Shuttle around, and they've been doing that for a long time, they've got very specific skills, and in the future we're going to have a Crew Exploration Vehicle, and we don't know what that vehicle is going to be specifically right now, but it's the hope of all of us, I think, is that it's going to require less maintenance at that level. So if you're a worker on the Space Coast who's been working on the Shuttle a long time, you know, what does an organization like yours tell people that is in this vision for them, and how do you tell them that the retraining that's going to be necessary is a good thing, and that it's going to be better than the status quo is?

## **Jeff Rainey**

Well I pushed that issue, and I pushed it by practicing what I preach. Every time something was offered to me, I took those classes. Whether it was the transportation of hazardous material—I had no idea what was being transported across our highways, and when I got into that it even made me more scared to drive on the highways, but I took all those trainings, and I used all training that I've had in many, many different fields. And I tell them, "You need to train, you need to get every bit of training, education that you can get." There was a point coming down where some of our technicians had to learn how to drive tractor trailers, and they said, "I don't want to do that."

And I said, “You know, you may need to do that one day. I mean, you could make money doing that, but you have to prepare yourself to adjust,” and I think we pushed that. One of the things that a lot of my members are involved in, there’s a program called Combat. Boeing and NASA are a very big sponsor. It’s not combat as fighting, it’s they take a bunch of wonderful students, they give them a bunch of parts, and they have to build a robot that does different things. Now this program, a couple of years ago, they had at Disney World, 12,000 young people, not one security officer, not one mishap, not a problem. If you give the kids the opportunity to learn and to train, they will do so. But the problem that bothered me, about a month ago, they came before the council to show us what they had done, because the cities sponsor these kids. Well one of them said, “We hope there’s somewhere in our future to use this.” And that’s what really drove this whole Commission. We’re getting the kids fired up, are we going to take their future away from them? I think we need to fire them up, I think—you know, in Titusville, alone, between the two high schools there’s about 3,000 to 3,500, about 3,000 students in the high schools, and you’ve got 60 kids out of 3,000 doing this. You know, and those kids are great, I love them, I support them, but we need to make—that should be bigger than the football teams. I love sports, I played sports, I enjoyed it, but that team needs to be bigger than the sport teams of the high schools. And I tell them, “Take all the training that you can get. You know, whatever they want to teach you to do helps you to tackle a problem later.”

### **Pete Aldridge**

Yeah, Bob?

### **Robert Walker**

Yeah, let me thank each of you for expanding on the vision statement. I mean, I think you have given us an underpinning for that vision statement, and labor can be very effective. Mike, I was obviously there when we won the one-vote victory on Space Station in there in the House of Representatives, and labor played a very important role in making certain that those things happened. But the work of this Commission is not just about vision, the President’s laid that out. We’re about implementation. We’re about the specifics of how you get there, and so just a couple of questions for you. One of you said the workforce has atrophied. Has NASA atrophied as well? Has NASA atrophied? Does there need to be a reorganization of NASA as a part of making certain that we can go on and do this mission going forward? And then secondly, if you could tell us one thing that you think is of foremost importance in getting us to an implementation strategy that will work, what is it?

### **Charlie Bofferding**

I can’t speak to the specifics of NASA, but I can also tell you an effort like this will not be done solely by NASA. It’s going to take the entire technological base, and indeed that is atrophying, and it’s aging, and it is going away, that’s a very real thing. The one thing that can be done, I think, is figure out a way to give a strong, positive long-term commitment so that people can

understand this is something they can grab onto, and stay with, and actually experience their vision.

### **Michael Balzano**

I don't want to denigrate Charlie's engineering group, but I will tell you that one of the people who helped testified before the congressional committees, 7 or 8 years ago, is a union president. He now is working for a company, he makes decals for toy trains. He now has a job, he's not worrying about the ups and downs. We've got to find a way to assure people who are going to come into this industry that there's going to be an industry. We're losing people before they even start. You know, I'm not saying I'm opposed to outsourcing, we're not; we believe in outsourcing for a whole bunch of different reasons. But one of the things that DoD is dealing with now is "How do we convince people?" There was a AIAA conference about 3 months ago, and some of the giants of industry were saying, "We have a problem, because engineers are not going into Defense." Yeah, right, why not? I mean, they're looking at the stats, and they're getting out. We need to convince the people that there's a future for them if they study, and there's a future for them if they get into it. Because right now we're losing that battle; that's got to be fought early, because we're going to lose the young group of engineers that are still in the pipeline saying, "I'm going to get out of here, there's no job for me here." And we've seen it at the production worker level in space, every time a company lays off, there's one company within rifle shot of here, they laid off a thousand people, June about four years ago, they only about 400 of them back. They're driving cabs or stacking—they've gone off elsewhere. You've got to convince people that there's a future.

### **Pete Aldridge**

Good. Mike?

### **Michael Jackson**

Thank you, gentlemen, for being here today. And I think the support of labor for the vision of the President is an indispensable part of the success of that vision, and so learning from you how to work through these issues is just indispensable. Mr. Bofferding, I work in a company where I'm surrounded by engineers, it's a big engineering corporation, and I admire the sort of can-do spirit that says, you know, "We can do this, just tell me what the [?] is and we'll get it done." But I'm not an engineer, Dr. Balzano. I too got a degree in political philosophy from the same institution where you got your advanced degree. Yes, sir. So you know, it's "How do you find your way to practical solutions for practical problems?" is the world that I'm dealing in now. And I have a practical problem that I'd like your counsel about. You mentioned that the public employee unions that are part of this workforce that we must employ to reach this vision have an understanding and have to reach an understanding about how we have to align ourselves. This is following on questions from my colleagues, but it's a very practical question: How do we talk to the labor movement, particularly in the public sector, to help them understand that we perhaps do

not have the correct alignment of assets and skills? We have phenomenal talent, but we are going to need to realign those institutions, the management structures, the organizational structures that will support a new mission. We have a structure that is the residue of an old vision, a vision that we nailed, but we have a new one to nail, some new frontiers to find, and we need an organizational structure and a management structure and a workforce organized to hit that mission in the right way. How do we talk about this, and accomplish this?

### **Michael Balzano**

Well, let me start off with the—the DoD is doing it right. I mean the DoD is very close to the issue, understands what’s going on, and is taking a leadership role in here, and is trying to talk to its own employees, and mind you, the whole idea of changing the mix of weapon systems and everything else, we went there a long time ago, and you were in the room, Pete, and we said, “Look, we’re here to support what you’re doing generically. We know some of us are going to wind up without a program. But we also know that that if we have a new vision, there’ll be a new program.” Okay? The biggest problem we’re going to have, and I’m not trying to denigrate NASA at all, but, you see, the problem is the President comes in, puts down a billion dollars, then says, “Okay, now, there’s 11 billion, you’re going to have to fight among yourselves.” Whoa! I’ve got a bird in the hand, I’m working on my own project over here. Now if you’re listening to the Congress, if the Congress comes, steps forward, and says, “Okay, look, you know, we want a new NASA, we want new programs, we’re here, and the word now is ‘transformation,’ okay?” NASA has got to convince its employees that there’s a place for them during the transformation, that there’s going to be a new place, and the only place you’re going to get that is you’re going to have to get congressional support, to “Look, we’re not going to run out on you.” Because if they think it’s a zero-sum game, and somebody’s going to win a program and somebody’s going to lose it, they’re federal employees, nobody’s going to get laid off anyway, they’ll be there forever, but the point is they won’t have a program. We need to work that problem real hard, and that’s NASA’s job. I mean, that’s something that NASA has to do internally to convince everybody. But they can’t do it without the Congress. They’re going to have to have the backing of a Congress that says, “Okay, look, we’re not running out on the funding, we’re going to be here with you.” What I said to you earlier was if Congress doesn’t come up with the money to support this program, you’re going to accelerate retrenchment. As I said to one cabinet officer last week, having been an administrator of a federal agency when the party lost the election, a year before that election, the bureaucrats sat down, start slow-rolling everything, “Let’s see where we’re going to come out here,” in four months they’re going to start building the reviewing stands for the inauguration. So people are going to wait, and that’ll hurt us more than anything. We’ve got to keep their focus on tomorrow, no matter who’s president, no matter who’s president we’ve got to focus on tomorrow.

### **Pete Aldridge**

Charlie, you have a—

## **Charlie Bofferding**

If you'll allow me, as I understood the question, it's "What do we tell the people?" And my answer is "You tell them the truth," and then you back up that you really mean it. I've been in a number of situations, transitioning people between jobs, companies changing programs, and my advice always is "People are smart; they understand the way the world works. Look them in the eye; tell them the truth. Tell them what your principles are," because I have this philosophy, it's PEA—principles, environment, action. I think your environment is always changing. So people need constants, you know, and what should be constant are your principles; your environment will change, so your actions will change, but every action you take responsive to your changing environment should be consistent with your principles. And the problem that the technological community is having is "Are we really committed to technology and pushing the envelope and blazing the trail? Yes or no?" And if we are, we will figure out a way to get there. But tell us what you really believe in, and then back it up with action.

## **Pete Aldridge**

Les?

## **Les Lyles**

Well, again, let me thank all three of you being here. This has been a very stimulating discussion. I think it's resonated with each one of the Commissioners. Let me go back just briefly, if I could, to heroes, and it sort of plays on a comment each one of you just mentioned. As I was listening to your testimony, listening to your responses to questions, I could not help but both smile and occasionally cry, because it resonates with the kind of things that you mentioned, Michael, that the Department of Defense is going through, both in terms of bringing a workforce together and transforming it, keeping the unions involved and making sure everybody understands their value, particularly garnering the interest, the stimulus of the engineers and scientific technical community. And as I think about it, one of the things that we did that I think probably resonated best through the entire technical community is showing them value. Our Secretary of the Air Force, as an example, pushed us to do something that we call re-recruiting engineers, taking the engineers that we already have, both military and civilians, and letting them know how valuable they were to the mission, to the United States Air Force. That little step—this is a very simple one when you think about—showing value to the engineering and technical workforce did more to stimulate their interest, their productivity, their desire for mentoring, both new people coming in and those who are currently in the workforce, and stimulating what I think is going to be sort of the future for the technical aspect of the United States Air Force. It's mentoring in some form or another. And, Charlie, you mentioned mentoring in one of your comments; I'd just like your thoughts—is there a role for mentoring and showing value to the technical workforce as part of this goal of stimulating science, and math and technology literally across the board?

## **Charlie Bofferding**

Absolutely. And I also think we're uniquely positioned to engage in new and exciting mentoring ways, particularly given the demographics of the workforce. And so, absolutely. And as you're saying, it's showing value, I'm right with you, and I think that goes the next step also to actually showing appreciation. We all like to be appreciated for the things we do, and I think that's at the core of it. Back to mentoring, frankly—again, we've got tremendous skills and abilities that are getting ready to go out the door, we need to capture that; mentoring is a wonderful way to do it. When you see the magic that happens between somebody who really knows their stuff and somebody who has a thirst to learn it, it's just a wonderful situation.

## **Les Lyles**

Let me just add, getting back to the word *heroes*: There's a folklore in the Air Force that the only heroes are the fighter pilots. And this step showed the technical workforce that they also are heroes, and it came from fighter pilots at the very top, as a matter of fact, to help stimulate that.

## **Michael Balzano**

Again, the point that I made earlier is that the industrial base does not only consist of machines, it consists of the skilled workforce, and they should be viewed as a part of that base. Without them nothing happens.

## **Pete Aldridge**

Unfortunately, we have run out of time, and this has been probably one of the more stimulating panels. Mike and Charlie and Jeff, we really appreciate your coming and sharing your thoughts with us. I know we have a lot of meat to chew on here, and we appreciate all your inputs. Thank you very much.

## **Pete Aldridge**

We have a second presentation this morning. And as Gary's walking up, we're pleased to welcome Gary Payton, who is the Deputy for Advanced Systems in the Missile Defense Agency, of the Department of Defense. Gary leads MDA's Advanced Concepts Process to evaluate new technical concepts for ballistic missile defense and also leads the technical evaluation of the small business innovation research proposals. He's going to talk to us today about lessons learned regarding in managing a system-of-systems approach, and clearly the President's vision with all its aspects of Moon and Mars and beyond, clearly is a system of systems that must be an integrated plan. And I think the approach that the Missile Defense Agency has had in addressing that type of problem would be of interest to the Commission. Gary retired from the Air Force as a colonel; he's also an astronaut—he flew in STS-51C in January 1985, I had the honor of pinning Gary's astronaut wings on him, so, Gary, welcome.

## **Gary Payton**

Thank you, sir. First of all let me apologize for my voice, I've been struggling with a chest cold all week. I'd like to talk today a little bit about some the implementation of grand visions and how at least the Missile Defense Agency has chosen to run, to manage a system of systems. I'd like to start with the mission of MDA. Next page, please.

Our mission is to defend the United States, our allies, deployed forces, and friendly nations against missiles of all ranges and defend our assets during all phases of flight of those missiles. That means while the ballistic missile is thrusting, we hold it at risk. While the warhead is coasting through space toward its intended target, we hold it at risk, and even attempt to kill it as it reenters the atmosphere. So it's a very—it's a global mission, and it's a very demanding mission. Next page, please.

Prior to defining this mission for Missile Defense Agency—can I have the next page, please?—the Pentagon, the Department of Defense, had several different ongoing and future programs that were somewhat disjointed—some of them funded by the Army, Navy and the Air Force, some of them funded by the Ballistic Missile Defense Organization. We needed to collect those elements into a single larger program with coordinated schedules, prioritized objectives, and, most importantly, proper funding for each of those projects. Next page, please.

Those projects included large radars, mobile X-band radars, a megawatt-class chemical laser inside a 747. The Patriot program which had performed both in Desert Shield, Desert Storm, and Iraqi Freedom, plus two different Navy missile intercept programs, and, of course, spacecraft from the Air Force. (Next page, please.)

While MDA was wrestling with the idea of how to manage this collection of elements, we looked at some historical precedents. Now, going all the way back to revolutionary programs like the Manhattan Project, the early ballistic missiles for both the Air Force and the Army and the Navy, and more recent programs like the C-17 and the Joint Strike Fighter, what we discovered was the vital role that systems engineering and system integration provides in managing a system of systems or, in our case, elements. Next page, please.

There are many functions in systems engineering. One of those is an architectural function. How do you really decide what you want each element to do? Our approach is to do thorough trades analyses between the sea-based capabilities, land-based capabilities, sensors, missiles. You need accurate engineering models of each element so that you can predict its performance. You need clearly accurate cost models, cost predictions of each program, and these are life-cycle costs and production costs. You need to apply uniform metrics across all these trades analysis. That is perhaps what a more disjointed program could not do, did not do. We needed to have uniform metrics met, measure the wealth, measure the work of each of these elements in the program. These analyses, architectural analyses, leads to budget decisions and program direction. Next page, please.

Another element, another function within systems engineering is configuration control, and this is, I use the term *ruthless*. Any single thing that changes the cost, schedule, or performance of

any of the subordinate programs has to be under configuration control. You have to maintain that rigorously, even to include not simply configuration in a physical perspective, but configuration of the contracts. Are the decisions being made relative to schedule and budget being implemented in the contracts? And, of course, reacting to budget realities or technical realities.

Again, it is an absolutely ruthless configuration control that we've implemented. We have at least once a month a Configuration Control Board for the performance of every element. At least once a month, the Configuration Control Board that controls the contracts on each element, and also end of month, a Configuration Control Board on a financial execution of the program and the budget, the future budget for the program. Clearly, interface control is crucial, both hardware and software. And this means what information gets passed from one element, from one program, to another, and communications protocols—the entire relationship amongst the elements, you have to maintain tight configuration control there. Next page.

The MDA has a very demanding mission. Again it's global, going all the way from short-range missiles like Scuds, of only 300 kilometers, all the way up to intercontinental missiles of 12,000 kilometers. Our job is again to hold those missiles at risk during each phase of their flight. It's a very daunting job; how do you go about doing that? Again, it's a daunting job that will take years and years and years and years, similar to the Moon/Mars effort. Our approach has been an incremental spiral development, where you deploy what you can early, learn from it, learn from that execution, do those trades analyses again, and then define the next step, define the next block.

You notice that these blocks are on two-year centers; I think that's intentional. The life cycle in the Congress is about two years; it's measured on two-year centers. But more importantly, I think it takes—when you have a rigorous test environment, a rigorous operational environment, it takes about two years to do that cycle of experimentation and testing, learning, and reengineering and then adding more capability block by block. (Next page, please.)

And again, spiral development is based on, again, realistic demonstrations. In our case it is not only math model simulations and wargames, and hardware-in-the-loop testing, we have a testbed that stretches from Vandenberg Air Force Base in California out to the Kwajalein missile atoll in Marshall Islands, and up to Alaska, at Kodiak launch site. And so we use that testbed, basically the entire Pacific Ocean, as a way to build tests, learn, and then, based on that learning, modify our objectives and modify our plans for each successive block, with more and more capability.

Now, based on my personal experience of both military and NASA—I spent 5 years at NASA headquarters—and based on my comparing that to what we're doing here in Missile Defense Agency, I honestly don't think NASA is currently constructed to pull this job off. NASA essentially, at least when I was there, which was before Sean O'Keefe, NASA was made up of 11 separate fiefdoms. Each center had its own objectives and its own prerogatives, very interested in protecting their historic projects, programs, and workforce. It even went to the extent that each center had their own full-time legislative liaison office that would occasionally, quite often, act without coordination with NASA headquarters' legislative liaison office. I think

in the commercial world that would be the equivalent of an operational division having routine and common interaction with the Board of Directors, without the CEO or CFO knowing about it, or doing anything with them. That perpetuates a set of 11 different little hierarchies, 11 different little institutions.

Another problem is workforce management, a bright, new, shiny young college graduate can enter a NASA Center, GS-9 or -10, something, and progress all the way to the Senior Executive Service, having stayed within that same center. In the military, whether you're an admiral or you're a general, which are the equivalent of Senior Executive Service, by the time you reach one-star rank, you've probably had 7 to 12 different moves in your career, probably 20 different jobs. And so each one of those moves gives that promoting individual a broader experience in what that Service can do. One of those jobs, and I believe it is at least for three years, has to be what is called a joint job, where that individual has to work shoulder to shoulder with peers of other Services. And so those are mandatory and traditional ways that somebody earns their way into a military general officer or admiral position. Again, at NASA you can start at the bottom of a center, and work your way all the way to the top and become the equivalent of a flag officer, and never having served in another center, never having served at headquarters, never having learned the breadth of what NASA can do, and should be doing.

So I think there's—again, those are only two examples of what perpetuates a problem that NASA has, has had, and it's one of the things I believe could severely limit NASA alone, pulling it off, the management of a system of systems. Again, relying on a strong systems engineering effort chaired at the leadership level, and running a program of this magnitude. Okay, that ends my prepared thoughts.

### **Pete Aldridge**

Well, you've thrown the hand grenade out on the floor. Gary, one of the things that, and you talked about the system engineering, and another one of the things we did when we were organizing the Missile Defense Agency, is we recognized not only the systems of systems, but the role of a system integrator. And that we decided at the time that the government could not be that system integrator, and we needed to pull together two very strong industrial teams to be system integrators, one for battle management and one for system integration. Do you see that as a model that's also applicable to the space exploration vision?

### **Gary Payton**

Clearly. Again, the systems engineering architectural work I talked about, and the battle management work, are functionally in the military systems. Functionally those are very closely aligned. We selected an approach where you establish a national team, is the term we used, and it's basically a consortium of participants from all the major aerospace contractors. And this national team attracts what we like to believe is the best and brightest out of that aerospace—each aerospace industry—and we have ways to encourage that attraction of the best and brightest because the award fee on the national team is much higher than on a typical cost-plus contract

from the military. And so that's an incentive for the industry folks to give their best and brightest to this national team effort. And we have one team that is, again, focused on battle management, command and control, and another team focused on the systems engineering. And to date there are growing pains when you start a consortium of that nature, and immense—a large number of—firewalls have to be set up for intellectual property and such, and so there's some bureaucracy at the startup of this. But we have attracted the best and the brightest, and we are reaching, again, the difficult decisions that we need—we're reaching the difficult decisions we need to make, because this national team has put aside their heritage as Boeing or Lockheed Martin or Raytheon or whoever, and they're working shoulder to shoulder with each other, and with the government folks so that the decisions that we make based on their trades analyses, and based on their work, is independent of what badge they came from.

### **Pete Aldridge**

Gary, one of the other issues of, and I know missile defense is quite interested in, is augmenting the technical talent that exists within the government, with a strong systems engineering talent that supports the government activities. Could you comment on how you approach that?

### **Gary Payton**

We have—we have, of course, within any large organization, we have a systems engineering shop that does this national team management. Conventional government organization, you have a government person in charge of a separate division within that shop. We didn't do it that way. We have again, based on the skills of the people, individuals, based on their heritage and their background, we have actually put members of the industry team in charge of what would in essence be a three-letter shop in that organization, within the Pentagon, and I think that's pretty unprecedented. And so, it is not—the national team is not really a “prime contractor” for our systems engineering office. It is—we are working, again, shoulder to shoulder, sharing ideas directly, sharing problems directly, and they are leading the pack, they're carrying the ball.

### **Pete Aldridge**

I think it's also interesting to point out that while the systems integrator role provides for the tradeoffs in the interfaces among the components, that entity cannot bid on the components of the hardware, they are prohibited from doing so, and there are agreements made by these contractors to permit that to happen, and so there is a protection for the government interest there that—

### **Gary Payton**

It's part of their firewalling I was talking about earlier.

## **Pete Aldridge**

Right. Les?

## **Les Lyles**

Gary, thank you for being here, and you figured that I'd have to ask a couple of questions, since I was the previous director of the organization there. First, let me acknowledge that Lieutenant General Ron Kadish, who succeeded me, your director, and you and the entire team have done a fantastic job of pulling together this very, very complicated mission of missile defense.

## **Gary Payton**

Thank you.

## **Les Lyles**

But one thing you did not mention that I think is a relevant part of the success of what it is that you're trying to achieve in MDA, but I'd like your thoughts and comments about it: When I ran the organization a few years ago, the hardest thing we had to do was to try to get support from all the different elements, all the stakeholders, that are involved in missile defense. As much as I tried, I still had a national missile defense program, but a separate sea-based, separate land-based terminal defense, and even a separate air element of activities. And part of the challenge of getting everybody to be focused in terms of one mission was the lack of top cover, if I can use that terminology.

Do you think that a major element of the success both of what you're doing, but also in terms of this vision for space, going back to Moon, Mars, and beyond, is going to require very, very strong top-down, vision, guidance, and continuous reinforcement? And when I say "top down," not just at your agency, but at the Secretary of Defense level, in your case the congressional level, and even the president. And you have that now in missile defense, which I did not have. I had two political camps that I was in the middle of at the time, so getting everybody together and working as a single mission was extremely difficult, if not impossible. But you seem to have that, you and Ron and Kadish have the luxury of having everybody from the President to the Congress to the Secretary of Defense all backing this vision and this mission. Do you think that's playing an element of success in trying to achieve this?

## **Gary Payton**

Clearly, hugely successful. Secretary Wolfowitz and Secretary Rumsfeld, this topic of missile defense gets to the President every year during the summertime, down in Texas. And the President is making decisions on the pace and the scope of the program, and Secretary Rumsfeld is obviously involved. I believe General Kadish has meetings at least once a week with Secretary Aldridge's successor, Mike Wynne. Several times a month he's seen Secretary Wolfowitz, and

that is, with that, if you have top cover, that has been a superb enabler for us to make progress. Additionally, that has helped us avoid much of the bureaucracy that the Pentagon lays on many acquisition programs. So it's a—we try not to make too many enemies while we enjoy this time in the spotlight. But the important part is that this is the structure that we put together when it became obvious that both congressional and executive branch leadership wanted a missile defense capability.

