

COMMERCIAL HUMAN SPACE FLIGHT

JOINT HEARING

BEFORE THE

SUBCOMMITTEE ON SPACE AND AERONAUTICS

COMMITTEE ON SCIENCE

HOUSE OF REPRESENTATIVES

AND THE

SUBCOMMITTEE ON SCIENCE, TECHNOLOGY, AND
SPACE

COMMITTEE ON COMMERCE, SCIENCE,
AND TRANSPORTATION

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COMMERCIAL HUMAN SPACE FLIGHT

THURSDAY, JULY 24, 2003

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE,
JOINT WITH U.S. SENATE,
SUBCOMMITTEE ON SCIENCE, TECHNOLOGY, AND SPACE,
COMMITTEE ON COMMERCE, SCIENCE, AND TRANSPORTATION,
Washington, DC.

The Subcommittees met, pursuant to notice, at 10:15 a.m. in Room SH-216, Hart Senate Office Building, Hon. Sam Brownback, Chairman of the Senate Subcommittee, and Dana Rohrabacher, Chairman of the House Subcommittee, presiding.

COMMITTEE ON SCIENCE, TECHNOLOGY, AND SPACE
SENATE COMMITTEE ON COMMERCE, SCIENCE AND TRANSPORTATION
AND THE
COMMITTEE ON SCIENCE
SUBCOMMITTEE ON SPACE AND AERONAUTICS
U.S. HOUSE OF REPRESENTATIVES

WASHINGTON, DC 20515

Joint Hearing on
Commercial Human Space Flight
Thursday, July 24, 2003
10:00 p.m. – 12:00 p.m.
216 Hart Senate Office Building

WITNESS LIST

Mr. Phil McAlister
Director of the Space and Telecommunications Industry Analysis Division
Futron Corporation.

Mr. Dennis Tito
CEO
Wilshire Associates, Inc.

Mr. Elon Musk
President and Chief Technologies Officer
Space Exploration Technologies (SpaceX)

Mr. Jeff Greason
President
XCOR.

Jon Kutler
Chairman, CEO
Quarterdeck Investment Partners, LLC.

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HEARING CHARTER

**SUBCOMMITTEE ON SPACE AND AERONAUTICS
COMMITTEE ON SCIENCE
U.S. HOUSE OF REPRESENTATIVES**

JOINT WITH THE

**SUBCOMMITTEE ON SCIENCE, TECHNOLOGY, AND
SPACE**

**COMMITTEE ON COMMERCE, SCIENCE, AND
TRANSPORTATION**

U.S. SENATE

Commercial Human Space Flight

THURSDAY, JULY 24, 2003
10:00 A.M.—12:00 P.M.
216 HART SENATE OFFICE BUILDING

1. Purpose

The Senate Science, Technology, and Space Subcommittee and the House Subcommittee on Space and Aeronautics will hold a joint hearing entitled *Commercial Human Space Flight* on Thursday, July 24, 2003 at 10:00 a.m. in the Hart Senate Office Building, Room 216. The hearing will examine barriers to investing in entrepreneurial space ventures. Topics will include the market potential of space tourism, regulatory issues, private sector vehicle technology development, and capital investment considerations.

BACKGROUND

In 1994, the U.S. commercial space launch industry performed a study identifying future launch market opportunities and defining next-generation launch systems and requirements. In particular, the study concluded that while space tourism could become an economically viable industry, the insufficient revenue potential for building a space transportation fleet posed a barrier to realizing public space travel. Since that time, however, a string of space tourism market forecasts and surveys have indicated a growing demand for space tourism. As a result, new investors are emerging that are interested in funding entrepreneurial space ventures.¹ Despite the current downturn in the commercial space market, which is a reflection of and launch vehicle overcapacity, recent long-term forecasts for the orbital and sub-orbital space tourism markets² indicate that space tourism has the potential to generate upwards of hundreds of millions of dollars in revenue.

Several U.S. entrepreneurial space ventures are developing sub-orbital launch vehicles. They believe these vehicles are uniformly smaller, have lower performance and range (and therefore have less destructive potential in the event of an accident), and are inherently simpler and more reliable than existing intercontinental ballistic missiles (ICBM)—derived expendable launch vehicles, which are used to launch objects like satellites into orbit. Many of these sub-orbital vehicles can be tested in an incremental fashion, with early flights limited to airplane-like performance demonstrations followed by sub-orbital flight tests.

¹Wealthy individuals, that are successful in business, have decided to enter the commercial space market. Dennis Tito, who reportedly paid a \$20 million dollars to fly with the Russians to the International Space Station in 2001; Elon Musk, who founded his launch vehicle manufacturing firm by selling his internet companies for \$1.8 billion; Jeff Bezos, the founder of Amazon.com has also started a commercial space research venture called Blue Origin; Bob Bigelow, a real estate and land developer in Nevada founded Bigelow Aerospace; and Andy Beal, V.P. of Proranking.Com, an Internet search engine developer, was involved in the development of a new launch vehicle design are among commercial space entrepreneurs interested in creating commercial space launch ventures.

²Studies conducted in 2002 by the Futron Corporation.

By law, any U.S. commercial space launch activity requires a Federal Aviation Administration launch license. Among the eight sub-orbital space launch vehicle manufacturers that have initiated commercial launch licensing procedures with the FAA, only three have the potential to receive a license within two years. Some sub-orbital space launch operators believe a launch license could be granted sooner.³

Because launch vehicles, capable of reentering Earth's orbit, are currently too expensive to develop, these sub-orbital vehicles offer the U.S. space transportation industry a new, independent source of technical innovation beyond government's attempts at space transportation development.

The X PRIZE Foundation, established in 1994 as an educational, non-profit corporation dedicated to inspiring the private sector to make technological advances in space travel, is offering \$10 million to the first competitor that can carry three people to 100 kilometers altitude and then repeat the same flight within two weeks. Donors to the organization include Bank One, the Danforth Foundation, and the author Tom Clancy.

Government's role in developing a space tourism industry will be one of creating a stable regulatory environment. Furthermore, legislation that provides financial assistance for the launch and launch range segment demonstrates Congress interest in this area. In particular, legislation offered by Rep. Rohrabacher, "Zero Gravity/Zero Tax Act of 2003" (H.R. 914), is intended to provide incentives to create new markets in space by providing a tax moratorium on space-related income and capital gains exclusion for the sale of stock in space companies, including those involved in space tourism.

KEY ISSUES

How optimistic are the space tourism market forecasts and surveys?

A variety of market surveys and forecasts suggest a difference of opinion on the future prospects of public space travel. Early market research on the demand for space tourism indicated the general public's interest in traveling to space. While the findings were promising, these surveys did not indicate a potential market. The Futron Corporation's recent "Space Tourism Market Study" was the first undertaking to poll the interests of those financially able to take sub-orbital and orbital space flights priced anywhere from \$100,000 to \$20 million. The study also includes 20-year forecasts that indicate commercial space travel could manifest into a \$1 billion industry by 2021. These findings are the basis for commercial space entrepreneurs deciding whether to enter the space tourism industry.

What is the status of regulatory development?

Currently, there is no clear policy concerning how the FAA will regulate space launch for sub-orbital space tourism. This is primarily because of a jurisdictional dispute between two FAA organizations involving which has oversight over commercial human space flight operations. FAA's Aircraft Certification and Regulations Office (AVR), which regulates the commercial airline industry, believes that it should regulate sub-orbital space vehicles carrying tourist, because according to the U.S. Code for Aviation Safety, it has regulatory authority over passenger-carrying vehicles that traverse the U.S. national airspace. But FAA's Associate Administrator for Commercial Space Transportation (AST), which regulates traditional rockets of the kind that launch satellites into orbit, disagrees. AST asserts that its authority under the Commercial Space Launch Act (CSLA) [P.L. 98-575] authorizes it to regulate the U.S. commercial launch industry, including sub-orbital launch vehicles, even those that carry passengers should they be developed. Congress may be required to intervene legislatively to resolving this agency impasse.

How significant are regulatory barriers in making investment decisions?

Several U.S. commercial space entrepreneurs have announced plans to develop and operate sub-orbital space vehicles, but they face very high regulatory burdens. High altitude flight tests for these vehicles are currently subject to FAA experimental aircraft safety regulations, but those regulations prohibit these companies from flying passengers for compensation. Commercial space entrepreneurs are concerned that the cost of complying with existing regulations for certifying passengers aboard aircraft would be too expensive. They also argue that applying an aircraft safety certification regime to sub-orbital vehicles is inappropriate, because of the cost involved to comply with experimental aircraft regulations. Burt Rutan has

³Burt Rutan's Scaled Composites Company is an X PRIZE contestant, and has test flown its two-stage sub-orbital launch vehicle system (White Knight/SpaceShipOne). Rutan predicts he will be ready to fly his launch system to 100 kilometers (sub-orbital altitude) by the end of the year.

claimed that the cost of compliance could be ten times as great as the vehicle's development costs. Moreover, entrepreneurs would not want to set a legal precedent that their launch vehicles are experimental aircraft, because these regulations prohibit sub-orbital space launch vehicles to carry passengers for profit. They believe this situation can be avoided if AST were to regulate the industry and build an affirmative, enabling regulatory and legal framework that promotes development of operationally safe sub-orbital vehicles and services.

Should the government provide indemnification for space tourism activities as it does for other commercial space launch entities?

Currently, the government provides indemnification to the U.S. space transportation industry as a condition for obtaining a license to launch a satellite into orbit. Government liability risk sharing for third-party claim (for example, if a rocket flies off course and lands in a populated area) against a space launch company follows a multi-tier regime, in which the FAA determines the level of financial responsibility (up to the first \$500 million in damages) for the company, and requires the company to obtain private insurance against such losses. The government agrees to be responsible for damages that fall within a range of \$500 million to \$1.5 billion. The responsibilities for damages that exceed this range revert back to the company. An indemnification regime regarding sub-orbital space tourism does not currently exist, and whether it should exist for these vehicles remains an open question. AST believes it is the responsibility of the launch operator to acquire liability insurance to cover passenger claims.

What are the benefits and drawbacks of indemnifying commercial human space flight ventures?

All commercial space entrepreneurial ventures are anticipating that they will be able to purchase third-party liability insurance. Commercial space entrepreneurs believe insurance providers are basing their willingness to serve the sub-orbital space tourism market on the assumption that the government will grant space travel ventures the same liability risk-sharing regime that currently applies to all other commercial launch and reentry activities. The commercial space entrepreneurs also believe that new companies appear prepared to meet the same statutory and regulatory financial responsibility and insurance purchase requirements as the large aerospace contractors who launch satellites into orbit. But commercial space entrepreneurs reasonably expect to share in the existing indemnification protection against excess third party claims. On the other hand, indemnifying space launch vehicles that perform like airplanes translates into higher frequency of launch activity, which in turn, suggests increases in the probability of government covering damages to third parties. Whether an accident involving a sub-orbital space launch vehicle could cause damage in excess of \$500 million is unclear.

WITNESSES

Mr. Phil McAlister is the Director of Space and Telecommunications Industry Analysis Division at the Futron Corporation. He manages the corporations' industry analysis and market research. Over his career, he has participated in the design and development of new launch vehicles, the redesign of the International Space Station, plus several commercial satellite endeavors.

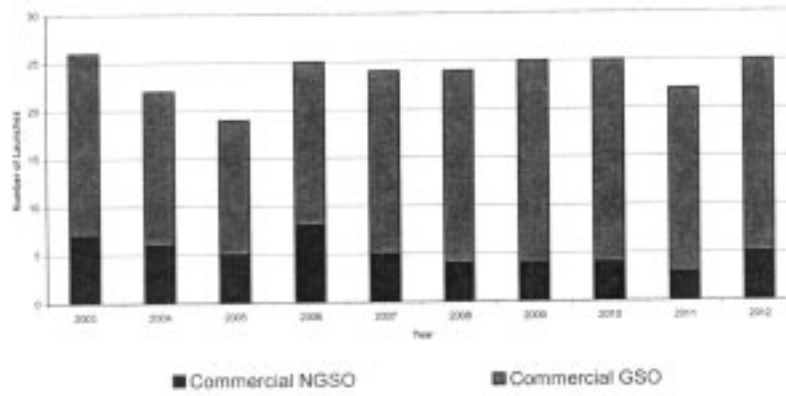
Mr. Dennis Tito is founder and CEO of Wilshire Associates, Inc., and created the first asset/liability model for pension funds long before actuarial and accounting firms began using the technology. Mr. Tito became the world's first space tourist in April 2001 when he was launched aboard a Russian rocket to the International Space Station.

Mr. Elon Musk founded two Internet companies Zip2 Corporation and PayPal. Mr. Musk is now founder and President of SpaceX, a launch vehicle manufacturing company that is developing a family of space launchers intended to reduce the cost and increase the reliability of access to space by approximately one order of magnitude.

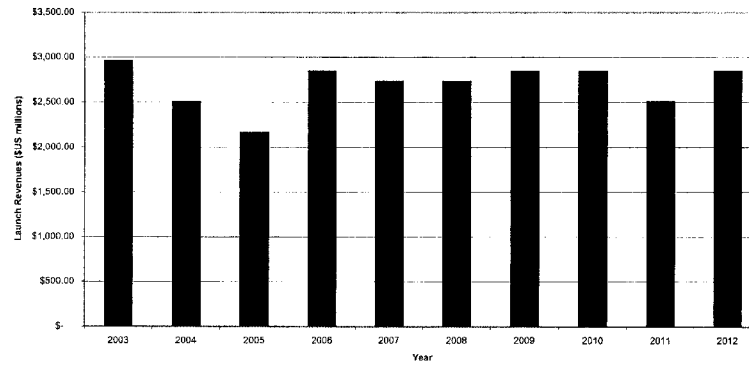
Mr. Jeff Greason is co-founded of XCOR. At XCOR, Mr. Greason has managed a team developing small rocket engines and complete rocket-powered aircraft. XCOR has demonstrated a very low cost reusable rocket vehicle, the EZ-Rocket, which has had fifteen flights. Previously, he spent two years managing the propulsion team at the Rotary Rocket Company.

Mr. Jon Kutler is Chairman, CEO, and Founder of Quarterdeck Investment Partners, LLC. Mr. Kutler is a nationally recognized expert in the field of aerospace and defense and he has served as Chairman of the White House Small Business Task Force on Defense Conversion.

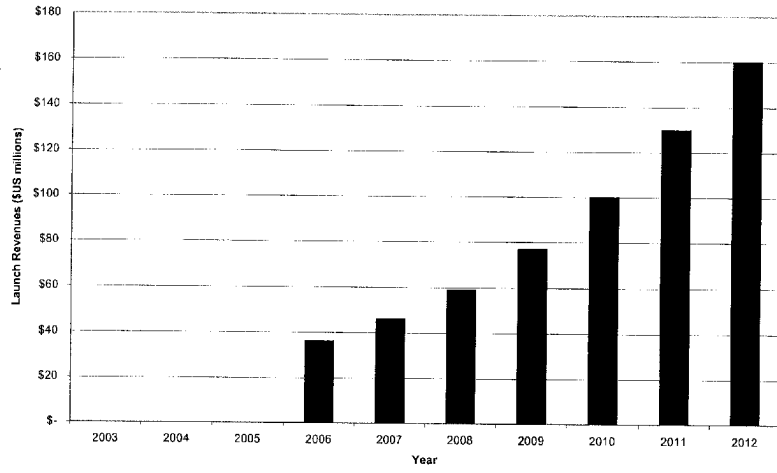
Total Worldwide Commercial Launches Projected for 2003-2012



Estimated Commercial Launch Revenues



Estimated Commercial Launch Revenues (Suborbital)



**OPENING STATEMENT OF HON. SAM BROWNBACK, U.S.
SENATOR FROM KANSAS**

Senator BROWNBACK: The hearing will come to order. Thank you all very much for joining us today. I'm sorry for being late. I was presiding and couldn't get out of the Chair, unfortunately.

Delighted to see the extent of participation this hearing has drawn as we delve into the future of space exploration, for the future holds—whether it be by way of governmental entities or by commercial space entrepreneurs, such as our distinguished panel that is joining us this morning.

I'll be having a brief opening statement, then I'll turn to Congressman Rohrabacher, the Chairman of the Subcommittee on the House side for this joint hearing, and his statement, and then recognize a Democrat from the Senate and then one from the House for an opening statement before we go to the witnesses. I hope that's acceptable to the other people.

I understand there may be votes in the House taking place. What we'll try to do is just keep the hearing going, if that's acceptable, just so that we can move on through the panel.

I appreciate the participation in this joint hearing that's taking place. I think this is a good forum and a good format for us to follow as we explore issues on space and how to move forward.

Over the past months, Congressman Rohrabacher and I have met to discuss our thoughts about space exploration and to help—he and I are both in positions to help push space exploration beyond the bureaucracy that's influenced the industry for so long. Through conversations with Congressman Rohrabacher, space industry representatives, some of our witnesses even here today, I realized that we have an important duty and opportunity for us in Congress. We must increase the sources and numbers of entities entering space.

In the 1960s, we had the goal of getting a man on the moon and return him safely to earth, and that served as an inspiration to so many across the Nation. Today, America is lacking a similar vision. I'd like to see the U.S. embrace a vision, a new vision, an idea of dominating, commercially, militarily, and for exploration, the Earth-Moon orbit. This is a goal that Americans can grasp and aspire to. NASA will be a key entity in this vision, but so will the private sector, which we'll hear from today. Also critical will be the military and intelligence organizations, and obviously the scientific and exploration community. We need to dominate space and the Earth-moon orbit for exploration, scientific discovery, as a base for future missions to Mars, for security purposes, and for commercial enterprise. We will do this for the benefit of humanity.

I stated that I embraced the recommendations of the final report of the *Commission on the Future of the United States Aerospace Industry* when I first took over the chairmanship of this Subcommittee. I believe this report is accurate, in assessment of the aerospace industry, and addresses several important areas of space exploration. The Commission recommended, quote, “the United States boldly pioneer new frontiers in aerospace technology, commerce, and exploration,” end of quote. It also recommended that, quote, “the United States create a space imperative, where partnerships between government agencies and industry share innovations

in aerospace technologies.” These are just a few of the many recommendations listed in the final report. However, these recommendations are why we are here today.

I want to examine how Congress can help ensure a strong future for the United States in the commercial aerospace industry. It’s my hope that today’s hearing will shed a great deal of light on the status of commercialization of space and the capability for space exploration. Additionally, I hope our witnesses will share with us today the experiences they’ve had in this endeavor and what barriers they’ve encountered that may prohibit the private sector from contributing fully to the effort.

I want to thank Congressman Rohrabacher for his leadership and efforts in this area. I welcome him and the other House Members here to the Senate today. I appreciate our witnesses being here today, and I look forward to their testimony and engaging in a question-and-answer dialogue.

With that, I would turn it over to Congressman Rohrabacher for his opening statement.

**STATEMENT OF HON. DANA ROHRABACHER, U.S.
REPRESENTATIVE FROM CALIFORNIA**

Representative ROHRABACHER: Well, thank you very much. And I wanted to thank my colleague, Senator Brownback, for his leadership in determining America’s space policy, and that’s what we’re here to do. What is America’s space policy, especially in this very important part of the space arena?

Today, we will examine the barriers to investing in entrepreneurial space ventures. Dennis Tito’s historic trip to the International Space Station made the dream of citizen space travel a reality. He and other visionaries are now in the forefront of revolutionizing—revolutionizing, yes—space transportation by supporting sub-orbital commercial human space flight.

The benefit of these ventures offer—and let us stress this—offer us things that go a long way beyond “joyrides for the rich,” as it has been characterized by some of its detractors. Opening space to those who are willing to pay for the experience of it offers our industrial base a new source of technical innovation well beyond the government’s sphere of activities. I predict that, in the future, we will be having a lot of technological advances that take place in the private sector being utilized by the government, rather than the other way around, which it seems to have been for these last few decades. Simply put, by building and flying space-launch vehicles, commercial space entrepreneurs have already overcome barriers that seem to plague NASA. And that, of course—what we’re really talking about, in NASA, which we don’t see in the private sector, is an amazing level of bureaucratic inertia. And I have been told—a long time ago, I learned that bureaucracy is perhaps the most effective method known to man of turning pure energy into solid waste.

