FUTURE MARKETS FOR COMMERCIAL SPACE

HEARING

BEFORE THE

SUBCOMMITTEE ON SPACE AND AERONAUTICS

COMMITTEE ON SCIENCE

HOUSE OF REPRESENTATIVES

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FUTURE MARKETS FOR COMMERCIAL SPACE

WEDNESDAY, APRIL 20, 2005

HOUSE OF REPRESENTATIVES,
SUBCOMMITTEE ON SPACE AND AERONAUTICS,
COMMITTEE ON SCIENCE,
Washington, DC.

The Subcommittee met, pursuant to call, at 9:35 a.m., in Room 2318 of the Rayburn House Office Building, Hon. Ken Calvert [Chairman of the Subcommittee] presiding.

COMMITTEE ON SCIENCE
SUBCOMMITTEE ON SPACE AND AERONAUTICS
U.S. HOUSE OF REPRESENTATIVES
WASHINGTON, DC 20515

Hearing on

Future Markets for Commercial Space

April 20, 2005
9:30 a.m. – 11:30 a.m.
2318 Rayburn House Office Building

WITNESS LIST

Panel I

Mr. Burt Rutan
Scaled Composites, LLC

Mr. Will Whitehorn
President
Virgin Galactic

Panel II

Mr. Elon Musk
Chairman and CEO
Space Exploration Technologies (SpaceX)

Mr. John W. Vinter
Chairman
International Space Brokers

Mr. Wolfgang Demisch
President
Demisch Associates, LLC

Dr. Molly Macauley
Senior Fellow and Director
Academic Programs
Resources for the Future

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HEARING CHARTER

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

Future Markets for Commercial Space

WEDNESDAY, APRIL 20, 2005
9:30 A.M.–12:00 P.M.
2318 RAYBURN HOUSE OFFICE BUILDING

Purpose

On Wednesday, April 20, at 9:30 a.m., the Subcommittee on Space and Aeronautics will hold a hearing to examine the future of the commercial space market and the government's role in that future. Last year, the President signed into law the Science Committee's *Commercial Space Launch Amendments Act,* which dealt with regulating one aspect of commercial space—private, human sub-orbital flights, which are generally intended for space tourism.

The first panel at the hearing will examine the potential for space tourism, with a focus on last year's successful flights by SpaceShipOne, the world's first privately-built and human-piloted spacecraft.

Built by famed aircraft developer Burt Rutan, SpaceShipOne last year won the Ansari X–Prize, a $10 million kitty raised by space enthusiasts to stimulate entrepreneurial interest in space flight. Rutan's ship was the first to fly to an altitude of more than 100 kilometers twice in two weeks, beating 25 other teams from seven countries.

Virgin Galactic, founded by the Virgin entertainment and airline company owner Richard Branson, has announced plans to buy a fleet of spacecraft based on SpaceShipOne's design to carry tourists into sub-orbital space (an altitude not sufficient to orbit the Earth), possibly as early as 2008.

The second panel will examine the potential of the wider commercial space market, which includes rockets to launch satellites and the satellites themselves, which provide services ranging from beaming images of landscapes and weather patterns, to global communications and entertainment. The commercial space market has had a spotty record of success. The government is very involved in the commercial space market in a variety of ways, including providing permits for launches and insuring private parties against catastrophic accidents. Perhaps most significantly, the government is a leading purchaser of both satellites and launch services.

Another potential aspect of the commercial market—private provision of services for the National Aeronautics and Space Administration (NASA) to service the International Space Station—will not be a focus of this hearing.

Witnesses:

FIRST PANEL:

Mr. Burt Rutan founded his company Scaled Composites, Inc. in 1982. For SpaceShipOne's achievements, Mr. Rutan this month received the Collier Aerospace Trophy, the most prestigious prize in aeronautics.

Mr. Will Whitehorn is the President of Virgin Galactic and Group Corporate Affairs and Brand Development Director for Virgin Management Limited.

SECOND PANEL:

Mr. Elon Musk is the CEO and Chief Technology Officer of Space Exploration Technologies (SpaceX) in El Segundo, CA. He formerly founded two Internet companies, PayPal and Zip2 Corporation.

Mr. John W. Vinter is Chairman of the International Space Brokers (ISB). ISB represents nine of the twenty satellite companies in the world and is the only insurance broker that is focused exclusively on the space industry.

Mr. Wolfgang Demisch, the founder of Demisch Associates, LLC, is an aerospace financial analyst.

Dr. Molly Macauley is a Senior Fellow and Director of Academic Programs at the Resources For the Future.

Overarching Questions:

The Committee will focus on the following questions at the hearing:

1. What is the outlook for the various aspects of the commercial space industry over the next five to ten years?
2. What should the government do or not do to encourage the nascent commercial space industry?
3. How can the commercial space industry avoid some of the pitfalls that have led to unrealized expectations in the past?

Background:

The Rise of Commercial Space Industry and the Role of Legislation

From the dawn of the space age through much of the 1980s, governments dominated efforts in space. Governments financed and owned most satellites, which were launched on government-owned vehicles, including the Space Shuttle.

The *Challenger* accident in 1986, however, helped spur private sector ownership of both satellites and launch vehicles. After the *Challenger* accident, for example, government agencies, particularly the Department of Defense, viewed the Space Shuttle as too risky to be the sole launch vehicle for U.S. Government payloads and began looking for alternatives.

The Science Committee passed the *Commercial Space Launch Act* (CSLA) of 1988, which required NASA to purchase launch services for satellites from private companies rather than purchasing the launch vehicle itself. The CSLA ensured a market for the nascent launch industry by requiring the government to be a customer.

The CSLA also provided another element intended to foster the success of the new industry—indemnification against catastrophic accidents. Because a single launch failure had the potential of causing billions of dollars of damage should the debris fall on populated areas, the private sector argued that no private insurance company would offer coverage to a satellite company or launch provider unless the government agreed to indemnify (that is, pay for) at least a portion of the potential damages.

The CSLA indemnifies companies for catastrophic losses—losses above the amount of damages that private insurers calculate to be the maximum probable loss (for which private insurers themselves provide coverage) to a ceiling of $1.5 billion. While there is debate over whether indemnification is necessary as the satellite launch industry matures, Congress last year, led by the Science Committee, extended the indemnification provisions of the CSLA through December 31, 2009.

The CSLA also established a permitting process within the Office of Commercial Space Transportation (known as AST), now housed within the Federal Aviation Administration (FAA), for all private commercial launches.

Last year, as SpaceShipOne became the first privately funded, developed, and operated spacecraft to carry a person into sub-orbital space, the Science Committee passed legislation designed to foster a commercial space tourism industry. The *Commercial Space Launch Amendments Act of 2004* gave AST explicit authority to permit launches with humans on board and provided guidance on how to use that authority. One key provision created a new kind of permit that would facilitate flights by experimental vehicles, modeled on the regime another part of FAA uses to regulate airplanes. (That part of FAA is known as AVR.) Another key provision limited the extent to which AST could regulate passenger safety in the near-term. (A summary of the Act is attached.)

The Challenges Faced by Commercial Space Industries

Commercial space industries today include communication satellite developers (including radio, television, and telecommunications), launch service providers (whose customers include the government), satellite imagery companies, and perhaps soon, space tourism companies like Virgin Galactic and companies servicing the International Space Station.

One of the first challenges these companies face is securing financing. Space assets are expensive, and launching into space is fraught with risk. One or two launch failures can drive a company into bankruptcy. Finding investors is thus very difficult for new entrants in the space business, who frequently must court risk-seeking, "angel investors" rather than relying on more established financing firms.

Space industries must also secure insurance. But there are limits to the private pool of insurance available, which can pose a challenge to newcomers to the space business, who necessarily lack a track record to demonstrate their reliability to insurers. Moreover, costly failures in one portion of the space industry can affect the availability of insurance for the rest.

Perhaps the greatest challenge commercial space industries face is capturing a market large enough to sustain them. Unfortunately, their history of success in doing so has been spotty. The commercial satellite imagery or remote sensing industry has failed to develop as originally expected. But satellite radio seems to be gaining in popularity despite the abundance of free competition on more traditional airwaves.

Still, markets can be elusive. For example, optimism for communications satellite manufacturers ran high in the 1990s when markets opened in China and the former Soviet states, where there was little permanent communications infrastructure. Three U.S. companies raced to take advantage of the seemingly boundless opportunities. Iridium, a Motorola spinoff based in Chicago, was the first company in the race. It launched 66 communications satellites into orbit. Next was Globalstar, which had planned to launch 48 satellites.

But the ground-based cell phone industry was quicker. Its penetration into the former Soviet and Chinese markets soon rendered Iridium's and Globalstar's investments practically useless. Iridum's assets were ultimately sold to a group of private investors, which continue to own and operate Iridium today. (The Department of Defense continued to use Iridium throughout the change in ownership.) A third company, Teldesic, had planned to launch 288 satellites, but could not attract enough investors after the failure of Iridium and Globalstar.

As satellite producers saw their fortunes fade so did those companies who had hoped to put those satellites into orbit. Lockheed Martin and McDonnell Douglas had earlier invested large sums, aided by the government, to develop a new generation of launch vehicles. Boeing launches Sea Launch and the Delta series of rockets (obtained when Boeing took over McDonnell Douglas), and Lockheed launches the Atlas series of rockets. The Europeans have a competing Ariane rocket.

Unlike the Space Shuttle, these rockets are used only once, so they are known as Expendable Launch Vehicles (ELVs). The most advanced of the Atlas and Delta class vehicles, developed with the U.S. Air Force, are known as Evolved Expendable Launch Vehicles (EELVs). Elon Musk is developing a series of rockets dubbed Falcon, which he believes will launch at a significantly lower cost.

With the decline of the satellite industry, the rocket manufacturers were left with too few customers to easily recoup their costs. That has raised the cost of launches to the government. The recently released White House Space Transportation Policy is designed to find a way to provide enough business to keep two competing U.S. entities in the launch market. NASA's pending decisions on how to launch its scientific satellites and on how to launch the planned Crew Exploration Vehicle would affect the market.

SpaceShipOne

Burt Rutan's SpaceShipOne is an effort to open a new aspect of the commercial space market—space tourism. Rutan had to complete two consecutive successful flights to earn the X–Prize. Those flights were not trouble-free. The vehicle rolled 29 times during the first flight; the vehicle shook but had only a "little roll" during the second flight, according to the pilot. No one was injured in either case.

Questions Asked of the Witnesses:

In their letters of invitation, the witnesses were asked to address the following questions in their testimony:

Mr. Burt Rutan:

1. What is the future of your commercial SpaceShipOne program and do you see other customers beyond Virgin Galactic?
2. What should the government do or not do to encourage commercial space endeavors?
3. If you develop other vehicles, where would you expect to find investors? Do you think the traditional investors of Wall Street are likely to step forward?
4. As you move into the commercial world, how do you expect to be able to get insurance coverage?

Mr. Will Whitehorn:

1. When does Virgin Galactic plan to take ownership of the five SpaceShipTwos that it has ordered from Scaled Composites? How soon do you expect to be flying? When do you expect to make a profit?
2. What is different in preparing to take ownership of a fleet of spaceships vs. Virgin Atlantic taking ownership of a fleet of airplanes?
3. What preparation are you engaged in for the commercial use of these vehicles?
4. What, if anything, should the government be doing or not doing to encourage commercial space?

Mr. Elon Musk:

1. What business plan do you have to make your launch vehicle a success in the commercial market?
2. What do you see as the outlook for commercial space activities in the next five years? The next ten years?
3. What, if anything, should the government do or not do to encourage the nascent commercial space industry?
4. Are there implications for the commercial space industry as you see it in the President's announced Vision for Space Exploration?

Mr. John H. Vinter:

1. What kind of activities does your company include for insurance purposes in its definition of "commercial space?"
2. As insurance brokers, what do you see as the outlook for commercial space activities in the next five years? The next ten years? How do you think we can avoid exaggerated expectations for the industry, such as those that occurred in the low-Earth orbit (LEO) market in the late 1990s?
3. What, if anything, should the government do or not do to encourage commercial space endeavors?