### **Les Lyles**

The obvious analogy of this particular case for this particular vision is this is not just a NASA vision, it's a national vision as we in the—the Commission like to think, and it's going to take very, very strong leadership, and continuous reinforcement from the top to keep everybody aligned.

### **Gary Payton**

Well, again, perhaps the government needs a Secretary of Science and Technology or some job like that in the cabinet level.

### **Pete Aldridge**

One of the other comments about the organizational structure was, again, the national vision. This is a high priority, the President's priority, and when we put together the management plan to make that happen, we made it somewhat unique in that it was a system of systems, and the management and the decision-making process would be very streamlined so that decisions could be made quickly, without any ambiguity whatsoever, and that we didn't waste time trying to go through the normal process, and then Secretary of Defense and the President agreed with that philosophy. It has something that we ought to think about if we are in fact going to do a national program of such as Moon to Mars and Beyond, we may want to think about unique management schemes to make sure we give it the maximum opportunity for success.

Paul?

### **Paul Spudis**

Yes. I was intrigued by your comment in regards to contrasting the career of a NASA scientist bureaucrat versus a military one. And given that this is a problem that's been long in making, because of the two different cultures, how would you go about changing it? How can you restructure NASA to fix this problem, not in 20 years, but on a shorter time scale?

### **Gary Payton**

Nobody gets promoted to SES-1 unless they've been in three different centers.

**Paul Spudis**

And then you sit back and wait for that to happen?

**Gary Payton**

Right. There would be a lot of people moving—

**Paul Spudis**

So in effect you don't see a near-term solution and that this is endemic to the way the NASA culture is, and it's going to take a long time to change it, and work it around?

**Gary Payton**

Yeah. Another—some people have said that when you have a revolution, the first thing you do is go build pine boxes. That's a little draconian to go in and fire the top leadership of each center or NASA headquarters. That's draconian; I don't think you want to do that. But I think a breadth of experience and while maintaining the depth of experience, I think the breadth of experience of people moving from GS-14/GS-15 to Senior Executive Service has got to broaden for NASA to really do this job, to be involved in this.

**Pete Aldridge**

Gary, back in 1990 there was a study called the Augustine Commission, which I so happened to serve on. One of the recommendations there was to change the whole concept of the centers to make it—in fact, to use the model that was more like the JPL model, where the centers would become more of a—at the federally funded research and development center type, I'm not sure that's the right answer, but something that would be more of the centers' taking on—having the ability to hire and fire like the industry, but operating under a quasi government-type operation. Does that also fit this model?

**Gary Payton**

Yes, sir. All of the Department of Energy labs are organized that way. JPL is truthfully one of the leaders in NASA when it comes to technology and innovation. And I would point, when you talk about workforce management, I like to point to Lincoln Laboratories up in Massachusetts. Every single year they get rid of 10% of their workforce. And so they've got fresh new people coming in every single year, all the time, and of course everybody performs, so they avoid being in that bottom 10%. And so there's several different ways to do it. I believe the government civil service rules can tolerate several different options here, but it's—we've clearly got to get rid of the insular mentality that pervades so many NASA centers.

**Pete Aldridge**

Bob?

**Robert Walker**

First of all, Gary, I think I'll go back and dust off the bill that I put in about 10 years ago into Congress to form a Department of Science. To use a shorthand, it sounds to me as though what you're saying is a systems-of-systems approach really needs to be both integrated and focused.

**Gary Payton**

Yes, sir.

**Robert Walker**

And the NASA that you've described is diffused and unfocused. Is that fair?

**Gary Payton**

Through most of its projects.

**Robert Walker**

So the question is, for this Commission, "How do we get to where we should be, a systems-of-systems approach, from where we are?" because it seems to me that one of the things that you had to do at the Pentagon was put together a new agency—that it turned out that you needed a Missile Defense Agency in order to carry out the objectives that Secretary Rumsfeld brought to it. So do you have any hints for us from your experience at NASA of where you've been, as to how we manage to get to where we need to be?

**Gary Payton**

The Defense Department has several of these what you might call single-purpose agencies: Defense Intelligence Agency, the National Security Agency, National Geospatial Agency, and Missile Defense Agency.

**Pete Aldridge**

And the National Reconnaissance Office.

**Gary Payton**

Yes, National Reconnaissance Office.

## **Neil Tyson**

Will DARPA fit in there as well?

## **Gary Payton**

Yes, sir. So there are four demanding problems, demanding objectives, that stretch across the entire Department of Defense. It's getting more and more common to establish the single agency to carry the ball for that. And in this case, if you're talking a project of this magnitude, you're stretching across Department of Energy, Department—maybe—Department of Defense, clearly NASA. There's many different agencies, so you would have to establish something that does this systems engineering and this system integration that I described, that does that, and then farms out or allows the other agencies to actually go out and execute the programs as defined in this systems engineering process I described. And that includes budget definition and the pace of the programs, and the content of the programs. And you've got to have, again, rigorous iron fists on all of those, and that's perhaps what we would best do for a Moon/Mars program, that has such broad answers, broad objectives, such enduring objectives.

## **Robert Walker**

Thank you.

## **Pete Aldridge**

Yes, Carly?

## **Carly Fiorina**

I want to spend a couple of minutes on the definition phase of all of this, because I think in your line of work and my in line of work, definition frequently is very important to mission success here, so could you talk a little bit about what you think is required in the definition phase? First of all, what does it entail, and you've just spoken a bit about that, but what does it entail, in your view, and how do you define an appropriate level of definition that then begins a successful spiral development program?

## **Gary Payton**

We divide our definitions into a couple of different—we define each of the blocks, the content of each block. And that's a lot of architectural analysis and technical—technology—assessments. What do we think is the risk of this technology being delivered by such and such a time, so we can start full-scale development of a real system? So there's technology assessments, technology maturity assessments, and the trades that I talked about earlier. There's also the program formulation job, which is—let's say that we want to have—the current newest version of a

Patriot, is something called Pac 3. Let's say we want to look at something called Pac 4, the next version of Patriot. That would be program formulation that says, "What are we yearning to do to for a next-generation endo-atmospheric interception?" Is it higher velocity, is it smaller weight, lower-cost missiles, whatever it is. Those yearnings come from in our scenario, what we call gaps analysis. We look at Block 04, we look at Block 06, we look at Block 08, and we define what is still yet to be done at the end of that block. That becomes our wish list, our yearnings, and so then we can formulate programs back, forward, or whatever it is. We can formulate new programs to satisfy that yearning. So the program formulation phase, the program formulation task, is based on gaps analysis that our systems engineer does, that says, "We still can't do this, this is a high priority, if you really want to do it, we're still void on some of our metrics." Again, our metrics are things like protected area, launch area denied, probability of a successful engagement; if we've still got a hole in one of those metrics, then we formulate a program to fill that hole.

### **Carly Fiorina**

So, in other words, success of the program requires you to establish a goal, understand what the gaps are between your current capabilities and achievement of that goal, and then program around filling the gap?

### **Gary Payton**

Yes.

### **Carly Fiorina**

Which is—I'll make a statement and then I'd like your comment—which is a fundamentally different approach than saying, "Here's where I am, now how do I take the next step based upon what I currently know how to do, what I currently am funded to do?" You're in essence defining a program by starting with the goal, and going back to where you currently are, and filling the gaps, as opposed to starting with a goal and then proceeding incrementally?

### **Gary Payton**

But we do acknowledge that we have to make incremental steps toward the ultimate goal.

### **Carly Fiorina**

Absolutely, but that's what your block approach does?

### **Gary Payton**

Yes, right.

## **Carly Fiorina**

Thank you.

## **Pete Aldridge**

Michael.

## **Michael Jackson**

Thank you, Gary, for this is tremendously interesting and vitally on target for our conversations. Two real questions: first, and looking at this historical approaches of the various different projects that you've laid out there, what best do you think would be the model for us to think through for the President's vision about Moon to Mars and beyond? That's one, and then the second one is, in your program how can you draw lessons from that to the space program for how you manage multiple spiral developments to draw in both certainly the larger contractors who you would think of as the integrators, but also to define the spirals in such a way as to stimulate, in the maximum degree possible, the nontraditional vendors in this area to get small business innovation, new formulations of corporate objectives, and therefore, you know, new businesses to basically to enter a sphere? So how do you balance those two things out in what you've done? What lessons can you draw for the NASA mission there?

## **Gary Payton**

Well, you're talking exactly about what I do hour-by-hour, day-by-day. And—

## **Michael Jackson**

Want a new job?

## **Gary Payton**

I'll take pride in one project that we started out. It is Lockheed Martin, but it's a commercial side of Lockheed Martin in Akron, Ohio. That's the group that builds the Goodyear blimps. We have embarked upon that part of Lockheed Martin in an effort to build a stratospheric airship, helium filled, that would fly at 65,000 feet for months and months and months and months. And again, it goes back to what vacancy, what void, what gap, can this new project do? And in our case, again we projected out to 2008 or so, and said this project would fill in the long-term on-station surveillance job for missile defense, and come to find out there's a whole bunch of other applications too, many of them commercial, if we're successful.

And so you need a workforce, you need a part of your organization that has carved out sort of the wild-eyed maniacs who are looking for the newest, again, whether it's conventional, the newest ideas, the entrepreneurial ideas, independent of whether it comes from a main airframe company

or some small shop. We're also—my part of the organization also runs the small business SBIR part of MDA, and we're looking constantly for, as a small business innovator moves from Phase 1 to Phase 2, historically it drops dead at Phase 3, because there's no money any more. But we're constantly screening those successful Phase 2's to bring them into our making teaming arrangements, encouraging teaming arrangements, between the big iron companies and these small innovators. We have a standing broad area announcement that's out on the street, we refresh it annually once a year. We have a standing broad area announcement out on the street asking for great ideas from anybody, and we get about on the average about one a day, and I fund those, the ones that pass peer review, I fund those, and, again, we flush out these great ideas and how can they apply to missile defense. So I—

### **Michael Jackson**

Okay. It's what kind of innovation you're baking into it, but it's also a question of what are the roles that the government does here in this project Moon to Mars, and what do you farm out to the private sector and how you balance it, that's the key part of how to manage this project.

### **Gary Payton**

Yeah. You have to have a very aggressive, forward-leaning—

### **Michael Jackson**

Culture.

### **Gary Payton**

You have to invite. You just can't sit back and wait for something to happen, you have to go out and invite these folks to come in. And they're from universities, they're from the incubators that surround the major universities, and we're getting, like I said, on the average of one a day.

### **Pete Aldridge**

Maria?

### **Maria Zuber**

Mr. Payton, thanks for your comments, which were very perceptive. I'm thinking more about the implementation of this program in the context of the comments that you made about the insularity of the NASA system, and you know, I think from my own experience on the robotics side of the program, which I think is a very successful part of the NASA program, that the insularity is not just one, in some cases, of attitudes, but it also extends to practices, okay? So you know, among the various centers, you know, if you're trying to implement a big program,

centers have different ways of doing things, and often they've been done based on many years of looking at what their best practices in the systems are, but in some cases things are done mainly because of tradition, and this goes to everything from parts screening to environmental testing, you know, to various other procedures. And I'm just interested if you could share some of your experiences of how you have dealt with these different cultural ways and procedural ways in the organization that you've done, and how that might apply to the different parts of NASA, and what other partners need to be brought in, in the future in sort of trying to take this mission forward? And so, you know, I think probably some standardization, you know, would be beneficial, but you also don't want to suppress innovation. And that's always an interesting tradeoff.

### **Gary Payton**

Gee, the Air Force works different than the Army. That's the same problem we have. They promote people differently, for different reasons. But, again, because missile defense is a top priority within the Pentagon right now, we are able to encourage within the Army, Navy, and the Air Force those individuals who do adopt our practices and who have been successful in running their programs. We do encourage the parent Services to give those folks promotions. And so it's, and additionally, we implement and impose certain milspecs, and federal standards, and such, through our Configuration Control Board process. We do implement consistent, across all the projects, all the elements, we do implement consistent, again, milspecs and federal standards. But I think when other folks who are working our projects, even outside of our projects, when they see a female colonel in the Air Force who's working the airborne laser program, very tough program, not 100% successful, is running into very difficult technology, and integration projects, getting megawatt-class chemical laser, and all the optics inside the 747, it's pretty tough. And even though we're behind schedule on that, we can—the Air Force promoted her to one-star general. On another Army program, we had another case of a really superb program manager who is a colonel, doing everything right, and satisfying our needs; he got promoted to general. And so by getting promotions and awards and notoriety, and recognition for your top performers who are changing an habitual way that the Army or the Air Force work, that is a crucial element in getting them to adapt. Secretary Aldridge talked about establishing the streamlined acquisition authorities for Missile Defense Agency. The first thing that happened was that we killed the Navy program. I mean it wasn't streamlined acquisition in order to get more money into the program, it was to kill an under-performing Navy program that didn't fit into as well—didn't fit in as well—into our larger systems engineering and block objectives.

### **Pete Aldridge**

Last question. Laurie?

**Laurie Leshin**

Yes, sir. I'll add my thanks. I appreciate your being here, I love systems engineering, it's—scientists love to think about big problems from all angles, so it's exciting. I have a—I wanted to resonate with the statement that you made when responding to Carly's question of needing to really articulate the goal that is out there clearly. And I want you to talk about it a little bit more, because one of the things I have a concern about is it seems to me that we need to be very clear about articulating the objectives of this mission, this vision. Because the program that you will build, the spiral development that you will do, that achieves exploration of new frontiers and creation of new knowledge at the Moon, Mars and beyond might look quite different from one where you said, "Well, our goal is to create a thriving space-based economy," or, "Our goal is to colonize the Moon." Those are different goals, and how important is it to have this clearly stated, articulated goal and really have it penetrate through the organization, so that everybody's day-to-day existence is about understanding that goal? And second, how much time, a practical question, do you spend in this formulation phase? How much time do you spend formulating a very forward-thinking future project? Or people are formulating all the time?

**Gary Payton**

I wasn't there at the time.

**Laurie Leshin**

OK.

**Gary Payton**

And you can talk to Secretary Aldridge about this, but I think almost the entire year of 2001 was spent, what I talked about earlier, all missiles and all phases of flight anywhere in the world. Does the Missile Defense Agency want to do that? If you do want to do that, how do we again boil that down into other sorts of metrics that you can then apply analytically, and that's where you get things like probability of a successful engagement, launch area denied, defended area, and so then you can parse those out, which one do I want to bite off first? Which one? All that takes at least a year—takes at least a year.

**Laurie Leshin**

And communicating this goal to the workforce or the—

**Gary Payton**

That's continuous, that's continuous. It takes a long time, because people have been doing—they've been in the Army and the Patriot program for 14 years.

## **Laurie Leshin**

So they know what it's about.

## **Gary Payton**

I kind of feel sorry about that, because they work on one program for 14 years, that's kind of a boring career. But you have to get to that person, whether it's industry or government, you have to get to that person and say, "Patriot is part of a larger system, it's crucial, and this is how Patriot helps, this is how you help," but again, it's part of a larger system. It's not simply Army air defense, and so it's a continuous job, it has to start at the top. General Kadish spends almost all his time talking about those topics.

## **Pete Aldridge**

Gary, thanks very much. This is again great input to the Commission, and you've given us a lot of thought about how to proceed with this slightly different, but equally important, exciting program. We appreciate you coming all the way to Washington, and hope your voice gets better.

## **Gary Payton**

Thank you very much.

## **Pete Aldridge**

Okay, thank you. We're going to take a 15-minute break. Thank you.

## **Pete Aldridge**

Let's get started again. Welcome back. Discoveries on and interest in the Red Planet have certainly increased lately, and "Safe on Mars" is the theme of our next panel of experts.

Frederick Hauck is the president and chief executive officer of AXA Space; before that, he served for 28 years as a combat pilot in the Navy and 11 years as a NASA astronaut. Rick flew three Space Shuttle missions, the last as the commander of *Discovery*. Rick, we're delighted to have you here.

Next on the panel is Harry McSween, professor of planetary geoscience at the University of Tennessee. Dr. McSween says unlike most geologists, he's drawn to rocks falling from the heavens rather than those already under foot, and he's especially interested in mapping the geology of the Martian surface from orbit.

Dr. Ronald Turner is the principal physicist for the ANSER Corporation and has over 20 years' experience in space systems analysis, orbital mechanics, remote sensing, and nuclear and particle

physics. He is participating scientist on the Mars Odyssey program and served on a National Research Council committee examining human operations on the surface of Mars.

I have the words “Gentlemen, start your rovers.” Some small, interesting thing here. OK. Rick, we’ll start with you.

### **Frederick Hauck**

Thank you. Several years ago, the NASA Mars Exploration Program Office established the Mars Exploration Program and Payload Analysis Group—the short title is MEPPAG—populated by more than 110 individuals from the Mars community with representatives from universities, research centers, industry, and NASA’s international partners. This group of researchers is chartered to propose the objectives, investigations, and measurements essential to the exploration of Mars. As you might imagine, the number of proposals is huge. In 2001 NASA commissioned this study from the National Research Council to critically examine these proposals as they relate to human exploration of the surface of Mars and to suggest which of them must be pursued prior to the first human mission. In other words, we were asked to be a filter—an independent filter—on the proposals. The principal objective of the study was to examine how robotic exploration missions could aid NASA in assessing the risks to astronauts posed by possible environmental, chemical, and biological agents on the surface of the planet. And I underscore that our focus was risks *on the surface* of the planet—not en route—but on the surface. The study was completed and presented to NASA in May 2002.

Our findings and recommendations were directed at the preparations for the very first human missions to Mars when the unknowns are the greatest and the steps taken must be the most cautious. As tasked, we addressed only those hazards that are unique to operations on the surface—as you might imagine, will be critical to determine whether it will be necessary to return Martian soil and/or airborne dust samples to Earth to evaluate and quantify these risks prior to the first human mission. Our report indicates which of those hazards will require either *in situ* assessment or the analysis of a sample returned to Earth. We’ve provided you with copies of our report, *Safe on Mars*, published by the National Academy Press, and a one-page summary of the report findings and recommendations. The full list of committee members is in Appendix B of the report.

You’ve already been introduced to professor McSween and Dr. Turner, who will address the highlights. Our study grouped the potential hazards as geologic, atmospheric, radiation-related, chemical, and biological in nature. I’ll start with some of the geologic hazards.

Robotic precursor missions will be used to map the three-dimensional terrain morphology of landing operation zones to assure safe landing in human and rover locomotion. The terrain must be fully characterized to ensure that the astronauts are provided with the most suitable equipment for their working environment. The greatest threats to the safe movement of humans and critical equipment on the surface of Mars will likely be degradation of mobility, instability that could result in the toppling of a human or a robot, collision of human and robot or robot with robot, and mechanical failures of critical components. Each of these hazards is associated with

interaction of the Martian regolith or outer layer of loose rock and soil. In the regolith's ability to support planned rovers and humans, it will be necessary to understand these hazards better to permit the design of appropriate systems and machines that will be used on the planet's surface.

First consider rock distribution in the shape of the landing area. Presentations to the committee—our committee—of the earliest conceptual designs of human-capable rovers presented designs using one-meter-diameter wheels. Vehicles using standard wheels can typically roll over objects one-third the diameter of the wheel being used. This suggests that if human transport and scientific rovers, if they will use one-meter wheels, the mission planners will need to know the distribution of rocks one-third of a meter and larger in the landing and operation zone. Imaging rocks this size require[s] a pixel resolution of 10 centimeters. The committee anticipates that the three-dimensional mapping would be conducted from Martian orbit.

Next consider regolith sinkage properties, including shear strength bulk, modulus yield strength, internal friction angle. The experiments required to determine these characteristics must by necessity be conducted on the surface of Mars. The rocks that would have to be analyzed are simply too large to return to Earth. And most rocks in the operation zone will be too small to view from orbit. Also, the bulk properties could only be measured in an undisturbed environment. We should note that the small rovers such as *Spirit* and *Opportunity*, and *Sojourner* before them, are eminently suited for their specific tasks of robotic exploration. The report cautions, however, that rovers meant to support human operations will be by necessity of a new class, with increased weight-bearing capability, mobility, and longevity—not simply scaled-up versions of *Spirit* and *Opportunity*.

Finally, NASA will need to have determined *in situ* the adhesive properties of Martian soil and airborne dust in order to evaluate the effect of dust adhesion on critical systems. Think of solar panels that have dust deposited upon them and are therefore degraded in their ability to generate electricity. NASA must fully characterize soil and airborne dust adhesion properties in order to design systems that minimize the risk of failure resulting from dust accumulation.

Turning to atmospheric conditions, the dry conditions and uncertainty about conductivity charging and discharging rates in the Mars environment pose concerns about electrostatic effects on human operations. The committee concluded that a risk to humans from electrostatic charging on the surface of Mars can be managed through standard design practice and operational procedures. And I'll highlight that one as one where we basically blessed scaling down or termination of some of the experiments that were planned. The strongest surface winds observed by *in situ* measurements on Mars are 30 to 50 meters per second, 67 to 110 miles per hour. Because of the low density of the Martian atmosphere, the wind must blow nine times harder on Mars to produce the same pressure on an object as it does here on Earth. Thus the pressures exerted by maximum-strength winds on Mars are not considered a barrier that cannot be overcome. However, the effects of abrasive materials being blown at the higher speeds must be one of the hardware design considerations.

I'll now turn to Professor McSween, who will discuss with you other geologic hazards and those that are chemical and biological in nature. Then Dr. Turner will present to you the committee's findings regarding radiation hazards.

### **Harry McSween**

Good morning. The truth is we don't know how dangerous is this red dot on your logo. And our report was an attempt to try to identify the minimum number of measurements that were required to assess whatever hazards there might be. In the planetary community, we are fond of saying that Mars is the most Earth-like of planets. But the truth is it's really different in a number of ways, and I'm going to give you a few examples that could pose a potential hazard.

I think the Apollo program demonstrated that it is inevitable that astronauts will track some dust and soil into their habitat. And if that material is respirable, then that's a potential hazard. We believe that NASA can design a good filtration system. The threshold that we proposed was one milligram of dust per cubic meter of air. And if NASA can design and implement such a system, it will get rid of a lot of the problems associated with airborne dust. If they can't, a sample will have to be returned to Earth to analyze for toxic metals. Even if they can reach this goal, there's one toxic metal left that is still a problem, and that's something called hexavalent chromium. It's a chromium ion in the plus-six state. You may know this particular material. It was the chemical villain in the movie *Erin Brockovich*, and this is the most carcinogenic substance known, or at least it is known to cause cancer in the lowest concentration of any material we've ever seen. And if Mars has hexavalent chromium—and there's some reasons to think that it might—the Mars rovers have analyzed something like a half a weight percent chromium in the Martian soil. We don't know how much of this would be hexavalent, but the Martian surface is very oxidized, and so there is a good chance that some significant part of that could be this particular oxidation state that is so hazardous. So what we recommended is that even if this filtration criteria, one milligram per cubic meter of air, can be met that NASA should measure the concentration of hexavalent chromium in Martian soil to a—and determine that it is present at less than a certain threshold. The threshold was 150 parts per million. And if you can't do that remotely, then you have to bring a sample back and do it in terrestrial laboratories.

There are some other ways that dust could be harmful at even lower concentrations than this threshold. The Martian soil has a lot of sulfur and chlorine in it; when combined with water in the atmosphere or with water vapor in human lungs, that could turn into acid. And we don't know what that would do as well, so another measurement that needs to be made is the acidity of Martian soil and dust.