Unfortunately, a major barrier for new space-launch ventures is the uncertainty in government’s ability to create a stable regulatory environment. It is clear that the future of space commercialization hinges on the Federal Aviation Administration’s ability to resolve the issue of how to regulate commercial human space

flight operations. In my view, the Federal Government has the power to promote investor confidence by providing a clear regulatory guideline for commercial space-transportation operators. It can do that, or it can strangle this baby in the cradle. We're either going to have a healthy industry because government is doing its part of the job, or there will be no industry at all. And this insights into this. We're looking forward to our witnesses to talk about just how important this is.

Senator Brownback and I are interested in helping this nascent industry realize its tremendous growth potential. Our witnesses will provide us with a private-sector perspective regarding these and other critical issues.

And, again, I certainly appreciate Senator Brownback's leadership in trying to make sure that we overcome the hurdles here, right in the beginning, of what could be a fantastic new venture and adventure for humankind going into space.

Thank you very much. I yield back the balance of my time.
[The prepared statement of Mr. Rohrabacher follows:]

PREPARED STATEMENT OF REPRESENTATIVE DANA ROHRABACHER

I want to thank my colleague Senator Brownback for his leadership in determining American's space policy. Today we will examine the barriers to investing in entrepreneurial space ventures. Dennis Tito's historic trip to International Space Station made the dream of citizen space traveler a reality. He and other visionaries are now at the forefront in revolutionizing space transportation by supporting sub-orbital commercial human space flight.

The benefits these ventures offer, however, go way beyond offering joyrides for rich guys. Opening space to those willing to pay for the experience of it offers our industrial-base a new source of technical innovation well beyond government's sphere of activities. Simply put, building and flying space launch vehicles, commercial space entrepreneurs have overcome a barrier that apparently continues to plague NASA's bureaucratic inertia.

Unfortunately, a major barrier for new space launch ventures is the uncertainty in government's ability to create a stable regulatory environment. It is clear the future of space commercialization hinges on the Federal Aviation Administration's ability to resolve the issue of how to regulate commercial human space flight operations. In my view, the Federal Government has the power to promote investor confidence by providing clear regulatory guidelines for commercial space transportation operators, or strangle the baby in the cradle.

Senator Brownback and I are interested to helping this nascent industry realize its tremendous growth potential. Our witnesses will provide us with a private sector prospective regarding these and other critical issues.

I welcome the opportunity to learn from the entrepreneurs who are revolutionizing the commercial space industry.

Senator BROWNBACK: Thank you, Congressman Rohrabacher.

I now recognize Senator Nelson, as the Ranking Senate Democrat here, for an opening statement.

**STATEMENT OF HON. BILL NELSON, U.S. SENATOR FROM
FLORIDA**

Senator NELSON: Thank you, Mr. Chairman. And what a pleasure it is for me to join with my old House colleagues, Congressman Rohrabacher and—

Representative ROHRABACHER: Are we really that old?
(Laughter.)

Senator NELSON: You don't look it. Nor does Congressman Gordon. But I had the privilege of serving with them on the House

Space Subcommittee, and we had some good times, and these are good Members.

For those of you that I didn't have the pleasure of serving with, these two Members know a lot, and I appreciate their expertise.

And, Mr. Chairman, I thank you for doing a hearing like this. We are, of course, in the news today, dominated by the need to get the Space Shuttle flying again and to find out the cause and to fix it. I'm impressed with the Gehman Commission. I think they're going to come out with a good report. I must say that I think what we're going to find is that we can't do space flight on the cheap. And I must say that I was disappointed as I have started to go through some of the testimony that is held in a confidential manner by the Gehman Commission, disappointed as I was looking specifically for testimony as to the linkage between not giving NASA the adequate funding for safety, and that, over and over in the testimony, where the questions were asked and re-asked and re-asked, of the testimony that I read, they dodged the question. So that is something that our Committees, I think, are going to have to really dig into as we try to fulfill the dream that all of us have, which is that we have a robust and successful space program.

And, Mr. Chairman, I appreciate you calling this hearing, on a little bit different tack, as we are clearly involved in trying to get the Space Shuttle up and flying again.

Thank you.

Senator BROWNBACK: Thank you, Senator Nelson.

And as the senior Democrat on the House side here, for an opening statement, Congressman Gordon.

**STATEMENT OF HON. BART GORDON, U.S. REPRESENTATIVE
FROM TENNESSEE**

Representative GORDON: Thank you, Senator Brownback.

And let me congratulate you and Chairman Rohrabacher for the precedent in having this joint hearing. I think it's a good way for us to try to gather information in an orderly way.

Senator Nelson reminded me of some old history. I was the deciding—as a first-term member—the deciding vote on helping him to jump our hierarchy in the Space Subcommittee some time back and become our Chairman, of which he did a very good job.

Let me introduce, or rather, welcome our witnesses today. I'm glad to see you. I've had a chance to meet and talk with some of you before, and our conversations were both thoughtful and stimulating.

It's too soon to say whether public space travel will ever be more than a niche market for wealthy adventure tourists, but time will tell. In the meantime, I know that individuals on today's panels are spending considerable money and energy on the development of sub-orbital vehicles that can carry passengers to at least the edge of space and back. And there are also serious attempts to build commercial passenger-carrying orbital vehicles.

I'd like to hear more about your plans, what you consider to be the main challenges that you face. I'd also like to have the witnesses address some specific issues of interest to Congress.

First, the FAA currently has the authority, under law, to license sub-orbital launches. However, the law was silent on the definition

of “sub-orbital rocket” and “sub-orbital trajectory.” Does Congress need to clarify those terms? And if so, what definitions would the sub-orbital industry seek, and why?

Second, if these vehicles are carrying passengers and licensed by the Federal Government, I believe that there will have to be some type of safety review. Does the industry have its own set of proposed safety recommendations? And if so, what?

And, finally, do you think it’s appropriate for the taxpayers to provide indemnification to companies whose main business is likely to be flying wealthy adventure tourists? And if so, why? And should you have some responsibility that goes along with that indemnification?

Well, we’ve got a lot to cover today. I’m glad that you’re here, and look forward to hearing your thoughts on these issues.

Senator BROWNBACK: Thank you, Congressman Gordon. And those are thoughtful questions I hope we’ll get the chance to get addressed.

Our panel will be testifying in this order. And what we’ll do is, we’ll run this clock on a—let’s run it on a seven-minute timer, so it gives you a good idea.

We will take all of your written testimony into the record as if presented, so you’re entitled to, if you’d like, to just summarize. You don’t have to read through it. If you choose to read through it, that’s your choice. If you can keep the testimony somewhere in that five- to seven-minute ballpark, and then that’ll give us the most chance to be able to have as much interaction as possible. And then we’ll go down through the Members in the order that they got here, after the lead questions by the Chairman and the Ranking Members, then we’ll go on the order that people arrived at the Committee for questions, and we’ll do five minutes of questions each.

[The prepared statement of Ms. Johnson follows:]

PREPARED STATEMENT OF REPRESENTATIVE EDDIE BERNICE JOHNSON

First of all, I would like to thank Chairman Brownback, Ranking Member Breaux, Chairman Smith and Ranking Member Gordon for bringing us together for this rare and noteworthy joint House and Senate Subcommittee on Space and Aeronautics hearing today. It is always an honor to convene with our distinguished colleagues from other chamber. We are also privileged to have such notable witnesses who have agreed to testify on this very important issue, and we thank you for coming.

The purpose of this hearing is to examine obstacles to advancing commercial human space travel.

The much-publicized space tourist flights of Dennis Tito and Mark Shuttleworth make it clear that an alternative motivation for human space flight has emerged. Human space flight is no longer only about meeting the priorities of national governments and space agencies, but is also about the tangible possibility of ordinary people seeing the Earth from a previously exclusive vantage point.

The rationale for human space flight is evolving due to a growing commercial motivation. Human space flight can profit from an increased synergy between the public and private sectors. Space tourism can benefit immensely from the development of the necessary infrastructure, while public space programs can benefit from increased awareness and support for human space flight, generated by high-profile space tourism flights and a growing perception that space travel is closer to being within the grasp of ordinary citizens.

It is imperative that we today discuss the role of the government in any commercial human space travel program. One primary concern will be the regulation of safety, since space travel is inherently dangerous. Under no circumstances should we allow the desire for profits to ever interfere with the responsibility of maintaining safety.

With that being said, I would like to again thank the Chairs and Ranking Members for holding this hearing and the witnesses for agreeing to answer questions.

Senator NELSON: Mr. Chairman, may I be excused at around the hour of 11:00 o'clock? We've got the Palestine Prime Minister meeting privately—

Senator BROWNBACK: Sure.

Senator NELSON: —with our Foreign Relations Committee, and I need to leave at that time, with your permission.

Senator BROWNBACK: Certainly. I understand that.

The panel will testify in the following order. Mr. Phil McAlister—he's the Director of Space and Telecommunications Industry Analyst Division for Futron Corporation, out of Bethesda. Number two will be Dennis Tito. He's CEO and founder of Wilshire Associates, Santa Monica, California, who—he, himself has gone to space. Number three will be Mr. Elon Musk, CEO and founder of SpaceX, out of California. Number four will be Mr. Jeff Greason, President of XCOR Aerospace, out of California. And number five will be Mr. Jon Kutler, Chairman and CEO of Quarterdeck Investment Partners, out of Los Angeles.

Gentlemen, we are delighted to have you here on the first hearing on this topic of this style, where we've had a joint hearing of the House and the Senate. We really are interested in how we move this overall industry forward—government, private sector, together. And we look forward to your testimony.

Mr. McAlister, please start us off. Welcome to the Committee.

STATEMENT OF PHIL McALISTER, DIRECTOR, SPACE AND TELECOMMUNICATIONS INDUSTRY ANALYSIS DIVISION, FUTRON CORPORATION, BETHESDA, MARYLAND

Mr. McALISTER: Thank you, Mr. Chairman. Thank you, Committee Members.

Futron's contribution to this issue was through an analysis of the market for public space travel. We conducted a nationwide survey to examine the demand for space tourism with a strong emphasis on realism. The survey that we performed presented a realistic portrayal of space flight to respondents, and selected a survey population that could potentially afford to pay for this service. And most of my remarks are extracts from that analysis that we performed.

The current picture today is that tourists that desire unique, challenging, and fun experiences are the ones that are driving the demand for public space travel. This desire is currently fueling a worldwide tourism industry with receipts in excess of \$450 billion-U.S. Given the generous revenues associated with tourism, public space travel represents a huge potential market. It is only potentially large, however, because of the technical ability to service this market. It is only potentially large, however, because the technical ability to service this market is currently very limited.

Orbital space tourism became a reality in April 2001. Fellow panelist, American businessman Dennis Tito flew into space, docked with the International Space Station and was followed by Mark Shuttleworth about one year after that.

Orbital public space travel is currently limited to one spacecraft, the Russian Soyuz vehicle. Russia regularly launches Soyuz on supply missions to the International Space Station. Because only

two cosmonauts are required, and there are three seats, the third seat is available to potential space tourists. This creates a steady stream of flight opportunities for those interested in orbital public space travel.

And while most of the attention has been on this segment, orbital flights, sub-orbital space tourism holds significant promise. Space Adventures, a space tourism agency, currently claims to have over 100 reservations for sub-orbital flights, at a price of \$98,000 each, despite the current absence of a vehicle capable of offering such a flight.

The projected price of sub-orbital travel is a small fraction of the price of orbital travel; and, as such, puts space tourism within the financial means of a much larger audience. While there are no vehicles currently that can serve this market, a number of vehicles are in development. The primary forum for development is for private entrepreneurial ventures competing the X PRIZE competition, which will award \$10 million to the first team to privately build and fly a spacecraft capable of carrying three people to a hundred kilometers altitude twice in a two-week period.

All of these ventures—I'm sorry—in addition to the X PRIZE participants, there are several other companies and entrepreneurs attempting to develop vehicles to serve the sub-orbital public space-travel market. All of these ventures face a number of obstacles in their efforts to turn plans and prototypes into operation.

In addition to the technical obstacles associated with any new aerospace vehicle, passenger spacecraft will undoubtedly face major financial and regulatory hurdles. Given the nascent state of public space travel, Futron examined the current demand for this service via a nationwide survey, which featured the following components.

Only affluent Americans were surveyed. That is, the population that is most likely to be able to afford this service in the near-term.

Survey respondents were given a realistic description of what space travel experience would be like, both the positive and not-so-positive aspects. A former Space Shuttle commander vetted our description.

We asked survey respondents direct questions on space travel, as well as many other questions on the perceived risk, their current health, past buying habits, et cetera, to validate their answers, and we interviewed over 450 millionaires. Interviews lasted approximately 30 minutes, and this gave us a margin of error of plus or minus 4.7 percent. So we felt very confident about the results that we got.

Although a number of potential space-travel scenarios can be envisioned, we chose to focus on two: a 15-minute sub-orbital ride to the edge of space, and a two-week orbital flight to an orbiting space station.

Regarding the interest level in sub-orbital space travel, our survey results indicated that almost 20 percent of those surveyed were either definitely likely or very likely to participate in sub-orbital space travel. Further, these individuals were interested at realistic price points.

Regarding the interest level in orbital space travel, again almost 20 percent of the respondents indicated that they were definitely likely or very likely to participate.

We also did some options from the standard missions, and we noticed that the ability to purchase a trip from a U.S. company or to complete the required training, which is quite extensive for orbital space travel, inside the United States were potential options that most positively influenced interest level. Twenty-seven percent of respondents were much more likely to participate in orbital space flight if the trip could be purchased from a U.S. company. And over 60 percent of the surveyed pool would be more likely to participate in an orbital trip if they could train within the United States.

So incorporating these results, as well as the other questions and significant secondary research, we developed forecasts for these markets. And Futron is neither an advocate for or a participant in these industries, so we had a very objective, what we feel, realistic view on this market.

Futron's forecast and our conclusion was that sub-orbital space travel is a promising market. Our forecast for this industry projects that, by 2021, over 15,000 passengers could be flying annually, representing revenues in excess of \$700 million.

Orbital space travel is also a promising market. Our forecast for that service projects that, by 2021, 60 passengers could be flying annually, representing revenues in excess of \$300 million.

The challenge for the U.S. aerospace industry is to develop a vehicle that can cost-effectively meet this demand. The company that ultimately meets this challenge may come from the X PRIZE competition, it may be a traditional aerospace company, perhaps leveraging some government-sponsored technology, or it may come from a company not based in the United States. However, regardless of where the company comes from or how it meets the challenge, the demand for public space travel is real, robust, will eventually make someone very wealthy, and is one of the few areas where growth can be predicted for the launch industry.

Thank you.

[The prepared statement of Mr. McAlister follows:]

PREPARED STATEMENT OF PHILIP MCALISTER

Introduction

Yuri Gagarin blasted off into space and into the history books over forty years ago when he became the first person to orbit Earth. Alan Shepard followed one month later with a 15-minute sub-orbital *Mercury* ride in May 1961. Today, we are witnessing the natural evolution of those early events—space travel for members of the general public.

Despite this clear evolution, a number of factors have constrained the development of the market for public space travel. One of those constraints is the lack of knowledge about the potential market size for this emerging market. Futron Corporation, the industry leader in forecasting space-related markets, decided to address this constraint by objectively assessing the current interest in public space travel, and quantifying and forecasting the future demand for this service.

As neither an advocate for, nor a participant in, the development of public space travel, Futron was able to maintain a balanced and objective viewpoint on the future of this industry. Futron conducted a nationwide survey to examine the demand for space tourism with a strong emphasis on realism. The Futron/Zogby survey presented a realistic portrayal of space flight to its respondents and selected a survey population that could potentially afford to pay the prices for the service. The full results of this survey are available in Futron's report, *Space Tourism Market Study*. My remarks today represent extracts from that report pertinent to today's hearing.

Public Space Travel—the Current Picture

Tourists desiring unique, challenging, and fun experiences drive demand for public space travel. This desire is currently fueling a worldwide tourism industry with

receipts in excess of U.S. \$450 billion. Given the generous revenues associated with tourism, public space travel represents a huge potential market. It is only potentially large, however, because the technical ability to service this market is currently very limited.

Two distinct services are currently envisioned for public space travel: travel to low earth orbit or orbital flights, and short excursions beyond Earth's atmosphere and back, or sub-orbital flights. Each of these markets is in a different stage of development.

Orbital Flights

Orbital space tourism became a reality in April 2001 when American businessman Dennis Tito reportedly paid U.S. \$20 million to fly to space. Mr. Tito was launched on a Russian *Soyuz* spacecraft, which docked with the International Space Station (ISS) during the mission. Mr. Tito spent eight days in space, six of which were spent inside the ISS.

Tito's successful flight, carried out over the initial objections of NASA and other ISS partner nations, opened the door to further flights by paying customers. In April 2002, South African entrepreneur Mark Shuttleworth became the second commercial space tourist as a member of another *Soyuz* mission to the ISS. At the time of this writing, a number of other potential orbital passengers have been announced.

Orbital public space travel is currently limited to one spacecraft, the Russian *Soyuz* vehicle. Russia regularly launches *Soyuz* on supply flights to the ISS. Because only two cosmonauts are required to fly the *Soyuz*, a third seat on each mission is available to potential space tourists. This creates a steady number of flight opportunities for those interested in orbital public space travel.

Sub-orbital Flights

While most public attention on space tourism has focused on orbital flights, sub-orbital space tourism holds significant promise. Space Adventures, a space tourism agency, currently claims to have over 100 reservations for sub-orbital flights at a price of U.S. \$98,000 each, despite the current absence of a vehicle capable of offering such a flight. The projected price of a sub-orbital flight is a small fraction of the price of orbital travel, and as such, puts space tourism within the financial means of a much larger audience.

While there are currently no vehicles that can serve the sub-orbital space tourism market, a number of vehicles are under development. The primary forum for development is private entrepreneurial ventures competing for the X PRIZE, a competition that will award U.S. \$10 million to the first team to privately build and fly a spacecraft capable of carrying three people to 100 kilometers altitude twice in a two-week period. In addition to the X PRIZE participants, there are several other companies and entrepreneurs attempting to develop vehicles to serve the sub-orbital public space travel market.

All of these ventures face a number of obstacles in their efforts to turn plans and prototypes into operational vehicles. In addition to the technical obstacles associated with any new aerospace vehicle, passenger spacecraft will undoubtedly face major financial and regulatory hurdles as well.

Understanding the Current Demand for Public Space Travel

Given the nascent state of the public space travel industry, Futron examined the current demand for public space travel via a nationwide survey, which featured the following:

1. Only affluent Americans were surveyed, i.e., the population most likely to be able to afford a trip into space;
2. Survey respondents were provided with a realistic description of what the space travel experience would be like—a former Space Shuttle commander vetted our description;
3. We asked survey respondents direct questions on space travel, as well as other questions on the perceived risk of this and other activities, respondent's health, past buying habits, etc., to validate their responses; and
4. The Futron/Zogby survey interviewed over 450 millionaires (interviews lasted approximately 30 minutes each)—the margin of error was calculated at +/- 4.7 percent.

Although a number of potential public space travel scenarios can be envisioned, Futron chose to focus the study on the two previously mentioned public space travel scenarios:

- A 15-minute sub-orbital ride to the edge of space, and

- A two-week orbital flight to an orbiting space station

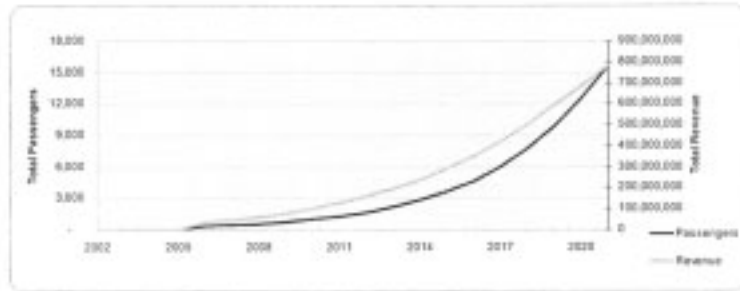
Regarding interest level in a sub-orbital trip, the Futron/Zogby survey results indicated that almost 20 percent of the survey population was either “Definitely Likely” or “Very Likely” to participate in sub-orbital space travel. Further, these individuals were interested in this service at realistic price points.