Mr. Wolfgang Demisch:

1. Considering some of the difficulties in the past for commercial space business, (the low-Earth orbit launches anticipated for Iridium, Teledesic, etc.) and the slow growth of the commercial remote sensing industry, what is your outlook for this nascent commercial space launch business and how do we avoid the failures of the past?
2. In the entrepreneurial commercial space arena, when would you expect traditional Wall Street investors to become classic "risk-reward" investors, in place of the "angel" investors that we see today?
3. What, if anything, should the government do or not do to encourage commercial space endeavors?

Dr. Molly Macauley:

1. What kinds of activities would you include in "commercial space?"
2. Is the U.S. the leader in "commercial space?" How does it compare with the status of international commercial space?
3. What do you think the government should do or not do to encourage commercial space?
4. What do you see as the outlook for commercial space activities in the next five years? The next ten years?

APPENDIX

Commercial Space Launch Amendments Act of 2004

H.R. 5382, the *Commercial Space Launch Amendments Act of 2004,* is designed to promote the development of the emerging commercial human space flight industry by putting in place a clear, balanced regulatory regime.

The Act assigns to the Secretary of Transportation jurisdiction over commercial human space flight and requires the Secretary to craft a streamlined experimental certification process for sub-orbital reusable launch vehicles. The Secretary of Transportation must ensure that only one license or permit is required to conduct human space flights. By its licensing or permitting of flights, the United States does not certify the safety of the flights for passengers or crew.

The Act requires the Secretary of Transportation to protect the uninvolved public when licensing commercial human space flights. The Act also requires that crew receive training and satisfy medical standards. Space flight participants must undergo appropriate medical exams and training requirements, and must provide written informed consent for their participation. For the first eight years after enactment of the legislation, the Secretary of Transportation may issue regulations governing the design or operation of a launch vehicle only if the design or operation has indicated likely safety problems through operational experience.

The Act extends the existing liability indemnification regime to the commercial human space flight industry, but excludes launches under an experimental permit.

SUMMARY OF H.R. 5382,
Commercial Space Launch Amendments Act of 2004

Introduced by Mr. Rohrabacher (CA) and co-sponsored by Mr. Boehlert (NY) and Mr. Gordon (TN)

Key features of the Act include:

- The Act will make it easier to launch new types of reusable sub-orbital rockets by allowing the Secretary of Transportation to issue experimental permits that can be granted more quickly and with fewer requirements than licenses;
- Under the Act, permits will allow an unlimited number of experimental flights, rather than requiring a license for a single launch or small number of launches;
- The Secretary of Transportation must ensure that only one license or permit is required to conduct human space flights;
- The Act will require the Secretary of Transportation to issue regulations for crews relating to training and medical condition;
- The Act will limit requirements for paying passengers (or "space flight participants") a medical exam, training, and to being informed of the risks of their participation and providing written, informed consent;
- By its licensing or permitting of flights, the United States does not certify the safety of the flights for passengers or crew;
- For the first eight years after enactment of the legislation, the Secretary of Transportation may only issue regulations governing the design or operation of a launch vehicle if the design or operation has indicated likely safety problems through operational experience;
- The Act will require paying passengers to execute waivers of liability with the Federal Government; and
- The Act will extend the existing liability indemnification regime to commercial human space flight launches, but the bill will not grant indemnification for flights conducted under experimental permits, which will be more lightly regulated.

Chairman CALVERT. Good morning.

Pursuant to notice, I hereby call this meeting of the Space and Aeronautics Subcommittee to order.

Without objection, the Chair will be granted authority to recess the Committee at any time. Hearing no objections, so ordered.

Today, we are going to examine the future of the commercial space market. We are going to have two panels. The first will examine the success of the world's launch, the hopes of our nascent commercial space industry that led to a robust market for space tourism.

Burt Rutan's SpaceShipOne is a manned, reusable launch vehicle that has successfully flown twice in two weeks carrying the equivalent of three people. His team won the X–Prize in October, and last night, his team was awarded the 2005 Collier Trophy, congratulations, which recognizes those who have made the most significant achievement in the advancement of aviation.

Joining him will be Will Whitehorn, President of Virgin Atlantic. Virgin Atlantic will be buying the first fleet of five of a derivative of these spaceships that takes space tourists into sub-orbital space.

On the second panel, we have Mr. Elon Musk, the CEO of Space Exploration Technologies, or SpaceX. I was most impressed with the work his folks are doing when I was touring his facility in El Segundo. His company is developing a new family of launch vehicles, the Falcon. He will offer his insights on the business plan and how he intends to emerge as a success in this commercial space business.

Also, on this panel will be Mr. John Vinter, the Chairman of International Space Brokers. He will offer guidelines that the insurance community requires for those start-up companies and how they must compete with the established aerospace companies for insurance coverage.

Our third panelist is Mr. Wolfgang Demisch, a pre-eminent expert and financial analyst in the aerospace industry.

And finally on this panel, we will have Dr. Molly Macauley, a Senior Fellow and Director of Academic Programs at the Resources for the Future. Dr. Macauley will examine what the government should do or not do to encourage this start-up commercial space industry. She will give her predictions on how the industry will look in five to 10 years.

The history of success in the commercial space arena has been spotty at best. Today, I want to see how the government can be an enabler rather than a hindrance to this important, high technology industry. I am proud of the bill that this committee was able to get enacted last year, the *Commercial Space Launch Amendments Act,* which Congressman Rohrabacher worked very hard to get passed. This committee has had a history of interest in the commercial space industry, and I plan to continue that interest. I am hoping that we will glean information today that will be valuable as we put together our NASA authorization in the very near future.

I look forward to working with the new Administration, Mike Griffin, on this objective. I look forward to hearing from our witnesses today on this very important topic.

[The prepared statement of Chairman Calvert follows:]

PREPARED STATEMENT OF CHAIRMAN KEN CALVERT

In today's hearing, we are going to examine the future of the commercial space market. We are going to have two panels. The first will examine the success of the world's first private effort to launch a person into space and to launch the hopes of our nascent commercial space industry that may lead to a robust market for space tourism.

Burt Rutan's SpaceShipOne is a manned, reusable launch vehicle that has successfully flown twice in two weeks carrying the equivalent of three people. Last October his team won the privately-funded $10 million X–Prize for the development of the first private, manned spacecraft to exceed an altitude of 100 km twice in two weeks, and last night, the team was awarded the 2005 Collier Trophy, an annual award that recognizes those that have made the most significant achievement in the advancement of aviation.

Joining Mr. Rutan on this first panel will be Mr. Will Whitehorn, President of Virgin Galactic. Virgin Galactic will be buying the inaugural "fleet" of up to five of the derivative vehicles of SpaceShipOne, named SpaceShipTwo. We are very interested in hearing when Virgin Galactic plans to take ownership and when they expect to be flying tourists into sub-orbital space.

On the second panel, we have Mr. Elon Musk, CEO of Space Exploration Technologies or SpaceX. I was most impressed with the work that his folks were doing when I toured his facility recently in El Segundo, CA. His company is developing a new family of launch vehicles—the Falcon. He will offer his insights on his business plan and how he intends to emerge as a success in this commercial space business.

Also, on the panel will be Mr. John Vinter, the Chairman of International Space Brokers. He will offer guidelines that the insurance community requires for those start-up companies and how they must compete with the established aerospace companies for insurance coverage.

Our third panelist is Mr. Wolfgang Demisch, a preeminent expert and financial analyst of the aerospace industry. He will address the outlook for the commercial space launch industry as well as outline when space is likely to be able to attract classic risk-reward investors to succeed the "angel" investors that we see today.

And finally, Dr. Molly Macauley, Senior Fellow and Director of Academic Programs at Resources for the Future, will examine what the government should do or not do to encourage this start-up commercial space industry. She will also give her predictions on how the industry will look in five and ten years.

The history of success in the commercial space arena has been spotty at best. Today, I want to see how the government can be an enabler, rather than a hindrance to this important, high tech industry. This committee has had a history of interest in the commercial space industry and I plan to continue to promote commercial space. I am hoping that we will glean information today that will be valuable as we put together our NASA Authorization in the very near future. I look forward to working with the new NASA Administrator on this objective.

Chairman CALVERT. And with that, good morning, Mr. Udall. You may proceed with your opening statement.

Mr. UDALL. Thank you, Mr. Chairman.

And good morning to all of us and all of you that are assembled here.

I want to welcome the witnesses as well, and particularly extend my congratulations, as did Mr. Calvert, to Mr. Rutan and his team on winning the Collier Trophy for their efforts on SpaceShipOne. This is a very prestigious and well-deserved award, and it puts Mr. Rutan in distinguished company, including Orville Wright, the crew of Apollo 11 lunar mission, and of course Mr. Rutan himself, because I just recently learned that you won the award back in 1986 as well. So congratulations. These are impressive accomplishments, and I think I speak for all of us when I say we consider you a real national asset. And we all hope you keep working and designing for many years yet to come.

Mr. Chairman, as you know, Congress, and this committee in particular, has long had a strong interest in promoting the growth of a healthy, robust commercial space sector.

Over the years, there have been some notable successes, such as the development of the Nation's commercial satellite communications industry.

There have also been some setbacks.

For example, the very optimistic projections made in the 1980's for the emergence of manufacturing in space, solar power satellites, and so forth, have not been realized.

And finally, there are the commercial space transportation and commercial satellite remote sensing industries. These are industries in which there has been growth over the years as well as the promise of exciting new applications and markets on the horizon.

At the same time, the current reality is that both of these industries depend significantly on government contracts to maintain their viability.

While the primary focus of today's hearing is on emerging commercial space transportation initiatives, I hope that the witnesses will share their thoughts on the broader issues facing all commercial space companies, whether they be entrepreneurial start-ups or established companies fighting for market share.

The question, for example, of what helps determine whether a potential commercial space activity succeeds or fails, and what should government be doing, as the Chairman mentioned, and equally important, what should government refrain from doing if it wants to promote a healthy commercial space sector.

In that regard, I have received some written testimony submitted by one of the commercial remote sensing companies, DigitalGlobe, that addresses some of those broader issues. Mr. Chairman, I would ask unanimous consent that it be entered into the record of this hearing. (See Appendix 2: Additional Material for the Record, p. 84.)

Chairman CALVERT. Without objection, so ordered.

Mr. UDALL. And I want to thank you for convening this hearing, and I look forward to hearing from the witnesses today.

Thank you.

[The prepared statement of Mr. Udall follows:]

PREPARED STATEMENT OF REPRESENTATIVE MARK UDALL

Good morning. I want to join the Chairman in welcoming the witnesses to today's hearing. And I would also like to extend my congratulations to Mr. Rutan and his team on winning the Collier Trophy for their efforts on Spaceship One.

Mr. Rutan, that is a very prestigious and well deserved award, and it puts you in very distinguished company, including Orville Wright, the crew of the Apollo 11 lunar mission. . .and of course Burt Rutan. . .because as I recently learned, you had already won the Collier trophy for the first time back in 1986.

That's a very impressive accomplishment, and I consider you a real national asset—I hope you keep working and designing for many years to come.

Mr. Chairman, as you know, Congress—and this committee in particular—has long had a strong interest in promoting the growth of a healthy, robust commercial space sector.

Over the years, there have been some notable successes, such as the development of Nation's commercial satellite communications industry.

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For example, the very optimistic projections made in the 1980s for the emergence of manufacturing in space, solar power satellites, and so forth, have not been realized.

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Those are industries in which there has been growth over the years, as well as the promise of exciting new applications and markets on the horizon.

At the same time, the current reality is that both of these industries depend significantly on government contracts to maintain their viability. . .

While the primary focus of today's hearing is on emerging commercial space transportation initiatives, I hope that the witnesses will share their thoughts on the broader issues facing all commercial space companies—whether they be entrepreneurial startups or established companies fighting for market share.

That is, what helps determine whether a potential commercial space activity succeeds or fails? What should government be doing—and equally importantly—what should government *refrain* from doing if it wants to promote a healthy commercial space sector?

In that regard, I have received some written testimony submitted by one of commercial remote sensing companies—DigitalGlobe—that addresses some of those broader issues.

I would like to ask unanimous consent that it be entered into the record of this hearing. Well, Mr. Chairman, we have a wide range of issues to consider, and I look forward to getting the perspectives of today's witnesses. Thank you, and I yield back the balance of my time.

Chairman CALVERT. I thank the gentleman.

And we are joined by Mr. Rohrabacher, the former Chairman of this subcommittee. Do you have any short comment? I would comment that what he is drinking there, ladies and gentlemen, is the energy drink. It is——

Mr. ROHRABACHER. This is not beer.