Finally, there are organic compounds, and when I use the word *organic* I don't necessarily mean compounds that were made by living organisms—there are organic compounds that are just compounds of carbon and hydrogen and oxygen that are made without recourse to life. But some of those are very carcinogenic as well or hazardous in other ways. And we also determined that Martian soil and dust could—should be analyzed for organic compounds. But it turns out that organic compounds are also the right way that you screen for possible Martian life. And the

threshold there for detection is much smaller than is necessary for toxicity, and so that requires a different kind of approach. The approach that we suggested to look for Martian life and operate in—on a planet that might have carbon-based life forms that could be hazardous would be to adopt a concept of zones of minimal biologic risk. The definition of a zone of minimal biologic risk is it's an operational area on the Martian surface determined to the maximum extent practical to be devoid of life or to contain only life forms that are not hazardous to humans or to the Earth's biosphere.

Now, it's a little ironic that the very thing that makes Mars a very interesting place to explore may be the most dangerous thing to humans on the planet—and that is the possibility of some life form. So we think that maybe adopting these zones of minimal biologic risk might be a way to address that. The search for life forms should include the analysis for organic carbon, as I mentioned. The problem is that at the time we did this study—and I think it probably still is correct—that we do not know how little amount of organic carbon is necessary as an indicator for life forms. We just don't have good information about that. But it's certainly a lot less than the 150 parts per million that are necessary to screen against toxicity. So we recommended that NASA should set an operational limit by drawing on a broad range of relevant expert advice, and if organic carbon above this limit is detected, then a sample should be returned to Earth for characterization prior to sending humans to Mars.

So I guess the bottom line of my testimony is that we don't know how dangerous this place is, but there is the potential from both the chemical and a biological point of view—that could be significant risks and we need to find out sooner rather than later what those risks are so that we can mitigate them. The committee basically decided that a sample return was not absolutely necessary, and if you can make these measurements *in situ*—I will say, departing from the committee's recommendations and giving you my own now, though—is that I think the measurements that we suggested are going to be very difficult to make *in situ* robotically on the Martian surface and that sample returns will probably be required to do this. And now I'll pass to Ron, who will tell you about our findings in regards to radiation.

### **Ron Turner**

Thank you. Radiation exposure will be a significant and serious hazard during any human expedition to Mars. But NASA has under way a substantial ground-based program to characterize the radiation risk to astronauts and the uncertainties associated with that risk. While the radiation risks in space cannot be addressed without a better understanding of the biological responses to radiation—a major area—our study looked at a much narrower question. We looked specifically at what radiation measurements need to be taken on the Martian surface to contribute to the effort to ensure the safety of the first human mission to Mars. For a one-year or longer stay, about one-third to one-half of the total dose may be accumulated while on the Martian surface.

The radiation on Mars is complex. The steady galactic drizzle is made up to some degree of nearly every element in the periodic table. As these particles rain down, they have collisions with

gases in the Martian atmosphere, with the Martian surface, and with any shielding designed to protect the astronauts. And these collisions occasionally shatter the atoms involved, producing a shower of energetic new particles, including penetrating and hazardous secondary neutrons.

Now, how much the radiation changes depends on your location on Mars, the season, the presence or absence of a global dust storm, how active the sun is, and what type of shelter your astronaut is in. Now, I went through all of this, you know, not to impress you with how complex the issue is but to help explain why the radiation environment cannot be measured directly under all the conditions that the astronauts may experience. Therefore, NASA will and should rely on computer models to characterize the environment and to support options to minimize the risk that radiation poses.

NASA has a project under way to complete the development of most of those necessary models. The space radiation shielding project managed at Marshall Spaceflight Center has elements addressing radiation shielding materials, accelerator-based measurements, the actual models themselves, and even deep space testbeds. With continued development of these models, the scientists expect that transport codes will be able to simulate the Martian surface radiation environment. These codes are going to be essential to the design of space vehicles, surface vehicles, surface habitats, and other shelters. But those estimates that are produced by these models are going to be used to help establish the rules for day-to-day operations affecting, for example, how long the astronaut may spend walking around outside and how far from a shelter an astronaut may go in a lightly shielded or an open rover.

Because of the vital role that these radiation models will perform in the planning and design of a human mission to Mars, it's imperative that the models be validated through direct measurement of the radiation on the surface of Mars. Now, the committee acknowledged that a single experiment could lead to some ambiguity in the validation test if the experiment design is too simplistic. A carefully crafted experiment will require input from the radiation transport modelers, from the scientists that are familiar with the response of the radiation detectors, and also with scientists familiar with the Martian atmosphere and as well as the surface and sub-surface Martian geology. When you take this measurement it should be done at a location that's representative of the place you want to send your first humans to Mars. An extreme example is if you expect the first human mission to go to an equatorial region, you don't send your detector conveniently to a polar location. So you have to be careful on what missions you send it to. The depth and profile of the Martian atmosphere will have an impact on the radiation dose, so the measurements should be done at a Martian elevation that's similar to where you send this first crew.

With a simple experiment the depth and profile of the Martian atmosphere—oh, I'm sorry, I lost my place—the full impact of individual variable inputs on model performance will not be resolved with this single experiment. However, if appropriate measurements of the total dose and the dose contribution from neutrons agree substantially with the model predictions, then the engineers will have confidence in one of the tools that they need to plan a human mission to Mars. And finally the committee recommended that this test be made a priority in the Mars program and conducted as soon as reasonably possible. Should the results of the experiments

suggest that the radiation transport models are flawed, time will be needed to account for the differences between the models and the measurement. And if the difference between the model and the measurement is substantial, then further measurements at Mars might be needed. Thank you.

**Pete Aldridge**

Thank you very much. A couple of quick questions. On the *Opportunity* and *Spirit* rovers, are there radiation measurements being taken off of those vehicles?

**Ron Turner**

There aren't direct measurements—no direct measurements of the radiation environment have been made on the surface of Mars.

**Pete Aldridge**

Okay. Now you made some recommendations to—for NASA to start that process. Do you sense that progress is being made along those lines?

**Ron Turner**

Well, I'm a participating scientist on one radiation instrument that's in orbit around Mars on the *Odyssey* spacecraft. Originally that was going to be coupled to an instrument that was going to be on the lander in 2001, but that 2001 lander did not—didn't go. That instrument hasn't been manifest on a successive lander. But, yes, there's certainly the community understands that there's a need to put a radiation monitor on the surface. It's just not manifest yet.

**Pete Aldridge**

Okay. You've talked about the—kind of the environment. I guess from that results in a set of requirements that come back to the habitat, to the EVA suits, and all the other things that have to be provided for the astronauts. But you've got to understand first the environment that which you then protect against. Okay, thank you. All right. Any questions? Yeah, Neil?

**Neil Tyson**

Yeah, Dr. McSween, I'm curious you gave your list of bad things that can happen, things we should look out for. Are you—does that include—now I read the title "Safe on Mars"; is there any concern given to Mars being kept safe from us in our search for life on Mars—the level of contamination we and our hardware represent in the very environment where we're trying to determine what life might be there today or before?

### **Harry McSween**

Certainly that wasn't part of the charge for our—this committee's report, but NASA has a planetary protection officer whose job is not only to protect the sanctity of the Earth but to protect other places in terms of contamination—particularly biologic contamination. And the focus here, I think, is in not contaminating a landing site with life if you're going to look for life, because you will basically hamper your own experiment. But it is something that NASA is focused on, and they spend a great deal of effort and money in minimizing the critters that ride along on spacecraft that go to Mars and elsewhere.

### **Pete Aldridge**

Yeah, let me point out that we've been told as we speak and ask questions, try to get the microphone a little bit closer to you because some in the back and recording is becoming—coming through somewhat weak—so to just point that out to you.

### **Laurie Leshin**

Okay. Thank you thanks to you all for being here. I think this was a really valuable effort. One of the reasons I think it's valuable is that it really points out the importance of the coupling of the robotic and the human exploration—that you need those robotic trailblazers not just to demonstrate technologies, and we haven't even talked about all of the precursor technology demonstrations that we could do on Mars to help us enable humans to get there, but just in terms of scientific measurements, if you will, for enabling humans to go, and I am curious about a couple of things. And you sort of said it, but I wanted to come back to this issue of the report was basically agnostic about *in situ* versus sample return measurements of the surface materials to really assess accurately the possible threats. You've now been not working on MER for the last—you know, however many Martian days it is.

### **Harry McSween**

Three months.

### **Laurie Leshin**

Three months and have seen firsthand sort of the cutting edge, if you will, of our measurement capability on the surface of Mars. Does that reinforce your view, and I'm not asking you to say anything bad about MER here, but just in terms of, you know, if we're going to be putting human lives there on the surface of Mars, is this something that seems pretty imperative to you? Would we have sent people to the Moon today if we didn't have return samples, for example?

**Harry McSween**

I think the MER mission demonstrates that 50 scientists and engineers on each rover can make that rover do amazing things when they're working every day. But what we're talking about in a Mars exploration program where you're going to put humans there is probably one astronaut directing a robot in real time, and we don't have a clue as to how to do that yet. I think one of the challenges here is not only for the technology—robotic technology to advance, but we need to learn how to interface with robots on a more personal scale than we do now. To more directly address your question, Laurie, about the capabilities that MER rovers have versus the ability to make these very difficult measurements—the instruments—we're not so much talking about robots or rovers, as you know, but its instruments, analytical instruments, and it's very difficult to make instruments that can measure really minute quantities of exotic chemicals or even molecules even at the molecular level and have them withstand the rigors of launch and landing on Mars if you can call what the MER rovers did landing. So I still think it's going to be difficult. I do expect marvelous improvements in instrumentation. But we can't wait too long. We need to know what the problems are if we're going to mitigate them. And I think waiting 10 or 12 years for technology to be able to do this may be a little too long.

**Laurie Leshin**

And just to follow up on that, but the measurements—if you were to have the stuff here on Earth, these measurements are not difficult? Right?

**Harry McSween**

That's correct.

**Laurie Leshin**

They're very straightforward.

**Harry McSween**

That's correct.

**Laurie Leshin**

Just to get that.

**Frederick Hauck**

Could I point out, Mr. Chairman, that at the bottom of my testimony, which I think you all have been given a copy, is backup material, which summarizes what has to be done on Mars to avoid

needing return samples. And there are five bullets there and you have to be able to do x, y, z, a, b. Otherwise you've got to bring the return sample back.

### **Pete Aldridge**

OK. Maria?

### **Maria Zuber**

Okay, a comment and a couple of questions: First of all, in addition to the planetary protection work that Happy mentioned is going on in Mars now, the National Academy has set up a committee that's currently looking at the contamination of Mars—or the limits that should be set for contamination of Mars, and that study's going on right now. Let's see, my first question is for Hap, and you defined something called the zone of minimum biological risk that you would want to try to identify, you know, ideally before you send humans there. But to me it—how are you going to do that, because, you know, I personally believe that if there is life on Mars, it's going to be awfully, awfully hard for a robot to detect, okay? And that it may actually take a human to go and to be able to collect the proper samples in the proper context to be able to look at that, so it just seems like what you're saying is, in a way, circular.

### **Harry McSween**

It's almost a contradiction in terms, and we agonized over this. And you have to realize this zone of minimal biologic risk may apply to the subsurface, too. So you might establish this zone on the surface, but if you haven't analyzed underground and determined it to be safe, then the operational rule would be that you can't dig. And so I suspect that what—if NASA adopts this procedure, the way that they would do it is a sample return from the site where you're going to land, but multiple samples, including samples in the subsurface—samples from everywhere around the site that astronauts are likely to go, looking for bad things. And if none of them pop up, then you're safe. And what this gives you is a place to operate from. That doesn't mean that you cannot then leave the zone that has been established and go to a more dangerous place, but you would probably do that with your robots rather than with the astronauts. And so you can gradually expand this zone by sending out your robots and making further measurements and proving that wherever you go it's safe. That's the concept.

### **Maria Zuber**

Well, it's actually a great example of how humans and robots could work together in space.

### **Harry McSween**

It is.

## **Maria Zuber**

My other question is, I guess, for Dr. Turner, and I would think that the observations that were made by the MARIE instrument on Mars *Odyssey* in terms of the radiation flux at Mars would be quite relevant to try and understand what the problem is—that the—how would that—the radiation would be extrapolated to the surface? Can you comment on that a little bit?

## **Ron Turner**

Certainly. I agree that what we're measuring now is relevant to establishing the radiation environment that we have to deal with. In fact, I also believe that we can take those measurements that are being made in the neighborhood of Mars, which are not dramatically different from the measurements that we would make if we were taking those same measurements in the neighborhood of Earth outside of our magnetic field, and use the proper models to propagate that environment down to the Martian surface to make estimates of what that radiation environment is on the Martian surface. So I believe that we will be able to successfully estimate that environment. The conclusion of the committee is that our belief is not enough—that what is necessary is a hard-and-fast measurement of the Martian surface that validates those computer models. And so it's not a very complicated experiment. It's got to be complex enough to know that you've got the right answer and you didn't get lucky.

## **Maria Zuber**

But you don't need just radiation measurements. You also need measurement of the atmospheric profile coming in so it can propagate those models.

## **Ron Turner**

That's exactly right. In fact, that's why I said in designing this experiment you need people that understand the Martian environment. You also need people that understand the detector response to the radiation that you're looking at. But it still need not be a terribly complicated instrument.

## **Pete Aldridge**

Bob?

## **Robert Walker**

I just wanted to deal with a couple of things that relate to the President's vision. And the first thing is, how important in your mind is it that we go to the Moon to test things like the filtration systems, the closed-loop environmental systems, the radiation mitigation systems—some of those kinds of things if we're going to advance on to Mars. And then, secondly, knowing what you now know—which obviously you would like to build a knowledge base much bigger—but

knowing what you now know, how risky a mission is this for humans? Significant? Medium? Low?

**Ron Turner**

Let me—let me jump in, first of all, on the first question about how the Moon can contribute to meeting the objectives that we laid out on the *Safe on Mars* study. And obviously anything dealing with the Moon is outside the bounds of what we addressed as a panel.

**Robert Walker**

True.

**Ron Turner**

But certainly in the radiation area, a radiation detector that's designed to go to Mars and measure the surface radiation environment at Mars could easily be sent first to the surface of the Moon. And the radiation environment on the surface of the Moon should be simpler to—for the modelers to predict. There's no atmosphere to transfer through. But it's complex enough that it'll be a good test because you still have the surface and the subsurface and the creation of the neutrons on the surface and your detector responses. So a lunar testbed of the instrument that you're going to send to Mars would be, you know, an outstanding experiment as a precursor to sending the instrument on to Mars.

Now, you know, as to me personally, how risky do I feel this mission is going to be? I spend most of my time, you know, talking to the scientists that look at the biological risk of radiation. I am not a radiation biologist. So I can't comment on the biology. Would I sign up to be on that first flight to Mars? In a heartbeat. Do I feel like I'm taking a huge risk? No. I think what it means is when I come back, assuming all the systems engineers have done their job and the components of this thing worked right, then I'm going to have to face the probability that I may have a higher than the population average risk of coming down with cancer. Maybe the NIH will help me out on that side. But I would sign up.

**Harry McSween**

I wonder if we were going to the Moon with humans for the first time, if we wouldn't be a whole lot more careful today than we were during the Apollo missions. So it may seem like we're being overly careful in suggesting these things. I personally think that there is at least medium risk to a Mars mission, but the risk probably is more from the problems in dealing with microgravity and radiation than it will be from the Martian environment.

**Pete Aldridge**

Laurie?

### **Laurie Leshin**

I just wanted to point out that this report was written before the President's vision was announced, so it was actually written from the context of "Okay, we have an existing Mars exploration program that is, you know, robotic science-based program that really doesn't have the ultimate goal of sending humans anywhere articulated officially and in fact perhaps even discouraged politically at some points." And so it was the strategy for exploring Mars—sort of would say, "Stick in a human precursor experiment when and if it made sense." Well, now we have a vision that is focused and articulated and exciting. And we also have a Mars exploration program. And I'm wondering if you can comment on how you view the measurements that have been laid out by your reports so nicely, how they will dovetail with the existing program, or is it going to require to you think some tough choices about the emphasis for future robotic missions?

### **Harry McSween**

There is a program that NASA has now called the Mars Scout Program that is—consists of modest-cost missions with highly focused objectives, and an expanded Mars Scout Program could certainly address a lot of these measurements. I don't think that this would require complete retooling of what NASA has in mind for Mars exploration, and I don't see that it would destroy the science program either. I think many of these measurements could be piggybacked on science missions, and science could be piggybacked perhaps on some of these technological demonstration missions and measurements that were called for in this report.

### **Laurie Leshin**

And inasmuch as where you do send things like landers, for example, and that's one of the places that I see a potential conflict of your—of the criteria you use for the places that you're going to send humans might be different than where you would want to go if it was just purely about robotic science and exploration.

### **Ron Turner**

May I comment just briefly?

### **Laurie Leshin**

Yes, absolutely.

### **Ron Turner**

I've seen the challenge that it has been. I mean—for one thing, I'm the beneficiary being a participating scientist on the MARIE instrument of including human requirements on the science missions. On the other hand, I've also seen the challenge that it is to get the kinds of instruments

that are needed to meet our criteria included on a instrument where the real estate is defined by the science community and when there's room left over they put an instrument on to meet the kinds of requirements that we are interested in. I have heard that there's talk at NASA headquarters of having a modified version of the Scout program (that I highly endorse) where every other opportunity there's a mission that's—where the—where it's flipped. The research announcement goes out for instruments to meet the questions that we've included in our *Safe on Mars* report, those are—that's what the primary real estate is assigned to, and then when there's room left over, let's see what kind of science we can do on top of that. Now, I think a every-other Mars opportunity, a Scout-type mission. I think that would be an adequate way to approach this.

### **Laurie Leshin**

OK. Thank you.

### **Pete Aldridge**

Before we end this session, one of the things that you—you've identified a lot of activities and measurements. Are there any enabling technologies that would be required before we are able to do what you've asked us—the program to do? I mean, are there sensors that have to be developed or maybe even algorithms which may be even more important than this (the sensors) anything that we're going to have to put a technology program in place to make sure we have the capability to do what you've expressed?

### **Harry McSween**

Certainly with analytical instruments there are technologies that need refinement or development, but I think NASA has in place programs to develop flight instruments perhaps of the kind that were called out here. It might take a little more emphasis in terms of funding, but I think those programs exist. But there are technologies that probably do need a program. For example, if there is life on Mars—I'm kind of a skeptic—but if there's life on Mars it's probably in the subsurface, perhaps in the deep subsurface, where it can get at water or ice and we don't presently have the ability to drill into the surface very deeply. You can go down, you know, maybe a meter or so. You can spin your wheels if you have a rover, but things like that, that require a lot of energy, we may need help with. And speaking of energy, a potentially huge problem for a human exploration program on Mars is how do you fund the energy sources that these humans will need. And I don't see any way around some kind of a nuclear program, which is tricky politically and is something that NASA is addressing now but not in the context of a Mars exploration program. It's in the—it's the *beyond* part of your charge.

### **Pete Aldridge**

Okay. Well, again we've run out of time once more. I'd like to thank the panel for coming. Rick, Harry, and Ron, we appreciate your testimony, and we look forward to trying to decide what does this Commission say about it. So we'll be working on that the next few months. Thank you very much.

### **Pete Aldridge**

Our fourth and final presentation we're looking forward to—on July the 16th, 1969, Apollo 11 astronauts Buzz Aldrin and Neil Armstrong landed their lunar module on the Sea of Tranquility. And since his retirement from NASA, the Air Force, and his position as commander of the test pilot school, Buzz Aldrin has remained at the forefront of efforts to ensure a leading role for America in manned space exploration. Buzz, we're delighted to have you here and look forward to your presentation. You always have exciting things to say, and I'm sure you'll say the same thing today.

### **Buzz Aldrin**

Thank you very much, Mr. Chairman. It's always a great pleasure to share my thinking and the experience that was garnered by thousands and thousands of people supporting what we were very privileged to do. Several members of the Commission are on my list of favorite people to talk to over a period of time. You have two former commissioners on future U.S. aerospace industry and I noticed that you can't keep them apart. You got to keep them together.

### **Pete Aldridge**

It's alphabetical, I think, or something like that.

### **Buzz Aldrin**

I have some just sort of preliminary remarks, and then I hope that I can get through some slides quickly and you can refer to them, and then there are some maybe major quick little observations that I'd like to just kind of throw out just to stimulate thinking because I think most may come from questions and—it's going to be hard to get all of this done before lunch—we're starting a little late. I come from an aviation pioneering family, and I grew up looking at the big picture, sort of, of World War II. And to get into aviation, like my father I went to West Point because there wasn't an air academy. From there I got into the Air Force for the last part of the Korean War. Met some great people in that process.

And I think I began to see my desire to want to look at the big picture instead of just staying in a flight and working my way up there, I wanted to get into squadron ops and group operations to look at the big picture. I came back from that and—it's about 50 years ago—I need to make that observation—that I was instructing in gunnery, getting ready to go to the Air Force Academy

and help as aide to the dean of faculty—it getting under way. From there I had a very choice assignment of flying supersonic F-100s in Germany, and I reunited with my buddy from West Point, Ed White. He had been there for a while. He rotated back. We both felt that augmenting our careers was the next step. He went to Michigan to test pilot school, and I went to MIT, 'cause that's where my father had gone.

I had the good fortune and wisdom—I can't believe it, really—in '60 and '61 to decide I'd write my thesis on space rendezvous—before John Glenn flew. That has stood me in great stead ever since. It opened a lot of doors and gives me a sense for not only orbital mechanics as docked or rendezvous in an Earth orbit but for what we could do in the strategy of transportation beyond the Moon.

I might say one of my big idols is—great idols—is John Hubolt, who with his determination, perseverance, had a concept that he felt was a better strategy for doing transportation, lunar orbit rendezvous, and he prevailed over the wisdom of Wernher von Braun, who brought us a great rocket, and the science adviser to the president. And I think we need that kind of looking at insight and variations. And all this background led me to look at better ways of doing things, like how to get back to the Moon and how to get to Mars. And I've participated actively or as a very interested observer in the many commissions that have taken place, especially my very close association with Tom Paine, who was the last administrator at NASA and his National Commission on Space that really looked ahead 50, 100 years, and that's what your group really has to do. In the process of looking at this grand vision of transportation, I concluded that it isn't going to happen unless we have a better way of getting into space.

And coincidentally I ran into an engineer who was in Korea when I was, we have great things in common. He washed out of pilot training, but he was an outstanding maintenance officer, and we have a lot in common, like the use of drop tanks and separate propulsion modules for boosters, so that's why I'm a part of Starcraft Boosters. And General Lyles knows and other people know that we have unique properties trying to make use of things that work and try to make them more reliable. We may be 10, 15 years ahead of our time, as far as fly-back boosters for NASA heavy lift, with the emphasis on moving ahead with whatever there is, and of course also the Air Force needs for strike mission launch with high reliability and high flight rate. So we think those things are going to happen, but in the meantime we have some engineering talent—this engineer I mentioned was the project manager on LEM 5 [lunar excursion module 5] that Neil and I landed on the lunar surface and he pioneered a good bit of the early evolution of the Space Shuttle designs. I participated in some of those and took note of why we went this way and that way for missions, the support of Air Force that never really materialized with the Space Shuttle.