Regarding interest level in an orbital trip, again almost 20 percent of the survey population was either “Definitely Likely” or “Very Likely” to participate at realistic price points.

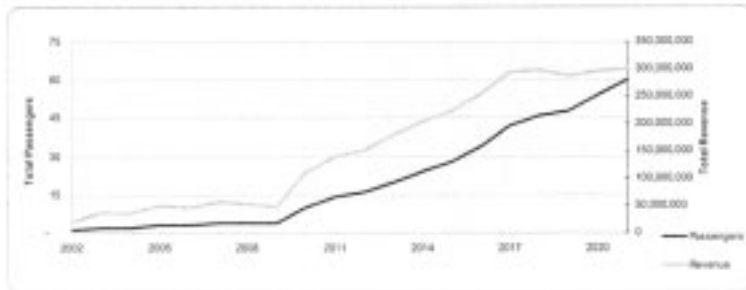
It is interesting to note that the ability to purchase a trip from a U.S. company or to complete the required training inside the United States were potential options that most positively influenced interest level. 27 percent of respondents were “much more likely” to participate in an orbital flight if the trip could be purchased from a U.S. company. And, over 60 percent of the survey pool would be more likely to participate in an orbital trip if they could train in the United States.

The Future of Space Tourism

Incorporating these results with other survey responses and secondary research, Futron developed forecasts of these markets. Our conclusion is that sub-orbital space travel is a promising market—Futron’s forecast for sub-orbital space travel projects that by 2021, over 15,000 passengers could be flying annually, representing revenues in excess of U.S. \$700 million.



Orbital space travel is also a promising market—Futron’s forecast for orbital space travel projects that by 2021, 60 passengers may be flying annually, representing revenues in excess of U.S. \$300 million.



The challenge for the U.S. aerospace industry is to develop a vehicle that can cost-effectively meet this demand. The company that ultimately meets this challenge may come from the X PRIZE competition; it may be a traditional aerospace company (perhaps leveraging some government-sponsored technology); or it may come from a company not based in the United States. However, regardless of where the company comes from or how it meets the challenge, the demand for the public space

travel is real, robust, will eventually make someone very wealthy, and is one of the few areas where growth can be predicted for the launch industry.

Senator BROWNBACK: Thank you very much, and I look forward to some questions about that.

Mr. Tito, you have been in space, and we look forward to hearing your thoughts and comments about this travel and this expanding industry.

**STATEMENT OF DENNIS A. TITO, CEO AND FOUNDER,
WILSHIRE ASSOCIATES, SANTA MONICA, CALIFORNIA**

Mr. TITO: Well, thank you, Mr. Chairman and Committee Members.

My space flight, two years ago, was probably the most euphoric experience of my life. And only by going to space, you realize what it's all about. And realizing that dream, after 40 years, was an experience that I felt, within about the first two seconds of burnout, looking out the window, and seeing that I was in orbit and had achieved my goal.

Over the last two years, I've given hundreds of speeches and spoke with over 10,000 people. A lot of people came up to me after these speeches and expressed their interest in human space flight and could identify with me, because I was pretty much like them. I was not some young pilot that had "the right stuff," other than the briefcase of money, which was labeled "the right stuff" in one cartoon.

(Laughter.)

Mr. TITO: They could identify with myself, you know, physically. They could see that it wasn't impossible to qualify medically or any other ways.

It began to dawn on me, although I had a very different opinion two years ago, that a sub-orbital experience was of real value, that even though it gave someone possibly only a three-minute slice of being in space, that, indeed, one achieved that goal, if, indeed, that was their dream. And for three minutes, they would be weightless, they would be able to look at 2,000 miles of California coastline or Florida coastline, and enjoy that experience and adventure of going to space.

This interest is confirmed by the fact that over 600,000 people have applied to NASA over the last 40 years to become astronauts and also Futron—Mr. McAlister's observations of the interest in space travel.

Now, I am an entrepreneur. I started my own business over 30 years ago, and I know a business opportunity when I see one. And this, indeed, is a huge business opportunity, not only to provide the first step of sub-orbital flights, but, in the long run, the development of a whole new industry of commercial human space transportation, point-to-point transportation that would eventually allow flights from New York or Washington to Sidney, Australia, in something like 45 minutes. It may be 50, 100 years before that's realized, but there eventually will be that kind of industry.

So I am ready to make an investment in a sub-orbital vehicle. I'm different than most investors, in that Wall Street will look at a business opportunity solely on the financial merits. I am a person that's passionate about space, so there's a lot more than rate-of-re-

turn-on-investment that is important to me. But, nevertheless, I don't want to pour my money down the drain. It's going to take a lot of money, and I want to have some reasonable probability of success.

I think the technological hurdles can be dealt with. I think the market is there. I'm not afraid of the competition. I would love to compete with Elon and—I think that would be a lot of fun, because I think there's big enough market for all of us.

The only problem, big problem, that stands before myself and others that want to do this is the regulatory risk. I understand what regulation is all about. I'm in the investment business. I have a firm that's a member of the New York Stock Exchange, regulated by the SEC. We also manage money, and we're heavily regulated. But we know who regulates us, and we know what the rules are. There are plenty of securities attorneys to explain that.

As far as sub-orbital space flight, we don't know who will regulate us. And it looks like the FAA might be involved in regulating us, at least on the aviation side, and that is very, very scary. For example, it's my understanding that it costs \$600 million to certify a Lear 45. Well, with that kind of certification cost, I would see that it would be impossible for this industry to begin. So we need some kind of separate recognition, as far as definitions, not only of what is a sub-orbital vehicle, but also the issue of space flight participants, namely—flying people in space, who is going to set the safety standards? What are the safety standards going to be?

If you take airplane-type criteria, say, for certifying a Boeing 777, I think it's one out of 10 million fatality rate. That is something that will be impossible with today's technology for space flight. The fatality rates, unfortunately, are very high, being one in 50. So we have a long way to go.

As a person interested in developing this business, I recognize that we will have to have a much higher safety standard. And one of the benefits of actually developing a commercial capability is, I think we will see much improved safety as we get a higher flight rate. There will be accidents. We have to look back at aviation 90 years ago and people that sacrificed to make commercial aviation what it is today.

The solution that I need comes in legislation. First of all, we need definitions of what is a sub-orbital RLV. Some definitions that have been suggested by AST, a division of FAA, say that the thrust should be greater than the lift of a rocket-powered vehicle for more than half the flight. That is a definition that I support.

We have to recognize that individuals are assuming risk, and, with some evaluation made medically, psychological, and training, they should be able to assume risks that are different than what the general public will assume by walking on an airliner. The people should be qualified, just like a scuba diver would be qualified to take—and trained—to take that risk.

The third area that I think is important is that there should be a clear distinction between the Office of Commercial Space Transportation and the aviation side of FAA, because if the aviation side of FAA gets involved, we're going to go on to a bureaucratic deadlock that's going to go beyond my life expectancy, and, therefore, be very difficult to invest. And that problem, of course, could also

be solved by taking the Office of Commercial Space Transportation out of FAA and having it report directly to Department of Transportation.

If this maintains—in five years, I see a successful business model being developed by people like ourselves, who can input capital plus the passion to make—show that the business works, that it can be profitable, and then we will see Wall Street lining up to invest the billions, tens of billions, maybe hundreds of billions, eventually, that will be required to develop the full reusable launch-vehicle capability, not only for sub-orbital, but orbital.

Thank you very much.

[The prepared statement of Mr. Tito follows:]

PREPARED STATEMENT OF DENNIS A. TITO

Thank you to the Chairmen and Ranking Members of both Subcommittees for your invitation to participate in this hearing today.

Over two years ago I achieved a lifelong dream by riding into space aboard a Russian *Soyuz* capsule, visiting the International Space Station, and returning safely to the Earth. I was fortunate enough to have built a very successful investment business, and equally fortunate that less than a decade after the Cold War, our former space race competitors had partially privatized their human space flight activities and were willing to sell me a flight.

Since returning from my mission, I have given hundreds of speeches to audiences in the U.S. and abroad in which I've shared my space flight experience. The response has been universally positive, and many listeners—especially young people—tell me how eager they are to go into space themselves. This isn't really newsworthy, given that some 600,000 people have applied to become astronauts over the past 40 years, and large percentages regularly tell pollsters they would fly on the Space Shuttle, even after *Columbia's* tragic loss. Perhaps more importantly, audiences seem genuinely inspired by the plausibility that one day they or their children could fly into space themselves.

Of course, very few people can afford to travel into space as I did, by paying roughly \$20 million for the privilege. Even that high price is probably artificially low, due to the ongoing economic hardships of the Russian aerospace industry. At the same time, NASA has had to postpone its development of a second generation reusable launch vehicle that could carry people and cargo into orbit at lower cost than current systems.

Yet there is a way to make at least a brief experience of space flight available to many more people. Just as Alan Shepherd and Gus Grissom flew sub-orbital Mercury missions before John Glenn eventually orbited the Earth, sub-orbital rockets can provide a person with a few minutes of weightlessness and a view of the Earth from 100 kilometers up. In just the past year, entrepreneurs in the U.S. and elsewhere have made significant progress in developing fully reusable sub-orbital vehicles which could economically loft adventure travelers into the shallow waters of space.

Two years ago, when I testified before the House Science Committee, I was asked if I would invest in a reusable launch vehicle company. At the time I said "no," and that was the right answer. . . .then. But today, after talking to thousands of people who want to fly into space and seeing the progress that's been made, my answer would be different. Today I would say "quite possibly."

There is, however, one barrier that keeps me—and probably many others—from writing out a check to fund the development of a commercial sub-orbital RLV. This stumbling block can only be overcome by people who work in this city, because the problem itself is located here.

Please understand me: I am not looking for government funding or technology. I don't need an investment tax credit or a loan guarantee. I'm not even looking to escape the regulations under which other space transportation companies operate. But I would like to know which government agency, and which set of regulations, will oversee this new industry.

You see, I am willing to risk my money on a technical concept and a team of engineers. I am willing to risk my money on the customers actually showing up. And I am willing to risk my money competing against other companies in the marketplace. But I am not willing to risk my money on a regulatory question mark, on

waiting for the government to decide who can give me permission to get into business, and what the regulatory standards for my business will be.

The Commercial Space Launch Act of 1984 gave the Office of Commercial Space Transportation the exclusive authority to license commercial launches, including sub-orbital rockets, and in 1998 Congress extended this authority to include reentries of reusable launch vehicles. But in the meantime, this office was moved into the Federal Aviation Administration, an agency that certainly has a lot of other issues on its plate.

Given that some proposed sub-orbital RLVs will have wings and take off and land from runways, a question has arisen whether these new vehicles will be regulated by the commercial space transportation office or by the FAA's much larger and more risk-averse aircraft and airline certification division.

This is not a matter of bureaucratic turf. When aerospace pioneer Burt Rutan rolled out his Spaceship One experimental RLV a few months ago, he declared that he had no intention of seeking FAA certification of his vehicle as a commercial airplane, because it would cost hundreds of millions of dollars to meet the same safety requirements as the Boeing 777. Rutan's whole privately-funded research and development program will cost perhaps a tenth of that amount.

If the Federal Government chooses to regulate this nascent sub-orbital RLV industry as stringently as it does the mature, 100-year-old airplane industry, then this new industry will die before it is even born. Even the possibility of such burdensome regulation may stop these new RLVs from ever getting off the drawing board, let alone flying into space.

One reason there is regulatory confusion is that the terms "sub-orbital rocket" and "sub-orbital trajectory" are used in the original Launch Act but never actually defined. Recently, the FAA has attempted to promulgate clarifying definitions of these terms, but has been unable to reach internal agreement. This paralysis is a perfect example of why investors such as myself are worried about how these ventures will be regulated.

Mr. Chairman, it was these two committees that originally crafted this legislation, and which share sole jurisdiction over the U.S. commercial space launch industry. I respectfully request that you reassert Congress' long-stated goal of promoting greater private investment in new domestic space transportation capabilities. This new industry needs the Congress to mandate in law an enabling regulatory framework for commercial sub-orbital human space flight, and ensure that this job be carried out by the Office of Commercial Space Transportation.

If Congress can reduce the huge regulatory risk faced by potential investors like myself, I believe that within five years we will ignite a revolution in commercial space transportation, and inspire a whole new generation of space-faring young Americans. That is a future I want to work towards for the rest of my career, and one I believe we will all be proud to have helped achieve.

BIOGRAPHY FOR DENNIS A. TITO

Dennis A. Tito is the Chief Executive Officer of Wilshire Associates Incorporated, a leading provider of investment management, consulting and technology services. Applying science to the art of money management, Tito and his team of 250 professionals utilize mathematical formulas to advise a wide variety of institutional and high net worth investors worldwide. Founded in 1972, Wilshire advises on about \$1 trillion in assets, directly manages about \$10 billion in assets, and provides analytical tools to some 350 institutions.

Tito earned a B.S. in Astronautics and Aeronautics from NYU College of Engineering and a M.S. from Rensselaer in Engineering Science. He began his career as an aerospace engineer with NASA's Jet Propulsion Laboratory at the age of 23. While serving at JPL, he was responsible for designing the trajectories for the Mariner spacecraft missions to Mars and Venus. Although he left to pursue a career in investment management, Tito remained interested in and committed to the exploration of space.

Employing the same methodology he used to determine a spacecraft's path, Tito is credited with helping to develop the field of quantitative analytics that uses mathematical tools to analyze market risks. In 1974, Tito developed the Wilshire Total Market Index (The Wilshire 5000), the broadest stock market index that Federal Reserve officials cite as a barometer of the U.S. economy.

Under Tito's guidance, Wilshire has consistently been an industry pioneer. As the world began entering the computer age, Wilshire integrated computers with engineering and investment concepts, to provide some of the first data to money managers, ultimately shaping modern portfolio management theories.

A philanthropist and civic leader, Tito supports and is actively involved in many charitable and civic causes including establishing the Dennis A. Tito Gene-Nutrient Interaction Laboratory at the UCLA Center for Human Nutrition. He formerly served as President of Commissioners for the Department of Water and Power of Los Angeles.

On April 28, 2001, Tito made history by becoming the first individual to personally pay to travel into space. Launched from Baikonur, Kazakhstan, Tito served as a crew member of an eight-day Russian *Soyuz* taxi mission to the International Space Station. By fulfilling his 40-year dream to travel to space, Tito captured the imagination of millions of people worldwide and renewed interest in the United States space program.

Born August 8, 1940, Tito has one daughter and two sons and currently resides in Pacific Palisades, California.

Senator BROWNBACK: Thank you, Mr. Tito. I look forward to our question-and-answer session, too.

Mr. Elon Musk, CEO and founder of SpaceX, who is looking to invest significantly in space travel, as well, from the private sector. Mr. Musk, delighted to have you here today.

STATEMENT OF ELON MUSK, CEO AND FOUNDER, SPACEX, EL SEGUNDO, CALIFORNIA

Mr. MUSK: Thank you.

On behalf of Space Exploration Technologies, I'd like to express my appreciation for being able to come before you here to address the issues related to access to space.

It is despairing to consider that the costs 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 the cost and increasing capability, often in ways we did not dream existed. We've improved computing costs by a factor of 10,000 or more, decoded the human genome, built the Internet, and made intercontinental flight available to the average citizen for no more than a few hundred dollars.

The exception to this wave of development has been space launch. But why? My best guess at the origin of the problem relates to the breakdown of a process that the economist, Schumpeter, called "creative destruction." He postulated that the way an industry improves is that new companies enter a market with a lower price or superior product. This creates a forcing function for the whole market to improve. Looking at space-launch vehicles, we see a situation where there's been not one single successful new entrant in four decades, apart from one company in the '80s. Even in that case, the solid rocket motors that constitute a majority of the manufacturing costs of its launches are, in fact, built by an old-line aerospace company. So we've really seen no truly new entrants to the American launch-vehicle market, and, therefore, should not be surprised that costs remain unchanged.

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 economic power in the world. If we can create such an environment, my expectation is that progress in space-launch costs and capability will be no less dramatic than in other technology sectors.

We are at a crucial turning point today. The recent entrepreneurial activity in space, my company perhaps included, shows promise, but it's still embryonic and fragile. It is very important

that our government, in all its forms, practically adopt a nurturing and supportive approach to new space-launch-vehicle developments.

It was to help change the equation of space exploration that I established SpaceX and set as our goal revolutionizing the cost and reliability of access to space, for nothing less is needed. Our first offering is a semi-reusable orbital launch vehicle called *Falcon*. Initially, we will deliver cargo to orbit in the form of satellites and spacecraft. However, we do believe in the long-term market for commercial human transportation.

There is no simple sound-bite that describes why our rocket is a fraction of the cost of efforts by existing launch service providers. Our approach has been to focus on reducing all of the cost elements of a launch-vehicle company, those being propulsion, structures, avionics, launch operations, and general overhead. We've also listened very carefully to the collective wisdom of key engineers involved with all major American rocket developments of the past three decades, to glean whatever lessons may be learned.

At this point, we're very comfortable that selling the *Falcon* for \$6 million per flight is economically viable. This is a reduction of over 75 percent, compared with our nearest incumbent competitor. Moreover, as SpaceX refines the recovery process for our rocket's first stage, we believe that the price can be further reduced.

As you will no doubt hear from others on this panel and have heard, there needs to be clear regulatory authority for commercial launch vehicles of all kinds. It is also critical that such regulatory authorities recognize the early and experimental nature of the commercial launch-vehicle industry, providing only the minimum regulatory burden necessary to ensure reasonable safety for the general public. I believe that should be the key criterion.

We recommend reaffirming the authority to the AST office of the FAA as the primary regulatory agent for space vehicles. Moreover, and very importantly, progress in fostering new launch-vehicle developments should be a key metric of success in the performance evaluation of AST and other federal agencies when they report to Congress.

Environmental approval is a significant issue. For existing launch vehicles—for existing launch facilities, where launches are routinely conducted, we believe that either a blanket environmental impact statement that covers all nontoxic launch vehicles, or a categorical exclusion, such as exists for airplanes, would be immensely helpful. This would save a substantial amount of expense, paperwork and processing time.

For example, certain issues of environmental concern seem to defy common sense. The population of seals in the waters around Vandenberg increased by 12.7 percent last year, yet much concern is raised about how rocket launches might disturb them, and we are forced to spend \$10,000 every launch to see if our relatively small rocket, which is nontoxic, affects their quality of life. This makes little sense. With that population growth rate, it seems clear that, if anything, the Vandenberg launch activity serves as an aphrodisiac.

(Laughter.)

Mr. MUSK: Liability. One of the surest ways of preventing companies like SpaceX from offering human transportation in the future is to make it an unlimited-liability business. Where a single unintentional mistake can result in a multi-hundred-million-dollar jury award, it would instantly kill not only the company that made that mistake, but the entire industry.

General aviation almost perished in the '80s as a result of one massive jury award, of questionable justice, after another. It was only revived once legislation placed reasonable limits on liability. Moreover, in contrast to the fledgling status of entrepreneurial space, aviation was a strong and mature industry with a well-developed immune system.

We believe it is appropriate that a limit be placed on liabilities such that, notwithstanding clearly egregious conduct, a mistake or force majeure event resulting in third-party injury, loss of life, or damage to property be limited to a reasonable maximum dollar figure.

For those that choose to fly on early passenger-carrying spacecraft, individuals should have the right to waive liability provided the risks are fully explained, just as would be done for extreme sports such as skydiving or mountain climbing.

And I'd like to say just a bit about how we see the market for commercial human space flight. The market for satellite delivery, while significant, has limitations in size and application. I suspect the far larger market in the long-term is serving people that wish to travel to space for enjoyment.

There is some skepticism about the market size and dependability. But such skeptics should study the early days of aviation as a guide. For many years before airmail service became the anchor that allowed the growth of commercial aviation, a thriving airplane business was underway around the Nation supporting the desire for an unprecedented adventure, an incredible notion that humans could fly.

Barnstormers satisfied that interest and became the crop of entrepreneurs and pilots from which commercial aviation would be developed. Why do we think that commercial space passenger services will be any different?