I figured that your leadership, Mr. Chairman, would energize me, but just in case, I brought Red Bull.

Chairman CALVERT. Well, it is appropriate that—at this hearing that you have wings. So——

Mr. ROHRABACHER. All right.

Chairman CALVERT. Without objection, the additional statements of other Members will be put in the written record so we can get right to the testimony.

Hearing no objection, so ordered.

[The prepared statement of Ms. Jackson Lee follows:]

PREPARED STATEMENT OF REPRESENTATIVE SHEILA JACKSON LEE

Chairman Calvert, Ranking Member Udall,

I want to thank you for organizing this important Subcommittee hearing to discuss the *Future Markets for Commercial Space.* This is one of those topics where we realize the future we only read about is not too far from reality. Commercial space encompasses a number of different issues, some which are still be developed and others that have been an integral part of our lives for quite a while now. The only way to advance our prospects in this field is to invest in R&D and put our knowledge and skills to use for improving the lives of people.

Space tourism is a subject that seems like science fiction, but in fact that fiction is now close to being reality. SpaceShipOne, the world's first privately-built and human-piloted spacecraft built by Burt Rutan shows that individuals can indeed take part in space exploration. Rutan's ship was the first to fly to an altitude of more than 100 kilometers, completing the feat twice in two weeks. Now, Virgin Galactic has announced plans to buy a fleet of spacecraft based on SpaceShipOne's design to carry tourists into sub-orbital space. Clearly, the future is upon us, but realistically it will be many years before regular flights into space for individuals will be possible. Before we get to that stage, it is vital that we discuss all aspects of what this kind of space exploration will entail.

First among our priorities must be the issue of safety for those who would take part in such flights to space. In discussing NASA I have long said that safety must be the first priority, now with the prospect of average citizens being propelled into space the issue of safety is even more paramount. I would suggest that a separate commission be organized to discuss the safety parameters that would need to be in place to make it feasible for average citizens to enter space. Clearly, as time goes

on so will the technology that will steadily allow people to gain even greater access to space exploration than is being proposed by Virgin Galactic. In accordance, guidelines and regulations must be put in place to meet the risks associated with such travel. We may be entering a new era in individual travel, but just like the passenger airplane before it we must ensure the safety of all passengers.

In regards to space tourism, it is also my belief that such travel should not be restricted to only the wealthy. Clearly, these businesses make large investments to startup such a complex operation and therefore huge fees must be generated to make up the costs. However, those who have a passion for space exploration; especially students should at least have a chance to experience space exploration. Of course, this could not be open to everyone, but even allowing a few individuals with lower means but high motivation to take part would be a wise investment. I believe in the long run this will be good for business and good for the science of space exploration because it will only increase the general public's interest in space. We must inspire a new generation to want to literally reach the stars, and with our new generation of technology this dream is more possible.

Commercial space has long yielded great dividends in the technology of satellites. In today's world we would be lost and confused without the aid of these stations in space. However, new technology must emerge and the ability for more businesses to use satellite technology must be enhanced. Lowering the cost of producing and launching commercial satellites would go a long way in bringing new business and therefore new revenue streams in to the fold. Together with space tourism, the future of commercial space is bright, but we can not relent in our pursuit of continued development. Only when we continue to push the boundaries of discovery do we yield innovations that affect the lives of everyday people.

Chairman CALVERT. I ask unanimous consent to insert, at the appropriate place in the record, the background memorandum prepared by the majority staff for this hearing.

Hearing no objections, so ordered.

Today, we will begin with our first panel: Mr. Rutan and Mr. Whitehorn.

Mr. Rutan, thank you for attending, and you may begin. You might—turn your mike on there. That little green button.

Panel I:

STATEMENT OF MR. BURT RUTAN, SCALED COMPOSITES, LLC

Mr. RUTAN. Okay. Thank you very much for the opportunity to address the hearing.

I will attempt to specifically answer the questions that showed up in the invitation.

I want to first point out that I will use the words "personal space flight" here. We tend to use that nowadays instead of "space tourism." And personal space flight is just access to flight above the atmosphere by the public, generally inferred that it is a commercial, revenue-like business.

I think the markets for personal space flight will take on two basic scenarios. The first is one in which commercial companies develop lower-cost versions of the classic government booster and spacecraft concepts and then conduct commercial flights that are funded by passenger ticket sales. This activity might properly be compared to trekking outfits that take courageous adventurers to the top of Mount Everest. That activity survives today even though more than nine percent of those who have reached the summit have died on the mountain and with the recent rate still at four percent. The safety record for all of government manned space flight is hardly better; four percent fatality rate for those who have flown above the atmosphere, and the fatality rate for government

space flight for the last 20 years has been much worse than it was for the first 20 years.

This first scenario's approach will result in, I think, a very limited market whose size will depend somewhat on the ticket prices. However, I do not believe this scenario will result in significant volume of operations, being limited by the same factors that limit the Mount Everest climbers. I believe these systems might begin commercial flight in four to six years, flying maybe 50 to 100 astronauts the first year, and I think the rate will top out at maybe 300 to 500 people per year.

The second scenario is quite different. It is a scenario in which the players do not find the dangers of space flight acceptable. They recognize that extensive improvements in safety are more important than extensive improvements in affordability. Those that attack the problem from this viewpoint will be faced with a much greater technical challenge: the need for new innovations and breakthroughs. If successful, however, they will enjoy an enormous market, not one that is limited to servicing only a few courageous adventurers. It is likely that systems that come out of this approach will be more like airplanes and will operate more like airplanes than the historic systems that are used for government manned space flight.

The future plans for my company regarding the new industry can not be revealed since they are only at a preliminary stage of technical development. They are not fixed—excuse me.

Chairman CALVERT. I apologize.

Mr. RUTAN. No problem.

Chairman CALVERT. They will go off in a second.

Mr. RUTAN. They are not fixed in business deals and, in general, the—when we approach these sort of things, we don't talk about them in the early years. So we are not ready to put out, in a public forum, the—any details on our plans. I could share that with you privately, but not publicly.

I can assure you, however, that our plans do involve this—do not involve the scenario one approach. Since we believe a proper goal for safety is the record that was achieved during the first five years of commercial scheduled airline service started in 1927. The first five years of commercial airline service, while exposing passengers to risks that were high by today's standards, were more than 100 times as safe as government manned space flight. Achieving that goal requires new generic concepts, ones that will come from true research, not development programs like the ones we are seeing with NASA's exploration plans.

I can tell you that we do not yet have the breakthroughs that can promise adequate safety and costs for manned orbital flights. That is why our early focus will be on the sub-orbital personal space flight industry. Our recent SpaceShipOne research program did focus on the needs for safety breakthroughs by providing an air-launched operation in which the rocket propulsion is not safety critical and the "carefree re-entry" concept assures that flight control is not safety critical for atmospheric entry. Those are biggies, and those are the things that allow us to move into a commercial industry in the short-term.

Another thing I can tell you is that our systems for the commercial private space flight industry will be focused on an early marketplace with multiple, competing spaceline operators in order to bring the experience to the largest possible audience. The airline experience has shown us that it is not just technology that provides safety, but the maturity that comes from a high level of flight activity. Airline safety increased by a factor of six within the first five years without an accompanying technology increase.

I am not able to reveal the schedule for the introduction of our commercial systems. However, I believe that once revenue business begins with these new systems, it will likely fly as many as 500 astronauts the first year, by the fifth year, the rate will increase to about 3,000 astronauts per year, and by the twelfth year of operations, at least 50,000, maybe 100,000 astronauts will have enjoyed that black sky view from sub-orbital flight.

Now that it has been shown that a small private company can indeed conduct robust, sub-orbital manned flights with an acceptable recurring cost, I do not believe that this industry will again be hampered by the inability to raise capital. The size of the potential market supports significant investment. The main barrier has been the perceived risk that the technical problems weren't solvable. Those that develop systems that have generic features that point to poor safety will continue to have trouble finding capital, as they should. Our ability to find funding for our research program, the one that we completed last year, was certainly tied to the fact that we had a goal of not just to fly in space, but to fly a system that could be immediately developed for the commercial market. We have had no problem finding investors for our future program, a program that involves the development and certification of commercial sub-orbital spaceships.

I believe the ability to insure will be greatly improved if the government steps up to the responsibility to require an operator to show his passenger safety by adequate flight and ground testing. Clearly, insurance will be expensive until it is shown that the aggressive safety goals are indeed being achieved. With maturity, that safety will continuously improve, as it did with airliners.

Over the last 33 years, my companies have developed 39 different manned aircraft types. All were developed via research flight tests flown over our California desert area, and all flights were regulated by the FAA-AVR, which is now—the airplane folk are who I am talking about, now AVS. We have never injured a test pilot nor put the non-involved public or their property at risk. In spite of that record, the FAA insisted that the Office of Commercial Space Transportation, AST, impose their commercial launch license process on our last five flights of our 88-flight research-only test program. That would have been fine, except that their process bore no relation to that historically used for research testing.

The AST process, focusing only on the non-involved public, just about ruined my program. It resulted in cost overruns. It increased the risk for my test pilots. It did not reduce the risk to the non-involved public. It destroyed our safety policy of always question the product, never defend it. And under AST, it removed the opportunities for us to seek new innovative safety solutions. The main reason for this is that AST, with their history of only regulating

the dangerous scenario one type of systems, applied the process of protecting only the non-involved and had no process to deal with the safety and prediction of failure for manned aircraft. Their process deals primarily with the consequence of failure, where the airplane folk, their regulatory process deals with reducing the probability of failure.

The regulatory process was grossly misapplied for our research tests, and worse yet is likely to be misapplied for the regulation of future commercial spaceliners. The most dangerous misapplication might be stifling innovation by imposing standards and design guidelines rather than the aircraft certification process that involves requiring a manufacturer to test to show his safety margins. AST has already used NASA and AIAA to develop design guidelines. This is an approach that must not be imposed on an industry that is still doing basic research. The AST launch license process might be applicable for the protection of those on the ground during flights of scenario one-like systems, but it will not work for the portion of the industry that promises growth and sustainability.

Time here does not allow me to elaborate on that, but I do have it included in my handout.

The basic problem faced by the FAA in dealing with the regulatory tasks ahead is funding for hiring staff that are familiar with aircraft certification and aircraft commercial operations. The FAA Administrator has told me that she is 300 people short needed for the current demands in regulating aircraft, thus it is impossible to shift the job of regulation of spacecraft, like mine, to the aircraft organization. I think it needs to be shifted to people who know how to regulate the systems that are being developed.

This problem must be solved quickly to support an industry that needs a proper research environment to allow innovation. The problem can not be solved by adding staff at AST, since having more people applying the wrong process is not the answer. I believe they are over-staffed now to do the current launch license process. Much of the work done in an attempt to misapply the expendable booster process to our aircraft was repeated numerous times with a staff that were not equipped to make relatively easy decisions and incapable of applying the needed waiver process. In fact, while my company was already flying initial test flights and waiting for time-critical responses from AST during 2003 and 2004, AST found time to expend extensive resources processing and awarding a launch license to a company that did not even have a vehicle in construction, nor even funding for the program.

We have spent considerable resources developing recommendations for specific regulatory processes to be applied to the new industry, that is a streamlined like certification for these new commercial spaceships, but we have not yet found interest within the FAA to consider them. We will continue our work to solve this problem and will hope to make progress within the next two years.

I want to point out also, this sub-orbital space tourism industry has been criticized by some as, well, this is just joyrides for billionaires and that—what is this all about? It is about fun. I want to tell this group that I am not at all embarrassed that we are opening up a new industry that will likely be a multi-billion-dollar industry that is focused only on fun. I want to remind you, I—when

we bought personal computers in the late '70s, a lot of people—you know, many thousands of people bought these things, and what were they for? Balancing our checkbook? Well, in general, they were for fun. The vast majority of uses on them were to play games. And the fact that it expanded as an industry and of something that we really didn't know what they were for, it left it wide open for somebody like Al Gore to come along and invent the Internet. And then, all of a sudden, the fact that it is out there, all of a sudden now here is an application, and the application is now our communication, it is our commerce, it is our, essentially, everything. And that was an industry in which the product was sold for a full decade just for fun. And I believe this is going to happen with space flying, also. I am not embarrassed that the first decade of personal space flight will be for nothing but fun. But I am confident that when there are 50,000 people that have left the atmosphere, and when there is a lot of capital investment on it, because it is profitable, all of a sudden we will get out there and we will solve the reasons to make it also safe to go to orbit and to go to the moon. And we will also find out new uses for it. There will be somebody that comes along and invent an Internet-like reason for changing this fun into something that is long lasting and significant for our Nation.