So with that background, more recently we looked at crew safety—ejectable pods from a fleet of four orbiters (this is before the *Challenger* accident, we did a little study on that, based on the experience that we had) and I think we bring to this phase of implementing the long-range mission that Admiral Steidle is going to be doing, I had a wonderful conversation with him just the other day in Washington, and I hope our team can contribute to that.

We did last summer object to the fact that NASA was going to take the three contractors and keep them the same and accelerate the Crew Return Vehicle from 2010 to '08; we felt that they were bundling requirements and they were excluding people other than the long-term growing, I think, short-term interests of big companies; we need to open up and get outside interests. So we didn't make to many friends by objecting to that with NASA; we shifted some emphasis when it became clear that the OSP (Orbital Spaceplane) was not pleasing a lot of people.

We heard of the interagency deliberations last summer that might culminate in something but we felt we had a team that could make a proposal on the Space Vision Institute. So we put this proposal into NASA on the first of December, and it involved 12 senior people who would meet four times a year, but it didn't have a 120-day limit on it, this was going to go on for a long time. It was a good idea, but fortunately the courage of our administration in coming up with a relatively specific vision for the future as Moon to Mars and Beyond is, in the contentious period of an election year, I give great credit to what was very much needed. Before *Columbia* and after *Columbia*, our commission concluded (this is the Commission for the Future of the U.S. Aerospace Industry) space needs an imperative. And I put together a conference right after Kitty Hawk to look at the next century of flight space imperatives. Look at the past. Lessons learned. Look at where we want to go. What are the pathways and then how can we stimulate the success of these pathways? It could have done better, but I think it did quite well, and it came out right after the President's, where I was at Kitty Hawk.

We now have a vision, and I commend the selection of this august group to look at a very difficult thing, and that is how we are going to implement this, and I have shared some thoughts with Dr. Tyson earlier this week in New York after the Explorers Club about what I think is one of the most crucial challenges you have, and that's how we're going to sustain this under projected budgets that will be politically acceptable and then how we can avoid the political criticisms that are bound to come as we shift in the nation and try to maintain a continuity.

Let me now expose you quickly to some of the things that I've put down in some charts.

If we could proceed on to the next one. We have a brand-new challenge, really, and it's unlike Apollo in many ways, mainly because it requires a sustained—I see you don't have a copy of this, or maybe—

### **Unidentified speaker**

It's not in color.

### **Buzz Aldrin**

Well, then it's not exactly as fine tuned as the great audiovisual people here have helped me at the last minute to put together something. But unlike Apollo, Skylab, and the Shuttle and ISS, we have great advanced technology, and we can learn from the benefits of that, but we're constrained greatly by budget realities, and we need to do something international as we can figure out what's the best way to integrate that into what we're doing.

What we do has to be—next slide, please—has to be reliable, safe and economical, and I would like to note again the observation that was made yesterday by, I think, Peter Diamandis, a very vibrant young MIT, where he said it's great to write a book about and observe the past about "Failure is not an option."

But we're probably not going to get to Mars if that becomes our sole guide light. We've got to accept risk, and if anything in this world that hates to see one or two body bags. We've got to learn to put things in risk and progress into an appropriate perspective. We need to have a plan that goes 30, 40 years or so into the future, and I think we need to emphasize "What can we really learn from what did happen in the past?" Next slide.

When we looked at heavy lift, because I think that's—next slide, please—even though our group felt that a crew module ought to be flexible and launched on something that has had a long history, so even before this initiative came along, when we were dealing with Orbital Spaceplane, we felt firmly that the crew module should be on a heavy-lift vehicle because it afforded much greater flexibility. When we looked at heavy lift, just compare the assembly of the ISS, over a period of time in terms of missions, people, dedicated workload to assemble things, and the international cooperation with Skylab that took one launch on a heavy-lift vehicle, and we didn't even use the combination of a dry workshop, wet workshop that are connected together maybe at launch. So if we want big volume up there, we can do that quite well. Or if we're sending a propulsion tank and a habitat somewhere, that tank when it gets there is empty; we can bring it back and refuel it or we can use it as it is. And we need to integrate all these factors. Next slide, please.

These are just some of the things that we feel heavy lift will benefit to us: reduce the number of delivery flights, reduce the complexity of Earth orbit rendezvous of several launches before we go on to then perhaps join up with the lander, or land the Crew Exploration Vehicle directly on the surface. I think those are some major decisions that are going to be looked at in the very near future. I'm not ruling out the very strong need short-term for the use of EELVs to support the Space Station to become an alternate access for human space occupancy, but I think the primary access should be the most versatile vehicle, a vehicle that we've put a lot of attention in, and the one that we can team up with the cargo missions that we're going to need. We can certainly launch a crew module without the manned necessary requirements for abort on the pad, we can launch a crew module up to rescue people and assure greater safety by the number of launch vehicles we can apply to this, but I really think we need to simplify things. Next slide, please.

I think we're already there. Retiring a Saturn V: You know, people say, "Gee, if we only had the plans for those F1 engines, we would probably use them, but not the way they were. We would redevelop them." It was with a little bit of disappointment that I read that a new kerosene engine that the U.S. has not developed has been set back or put on hold or canceled—the RS-84, I think it is—because at some point in the next 20-30 years I really think we're going to need all the U.S. engines we can develop. Right now, as you know, one of our major EELVs has a Russian engine and its derivatives. When we retire the STS system, as the accident board mentioned, do we retire the whole thing and just send it away, or is it the orbiter that is really the thing that needs to be retired because it's aging? The solid rockets are almost new every time, the tank is

new every time, and all of these parts can be upgraded. We have a solution to that, and the next slide gives you an indication of how we can take, in the upper left-hand corner, the STS system and underneath that the two EELVs, take the engines from the one on the left, three engines from the Delta IV, and put them underneath the tank, off to the right, three engines so that we can thrust at two-thirds thrust and have engine-out capability all the way to ET set and we can use a second-stage payload-fairing RL-10 rocket that's from another EELV and side-mount that. Our first approach was to side-mount that on a tank, because that's the way the orbiter is, that's the way the infrastructure is. But if we're eventually going to go considerably beyond that, then maybe instead of taking that intermediate step, we'll go right to inline launch.

But if we look at the capabilities in the lower right-hand corner of this pod that can be on there, it can be in our calculations to the International Space Station, eight people plus 60,000 pounds of cargo or 115,000 pounds of cargo, and the bottom one there is the one that really turns me on: by lengthening the tanks just a little bit in that upper stage, we can put more fuel in and put six people in the same crew module we looked at to L1, the vicinity of the Moon.

One launch, we can have the crew there to rendezvous with the lander that will have been put there. That's a mission mode. The next slide shows variations—next slide, please—shows some other potential evolutionary variations of this, making use of drop tanks that are derivatives of the tankage of the Delta IV. We can put the engines on there and have a stage, but there are other combinations that can combine what it is we've developed, until we can really afford to learn what is it really new that we need to go ahead and develop. Next slide.

And you can see some of the words here that talk about how we could go to what we call Aquila or the Flying Eagle. This is before constellation came out as a buzz word. I really think we were on the right track with Mercury, Gemini, Gemini, and Apollo, but then we didn't make use of the wonderful word for that winged workhorse of the future, the Shuttle, the STS. Pegasus would have been an outstanding name for that. International Space Station doesn't have a really inspiring name to it either, but I think it's time to maybe get back and consider what it is we're trying to market this program, who we're trying to market it to, and what will be lasting.

The next slide shows the evolution of introducing the choice of not only going from four- to five-segment solid rockets. I think that would probably be inadvisable, but that's a tradeoff for this to be looked at. At some point we can have liquid expendable and the n liquid reusable boosters in here as we project out 30-40 years with a launch system that grows, that makes use of the vertical assembly building and all the infrastructure that's built up. I would surely think that before too long we should make use of not only pads 39A and B as we did in Apollo and Shuttle, but we should activate 39C for the variations of what we're doing.

Now we learned some lessons—next slide—I think in the Crew Exploration Vehicle. To me, somehow, just because Apollo was so wonderful with its symmetrical capsule and ejection tower and we went so far in the other direction with a big fuselage, big cargo, and wings to land on a runway to go back to just a ballistic entry, I think we're missing the boat of a compromise in between, and I'd call to your attention the Russian Kliper, the follow-on to Soyuz, which is a biconic lifting body. We've studied that. But just because we've studied it in the past, 5-10 years

ago and we didn't implement it then, it doesn't mean we shouldn't consider it now and look at the variations between blunt bodies—next slide—and the various ones that we can look at that are lifting bodies.

If we go to the next slide, this is an example of what we have looked at. It's really based on the BOR-4 Russian demonstration lifting body that went into the Pacific Ocean that the Australians photographed and then we sort of re-engineered. Langley Center did a lot of work on this—wind tunnel tests—and the feature that we found in this that I like is just like Burt Rutan, you can have variable geometry between reentry in the high Gs and then what you do when you're subsonic. What he does, has the tail sticking back here in the wind but he deploys it back down again to make a landing. Well, variable geometry is a parachute or a parafoil that's deployed, but maybe there are other ways that we can look at, and if the fins can fold up and down for putting it inside the cargo bay of the Shuttle, so could larger fins or wings deploy. Obviously the weight penalty would probably not advise using that for a lunar return, but I'm looking at the evolution of crew modules just the way the evolution of airframes have progressed in the aircraft industry.

The next slide is just an example of the different applications that we feel of the propulsion module, the cargo, and the crew module. Let me try and make a point here. I do not believe in the myth of saying because a Shuttle was crew and cargo that we absolutely should not put crew and cargo together again. The accident board in my estimation in talking to people didn't really say that. They implied that crew and cargo in the same reentry vehicle that you're bringing back makes that reentry vehicle way too big and safety and abort conditions on the pad are not so good.

But if you have crew cargo propulsion that you can trade off the amount of each one, you have great flexibility, and if your departure point is the same for crew and cargo and your destination is the same, why not a secondary payload? These are going to be tradeoffs, but I don't think just because—my son works for Boeing—just because Boeing and Lockheed need payloads for EELVs and the Air Force wants payloads for them and Marshall Spaceflight Center baselined OSP to have EELVs that we automatically put the crew up on one launch vehicle and cargo on another. Obviously I feel pretty strong about that.

The next slide just shows what our experience level in Starcraft boosters has done over the past. We're barely surviving. We may or may not make it in the next consideration of whether we can respond to proposals for the Air Force programs or whether we fit in somewhere. I really do think that we have an expertise and a credibility that ought to be brought to bear for the deliberations that the Code T is going to be making as they approach the level-one requirements later this fall, and I think there are mechanisms where we could fit into a block called independent assessment with something that brings in a lot of outside points of view and retains an open mind but sort of looks at what NASA's plans are for first lunar outpost, lunar oxygen, and lunar resources to supplement the vehicle.

Now in summary for these charts, on the next slide you can see that we've got to learn from the lessons of the past, and in order to get accomplishments by 2008 we need to really kind of move out and maintain this momentum, but we've got to have building blocks that are sustainable, and

there are many other lessons to learn, and I think our group is quite capable of doing that. I am excited about the various ways of supporting Moon operations. I believe that visits to asteroids by robots for planetary defense are a next step. Going to Mars, I really think we need to explore the moons of Mars and perhaps occupy them on a mission or two. I think there are multitudes of transportation systems, semi-cyclers and cyclers that can be filtered into this, making use of the nuclear propulsion for low thrust, certainly electrical power and high thrust.

Without a doubt I feel the most challenging aspect that you have is sustaining this, and I've spend some time really thinking about who are some of the people that we can, that I can, consult with to see how my visibility and enthusiasm can be best brought to bear on avoiding this contention of "We want to do this, you don't want to do that." I would suggest that we consider that NASA's decadal plans where every ten years we do something that's measured in an order of magnitude has nothing to do with how we actually operate. We operate on four-year cycles, and those four-year cycles begin on January 20th with the inauguration of a president, and six months later, after he's evaluated the future, is the anniversary of our landing on the Moon, precisely. But I think we need about eight four-year cycles, and they are our best guess as to what we're going to do. Thirty-two plus '05 takes us to 2037, which is a little more than the 66 years from Kitty Hawk to the Moon, and 66 years from there ought to take us to Mars, but we need to look beyond that, too. So I stand willing to help work with various people here on into the future, and hope I haven't encroached on the lunch period too much. Let me take a stab at—

### **Pete Aldridge**

Buzz, thank you very much. As usual you're stimulating a lot of thought. One of the issues, and I know NASA is working on the architecture for the Moon, Mars, and beyond, and I know a lot of work is ongoing in the technical aspects of it, but I'd like to get your perspective on, based on comments made earlier this morning, about is NASA organized to carry this program out? You've dealt a lot with the organization. Are we set up to make this all happen?

### **Buzz Aldrin**

Well, I at MIT got a Ph.D. or doctor's degree in a kind of narrow field of technical orbital mechanics, not the Sloan Fellowships or not an MBA, and I'm not making a lot of money off the stock market due to management and those other necessary things to move up the ladder into high-paying jobs. I think NASA is an institution now, and it's vacillated back and forth between strong headquarters direction and center activities. I do think from a personal perspective that the competition that came up during the Apollo era and right after between the two centers, two major centers of equipment that carried out Apollo, has been unfortunate. And I think when we first defined the Shuttle there was a booster at Marshall; there was an orbiter at Manned Spacecraft Center or JSC. Why a cockpit was needed in the booster I did not understand except that Marshall wanted a cockpit in their booster because they'd have astronauts in it. So they did a study and the contractors of course wanted to build a booster with a cockpit in it because it's more return for their—anyway, that kind of thing there's no business for now and I think, but it

still continues. To me, for an orbital spaceplane that's got a crew in it to be managed by a booster center when that booster center has not developed the rockets that we should have because we have to go to Russia to get the rocket engines, something's not quite right. And I think it needs central organization, and I see this coming along right now with what I've seen so far of Code T.

### **Pete Aldridge**

Good. Neil?

### **Neil Tyson**

Buzz, thanks for that testimony. I've got a question I want you to draw upon your baseline of time to reply to. After the *Columbia* disaster, the op-ed pages were filled with people with strong opinions about what the future of NASA ought to be, and while some of them occasionally agreed, there was one common thread that NASA had been operating for 30 years without a vision. And so then a vision comes out which has relatively modest goals with return to the Moon. Of course, Mars is in there. Yet, we now see people criticizing that vision. So I just wonder if you go back in time, were people driven—was public sentiment driven by the vision, was it that the Moon was a holy grail in the way Mars is not today? What—could you compare and contrast public sentiment in the days there were parades for you and today when we're trying to recreate a vision that everyone can rally around and even take ownership of?

### **Buzz Aldrin**

Well, those were pioneering days. Everything we did was kind of new and fresh, and when you start out something that the immediate results are quite amazing as to what you can get done, as that industry, whatever it is matures, a little bit, it becomes more difficult. And of course, you have stated so many times in our previous commission that Apollo was not about inspiration, exploration, it was defense. I mean, it was motivated by the competitiveness that existed in the world. We don't really have that today, and look at the chaos that exists in the world because we don't have a cold war going on anymore, which really focuses the two sides. I'm not sure how you can ever recreate the excitement that went along with the pioneering of the fighter pilots program, Gemini, where everything we did was adding just a little bit more each time, how we're going to sustain interest on real long-term missions.

As many of you know, I think we do need somewhere along with this exploration program, we need another excitement-driven program that involves people, and that's why I've encouraged not only the suborbital, but I have reservations about, that because of the massive jump between suborbital adventure travel and orbital adventure travel. But we've got to get the excitement, and that's why my last book we took a fictitious Michael Jordan into the Shuttle into orbit. Well, we're not going to do that, but there are other things that I have in my hip pocket that we could do that could help bring along this excitement, but it's got to involve the public more than that, and we have to have the role models of those people who have flown in space who are role

models for the public. And I'm trying to get Jake Garn and those others, non-professional astronauts, the test pilots, the engineers, the Ph.D.'s who are hired astronauts. We need to expand that, because that's a pretty narrow group of people, and unfortunately I think when we move into exploration there are going to be a number of astronauts that are not going to get to fly who thought they were going to.

### **Pete Aldridge**

Les? You want to—

### **Les Lyles**

Buzz, thank you again for being here. You just touched upon the subject of sustaining the vision that you talked about earlier, and certainly this Commission believes that's a very, very important element of this. I wonder, in your Space Vision Institute, and we've talked about this before, one of the goals of that initiative was to both craft a vision—that's now done, obviously—but helping to sustain a vision. Is that still alive, the SVI, or do you think something like that might be necessary to help continue sustaining a vision through both generations and certainly administrations?

### **Buzz Aldrin**

Well, with what was going on last summer I'm not sure that our proposal was met with great enthusiasm by NASA. They're wondering what to do with it, and I've hesitated withdrawing it until I thought I had something else, and that's sort of in work right now. There may be ways of refocusing that a bit more on—well, my expertise again is in the “How do we do this, how do we get it done, what are the choices?” The “why”—why, Neil and other members will try and debate how we can excite the public as to the “why.” I think we need to not over promise and science fiction and Hollywood, as each one has to be more exciting than the other and people, young kids grow up thinking that, sure, we'll go warp 7 one of these days and we'll beam people up and down, but that's not the reality. In a lot of ways we call suborbital adventure travel going into space. Well, it's going up and coming right back down again. You need a lot more energy, and if we have some setbacks in that program it could be detrimental to a number of enthusiastic things. I think we can lead ourselves into thinking that we can take off in an aircraft and go into orbit. The Orient Express—how many people thought we were going to do that? In contrast to Chairman Walker down there, I'm very skeptical of the ability to support large missions with horizontal takeoff, air breathing, accelerating through Mach 1—where are you going to stage, where's all the mass come from, how much do you get into orbit? Until we've demonstrated a lot more progress in hypersonic and accelerating to that, I don't think we should talk about that as being a launch vehicle.

**Pete Aldridge**

Bob?

**Robert Walker**

I just wish we'd flown with X-33, Buzz.

**Buzz Aldrin**

Single stage to orbit, it's really advanced.

**Robert Walker**

The reaction to you personally during the time that we were together working the previous commission convinced me of one thing, and that is that one of the things that people respond to in this is the people who are involved and the people who actually go out and do the missions. One of the things that we've been exploring on this Commission is the idea of picking the next Moon crew early so that people could begin to focus on those people and understand that they are a real crew and that they are training to do the next mission so that you could build some of that kind of personality into the program. I'd just like your reaction to that idea.

**Buzz Aldrin**

Maybe I could write a book before their mission. I'm not—excuse me, Bob. You know, we never really know who's going to go on what missions, and that may change. It may become much more stable when we get to these longer-term missions. It indeed is a challenge how we're going to train a crew on such an extensive mission, and let me remind people that Mars should be a commitment to growing permanence or we shouldn't bother with humans, because it's such a massive investment. If we're going to go once or twice and then let Congress cancel this because we've done that, then we probably should think very seriously about that investment to do it. So I look upon what your job is to create an ongoing Mars and Beyond and we're going to continue to build this up unless there's some major reason why we shouldn't.

**Robert Walker**

But that is part of the question, your sustainability.

**Buzz Aldrin**

Yes, and what it means is that because people have to leave Mars, before the people relieving them get there by five or six months with conventional and reasonable trajectories, we don't want to leave that base empty, so that means somebody has to arrive there, stay over while someone else goes back. We're talking about five-year tours of duty, missions. And we have to

start thinking about that total kind of a commitment of people and then, to get to your question, how are we going to identify who these are and then have them—

### **Robert Walker**

I don't think we're thinking about Mars initially, but at least the Moon crew that would be flying, say, within ten years that you would begin to identify real people who are going to go out and at least do the Moon mission. So if you were in training for a considerable period of time before you actually took your flights to the Moon and you were in fact public personalities for the space program during that time before you actually flew.

### **Buzz Aldrin**

That diverts an awful lot of attention from your training job. The other extreme is like what the Russians were thinking about doing, and that is having a contest, and three guys go out there to the launch pad and then they finally announce the survivor, winner, and he goes up and flies. Now that's the other extreme.

### **Robert Walker**

Fox would probably broadcast it.

### **Buzz Aldrin**

But that's an attention-getter and we need things that stimulate ongoing and we need James Cameron, a real good friend of mine, to help his NASA advisory council knowledge and his projection of winning and entertainment and Tom Hanks and the rest of these people to really get onboard.

### **Pete Aldridge**

Laurie, you get the last question again.

### **Laurie Leshin**

OK. All right, and I'm going to make it a little bit of a touch-feely one, if you'll forgive me. You have stood on the surface of another world and gotten Moon dirt on your shoes and come home and met probably hundreds of thousands of people now and interacted with them and have had an experience that has extended humanity beyond Earth, and that was an experience that forever changed our culture.

## **Buzz Aldrin**

It changed me.

## **Leshin**

I'll bet. And I wanted to just get you to comment some about what you think it will mean to return to being a culture that is doing that and that the reactions that you have seen from the people that you have interacted with. I don't think it's remembered as one of the greatest accomplishments of our nation and our culture because we beat the Russians. I think it's remembered because it inspired us in a very fundamental way. And I just wondered if you would comment on that, what you observed, and what we might be able to expect in the future.

## **Buzz Aldrin**

We may have made it look too easy. We had great success and we had a great team that came together because they were all inspired. I remember somebody saying after it was all over and they were thinking about what's next, saying to each other—I don't know who it was—"When they get around to doing this again, they're going to find out just how difficult it was." It seems so simple, making those decisions, putting those things together. It's not. There are some tough choices, especially when we're building something to just not put a man on the Moon and bring him back safely, and we're going to have a bunch of chances to fulfill that, but we want something that has continuity. We want something that builds for a long range, and I guess I get disturbed when a op-ed piece comes out and says reusable rockets are threatening the life of expendable ones. Gee, we've convinced ourselves that if you keep throwing something away it's not going to be very reliable. If you bring it back and look at it, you see where it's beginning to wear out and if you want reliability in the long run, you've got to reuse something, you've got to bring it back and look at it. And you don't have to build as many of them but it's that upfront cost that keeps killing us all the time. I'm wandering from your question.

## **Laurie Leshin**

How it's going to transform us as a people.

## **Buzz Aldrin**

We, a few of us just with great appreciation of the timing accident that came our way, were given such a wonderful opportunity. It's a little regretful that we don't have reunions a bit more than we do, but this is a prima donna group of people, kind of competitive, and some of us were more fortunate than others, but that—there's something powerful about the people who reach lunar distance, and I want to see before it fades to one half of us are alive that we can make some meaningful use out of that organization.

### **Pete Aldridge**

Buzz, we've imposed upon your time far too long. Again, thank you for coming and thank you for your service to your country and to the space program. It's been delightful to have you here, and best wishes for your future. Thank you.

### **Buzz Aldrin**

Anyway I can help.

### **Pete Aldridge**

We will re-adjourn at 1:15.

### **Pete Aldridge**

Okay, welcome back, everyone. It was an exciting morning, I think, with some pretty interesting comments. Commercial Space and Economic Feasibility is the title of the first panel this afternoon, and we're pleased to introduce three accomplished professionals who will testify before us.

Michael Kearney is the president and CEO of Spacehab, Inc., a leading provider of commercial space services. He was responsible for positioning the company for International Space Station business. His background includes government procurement and quality assurance, flight crew issues, and production management. Michael, glad to have you here.

Marco Caceres is a senior analyst and director of space studies for the Teal Group. He has edited the Defense in Aerospace Company's briefing service and is now lead analyst on the World Space Systems briefing, which he created in 1992. Regularly cited by the trade and popular press for his space market forecast, Mr. Caceres has written for numerous space publications and is a frequent speaker at industry conferences.