If we believe humanity should one day expand to the stars, then people must have some way to see for themselves what space is all about. They must share in its wonders and experience, firsthand, its meaning, and, in so doing, open the doorway to space for all.

Thank you.

[The prepared statement of Mr. Musk follows:]

PREPARED STATEMENT OF ELON MUSK

Senator Brownback and Members of the Senate Science, Commerce and Technology Space Subcommittee; Congressman Rohrabacher and Members of the House Space and Aeronautics Subcommittee; on behalf of the Space Exploration Technologies Corporation I would like to express my thanks and appreciation for the opportunity to come before you today to address issues related to access to space.

It is despairing to consider that the cost and reliability of access to space have barely changed since the Apollo era over 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 have improved computing costs by a factor 10,000 or more, decoded the human genome, built the Internet and made inter-continental flight available to the average citizen for no more than a few

hundred dollars. 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 a process that the economist Schumpeter called “creative destruction.” He postulated that the way an industry improves is that new companies enter a market with a lower price or superior product. This creates a forcing function for the whole market to improve. Looking at space launch vehicles, we see a situation where there has been not one single, successful new entrant in four decades, apart from one firm established in the late 1980s. Even in that case, the solid rocket motors that constitute a majority of the manufacturing costs of its launchers are in fact built by existing aerospace companies. So we have really seen no truly new entrants to the American launch vehicle market and, as such, should not be surprised that costs have not been reduced.

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 economic power in the world. If we can create such an environment, my expectation is that progress in space launch costs and capability will be no less dramatic than in other technology sectors. If we truly desire to reduce costs and substantially improve access to space, we must seek new approaches, new ideas, and support new entrants into this difficult and challenging field.

We are at a crucial turning point today. The recent entrepreneurial activity in space (my company perhaps included) shows promise, but is still embryonic and fragile. It is very important that our government in all its forms proactively adopt a nurturing and supportive approach to new launch vehicle developments, whether orbital or sub-orbital, manned or unmanned.

The SpaceX Approach

It was to change the equation of space exploration that I established SpaceX and set as our goal revolutionizing the cost and reliability of access to space, for nothing less is needed. Our first offering is a semi-reusable orbital launch vehicle, called *Falcon*. Initially, we will exclusively deliver cargo to orbit in the form of satellites and spacecraft, however we do believe in the long-term market for commercial human transportation. The reasoning for an early focus on satellites is that we feel this is the path of least market risk and it allows *Falcon* to prove itself as a satellite carrier, before we extend its use to other payloads.

There is no simple sound bite that describes why our launch vehicle is a fraction the cost of efforts by existing launch service providers. Our approach has been to focus on reducing all the cost elements of a launch vehicle company, those being propulsion, structures, avionics, launch operations and general overhead. We have also listened carefully to the collective wisdom of key engineers involved with all major rocket developments of the past three decades to glean whatever lessons may be learned.

At this point, we are very comfortable that selling the *Falcon* for six million dollars per flight is economically viable. This is a reduction of over 75 percent compared with our nearest competitor. Moreover, *Falcon* has 30 percent more payload and objectively fewer catastrophic failure modes, which speaks to reliability.

How Can the Federal Government Support This New Era of Space?

What I will provide today is the SpaceX view on concrete and rational actions that can be taken by the government to foster the nascent entrepreneurial activity. SpaceX is just over a year old, so these reflect only what we have learned to date. No doubt, there will be more to report a year from now, when, if the future is kind, we will have placed our first satellites in orbit.

It is worth noting that the perspective I bring to the launch vehicle industry is drawn from a particularly Darwinian experience in the business world, having founded and helped build two successful Internet companies in Silicon Valley. Seldom have we seen a faster moving, more voraciously competitive business environment or one with more tombstones. However, for all the problems associated with that era, the rise and fall and perhaps rise again of the NASDAQ, it is easy to forget that the vast majority of the monumental work required to build what we know as the world wide web was done in less than a decade.

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 private enterprise entered the picture. At that point, growth accelerated by more than a factor of ten. We saw Internet traffic grow by more in a few years than the sum of all growth in the prior two decades.

Our Suggestions:

Regulatory Authority

As you will no doubt hear from others on this panel, there needs to be clear regulatory authority for commercial launch vehicles of all kinds. It is also critical that such regulatory authorities recognize the early and experimental nature of the commercial launch vehicle industry, providing only the minimum regulatory burden necessary to ensure reasonable safety for the general public.

We recommend reaffirming the authority of the AST office of the FAA as the primary regulatory agent for space vehicles. Moreover, progress in fostering new launch vehicle developments should be a key metric of success in the performance evaluation of FAA-AST and other federal agencies when they report to Congress.

Environmental Approval

For existing launch facilities, where launches are routinely conducted, we believe a blanket Environmental Impact Statement that covers all launch vehicles within a certain size and capability would be very helpful. This would save a substantial amount of capital and processing time.

In particular, certain issues of environmental concern seem to defy common sense. For example, the population of seals in the waters around Vandenberg increased by 12.7 percent last year, yet much concern is raised about how rocket launches might disturb them and we are forced to spend \$10,000 every launch to see if our relatively small rocket affects their quality of life. This makes little sense. With that population growth rate, it seems clear that if anything the Vandenberg launch activity serves as an aphrodisiac.

Range Safety Approval

SpaceX has been asked by senior leadership in the Air Force to prepare a report on range safety approval once the process is complete for *Falcon*. That will be our definitive view, but these are our preliminary conclusions:

First, we suggest funding a zero-based revision of EWR-127-1 and the FAA equivalent documentation with a focus on simplicity, along with a clearly defined process for range approval. Rather than trying to amend the existing document, we feel, based on conversations with range safety personnel who have said as much, that the right approach is to do a ground up revision.

Second is the difficulty of designing and obtaining approval for flight termination systems, an important system on untested, high energy launch vehicles. This is the on-board equipment and explosives that, if needed in a major malfunction, would destroy the launcher and its payload. Today's low launch rates only sustain a few companies that provide these components. The result is that our flight termination system is one of the most expensive and difficult to integrate elements of our launch vehicle.

If the U.S. government wishes to advance commercial launch at our ranges, we suggest that range safety offer a standard, integrated flight termination system that it could pre-certify and then have launch firms simply buy them from the range authority. This would also improve issues of compatibility across launch vehicle designs. Our discussions with range safety indicate they would be amenable to such an approach. We would also strongly recommend eliminating the use of explosive for flight termination in favor of non-explosive engine shutdown, particularly for reusable components where explosives present a hazard upon recovery.

Liability

One of the surest ways of preventing companies like SpaceX from offering human transportation in the future is to make it an unlimited liability business, where a single, unintentional mistake can result in a hundred million dollar jury award. It would instantly kill not only the company that made that mistake, but the entire industry.

General aviation almost perished in the 1980's as a result of one massive jury award of questionable justice after another. It only revived once legislation placed reasonable limits on liability. Moreover, in contrast to the fledgling status of entrepreneurial space, aviation was a strong and mature industry with a well developed immune system. We are seeing a crisis in medical care for similar reasons.

We believe it is appropriate that a limit be placed on liability such that, notwithstanding clearly egregious conduct, a mistake or force majeure event resulting in third party injury, loss of life or damage to property be limited to a reasonable maximum dollar figure. For those that choose to fly on early passenger carrying spacecraft, an individual should have the right to waive liability provided the risks are fully explained, just as would be done for extreme sports, such skydiving or moun-

tain climbing. Whatever the final outcome of such efforts, it is critical that a complete review be conducted of the liability issue as applies to new passenger carrying commercial launchers.

Access to Government Markets

All we seek is the opportunity to sell our launch vehicles to the various agencies of the Federal Government. That requires full and unfettered access in which the government buys services, and does not enter into competition with us, using the public's money. Several ballistic missile assets have been retrofitted into commercial launchers. These vehicles, built and paid for to defend the country, might now prove to be an obstacle to commercial development of space. We seek government as a customer, not a competitor.

The Value of Commercial Human Space Flight

The market for satellite delivery, while significant, has limitations in size and application. I suspect the far larger market in the long-term is serving people that wish to travel to space for enjoyment. For many people, as shown by a number of marketing studies, this is the fulfillment of a lifelong dream and they are willing to spend a substantial portion of their savings to see that dream realized.

There is some skepticism about the market size and dependability, but such skeptics should study the early days of aviation as a guide. For many years before Air Mail service became the anchor that allowed the growth of commercial aviation, a thriving airplane business was underway around the Nation, supporting the fun or adventure factor.

Barnstormers satisfied that interest and became the crop of entrepreneurs and pilots from which commercial aviation would be developed. Why do we think that commercial space passenger services will be any different? If we believe humanity should one day expand to the stars, then people must have some way to see for themselves what space is all about. They must share in its wonders and experience firsthand its meaning.

And, in so doing, open the doorway to space for all.

That is what true access to space is about: creating affordable ways for people, payloads, satellites, and experiments to develop the space frontier.

Again, my thanks for the opportunity to come before you today, and I look forward to answering any questions that you may have.

Senator BROWBACK: Thank you, Mr. Musk. I look forward to your question-and-answer session.

Mr. Jeff Greason, the President of XCOR Aerospace. I apologize for mispronouncing your last name earlier.

Mr. GREASON: Understandable.

**STATEMENT OF JEFF GREASON, PRESIDENT, XCOR
AEROSPACE, MOJAVE, CALIFORNIA**

Mr. GREASON: Thank you, Mr. Chairman.

Today, I will discuss the different ways in which aircraft regulation and launch-vehicle regulation protect public safety, explain why the launch-vehicle approach is more appropriate for us, discuss how the line between them should be drawn, and close with a few remarks on commercial human space flight.

Aircraft regulation has always developed after-the-fact. The first aircraft regulations did not occur until after 20 years and tens of thousands of flights of operational experience in the aviation industry. When those first regulations came into play, the objective was to identify the best practices already present in the industry, identify what worked, and get rid of that which didn't. The assumption has always been that the only way to protect the public is to keep the airplanes in the air.

Over time, more and more such regulations have been drawn up. And after 75 years of this, the aviation industry is one of the safest human enterprises in the world and also one of the most resistant to the commercial introduction of new technology. Any innovation

that comes along, before it's adopted, has to prove itself at least as safe as existing practices. That's a very difficult thing to do, given that there are millions of flights experience with the current technology. Experimental aircraft are allowed to use new technologies, but only for noncommercial purposes.

Reusable launch vehicles are dramatically less mature. All launches to date have been single-use expendable vehicles, except for the Space Shuttle and very small sub-orbital rockets that are recovered by parachute.

The safety record of current launch vehicles is poor. A launcher with a safety record of one in 50 failures is considered to be reliable. As a result, launch-vehicle regulation has developed completely independently of aircraft regulation. In launch vehicles, we assume there is going to be a failure, and the emphasis is all placed on, "How do you ensure that that failure does not endanger the people on the ground?" As a result of that practice, no launch-vehicle accident has ever caused a casualty on the uninvolved public.

This safety is achieved by a combination of flying in sparsely populated areas and by providing a highly reliable means of stopping the flight if it goes awry.

In 1998, Congress expanded the field of launch-vehicle regulation to include reusable launch vehicles, and the Office of Commercial Space Transportation, AST, developed regulations to encompass those vehicles, based on their predictions of what their operation would be like. Because of that, it has taken four years of constant effort to work out how to interpret those regulations, because there were no precedents to point to see how they should be interpreted. But, after that work, we're finally getting there. Today, there are three companies, including our own, that are going through the licensing process for their reusable launch vehicles, all sub-orbital, plus there's Elon doing the orbital thing.

The only way that the emerging launch industry is ever going to develop into a profitable taxpaying industry is to fly, and to fly for revenue. While we fly for revenue, it's obvious that the uninvolved public has to be kept safe. And the only regulatory regime we have that allows safe flight for the general public while permitting revenue operation of untried vehicles is the launch-vehicle regulatory regime. That's how we have to fly.

Now, because some of the reusable launch vehicles being developed have wings, and some have pilots, the argument is being made that they are not launch vehicles, that they are airplanes. That is in spite of the Space Shuttle and Pegasus, well-established launch vehicles that have wings.

Congress defined "launch vehicles" to include sub-orbital rockets. Now, you might think, well, these are rockets, and they don't go to orbit, so isn't it obvious that they're sub-orbital rockets? It's a little more complicated than that, because we don't want to create a loophole in which somebody can take an existing aircraft, mount a rocket on it, but fly it in an aircraft-like manner and claim exemption from the aircraft regulations.

So it has taken a year of work for AST to come up with a definition that is new and that we think makes a lot of sense, which is that launch vehicles are rocket-propelled vehicles in which the

thrust exceeds the lift for the majority of the powered flight. And since aircraft are defined—or, rather, airplanes are defined as vehicles that are held up in the air by their lift, this is a distinction that we think makes sense and we can work with.

I'm going to close with a few remarks on the question of carrying people in launch vehicles. Launch-vehicle regulation already protects the uninvolved public. But, just as with aviation in the early days, there are people who think that enterprise is important and exciting, and they want to go. Also, just as with aviation in the early days, there's no question that the early flights are going to be risky and costly. But if we are allowed to proceed, that cost and risk will both go down over time.

We need to go through the same process aviation did. We have start flying, find out, with experience, what works and what doesn't, and then start improving. If we insist on perfect safety at the beginning of the industry, we will get it, because nobody will fly.

I have been responsible for committing a rocket-powered vehicle to flight with a pilot on-board 15 times, and I take that very seriously. I assure that I and my engineers are going to fly on these vehicles before we ever consider them safe enough for a paying passenger. And, also, we would never consider taking someone who is not fully informed and prepared of the risks that they were about to undertake.

But if Americans are willing to risk their lives and their wealth to open a new frontier, why should we stop them? There wouldn't be an America if our ancestors hadn't been permitted to do the same. Our first flights may seem small and unimportant, but they're only the first steps on a very long and very important road.

Thank you.

[The prepared statement of Mr. Greason follows:]

PREPARED STATEMENT OF JEFF GREASON

Today I will discuss the different ways in which aircraft regulation and launch vehicle regulation protect public safety, explain why the launch vehicle approach is more appropriate for the emerging sub-orbital space flight industry, and discuss where the line between aircraft and launch vehicle regulation should be drawn. I will close with a few remarks on commercial human space flight.

A few words about my experience in this area are in order. I am President of XCOR Aerospace, an entrepreneurial space company in Mojave, California. We have been working on safe and reliable rocket propulsion systems and vehicles since 1999. I have been involved in launch vehicle regulation issues since 1998 and have been traveling to Washington regularly to work with the FAA since 2000. In the last few years, XCOR has accumulated over 1,800 firings of rocket engines without any safety issues, and we have flown a manned rocket-powered vehicle fifteen times. These early flights took place as an experimental aircraft, and we are now ready to begin construction on higher energy vehicles. We are therefore bridging the two worlds of aircraft and launch vehicle regulation.

Aircraft regulation has always developed after the fact. The first aircraft regulations did not arise until after more than 20 years and tens of thousands of flights' experience. When the first regulatory actions were taken, the operating experience of the industry was used to identify best practices and to eliminate things that didn't work. The assumption has always been that to protect the public, we must prevent crashes. Over time, more and more such regulations have been written; usually toward a specific technology, e.g., this kind of riveting is acceptable, that kind is not. This kind of instrument is acceptable, that kind is not. After 75 years of such rule making, the aircraft industry is among the safest enterprises in the world, and also one of the most resistant to the commercial introduction of new technology. Any innovation must prove itself safer than the established practices;

a difficult burden indeed, given the millions of flights' worth of experience with established methods. Experimental aircraft are allowed to use new technology, but only for non-commercial applications.

Reusable launch vehicles (RLVs) are dramatically less mature. All space launches to date have been single-use expendable vehicles, except for the Space Shuttle and small sub-orbital rockets with parachute recovery. The safety record of expendable launch vehicles is poor, since a launcher with a failure rate of one in 50 is considered reliable. As a result, launch vehicle regulation has developed quite differently from aircraft regulation. In launch vehicles, we assume that failures will happen and we take steps to ensure that those failures will not endanger people on the ground. As a result, no launch vehicle accident has ever caused a casualty among the uninvolved public.

This safety is achieved by a combination of flying in sparsely populated regions and providing high-reliability means of stopping the flight if it goes awry.

In 1998, Congress expanded the regime for launch vehicles to include reusables. Since then, AST developed regulations for RLVs based on what they expected operational practices would be. It has taken four years of constant effort by AST and industry to devise and refine interpretations of those rules in the absence of precedents to point to, but we are finally getting there. Today, at least three companies, including XCOR, are going through the licensing process for sub-orbital RLVs.

The only way that the emerging RLV companies will ever be able to develop into a profitable, job-creating and tax-paying industry is to fly, and fly for revenue. And while we fly for revenue, the uninvolved public has to be kept safe. The launch vehicle regulatory regime is the only available means to protect the public while permitting revenue flight.

As recently as a year ago, I would have thought it obvious that our vehicle would be regulated as a launch vehicle. But events over the past year have shown that there are contrary opinions, which I hope we will lay to rest. The Commercial Space Launch Act of 1984, as amended, states clearly that if you have a launch license, no permission from any other executive agency is required. That language was put in place because the first attempts to launch commercially were stymied by overlapping jurisdiction; dozens of federal agencies all claimed the authority to say "no," but had no responsibility for the consequences, and hence no motive to say "yes."

Now, because some of the sub-orbital RLVs being developed have wings and pilots, some argue that these are not launch vehicles, they are airplanes. This claim is made despite the fact that NASA's Space Shuttle orbiters and Orbital Sciences's Pegasus both have wings. In 1984 Congress defined *launch vehicles* to include *sub-orbital rockets*. One might say "Well, it's a rocket, and it doesn't go to orbit, so it's a sub-orbital rocket." However, we don't want to create a loophole, in which an otherwise conventional aircraft could mount a rocket on it and claim exemption from aircraft regulation. After almost a year of work, AST proposed a new definition, in which *a sub-orbital rocket is a rocket-powered vehicle whose thrust exceeds its lift for the majority of its powered flight*. Since airplanes are defined as vehicles supported by lift, we think this is a good definition.

For those who have exclusively flown experimental-type aircraft, the launch vehicle regulatory world can seem daunting. On closer examination, it is less so: all that is needed is to demonstrate that the public is safe. This is only more burdensome than for experimental aircraft because the precedents are not yet set. The regulations and regime for test flying experimental aircraft are well known, and the failure modes are well explored. There are procedures for communications, emergency response, etc., written down. XCOR believes that requiring launch providers to document their procedures is worthwhile.

The largest burden in moving from aircraft to launch vehicle operation, and the least justified, is that launch providers and launch site operators have to assess their environmental impact. Aviation, including experimental aviation, operates under a categorical exclusion (CATEX) to the National Environmental Policy Act. We have discussed pursuing a CATEX with AST, but until there have been a number of reusable launch vehicles using non-toxic propellants, it is difficult to establish parameters for a category to exclude. Let me make it clear that the vehicles we and others are developing have very low environmental impact. And while the burden of documenting this is substantial, it is likely unavoidable.

Another advantage of the launch vehicle regulatory regime is that liability insurance is already established. Launch vehicles are required to carry liability insurance up to a level called the maximum probable loss (MPL). Let me make that a bit clearer. For me to launch, I have to carry sufficient insurance to cover any reasonably possible damage to third parties. The loss probability is set to a one in ten million threshold, which is so high that we could fly four times every weekday for ten thousand years before an event exceeding the MPL would occur. Only in the case

of a freak accident, with losses exceeding the MPL, does the U.S. government's promise of indemnification come into play. By eliminating the need for insurance carriers to consider wildly improbable accidents in setting insurance premiums, the insurance costs to launch providers are reduced, so far at no cost to the taxpayer.

I would like to close with a few remarks on the question of carrying people in launch vehicles. Launch vehicle regulation already protects the uninvolved public. Just as with aviation in its early days, many adventurous people see this enterprise as exciting and important. They want to go. Again, just as with aviation, this enterprise will be risky and costly in its beginning; but if allowed to proceed, the cost and the risk will go down over time. We need to go through the same process as aviation; start flying, find what works and what doesn't, then make improvements. If we insist on perfect safety, we will get it because no one will ever fly.