Thank you.

[The prepared statement of Mr. Rutan follows:]

PREPARED STATEMENT OF BURT RUTAN

Thank you for the invitation to address this important hearing. I will attempt to specifically address the subjects outlined in the invitation.

The markets for a future Personal Space Flight industry (access to flight above the atmosphere by the public) will likely take on two basic forms: The first is a scenario in which commercial companies develop lower-cost versions of the classic government booster and spacecraft concepts and then conduct commercial flights that are funded by passenger ticket sales. This activity might properly be compared to the trekking outfits that take courageous adventurers to the top of Mount Everest; the activity survives even though more than nine percent of those who have reached the summit have died on the mountain, with the recent rate still at four percent. The safety record for all of government manned space flight is hardly better; four percent fatality for those who have flown above the atmosphere, and the fatality rate for the last 20 years being much worse than the first 20 years. This first scenario's approach will result in a very limited market whose size will depend somewhat on the ticket prices. However, I do not believe this scenario will result in a significant volume of operations, being limited by the same factors that limit the Everest climbers. I believe these systems might begin commercial flights in four to six years flying maybe 50 to 100 astronauts the first year with the rate topping out at maybe 300 to 500 per year.

The second is a scenario in which the players do not find the dangers of space flight acceptable and recognize that extensive improvements in safety are more important than extensive improvements in affordability. Those that attack the problem from this viewpoint will be faced with a much greater technical challenge; the need for new innovations and breakthroughs. If successful, however, they will enjoy an enormous market, not one that is limited to servicing only a few courageous adventurers. It is likely that systems that come from this approach will be more like airplanes and will operate more like airplanes than the historic systems used for government manned space flight.

The future plans for my company regarding the new industry cannot be revealed since they are only at a preliminary stage of technical development. I can assure you that they do not involve a 'scenario one' approach, since we believe a proper goal for safety is the record that was achieved during the first five years of commercial scheduled airline service which, while exposing the passengers to high risks by today's standards, was more than 100 times as safe as government manned space flight. Achieving that goal requires new generic concepts; ones that will come from

true research, not merely development programs like the ones we are seeing with NASA's exploration plans.

I can tell you that we do not yet have the breakthroughs that can promise adequate safety and cost for manned orbital flights. That is why our early focus will be on the sub-orbital Personal Space Flight industry. Our recent SpaceShipOne research program did focus on the needs for safety breakthroughs by providing an air-launched operation in which the rocket propulsion is not safety critical and the 'care-free re-entry' concept assures that flight control is not safety critical for atmospheric entry.

Another thing I can tell you is that our systems for the commercial Private Space Flight industry will be focused on an early marketplace with multiple, competing spaceline operators in order to bring the experience to the largest possible audience. The airline experience has shown us that it is not just technology that provides safety, but the maturity that comes from a high level of flight activity. Airline safety increased by a factor of six within the first five years without an accompanying technology increase. I am not able to reveal the schedule for the introduction of our commercial systems. However, I believe that once the revenue business begins it will likely fly as many as 500 astronauts the first year. By the fifth year the rate will increase to about 3,000 astronauts per year and by the twelfth year of operations 50,000 to 100,000 astronauts will have enjoyed that black sky view.

Now that it has been shown that a small private company can indeed conduct robust, sub-orbital manned flights with an acceptable recurring cost, I do not believe that this industry will again be hampered by the inability to raise capital. The size of the potential market supports significant investment. The main barrier had been the perceived risk that the technical problems were not solvable. Those that develop systems that have generic features that point to poor safety will continue to have trouble finding capital, as they should. Our ability to find funding for our research program was certainly tied to the fact that we had a goal of not just to fly, but to fly a system that could immediately be developed for the commercial market. We have had no problem finding investors for our future program that involves the development and certification of commercial sub-orbital spaceships.

I believe the ability to insure will be greatly improved if the government steps up to the responsibility to require an operator to show his passenger safety by adequate flight and ground testing. Clearly, insurance will be expensive until it is shown that aggressive safety goals are indeed being achieved. With maturity I expect that safety will continuously improve, as it did with airliners.

Over the last 33 years my companies have developed 39 different manned aircraft types. All were developed via research flight tests flown over our California desert area and all flights were regulated by the FAA–AVR (the airplane folk, now AVS). We have never injured a test pilot, nor put the non-involved public or their property at risk. In spite of that record, the FAA insisted that the Office of Commercial Space Transportation (AST) impose their commercial launch license process on the last five flights of our 88-flight research test program. That would have been fine, except that their process bore no relation to that historically used for research testing. The AST process, focusing only on the non-involved public, just about ruined my program. It resulted in cost overruns, increased the risk for my test pilots, did not reduce the risk to the non-involved public, destroyed our "always question, never defend" safety policy, and removed our opportunities to seek new innovative safety solutions. The main reason for this is that AST, with their history of only regulating the dangerous 'scenario one' type of systems, applied the process of protecting only the non-involved and had no process to deal with the safety and prediction of failure for manned aircraft. Their process deals primarily with the consequence of failure, where the aircraft regulatory process deals with reducing the probability of failure. The regulatory process was grossly misapplied for our research tests, and worse-yet is likely to be misapplied for the regulation of the future commercial spaceliners. The most dangerous misapplication might be stifling innovation by imposing standards and design guidelines, rather than the aircraft certification process that involves testing to show safety margins. AST has already used NASA and AIAA to develop design guidelines. This is an approach that must not be imposed on an industry that is still doing research. The AST launch license process might be applicable for the protection of those on the ground during flights of "scenario one" systems, but it will not work for the portion of the industry that promises growth and sustainability. Time here does not allow elaboration, so I must refer you to the handout.

A basic problem faced by the FAA in dealing with the regulatory tasks ahead is funding for hiring staff familiar with aircraft certification and commercial operations. The Administrator has told me that she is 300 short in staff needed for the current demands in regulating aircraft, thus it is impossible to shift the job of regu-

lation of spacecraft like mine for "scenario two" to the aircraft organization (AVS) who will know how to regulate the systems being developed. This problem must be solved quickly to support an industry that needs a proper research test environment to allow innovation. The problem cannot be solved by adding staff at AST, since having more people applying the wrong processes is not the answer. I believe that they are over staffed, to do the current launch license process. Much of the work done in an attempt to misapply the expendable-booster process to our aircraft was repeated numerous times with a staff that were not equipped to make relatively easy decisions and incapable of applying the needed waiver process. In fact, while my company was already flying initial test flights and waiting for time-critical responses from AST, during 2003 and 2004, AST found time to expend extensive resources processing and awarding a launch license to a company that did not even have a vehicle in construction, or even funding for the project!

We have spent considerable resources developing recommendations for specific regulatory processes to be applied to the new industry, but have not yet found interest within the FAA to consider them. We will continue our work to solve this problem and will hope to make progress within the next two years.

Thank you for your attention to my opening remarks. I will be happy to answer your questions.

Regulation of Manned Sub-orbital Space Systems for Research and Commercial Operations

A summary prepared by Burt Rutan, Scaled Composites

Safety Requirements for the Private Spaceline Industry

- New generic solutions for safety as compared to historic Government manned space operations will be mandatory
- Cannot run a Spaceline without a huge reduction of current risk

Safety Goals: Airline experience as a model

- Risk statistics, fatal risk per flight
  - First 44 years of manned space flight = one per 62 flights
  - First airliners (1927 & 1928) = one per 5,500 flights
  - Early airliners (1934 to 1936) = one per 31,000 flights
  - Current airliners = one per two to five million flights
  - Modern military fighters = one mishap per 33,000 flights
- Logical goal:
  - Better than the first airliners
  - < one percent of the historic government space flight risk

Different Systems Need Different Regulation Methods

- The AST Process
  - To show that the consequence of failure, i.e., the expectation of casualty (Ec) for the non-involved public (NIP) is low.
  - Deals with systems that are historically dangerous.
- The AVR (now AVS) Process
  - To show that the probability of failure (Pf) is low.
  - Assures safety of crew and passengers.
  - Deals with systems that need to be reliable.
- The risk method approach by AST
  - Risk is product of failure probability and consequence.
  - NIP risk with dangerous systems is assured only by selection of flight area.
  - Flight crew risk with dangerous systems can be addressed only by flight termination staging.

  - However, since Pf cannot be calculated for immature systems, AST has no acceptable process for new systems that have to be safe enough for commercial passenger service.
- AST Methods for Booster-like systems
  - Computer-flown or remote operation
  - Automation that requires backup via flight-termination systems
  - Ground-launched
  - Safety-critical rocket propulsion
  - Un-piloted stages dropped
  - High-scatter landing
- AVR Methods for Aircraft-like systems
  - Human Piloted flight
  - Expendable-like flight-termination systems are not appropriate
  - Runway takeoff
  - Rocket propulsion not safety critical
  - No "bombing" of hardware that presents risk to NIP
  - Horizontal aircraft-like runway recovery
- If the safety approach is based on failure consequence it should be regulated by AST.
- If the safety approach is based on failure probability it should be regulated by AVR or by staff experienced in aircraft safety assurance.
- If safety is based on both consequence and vehicle reliability, then consequence should be calculated by AST, but Pf must be accessed by those with aircraft safety regulation experience.

Experimental Research Testing of Airplane-like Systems

- Cannot be addressed by enforcing standards or guidelines—the important need is to allow innovation; to seek safety breakthroughs without regulatory hurdles. Regulators must not be expected to appreciate this need during a research test environment.
- Pf cannot be calculated, thus historic data must be a guide for approval of an adequate test area to meet Ec intent for NIP.
- Environmental requirements, like for aircraft are not needed, but they can be tolerated, with costs not the full burden of the developer.
- The AVR waiver method for all regulations is mandatory. The developer must be able to argue the equivalent safety justification for non-compliance to any regulation. This is critical, especially for an immature industry with indeterminate technical issues.
- The AST launch licensing process is not acceptable due to its costs, its hindrance of innovation and its negative effect on safety policy. The AVR-EAC (Experimental Airworthiness Certificate) method works and must be implemented. The system is based on respect for a developer's safety record and the expectation that he will follow the license rules.

Certification, or Licensing Spacecraft for Commercial Sub-orbital Passenger Operations

- The manufacturer and the operator cannot accept a scenario in which the FAA has no role in approving the safety of crews or passengers. His responsibility to do adequate testing to assure passenger safety must have acceptance by the FAA. Otherwise he has no unbiased defense at trial following an accident.
- Part 23 & 25 Certification are based on defining conformity. Then, by test and analysis showing adequate margins for the conformed vehicle. Subsequently the holder of the certificate can then produce and operate unlimited numbers of vehicles that conform. The main costs of certification are the issues related to conformity, not the specific tests to show margins.
- Any ethical manufacturer or operator must test to show margins, even in the absence of any government regulation.

- However, initially the manufacturer and operator will build and operate only a very small number of vehicles, thus making the detailed conformity process debilitating. Also, the intensity of the process would interfere with the need to solve new technical problems and to maintain a "question, never defend" posture while system technical status is not mature.
- Our proposal: an applicant seeking approval to fly passengers will be required to define the tests needed to show adequate margins for his design and define the required systems safety analysis. He must then obtain acceptance of the test plan by FAA regulators and later get acceptance that the tests were satisfactorily completed. The process will be design specific and repeated for each flight article.
- Conformity of the design, the tools, the systems or the manufacturing process will not be required.
- A manufacturer can select the conformity process as an option if he desires to avoid the individual tests of each production article.
- Conformity may be mandatory after the industry matures (the aircraft certification process).