Stephen Fleming is the general partner of EGL Ventures, a venture capital firm that specializes in telecommunications and information technology startups. Mr. Fleming is a graduate of Georgia Tech and probably the only Atlanta native in the room. He has invested in 19 startup companies, including XCOR Aerospace, and is on the steering committee of the Suborbital Institute. Okay, Michael, I guess we start with you. Welcome.

### **Michael Kearney**

Thank you. Mr. Chairman, members of the Commission, thank you for offering me the opportunity to share our company's experience and perspective on commercial space. I'm going to focus my remarks on the government's goal to attract private investment to deliver commercial service to [?] separation of cargo and crew to the International Space Station and beyond. Spacehab is an entrepreneurial company. We were founded in the 1980s with the intent

of using a proven commercial business model to serve a frontier market in low Earth orbit. Although our determination and persistence was tested in the process, we have met that goal over the course of the last 15 years.

My first viewgraph illustrates this model. In 1990 NASA awarded us our first contract for the equivalent of 4.5 research laboratory missions on the United States Space Shuttle for a fixed price of \$184 million. Using private equity, we developed the necessary laboratories and flew our first mission in 1993. And we did that, by the way, General, without cutting steps. To illustrate the value of this service, NASA chartered a Price Waterhouse study that concluded our price for these services was less than 20% of the cost that NASA would have estimated for such a service using standard government procurement practices. And that study is available in the public forum.

In our second contract we supported seven research and resupply missions to the *Mir* space station during Space Station Phase One over a three-year period while establishing benchmarks for quality of service and turnaround time.

The success of these early station services led to our third contract, providing dedicated laboratories and ISS resupply services and adding a second major privately developed asset, an unpressurized cargo carrier that spans the payload bay of the Space Shuttle.

Today we are providing services on four of the next six Space Shuttle missions. In parallel with our delivery of services to our NASA customer, we developed a small, value-priced commercial market using space access and resources that we purchased back from NASA on our own assets. On the John Glenn flight in 1998, for example, 45 percent of the total research customers were non-NASA. Over the last decade we have generated a revenue of approximately \$40 million from this market.

While the value of these services has been consistently rated excellent by NASA, this contract approach has been problematic for them for two reasons at least. First, the government's current contracting structure of value-based price for commercial fixed-price services is difficult to establish when the typical mechanism of cost-plus contracting prevails. And second, the dynamic nature of spaceflight operations has created a requirement for price adjustments when the government has been unable to launch within the parameters of that fixed-price mechanism.

For Spacehab, the same market uncertainty has affected our revenue and profitability. Having the government as both our supplier and primary customer has inhibited the development of a robust commercial market. On both sides, the intent and the results were appropriate, ethical, and professional, but the outcome was not exactly what was originally envisioned. As a sole supplier of both space access and operating infrastructure, appropriate government business practices dominate our environment. We have concluded that for space commerce to thrive in low Earth orbit, commercial business mechanisms will have to be predominant. Can I see the next viewgraph please?

This viewgraph shows that in the current environment the government is the supplier directly to a customer, and the other viewgraph is intended to show that where you have an environment web, multiple suppliers of space access, you have B-to-B services in space, and then you have

B-to-C suppliers directly to customers. Customers typically like a very tailored approach in a B-to-C supported by B-to-B, and that is what's missing. We have right now where the government really is directly supporting the customers in all the Space Act things that have been done by NASA to date. With multiple suppliers of space access and infrastructure, capitalist economic mechanisms would foster development of emerging commercial uses for space as NASA moves on to explore the rest of the solar system. B-to-G, B-to-B, and particularly B-to-C services would be able to use private investment to serve customer needs. Once a robust market is established, the companies would be motivated to attract new users and increase market share by becoming more efficient, growing the markets, and improving products and services. As the primary customer for these services, NASA would benefit by higher value and lower prices as the natural result of competition and private investment for both low-Earth-orbit operations and for planetary exploration.

Now let's look for a moment at the commercial cargo resupply to the International Space Station as described in the new national space vision. President Bush specified a goal that NASA will pursue commercial opportunities for providing transportation and other services, supporting the ISS and exploration missions beyond low Earth orbit. There are at least six companies today offering affordable, privately developed space access at a fixed price with the ability to rendezvous and dock with the ISS. Each of these companies is different in capability and availability, but they potentially have the ability to deliver cargo to the ISS and other orbiting locations at a fixed market price. Therefore, the government has the option of creating a commercial market within 30 months simply by deciding to purchase these services from two or more commercial suppliers using fixed-price contracts. In other words, NASA has the ability to create a market that would be controlled by the standard mechanisms of commerce simply by deciding to purchase a significant quantity of cargo annually over the next ten years, to be delivered to the ISS at a fixed price. My recommendation is simple: NASA should solicit commercial fixed-price bids for cargo to and from the ISS, and I believe this action would benefit NASA, space commerce, and the vision to explore the solar system. Thank you for the opportunity to comment to the board, to the Commission.

### **Pete Aldridge**

Michael, thank you. Marco?

### **Marco Caceres**

Thank you, Mr. Chairman. I'm a space market analyst, and my job is essentially to look at hundreds of proposed programs, space programs, and try to get a feel as to which ones are real and which ones are make believe. Then I come back to my clients, which include NASA, Lockheed, Boeing, and some very small companies like Kistler Aerospace, and I give them my opinions of what I think. Now, honestly, when I first heard of the President's initiative, I was a bit skeptical, and I continue to be a little bit of a skeptic, but I'm very open to being convinced otherwise. On January 14th, when President Bush revived his father's 1989 plan to establish a

base on the Moon and then proceed with manned exploration of Mars, our first inclination was to dismiss it as an election-year publicity stunt. There was nothing in the initial outline of the program that led us to believe that this was a serious proposal. There was no mention of its estimated costs or how we intend to fund it. Given that the price tag for the effort will almost certainly start in the hundreds of billions of dollars, we could accept the lack of immediate budgetary information from the Bush administration. After all, there is no use in scaring U.S. taxpayers until you've at least had a chance to sell them on the benefits of the program.

Even though we suspect that the Moon-Mars combo does not approach being affordable, it is the nature of space market analysts like myself to give the benefit of the doubt to new space programs. We want new satellites and rockets to be launched. We hope for the development of new applications for space-based technologies. We wish to see more private investment in space ventures. We long for more government dollars to flow into NASA's R&D and procurement accounts. We are completely open to being influenced, even manipulated, by our industry to think that anything is possible. We possess an innate desire for our market to grow, our industry to create thousands of new jobs, and our companies to make lots of money. Thus, whenever a company or an agency announces that they will undertake to build a new satellite or launch vehicle regardless of how much of a long shot the program may be, we will include it in our calculations of what we believe will happen in the future.

In most cases we eliminate programs from our forecast because they're inadequately funded or because they appear to be overly ambitious from a technological standpoint. Often we drop programs due to sparse information about the originator or the proposed system itself. Sometimes we fail to include programs because they just don't sound right, as was the case when we first read in 1993 of Craig McCall's 924-satellite LEO Teledesic constellation. Teledesic definitely seemed like a pipe dream, a \$6 billion commercial broadband system. Hardly anyone had even heard of the word *broadband* back then. And the 73-satellite Iridium program, which had been made public only three years earlier, was considered to be an enormous undertaking at \$1 billion. Eventually Iridium was a \$5 billion-plus program. Yet even with a system the size and complexity of Teledesic, the temptation within the industry was to be cautiously optimistic that it would be built and launched, given that its initial investors included mobile telecom pioneer McCall, Bill Gates, and Saudi Arabia's Prince Al-Walid. Almost everyone wanted to believe in the program. Although few openly voiced much confidence in it for fear of being seen as too naïve, the general consensus in the industry, in our industry, was "Let's see how Iridium goes before we get overly excited about Teledesic." We continued to closely track Teledesic throughout the mid to late 1990s, and eventually when we'd gotten a little more used to the concept, and the architecture had been downsized to closer to 300 satellites, not 900-plus, we began to include the system in our forecasts.

The selection of Boeing as Teledesic's prime contractor in 1997 and Boeing's commitment to invest \$100 million were other factors that influenced us. Ultimately Teledesic went nowhere. After a decade and hundreds of millions of dollars invested in satellite design and development, McCall finally pulled the plug on the program in 2002. But the fact of the matter is that even though we did not include Teledesic in our forecasts early on, we took the program seriously

from the beginning primarily because we could at least foresee the day when it might be completed. The program was officially never more than five to six years away from launching its first batch of satellites. According to Teledesic's filing for orbital slots with the International Telecommunications Union in Geneva in 1995, the constellation was to be operational by 2004, with satellite launches expected to commence in 2001. The first-launch timeline of five to six years was fairly common for other large commercial satellite programs of the 1990s, like Motorola's Iridium and Loral's GlobalStar. The proposed first-launch timeline for civil space programs like Apollo, Space Shuttle, and the International Space Station was a little longer—seven to ten years. Still, they were all within the span of a decade.

We do not view the within-ten-year first-launch timeline for major programs as purely coincidental. From either a business or political standpoint, it is unreasonable to expect that you can hold the attention of your supporters, your target audience, or your consumers for much more than a decade and actually accomplish what you set out to do. There has to be some sense of urgency and clear purpose attached to multi-billion-dollar space programs, or else they will lose the public's attention and confidence. Our industry tends to view the future in terms of 5 to 10 years out, which is why our market forecasts are usually 10-year forecasts, not 20-year forecasts. Our worldwide mission model, which tracks proposed space payloads, is published as a 10-year model. Of the 1,392 payloads we currently count, 98% of them are proposed for launch during the next ten years. When we learn of a payload or mission that will be launched in 10 to 15, or 15 to 20 years, we include it in our model. However, we think of it more as an interesting bit of data rather than something real. It is hard to get excited about these kind of long-term programs, because we know from experience that the chances are that they will never be implemented the way they were envisioned originally. Our attitude is generally "Anything that is being planned for launch that far into the future cannot be that important or have much of a consensus behind it, or else they'd want to do it sooner."

One of the things we find most curious about public commentary in support of President Bush's space exploration initiative is the repeated reference to President Kennedy's speech in 1961 in which he challenged the U.S. scientific and industrial communities to send humans to the Moon before the end of the decade. The Bush administration and many within industry would like to recreate the enthusiasm and spirit of that era by laying out a bold vision of returning to the Moon by 2020 and then moving on to Mars and beyond years after that. The part of the equation that is being lost, though, is the fact that Kennedy's vision was a short-term one, not a long-term one. It is safe to assume that Kennedy's speech would not have been as powerful or had anywhere near the same impact had the challenge been stretched out over 20 or 30 years. The average person cannot see that far ahead or doesn't want to.

The U.S. started launching manned Apollo missions to the Moon in 1968; Apollo 11 astronauts landed on the Moon in 1969. It took just eight years to meet Kennedy's challenge. President Reagan attempted to emulate Kennedy in 1984 when he proposed that NASA build an orbiting space station by 1991. He had the right idea with regard to the timeline. The problem is that his administration vastly underestimated the costs and technical difficulties of the program. This caused delays, which in turn contributed to additional cost overruns and forced constant

redesigns to relieve budgetary pressures, which in turn caused further delays, and so on and so on.

Most of the history of the Space Station has been one of a program trying to avoid cancellation by any means rather than one dedicated to achieving a scientific goal. Once the Space Station lost its scientific purpose, it became little more than a unique construction project, and that has made it difficult for it to sustain political support and the imagination of the public. Here we are more than 20 years into the program, and we're still two to three years away from final assembly. The fact that the Space Station has survived this long is a credit to the politicians and program managers who have scattered the workload throughout as many states and congressional districts as possible. It has been a great jobs program for our industry, and along the way we have gained some valuable knowledge and experience in transporting and assembling large pieces of hardware in orbit. However, the Space Station has not succeeded in capturing the enthusiasm of the U.S. public the way Apollo did. The two likeliest reasons for this are that space was still a brand-new frontier in the 1960s, and we were engaged in the race to the Moon with the Soviets. There's nothing like a good old competition to stir up emotions. We believe another big reason is that the Space Station program has simply taken too long. At some point the public got bored of hearing about the Space Station.

It's not dissimilar from our industry's eventual boredom with Teledesic. By the time Teledesic had been downsized to a constellation of only 30 satellites in medium Earth orbit and Italy's Alenia Spazio had replaced Boeing as the prime contractor, few people honestly felt the system would be built or cared very much. More than a decade of press releases and announcements promoting this incredible broadband satellite system that would revolutionize the industry created tremendous fatigue within our industry, because there was little to show for all the time and money that had been invested. Years before the program was finally canceled, people's eyes would glaze over at the mere mention of Teledesic. We have been talking about the Space Station for nearly a quarter of a century and have spent more than \$60 billion in its development. This was originally to have been an eight-year program at a cost of about \$10 billion.

The good news is that the Space Station offers us an excellent model of how not to do a space program. There are many lessons to learn from this model, and one of them is that in order to stay focused on and achieve a specific goal the program must have a clear starting point and a clear ending point. And the closer those two points are to each other, the greater the probability of success, assuming of course sufficient funding. The within-ten-year first-launch timeline is a pretty good place for NASA to start as it seeks to fill in the details of President Bush's space exploration initiative. But the agency cannot do this unless its Moon/Mars efforts are clearly defined and marketed on their own specific merits, starting with the Moon since that's the mission that is most doable in a reasonable timeframe.

It is fine to have a broad plan to send manned missions to the Moon and then to Mars, but if you keep linking the two, we project that the public will get confused by information overload and eventually they will tire of hearing about this grand scheme that will take 20 to 30 years to achieve, as has been the case with the Space Station. De-link the two missions. Otherwise there is a better-than-even chance that you will end up dooming both. We understand the assumption

that you have to talk about Moon/Mars together in order to create the kind of excitement you need to sell the initiative. Selling a manned mission to the Moon by itself is not a particularly sexy endeavor, since we've already been there, done that. That challenge, however, should be sizably easier than holding the public's attention for three decades and through at least eight presidential administrations. Thank you.

### **Pete Aldridge**

Thank you much, Marco. Stephen?

### **Stephen Fleming**

Ladies and gentlemen, thank you for having me here today. As Chairman Aldridge said, I'm a venture capital investor. I have made 19 investments over the last 10 years; most of them have made money. One of them is in an aerospace company, XCOR Aerospace, as CEO Jeff Greason testified yesterday.

I think I'm probably the only professional venture capitalist in the United States who has actually invested in a space startup. I think that's why I'm here today. I would like to talk a little about the role of private investment in fulfilling the President's vision.

### **Pete Aldridge**

Stephen, would you move the microphone just a little closer, please? Thank you.

### **Stephen Fleming**

How's that?

Next slide—I'm going to rattle through a lot of slides real quick, so—

Americans have been traveling in space for 40 years. We have heard that repeatedly this week, but manned spaceflight is still a monopoly of governments. Wall Street has never invested in manned space transportation. As we heard yesterday, there are some entrepreneurs on a shoestring pursuing the XPrize, but none of these entrepreneurs have been able to attract any sort of professional Wall Street investment. Why is that? Let's take a quick history lesson—very quick.

Next slide—a national railroad program in the 1870s would have been doomed to failure. The railroads got built, but the government didn't build them. The government partnered with railroad companies to get them built.

Next slide—same for the auto industry. And I apologize; why my titles are screwed up there, I have no idea. Same for the auto industry—a national automobile program in the 1910s wasn't necessary. Henry Ford found the money. He was able to build cars.

Next slide—airline industry—same thing—1930s. The government was clearly the largest customer, both from the military and the civilian point of view; but the government didn't build the airplanes. The government didn't run the airlines. Private industry did.

Next slide—so why did we wind up with a national space program in the 1960s? Go to the next slide.

Until the 1960s it was assumed space would follow the same pattern as previous transportation mechanisms: government would act as a very large customer, but act as a regulator, would work on infrastructure issues, and would have a military presence. But Pan Am was going to run the space lines and Hilton was going to build the hotels. If you remember the movie, *2001*—next slide—2001 came and went and it didn't quite work out that way. Private industry has never really engaged in manned spaceflight. So 43 years after Alan Shepard rode a Redstone into space and 35 years after Buzz Aldrin walked on the Moon, we still have never seen a privately funded manned spaceflight. Compare that to what we saw 40 years after the Wright Brothers flew at Kitty Hawk—quite a difference.

Why did we wind up with a space program and not a space industry? Next slide—43 years ago we said the four most dangerous words in the English language: “It's different this time.”

Go to the next slide—excerpting a speech that Marco referred to that is one of NASA's sacred texts—go to the next slide, if we could—NASA's sacred text: President Kennedy announced, “This nation should commit itself before this decade is out to landing a man on the Moon and returning him safely to Earth.” Noble goal—read the next sentence. He describes the project as impressive, as long-range, as difficult, and as expensive. Those are not adjectives that are going to attract a lot of investment from Wall Street. At that point, in 1961, we set ourselves on a path of saying space was different, and we've been on that path ever since.

Next slide—it's the legacy of Apollo: flags and footprints make a lousy business plan. It's a spectacular technical achievement, but as a business investment, it's a complete failure. I don't care how much Velcro and how much Tang we got out of the Apollo program; we don't have a sustained presence on the Moon. We don't have a sustained infrastructure. We went to the Moon too early and we never went back.

Then we have Shuttle—next slide. I don't need to beat this horse here. If Shuttle had been profitable, Rockwell would have built a fleet of them and sold them to FedEx. It didn't happen. I think we all know why. Don't need to go into that for this audience.

Next slide—and Marco just discussed ISS in some detail. Goals are primarily political; a little science is tacked on when we can afford it. Nobody from industry has ever shown any interest, serious interest, in investing in ISS. So here we are 40 years later, and we're still wandering in the wilderness of a government monopoly.

Now, President Bush—God bless him—has proposed—next slide— has proposed we go back to the Moon and on to Mars. Like Apollo, like Shuttle, like ISS, this will probably be, as Marco said, extraordinarily expensive. That's okay. We are an extraordinarily wealthy country. We can afford this, but what are we going to do with it? Are we going to do flags and footprints again

just to impress the public, or are we going to build an industry that can actually transform the American economy? I think that is the most important choice this Commission is going to make over the next 120 days.

Next slide—what if we go to Mars? Flags and footprints still make a lousy business plan. We can plant the flags. We are not going to plant anything of sustainable value. That's not a good use of taxpayers' money.

Next slide—I think this Commission has two decisions. One is how to prepare missions that minimize the cost for the American taxpayer. That's fiduciary use of the taxpayer's money. But I think it's even more important to use the Moon to Mars initiative to finally break out of the space program mindset. I don't want another space program. We have done that for 40 years. I want a space industry. We don't want a series of spectacular stunts. We want a clearly thought-out series of steppingstones that build an infrastructure here on the ground, in orbit, on the Moon, and on Mars where people can make money.

Next slide—we've heard a lot over the last day and a half about the cost of space access. Just think for a minute that putting anything into orbit today, and I don't care whether you're talking Shuttle or Ariane or the Long March out of China, is going to cost about twice that object's weight in gold. So whenever you see a nifty computer-generated image of the new lander or new launcher, think about seeing that thing built out of solid gold bricks. It costs a lot of money.

Those launch costs have got to come down dramatically—ten times or a hundred times. No matter what you want to do in space, whether it stays in low Earth orbit, whether we go back to the Moon, whether we go to Mars, whatever we want to do, that is going to control what we're able to do with future space missions.

Next slide—think for a minute what a hundred times means. To someone thinking about investing in a business, somebody like me—I'm looking at a business plan. Imagine trying to run a business with \$37 stamps. Imagine trying to run your business if a FedEx envelope cost 1500 bucks. Imagine trying to run your business if filling the tank with gas costs \$200 a gallon. No wonder Wall Street hasn't been interested in space. These costs are insane. You can't run a business this way; therefore, no one has run a business this way. Only governments have been able to play this game.

Next slide—it's really hard to build a factory if a wrench costs \$10,000 and if getting the guy to turn the wrench to the worksite costs \$3 million and two years' worth of planning. It's just impossible.

Next slide—If I could only leave you with one point this afternoon, the high launch costs we see currently and projected for any system I have seen, is going to doom us to doing flags and footprints on the Moon and Mars. That's all we'll be able to afford. That's wrong.

Next slide—we know how to fix this problem. We heard yesterday from some there's a dozen other entrepreneurs that can lower those launch costs to the range where we can make money. I have talked to a lot of them. The barriers are not engineering. The barriers are economic; the barriers are political. I believe if we can get them the money, they can build the equipment. It can

be single stage to orbit, it can be two stage to orbit, it can be expendable, [?] expendables, it can be heavy lift. I don't care. That's not the job of this Commission. Build them all. Let the market sort it out. Get the payloads in place and get the launchers running.

Next slide—I'm an early-stage investor. That's what I do. I'm really comfortable taking technology risk. I have to do a lot of due diligence and examining the business opportunity, but at the end of the day I believe engineers can build widgets. I will invest in engineers building widgets. What really scares me is if they build a widget and it turns out the market doesn't want to buy their widget—or worse, the government as a regulator will not let them sell that widget. That's what kills business plans.

Next slide—the government through this Commission can reduce those risks on market and regulatory issues. We talked a bit about risk yesterday. If you are able to bring those risks down and bring launch access costs down, it will vastly improve the number of options that you have for Moon to Mars missions.

Next slide—how do we do that? Act like a customer. Congressman Walker, as you suggested yesterday, put out RFPs; specify how many payloads you want, how big you want them to be, when you want them to go. You can put performance penalties on there. Businessmen deal with that every day. But commit to the launches so the entrepreneurs can actually get into mass production, so these things aren't all handcrafted one-off nonsense. Minimize the regulatory burden—and FAA is doing a good job of starting on that—and don't insist on design control. Let a thousand flowers bloom. We don't know what the right design is going to be until it's flown a hundred times. If you try to freeze things in amber too early, it would be like trying to freeze design at the Wright brothers. We would still be flying with fabric wings. Let the entrepreneurs be creative. Some of them will go broke. That's okay. That's called capitalism.

Next slide—with those contracts, entrepreneurs absolutely will be able to raise money from Wall Street. We have had this debate over lunch and some very qualified people disagree with me, but I believe it's true. Compared to an oil rig, compared to a chip fab, we can afford these things in American private industry. We will finally, after 40 years of wandering in the wilderness, develop reliable and routine space operations. I don't know what they are going to look like. I don't know who is going to build those launchers. I don't know what the name on the side is going to be, but they are going to be operated like airliners. They will have profit margins like airfreight, and they will have the reliability of a DC-3 or 737. We will finally succeed in making space launch boring.

Next slide—some closing thoughts—we have talked a lot about sustainability the last day and a half. Profitable industries are sustainable; government programs are not. If you are trying to put something in place that's going to last 40 or 50 years, it 's got to be profitable. There is no other way to sustain it over that period of time. Either that or the threat of war, and the aliens are not invading any time soon.

Next slide—if we build a private launch industry, the missions you want to plan to the Moon and to Mars will become ten to a hundred times cheaper because you will be able to buy those launches commercially at vastly lower rates than NASA can offer. Last slide—I close with a

quote from my favorite author, Robert Heinlein; speaks to the difficulty of struggling out of earth's gravity—"Reach low orbit and you're half way to anywhere in the solar system." Dr. Jackson, to answer your question from yesterday, it's time for private industry to take over the task of getting halfway. We will get NASA halfway. The second half—the Moon, to Mars, the rest of the solar system—that's an exploration challenge that will keep NASA busy for the next 50 years, but we need to do the first step. Thanks very much; appreciate being here today.