I have been responsible for over a dozen flights of a piloted, rocket powered vehicle. I assure you that I and my engineers will fly aboard our vehicles long before we consider them safe enough for paying customers. Nor would we ever consider flying someone who was not fully informed of the risk involved. If Americans are willing to risk their lives and wealth to open a new frontier, why should we stop them. America would not exist if our ancestors hadn't done the same. Our first flights may seem small and unimportant—but they are only the first steps on a very important road.

BIOGRAPHY FOR JEFF GREASON

Jeff Greason co-founded XCOR in September 1999. At XCOR, Mr. Greason has managed a team developing small rocket engines and complete rocket-powered aircraft at a cost and schedule far superior to prior practice. XCOR has demonstrated a very low cost reusable rocket vehicle, the EZ-Rocket, which has had fifteen flights. Previously, he spent two years managing the propulsion team at the Rotary Rocket Company. There he built a world-class development team, and led key technical efforts in rocket engines. Mr. Greason has been involved in space vehicle regulation since 1998 during the rule-making process for reusable launch vehicles and has been an active member of the FAA's Commercial Space Transportation Advisory Committee (COMSTAC) RLV Working Group since 1999.

Prior to joining Rotary Rocket, Mr. Greason served as a technical manager at Intel Corporation. In 1992, he received the Intel Achievement Award for his work discovering a less expensive BiCMOS technology than competitors, which became the basis for the Pentium product line. Mr. Greason is an experienced technical manager, has wide knowledge of rocket engine and rocket vehicle design from five years study and four years experience, and has nine years experience in other high tech product development. He holds 18 U.S. patents, has authored numerous publications and has a BS degree in engineering from California Institute of Technology.

Professional awards:

- Received Intel's Portland Technology Development S.T.A.R. award in 1997, an award given only twice before to recognize outstanding technical achievement, for work in defining the interconnection technology on Intel's 0.18u CMOS process.
- Received the 1992 Intel Achievement Award for contributions to "defining and implementing a unique, cost-effective approach to BiCMOS processing for Intel"
- Received Intel PTD divisional recognition awards:
 - 1992: "Implementing and validating Full Self Test features on the 51S6."
 - 1989: "The development of CLCD programs for hot electron checking."

Professional memberships

AIAA, IEEE, Society of Allied Weight Engineers, British Interplanetary Society, National Space Society, Space Access Society, Reaction Research Society.

Senator BROWNBACK: Good points. I was just coming from the floor, and we were discussing Lewis and Clark, who went on a bit of adventure, themselves, at one point in time.

Mr. Jon Kutler, Chairman and CEO of Quarterdeck Investment Partners, welcome, delighted to have you here.

STATEMENT OF JON B. KUTLER, CHAIRMAN AND CEO, QUARTERDECK INVESTMENT PARTNERS, LOS ANGELES, CALIFORNIA

Mr. KUTLER: Thank you. Thank you, Mr. Chairman, Committee Members.

I am here today to talk about what Mr. Tito referred to as, I think, “the Wall Street perspective,” and how institutional investors would look at funding developments in this sector. I’d personally like to applaud the efforts of the individuals before me. I think we all can appreciate that they are the type of people who have traditionally taken our country to new heights of technological development, pushed the envelope, and created new industries and new jobs. That’s why I think it’s appropriate that we sit here on the centennial anniversary of the Wright Brothers’ flight to talk about the transition of human space flight from a government venture to a economic business pursuit.

I think one major issue, though, is a hundred years ago, when the Wright Brothers were figuring out how to get into the air, the only question they had to ask was, “Can we?” Today, all these people here with me are really asking, “Will we be allowed?” And the answer to that question is—while there are some technological implications—really will be answered by regulators and by investors. I’m quite comfortable that the technological advancements will come.

So who are these investors, and how do they come to want to place their bets in this sector? Well, to date, most of the investment has come from angel investors, wealthy investors, like Mr. Tito, who would view the passion of space flight to supplement their classic return-on-investment calculation. For this industry to be successful and take the next step, however, it has to attract dispassionate people, who will make the classic risk-reward tradeoff and view this as a place to make their investment decision.

So, in the risk-reward dilemma—the people before me have already talked about the reward, to some degree, so I think it’s important to discuss the risk profile. If all these people were bringing a business plan to a number of investors, what would they say? What would they focus on?

I think the first one they’d focus on is—what I just mentioned—is the regulatory risk. And a number of other people have talked about that, too. I don’t think the industry or investors expect there to be an absence of regulation. I think they expect, however, to know what the rules of the game are.

We talked about different industries that are regulated, like the SEC. I think another one which is relevant to investors is the biotech industry. Billions of dollars have been raised on Wall Street by biotech entrepreneurs on just a dream and a desire to create something. The difference there is, they knew what the rules of the game were for developing drugs and having them been approved by the FDA, because it was already in place prior to them making the investment decisions. So investors know that the FDA decision can mean, not only life or death for a patient, but also life or death for an investment, and they are able to evaluate that risk, the risk of being turned down, and the length of time it will take.

In this industry, the nascent human space flight industry, they don't know. They don't know whether it'll be regulated as an airplane, a rocket, what that will mean, whether it will be regulated today and it will be changed tomorrow. That is a very difficult scenario in which to invest significant capital.

On top of the regulatory issue, frankly, the timing is also bad. Now, clearly, this is a long lead-time business, but if you look at the number of the financing hurdles these gentlemen have, they're significant.

The first is that despite last quarter's stock market appreciation, venture investors are returning to being extremely conservative. In the late '90s, we all know that you could raise hundreds of millions of dollars on merely a story and not a very significant business plan. That era is gone. I'm not sure it won't come back in the future, but, for time being, it is.

In addition, there has been a terrible history on Wall Street with investing in commercial startup space ventures. Two that come to mind are the LEO (the Low Earth Orbit) satellite ventures, were, in the '90s, starting in the early '90s, and lots of money was raised to create constellations of satellites, for communications purposes, primarily. \$14.5 billion of equity and debt capital vanished in the last few years through bankruptcies and restructurings. That sits hard in people's memories through names like Iridium, Globalstar, and others.

Another venture which these gentlemen would have to sell against is the remote-sensing business, which is also an attempt to create what used to be government technology and remote sensing from space—spy satellites—and use them for commercial purposes. That venture has fared a little bit better. But, clearly, what has happened there is, money was raised on the promise of commercial applications, which really have been extremely slow to mature. So what has kept that sector on life support is something that was not anticipated; it was government funding, government contracts for supplemental imagery. And this whole concept of government contracts is an important thing to think about as you think about what government could possibly do to help this industry.

In addition, we have a period of time where safety is of a primary concern. Until we put the Space Shuttle back into operational performance and solve what are perceived to be risks once again in people's mind about the safety of human space flight, investors will react negatively to the concept of spending money for a commercial venture if NASA still is not flying. So that's another significant timing issue.

So, clearly, these investors need time, need time for the concept to mature, for some of these issues to mature. And government, if it chooses, can play a role. It can play a role, first, of—in deference to the Hippocratic adage, “do no harm,” you know, in terms of—tell people what the rules of the game are, and encourage people, by a fair, up-front forecast of what the rules are, and let the capital markets raise money.

Second is increased R&D funding. There are some technological challenges. Some of it has dual-use capability between commercial markets and federal markets, and there are lots of ways for people

at this table and the industry they represent to develop technologies that could be useful for the government.

Third is government contracts. It has been the lifesaver for the remote-sensing industry right now, while they're waiting for commercial markets to come back, and it would be an important aspect here, if the government chooses to do so.

So, in conclusion, my sense is that, in the near-term, this industry will likely only be funded by wealthy investors until a business plan can go full circle and get to the point where there is more visibility on risk and more visibility on profitability. A business case has not been made yet for large investment. There's a significant role government can play, should it choose to help facilitate that, but, in the meantime, it will take incremental business successes before we're able to reach for the stars.

Thank you.

[The prepared statement of Mr. Kutler follows:]

PREPARED STATEMENT OF JON B. KUTLER

Chairman Brownback, Chairman Rohrabacher and Members of the Subcommittees, thank you for inviting me to testify this morning. My name is Jon B. Kutler and I am the Chief Executive Officer and Founder of Quarterdeck Investment Partners, LLC, an investment bank focused exclusively on the aerospace and defense industries. Today, it is my pleasure to discuss what we see as the major issues facing the commercial human space flight industry as its pioneering companies progress to the point of seeking external financing from the capital markets.

I must start by applauding the efforts of the individuals who have spoken before me. They are the kind of leaders and risk takers who have traditionally pushed this country to new heights of technological advancement and created whole new industries and jobs. It is appropriate that we sit here today in the centennial year of celebration of the Wright Brothers' successful completion of the first manned powered flight, to discuss the transition of manned space travel from a government pursuit to an economic business opportunity. The only question the Wright Brothers faced as they started their tests was "can we?". They did not have investors questioning their return on investment or a federal regulator asking to certify the aircraft. The question before these gentlemen today, however, has become "will we be allowed?".

The most important people to answer that question are not scientists pushing the bounds of technology. They are regulators here in Washington, D.C., who set a framework for these efforts and institutional investors who will judge whether this industry is ready to be a profitable business opportunity worthy of large-scale investment. I am sure that most regulators and investors believe that at some point in the future there will be a prosperous commercial human space flight industry. The foundation of this discussion, however, remains whether the transition from novelty to viable industry will be observed in our lifetime.

To the surprise of many, the sheer size of the capital required to fund commercial human space flight is not the issue. There are numerous examples of new companies in fields such as biotechnology and telecommunications that have raised billions of dollars on the basis of someone's dream. The hurdle is the perceived risk profile and return on that investment. Some initial start-up capital has already been raised and will continue to be available to these commercialization pioneers from wealthy "angel" investors who have the wherewithal to supplement their return on investment calculation with the passion that human space flight often evokes. The next critical junction will involve institutional funding, however, where the investment decision will be based solely upon quantifying the magnitude of return a company can potentially generate if successful, measured against the risks that could cause the endeavor to fall short of the finish line. The capital markets currently believe that this market will remain, in the near-term, a niche opportunity with a number of substantial barriers limiting total demand thus delaying the timing of its growth. Although individually manageable, the combined belief of a limited market opportunity and potential regulatory obstacles currently results in an unattractive investment opportunity.

Biotechnology companies have raised billions of dollars from investors who are quite familiar with the concept of regulatory risk through the Federal Food and Drug Administration's drug approval process. The pace of approval and ultimate

outcome is a life and death decision, not only for patients, but investors as well. This process is a known and calculated investment risk, which predates the biotechnology industry. The commercial human space flight industry and its potential investors, however, face the prospect of unknown regulatory hurdles, which could entail “piggy-backing” off the FAA certification process for aircraft or the potential drafting of new restrictive regulations.

The question of potential market size has become the “Holy Grail” of early-stage investors. Typically, these venture investors will take large financial risks if they are confident that the return potential, should the funded idea/entity become successful, is proportional to the magnitude of risk taken. For example, although with the benefit of hindsight Microsoft’s success seems obvious, its early investors made large financial bets with little tangible assets to show for it. The Microsoft investment was a huge success in large part because once they had a successful product there existed an untapped and reoccurring global opportunity to sell affordable software for billions of customer applications. The current per event costs for commercial human space flight events are very high, which immediately eliminates a large segment of the population from participating. As you know, Mr. Tito’s orbital trip has been reported to cost \$20 million and near-term sub-orbital trips are still projected to be several multiples of the average U.S. annual household income. While Rolls Royce and Ferrari also make luxury consumer items that have similar cost parameters, they can still be considered an investment—a tangible, saleable asset—not an expenditure on a onetime event. As you can imagine, investors in either of those car companies might question the capital expenditure plan for a new car line if they were told that a prospective customer would have the single ride of a lifetime, but subsequently have to throw away the vehicle.

Investors will also further factor the potential addressable market by an allowance for competition. This is not just a question of measuring the potential market share that could be captured if more than one company presenting today becomes fully operational. It is also an acknowledgement of competing tourism approaches. Many current commercial human space flight business plans are based upon the building blocks of an initial sub-orbital joyride approach. Without the unique characteristics of a longer stay space tourism destination, other companies may be able to further fragment the market by offering specific aspects of space travel in a less technologically and financially demanding fashion. For example, weightlessness can be simulated for commercial customers through conventional aircraft in a manner similar to the training regimen for all astronauts. Owners of demilitarized Russian aircraft could meet the demands of those seeking the g-forces of launch and the thrill of supersonic flight.

In order to attract investment capital into a risky, new industry in its relative infancy, the business plan should have the potential for a large financial return, be differentiated in the marketplace and based on credible demand patterns. The most likely scenario for this may ultimately rest in the build-out of a “destination” travel model. By offering an overnight stay in space or turning a Mach ten flight from a quick joyride to a reliable transportation system that features global travel measured in minutes instead of hours and days, the time-tested demand for destination travel could be leveraged effectively and a much larger investment opportunity created.

Despite the rapid appreciation of stock market indices in the past quarter, the capital markets still remain reasonably disciplined with respect to calibrating the risks of such early-stage investments. Assuming we were still at the height of last decade’s investment bubble, these financial metrics might have been pushed aside by merely the “story” of commercial space travel. Unfortunately, companies seeking investment in the commercial human space flight sector not only have to deal with a more disciplined financing market, they also must address the disastrous results of investments made by such investors not that long ago based upon the dreams of other commercial space start-up ventures. In the mid to late 1990s, companies poised to develop and address the low earth orbit (“LEO”) satellite market successfully raised billions of dollars of capital by extrapolating for investors the rapid growth of bandwidth usage and cell phone development. Their business plans implied that nearly the whole world would, in the near future, be utilizing the services provided by the winners of this race. Since then, more than \$14.5 billion in debt and equity capital has disappeared as a result of the industry’s collapse and subsequent corporate sufferings of Iridium, Teledesic, Globalstar and ICO. Today, only two of the four companies remain; limping along in attempt to stay alive until the market catches up with their business plan. Following the Microsoft example, the return potential and market opportunity presented to those LEO investors was substantially different than the business cases currently provided by commercial human space flight ventures. While the longer-term opportunity may very well be

larger, the current opportunity for which the capital is being raised is perceived as much more of a niche.

In addition to the aforementioned investment history, which has not yet been forgotten, there other risks remain that institutional investors will consider. In the case of the LEO satellites, many of the individual satellites that were intended to build out these constellations did not reach orbit or even deploy successfully. This potential outcome was factored into business plans and considered a business risk, as well as an insurance issue. Should one space tourist not safely return during the initial stage of developing the commercial human space flight market, the industry would likely shutdown for years. It will also take some time to erase the recent image of the Shuttle *Columbia* from the minds of potential investors and tourists, and restore confidence in the safety of human space flight. Of course this will also be coupled with the risks of litigation and insurance costs that will be present in the early days of this market, regardless of the obvious use of legal disclaimers. These risks and uncertainties that face the commercial human space flight industry can constrain the near-term investment prospects and delay the fruition of these pioneers' vision, until reasonably quantified.

What the commercial human space flight community needs is time: (i) time for Wall Street to forget earlier failed commercial space investments and change its risk profile; (ii) time to get the Space Shuttle fleet flying again in a safe and reliable manner; and (iii) time for certain new technologies to mature. I expect all three of the aforementioned to happen. Time, however, is often the unfortunate enemy of many investments and investment ideas. There are a number of actions the government can take to buy some of that time should it chose to:

- First, the Hippocratic adage, “do no harm” can provide a useful guideline in evaluating any proposed regulatory structure. Burdening the sector with either an inappropriate degree of regulatory control or the lack of early consensus in this area would kill the investment raising ability of otherwise fundable companies.
- Second, increased research and development funding in certain key technologies could have the “dual use” benefit of supporting NASA and Defense Department missions while shortening the life cycle of longer-term human space business opportunities with broader market appeal. Over time, this could include developments such as the transition of sub-orbital joyrides to hypersonic single-stage-to-orbit vehicles serving as high-speed commercial transports.
- Lastly, start-up ventures can leverage the stability of mutually beneficial government contracts such as those afforded to the space based remote sensing sector, into further external funding.

Although not insurmountable, the near-term institutional investor interest given to the commercial human space flight sector will be limited by a number of risks and constraints that could adversely affect investment return. In order for start-up companies to participate in the natural transition from the small pools of capital available through wealthy individuals to the investor base required to fund their next level of growth, the regulatory and financial risks associated with these ventures must be further quantified. While these ventures may spark the imagination of many, to quote *The Right Stuff*, “No bucks, no Buck Rogers.”

BIOGRAPHY FOR JON B. KUTLER

Jon B. Kutler is Chairman and Chief Executive Officer of Quarterdeck Investment Partners, LLC, an investment banking firm he founded in 1992 to focus exclusively on the aerospace and defense sector. Mr. Kutler has advised on hundreds of transactions involving most of the leading companies in these sectors. In December 2002, he sold the firm to Jefferies & Company, Inc., a NYSE traded investment bank. Quarterdeck currently operates in five offices globally as a wholly-owned subsidiary of Jefferies & Company.

Mr. Kutler began his investment banking career on Wall Street in 1984, after serving ten years in various positions in the U.S. Navy. He has worked with Goldman Sachs, The First Boston Corporation and was Managing Director in charge of the West Coast office and international aerospace and defense practice of Wasserstein, Perella & Co., an international merchant banking firm.

Mr. Kutler is a nationally recognized expert in the field of aerospace and defense. His articles on consolidation, restructuring and defense conversion have appeared in *Business Week*, *The New York Times*, *Fortune*, *The Los Angeles Times*, *Defense News*, *Washington Technology* and *Aviation Week & Space Technology*. Mr. Kutler has testified before numerous Congressional committees, has served as Chairman

of the White House Small Business Task Force on Defense Conversion and was a member of an advisory panel established by the Congressional Office of Technology Assessment to evaluate the status of the space launch vehicle industry.

Mr. Kutler is a graduate of the United States Naval Academy and holds a Bachelor of Science degree in Naval architecture. He received his Master's of Business Administration degree from Harvard University.

DISCUSSION

Senator BROWNBACK: Thank you, Mr. Kutler.

Thank the panel. It's been an excellent presentation, and I look forward to a discussion.

We're now in a period of five-minute questions, and we'll go back and forth, and we'll go in the order of people coming into the room, so we'll recognize those who have been here and waiting the longest, after we go with the Chair's questions for a five-minute time period. We'll go until we're concluded here in time.

IMPEDIMENTS TO EXPLORATION

Let me ask—Mr. Musk, I want to build on your statement, because this is something that's really troubled me and perplexed me a great deal. After we go to the moon, we develop a computer industry that's fantastic, an Internet industry that—I just got an Internet e-mail from my wife, while I'm sitting here—fabulous things, and yet we're stuck in low-space orbit with government contracts in space.

Now, you say it's the breakdown of creative destruction. Others, I take, are saying here that it's the lack of commercial entry into the field that's been blocked for some reason here. And I appreciate your notion of a space-tourism industry, Mr. Tito, and others. Mr. McAlister, you were talking about—I have to admit to you, that doesn't attract me a lot, from a public-policy perspective, when my view is that we should be expanding exploration. I'm willing to be supportive of it. I like it. But I want to see us going further in space. I want to see us back to the moon and beyond, and pressing the bounds of humanity is what I'm after.

What else is there that has stopped us, as a society, from going further than we have over the past 30 years?

Mr. MUSK: Well, I think, as far as the, sort of, greater-good-of-humanity type objectives, it's difficult to generate a commercial return from such things. So that is, sort of, necessarily the funding purview of government, the Federal Government, and its vessel for doing so, which is NASA. And the bias, the exclusive bias, really, of NASA, as far as contracting for any significant project, is to go to the incumbent corporations—that being, Boeing, Lockheed, and, on rare occasion, Orbital Sciences—but, really, not going to any new players.

And that's really what I meant by shutting down Schumpeter's process of creative destruction. If you shut down the process of new companies getting into such a market, you won't see the price decrease, you won't see the quality improvement, because there is no forcing function for incumbents to change.