Lessons from the Regulatory Process During the SpaceShipOne (SS1) Research Flight Tests

- The Tier1 test program involved 88 flights, 17 for the SS1 and 71 for the White Knight. 83 of those flights were licensed via an AVR–AIR–200 Experimental Airworthiness Certificate. Those flights were done under the authority of the EAC and directed via the information in its Operating Limitations list. The EAC was in effect for the duration of the program, July 2002 to October 2004.
- Five flights of SS1 were flown under the additional authority of an AST Launch License. License was in effect from March 2004 to October 2004.
- The 83 flights flown under the EAC involved the highest risk, both to the pilots and the NIP: first flights of unproven vehicles and nearly all envelope expansion, including first supersonic flight of SS1 to max-q.
- The EAC flights were regulated similar to the 1,800 research flights conducted by Scaled on 36 aircraft types over a 30-year period: we were expected to fly within the Ops Limits list, and were trusted to do so. The program allowed the innovation always present in aircraft research, and did not interfere with our 'question, never defend' safety policy.
- Development of the new safety innovations were done under the EAC: the new type hybrid rocket motor, the air launch and the 'care-free re-entry' feathered concept.
- The EAC process provided an efficient environment for exploratory testing and continued the historic research aircraft record of safety for the NIP.
- The AST Launch License process enforced on the remaining five flights of SS1 was a very different regulatory environment. We were assured streamlining from the certifications needed for commercial operations approvals but were kept in the dark on specifics. The process involved a 15 month, three party Ec analysis that failed to arrive at an adequate calculation for Pf, thus rendering the Ec determination to be useless. The process was misguided and inappropriate, at times resembling a type certification effort and left the applicant without the basic information needed to determine status. The regulators requested Ec analysis, then ignored those results without informing the applicant or allowing him to defend, to revise or to resubmit the data. The regulators refused to reveal the government's analysis method for Ec calculation. The 'shell game' continued for the majority of the program, resulting in a severe distraction to key test personnel as well as high costs and a disregard for our safety policy. The environment also precluded innovation.
- The Launch License process, as applied to the aircraft research test environment resulted in increased risk for our flight crews, the very people that bear the true risk in experimental flight tests.
- The AST office had no waiver policy, and answered our requests by a written denial from the Administrator without giving the applicant the opportunity to debate or negotiate the technical merits or to get an opinion from the EAC's regulatory staff.

Conclusions

- An applicant for approval to fly research flight tests of piloted, aircraft-like systems must have a defined process, one that allows him to plan his program staffing and financial needs. It is not acceptable to impose undefined, inappropriate forced oversight. The specific EAC process has served the industry well for decades and should be used and enforced by regulators familiar with research aircraft testing.
- The Ec process, developed for protection of population from the dangers of ground-launched, expendable rocket boosters, is not workable for application to piloted, aircraft-like systems during research tests and must be replaced by the AVR method of having test-experienced regulators select an appropriate flight test area for research tests. The Ec process might be justifiable for commercial operations, but it must be regulated by those experienced with commercial aircraft operations.
- Regarding licenses to conduct commercial flights that carry revenue passengers, it is not acceptable for FAA to ignore the approval or acceptance of the vehicle's ability to safely fly people. Regulation must be done by experienced (aircraft experienced) staff.
- The acceptance of the system's probable safety can be done via a vehicle-specific test requirement process for structures and safety analysis for systems, rather than the more expensive Type Certification process that includes full conformity assurance. These processes cannot be defined in advance by specification of standards or by design guidelines, since every new system will have unique features. The testing details and systems safety analysis process must be specific to the vehicle and its intended operation. This process does not have to be significantly more expensive than that which would be done by any ethical manufacturer in the absence of government regulation.

BIOGRAPHY FOR BURT RUTAN

Burt Rutan was born in 1943. He received his Bachelor of Science degree in Aeronautical Engineering at California Polytechnic University in 1965. His education includes the Space Technology Institute at Cal Tech and the Aerospace Research Pilot's School at Edwards Air Force Base. Mr. Rutan holds, in addition, the honorary degree of Doctor of Science from California Polytechnic State University, San Luis Obispo, June 1987; Doctoral of Science, *honoris causa,* from Daniel Webster College, May 1987; Doctoral of Humanities, *honoris causa,* from Lewis University, May 1988 and Doctorate of Technology, *honoris causa,* from Delft University of Technology, January 1990.

Mr. Rutan worked for the U.S. Air Force from 1965 until 1972 as Flight Test Project Engineer at Edwards Air Force Base, California. His projects ranged from fighter spin tests to the XC–142 VSTOL transport.

In March 1972, Mr. Rutan became Director of the Bede Test Center for Bede Aircraft in Newton, Kansas.

In June of 1974, at Mojave, California, Mr. Rutan formed the Rutan Aircraft Factory (RAF) to develop light homebuilt aircraft. Through this company, the VariViggen, VariEze, NASA AD–1, Quickie, Defiant, Long-EZ, Grizzly, scaled NGT trainer, Solitaire, Catbird, and the world-flight Voyager aircraft were developed.

In April 1982, Mr. Rutan founded Scaled Composites (Scaled) to develop research aircraft. Since its founding, Scaled has been the world's most productive aerospace prototype development company, developing new aircraft types at a rate of one each year. Past projects include the 85 percent scale Starship 1 for Beech Aircraft Corporation, the Predator agricultural aircraft for ATAC, the Scarab Model 324 reconnaissance drone for Teledyne Ryan Aeronautical, the Advanced Technology Tactical Transport (ATTT) for DARPA, the 1988 America's Cup wing sail, the Triumph light executive jet for Beechcraft, the ARES close air support attack turbofan, the Pond Racer, the Pegasus Space launch vehicle flying surfaces, the Model 191 general aviation single for Toyota, a 40 percent scale B–2 bomber RCS model, General Motor's 1992 show car (the GM Ultralite), the Bell Eagle Eye prototype tilt rotor RPV, the Earthwinds pressurized gondola, the McDonnell Douglas DC–X single stage rocket structure, the VisionAire Vantage business jet, the Raptor and Raptor D–2 high altitude RPVs for BMDO, a 40-meter wind generator for Zond, three NASA X–38 crew return vehicles, the Williams, International V–Jet II, the high-altitude Proteus aircraft, the Adam Model 309 business aircraft, and the Rotary Rocket Roton atmospheric test vehicle. Recent projects include the White Knight and SpaceShipOne. On 21 June 2004, with Mike Melvill at the controls, SS1 flew his-

tory's first private manned space flight. On 4 Oct 2004, SS1 won the $10M X–Prize (two flights within five days flown by Melvill and Brian Binnie). The Virgin Atlantic GlobalFlyer designed and built at Scaled made its maiden flight in March 2004 and a record setting solo world flight in March 2005.

A few of the awards which Mr. Rutan has received include:

- EAA Outstanding New Design, 1975, 1976 and 1978.
- Presidential Citizen's Medal presented by Ronald Reagan, December 29, 1986.
- Grand Medal of the Aero Club of France, January 29, 1987.
- National Medal of the Aero Club of France, January 29, 1987.
- Society of Experimental Test Pilots, 1987 J.J. Doolittle Award and 2004 J.J. Doolittle Award.
- Royal Aeronautical Society, British Gold Medal for Aeronautics, December 1987.
- Design News Engineer of the Year for 1988.
- Western Reserve Aviation Hall of Fame, Meritorious Service Award, 2 September 1988.
- The International Aerospace Hall of Fame Honoree, 24 September 1988.
- Member, National Academy of Engineering, 1989.
- 1987 Robert J. Collier Trophy for ingenious design and development of the Voyager 15 May 1987 and again on 19 April 2005 for SpaceShipOne.
- National Aviation Hall of Fame Honoree, 21 July 1995.
- EAA Freedom of Flight Award, 3 August 1996.
- EAA Homebuilders Hall of Fame, 23 October 1998.
- Designer of the Year, *Professional Pilot Magazine,* 13 March 1999.
- Clarence L. "Kelly" Johnson "Skunk Works" award by the Engineers Council, February 2000.
- 2000 Lindbergh Award by the Lindbergh Foundation, May 20, 2000.
- *Aviation Week & Space Technology* magazine's "Laurel Legend" and Hall of Fame in April 2002, Current Achievement Award for first privately-funded manned space flight by SpaceShipOne in April 2005.
- *Aviation Week & Space Technology* magazine's "100 Stars of Aerospace" (ranked 29th), June 2003.
- *Scientific American* magazine's "Business Leader in Aerospace," November 2003.
- *Time Magazine*'s "100 Most Influential People in the World," April 18, 2005.

Chairman CALVERT. I thank the gentleman for his excellent testimony.

That—Mr. Whitehorn, and I apologize, President of Virgin Galactic, not Virgin Atlantic. I just—it morphed in my mind, but——

STATEMENT OF MR. WILL WHITEHORN, PRESIDENT, VIRGIN GALACTIC

Mr. WHITEHORN. Thank you very much, Chairman Calvert.

Can I first of all start by moving slightly away from my testimony and express my total agreement with Burt Rutan's last comment there with regards to the reasons why personal space flight, as a concept, is incredibly important?

Our belief at Virgin Galactic is that the proof of concept in creating a profitable business in the private sector without government funding to take individuals into space to experience the blackness of space, the curvature of the Earth, weightlessness, and all of the attendant things that they will feel and experience during their two-hour trip to space is not just about fun. It is certainly not all about fun for us. We see this is as a proof of concept, proof of the idea that it is possible to develop viable, reusable space systems that can be safe in their operation.

As a major airline group operating three airlines around the world, Virgin Atlantic and its sister companies have not taken lightly the idea of venturing into the personal space flight market. There has been a lot of handling over the issue internally, because we have a worldwide brand and a reputation, and we have a reputation for safety in the commercial airline industry, which is second to none. In the 20 years we have been operating, we have not lost a single passenger. We also operate one of the largest rail networks in Europe operating high technology tilting trains, which are a new technology to the UK market. And we carry 50 million passengers a year in that business, and we haven't had a single accident or incident involving the death of a passenger on board.

And for us, the principle of entering this is the principle of proving a concept, proving that something can be done in the private sector, can be done safely, and through the personal space flight experience of the pioneers who do pay at the beginning of this process, we believe within five years we can create a viable business, which will be profitable, and that would allow us to bring down the costs of personal space flight to levels which would be affordable across the board in the United States and around the world.

I will move on now to talk a little bit about some of the questions that the Subcommittee put to us. You asked us about a timetable, and I think my answer to the issue of the timetable is pretty similar to Burt Rutan's. The timetable for us depends upon the ability to go through the process of completing the design of SpaceShipTwo, as we will call it for the purposes of today, and proving and testing the vehicle. For us, the issues of coming to a contract with Mr. Rutan's company to build SpaceShipTwo are bound up in a number of issues of bureaucracy, which we are not unhappy about. We believe we can cope with them. We have got the Defense Department and the DDTC to deal with over the issue of technology transfer. And that is a process which has to be completed before we can complete the design work with Burt Rutan's company and move towards a final contract to construct a fleet of space ships.

But an outline, our view of the issue is that we would like to order at least five SpaceShipTwos, as we will call it for the purposes of today, from Mr. Rutan's company, and we would like to be in operation before the end of this decade. And we would like to be going through a testing process by the end of 2007 and commercial operation by 2008, if that was possible. But we can not allow ourselves to be dictated to by a commercial need. The most important factor for us will be developing a safe vehicle and operating that vehicle safely. And if that can be proved, then we believe that we can take the people into space and the people want to go.

To give you an example of where we believe the marketplace is for commercial space tourism, we announced the formation of Virgin Galactic formally before the X–Prize flights last September, and we, at that state, set up the marketing operation to market the flights. We have, since we set up, had 29,000 applications to fly. That is 29,000 people who said they are willing to pay a deposit of up to $20,000 for space flights within a range of prices of up to $200,000. We have also had 100 people who have actually signed terms and conditions with us now to pay the full cost of a $200,000

flight up front in order to fly in SpaceShipTwo, should that be developed. Clearly, if we fail to develop a viable vehicle, they will get their money back.

And moving on to some of the other questions that you asked, and the question of profitability for us is a very important one. We are not doing this as a rich billionaire's toy adventure and as a loss leader or just as a grand representation. We are doing this to create a profitable and viable business to prove a concept. And we believe that if the initial work that we have done on the business plan can be met, that this business can be profitable within five years, and the cost of space flights could fall by a factor of 75 percent by the end of that five-year period. And the pioneers, who are going to be the pioneer astronauts who pay to fly commercially into space, will help to fund the process of making commercially viable personal space flight something that people across the country can enjoy and afford in the future.

And you asked one of the questions about the differences between acquiring a fleet of commercial spacecraft compared with the process of buying commercial aircraft in the commercial airline market and our experience of both. At the risk of sounding trite, the short answer is that the differences between the process we are going to undertake with Burt Rutan's company and buying aircraft from Boeing are chalk and cheese. We are in uncharted territory here, and it is relatively easy now, on the basis of an output specification from an airline, for one of the major manufacturers to provide one's needs within the parameters of their manufacturing capability. And the business is highly regulated. We work in a highly regulated environment in commercial airline operation, and rightly so.