### **Pete Aldridge**

Stephen, thank you very much. That was very interesting. All of you are implying something that is to me a major cultural change in the approach to the government in doing these type of missions and it's—I guess the position of the government is that we will do it and, oh, by the way, we will have industry help us get there by farming out components and pieces, but we will put them all together. The culture change is that the government will kind of identify what needs to be done but will turn it over to industry to do that supply. We will buy the capability from industry as opposed to building it in the government. Is that—

### **Stephen Fleming**

The Post Office didn't tell the early airlines how to run airmail. They said, "We want to take this number of letters from city to city, you figure it out, we will pay you." Same thing.

### **Michael Kearney**

That's why there are no airmail stamps anymore—it's because it's cheaper to fly on the airplane than it is to try to ship it by truck. It's the same idea. We are all talking about the same thing. They were talking about it yesterday when Mr. Musk was talking about this and Peter Diamandis. If you allow the space access business to be driven by private investment and commercial mechanisms, you will get investment. And there are people out there that have money, and they are looking for good things to do, as you know, obviously, with a CD being one and a half percent or whatever. There's plenty of opportunities to go and get return on your money.

### **Pete Aldridge**

What would it take? What can this Commission do to make that happen? Is there an action that we would take, a recommendation that we would make?

### **Stephen Fleming**

I'd strongly recommend that any launch, whether it's for orbital, Moon, Mars, what have you, will be competed on the public markets and that access to those launches will be made available

to any vendor who can prove they can launch, and that NASA doesn't run those launches. NASA provides a payload, provides a plug interface, and provides a check.

### **Michael Kearney**

In answer to your question there are—as Congressman Walker pointed out—there are standard mechanisms, and you can go out with an RFI and get the characteristics of what you need and then just buy at the market price and, say, if you just put out today that you're willing—it has to be a significant amount of mass, we are not talking about deciding you are going to go out and try to buy 2,000 pounds a year or something, because there has to be enough revenue in this to generate the margins that are necessary to pay back the investment. But if you said you were going to buy—right now the Space Station needs on the order of magnitude of a hundred thousand pounds per year, and part of that can be transported in the process of doing the final assembly and all the things that are being done on the Shuttle. What remains is at least 50,000 pounds, and instead of transporting it on the Shuttle over the next—right now they are looking at a Shuttle use of about 30-plus missions, roughly 30, 31—you could reduce the number of times the Shuttle has to fly yet to finish the assembly of the Space Station by four to eight missions by deciding to move all of the cargo of any kind off of the Space Shuttle whenever possible. And there is already a NASA policy that it is more desirable to buy services commercially when commercial services are available, and we're not following it.

And by the way, this is all for good appropriate reasons of the NASA people that are doing this—are doing it—because we are directing them to be good stewards of a national asset. Not criticizing the people involved, it's the process and the policy that we are talking about. We also run an operation down in Florida do to telecommunications satellite launches. We have launched a hundred percent—we have processed a hundred percent of all the spacecraft launched for telecommunications in Florida in our subsidiary, Astrotech, and in that environment, because we have a commercial facility which we just upgraded using private investment to build a \$30 million new building, we now have a world-class facility that's better than anything for the EELV market. We have a facility that's better than anything on site at either the Air Force or NASA, and we have the Air Force coming to us and we have NASA coming to us now for missions as was Boeing and Lockheed for their communications commercial missions.

### **Pete Aldridge**

Carly?

### **Carly Fiorina**

Sticking to this issue of a very clear recommendation, which is to commercialize space access and the very difficult historic and cultural problem, I want to go back to the very first contract your company was ever let. You said it was in the 80s, you were let a contract; why do you think

that contract was let in that particular way at that particular time? What caused NASA to decide to do it that way that time?

### **Michael Kearney**

That's a really good question. And I have to say, to start with, that I was not in space. I have been in Spacehab for over ten years, but that was in 1990. And by the way, it was with totally with private investment, you know, space access; but, in fact, our original business plan in 1985 was to go and do passengers to orbit on the Space Shuttle. But the fact is that there were people at NASA who were very motivated to help develop the space-based economy that Dr. Komerath was talking about yesterday. The deputy director of NASA or deputy administrator of NASA was very much involved as well as several of the other senior people in trying to find a way to stimulate the development of a commercial business or commercial activity in space.

Now, as with, and one of the key things that Stephen said, is that nobody—there is nobody that will know what business plan—you could take all of the best people, the CEOs of all of our biggest companies, and give them five business plans and ask them which one of these is going to be wildly successful—and, excuse me, but I think Carly would probably agree—they will not—they cannot predict it. It's the capitalist system that does that. It just cannot be done. And you just don't ever know, and it's the commercial mechanisms that allow it. At the time it was almost visionary that NASA allowed that contract to happen. And, by the way, General, there were a whole bunch of people that didn't think we'd ever be able to do that because of the steps, and not cutting the steps, to do that. But now, today, when NASA goes to fly a mission, they have a stack of stuff about four feet high to get on orbit and we can't afford to do that because we do have commercial customers. Ours is about that high, and we do all the work for them. And we follow all of the steps and we do it for 20% of the cost. The fact that they were visionary in setting up that up, missed—and I even—when I first joined Spacehab, I didn't realize how complicated it was going to be to operate in a market that is predominated by government contracting policies and procedures. It's just very, very complicated. All the pass-down—and General Lyles, I'm sure, is good to talk on this subject—but there's a huge amount of boilerplate and pass-down in every contract and there's all these other factors that are not involved in a commercial contract. We can write a commercial contract that is similar to the one that the Wright brothers used that's two pages long. And in fact, we signed a contract with the Russians about five years ago to move forward and build a commercial module for installation on the Space Station, and it was actually done on a napkin made out of this same fabric right here at one of those vodka drinking parties that—you know—OK, we agreed and we all signed on this napkin.

And so in the commercial world—and we took that and we went off and started doing business. And it can happen; you can do it on a handshake if people trust each other. But in the government world, the contracting and the whole process is so complex, it just completely inhibits the development of commerce. The difference now is what you have aligned—and I know all the planets are aligning this week as well—but you have aligned the fact that NASA really needs to transport things to the Space Station without having to use the Space Shuttle. And

the vision of going to the Moon and Mars needs a much cheaper way to get there. And industry at this point, we have—not only do we have four alternate-access contracts that our contractors developed ways to get to the Space Station under contract to NASA, and then we have Kistler and Spacehab all having ways that we can offer to get to Space Station with a commercial basis in 30 months; but on top of that, you have all these guys that are doing the XCOR and the X Prize things that are following right behind that, that could have and could develop capabilities to do—the biggest issue on the Space Station is the last-mile problem of how do you get from the last mile. The astronauts looking out the window see things coming towards them like guided missiles, so you have to—that’s a very expensive problem to solve, but there are ways to do that. And once you have it, you can deliver much cheaper than \$10,000 a pound.

### **Pete Aldridge**

Neil?

### **Neil Tyson**

Yeah, I’ve got a quick question. Something I guess I don’t understand, and perhaps you can help me on it: when I think of a business model with venture capitalist money being pumped in, I don’t think of a model where your only customer is the government. I think of one that has a whole other support because there’s a demand outside of what the government represents. And obviously, in the case of the development of airplanes, it was extremely clear that if you could make that affordable, I would want to take an airplane because it would shorten my time compared with a stagecoach or with an automobile. From our work in the Aerospace Commission, one of the things I found remarkable—tell me if it’s not still true—was that there was right now excess launch capacity compared with launch demand. So that even if you brought the price down, not a factor of a hundred, but let’s say you brought the price to a half, you wouldn’t get a corresponding increase in demand. And so where do you say—well, how does this square? Even if NASA says, “Yeah, go ahead and do it. We will be your customer,” if you don’t have any other customer to up the usage rate to make what you say possible. And we all agree that if you’d bring it down a factor of a hundred, then we can all go home. But we have to get there through these other steps and for that to work, do you need more of a customer than just the government?

### **Stephen Fleming**

I think we need government to be the first customer. And the analogy we were using over lunch was the KC-135 tanker, which turned into the 707. You know, Boeing probably couldn’t have built the 707 on their own without the government—the military, in that case—as the anchor customer. I do believe we are going to need, you know, an anchor tenant being a certain amount of mass launch to station or a certain amount of mass launch for other purposes from the government. But if the volume is there, and the key is not the—what’s going to drive the price is the volume in getting these devices into mass production. You know, every rocket engine ever

built has been built by hand. There's not a production line for rocket engines. If we can get those into mass production, the cost will come down; maybe not a hundred times, more than two times, into an area where the demand curve does become elastic. And I do believe there are commercial—

**Neil Tyson**

You believe there is a demand curve there then?

**Stephen Fleming**

Absolutely.

**Neil Tyson**

OK.

**Stephen Fleming**

I don't believe half is enough to get us there, but I do believe—

**Neil Tyson**

Factor of ten.

**Stephen Fleming**

Factor of ten—well, if you'd cut the launch prices for Teledesic by a factor of ten, would that have flown? Maybe.

**Marco Caceres**

Maybe. I mean that was more of a lack of a consumer demand for the kind of services they were going to offer.

**Stephen Fleming**

It may have just been too early, but there's—and pricing—but there's applications that will, I think, consume a number of launches if the anchor tenant gets the first launches out of the way and gets mass production going.

**Pete Aldridge**

Paul?

## **Michael Kearney**

By the way, we do commercial—we sell to commercial customers or non-NASA customers to do research in space using both the NASA system and also Progress. We have a Russian Progress science payload getting ready to go. And there is a backlog of researchers out there internationally who have an interest in flying in a variety of ways, and there is very little access for them to get up there within a reasonable price range. And really \$10,000 a pound is affordable for some of the research that they would like to do. We have actually cancelled almost \$10 million of contracts that we had written for delivering utilization or science payloads to orbit because we could not get access. And right now that Space Shuttle is dominated by the need to get the Space Station built. So there is a market out there. Now, how much of that in addition to NASA there is will depend on some other factors that are kind of hard to predict. When you get the numbers down low enough, there's all kinds of things from protein—there's some unique things about proteins that can be done in space. The whole idea that once you take G out of the equations of motion, that you have all kinds of things that you can explore. The vacuum—the necessary vacuum—you can make gallium arsenide, which is critical to some of the chips, and everything like that in a vacuum at a very low cost. But, again, and Stephen pointed this out, you can't do that when it costs \$1500 to mail a letter.

## **Pete Aldridge**

Paul?

## **Paul Spudis**

Yes. I want to make a comment in response to the flags and footprints; that's what this is about. We may have listened to different speeches, but, Stephen, I'm going to use your four most dangerous words: "It is different this time." And fundamentally what's different this time is that one of the things the President mentioned in his speech was learning to use space resources, learning to use the things that are already in space. I look upon this initiative not as a Moon base or even a manned Mars mission, but rather it is a mission to change the rules of the game, to changed the paradigm. Fundamentally, we are mass limited in what we can do in space. Everything we have—everything that we need in space we have to drag up from the bottom of the Earth's gravity well. I look as this as an opportunity to change that rule. And the question is not where we are going to do this to make spaceflight cheap. We are going to go to the Moon and go to other destinations and to go to Mars to use those resources to create new capability that we don't have now. So in that sense, I reject the way you guys have characterized this initiative. It's not a flags and footprints. Obviously, no one is going to buy that, because there's—it can't be justified politically. But on the other hand, if you created a system where you are going to learn new skills and the skills you need to thrive in space and to thrive off planet, I think it's a very different situation.

**Stephen Fleming**

Couldn't agree with you more, and I absolutely hope you're right.

**Pete Aldridge**

OK, yeah, Bob?

**Robert Walker**

A couple of questions: first of all, if we were to put an RFP or an RFI, depending upon how you want to structure it, on the street reasonably quickly, how soon would the half a dozen or so companies be prepared to begin delivering goods to the Space Station?

**Michael Kearney**

Well, at least on the order of 30 to 36 months. Now, our system is based upon the Russian capability and a variant of the Progress launch system, launched on the Sea Launch with the Boeing Company. And because of that, because of that, because it's a variant of a known system, and the Russians do that very well—the variants of a known system—we could be really, we could flying in 24 to 30 months. I think Kistler Aerospace, they've got all—

**Robert Walker**

Sometime before the gap of 2010 to 2014?

**Kearney**

Oh, yes. But, you know, right now, for example, there's only one way to get crew back and forth other than the Shuttle is on Soyuz, but imagine if you really created a market out there and created companies that had a flow of cash from operations and because they have margins, and you don't worry about the fact that profit—by the way, I used to be a program manager in the Navy, so I can tell you that profit in that environment is offensive. Maybe the general got past that at some point, but it is a—

**Pete Aldridge**

Profit is not a bad word.

**Kearney**

If you accept that profit is okay, then they are going to be generating margins and they will invest in turning some of these great ideas that are being built for transporting people to space as a cheaper and more efficient way to get the crew rescue situation solved.

**Robert Walker**

Mr. Fleming, I would just like you to comment for a brief moment on something that was in your supplemental materials. And that is a statement here under a title called Moon Prize; it says, “Be it resolved the U.S. Treasury shall pay five billion dollars to the first U.S. entity to place and sustain six American citizens on the Moon for one year and then return them safely home.” Is five billion dollars a research figure—

**Stephen Fleming**

B—five billion with a B.

**Robert Walker**

Yeah, five billion, right.

**Stephen Fleming**

Correct

**Robert Walker**

Five billion; is that a research figure or could it be done for a billion?

**Stephen Fleming**

I don’t know if it could be done for one billion. I have seen some reasonably good numbers that it could be done for three. So at five, somebody is making two billion in profit. I believe it could be done for five. And there’s no risk to the federal government, because if nobody can do it for five billion, you pay zero. I didn’t propose that in my remarks as a lack of time. We talked about prizes yesterday. Prizes do not make a business plan, but prizes absolutely can stimulate development of advanced technologies. And I believe if that were dangled in front of American industry that there’s five billion dollars out there for a six-person Moon base, you would see one.

**Pete Aldridge**

Carly.

**Carly Fiorina**

Well, I have to apologize to the panel briefly because I’m cheating. I’m not actually going to ask a question. I am going to summarize what, at least I think, I’ve heard this morning, not just in your testimony, but in other testimony as well, and ask you to comment if you would. I think what we’ve heard today as well as on other days in which we’ve listened to testimony is that the

President's vision to go to Moon, Mars, and beyond is bold; that we should approach this bold goal—and I think this was your point—with focus, with a sense of urgency so that we have a chance of completing it, and with commitment. I think we've heard that we need to approach it with the full set of resources at our disposal, and that full set of resources includes the entrepreneurial and inventive capacity of the American people. But I think fundamentally what we have heard as well is that the mission should actually be even more bold than simply going to the Moon, Mars, and beyond. I think what we've heard is the mission should be to transform the American economy and the American worker in the process. And I wonder if you'd comment on that.

### **Stephen Fleming**

I couldn't agree with you more. I absolutely agree that this is a step that we can look back on in a hundred years as being just like when the railroads got built in 1870 and what that meant to the American economy as suddenly we went from a coastal minor power to what became the world's only superpower by linking together all the resources of this continent. If we can link our entrepreneurial spirit to the resources that are available off this planet, on the Moon and Mars, asteroid-built energy in space, what have you, we will see that it is just as transformational as the railroads were a hundred and fifty years ago.

### **Marco Caceres**

I think that's true. You're going to have to do something bolder than just exploration to recreate that or to create that kind of excitement and enthusiasm, because people talking about recreating something that existed back in the 60s—we are a different society or a different world—and the same kind of things that excited the youth back then are not going to be the same things that do it now. So I think you are looking at something much bigger.

### **Michael Kearney**

And I think that the kind of excitement that you can get by allowing the free-market mechanisms to work in this environment—when the space program draws a lot of things from just really outstanding people. I hired—about 12 years ago—I hired a guy who was the number-one graduate from MIT from the mechanical engineering department for half of what he was offered to come here to Georgia Tech. So, and then on the other end of this we have guys that are out there like Elon Musk—there's a gentleman named Bob Bigelow in Las Vegas, who is—and he has about 60 people working on inflatable structures in space on his own money. There's a—the difference for the United States is that people feel the ability to do anything that they feel they can envision as something to do with their time and energy and money and they go and do it. And they can drive a whole string of jobs that are possible there. And even though we may not be able to predict, just like all over the free market we can't predict what those jobs are going to be, if we take the first step and create it—and, you know, responding to Mr. Tyson's comment or Dr. Tyson—when they originally did air mail, there were no passengers on the first flight. The

government was the only customer for those flights. It was only—it became viable when they said, “Do you have any problem with our flying passengers as the same flight as the mail?” and the government had the foresight or perhaps just serendipity to say, “No, no problem, go ahead and do it.” And that’s where the whole thing came from.

### **Pete Aldridge**

Mike?

### **Michael Jackson**

Thanks, gentlemen, for this line of testimony. I would like to try to unpack just a little part of it. If we are going to do business in a different model, something that I am personally highly sympathetic to, I want to try to understand what the full toolkit looks like to maximize the prospects of success for the private sector filling the role here that government has previously filled to the maximum extent possible. And I’m just going to say that I understand that there are elements of what has to be accomplished to meet the President’s vision that we can’t immediately off-lay to the private sector; so that getting into low Earth orbit might be one very obvious thing now. And, I would say, as we develop in a spiral development mechanism, more assets, where that line is will continue to grow farther out.

But that being said, it’s really the launching of the enterprise that seems to me to be the hardest and setting it on the right course, and so I’m looking for the toolkit. So some of the things that I have heard here are we have talked about trying to get the private sector, the VC market, and the normal sort of capital investment tools to work. What other things can we use to help that? So, for example, we heard yesterday from states who are trying to do economic development work who will make it attractive to support businesses that invest. That’s a tool we need to be having in our toolkit. We have heard about the idea of prizes, and I think that it seems like there may be some role properly configured for prizes. I’m curious about how you sort of jump-start the first six or eight people. Do you—I’m thinking of In-Q-tel, for example, the CIA’s venture capital firm that goes out and picks promising technologies and firms and in essence becomes a venture partner with those firms. DARPA at the Defense Department has a similar sort of role. When we build aircraft for the Air Force, we have a bake-off and typically put some money up front to partner with the people that are going to make it. What—I am just throwing out ideas here, and I would just like to ask one other layer—is this all just U.S. focused, or should we be getting help in this enterprise internationally, and if so, how does that work as well? So that’s a broad plate of open invitation, but talk about tools.

### **Stephen Fleming**

Let me focus on the first half of your question, if I could—what tools do we have? I do think there is a lot—as we heard earlier, I think there is a lot we can learn from DoD. I think DARPA has worked very well. I think the bake-offs have worked very well. I think some of the FAR

regulations and the requirements of FAR are incredibly hostile to startup companies. I believe in startups; it's what I do for a living. And when I realize that I have to hire more accountants than engineers simply to fill out all the paperwork required so that somebody can checkmark that, yes, they qualify for FAR regulations, that's extraordinarily frustrating. Am I suggesting we overturn the federal acquisition system? I'm not that bold. There ought to be a way to carve out some sort of relatively small acquisitions, whereas we mentioned at lunch we could just do them as fixed cost and say, "Hey, you bid a price, you know, we will pay it, and if you make an obscene profit on that, that's okay." But the DARPA model, something like that I think could go a long way towards getting some of these things jump started.

### **Michael Kearney**

On the subject of the FAR, there is a way, and our—the third contract that I mentioned earlier was actually—there are two parts of the FAR. The FAR part 15, which is the normal cost-[effect?] contracting mechanisms that is used on for everything for development and operations and everything else; but there also is a FAR part 12, which is a commercial one. And when they buy—when the government buys from Hewlett-Packard, they buy under FAR part 12. And under FAR part 12 you can essentially waive all of those boilerplate and pass-down and specs and ISO 9000 and everything else and just buy from the commercial market. So as long as there is a—and in the case we are talking about here where we might go to buy space access with multiple suppliers, which is key, add a fixed price, which is another key, because then you don't have the DCAA and all the other complications of that process. But then, and you know, and the fact that the second issue is that the first and foremost—and Stephen said this, but I want to reemphasize it—that when you are doing a business case, and I have done a lot of them, not as professionally as Stephen does them; I did it within the company of doing business cases—but the first and foremost issue is the market. How many of these am I going to be able to sell? And, you know, that's why when Hewlett-Packard does a market, they look at a market that exists and they look at "What share could we get?" That's a much easier argument than saying, "Well, I wonder if we built"—back in the 50s—"if we built a PC, I wonder how many people would buy it?" Well, how do you make that judgment? It's almost impossible. So the first step is creating a consistent, stable, profitable market where you can operate with competition. And it's essential that there be multiple suppliers so that that competition is there. I'm sorry—

### **Michael Jackson**

Does advertising play a role in this? You guys feel like that we should have brands on the sides of rockets going up?

### **Stephen Fleming?**

Why shouldn't we?

### **Michael Kearney**

You could certainly allow that to happen. But that and everything—I mean, if somebody wanted—people in the current environment—we actually had some guy come to us and he wanted to pay to bake a cake in space for his fiancé or something. And, you know, obviously, this is not something that NASA is going to say, “This is a great idea.” But the fact is, that from a commercial perspective, as long as it’s safe and it doesn’t harm the astronauts, we don’t care; we will take that money. FedEx doesn’t question, you know, that you’re sending something useless and frivolous across the ocean.

### **Pete Aldridge**

Gentlemen, we have run out of time again.

### **Stephen Fleming**

One more answer to Mike. Not only should we allow advertising; NASA should be able to advertise. We have talked about the workforce. We need to get a whole cadre of young people interested in this. They see ads for the Army; they see ads for the Navy; they see ads for the Marine; they never see ads for NASA. Why?

### **Pete Aldridge**

I would like to thank the panel. It’s been very interesting. Michael and Marco and Stephen, we appreciate your time. It’s been stimulating for us to hear what you have to say, and thanks for coming.

### **Pete Aldridge**

There was a time for a break; we’re not going to do the break; we are going to go into the last panel of the sixth presentation of the last day and a half. We’re going to depart from our usual format. For this conversation as opposed to formal testimony, we’ve invited representatives of the media to give us their perspectives on the level of public interest in space exploration. And I think they’re on their way. I’ll introduce them as they come. Have we got name tags or are you just going to take them down?

Daniel Stone is the president and CEO of Space Holdings, which includes Space.com, *Space News*, and Starry Night.

OK. And from the West Coast is Gary Robbins, the science writer from *Orange County Register*, the second-largest daily newspaper in southern California. And Gary covers human spaceflight and robotic exploration. His readers are very knowledgeable, given their pivotal role in shaping our nation’s space program.

And third, I hope we have here is Dr. John Copeland, who is a professor and John H. Weitnauer, Jr., chair; he is Director of Communications Systems Center in the School of Electrical and Computing Engineering here at Georgia Tech. He's a web specialist. Okay.

Well, I know I pulled a sneaky one on you, but I thought it better than trying to break and have to come back and then not have enough time. We were just going to press on. We will take the break afterwards. OK? Daniel Stone.

### **Daniel Stone**

Thank you, Mr. Chairman and members of the committee, the Commission. Thank you for the invitation to take part in these public hearings. We at Space Holdings are very pleased that you're focusing on the role of marketing media can play in sustaining the interest in the President's mission. By way of introduction and the slides—could we have the slide up there?—just to introduce Space Holdings, we are a multimedia company focused on capturing the value of people's fascination with space, science, and technological innovation. We're the parent company of brands including Space.com, the world's leading website for space technology and astronomy. *Space News* is a leading aerospace industry trade newspaper, led by Lon Rains, whom many of you know, and Starry Night, which is the award-winning family of astronomy software and DVDs. So we're all about bringing consumers and business people together with the universe around them through media.