The reason, I think, that space tourism is very important is because this is something where you have an objective customer. You have someone that is going to choose to fly or not to fly based upon

the price and the merits of the vehicle, exclusively. They don't care who made it. They don't care where you're from. The consumer is an incredibly objective judge of product. And that's what I've seen in my prior businesses, PayPal, in particular. They didn't—we were up against Citibank, were up against Microsoft, we were up against AOL, and so forth, but—

Senator BROWNBAC: Let me put a better point on my question, because my time's very limited. Is the key for us, going forward in space exploration, to engage this commercial sector much more robustly, and particularly as the near-term point being space travel by tourist?

Mr. MUSK: I think that is it not just the preferred way, I think it is the only way.

Senator BROWNBAC: Mr. Tito, you talked about a number of regulatory issues, and I've got those down, and I appreciate your identification of those. What are the technological issues that you believe are the biggest hurdles for you to face in moving forward with a vehicle to take people into space in a safe manner?

Mr. TITO: Well, I think the major technological hurdle is reliability. If you're going to have a commercial venture, you have to demonstrate a high degree of safety. But part of the development will be not only the standard reliability testing procedure, but, in addition to that, a lot of flights, a lot of flights, none commercially, to demonstrate a very high degree of safety.

Senator BROWNBAC: And you would do this before you would take your first passenger? You would fly a number of flights up and down before you would take your first passenger?

Mr. TITO: Yes, before I would take my first paying passenger. I might be a passenger, myself, but I wouldn't pay.

(Laughter.)

Senator BROWNBAC: Mr. Rohrabacher.

Representative ROHRABACHER: Well, that's very interesting, this concept of entrepreneurs and trailblazers actually risking their own personas in their vehicles before they open it up to the public. I think that speaks very well of you. And I would say, in the ancient Romans, you know, there was a—the architect, when they—in order to ensure the quality of the—I guess, the arch, that the architect was supposed to stand underneath the arch as they took away the final beams that were propping it up. And so if the arch didn't succeed, of course, the architect would face the consequences. So this is a very interesting carry-on to that principle, sort of, started by the ancient Romans.

Also, it's interesting to note that, when you asked Mr. Tito about the technical obstructions to success, what—he came back with liability, which is not really a mechanical technical obstruction, but a technical obstruction that's based on law, which is based on regulations and law, rather than obstacles in engineering, and technology. So that's fascinating.

Also, last night, when I talked to Mr. Tito, we went out for dinner, and he said something that I thought fits right in with what Mr. Musk was saying today, which is, you have a certain establishment in this whole—in the business, but also—and I'm including government in that—there is an established—there's a space establishment within the corporate world as well as within the govern-

ment world. And today we're looking at some of the government impediments. But big business has its own bureaucracy, has its own obstacles in the way. And Mr. Musk alluded to that by talking about the incumbents not being able to innovate. But, last night, Mr. Tito, you mentioned that if we would have relied on the railroads, then we might—remind me what you said about space flight—railroads were the number-one transportation industry of the day, and yet that's not where airplanes came from. And you might give us an insight into that.

Mr. TITO: Well, you would think that major transportation companies would be the innovators for the next form of transportation, but, instead, it took a couple of bicycle mechanics to develop the first airplane. And so you would not expect to see a Boeing, for example, develop the first single-passenger sub-orbital vehicle. They're focusing on their business and do not seem to have any interest in this vehicle, other than, once we get started, maybe try to buy us out.

Representative ROHRBACHER: I think the dynamics of that is important for us to realize if we expect to have progress in this area. The railroads didn't finance the—I might note, the Wright Brothers, as well, but we also have to note that the government didn't finance the Wright Brothers. And also, if it would have, they probably would have—it would have taken a lot longer to—matter of fact, they probably never would have qualified for those government loans at that point, as well as the liability factor of having that strange craft going over there in North Carolina. Perhaps the North Carolina legislature would have had all sorts of liability regulations. And, who knows, Mr. Musk? Maybe the Wright Brothers would have disturbed the reproduction patterns of the local crabs, or whatever, and would have had to have been prevented from moving forward.

Let's get down to a couple of things—and I see my time is running out, as well—in terms of—we're mentioning the things that are preventing people from moving forward, and contracting by the government and dual-use has been mentioned as something that could stimulate investment in this area, of course. And I have a bill, zero gravity, zero tax. Tax incentives might. But, just looking at the obstacles now, we find that the FAA and the way they are approaching, especially, Mr. Tito's venture and sub-orbital space travel for regular citizens, what needs to be done, Mr. Tito, to make sure that the FAA does not prevent you from investing in this venture, which would then create a whole new vehicle for humankind?

Mr. TITO: Well, I think the Congress has to assert its authority and allow a definition of sub-orbital RLV, and that the Office of Space Commercialization will have exclusive authority, not only to license, but also to regulate the passenger aspect of it. And the aviation side of the FAA will not be part of it.

Representative ROHRBACHER: So this should be taken totally out of the hands of those people regulating airplanes, and should be a totally different category, or it will not work. Is that correct?

Mr. TITO: That is correct.

Representative ROHRBACHER: All right. Thank you.

Senator BROWNBACK: Congressman Gordon.

SAFETY AND CERTIFICATION

Representative GORDON: Thank you, Mr. Chairman.

I'd like to have a little talk with the panel concerning safety, and explore that some more. It would seem to me that if we're going to have a successful commercial space tourism industry, that there's got to be a perception that there's at least some reasonable level of safety and reliability. So I'd like to ask the panelists, what is safe enough, and who should verify that?

Mr. Tito is—I think, really, has set a fairly high standard. You're talking about maybe a thousand flights before—that's pretty expensive a venture. So, again, let me ask you. What is safe enough, and how do we verify that?

Mr. TITO: Well, again, you have to go through the standard qualification of a vehicle. And then once that is accomplished, if you have a vehicle that can be turned around at a fairly low cost—for example, the vehicle that I'm looking at would be turned around in something like \$10,000, and a thousand flights would be \$10 million. And if one could fly this vehicle many, many times a weekend, fuel it up, turn it around, and have a simple mission profile—taking off and landing at the same runway, and demonstrate a flawless flight, what I like to call is a “textbook flight”—and we do this a thousand times, I think it'll become readily apparent—

Representative GORDON: So what's it's going to cost you to do that a thousand times?

Mr. TITO: \$10 million.

Representative GORDON: I don't mean to cut you off, but we've got a short time here. Let me ask, does anybody have a—sort of, a “Katy bar the door” attitude, sign a waiver and take your chances?

(A show of three hands.)

Representative GORDON: You do? Okay. Well, so why don't we—so almost everybody does, then. So you're all—you're in disagreement with Mr. Tito. So why don't you give your side of the story, then.

Mr. GREASON: I don't think that those attitudes are necessarily in conflict. I mean, it's safe enough when the customers start to show up, and you go through a process of demonstrating the vehicle over and over and over again. Now, we have our own internal business targets about how safe we have to know it is before we can base a business on it. But it's important to realize that long before we get to the point where we know it's safe enough that our expensive asset won't crash and be lost to revenue service, something we have to do for our own business, long before that point, we will have demonstrated safety far superior to what people think of as space flight safety as being right now. I mean, the test program, alone is probably going to be 50 flights.

Representative GORDON: I don't want to be discourteous. This five-minute, sort of, thing makes it—

Mr. GREASON: Yeah. Go.

INDEMNIFICATION

Representative GORDON: So let me ask you, our sign-a-waiver-and-take-off folks, do you think there should be indemnification by the Federal Government also?

Mr. GREASON: Of who?

Representative GORDON: Some amount of—you know, of the company, for some amount above your level of insurance.

Mr. GREASON: You're referring to the third-party liability indemnification?

Representative GORDON: Right. Yes.

Mr. GREASON: It would be—it's hard to see why we should—why the Federal Government should take steps to make insurance harder to get than it is already. I mean, it would be nice if the currently-existing regulatory regime were left untouched.

Representative GORDON: Well, then if we're going to provide some type of indemnification, then aren't we, in some way, making the public think that the government has signed off on this, and wouldn't the government have a higher responsibility to certify safety?

Mr. GREASON: I think you're mixing the issues of the safety of the passengers with the safety of the uninvolved public. I mean, I already have to carry, before I can launch a launch vehicle, insurance to cover events so improbable that I could fly for 10,000 years four times every weekday before they would be likely to occur. I mean, it's not like I'm getting some kind of break.

Representative GORDON: But if you're a citizen—maybe you read, and you should, all of those pages that go along with doing a real estate, you know, closing with your house, and maybe when you go into the doctor's office and you've got a problem, you read all those waivers, and you should. I think a lot of folks don't. I think they somewhat think that if you are an operation—again, if you're going to be indemnified in some way by the Federal Government, that there probably is somebody in some safety office that's at least given this a review.

But, that's fine. You don't agree with that, and—so, Mr. Tito, are you our loan—or what about if you're—what's the investment community think about—

Mr. TITO: I think—

Representative GORDON: —some type of safety—

Mr. TITO:—I think—a similar issue, which—I think investors won't line up until they can be convinced there's some repeatability. The real issue, I think, is not so much will an accident happen, because eventually it will, it's what's the liability for the company if an accident happens. So there's a liability to the passenger, which—I think that investors could be comfortable that the waiver covers them there. It's really the third-party liability, and could somebody else make some claim on that company for some liability? So I think it's really an issue of cap, not a question of occurrence.

Representative GORDON: I guess I won't—

Senator BROWNBACK: You'll probably get a next round in, if we can. We'll see if can do that.

Representative GORDON: If I could, I would just like to ask the panelists if they could maybe submit their opinions on this issue and where we should go? I don't have a strong opinion, but I would like to get more information on it.

Thank you.

Senator BROWNBACK: That would be good. That's an excellent request.

Let's see. Congressman Lampson.

Representative LAMPSON: Thank you, Mr. Chairman.

I appreciate the opportunity to come over and participate in this panel, and all of you for coming over here. This is very interesting.

In the last Congress, I introduced a piece of legislation to address the issue of space tourism, the Space Tourism Promotion Act. And the bill would create federally guaranteed loans, tax credits, and hopefully a predictable regulatory structure for space tourism. The legislation would also spur research and development in technologies that will assist the private sector to develop operational passenger-carrying space-transportation systems and on-orbit habitations.

Humans, obviously, have had a long yearning to travel into space and experience the conditions beyond Earth's atmosphere. Hopefully, that won't ever go away.

Forty years of human space flight experience have demonstrated the feasibility of travel to and from space, as well as the ability of humans to live and work in space. The Nation's human space flight program has developed technologies and operational procedures that the private sector could make use of to enable American citizens to experience space travel.

Space tourism has the potential to become a significant industry and powerful stimulus for advances in space transportation. And all of the different ideas that so many different people have had have been fascinating to listen to. And so I hope that you all do well in promoting this and that we do the right kinds of things to make sure that you have those opportunities.

I plan on reintroducing a similar version of that legislation in the fall, and I look forward to working on these issues with my colleagues. And I would hope that you, too, would have suggestions for me, and us, in making sure that we include the kinds of things that you want.

EFFECTS OF THE COLUMBIA ACCIDENT ON INVESTMENT

Now, let me ask a couple of questions. My first thought in all of this is, how has the investment community reacted to the Space Shuttle *Columbia* accident? Has it affected your ability to attract capital? Did that frighten people away? And how will it make the transition into a potential accident that might occur in your development stages? And any of you can begin.

Mr. GREASON: Somewhat to my surprise—I expected that, after *Columbia*, there would be a lot of people who had signed up and saying, "Yeah, I want to ride," that would go away. If anything, the reverse has happened. The people who are looking to go to space in the early days of this emerging industry are fully aware that it's a risky endeavor. And I think the events of February reminded

them that, in their own way, they're doing their part by being willing to take that risk, and increased their eagerness to do so.

I don't think anybody—I don't think the perception that the shuttle was safe was held widely in the informed members of the public, and so I don't think there was the degree of surprise that there was in some other quarters.

Representative LAMPSON: Does anybody else have a—

Mr. MCALISTER: I concur. When we surveyed individuals for this market study, we actually explicitly asked questions about the perceived risk of space flight, and most of the respondents equated it on the order of mountain climbing. Skydiving is the most risky, mountain climbing, space flight was right on the order. And so that's a fairly risky activity. And so individuals know that this is an inherently risky activity and are still willing to go. And a lot of people have asked me has—is my impression—has the results of the market study changed because of that *Columbia* accident, and I would say no, because people understand that this was risky. We explicitly said that it was risky when we asked about their interest level. So I think people had a common understanding of what the realistic aspects are.

EFFECTS OF RUSSIAN PARTICIPATION ON THE INDUSTRY

Representative LAMPSON: The Russian Space Agency has already flown tourists into space, including Mr. Tito. Agency officials have suggested that Russia might attempt to develop more space tourism capabilities. What would happen? What would be the impact on the emerging commercial human space flight industry if the Russian Government decided to pursue that development of a government-sponsored space-tourism program?

Why don't you start—

Mr. TITO: Well, there's an effort right now in Russia, which is more privately oriented, to build a sub-orbital vehicle. And the investment required would be similar to what would be required here. And I know, for myself, I would strongly prefer investing in America, because, well, I'm an American, but also, this is where the market is. And I think a very small percentage of those that might be interested would actually go to Russia and have to train in Russia and fly in a Russian vehicle. So I don't see that as a threat. I think it should be done here.

Representative LAMPSON: One final comment, and I'll turn it back to the Chairman. Mr. Rohrabacher made the comment awhile ago that the government wasn't involved in the Wright Brothers' efforts. But I might add that the very first thing that happened, shortly after that short flight, was the sale of an aircraft to the United States Army, and they trained the flyers right out here—under contract with the United States Government, right out here at College Park.

Senator BROWNBACK: Excellent comments and excellent questions.

Ms. Johnson.

Representative JOHNSON: Thank you very much, Mr. Chairman, and thank you for having us join you this morning. And thanks to all the witnesses. It's been very interesting.

About eight years ago, I had a couple of gentlemen come by my office and talked about commercializing space exploration, and I thought it might have been a joke. I've lived long enough now to know that all the things I saw in movies as a kid is a reality now.

Are you all planning separate ventures in different parts of the country?

Mr. MUSK: Yes.

TIMELINES

Representative JOHNSON: And how quickly do you think you can be ready to do it?

Mr. MUSK: Well, in our case, we're building an orbital launch vehicle to initially deliver satellites and then, subsequently, once it's proven, human transportation. We expect to do our first flight sometime in the next eight months. We're currently scheduled to launch January 22nd, from Vandenberg.

Mr. GREASON: We've been flying a rocket-powered vehicle with a pilot on-board for two years, and when the bigger engine's ready, in about a year, we expect to be ready to move on to a bigger vehicle.

Representative JOHNSON: And these are occupied? By human beings, I mean.

Mr. GREASON: Yes.

APPROPRIATENESS OF GOVERNMENT REGULATION

Representative JOHNSON: How do you—do you think it's appropriate that there is any kind of government standards or any government involvement as you begin these ventures?

Mr. GREASON: I think it's very appropriate that government continue as it has begun in having standards that protect the uninformed public. I mean, the public will not accept hazards from things—nor should they—hazards from things that they have no say in, and there already are very exhaustive standards—I mean, I could break this table with the amount of paperwork we have to wade through—to keep the uninformed public safe.

I resist the suggestion that government would put in standards for the safety of the people who want to fly, not because it is in any way inappropriate, but because it's too early. We don't know what standards to put in. The probability of doing the wrong thing is very high. And I think we have to let the industry develop for awhile and start flying some people for awhile before we will gain experience about what works and what doesn't.

Representative JOHNSON: Mr. Tito, good to see you again. You went on a government-sponsored flight. Is that correct?

Mr. TITO: Well, I would say that it was somewhat government sponsored, in that the Russian Space Agency launched the vehicle. But, from a financial standpoint, it was sponsored by myself.

Representative JOHNSON: Yeah, 20 million.

Mr. TITO: Right.

PROFITABILITY

Representative JOHNSON: Do you think that—do you feel confident that a commercial venture would be profitable?

Mr. TITO: Absolutely. And I wouldn't be interested in doing it unless it was going to be profitable.

Representative JOHNSON: What did you see?

Mr. TITO: Pardon?

Representative JOHNSON: What did you see?

Mr. TITO: From space?

Representative JOHNSON: Yes.

Mr. TITO: Well, I saw that this is something that, not only I, but thousands of people would get an experience of a lifetime. And as those people experience it and relay their experiences to all of us here, I saw an opportunity to make space flight available to a large number of people, not just people that could afford \$20 million. But, eventually, people who can afford an SUV should be able to afford a flight into space.

Representative JOHNSON: Let's see how I'm going to formulate this other question. The vehicles that you have that you are trying out now, how many passengers will they load?

Mr. GREASON: Our initial revenue-generating vehicle will only carry one passenger, plus the pilot.

Representative JOHNSON: What is the cost to operate?

Mr. GREASON: That's proprietary. But the prices, which includes our profit, will initially be about a hundred thousand. It will probably come down as new entrants enter the field and competition drives the price down.

Representative JOHNSON: So, initially, persons who would want to make a flight, they would pay, not 20 million, but something over a million?

Mr. GREASON: No. About a hundred thousand per flight—

Representative JOHNSON: A hundred—so it's—

Mr. GREASON: —is what the initial people are looking at.

Representative JOHNSON: —a hundred thousand.

What do you expect the government role to be?

Mr. GREASON: Let us fly, and keep the public safe, the general public.

Representative JOHNSON: So meeting safety standards?

Mr. GREASON: The safety standards that we have to already meet as a launch vehicle, to protect the uninvolved public, yes.

Senator BROWNBAC: Ms. Johnson, we'll—

Representative JOHNSON: Thank you very much, Mr. Chairman.

Senator BROWNBAC: Thank you very much.

And we'll go to Mr. Burgess.

LIABILITY

Representative BURGESS: Thank you very much, Mr. Chairman. And I apologize for being late. This has been a fascinating discussion.

I guess my question, first, is for Mr. McAlister. And you talked about how people generally understand the nature of the risk when a citizen such as Mr. Tito undertakes this type of adventure, but I couldn't help but think about the general aviation industry and how that industry was almost taken from us because of the costs of liability. And that was not liability generated by people who were harmed on the ground when a plane crashed, that was liability that was generated by pilots, themselves, in some instances,

and loved ones who were left behind, who perhaps didn't understand the nature of the risk that someone undertakes when they strap themselves into their small plane and take off into bad weather.

So I guess my question is, How do you look to manage the liability from that standpoint? That is, Mr. Tito had a very clear understanding of his risk when he took off, I suspect, or at least could get his arms around it to some degree. But I would have a strong suspicion, if there had been a very bad outcome, then would his family have been so understanding? And then that gets to the questions that Mr. Gordon and Mr. Lampson were bringing up about the issue of liability and how in the world are you going to pay for insurance for someone to go up in a commercial space venture.

Mr. MCALISTER: I think Jeff's probably more qualified to answer that specific question, because he's dealing with how to get insurance right now, so I'm going to defer to him.

Representative BURGESS: Okay.

Mr. GREASON: I don't think—I mean, this is not a hundred years ago. So the only way that it's practical, in the near-term, to take people is, they have to be able to waive their liability. And there's no—it's going to take years, maybe decades, for enough of an operating track record to be built up that any insurance carrier would consider writing a policy for somebody who actually wanted to ride. I mean, it was only a few years ago that you started to be able to get life insurance policies that didn't have an exclusion that said if you flew on an experimental aircraft, your life insurance was void. Sixty, seventy years from now, maybe space travel will be so common that we won't have that problem anymore, but today we certainly do.

So when I talk about liability insurance or indemnification or any of those issues, I'm really talking only about third parties, because I don't think there's any alternative. But the people who fly on experimental space vehicles do so at their own risk.

Representative BURGESS: Well, very good. All I have to add to that is that when Chairman Rohrabacher takes the first Codel into space, I'd like to be included in that.

(Laughter.)

Representative BURGESS: And I will waive my liability.

(Laughter.)

ACTIONS THAT WOULD FACILITATE GROWTH

Representative BURGESS: One last point, then, is, if you could just sum up, Is there one thing that you would like to see us do in the near-term—us, here in Congress—that would facilitate you all getting off the ground? No pun intended.

Mr. GREASON: Define sub-orbital in a way that keeps it out of the hands of the airplane guys.