In this area, the area of personal space flights, we are going to have to design different ideas as to how we create a viable vehicle, and we are going to be working very closely with scale composites to come to a contractual arrangement with each other, which will work for both parties to ensure that we get the thing built and we get it operating viably as quickly as possible. But it will not be like buying aircraft in the commercial airline market. We are at the experimental cutting edge of a new industry here, and between the two of us, with our commercial experience and Burt's experimental aircraft experience, we are absolutely convinced that we can come up with something which will be viable and acceptable in terms of safe operation to the FAA and the other organs of government who are going to be involved in regulating the venture as it unfolds.

It is—one of the other questions that you asked was the question of the space act of last year and issues within that act, which are important to us and things that the government can do to help. Frankly, the most important thing to say is we don't want help from the government. This is an important point of principle here that the parties undertaking this venture do it in the private sector and do it off their own back. However, in a nascent industry like this, enabling by the government is a very important thing. And I think one feature of the act that we would like to look at more closely is the issue of the insurability of this industry. For this industry to be viable, the commercial personal space flight industry to be viable, it is important that some of the breaks on insurance

and support from the government in the insurance area are carried through beyond the current plan of 2008 to 2009 and that when the government looks at this issue, they do extend the insurance provisions within the act to cover a longer period of time to allow this industry to get going with the kind of support it needs. Because with the support of the government, the insurability of the third party uninvolved risk is going to be a much easier thing to undertake.

I think the other thing that the government can help us with is enabling, enabling the processes that we undertake and taking an active role in preventing roadblocks on the way. We believe that the FAA is an organization that is well up to the job of helping this industry to form and form a safe pattern of operation. We believe the Defense Department can take its responsibilities to protect the U.S. public very seriously and at the same time not hold up this project. We don't see roadblocks on the way at the moment, but if they appear, we would like the chance to come back before this group and have the chance to tell you about it.

Thank you very much.

[The prepared statement of Mr. Whitehorn follows:]

PREPARED STATEMENT OF WILL WHITEHORN

Chairman Calvert, Ranking Member Udall, and other Members of this distinguished subcommittee, on behalf of Virgin Galactic, thank you for the opportunity to testify today. Virgin Galactic appreciates the chance to explain how, with an unwavering commitment to safety, we plan to make available and affordable an adventure of a lifetime. We are proud to be on the leading edge of the commercial space industry and honored to have Burt Rutan as our future partner.

I am Will Whitehorn, the President of Virgin Galactic. I also am Group Corporate Affairs and Brand Development Director for Virgin Management Limited. I have nearly 30 years of aviation experience having previously worked for British Airways and Thomas Cook before joining Virgin in 1987.

At the outset, I wish to acknowledge the invaluable leadership the House Science Committee and this subcommittee provided last year for the nascent commercial space industry. You ensured Congress struck a proper balance in the *Commercial Space Launch Amendments Act of 2004.* Had it not been for that sensitivity in crafting a proper regulatory oversight regime consistent with the goal of permitting our emerging industry to realize its full potential, it is unlikely the Virgin Group would have made our considerable commitment to Virgin Galactic.

Virgin Galactic is a private sector venture. We receive no state aid. Frankly, we think that is the way it should be. Entrepreneurs like Sir Richard Branson who are willing to shoulder the economic risk and challenge of commercializing space will be the most successful innovators who lead this industry and chart its course. Government's proper role is regulatory oversight and creating a climate in which entrepreneurs can translate their vision into reality and innovation can flourish.

The history of Virgin Galactic goes back to the mid-1990s when Sir Richard Branson identified that new technologies in composite materials, rocketry and computing could easily lead to the development of safe, economical reusable spacecraft in the future. At that time, we registered the Virgin trademark in the area of space travel. In 1999, we registered the Virgin Galactic name.

Virgin has a long history of working with Burt Rutan going back to the early 1990s. When Mr. Rutan informed us he was building a spaceship for a private customer to win the X–Prize, we made a commitment to him that we would be prepared to develop a commercial version of SpaceShipOne should he be successful. Over the last year we have negotiated with Paul G. Allen, the visionary and financier behind SpaceShipOne, to buy the rights to use his technology. Following the successful conclusion of these negotiations, we signed a $21.5 million deal for the use of that technology and developed a $100 million investment plan to build up to five spaceships at Mr. Rutan's factory in Mohave, California. The plan for the ships themselves is being developed by Mr. Rutan to a specification created by Virgin Galactic.

Safety obviously is our first priority. Our commitment to safety extends beyond the Virgin name, one of the best-known and most valuable brands in the world. Sir Richard Branson has said that he, along with his parents, son and daughter plan to travel in Virgin Galactic's first space flight. If the Federal Aviation Administration permits me to do so, I hope to be on an earlier test flight. Our commitment to safety is very real and personal to us. Safety is and will continue to be Virgin Galactic's North Star.

Suffice it to say that the Virgin Group has considerable experience in issues regarding passenger carriage and an unwavering commitment to safety. Virgin currently operates three separate airlines around the world which together carry over 50 million passengers a year. The best known of these is Virgin Atlantic Airways whose main business is operating scheduled services between the United Kingdom and a variety of destinations in the United States, as well as flights to the Far East, Africa and Australia. We have an unblemished safety record having never lost a single passenger in over 21 years of operation. All of our airlines also are profitable without ever having received any state subsidy. We also operate the U.K.'s largest long-distance rail company which also has an unblemished safety record despite carrying 35 million passengers per year at speeds over 125 miles per hour.

Let me briefly describe the out-of-this-world service Virgin is known for that, quite literally, we intend to offer to Virgin Galactic customers. It is envisaged that the astronauts we carry will experience a two hour trip. Half of that will involve the thrill of climbing to a safe altitude with the mother ship and then our astronauts will experience the exhilaration of spending an hour on SpaceShipTwo as it accelerates to over three times the speed of sound and climbs to well in excess of the 100km altitude officially recognized as entering space, and becoming one of the few humans to have left the planet. Our current plan is to begin operations in Mohave and then develop a second site in another location that could possibly be either Florida, Texas or New Mexico. The flights will be what is known as sub-orbital. The pioneers who become astronauts with Virgin Galactic will initially pay $200,000 for the trip but the Company hopes to reduce the cost over time as the business develops. Our long-term goal is to develop commercial space tourism into an orbital business which could in the future carry payloads as well as people into orbit.

Chairman Calvert, the Subcommittee asked that I address several specific questions in my testimony. Let me turn to them now.

The Subcommittee asked about the timetable for taking possession of the Virgin Galactic spacecraft, first flight and expected profitability. At this time, Virgin Galactic has a memorandum of understanding with Mr. Rutan's company, Scaled Composites, to customize the SpaceShipOne vehicle for commercial use. Design work to that end continues. However, we have not yet formally ordered the spacecraft. After U.S. Government technology transfer issues are clarified and addressed if deemed necessary, we hope to place a firm order for the spacecraft. At this point, due to uncertainty about possible licensing requirements, we are not able to even view Scaled Composites' designs for the commercial space vehicle.

Mr. Chairman, we are not concerned about this lack of clarity on the technology licensing issue and the nominal delay it has caused to date. Like any nascent industry overseen by government oversight agencies faced with issues of first impression, we understand instances such as this are to be expected. We are continuing a robust and cordial dialogue with the Department of Defense and other agencies that provide input on technology licensing issues. We hope a consensus can soon be reached that will clear the way for us to move forward with a formal order for Mr. Rutan's spacecraft.

In terms of first flight, we are hopeful Virgin Galactic will begin service in either 2008 or 2009. Let me be clear, this is an estimate only. As I testified earlier, safety is our North Star and it will determine our launch date. We will launch as soon as our safety assessments and training dictate we do so, and not a day before. Our launch date estimate also assumes prompt clarification of the U.S. Government technology licensing issue I just mentioned. The longer it remains unresolved, it could adversely impact our projected launch date.

As far as profitability is concerned, our business plan projects that we will attain profitability in our fourth or fifth year of operation. Importantly, this estimate assumes five spaceships, two launch aircraft or mother ships, and two launch bases in the United States. If the schedule for deploying any of these assets slips, it would negatively impact our target date for profitability.

Mr. Chairman, the Subcommittee asked that I comment on the differences in procuring a commercial spaceship fleet and Virgin Atlantic's experience acquiring a fleet of commercial aircraft. At the risk of sounding trite, the short answer is everything. Virgin Atlantic is a customer of both Boeing and Airbus aircraft. Being a customer of commercial aircraft essentially is a passive process. While you can request

some custom features, the aircraft as designed by the manufacturer essentially is a complete unit and customer suggestions and requests tend to relate to the margin. Virgin Galactic's relationship with Scaled Composites is very different. It is an active partnership. It is envisaged that we will work very closely together designing the aircraft and sharing our complementary expertise. Simply put, it will be a symbiotic relationship where ideas and intellectual capital are shared by the customer and manufacturer to ensure a successful product that benefits both.

This active partnership dynamic is precisely why we are so pleased to have Burt Rutan as our future partner. Incidentally, in a decade or so when the history books are written describing the birth of the commercial space industry, I am confident that just as the Boeing brand is synonymous with ushering in the age of commercial jet travel, Scaled Composites will deservedly receive similar recognition for its trailblazing role in our industry.

Mr. Chairman, let me now turn to the question the Subcommittee asked about what preparations we presently are undertaking for the use of the spaceships we plan to purchase from Mr. Rutan. We are focused on complying fully with the letter and spirit of the *Commercial Space Launch Amendments Act of 2004.* Scaled Composites will have sole responsibility to certify the spacecraft. However, together, we are engaged in an active dialogue with the Federal Aviation Administration on other aspects of our business. At the same time, we are designing a program to prepare our astronauts for an incredible sensory experience and to allow them to gain the maximum from their journey to space. That program will include training in all areas from physiological to psychological. We want to ensure our passengers have the optimum sensory experience but, even more importantly, that the operation will be undertaken with the utmost safety, consistent with safety being our absolute priority.

Finally, Mr. Chairman, you asked what, if anything, should the government be doing to encourage commercial space. Let me reiterate a point I made earlier. Virgin Galactic is a private venture. Consistent with our belief that the proper role for government in encouraging the commercial space industry should not include financial subsidies, we receive no state aid. We believe there is great potential for mutually beneficial partnerships between NASA and private companies involved in our emerging industry. In other words, we support public-private partnerships. For instance, NASA should seek opportunities to contract with private sector manufacturers for cutting-edge designs and outside-the-box thinking. I am encouraged by signs of progress in NASA's willingness to engage with the private sector in idea sharing. This spirit of cooperation should be encouraged and broadened whenever practical to do so. Virgin Galactic, for example, would welcome the opportunity to provide assistance to NASA for aspects of astronaut training. If NASA's first instinct is to look to private sector commercial space partners for opportunities to work together, I believe both NASA and our industry will be the better for it.

Mr. Chairman, let me conclude by again thanking you, Ranking Member Udall, and other Subcommittee Members for the opportunity to testify today. Virgin Galactic looks forward to working with you and your staff. Burt Rutan has expressed his wish to put the first private spacecraft on Mars. It may be several more years before I get the chance to address the Subcommittee on that subject! I am pleased to respond to your questions today and to keep you apprised of relevant developments as we prepare to take-off.

BIOGRAPHY FOR WILL WHITEHORN

Will Whitehorn is Brand Development and Corporate Affairs Director of Virgin and one of five members of the Management Board of the group. He is responsible for the corporate image of Virgin, public affairs, global brand development and a number of new business development activities most recent being the formation of Virgin Galactic, the new Virgin space tourism operator due to launch flights in 2007–8, of which he is President. In addition he acts as Richard Branson's spokesperson.

Aged 45, he joined Virgin Group in 1987, as Head of Corporate Public Relations. Previously he was an Account Director at Lombard Communications where he had worked on numerous flotation's and bids for companies as diverse as Chrysalis Group, Ward White and Grampian Holdings. Before entering the public relations industry he had worked for British Airways as a helicopter crewman in the North Sea, was a Graduate trainee with Thomas Cook Group and finally Market Intelligence Officer for the TSB Group flotation. He was educated in Edinburgh and graduated from Aberdeen University in 1981 with an honours degree in history and economics.