I'm here to address problems that are very much on the radar screen of a CEO of a company that covers space extensively. That is NASA's seeming inability to excite and engage the public about the great work it is already doing and the great work it can do if the President's vision is fulfilled. This is a major stumbling block for NASA and our country's position of leadership in space exploration. Today I hope to lay out some of the challenges as I see them and some recommendations for how NASA can use marketing and the media to further its goals. When I was 7 years old, I remember my parents tugging on me to keep me awake watching Neil Armstrong and Buzz Aldrin on the Moon. And little did I know 35 years later I'd be on a board with Neil Armstrong. But not everybody is as fortunate as I am to spend all day long in the space industry and having to have dinner and chitchats with people as renowned as Neil Armstrong. And so there is the challenge and there is NASA's challenge. Neil recently was quoted as saying our economy can certainly afford an effort of this magnitude, but the public must believe that the benefits to society deserve the investment. And I strongly agree.

Kids are born with a natural interest in space, and this is evidenced by the success of the *National Geographic*, the Discovery networks and the Space Holdings—the media companies of the world that focus on reaching intellectually curious people. And with kids it's easy. It seems to be innate with kids. But NASA seems to have lost the ability to capture and retain this interest in furthering life and to ignite the passion. So NASA has a two-fold problem: It needs to excite the public and win their support in order to fulfill its goals, and it needs to invigorate its workforce with younger new talent to complete its long-term ambitions. In marketing parlance we call this a womb-to-tomb marketing strategy: getting them while they're young, all through

school, through professions, through their hobbies, and probably most importantly through popular culture—that's when the payoff really hits.

So to tackle these problems, NASA needs to go where it has never gone before. It has to enter the universe of marketing. For an organization that is dependent on public support and taxpayers' dollars, marketing should not be a four-letter word. And you only have to look as far as the U.S. armed forces to see examples where marketing works in the public sector. "Uncle Sam wants you," "Be all you can be," "An army of one." All these catch phrases are part of American culture just like "one small step for man." I spoke recently to a young astronaut, a good-looking guy, smart, quick wit. And he told me that on several occasions he talked to superiors at NASA about becoming involved in marketing, and they said, NASA doesn't do marketing, NASA does outreach. Outreach. Well, this is an example of outreach. This is a media kit that NASA gives out and it's a rather quiet presentation. And here's a story called "Information Summaries," which is a story of the Shuttles. Now this is a demonstration of outreach. And outreach itself sounds like a request for sympathy. Outreach by its nature doesn't inspire. NASA needs to do more than outreach. It needs to go out there and sing its praises from the highest mountains and sing its praises using satellite technologies that it helped develop to get it into people's homes.

The power of space to evoke and excite reverberates to the popular culture with mainstream advertisers harnessing that power from HP to MTV, from Radio Shack to British Airways, to the latest Diet Pepsi commercials, which poke fun at the Mars rovers. And so here is a copy of an HP and Disney ad, which is a very dramatic representation, and here is the outreach, and you can see the difference. So these companies like HP and Disney and Radio Shack are not as a rule space-oriented companies, but they understand the value of the idea of space exploration and the power it has over the public's imagination. Space is aspirational, it is intelligent, futuristic, innovative, high tech, and fun. All these companies I mention use space to market their ideas and products because space is where dreams and imagination take flight. And if they can do it, why can't NASA use the power of space to evoke space?

In the last year the American public experienced two historic events: the loss of the Space Shuttle *Columbia* and the successful landing on Mars with the *Spirit* and *Opportunity* rovers. During that same period, our website Space.com saw our audience of millions double. Why? Because a bold, effective NASA program was once again at the center of popular culture and political debate.

This audience goes far beyond hard-core space enthusiast to include a mass audience of intellectually curious people. But for many Americans, the work that NASA does is the closest they will ever come to seeing their best science fiction dreams come true. They love that they will live at a time when this is all happening, but while successful moments are uplifting, they're too few and far between to maintain the momentum that NASA needs throughout the program. Sustainability in the public consciousness—in other words, the popular culture—is key to the sustainability of the whole program. The American people need to know why is it they should care about the space program. They need to know what this means for them. They need to know that this is ultimately far more important than who, at any given time, occupies the office of the President or who is seated in Congress.

But NASA, I believe, has felt itself constrained from delivering that message. Unlike the armed forces, NASA does not advertise in any meaningful way in consumer or business media. And only a few times in the past has the space industry or one of the many space not-for-profits mounted a serious public relations campaign to let people know what NASA is doing. There is a widely held public perception that NASA is doing very little compared to what it did in the 1960s. I think everyone in this room knows that there are many, many great things that NASA is currently doing, yet I suspect that the public only knows of a few of them. And just coincidentally today in the *Wall Street Journal* in the regular advertising column is a story about the Army's advertising program recruiting recruits to the Army. So just as our branches of the military service advertise for recruits, so NASA can, and must, advertise for the support of its vision and inspire a new generation of Neil Armstrongs, Sally Rides, and Steven Squires. It's imperative that whatever prohibitions NASA has in place to actively recruit bright, young workers in an aggressive media-savvy way needs to be lifted. And to do that, NASA needs to harness the power of modern marketing techniques. NASA needs to sell itself to the American public.

Yet unlike the heroes of the Mercury, Gemini, and Apollo era, many of today's astronauts work in relative obscurity until a tragedy like *Columbia* thrusts them belatedly into the spotlight. NASA needs to market these people as natural heroes. It's about the popularization of dreamers who are also doers. Shortly after the *Columbia* tragedy I heard Commissioner O'Keefe talk about what a shame it is that astronauts don't appear on boxes of Wheaties. He was sitting there having breakfast with his kids and they were looking at the latest basketball player on the Wheaties box and said, "Astronauts belong on this box." Absolutely. And it's where kids can dream about their future plans beyond sports and into areas of science and technology and in this case, space. At Space.Com, *Space News*, and Starry Night Software, our three major brands, we have taken this several steps further. Wherever possible we let the scientists, the engineers, the program managers, the NASA center workers, tell their own stories in their own ways directly to our audiences, because these people are each a vital piece of something tremendously significant. At the same time we surround these messages with editors, professional commentators, and entertainers to provide context and to help make the message more entertaining.

Marketers use a shorthand to describe the aggregation of attributes that make an enterprise self-promoting. They call it the Cool Factor. If the Moon to Mars vision has one major strength, it is that it is very cool. We need to nurture this. The Cool Factor is a major touchstone with the public that's been put out of touch with the space program. Cool is not a pejorative. Cool is what people expect from the space program. NASA should be a cool place to work, doing cool things that beg everybody's imagination to get involved and support it. So in summary, my recommendation to the Commission to maintain public support and interest in the space program is three-fold: First, NASA needs to explicitly embrace marketing and invest behind it in popular consumer and business media, utilizing its greatest assets in the process: its people. Second, NASA needs to solicit the advice and counsel of professional marketing firms like any company would, and the armed forces certainly do. And third, NASA needs to work with established media and consumer products brands in public-private partnerships to more effectively reach its

target audiences in a consistent and impactful way. By doing so, NASA will have become much more intertwined within the fabric of the American public to help create the future together. Thank you.

### **Pete Aldridge**

Thank you very much. Gary?

### **Gary Robbins**

Good afternoon, Commissioners. Thank you for the opportunity to join this much-needed discussion between the media and the science community. I represent a company that is not just a newspaper; it's an information company. We have a newspaper, we have a very large website, we publish magazines, we produce CDs, we do things that end up on radio, and that's where our businesses are going. We're not just newspapers anymore. And we cover a county that has had a phenomenal contribution to the space program for 40 years. The second and the third stages of the Saturn rocket were built in Orange County. Skylab was built in Orange County. Segments of the International Space Station were built in Orange County. The two rovers that are on Mars at this hour were launched by Delta II rockets that were designed in Orange County. So what happens in the space program is of great interest.

I'm going to say something similar to him but a bit different. I was asked to address a very specific question: What makes a long-term program like the President's space initiative of interest to the public? What types of events and activities generate attention? In a second, I'll give you a couple of very specific suggestions. But I'm going to start by briefly putting the question into a broader perspective. Everyone involved in the Moon and Mars program needs to think about how they're going to deal with two largely overlooked issues that will greatly affect NASA's ability to generate interest and support. The pace of life today is much, much faster than it was during the time of the Apollo landings. We always seem to be in a rush, we don't have any time. This has had the effect of shortening people's attention spans. The front page of my newspaper has increasingly become an index. Readers tell us they want to skim a news menu because they don't have time to search for what they're looking for. That's a complicating factor when you're asking people to support a space initiative that would play out over decades, and which is unlikely to have few dramatic moments in the near term.

Secondly, it is useful to keep in mind that grabbing and holding people's attention is difficult and getting harder. We live in a media-saturated society, where people are bombarded around the clock with information, entertainment, advertising, video, sound—the onslaught just overwhelms our senses and it's tough to avoid. When I buy a can of soda at Seven-Eleven, I see news flashing on a TV screen at the front counter. I see the same thing at the supermarket. I see the same thing at gasoline stations. I'm subjected to a video when I take money out of my ATM. Everyone is competing for our attention, and the competition is getting more intense. TV is awash with reality shows and celebrity gossip programs that are becoming more outrageous in their quest for an audience. Local news outlets and cable news operations increasingly use

dramatic snippets of music and the words “breaking news” to draw you into stories that often aren’t newsworthy.

Newspapers like to say they’re immune to this, but that’s not true. We constantly tinker with the design to make it more eye catching, and one of the first things we do at my newspaper each morning is review a list of the ten stories that got the biggest number of hits on our website during the previous news cycle. That list is tantamount to TV ratings, and it subtly influences what subjects we cover and how much attention we pay to those subjects—subjects like the space program. So far, most papers have largely resisted the pressure to publish a lot of celebrity news on their front pages, but the pressure mounts. It’s there all the time. As a science writer, I’ve got to tell you, I was very thankful last week when Caltech and NASA announced the discovery of the planet-like body Sedna on a day when we were not distracted by Martha Stewart or Michael Jackson.

All right, so how do you break through this? What are the solutions to dealing with this? Although there are several that I think that you can do, and the good news about them is that most of them don’t cost anything. First, NASA needs to do a far better job of conveying what it is to live and work in space if it is going to build support for placing crews at a lunar outpost or sending people to Mars. The agency needs to put the *human* back into human space exploration. The public doesn’t have a feel for it.

Last week I asked a reader from Newport Beach—he was about my age and knows the Apollo program very well—if he could name even one of our current astronauts. He said, “No, but why would I be able to? I never see them on *David Letterman* or *Survivor*.” Well, he wasn’t being glib. What he was saying is that the public doesn’t have regular exposure to astronauts on mainstream television. He rarely sees them featured in the newspapers or on radio, on media websites like the one you see before you. The public needs to become more familiar with our astronauts. I’m not suggesting that you try to make celebrities out of them. But I am saying that astronauts like Michael Foale are fascinating people, they do interesting work. And the public should see them and hear them in a timely manner. NASA should book Mike Foale on the *Tonight Show* or *Letterman* or the *Daily Show* as soon as he returns from Space Station so we can hear him describe what it was like when he and Alexander Kaleri recently left the Space Station unmanned while they went on a space walk.

Foale should also do taped interviews with high-speed media outlets like OCREgister.com and Space.com. These sites are skilled at packaging interesting material in interesting ways. I have heard NASA say that the astronauts are too busy to do things like that. Are the astronauts any busier than Ms. Fiorina? Are they any busier than Dr. Zuber? No, they’re not. It’s a culture. That’s where the problem lies. It lies in the culture. And these venues are very important. I would ask you to remember that Arnold Schwarzenegger didn’t announce that he was running for the governorship of California at a news conference. He did it on the *Tonight Show*. The underlying point here is that people relate to people. The tragedy of the *Challenger* explosion was magnified by the fact that millions of people felt, on some level, that they knew Christa McAuliffe. The tragedy of *Columbia* was magnified by the fact that virtually no one outside of Houston and the Cape knew the names of those astronauts until the explosion occurred.

My second idea involves something the President said when he delivered his vision for NASA on January 14th. Mr. Bush said, "Beginning no later than 2008 we will send a series of robotic missions to the lunar surface to research and prepare for human space exploration." I immediately wondered whether the President was talking about the kind of robotic rovers that are now at work on Mars. If that is the case, then you might have the type of robotic explorer that could potentially stir significant interest. The Moon is comparatively close, is far more navigable than Mars. That means you could outfit a lunar rover with a camera that could transmit high-speed resolution images in near real time directly to media websites or to people's laptops or to their picture phones or to their PDAs or to their CDs, and while it may not sound likely, I see four people on this panel wear glasses. I've seen people at the media lab at MIT working on technology in which they're going to project full-length movies directly into your eyepieces. It's coming. It's not far away. The information needs to be vibrant and stimulating and in real time if you're going to get anybody's attention. You don't have to convince me of it. I would turn everybody's attention on this Commission to the back of the room. Look at the very back. There's a young girl sitting there. She's 15 years old. The girl with the stripes and the glasses, she's 15. You don't have to convince me that what we're going to do in space is important. What you're going to have to do is develop some type of program that say in four years, if we have a rover, appeals to her, and maybe she begins reading our stories and she becomes interested in going to Georgia Tech or MIT or U.C. Irvine or other schools that are involved in the sciences. That's who you need to reach.

Public interest in images from the rover is potentially huge. If you look what has happened on Mars between January 3rd when *Spirit* landed and yesterday, the websites run by NASA, the Mars websites have received almost 9 billion hits. And those are just the NASA websites, they don't count that website, OCREgister.com or Space.com. There is interest there; it just has to be channeled. People are paying attention because they can understand that. That makes sense to them. It's a clear mission, it has a goal. People don't pay attention to the Space Station because they don't think that it has a clear goal.

So you're going to have to do things that allow people in the public to participate on some vicarious level in space in order to keep them interested. I was talking to someone at NASA on Tuesday and he said, "You know, Gary, I would like you to look at something. NASA just put up a new feature on its website in which you can use your mouse to click on one of the rovers and you drag it to move it." The idea is that you would drive the rover on Mars. Well, I went to the web page and I took a look at it and I thought, "This is just horrible. The quality of what I'm looking at is just horrible." Do you think you're going to get any kid's interest when kids like that play with Play Station Two's and Nintendo's that have more computing power and higher-resolution graphics than anything that appeared during the Apollo program? The technology—when you think about what you're doing and as you go ahead, the emphasis needs to be not only on new spacecrafts and not only on new rovers, you have to pay attention to what the media technologies are going to be. Four years from now my newspaper probably won't be very much like it is today. Its website will be far different. So you've got to think what are the ways you're going to—what are you going to do to reach those folks? How are you going to do it? You need

to look outside of NASA. The reality is that Space.com is interesting, NASA.gov isn't. Thank you.

**Pete Aldridge**

Thank you, Gary. John? Thanks for coming.

**John Copeland**

Well, thank you. I was just recruited a few hours ago—I have a coat that's a couple of sizes too big for me—and asked to come up here and participate in the panel. I graduated in 1965 from Georgia Tech with a Ph.D. in physics. Back in '62 I spent a summer out at JPL working on magnetic memories for the Ranger series, and consequently have been very interested in spaceflight since then. My work for the last 11 years here at Georgia Tech has been with J-CAT. We developed this building in order to encourage the convergence of the various telecommunications technology along with media.

As an engineer, I can tell you that my interest and efforts are really in providing the ability to do things such as doing multimedia over the Internet. I'm sure the technical people at NASA are very similar to myself, and what they don't think about is the content in the marketing. And I think the other two gentlemen on the panel have made very good points that it would be very worthwhile if NASA would spend a little more time—somehow could get the budget to do this; I'm sure there are budget constraints—to provide good multimedia coverage of their efforts in space. You know, there was a lot of hoopla about multimedia five or ten years ago. We haven't seen that yet but it's coming. We're seeing high-resolution TV, it will probably be here in another three or four or five years, and as we're seeing with multimedia goggles, you can actually get a feeling as though you are present. I think of the impact that those black-and-white pictures from the Moon had, you know, back in the '60s and I see there's only a few people on the panel that probably watched those in real time. But my son was crawling around on the floor then about six months old and his grandson will be probably that age by the time we get back to the Moon. So it's a shame that we've let things lapse.

But when we go back I'm hoping there will be much more of an opportunity for many of us to go along in a virtual presence and participate in those activities. That virtual presence, I think, is going to be very important. And I think Buzz Aldrin probably made a good comment here that if we send people, we ought to make sure there's a good reason for sending people. Before we send people, robotic exploration can accomplish a lot and particularly if you have good communications so that you can get virtual participation in those robotic missions. Then as the conditions are ripe to have actual people following, I think that's an ideal situation to have. So I appreciate your listening to my two cents' worth. Thank you.

**Pete Aldridge**

Thank you. Les?

## **Les Lyles**

Well, thank all three of you again for being here. This is, again, a very, very important message that you're conveying to all of us here and obviously to NASA also. I was just thinking, the other day I was walking through George Washington University Law School with one of my twin daughters who will be going there next year. And I noted as we passed one of the bulletin boards in the law school a copy of the article from the *Federal Register* and *Washington Post* about a month ago rating the top government agencies—the top agencies to work in, and at the top was NASA. And I started to think when I saw that, “Boy this is something I bet the public does not—is not aware of. Unless they happen to read the *Washington Post* and the federal pages, they'll probably never see that at all.” I also started thinking back to my Air Force experience over the last five years and we, like NASA perhaps, up until about five years ago did no advertising until we got to a crisis stage. In our case the crisis was recruiting. We could not meet our recruiting goals. Army, Navy, Marine Corps were meeting theirs, we couldn't. So for the first time we started advertising and started marketing. We went from virtually zero dollars in marketing to now about \$60 million a year, and we hired a professional marketing firm to help us to do that. And it just sort of reinforced, again, when I saw that article on the bulletin board at George Washington University the other day that there's a tremendous message out there and somehow it needs to get out and somehow that's not being conveyed to the leadership of NASA. Maybe they don't think they're at a crisis stage yet; I'd perhaps like your comments and thoughts, whether you think they're at a crisis point where they need to think of and consider things like that.

## **Daniel Stone**

Well, I would think they absolutely are at a crisis point. The crisis is that you're not going to get many—NASA is not going to get many chances like this to make the types of investments that are on the table and that are capturing people's interest. Coinciding with a almost once-in-a-lifetime type of event with the Mars rovers or Mars being closest to Earth and the ability of people without telescopes to look up and see Mars. It's—a lot of events are coinciding to make all this be a very special time. So I think terming it a crisis is probably a good thing. And to pick up with something you said, you know, the NASA website is the second most active government website, and the first is IRS.gov. And without research to prove it, I'm willing to bet that NASA.gov is the most popular website. And if you look at the National Air and Space Museum, if you look at visits to planetaria, I mean, the numbers are huge. And then there's such a huge disconnect between that and the public image of NASA and NASA's involvement in popular culture. So it's almost—I wouldn't want to call it a [layup?], but, and I do disagree with one thing: While there are many ways that NASA can piggyback on other brands and other media companies because of how attractive it is to associate with NASA, it is going to require a lot of money, and it's money well spent. Just like the armed forces do spend a lot of money. It takes money to do it, but it's a good investment. But NASA does have the advantage of having the value of their brand rub off on partners, so they are probably going to get a much better deal than a commercial advertiser would.

## **Gary Robbins**

And what are you going to market? Two years ago I had a conversation—a ground-to-space conversation—with Peggy Whitson when she was on the International Space Station, and the conversation lasted for about 20 minutes, and the entire point of the conversation was to focus on the science going on aboard Space Station. I looked back at the transcript a couple of days ago in preparation for coming here and I realized, as I did before, that we really didn't have much to talk about because there isn't a great deal of science going on on Space Station. The public was promised that there would be, but there isn't. The size of the Space Station is nowhere near what it's going to be. So if you're going to market NASA, what are you going to market it to do?

I live in a county where people are deeply interested in space. After the President's speech, though, I didn't receive a lot of phone calls and e-mails about, "Oh, isn't this grand?" or, you know, "We've got to gear up and get ready to do this." I think people are kind of holding back a bit to see if it's real. They're holding back to see what you say. They're holding back to see if the money will come, to see if there's some kind of cogent program that makes sense. I would ask people to remember the real lesson of Apollo: The world stopped when Apollo 11 occurred. Everybody just stopped. Everybody remembers what Neil Armstrong said, many of us remember what Buzz Aldrin said, but does anybody remember what Pete Conrad said? He actually said, "Whoopie!" because Pete was five foot four and he was one of the funniest and most interesting people I ever had the privilege of knowing. But the point I'm trying to make is that by the time Apollo 12 took off, interest in the Apollo program had started to plummet. If you looked at the amount of media coverage and the amount of television coverage, it started to go down, and the reason it went down is that the public didn't feel that one thing was building on another, that it was building on another, that it was building on another, that it was leading to somewhere else. So as a reporter looking at this subject, I find myself wondering: this plan—is one thing going to lead to the next, is it going to lead to the next, is it going to lead to the next?

## **Pete Aldridge**

Maria?

## **John Copeland**

One of the things that NASA can certainly do is help us attract young people into science and mathematics. And I think it's important for them to think of their recruiting activities not only as recruiting the best from our schools but helping us create the largest possible pipeline of students going into the schools, because if we can attract people, more people, into engineering and math and technology, that's going to certainly benefit the U.S. economy. The truth is now, if you look at the graduate schools, you'll find that most of the students in graduate schools are coming from other countries, and that's certainly a shame.

## **Pete Aldridge**

Maria?

## **Maria Zuber**

Yeah, one of the things that I've always felt is that the popularity of space should become part of the fabric of our life, and this is a place where things like you people do, I think, plays significantly. Let me tell you a suggestion that I made to NASA awhile ago that just sank like a rock, okay? I said, "Well, we've got two orbiters in orbit around Mars right now, why aren't we doing—we could do a weekly weather report from Mars on the weather channel, okay? And, I mean we have this data, it's not at the popularity of the Mars rover stage, but we have this information, we know the high-low temperature, the cloudiness, the opacity, the dust loading, and you could do a 30-second spot on that once a week." And I was told this was just a terrible idea, okay? You know, but I said you'd look at that, you'd have kids looking at that, they could see the extremes. You know in the *Boston Globe* we publish the weather on the top of Mount Washington, which everybody looks at because the winds are always blowing horrendously and even in the middle of the summer the temperature is in the 20s up there, because it's an interesting micro-climate. Let me ask you, is there, would there be—maybe for Gary—is there like a place in the *Orange County Register* to do a little corner in the weather page about what the weather on Mars is like or on the Moon or somewhere else once a week?

## **Gary Robbins**

Absolutely. It would be—roughly once a week we publish whether the International Space Station is going over, when you could see it. That very kind of thing is something that I've actually looked at the NASA website for because sometimes you see references to weather on Mars. Absolutely.

## **Maria Zuber**

Well, that—let me just tell you that data exists regularly. And it—

## **Gary Robbins**

Where? And does it—Dr. Zuber, does it exist in a form that is easily absorbed and used?

## **Maria Zuber**

Well, it takes just a little bit of work, but it's just a little bit of work.

## **Gary Robbins**

Okay, I'm glad you used that phrase "just a little bit of work," because there's one thing I wanted to build on. We've been talking here and everybody else has been talking here about the need to change the culture of NASA. It doesn't end there. We need to change the culture of academia. I spent most of my life dealing with people like yourselves, people from the science community, and I spent most of my time trying to decode what it is exactly that people are saying. We need to change academia in a sense of giving people assurances that it's okay to talk in plain terms. A plain idea doesn't mean it's a simplistic idea, it just means it's an idea plainly stated.