Representative BURGESS: Is that in general agreement from everyone there?

Mr. TITO: And also define the role of flying passengers for hire and, you know, recognize the ability of the individual to go through certain checks and ultimately waive his or her rights, you know, to any claims.

When I flew to the ISS, I waived all claims that either—would be made either to the Russian Government and to the U.S. Government. My kids would have gotten nothing if I did not come back.

Representative BURGESS: I guess that's really the question. Would the heirs and signs of the Wilshire Corporation have been so understanding if something bad happened? Would that be defensible? Would that hold up in court? I'm not a lawyer, and I don't play one on the floor, but—I guess that's a question I need to find out.

Thank you.

Senator BROWNBACK: Thank you, Mr. Burgess.

We'll go through another round here, as long as we can. If the panel can continue to participate with us, we'd like for you to do that.

Mr. Kutler, if we got the regulatory structure right, limitation and liability right, the various regulatory issues, to where this industry—where we were, in Congress—the Administration was saying, "We want this industry to move forward. We think it's a key portion of the U.S. dominance in space, is we've got to engage the private sector of this country." If we got that right, do you think that we could attract the billions of dollars private-sector money to cause this industry to move forward?

Mr. KUTLER: I think there's no question you could, over time. Obviously, whether it's investors or it's passengers, these things tend to happen in a stair step function. You start at a small threshold, you have some successes, you, therefore, go out and do it again, and you work your way up the chain. So I think, in a logical progression, you certainly can raise the capital required to do this over a period of time.

Senator BROWNBACK: And do you see any key particular factors we have to get right in order to attract the capital into the private sector of this business?

Mr. KUTLER: Well, I think there's two elements to assess—we've already laid out, or the panel has, from a regulatory standpoint what needs to happen. If that happens, then the burden really is on industry to have these incremental successes in order to prove the concept to raise the capital required to get to the next level.

Senator BROWNBACK: Okay. Now, the same question to you, Mr. McAlister. If we get the regulatory structure right, we get the limitation of liability right that this industry can move forward, will we be able to attract the billions of dollars, either from investors or from consumers willing to take these flights?

Mr. MCALISTER: Yeah, I concur with Jon. I think, almost certainly, the money would be made available. The question is—the key question is, Can we produce a—can we produce a vehicle that can satisfy this demand in a cost-effective manner so that a profit can be shown to be made? But if that business case can be made, then, yes, the investment capital would come.

Senator BROWNBACK: Mr. Musk, do you concur?

Mr. MUSK: Yes, I do. I think it's really critical to have that one good example. The Internet was really quite stagnant until Mark Andreessen and Jim Clark got together, funded by Angel Capital from Jim Clark. Where Netscape was shown to be successful, that

really broke open the flood waters, and the Internet became what it is. I think the same can happen with space.

ANTICIPATED LAUNCHES

Senator BROWNBACK: And, for me—I want to, you know, reiterate—my interest in this is, I want to see the United States dominate the Earth-moon orbit. I want to see it for the good of humanity, for commercial, military, intelligence, exploration, scientific purposes.

It seems to me what you're presenting here today, which is a rational presentation, is that the key for us is going to be unlocking billions of dollars of private capital for that to move forward. We've been stagnant in the public investment area. We've invested fair in it, but not heavily. And we need to unlock that private capital, and this would be a key for us to go forward.

Mr. Greason, when would you be ready to take your first commercial passenger up in space? And I'm going to ask the others, as well.

Mr. GREASON: That depends, in part, on factors that are not entirely in my control, like how fast we lock up some of the remaining investment. But if the investment is in hand, not sooner than about three years, because we have an extensive test program we have to go through.

Senator BROWNBACK: So you believe you would be ready to offer commercial space flights for private-sector individuals by 2006?

Mr. GREASON: We could be, yes.

Senator BROWNBACK: That presumes that we will be able to get the regulatory structure and limitation of liability?

Mr. GREASON: Yes, sir.

Senator BROWNBACK: And how is your capital formation? I know that's proprietary, but are you being fairly well received to date?

Mr. GREASON: It's been a long road. There was—as the gentleman to my left said, this has been a track record of bad results, but I'm quite optimistic about our prospects for getting the rest of the money that we need. And right now, we're solvent, based on current contracts.

Senator BROWNBACK: Mr. Musk and Mr. Tito, when could you take your first commercial paying human customer into space?

Mr. MUSK: Well, the task that SpaceX has set for itself is probably an order of magnitude greater than sub-orbital flight. We've really aimed at orbital flight, really essentially the job that the Space Shuttle does. That's a longer road. But I think it's conceivable we could get something done in the 2006 time frame, as well.

Senator BROWNBACK: Mr. Tito.

Mr. TITO: Well, my time frame is the time that I would make a commitment to invest. And then, depending on who I invest with, it would depend on their timetable. But it would be consistent with, you know, the three- to five-year period. But as far as my personal timetable, I'm ready to write the check, have the pen in hand. It's a matter of getting the regulatory approval.

TAX INCENTIVES

Senator BROWNBACK: Congressman Rohrabacher.

Representative ROHRABACHER: When talking about attracting investment, of course, we attract investment by individuals who are excited about the idea of being involved in space projects, but also just regular investors. And when you can attract regular investors, that's when a flood of revenue may come in. I have the zero tax, zero gravity legislation, Mr. Chairman, that you might think about on the Senate side—it's H.R. 1914—which excludes new space ventures from capital gains and other type of business-related taxes.

Mr. Kutler, do you think that this—giving people an incentive in this way would attract the type of capital that's necessary to kick off this part of this adventure?

Mr. KUTLER: Well, I think, obviously, anything helps, because what it does is changes the return-on-investment equation for an investor. But that will only help if some of the preliminary steps are taken to solve the regulatory and other issues we talked—

Representative ROHRABACHER: I see.

Mr. KUTLER: —about today. If those aren't taken, then nobody will take you up on your offer and start companies to go ahead and advantage themselves of the capital gain.

Representative ROHRABACHER: So for our tax incentive to work, we've got to make sure we have the liability and regulatory reform—

Mr. KUTLER: Correct.

Representative ROHRABACHER: —that's necessary. Well, that's a very good answer. But let us note that, under this bill, space tourism is certainly a new venture in space that would be covered by zero gravity, zero tax.

I thought that the comparison with general aviation, about liability, was an important point, Mr. Chairman, to come out of this hearing, that general aviation in our country was almost strangled in the cradle. I mean, it wasn't even in the cradle, it was actually—it was an adult by then, and we almost killed an adult industry with an irrational liability standard. And today, of course, general aviation is thriving, and many thousands of people, if not tens of thousands of people, earn their living manufacturing general aviation planes, servicing general aviation planes. It's a very important part of our economy.

I remember, when I was a young man, I would go to Palm Springs and celebrate Easter, and it was a pretty wild time out there. And one of the things we would do—Mr. Tito remembers these days very well—and we would rent motorcycles, and we'd go out in the desert and ride our motorcycles that we would rent. But something that's happened that today's generation of young people don't have the ability to rent a motorcycle and go out in the desert and enjoy the same type of thing that I enjoyed, the freedom, the exhilaration, the experience of riding a motorcycle in the desert in that same area. And why is that? Because someone along the line sued someone. Because when I rented the motorcycle, I assumed my liability. And somewhere along the line, a lawsuit or a law case by some lawyer who was seeking financial reward—for himself, I would imagine—was able to change the rules of the game. People can no longer sign off their liability in renting motorcycles in the desert.

So what do we have? We have a whole generation of young people that aren't able to experience this, and we've got people, who are in that industry, who no longer have jobs, renting motorcycles to people who want to go out and experience something on the weekend or in their holiday.

It almost happened to general aviation. We want to make sure, in this industry, which we believe will have a tremendous benefit to the United States and to humankind, that we don't eliminate this industry with that same sort of irrationality of liability standards that are irrational.

In fact, as I say, I think that we are entering an era when the spinoffs of investment by private individuals, like Mr. Musk and Mr. Tito, will actually help us in our national defense. We will actually—instead of having the Defense Department invest in technology that flows into the private sector, we will actually see people move forward in Wright-Brothers-type entrepreneurial activity, producing technologies that will flow into our own defense system and into other commercial endeavors. And that's why it's important that we permit the entrepreneurs to get involved by having the right regulatory and liability standards, and perhaps some of the tax incentives, as well.

And, with that, I want to thank, especially Mr. Musk and Mr. Tito and the others, who are willing to put their money where their mouth is. The fact is that these two gentlemen—Mr. Musk has invested considerable amounts of his money into a space venture. Mr. Tito is willing to do that as long as we make sure we're doing our job. And I think that this is a—this type of entrepreneurship is in the best tradition of the United States of America, and that's why we lead the world, because we've got people like you.

So thank you all very much. And thank you, Mr. Chairman.

Senator BROWNBACK: Thank you, Congressman Rohrabacher.

I want to thank the panelists for joining us today. It's been an excellent hearing. We're going to try to put together a series of those, of how we can move forward in the space ventures for the United States, that's leading up to and then past the Gehman Commission that'll be reporting out, I presume sometime in September. So it's all part of that effort to try to figure out how we can move forward in space as a country, and move forward aggressively.

Thank you very much for being here. The hearing is adjourned. [Whereupon, at 11:55 a.m., the hearing was adjourned.]

Appendix 1:

ANSWERS TO POST-HEARING QUESTIONS

ANSWERS TO POST-HEARING QUESTIONS

Responses by Phil McAlister, Director of the Space and Telecommunications Industry Analysis Division, Futron Corporation

Questions submitted by Chairman Dana Rohrabacher

Q1. What barriers must be overcome for commercial human space flight to succeed as a viable business?

A1. Within commercial human space flight, there are two segments: orbital space travel and sub-orbital space travel. These are very distinct markets, each with their own issues.

Orbital commercial human space flight currently exists with the Russian *Soyuz* launch vehicle. The primary “barrier,” or rather the primary “hindrance” is financial—the current price for orbital space flight on the *Soyuz* limits the potential market to the super-affluent population.

There is no current supplier within the United States of orbital space flight, and the barriers to this market are similar to that of sub-orbital space flight within the United States. The barriers are technical, financial, and regulatory. Technically, no organization has ever built a reliable production-level sub-orbital space vehicle. And, no organization has ever come close to doing it cost-effectively (the financial barrier). From a regulatory perspective, the lack of a clear regulatory framework for this industry is also a major barrier.

Q2. How optimistic are you that these barriers will be overcome?

A2. I am somewhat optimistic that the barriers within the U.S. will be overcome. I put the odds at 50–50.

Q3. When, if ever, do you think commercial human space flight will become a viable business?

A3. As mentioned, orbital commercial human space flight is a business; although, it is debatable whether it is “viable.” Futron estimates that the earliest sub-orbital commercial human space flight could provide service is 2006, and it would be several years after that when the business would become “viable,” depending on how you defined that term.

Q4. What barriers must be overcome for commercial human space flight to succeed as a viable business? How optimistic are you that these barriers will be overcome? When, if ever, do you think commercial human space flight will become a viable business?

A4. There is no question in my mind that commercial human space flight will become a viable business. The major determinants are economically, not technologically driven. Furthermore, the major economic unknown “barrier” is the regulatory framework which is within the control of the Federal Government and therefore so is the projected time frame is for the maturation of the business opportunity.

Questions submitted by Representative Bart Gordon

Q1. Should the Federal Government provide third-party liability indemnification for commercial human space flight activities, and if so, why? What, if any, “cap” should there be on the government’s level of indemnification?

A1. It depends whether the space flight activity in question is sub-orbital or orbital.

For orbital space flight, indemnification already exists. There is no qualification for indemnification regarding the purpose of the flight (e.g., commercial human space flight, launch of a telecommunications satellite, etc.).

For sub-orbital space flight, it would depend on the goal of the government. If the goal is to treat sub-orbital and orbital activities in a consistent manner, then the government should provide indemnification. If the goal is to stimulate sub-orbital space travel, then again the government should provide indemnification. The government should not provide third party indemnification if the goal is to minimize government involvement in private sector activities. Commercial insurance companies can provide third-party liability insurance. It may turn out that commercially-provided liability insurance is exorbitant, and therefore it may be a barrier to the expansion of sub-orbital commercial human space flight. However, theoretically, any activity can be insured.

If the government decided to provide indemnification, it should be at a level consistent with orbital space flight indemnification, i.e., at a level equal to the maximum probable loss of the vehicle.

Unfortunately, litigation, and the potential for extraordinary financial awards, are a way of life in this country. It brought a mature general aviation industry to its knees in the 1980s. This bankrupted many participants, cost a large number of jobs and delayed any significant new investments/advancements for over a decade. The industry is still digging out from that train wreck. The potential for a single similar judgment could kill the entire fledgling commercial human space flight industry before it gets off the ground. Should the Federal Government seek to promote this industry, third-party liability indemnification will be an essential part of the plan. Such indemnification should, however, be carefully legislated so that it is a temporary, not institutionalized benefit. Once a track record of successful space flight is achieved, I am confident that the corporations involved will work with industry insurers to consider what an appropriate risk sharing is going forward. The other important insurance element is the ability for a reasonable waiver of liability signed by passengers to be considered valid/enforceable and not subject to reversal in court.

Q2. What, if any, regulatory role should the Federal Government play relative to the commercial human space flight industry, and why?

A2. Again, for orbital space flight, the regulatory regime is already established.

For sub-orbital space flight, the government should regulate the safety of the uninvolved public. In this regard, the orbital space flight safety regime should be used as a template for sub-orbital space flight.

Other than the safety role, the government should not be involved. Particularly, the government should not be in the business of determining what is an acceptable risk level for paying passengers of sub-orbital space travel. The provider of sub-orbital space travel and the customer are involved in a consensual, private transaction. The customer should be free to weigh the risks, rewards, and price of such a service and decide whether or not to purchase the service. The customer should also be free to decide whether or not to waive his/her liability against the supplier.

Like many sectors with large potential legal risks, the industry is not likely to receive the full funding required to develop without a regulatory framework set by the Federal Government. Investor's fears of what could be, may be even more harmful than having a set of regulations which are only partially industry-friendly. There should therefore be early Federal Government oversight regulating commercial human space flight. The key is to balance the regulatory burden to be placed upon start up companies and primarily focusing on the risks of the uninvolved public.

Q3. Should the government certify the safety of your vehicles prior to the commencement of commercial, passenger-carrying operations? If so, how should that be done? If not, how should your industry address safety considerations?

A3. No (see the answer to question 2). The government should only certify/license vehicles as safe for the uninvolved public. Again, the orbital regulatory regime can be applied for this purpose.

It is up to the industry to demonstrate to the public that its vehicles are safe. The risk/reward equation is unique for each individual and it should be left up to the individual customer to make that determination. Even if sub-orbital human space travel turns out to be enormously risky, it should be up to the individual to determine if the risk is worth the reward. If the industry cannot demonstrate its safety, it will not get any customers and the question becomes moot.

Government certification of experimental spacecraft will place a huge financial burden on start-up companies. Unlike the early days of the commercial aerospace industry, today there are minimal technological contributions made by small companies. The current regulatory burden on the industry has become an effective 'barrier to entry' for new technologies and ideas, except those developed by the largest of companies. Of course since those large companies have huge investments in the current state of technology, development will continue to lag what is otherwise technologically possible. For that reason, the Federal Government should recognize the inherent experimental nature of early commercial manned space flight and not require companies to spend more on attorneys than engineers. Paying passengers should be permitted to assume risk for themselves, rather than relying on a Federal Government to regulate space flight to a safety level comparable to a commercial aircraft in these early developmental days. Over time, as the industry matures, safety metrics will develop and at some point it would be appropriate for the government to regulate the industry just as it does other means of transportation.

One analogy to compare it to is the regulatory oversight of the Securities & Exchange Commission. The SEC has a regulatory framework in place to protect inves-

tors. Certain sophisticated investors, as defined based upon their net worth and experience in investing, are permitted to make investments with minimal disclosure that otherwise would not be generally available to the public. In this case the SEC views those investors as being capable of making a risk assessment for themselves. During the early days of human commercial space flight, the cost of a ticket will be high enough to permit the Federal Government to think about this risk assessment by individuals alone in a similar manner.

ANSWERS TO POST-HEARING QUESTIONS

Responses by Dennis A. Tito, CEO, Wilshire Associates, Inc.

Question submitted by Chairman Dana Rohrabacher

Q1. In establishing safety standards for commercial human space flight activities, what features of current aircraft safety standards and space launch safety standards should be applied to commercial human space flight?

A1. As I stated in my testimony, commercial aviation is a mature and well-established industry. Aircraft safety standards reflect 100 years of powered flight experience, and are part of a 75+ year history of federal regulation increasingly focused on protecting the safety of airline passengers as well as uninvolved third parties.

The commercial space launch industry is a somewhat less mature industry, with just over two decades of commercial experience. This industry's heritage, however, is based on over a half-century of military and civilian development and testing of ballistic missiles and their descendant launch vehicles. Missiles and most current launch vehicles have significant destructive potential and, because they are expendable, cannot be flight tested, fixed, and re-tested in the way aircraft or other reusable systems can. Launch safety standards have therefore focused on detailed oversight, complex system redundancy and flight termination (self-destruct) capabilities.

Neither of these two operational safety paradigms is appropriate for commercial human space flight. There may be some similarities between aircraft and sub-orbital reusable launch vehicles, and others between RLVs and expendable rockets. However, I predict that these new space planes will in fact merit their own operational safety approaches. At this point, we need to develop and fly some vehicles so we can learn what to do and what not to do. That, after all, is the beauty of the competitive marketplace: better ideas are rewarded while less-good approaches suffer until they are improved or die off.

Questions submitted by Representative Bart Gordon

Q1. Should the Federal Government provide third-party liability indemnification for commercial human space flight activities, and if so, why? What, if any, "cap" should there be on the government's level of indemnification?

A1. In general I believe that the Federal Government should provide a level playing field for all commercial space transportation endeavors. If policy-makers believe that the current third-party excess liability risk-sharing regime, commonly known as "indemnification," should be continued for expendable launch vehicles, then I would expect it to apply to reusables as well.

Personally, continued provision of indemnification is not an absolute requirement for me to make an investment in the sub-orbital RLV industry. I am not seeking to be regulated by the FAA Associate Administrator for Commercial Space Transportation in order to obtain indemnification. I am seeking a predictable, stable, and streamlined regulatory environment so that if my investment leads to a successful RLV, the company I invest in will be able to pursue commercial revenues in the marketplace without the burdensome regulation faced by the existing mature aviation industry.

I predict that the inherent reliability and fairly small size of sub-orbital RLVs will make their likelihood of incurring significant third party liability much less than current large commercial ELVs. To the extent this is proven out over time, the government's risk of ever actually paying an excess claim will decrease even as the number of RLV flights dramatically increases. That is certainly a win-win for all parties.

Q2. What, if any, regulatory role should the Federal Government play relative to the commercial human space flight industry, and why?

A2. First and foremost, the government should continue its space transportation regulation focus on protecting uninvolved third parties. Just as the Federal Aviation Administration allows people to risk their lives jumping out of planes while protecting other air traffic and people and property on the ground from skydiving operations, the Federal Government should allow people to experience the inherently risky adventure of human space flight. So the primary regulatory focus should be to protect public safety.

Because this industry is not even in place yet, I would be very hesitant to suggest that the government take a prescriptive approach to regulating the design or operation of vehicles in order to somehow guarantee the safety of space flight partici-

pants. The only way to guarantee safety is to not allow these vehicles to fly in the first place. If policy-makers agree that it will help America's national space enterprise to allow more of its citizens to personally participate in the opening of the space frontier, especially if citizens will voluntarily pay for the experience and/or invest in developing these vehicles without federal funding, then you cannot preempt the industry's need to naturally evolve through flight experience. In short, if vehicles can't be funded to fly for revenue because someone might get hurt, we won't learn to build safer and more cost-effective vehicles and achieve the kind of safe operation of RLVs that aviation enjoys today. Government cannot short-circuit the risky "barnstorming" phase of space flight, although it can work with industry to maximize the learning from these early years.

Q3. Should the government certify the safety of your vehicles prior to the commencement of commercial, passenger-carrying operations? If so, how should that be done? If not, how should your industry address safety considerations?