DISCUSSION

5–10 YEAR COMMERCIAL SPACE INDUSTRY OUTLOOK

Chairman CALVERT. I thank the gentleman.

Now we will open up for questions.

Mr. Rutan, this is obviously very exciting, and this is moving a lot quicker than we imagined just a year ago that we would be moving to this next stage of space exploration.

What is your outlook for the commercial space industry, you kind of mentioned this in your testimony, but maybe you would like to expand on this, over the next five to 10 years? And how do you expect SpaceShipOne or SpaceShipTwo to fair commercially? Do you—how—what do you see the vision of this?

Mr. RUTAN. Yes, I did try to summarize that in my opening remarks, but I will tell you that we won't sell spaceliners or spaceships to spacelines that aren't safe to fly. And we don't plan to develop ones that will have large direct operating costs, because we don't need to. We believe we have all of the technologies demonstrated. There are several new technologies. There are probably a couple of new patents in work now relating to the new vehicles that will be commercial. But I think our risks that we need to take right now are tiny compared to the risks that we took in the year 2001 to get to the goals of SpaceShipOne. When we have available spaceships that can be flown at low direct operating cost per seat and provide the real experience, and I want to point out this will not be the experience like you saw in SpaceShipOne where you have a small cabin and people are strapped down and they have little windows. The very first generation of commercial sub-orbital spaceships will be experience-optimized. There will be large cabins. There will be big windows. There will be—since you only have four or five minutes of weightless time, they will pull a bar open, and you will float your body about the cabin. We think that is extremely important to do on a short space flight.

So we are working very hard on assuring that this will be extremely attractive to the public, it will be extremely affordable, and it will be at least as safe as the early airlines. If we achieve those goals, and I think we really can, we don't have tough answers to—in front of us or new challenges in front of us to get there, but if we achieve those goals, I think this is going to be a much, much bigger market than anyone imagines. I think once it is determined that this is a business that is profitable, I think very much like the early airlines, you will get dozens of businesses wanting to be—wanting to compete with Virgin, for example, and wanting to be space flight operators. I believe that a lot of those will fail either financially or their ability to raise capital or their inability to follow—to support and follow the maintenance and other guidelines that we will set up. And in fact, we are looking at having this not like selling a spaceship that says, "Here, take it and do what you want," but we are looking at doing it as a franchise, like a Wendy's franchise. You buy our product, but you have to follow very carefully our rules in how to maintain it and how to operate it and the limits of its operation.

Chairman CALVERT. I don't know if you want to use Wendy's as an example.

Mr. RUTAN. Well, okay. McDonald's franchise, right. But at any rate, the important thing is because of where we stand in the marketplace now, I think we will be able to assure that all of the operators operate it safely.

Now I believe, like the early airlines, most of these that want to that will try, I think most of these will fall out for the same reasons that the early airline companies did. But I expect to see that, say, in the—between five and 10 years into the operation of these, I expect to see that you will have three or four operators with multiple sites that are operating reliably, and they are going to be competing with each other, and they are going to have an enormous, enormous market. The space market has never had any product, any payload that is high volume. Generally, nowadays, if you are doing something commercial in space, you don't complain a lot that you have to pay $80 million to buy a booster, because your payload that is in it, you may invest a half a billion dollars to build this payload. Well, the payloads for this industry don't cost anything. In fact, they pay to fly. That is a totally different concept for the space industry. In fact, the payloads can be easily reproduced by unskilled labor. And I don't see a limit to it, whereas there has been very specific limits to everything.

Another thing, if we reach our goals on affordability and safety, it will affect everything else that is done in space. For example, as we flow this capability of very high volume, very low cost, high safety into the orbital market, all of a sudden, those that go out and want to do exploration of the planets, instead of being able to afford to build one or two of these every couple of years, we can build thousands and hundreds and send them everywhere and do real exploration because it will be affordable. I have had NASA, two different centers, including NASA headquarters, insisting that I keep SpaceShipOne flying so that they can fly their payloads on it. You know, they have made a lot of these payloads for student projects and so on, and they just don't have an ability to fly it.

My position on that has been that NASA certainly has a lot more capability to fly science payloads than we do. They have a space station. They have a reusable Space Shuttle. The reason that they can't fly their own payloads is not my fault. And I have refused to do that, because I have refused to have anything in my way in order to, as quickly as we can, get an operable system that flies safe and flies cheap. And I think it is much better for NASA to just wait and buy tickets rather than us doing science projects to develop that kind of capability along the way. We have put all of this other interest and all of this other stuff aside so that we can quickly reach the goal. And that goal will help everything else.

Chairman CALVERT. Thank you.

Mr. Udall, a skilled man.

Mr. UDALL. Thank you, Mr. Chairman.

The testimony that both of you presented was fascinating, and I am looking forward to hearing more about your point of view.

REGULATORY AND APPROVAL PROCESS

Mr. Rutan, you talked about some of the challenges working through the—an approval process for SpaceShipOne. As you look ahead at developing a commercial version of this spaceship, have

you had any discussions with FAA as to what you will have to do to get your vehicle approved for commercial service? And would you be willing to talk with us and/or provide some specific ideas about changes to the process? And perhaps you could do that for the record. Again, we have got limited time today, but——

Mr. RUTAN. Absolutely. I have had multiple meetings with the FAA Administrator. I have insisted that at least one of those meetings including having the airplane people as well as the space people, you know, AVR as well as AST, and I did succeed last month in having that meeting where all three were in the same room. And that was in the FAA Administrator's office. It was a meeting of more than two hours, and I made my point that the FAA does need to stand up to the responsibility for assuring the safety of the passengers. And I believe that that process can be structured so that the applicant for flying commercial flights can get an acceptance by the FAA that he has indeed done his testing and has defined the testing that is needed for—to show his margins, his safety margins. I believe that can be done with a very minor effect on the cost of the developer.

However, this is a subject that FAA seems to be afraid of. They seem to be happy that they are not required under the new legislation to certify these ships. And I think it is—really comes down to the problem is that they just flat don't have the people that are qualified to do it. I don't believe that the new ships will go through a conformity process like you do in a part 25 certification for airplanes. And we have developed specific processes for that as suggestions. And I am—I hope to, over this next month or two, have a meeting with the working level certification people so we can present this. But we have not had that opportunity yet.

SIMILARITIES TO AIRLINES

Mr. UDALL. Thank you.

If I could, I would move to Mr. Whitehorn.

You have got a background in the airline industry. Would you talk a little bit about what aspects of your operations that you think will be similar to the airline industry and which aspects would be different?

Mr. WHITEHORN. Yes. I mean, I think when we look at issues such as the certification of the spacecraft, I mean, Burt Rutan's company, Scaled Composites, will be responsible for certifying the SpaceShipTwo, which we have developed into a commercial business. So I won't talk about those issues at all. We will leave that to Burt.

We will receive—we have engaged in an active dialogue as well with the FAA at the moment, which is in a much happier area, which is the area of what the passenger experience will be and the program to prepare the astronauts for flight and the regime that we will operate in terms of the safety of those astronauts, what we will need to do on the medical front to ensure they are fit to fly. We are planning to buy a system from Burt Rutan, which would allow 80 percent of the population of the world to fly in terms of medical areas. And in terms of age, it would be open to anybody of any age to fly. But obviously, from the point of view of the FAA, we will come up with a set of standards and guidelines as to what

we will deem acceptable. And what the legislation allows us to do is to work in quite an open forum on those issues of the guidelines as to what the passenger will have to experience.

Where I think this differs from the commercial airline industry is that the commercial airline industry has been regulated now for the best part of 70 years, properly regulated, in the United Kingdom and the United States. And the difference here is that there is no precedent to base things upon. The precedent of the past is to look at the best that has happened in the world of commercial aviation and try and apply the important principles of that but not create rules before we know exactly the direction of where we are going is, but to try and develop the rules that will be there for the future in as open a forum as possible between the parties involved in this industry. And I think that is achievable. I think the FAA has an open attitude to those aspects. And I think that when it comes to the certification of the craft itself, that is Mr. Rutan's area, the principles around how it operates the business will be our area, as the commercial operator. And you know, I think the principles of safety for us are paramount. The principles that we do want to create an experience for the customers that they can have confidence in, and the kind of sophisticated individuals we are dealing at the moment have an understanding of risk, but they are expecting an experience, which will be along the lines—I mean, as Burt said, the early days of commercial aviation, back in the 1920s and 1930s, or somewhere around where private aviation got after the second world war in the USA in terms of the level of safety. That is what the audience expects that we are addressing this product to. And I think that our north star in safety is going to be ensuring that the standards that we introduce to service at the beginning of the operation of this by the end of this decade are standards that then can be improved by experience all of the time.

And if one starts from a prescription of where you begin, you are never going to get to the position of creating guidelines that can be improved and developed with experience. And one of the things I am encouraged by, though, is in that particular area I think the FAA is spot on in the way it is working.

Mr. UDALL. Thank you.

Chairman CALVERT. Mr. Rohrabacher.

Mr. ROHRABACHER. Well, I thank you very much. And let me just sing the praises of Burt Rutan, who, of course, everybody sings the praises of Burt Rutan. I don't know if you are Hans Solo or Charles Lindbergh, but whoever you are, Mr. Rutan, you are an historic person, and it has been my honor to have had the opportunity to know you and to watch with amazement some of the things you are doing. So thank you very much for being just a role model to young—the young people in America and old people in America as well.

Mr. RUTAN. Well, thank you, Dana. I consider myself someone that just hides out in the high desert in California and has as much fun as I can. And I don't look at it that way at all, but thank you very much.

Mr. ROHRABACHER. Well, I would hope that when people are studying in our universities and in our high schools that when they pick people out to study and to see what type of person they were

and to use as examples for—I would certainly hope that the education community takes a look at Burt Rutan and makes him a full chapter in the book, because that is what our young people need.

Mr. RUTAN. I believe that the education, which has—NASA has spent a lot of money over the last three decades on trying to keep the interest in education, I believe that problem will totally disappear once there is a growing industry out there and kids can not just kind of be prompted to dream about being an astronaut, they will be making their plans to fly. And once you have that, I think we are going to get an enormous amount of increase in those that go to school to learn engineering and science and those that deal with all of the aspects of this new industry. And I don't think our education problem will be a problem at all once there is something real that is going on.

Mr. ROHRABACHER. Okay. Thank you very much.

The—I had to leave a few moments ago, because Lieutenant General Arnold, who is the command of the Space Missile Center there in Los Angeles, was—needed to meet me right outside the room here. And I think that it is significant, and you mentioned this in your testimony in passing, that in the past—as in contrast to the past, where there were spin-off effects from America's defense spending to the private sector. You believe that there is going to be a great spin-off or collateral effect for national defense and other type of issues from the private sector investment in space.

Mr. RUTAN. I have got an example that supports that, and let me just state that I don't think the primes—Lockheed and Boeing, for example, I don't think they know it yet, they will be developing large numbers of low-cost launch capabilities. And the reason I say that is we have an example in front of us that I really truly believe is a parallel and that is in the late '70s, IBM did not know that in a few years they would be building tens of thousands of $700 computers. They really didn't know that. They found out that they had to force themselves into that market. They had to realize that, "Hey, we are not just a company that makes a handful of mainframe computers." And they changed very quickly, and they got in and they competed. And I think that is going to happen also as this paradigm changes to where there are the benefits of cost and safety and an enormous lot of activity.

Mr. ROHRABACHER. Which leads me to a question for Mr. Whitehorn. And of course, let me applaud you, as well. Very rarely do we have a witness come here before us in Washington saying that they aren't asking for any help.

Mr. WHITEHORN. Well, that is because I come from the United Kingdom, and if you ask the government for any help, they just don't get it.

Mr. ROHRABACHER. But I noted—I think we noted two things here. Number one, you were asking, basically, correct me if I am wrong, for making sure that we have definitions of liability that will permit your business to succeed. And I think that that is something that we understand.

EXPORT CONTROLS AND TECH TRANSFER

Number two, you also mentioned tech transfer, just in passing. Is there a problem? And again, there are military and security im-

plications to the craft that is being developed, because obviously, frankly, what Burt is developing here as something for the general public has some very great implications for the security of the United States and the free world. Are there problems with transfer to Britain, to a British company and——

Mr. RUTAN. Yes, I thought that Britain—or that England was a relatively friendly nation to America. And at least reading the papers, you would see that. But when you try to export designed things that are tied to either rockets or the avionics that go in rockets, we have seen this as an extremely difficult thing. And it has been one of the reasons that we have had to move away from the basic concept of this being a foreign-funded development of the ship, even though it is a very friendly country. And I have been to London. I found these people seem to like us, too.