I was driving in Orange County a few weeks ago and I went by a field and there was a lot of people playing soccer. Soccer is very popular in Orange County. And there was a woman, a mom, holding a baby in one arm and holding our paper in the other, and she's, you know, probably has a kid on the field. So she's watching her kid, she's holding her child, and she's trying to glance at our newspaper. If the scientific community isn't speaking in a clear voice that I can put in the newspaper, I can't catch their attention. What you really need—you need a bunch of Eric Landers. Eric Lander is a geneticist at the Whitehead Institute at the Massachusetts Institute of Technology, and I don't know that I have ever met anyone who is a better speaker, even more so than Carl Sagan, when it comes to the subject of science. His ability to convey the human genome is just extraordinary. His passion and his ability to relate it to everyday life. So science, the academic community, needs to do it, too.

## **Pete Aldridge**

Neil?

## **Neil Tyson**

I have a million questions, I'll keep it down to just a couple. I see a fine line between—no, it's not a fine line. Go back to the 60s and you had the Mercury 7; NASA didn't pay to advertise the Mercury 7, it was just well known that the public would be interested and the media came running. And *Life* magazine wrote the profiles. And so in a sense it was free advertising because the subject matter in a sense earned it. The reason why marketing is a four-letter word, it's because when you hear that someone is going to have to market an idea so that you like it, it kind of leaves a bad taste in your mouth because you're thinking that you'd be brainwashed into liking it rather than have your interest happen through natural causes. So I'm wondering where the line is that you draw between marketing something that you know people will feel good about having learned about and then what might be a backwash on that by people saying if they've got to—now NASA thinks they have to sell it to me even though I don't want to be sold it to begin with. How—

## **Daniel Stone**

I'd say the underlying premise is in fact it is very interesting, but that is insufficient, and I think it has to be somewhere in the middle between what is good for people and what people want to digest from a media standpoint. And so it has to be served up in a way that, and particularly with children, will enjoy and will be willing to consume. So if it's embedded that they learn something while they're playing a Play Station game, that's not bad. I think there's a little bit of arrogance, whether it's in the scientific community about deciding what's good for you, and I think it has to be a combination of the truth and being credible but at the same time packaged in a way that's consumable. And I don't think that's a four-letter word, *marketing*. I think the fact that having seen you recently speak and hear you eloquently talk about the cosmos is making it in a consumable, digestible way, and that's what I mean when I say *marketing*. It's associating with people and with personalities and with life and done in a way that makes it fun and interesting, but it doesn't take away from the credibility of the underlying information.

## **Gary Robbins**

I don't think you have to do an extreme amount of marketing if you're savvy. Look at the Jet Propulsion Laboratory in Pasadena. They have an extraordinary PR staff. They know how to work with reporters. They understand what they're doing is important and how to explain it. And they get you to the scientists, to the actual people who built it, who operate it, who run it, and who can explain it in lay terms in light speed. That's not the case if you deal with the Johnson Space Center and other aspects of NASA.

## **Neil Tyson**

So you feel they're meeting them halfway, basically?

## **Gary Robbins**

Yes, more than halfway.

## **Neil Tyson**

Just real quickly, my second one, and I'll stop there. Could you judge, based on your corporate profiles, what is the distribution of interest between space as represented by missions, hardware people, and space as represented by scientific discovery that's not specifically tracking the hardware? So for example, it may have involved the space-launched hardware, but the story line is not the hardware itself. For example, the WMAP mission to map the cosmic microwave background. That's a cosmology mission that did make headlines at its time. Can you judge where the split is in the interest in your various holdings?

## **Daniel Stone**

Yeah, our baseline—Space.com is probably the best example to use. Our baseline traffic in consumer interest is on astronomy and scientific discoveries. That creates the baseline, and then we get surges when there are space exploration or missions. We get surges. And then over time, though, what we've seen, because we've been in business since 1999 now, is we see an increase in the base as more and more people are kind of sucked into the interesting parts of what's going on, and we've never seen that more true than in the last couple of months with Mars, which kind of brings it together. You have rovers on the space exploration side and then you have the science of what they do on Mars. And so it brings it together and I think one of our key goals as a media company is to help bring those two worlds together, to help associate space exploration with astronomy and science, because then it really gets interesting and fun and it ties it altogether. It's not discrete scientific discoveries and it's not discrete missions. They all kind of fit together.

## **Gary Robbins**

You don't have to launch a rocket to grab somebody's attention; it simply needs to be interesting. In about a week the author, Paul Davies, is going to be coming to U.C. Irvine to speak about multiverses, about multiple universes. This is a person that's a pretty extraordinary communicator. People are interested in that, they've already started to call us about "Where exactly is he speaking and what time?" If you get the information out there in a way that is compelling or allow them to find what's compelling about it, people are interested. Our surveys show over and over that the public is really interested in science, but you're dealing with a very big problem. It's called the Flintstones factor. The public literacy rate for science in America is very low. The National Science Foundation has done studies on this in which they asked the public a series of questions about basic science, do you know this, do you know that? Fifty percent of the people who were asked whether humans lived at the time of dinosaurs say yes. And they did it because most of them watched the Flintstones on TV. So you're dealing with that problem as well, but if scientists are better able to convey what their work is about, then that percentage would start to go down.

## **Pete Aldridge**

We have run out of time again, unfortunately. I'd like to thank the panel for coming and giving us some very interesting thoughts about how NASA can take their message to the people. Thanks for coming. We're going to take a quick five-minute break. We're going to reconvene and then I will draw some names out of this basket here for the audience to participate with us and make some statements, and then we will adjourn after that around 3:30 for a press conference. Five minutes, please.

### **Pete Aldridge**

OK, let's get started. We have a short period of time, and I'm drawing the first name. We have microphones here—is that the only one? OK. David Christensen? Where is David? Ah, good for you.

### **David Christensen**

First of all, thank you for this opportunity, and I must say I certainly got a lot of information.

### **Pete Aldridge**

David, before you get started, you have two minutes, and it really is a statement that you would like to portray to us, I don't—we're not in the mode of answering questions or things like that, but if you have a viewpoint, what ought to be done, what could we do better, we'd be delighted to hear it. OK?

### **David Christensen**

I think the challenge is absorbing all the information that's been put out here today and in previous meetings and future meetings and putting that into a very compact, straightforward document that communicates the essence of what you've heard here today. So I think that's a real challenge and I certainly hope you can do it.

### **Pete Aldridge**

It will be a challenge, I can guarantee you. But we are beginning to see some overall themes being portrayed to us, and it's very helpful. Also, I will introduce your name, but if you'll say what your affiliation was, that will also be very helpful. OK, I'm going to read three, and then they can all come down. Earl Babbitt, Richard Sylvan, OK, and the third one is Erian Armanios. OK. So, Earl Babbitt, number one. Earl?

### **Earl Babbitt**

I'm with Georgia Tech, but I'm here as a private citizen, I'm not professionally involved with the space program. I grew up with the inspiration of the Mercury, Gemini, and Apollo program, so by the time I finished high school, I knew I was going to be an astronaut. I was going to see and do things far beyond the horizon. And when Georgia Tech student Daniel Hegeman spoke here yesterday, it brought me back about 29 years ago when I was an aerospace engineering student at Georgia Tech. And back in the mid-70s I found there were a lot of former AE majors around campus, because at that time some of them, like me, found other interests, ran into too many calculus courses, or just found that job prospects were just more promising in other areas, because the space program was not continuing to inspire or create as many jobs as it did in the

60s. Now, there are some people who had a strong enough character and personal drive to maintain that vision. Many of the panel members who've been speaking before you or are members of the Commission itself. And these are the people who can lead us into becoming more of a space-faring society. America needs to encourage the development of space, not only to inspire our young people, but to nurture the vision of those who are so inspired, so that they can go on to do great things. I let the vision of my youth get out of focus, I drifted into other areas, still had a good life, been productive, but if I had gotten my act together, I really feel I could have been much more. I hope that America doesn't become like I feel I've been, that we don't waste the potential that's found in the ideas of our visionaries. As our nation's goals inspire people, I would hope our nation is inspired by some of the great people in our country. Many of those are folks you've seen or will be seeing before your Commission. Please help us develop an enduring vision so that this nation will become more than what it is, but more of what it could be. Thank you.

### **Pete Aldridge**

Richard, thanks very much, Earl. Richard?

### **Richard Sylvan**

My name is Richard Sylvan, I'm a family medical oncologist, I'm also on the Mars Society Political Task Force, and I've written a number of position papers on a variety of areas that are relevant here, which unfortunately I've not given to you, but at some point we may. Our feeling is that in 1986 many of the same things occurred that are occurring now, and after about two or three years of improvement, the [hysteresis?] of NASA got it back in its original position. Our feeling is that very much NASA will need continued oversight by a panel that is somewhat similar to this and has a constant renewal of new people coming on it to keep it on the straight and narrow; otherwise it will not succeed. It will change its current form under your pressure, but it will have a tendency to back as it has before to its more bureaucratic nature, and it needs to have a constant push to make it vibrant and alive, like the Lincoln Laboratory concept, constantly bring new people in, be competitive, get new ideas, and have the new ideas continue to formulate—new ideas and particularly young ideas, not ideas from old fogies like me, but from the people like Daniel.

Second thing, you need a broader base, and lots of people discussed how to get there. There are lots of areas of broader base you need. You need a broader technological base—private enterprise would be helpful there. The Suborbital Institute, [Pat Bond?], XCOR, will give you a broader base, but that's not sufficient. You need a broader idea base, and that could come on the cheap. The Mars Society is developing rovers from the University of Michigan. We've asked for volunteers to build it, give up three years of their lives, and what happened, we had to avoid being killed by the crush of people coming in the door. The Trans-Life program that you now have actually started as a Mars Society program, it's now at MIT, started in a similar way—ask Cal Tech and MIT if they wanted some volunteers, once again we had young people coming in

the door in a crush to create a private satellite in space with doing animal experiments. People—if NASA were to ask young people for very little money—give them perhaps a basic bus, develop an idea, have it be a piggyback, you would get ideas up the wazoo, most of which are crazy, many of which will be crazy and formulative, and you'll be able to bring young people in with new ideas, and it doesn't take a lot of money to do it.

Third thing is you need to increase your populational base. If you go out on the street, which I do, and give talks, to people on the street, or to schools, or to home schools, their eyes widen when you tell them about what's going on on Io with this huge volcano and this electric power plant going between Jupiter and Io, or the fact that there's a water world out there that we're going to examine, and we're going to fly to Pluto. And it's not just the kids; the adults' eyes get wide too. It takes NASA to make space boring. And space is not boring. It's not boring in Europe. I get European space journals; they have fun there. They're interested in *Mir*; they don't talk space down. And we've for some reason become cynical in this country and we do, and that cynicism is easily broken, because all you have to do is tell them about the cool stuff you're doing. As I said, I agree, *cool* is a great word.

Next, finally—

### **Pete Aldridge**

Richard, you're running out of time.

Richard Sylvan

OK. The last thing I want to mention, and this has to do with my personal area of radiation oncology and preventative oncology. You have to get physicians in your evaluation program of radiation risk. I do preventive oncology, or used to before I retired, and the risks that you're talking about populationally are huge. But a 3 or 5% increase of risk, we wouldn't even call that—that's within the variations of normal. We handle risks a hundred times greater than that with our current tools, and with the tools that are coming out now for genetic evaluation of people with high risk, we can handle that risk. The radiation risk—the maximum radiation risks that you have seen are far less than what we handle on a daily basis with high-risk cancer patients, high-risk genetic cancer, people with a propensity to cancer. And as I said, I'll probably send you a note on that if I may.

### **Pete Aldridge**

Okay, thank you. Erian? Before you step up, Erian, Judd Ready and David [Hitt?] are next.

### **Erian Armanios**

My name is Erian Armanios, I'm a professor in the School of Aerospace and the director of the Georgia Space Grant Consortium. Yesterday Daniel spoke [and it's rewarding?] I am teaching him [?] 120. Despite all of that, he spoke quite well. The point that I would like to make is two-

fold. The first one is I hope and I wish that your Commission will take a look at our litigation system. The current one, in a nutshell, stifles innovation. I would like for the students, for all learners to be free from the fear of making mistakes. That's how innovation comes. And the norm is there are no exact solution to every problem. Most of the problems have more than one solutions, and we need to help them, you know, have that in their mind as we set up our litigation system. I hope that your Commission will do something about that.

**Pete Aldridge**

That's one of our tasks. We're going to take a look at that.

**Erian Armanios**

The second point is being the director of the Georgia Space Grant Consortium I would like to urge you to use the resource of the National Space Grant program to do for space what the Sea and Land Grant Institution did for America on Earth. Thank you.

**Pete Aldridge**

Thank you. Neil, yeah.

**Neil Tyson**

There are some school systems that innovative teachers who have attempted this alternative way to teach so people can think about problems as broad things to solve rather than as singular solutions, and there are many parents who have resisted that because they fear that the children will not do well on standardized exams where there's only one correct answer. So the problem may be more complex than just changing the system. We have to change the attitudes of the adults who fear that their kids are not getting properly educated for having that kind of exposure.

**Erian Armanios**

Yes, and when Daniel yesterday was saying about the risk of jumping on the trampoline, according to you that's not a risk because it's a routine exercise, but for his parents I'm sure that it is. Thank you.

**Pete Aldridge**

Thank you. Judd Ready? And you're from where?

## **Judd Ready**

Judd Ready, I'm on the faculty here at Georgia Tech. Mr. Chairman and ladies and gentlemen of the distinguished committee, many Americans feel a malaise towards the U.S. space agency. It has even covered it all; news of this very public hearing will likely be a misrepresentation about the crew health hazard, the possibilities discussed earlier as a doom-and-gloom realistic certainty. If it bleeds, it leads. Mr. Chairman, you spoke yesterday and today that you seek a strategy to implement this vision. I say to you and other committee members that we need a vocal leader for this effort. We need a spokesman, a torch bearer to carry the regimental colors forward, a person of eloquent tongue, a person that exudes wit and charm and that possesses infectious enthusiasm and youthful vigor for space. We need someone that will not wither from a firestorm of false criticism but will rise to the challenge in its defense. Mr. Chairman, we're at a critical juncture in our journey into infinity. We're at a time when NASA may soon begin the task of lofting humans to the Moon, to Mars and beyond. This effort will be a program with unknown costs, incalculable benefits, and seemingly unconquerable challenges. Many, particularly those in the media and within the Beltway, speak of the inordinate and unreasonable cost of this effort, yet how many of those nay-sayers are aware that both the current and proposed NASA budget is less than a single penny out of every tax dollar paid. In fact, the amount proposed to be given to NASA by each taxpayer per year amounts to less than the cost of a cable television bill for a single month. Mr. Chairman and committee members, you must spark a vision in others of this promise of the future. You must hold our attention beyond the five-second sound bite or video clip teaser. You must reinforce the idea that there are things that are known and there are things that are unknown, and in between, therein lies exploration. That is what this public hearing is all about. By expediting this effort, we will rekindle the indomitable American frontier spirit. This program will be a long-needed reminder of our unquenchable desire to explore. It must commence immediately, not in 120 days, for this effort will truly make a difference in this society and perhaps it will rescue this nation, this space program, this generation, from a downward spiral of visionlessness and awaken us from our media-induced intellectual slumber.

## **Pete Aldridge**

Thank you very much. I think we got the message. David, as you walk up, Nick Furman and Ronald Menich are up next.

## **David [Hitt?]**

I'm David [Hitt?]; I'm a science writer. Ladies and gentlemen of the Commission, I thank you for your time. Mr. Stone and Mr. Robbins said most of what I had to say, but I wanted to respond to something that Dr. Tyson raised addressing the difference between the announcement of Mercury 7 quite a while back and today when Buzz Aldrin speaks before this room. The gentleman before me spoke of the need for heroes, and he had a long laundry list of their requirements. I would say that there are many, many people who meet those requirements in

today's astronaut corps and in the former astronaut corps, but it's no longer enough to say, "Here they are, come to them." We're living in a media age where we have to bring them to the public. You raised the issue of how do you sell something that should already be interesting. Well, you go to Hollywood, you look at Mel Gibson, you look at Julia Roberts, on and on, people that are interesting, that are headline names, and yet I guarantee you every one of them has an agent. Every one of them has somebody responsible for getting them on magazine covers, getting them on TV talk shows, getting them cameo roles wherever, getting them public appearances. This is something that it's not just a NASA issue. Dr. Aldrin said he is trying to figure out how he can best get out there to talk about these issues. They need someone, not just marketing but personal marketing, agent-type marketing, to get these people before the public. I thank you for your time.

### **Pete Aldridge**

Thank you, David.

### **Ronald Menich**

My name is Ronald Menich, I work for Manugistics, a mathematical software firm, but I'm speaking here as a private citizen, and my remarks don't reflect the views of my employer. Near-Earth objects or NEOs are asteroids and burnt-out comets that approach Earth a lot closer than other asteroids in the main asteroid belt. When Buzz Aldrin landed on the Moon in 1969, there were about 30 near-Earth objects that were known. When the *Challenger* blew up in 1986, there were about a hundred near-Earth objects that were known. And as of this morning when I logged onto the Minor Planet site of the International Astronomical Union, there were 2,717 near-Earth objects known, and scientists estimate that there are probably 100,000 or more that are out there, in which case we've only discovered less than 3%. This is a new phenomenon that I don't think that the American public really understands yet and doesn't understand the exploration potential that is there with near-Earth objects, and nor how easy these objects are to get to relative to other targets that have been identified in the President's vision, such as Mars. We all know how the MER rovers had a very challenging reentry into the Martian atmosphere, and they have fired retro rockets and bounced all over the place. It's much easier to get to many of these near-Earth objects, and if you could just imagine the new vistas that could be presented to the American public, the visuals of near-Earth objects, you know, good high-quality images from a carbonaceous asteroid that is blacker than soot, or of two bodies of equal sizes rotating, but there are some really exciting possibilities in the exploration of near-Earth objects, and they're at least as easy to get to as Mars.

### **Pete Aldridge**

Thank you very much.

**Neil Tyson**

Could I make a comment on that?

**Pete Aldridge**

Yeah, sure.

**Neil Tyson**

I just have a quick comment: Well, one of the things that astonished me, astonished me with disappointment, was the summer when we had tandem Hollywood budget blockbuster movies on that very subject; it was *Deep Impact* following *Armageddon*. There was a temporary interest and then it just went back to what it was before. I did a couple of interviews and I thought maybe there would have been a sustained media public interest, and it just did not stick around, and there we have all the ingredients—fear, danger, destruction, the stuff the public loves to read about and to hear about, and so I don't have the answer, but I agree it's something, it's an unappreciated, poorly recognized, important thing going on in space. And we'll work on that, but I'm a little bit at a loss.

**Ronald Menich**

I think high-quality, color images are what people love, and we need to get those from the surface.

**Neil Tyson**

Would it have [Earth?] written on it?

**Pete Aldridge**

We're going to have to go on. Nick Furman?

**Nick Furman**

I'm going to astonish some people that may know me here and pass and get with the Commission in writing, so thank you very much.

**Pete Aldridge**

Okay, thank you. Randy Avera and Grant Turpin.

## **Randy Avera**

Randy Avera. I'm former lead engineer for the structure of the Space Shuttle orbiters, 14 years at Kennedy Space Center as a NASA engineer. I'm also the author of *The Truth About Challenger* book, which was published three days before the re-entry crash of *Columbia* in 2003. There are three things that I would like to point out very briefly and request that this Commission relate this to the President and to the Congress. The first thing is that in my book and in public speaking that I do, very few Americans—in fact, I haven't met a single one yet—that understands where the charter of NASA is located in our public law, and so I educate them: it's in Title 42 of the Public Health and Welfare Codes, and they're stunned that this is where the NASA charter is located. That charter was written in 1958 and revised with the Space Act later, I believe, in the 1990s. What we've heard here the past day and a half about entrepreneurial businesses marrying with government responsibility, the government role is very important as well as the business role, but it's clear to me that as a nation we need to overhaul that NASA charter and bring it into a 2004 currency and relevant nature, and that's how we're going to implement all these great ideas. The implementation in my view is cornerstoned on that overhaul of that NASA charter.

The second point is that to be in the space business without heavy-lift-capability rockets that can place large masses and substantial volumes to distant places or even nearby places, we would not be in the game if we do not have heavy-lift capability. I was fortunate when I was in junior high to see three Apollo launches. They're spectacular, but what I like to say, we build the rocket to do the science, and what we're also talking about today is we not only are to do the science, we're to do the business—the tourism that we hear about, and other aspects of business.

And the last and third thing that I would like to say is that propulsion research and development is vital. We only know what we don't know, and we need to find out what we should know about this. Whether it's cryogenic, chemical, nuclear, electric propulsion. One of my mentors is Dr. Ernst Stuhlinger, who was on the von Braun team. He's about 90 years old now and he's still talking about developing electric propulsion. But we need to hit this with our academia and we also need to restore not the theory but the total belief that the American people own NASA. It is their investment, it is their space agency, and we have got to do everything that we can do. I spend my own time and money to remind people that we can't just depend on the President; we can't just depend on Congress or this Commission, it has to be the will of the people, and we have to move together and decide what the plan is and go forward with it and be firm about it and be long term about it, not giving up and not backing down, and anything that I can do to assist this Commission, the President or the Congress, as a citizen I volunteer my time and effort towards that goal.

## **Pete Aldridge**

Randy, thanks very much.

**Randy Avera**

You're welcome.

**Pete Aldridge**

Grant Turpin?

**Grant Turpin**

Good afternoon. My name is Grant Turpin. I'm with EchoStar Communications Corporation but I'm here representing myself. It's an honor to be here today and have my opinion heard by this Commission. I've got a hundred things I'd like to say and most of it's been said already by the panels that we've heard in the last day and a half. So I think I'm going to point out some unfortunately obvious things that have been on my mind. You've got 60—what was it, 65 countries, 3 million people hit the website for this organization as of yesterday. That's less than the population of Atlanta, where in Atlanta, Georgia, there's about 4 million people here in this city alone. It's a high-tech industry in this city as well, if not space oriented. Where are those people today? "Why are not more of them here?" I guess would be the question. And part of that does go to marketing and the media coverage. The last two days I have been watching the local news and have seen not one single report about the meeting of this Commission here. It's an open public hearing, and if you're going to get people interested, this information needs to get out there to them. But not one media report have I seen on any local news coverage. That concerns me, because if this is going to be a multi-administration, multi-decade program, you have to have solid public support behind the entire thing—not just the youth and not just the teachers, but the average person on the street who, you know, lives paycheck to paycheck. If you get that, if you get a solid public support behind this, that generates political support. From political support comes the money, and that will actually bridge across the administrations. Thank you.

**Pete Aldridge**

Thank you, Grant.

**Robert Walker**

Just to defend the local media for a moment, Mr. Chairman, I was watching Fox News this morning, the local Fox news station, and they had a fairly substantial piece on this Commission.

**Pete Aldridge**

We have run out of time. This concludes the third public hearing for the President's Commission. It's been an exciting time here in Atlanta. We appreciate all the help from all the

staff and support here. We've heard testimony from a wide variety of people, experts. We will continue to have hearings. We are having hearings in San Francisco on the 15th and 16th of April and again in New York City on the 3rd and 4th of May. At that point it will conclude our public hearings, and we will get in the mode of preparing a report for the President to be submitted the first part of June. Thank you for your participation, and we adjourn this meeting, and there will be a press conference shortly thereafter. Those of you who wish to stay are certainly invited to stay. Those who wish to and want to depart can depart. Thank you.