A3. If by "certify" you mean the same process used by the FAA to certify a commercial airplane for regular passenger operation, the answer is clearly no. Neither the FAA nor industry know enough about reusable launch vehicles to conduct an aircraft-style certification process. And we will never learn unless vehicles can fly for revenue under the existing RLV licensing process. Furthermore, any functional equivalent of government certification would create an inappropriate expectation on behalf of RLV customers that their space travel experience will be as safe as riding a Boeing 737 from Los Angeles to San Francisco.

That does not mean that the RLV industry does not need to pay attention to the safety of its customers, nor that the government should take a passive role. First and foremost, the government's regulation of RLVs to protect safety of the general public will encourage increasing vehicle reliability and other features (e.g., fail-safe designs and multiple abort modes) which will inherently tend to protect space flight participants as well. Furthermore, the government must require that RLV companies fully disclose the safety record of their vehicles to potential customers, and help RLV companies to set appropriate medical and training standards as part of the licensing process.

However, the industry also must bear a significant responsibility for developing its own "best practices" to evolve towards safer space travel experiences. In this regard, another historically risky "adventure travel" industry—commercial scuba diving—may provide an excellent model for the commercial human space flight industry.

With the commercial introduction of Jacques Cousteau's aqualung after World War II, more and more scuba-oriented diving shops opened up around the U.S. during the 1950s. As more people began to participate in the late 1950s and early 1960s, more accidents occurred. The industry responded by creating professional certification organizations and training courses to ensure that diving customers had the requisite training and skills to safely enjoy their diving experience. By the 1970s, diving certification cards were regularly required for the purchase or rental of diving equipment, and new technological innovations were diffused throughout the industry to improve the reliability of all manufacturers' equipment.

I see no reason, particularly with an active facilitating role by the Federal Government, why the commercial human space flight industry cannot develop similar practices and methods to provide an increasingly safe—but still adventurous—space flight experience to our customers.

ANSWERS TO POST-HEARING QUESTIONS

Responses by Elon Musk, President and Chief Technologies Officer, Space Exploration Technologies (SpaceX)

These questions were submitted to the witness, but were not responded to by the time of publication.

Questions submitted by Chairman Dana Rohrabacher

- Q1. The Space Launch Initiative (SLI) was intended to encourage innovative ways for reducing launch vehicle development cost. In your opinion, why didn't SLI succeed?*
- Q2. To what level should industry standardization be pursued during the early stages of commercial human space flight development? How does standardizing launch vehicle components contribute to the goal of low-cost launch operations?*

Questions submitted by Representative Bart Gordon

- Q1. Should the Federal Government provide third-party liability indemnification for commercial human space flight activities, and if so, why? What, if any, "cap" should there be on the government's level of indemnification?*
- Q2. What, if any, regulatory role should the Federal Government play relative to the commercial human space flight industry, and why?*
- Q3. Should the government certify the safety of your vehicles prior to the commencement of commercial, passenger-carrying operations? If so, how should that be done? If not, how should your industry address safety considerations?*

ANSWERS TO POST-HEARING QUESTIONS

Responses by Jeff Greason, President, XCOR Aerospace, Mojave, California

Question submitted by Chairman Dana Rohrabacher

Q1. In establishing safety standards for commercial human space flight activities, what features of current aircraft safety standards and space industry launch safety standards should be applied to commercial human space flight?

A1. Because of the immaturity of this industry, we believe that standards should be generic rather than specific, guidelines rather than specifications.

We have sought in vain for a set of applicable standards covering the type of vehicle we are developing. Many existing standards cover systems, subsystems, and components of aircraft and launch vehicles. These are derived from FAA, NASA, DOD, OSHA, DOT and non-governmental bodies such as AIAA, SAE, and NFPA. While we refer to these standards frequently we have found few to be wholly applicable.

Standards are often written in a very prescriptive manner: “you will do it this way.” As one example, a certain common aircraft material (such as aluminum alloy 2024-T3 per Federal Standard QQ-A-250/4) may be specified for a pressure vessel, and it works quite well when used on an aircraft. It may, however, be completely incompatible with launch vehicle propellants, or reentry temperatures, or it might simply weigh too much to be acceptable in a launch vehicle. Any given standards document usually covers multiple systems, and while one element of it may apply to our case, several others will not.

Therefore, if by “features of current standards” you mean pieces of the standard that we can adopt, I cannot recommend adoption of any such combination of standards.

We think more in terms of design criteria than standards. A standard suggests something uniform across several vehicles; and successful standards are based on experience. It is clearly too early to develop such standards for sub-orbital or orbital commercial manned vehicles, since there are no such vehicles to use as the basis of experience. In setting the design criteria used in any given vehicle, we have examined a large collection of standards used in various arenas. We have often found that these standards are useful resources in developing design criteria for a specific vehicle. The requirements in a standard are there for a reason; usually in responses to some failure that has occurred in a given system. While we may not be preventing that type of failure in the same way, we need to prevent it in *some* way. The applicability to any given vehicle can only be determined on a case-by-case basis.

Therefore, at the current stage of maturity in commercial human space flight, we need a regulatory framework that avoids design standards that are too specific to an assumed design. Vertical takeoff rockets may need a completely different set of standards than winged vehicles that take off from a runway. Instead, we need performance-based standards; an approach which says “you will demonstrate this level of performance,” rather than “here is how you do it.” As the industry develops a track record, the time will come when design standards will be appropriate, but this can only be learned through experience.

While the current AST regulations have many shortcomings, their outstanding feature is that they are being developed in a performance-based manner. Their approach to public safety relies on a quantitative safety standard (expected casualties) rather than specifying the design methods which will achieve the desired level of safety. This leaves each launch company free to develop the designs which will be used to achieve that level of safety, and AST is left with the task of confirming that they are adequate to protect public safety. The single most useful feature of the existing regulations is that they preserve the performance-based approach to regulation.

Questions submitted by Representative Bart Gordon

Q1. Should the Federal Government provide third-party liability indemnification for commercial human space flight activities, and if so, why? What, if any, “cap” should there be on the government’s level of indemnification?

A1. The government currently does carry such third-party indemnification per international treaty, and I see no reason to change this. In other words, there is no reason why the current launch of, for example, a satellite that will be used to broadcast entertainment should be treated differently in this respect from the future

launch of space flight participants. The justification for third-party liability indemnification for commercial launches of non-government payloads is that the health of the industry is important to the United States. The health of an industrial base for frequent, safe, reliable, and affordable space transportation is at least as important, economically and strategically, as the commercial direct broadcast satellite industry.

Singling out one segment of space transportation to be excluded from the already existing indemnification regime would make it extremely difficult to obtain third-party liability insurance. Space insurance is already a small and highly specialized business, and the existing insurance suppliers and customers have stated publicly that the current indemnification regime is important to them. Therefore it would be an unfair burden to emerging space transportation developers, who are least able to afford expensive insurance, to drive up their insurance rates while leaving the existing players indemnified. This is essentially the same argument I made at the hearing: "why make insurance more difficult to get than it is already?"

So far, I have asked only for equality of treatment. This is separate from the question of what the indemnification regime should be. Let me summarize the current situation. The only "indemnification regime" for launch vehicles covers third-party losses in excess of the maximum probable loss. The intention is that the losses to the uninvolved public from unforeseeable, extraordinary, less than one-in-ten-million accidents be covered by the U.S. government. That, in turn, was necessary because the Liability Convention, to which the U.S. is a party, establishes the U.S. government as the ultimately responsible party for third-party damages in international launch accidents. The so-called "indemnification" regime actually *limits* the exposure of the U.S. government by requiring launch operators to purchase very expensive insurance to cover a significant fraction of the potential risk which otherwise, by treaty, would be the province of the U.S. government.

Furthermore, before the government provides indemnification and issues a launch license, all parties to the launch activity must agree to waive liability claims against all other involved parties, including the government. This "cross waiver" means that the government does not protect a launch provider against claims by, for instance, the launch customer. This situation would continue in the case of the sub-orbital RLV industry, so that the government would not be placed in the role of indemnifying the vehicle operator against claims by a space flight participant. Nor could the participant expect to make claims against the government, since they would have waived that right as part of the cross waiver which is required as a condition of the launch license.

In 1988, the Congress and Executive Branch decided that the brand-new U.S. commercial launch industry could not bear the burden of assuming unlimited liability for every possible (however improbable) launch accident. Insurance for such liability would be unobtainable or prohibitively expensive. The result was the current indemnification regime.

It should be noted that other countries offer indemnification provisions to their launch operators which are at least as generous as that offered by the U.S. From time to time, the U.S. Congress has questioned whether these justifications still apply, and that discussion will probably go on. I will note in passing that it is easy to criticize the indemnification regime, but not so easy to suggest an alternative without at least some substantial drawbacks. I also note that the government has never paid a claim for a commercial launch accident, only for government launches.

If the sub-orbital RLV industry is encouraged and fostered, we will be able to build up a large flight database. Once this has been done, the nature of the insurance problem may change. One reason that space insurance is so specialized and so expensive is that the flight frequency is too low to apply normal statistical techniques. As customer demand and flight rates increase, this will change; when there are hundreds of flights per year, failure rates will be predictable and the pool of possible insurance providers will be much larger. At that time, a reexamination of the indemnification strategy will be called for.

But for now, the indemnification regime has helped foster the existing ELV industry, can help foster a new RLV industry, and has not cost the taxpayers a dime. It is difficult to see a near-term need for change.

Q2. What, if any, regulatory role should the Federal Government play relative to the commercial human space flight industry, and why?

A2. The Federal Government has two critical roles in the commercial human space flight industry: protecting the public, and promoting the development of the industry.

Striking the right balance between these objectives calls for vigilance; the regulations need to evolve with the industry. Right now, we face regulations which are a mix of old missile-derived ELV regulations and RLV regulations based on regu-

lators' best guesses about how the RLV industry would develop in the future. There is also the usual human tendency towards regulatory mission creep, developing new regulations in advance of a clear requirement, even in advance of the regulated activity actually occurring (and along with it any experience base that would properly inform the regulatory process).

What the nascent sub-orbital RLV industry needs is a flexible and enabling regime in which we face the minimum set of regulations necessary for the protection of public safety. It should not be sufficient that a proposed regulation be useful or plausible, it has to be demonstrably necessary. The AST regulatory approach has elements of this approach but much work remains to update and streamline the regulations. We believe that as soon as several RLVs are actually flying, a review of the regulations will be necessary, and we will likely find that many of them need to be revised or replaced. Today's RLVs are turning out to be somewhat different than what was predicted a few years ago when the existing regulations were originally drafted.

The "promotion" mission could use some more emphasis. The most important way to promote the industry is with a predictable and workable regulatory regime, but more could be done. AST has many initiatives underway which will take time to bear fruit, including tools to simplify the safety analyses, and most importantly, developing a categorical exclusion (CATEX) from the National Environmental Policy Act for sub-orbital RLV activities to lift the needless burden of individually assessing each launch license for NEPA compliance.

It also seems to us that AST would profit from shifting resources away from regulatory development and towards field experience with the RLV developers. We believe AST has the right ingredients to grow into an effective agency for promoting the development of a safe RLV industry. However, because this industry is so young, they lack practical experience needed for developing future regulations. Assuming that sub-orbital RLVs will continue to be regulated by AST, these suggestions represent more a fine-tuning of their regulatory approach than a radical change.

There are some who have suggested rolling back the progress since 1984 and placing sub-orbital RLVs under the aircraft regulatory regime. That would be a huge mistake; a nascent new area of technology and business cannot be appropriately regulated by an agency that oversees a fully mature industry and has no promotional mandate. Much of aircraft regulation is design-specific, rather than performance based. Certain technologies are either explicitly or implicitly assumed to be in use in the aircraft world, and flight regime is assumed to be subsonic in air thick enough to lift the vehicle. While some RLVs will employ some aviation-derived techniques, they will deviate from aircraft practice in many ways, far more than the most unusual certificated aircraft has ever done. The aircraft regulatory system simply cannot evolve fast enough to keep up with the pace of technological development in this new industry because it, appropriately, errs on the side of caution to protect the general public which rides on commercial airplanes. As discussed above, the AST regime is not perfect either, but our chances of succeeding with this much smaller and more flexible agency are much better.

I believe the government also has a very important role to play in developing passenger safety, by adopting a paradigm of seeking continuous improvement in passenger safety, rather than imposing a specific solution. I discuss this more in the answer to the following question.

Q3. Should the government certify the safety of your vehicles prior to the commencement of commercial, passenger-carrying operations? If so, how should that be done? If not, how should your industry address safety considerations?

A3. The government should absolutely not certify the safety of our vehicles prior to the commencement of commercial, passenger-carrying operations. Today, we have a gap of one-million-to-one between the safety of space flight (roughly 40 fatalities per *thousand* emplanements for U.S. space missions) and aircraft (roughly 25 fatalities per *billion* emplanements for U.S. scheduled air carriers). When aviation started, its accident rate was as bad or worse than today's space transportation technology. In the early days, carrying passengers for "barnstorming" was one of the few sources of revenue in the aircraft industry. Today, risk tolerance is lower than in the 1920s. We believe we can and must do better. But if commercial RLV operators are ten times safer than government space flight efforts (which may be achievable), that is still 100,000 times less safe than aircraft. We are clearly too early for any kind of certification regime as that practiced in commercial aviation.

Early generation RLVs should be allowed to fly as long as the uninvolved general public are kept reasonably safe. The key is a system which investigates failures and shares the methods used successfully. *The best and fastest path to safety is estab-*

lishing a regulatory culture of continuous improvement based on experience; and the more flights we get, the faster we will gain that experience. Attempts to shortcut this process by establishing standards based on guesses or predictions about future technologies will stifle innovation, fix in place present practices, and slow the pace of safety improvement. This might not be so bad if the current safety record of space transportation were something to preserve. But it is not; it is something to change for the better.

If this is so, how *should* our industry address safety considerations for passengers? We will field an array of quite different vehicles with different costs, safety records, level of training needed for passengers, and passenger comfort. Among the adventurous early participants, we face a spectrum from the old to the young, from the very fit to those with various medical limitations, and a wide variation in tolerance for risk. There are those who have spent much of their life seeking a way into space and would gladly risk their lives, and those for whom it is merely a passing fancy. Trading off these many variables is not a task for regulation; no regulator can look into the hearts and minds of the passengers and decide, whether an operation is safe enough for this or that passenger.

I am not suggesting a passive role for regulators regarding passenger safety, however. For passengers to be able to make these decisions in an informed manner, the operators must be required to fully disclose their safety operating record in unambiguous terms. How else can the passengers seek out the safer vehicles? Furthermore, some vehicles will require more stringent medical standards than others, and some will require more training than others. What is the right level of each? Currently the answer is “we don’t know.” Nobody knows what the market will support; and it is likely not going to be a single answer. There will probably be those space flight participants who seek a hands-on flight, which will require substantial training, and those who just want a thrilling ride.

Market mechanisms can work only when consumers have access to the information they need to make decisions. So we certainly need some regulation so that all operators are forced to disclose their safety records, giving safer operators a way to attract customers. But arbitrarily requiring some level of safety today, possibly more than today’s technology will permit, will only drive up costs and actually slow down the rate of progress toward safer operations. What is the right trade off? It is different for different customers, but the safer we get, the more customers we will attract.

The training and medical issue is less obvious but similar in nature. If one vehicle requires strict screening and extensive training for hands-on participation, and another is hands-off, then applying the same standard to both vehicles has negative effects. If the standard is loose, passengers in the hands-on vehicle are not being adequately screened, with safety implications for both the passenger and the public. But if the standard is strict and all passengers must be screened and trained, then what of the innovator who sought to bring space to the masses with a hands-off vehicle? That operator is out of business: no customers have been attracted because the passengers all had to be trained and screened for a competitor’s vehicle.

The argument is sometimes made that decisions on safety are too difficult for passengers to make. I believe in the wisdom and ability of free citizens to make such decisions for themselves; and that it is proper in a free society to let them do so. People are allowed to risk their lives mountain climbing, parachuting, SCUBA diving, or driving race cars—we do not believe the decision to travel to space, facing the risks of doing so, is any different.

The current safety situation will change when operational track records are established. It is very likely that there will be dramatic differences in safety between vehicle types. When that happens, AST, industry, and the NTSB need to collaborate on raising the bar, perhaps by establishing minimum safety records, perhaps by design standards, or a mix of both. As this evolves, it will be important to avoid applying these new regulations to vehicle test flights. Research and development test flights should continue with the sole burden of protecting the safety of the general uninvolved public. In this way we can hope that people will look back on the first century of private space flight and see the same dramatic improvement in safety which has been demonstrated by aircraft.

ANSWERS TO POST-HEARING QUESTIONS

Responses by Jon B. Kutler, Chairman, CEO, Quarterdeck Investment Partners, LLC

Question submitted by Chairman Dana Rohrabacher

Q1. What barriers must be overcome for commercial human space flight to succeed as a viable business? How optimistic are you that these barriers will be overcome? When, if ever, do you think commercial human space flight will become a viable business?

A1. There is no question in my mind that commercial human space flight will become a viable business. The major determinants are economically, not technologically driven. Furthermore, the major economic unknown 'barrier' is the regulatory framework which is within the control of the Federal Government and therefore so is the projected time frame is for the maturation of the business opportunity.

Questions submitted by Representative Bart Gordon

Q1. Should the Federal Government provide third-party liability indemnification for commercial human space flight activities, and if so, why? What, if any, "cap" should there be on the government's level of indemnification?

A1. Unfortunately, litigation, and the potential for extraordinary financial awards, are a way of life in this country. It brought a mature general aviation industry to its knees in the 1980s. This bankrupted many participants, cost a large number of jobs and delayed any significant new investments/advancements for over a decade. The industry is still digging out from that train wreck. The potential for a single similar judgment could kill the entire fledgling commercial human space flight industry before it gets off the ground. Should the Federal Government seek to promote this industry, third-party liability indemnification will be an essential part of the plan. Such indemnification should, however, be carefully legislated so that it is a temporary, not institutionalized benefit. Once a track record of successful space flight is achieved, I am confident that the corporations involved will work with industry insurers to consider what an appropriate risk sharing is going forward. The other important insurance element is the ability for a reasonable waiver of liability signed by passengers to be considered valid/enforceable and not subject to reversal in court.

Q2. What, if any, regulatory role should the Federal Government play relative to the commercial human space flight industry, and why?

A2. Like many sectors with large potential legal risks, the industry is not likely to receive the full funding required to develop without a regulatory framework set by the Federal Government. Investor's fears of 'what could be' may be even more harmful than having a set of regulations which are only partially industry-friendly. There should therefore be early Federal Government oversight regulating commercial human space flight. The key is to balance the regulatory burden to be placed upon start up companies and primarily focusing on the risks of the uninvolved public.

Q3. Should the government certify the safety of launch vehicles prior to the commencement of commercial, passenger-carrying operations? If so, how should that be done? If not, how should the industry address safety considerations?

A3. Government certification of experimental spacecraft will place a huge financial burden on start-up companies. Unlike the early days of the commercial aerospace industry, today there are minimal technological contributions made by small companies. The current regulatory burden on the industry has become an effective 'barrier to entry' for new technologies and ideas, except those developed by the largest of companies. Of course since those large companies have huge investments in the current state of technology, development will continue to lag what is otherwise technologically possible. For that reason, the Federal Government should recognize the inherent experimental nature of early commercial manned space flight and not require companies to spend more on attorneys than engineers. Paying passengers should be permitted to assume risk for themselves, rather than relying on a Federal Government to regulate space flight to a safety level comparable to a commercial aircraft in these early developmental days. Over time, as the industry matures, safety metrics will develop and at some point it would be appropriate for the government to regulate the industry just as it does other means of transportation.

One analogy to compare it to is the regulatory oversight of the Securities & Exchange Commission. The SEC has a regulatory framework in place to protect inves-

tors. Certain sophisticated investors, as defined based upon their net worth and experience in investing, are permitted to make investments with minimal disclosure that otherwise would not be generally available to the public. In this case the SEC views those investors as being capable of making a risk assessment for themselves. During the early days of human commercial space flight, the cost of a ticket will be high enough to permit the Federal Government to think about this risk assessment by individuals alone in a similar manner.