Mr. ROHRABACHER. Well——

Mr. RUTAN. But let me point out——

Mr. ROHRABACHER. And people will be able to get to London a lot quicker in your——

Mr. RUTAN. First of all, I don't think we are going to have this problem in the short term now by developing the ship here. And if we fly them within the United States, I think that problem will be minimized. However, relatively soon, and I think this will happen in the first decade of commercial operations, there will be requests, and very serious, well-funded requests. We have gotten them even from the guys building that new city outside of Dubai. They want to run space lines in their country. And when you take something that does have some technologies that would transfer over—that could be transferred over into a weapon, even though these technologies are all really in the public domain, we run into very severe restrictions. We have wrestled with this problem in terms of technology transfer to Virgin Atlantic for about five months now. And it has been—it doesn't seem to meet logic, and it has been difficult. I think—and as a result of that, we are discouraging, until there are routine commercial operations going on in this country, and it can be shown that for the same reasons that we sell airliners that we don't want to have technology, that they don't have to have the technology in order to operate a spaceline. And I think that is not going to work on the early stages, because we just flat can not export it. But I believe once there is routine operations going on this country, then we will be able to surpass those roadblocks and be able to set up sites in Dubai or in Australia or in Europe.

Mr. ROHRABACHER. Mr. Chairman, just one note, and I know my time is up, and that is I have been a long-time advocate of a two-tiered system of technology transfer controls where countries like Australia and England and other countries that are totally friendly to the United States should not have the type of restrictions on them as compared to a country that poses a potential threat to the United States. And thus, it should be a totally free market with those countries.

Chairman CALVERT. The gentleman——

Mr. ROHRABACHER. Thank you very much.

Chairman CALVERT. The gentleman is correct, however, you know, there are still some burn marks from 1812 over at the Cap-

itol. We may have to send Virgin a bill for cleaning some of that up.

Mr. WHITEHORN. I would just like to add a couple of comments to what Burt said there. We don't envision a problem with the DDTC or with the Department of Defense. We are having a robust and very friendly dialogue on this issue. But we have made it clear to them that we are not planning to export the vehicles, and we are planning to operate the vehicles only in the USA to start with. But if you look at the marketplace, and I think back to Burt's point about Boeing selling aircraft around the world or Lockheed selling aircraft around the world, the market for this is worldwide. Of the 29,000 people who have registered that wish to pay the deposit, only 40 percent are from the U.S. Now a lot of the people are going to be coming from other parts of the world to fly in the U.S., but this could be an export industry for the U.S. And you know, this country has a balance of payments problem, there is no doubt about it. And you know, you have to look to the methodologies which you are adopting in terms of every aspect of export of technology from this country, because, you know, it is the export of technology, which is the lifeblood of an industrial country. And at the moment, there are issues to deal with on this front.

Chairman CALVERT. I thank the gentleman.

Mr. Costa.

Mr. COSTA. Thank you very much, Mr. Chairman and the Ranking Member for having this hearing today. I think it really focuses on a very important growing technology that I think all of us are excited about. And I, too, want to commend Burt Rutan as the recipient, for the second time, of the Collier Trophy. It just goes to show that kids that grow up in Silicon Valley can do good, as a native not far away from Fresno. We are very proud of all of those accomplishments, obviously.

I have two questions, and I think it was important in your—both—Mr. Rutan, your testimony, and Mr. Whitehorn, to remind us of the history of aviation in the 1920s and the 1930s. Douglas and Northrop and a little company in San Diego called Ryan that built an airplane for a fellow named Lindbergh, and how that whole relationship developed between entrepreneurs who had a vision and had a dream to fly and the partnerships, the public partnerships that later developed. Obviously, if it weren't for the establishment of the Federal Postal System giving contracts to the fledging airlines of those days, because the passengers certainly weren't paying for the airlines to come together, but if you could get a postal route, it made a big difference. And that whole evolution process, and I think there are certainly applicable lessons to be learned as we develop this industry, as you so well stated, Mr. Rutan, in your comments, and you as well, Mr. Whitehorn.

ECONOMICS OF COMMERCIAL SPACE

Two questions. One, and I don't know if you are yet at this level in terms of developing your economic model. You talk about 27,000-plus interested parties that have indicated, and we hear the number thrown around about $200,000 per flight per individual, and say, maybe half of those actually end up purchasing a ticket. And you can do the math, obviously, but have you done any economic

models in terms of the multiple impact? I spent some time in high-speed rail and others, and they like to talk about a two-to-one factor, for every dollar spent, there are $2 benefit in return in terms of the ripple impact to other economic sectors or subcontractors or the like. Have you developed anything like that yet at this point in time?

Mr. WHITEHORN. No, we haven't done it at this stage. I mean, what we have done is we have taken Burt's costs in the development of SpaceShipOne and some feasibility work that Burt did for us last year before we signed the contract with them to buy the technology. And we have modeled. We believe that with it—for the expenditure of $120 million, we can get to a viable business and that the early pioneers will pay $200,000 to fly on this model, and we believe that by year five we can be reducing those costs very considerably. And from the point of view of the individuals, we believe that eventually we could get it down to $25,000 or $30,000 after a number of years per flight per person.

In terms of the economic impact outside of Virgin Galactic's own business plan and Burt's own business is he uses us as the launch customer, as Boeing would describe it. And our status as a launch customer will obviously give Burt the basis on which to invest in developing further projects. And we, in a symbolic relationship, would envision ourselves developing an orbital business eventually out of the Virgin Galactic business.

My personal view is that the developments that we undertake together, Burt as the manufacturer and ourselves as the customer, will have a considerable effect on the industry as a whole, on the space industry in the United States. NASA, for example, you know, will be able to help us by being a customer. But the reason they should come to us as a customer is because we can do for them what needs to be done more efficiently than they can do it themselves. And that is how public-private partnerships work. One thing that the UK has actually excelled in the past 20 years is privatizing its publicly owned industrial structure and creating partnerships between the public sector and the private sector. If you look at our National Health Service in Britain, for example, it was run like a Soviet operation 10 or 15 years ago. Everything was done inside the health service. Now 10 billion pounds worth, so about $20 billion worth, of contracts per year are let by the National Health Service, which is a publicly owned institution, to the private sector. I don't think NASA has gotten as far as that in terms of its attitude to the private sector yet.

Mr. COSTA. Yeah.

Mr. WHITEHORN. But when it does, and when organizations, such as NASA, buy in more and more from the private sector, as this industry develops, and I don't mean the Lockheed or Boeing private sector.

Mr. COSTA. Right.

Mr. WHITEHORN. I mean, not the primes, but the new industry that emerges, I think you will see a ripple effect in terms of investment. But it is too early to model that for the moment.

Mr. COSTA. Thank you. And——

Mr. RUTAN. Could I comment briefly on the launch customer point that——

Mr. COSTA. Sure.

Mr. RUTAN.—Will made? I think it is extremely important to us that we have a Virgin as a launch customer, because if I would look back before Richard Branson's interest in this, my business model assumed that this business would start off from a low-credibility standpoint, both from developing and building spaceships and for those that operate them. I didn't dream and expect that a Jet Blue or a United or American Airlines would come in and buy spaceships early in this game. I just—my gut told me that they will pass on that. The fact that a major world airline has stepped up and has told us that they want to buy the first five spaceships and that they want to operate, and they have already gone out and done market surveys and so on, that fact that an airline, not just whatever else would—you would think would be there, has stepped up has given me the ability to go out and get the investment that is needed to develop and certify the spaceships. So I didn't expect that we would start off from that strength. The fact that we have a launch customer, which is a successful, major airline is absolutely huge.

Mr. WHITEHORN. I have to add, of course, that Virgin Atlantic is just another normal airline. As they say in Denmark about Carlsberg, it is probably the best airline in the world.

Mr. COSTA. Mr. Chairman, I know my time has run out, but I do have a technology application question that Mr. Rutan might want to respond to later on to the Committee, but I—in terms of the application of this technology, I know there has been a lot of investment by NASA and by some other companies on hypersonic space flight to bridge the continents, and I would like to have a better understanding of whether or not there is an application of this technology to that at a later stage. And you can maybe do that in a written statement or whatever suits the Chairman.

Chairman CALVERT. Certainly. We could move into our next—Mr. Honda.

Mr. HONDA. Thank you, Mr. Chairman and Ranking Member.

Let me just piggyback on my colleague's question, and maybe you could answer that question at the same time that—piggyback on the question that I am going to ask.

First of all, I—you know, as a kid that grew up watching Flash Gordon in his young adult, the—you know, Star Trek and all of that sort of stuff, I find this subject very interesting.

A quick comment on NASA. I think NASA will probably be in a position to do more partnering if this Administration had the foresight to invest more into the projects that we have, because currently we are looking at massive cuts, and massive cuts that would affect young people who would consider space flight and manned space flight if we were to invest properly in a more healthy way into this area. That is a personal comment, because I agree with both of you that NASA has a great role to play. And as a schoolteacher, I do believe that NASA has a role to play in terms of education and primary research.

SAFETY CONCERNS

Having said that, along with Mr. Costa's question, in terms of research in manned space flights, do you believe that there are—that

humans can be subjected to unknown kinds of exposures that we haven't even thought of as of yet that we should be looking at in terms of safety and long-term safety, whether it is intercontinental, high-speed, supersonic travel or orbital space flights? What would be your reaction to that?

Mr. RUTAN. Well, there is nothing that is unknown about what we are going to put humans exposed to in order to have this sub-orbital industry grow and be healthy. We know all of the answers to those things. They are very straightforward. They are very acceptable, and they are—you—by the way, you do want to expose someone to forces in order for it to be fun. And the—there are now showstoppers out there at all. Now as we move on and go to the planets where you have long-term exposure to radiation and so on, there are serious things that need solutions, but that is not for the work that we are likely going to be doing this decade. That is the next step. But I don't see any roadblocks at all on technologies, and I don't—I do not believe we need any research work done at NASA to support the sub-orbital private space flight industry. I believe when the private space flight industry moves to taking people to the moon and the planets, NASA will be a very strong player, because they do need to get back into their role of doing basic research rather than running the airline. And I see a big role for NASA as we go to low-Earth orbit, and particularly as we go above low-Earth orbit. And I think Mr. Musk will comment more on his, because he is working on orbit, and we are not. But for this new industry that we have been developing here on this panel, we don't see a role at all for NASA.

Mr. WHITEHORN. If I can just add to that, very quickly. I—one of the things we are working with the FAA at the moment is the guidelines. And one of the guidelines is that we explain to the customers exactly what the risks are. And those risks are known, so the risk of——

Mr. HONDA. Oh, okay.

Mr. WHITEHORN.—gamma radiation, for example, will be explained to the customers. And you know, you are talking about a level of risk of a CT scan for a flight on a sub-orbital craft.

Mr. HONDA. So you have research on that, then?

Mr. WHITEHORN. There is plenty of research on it, which goes back decades now. And the research in the airline industry and the research that was done around the introduction of Concord back in the 1970s is all perfectly relevant to this particular situation. I mean, the only risks we don't know about is, you know, the possibility that we might meet aliens since there will be several thousand flights rather than just a few hundred over 40 years.

Mr. HONDA. Well, that is a buzzword in this country.

Thank you.

Chairman CALVERT. Thank you.

Mr. Wu.

Mr. WU. Thank you very much, Mr. Chairman.

I have a couple of questions, but I just want to start by saying that, you know, my dad was in the aerospace industry. By then, the industry was already fairly mature, and names like Northrop and Boeing were institutions rather than individuals, but by having an affection for whatever field I am in, I dig into the history.

And it was interesting for me to find the individuals behind those institutions, and that was a romantic era when the founders of these great institutions were first starting their businesses.

RETURN-TO-FLIGHT

I want to salute you all for your cutting-edge work, and I truly believe that Mr. Whitehorn, Mr. Rutan, you and Mr. Branson will be remembered in the aerospace pantheon with the likes of Jack Northrop and others, and I really want to recognize that.

And Mr. Rutan, it was a long time ago, but I made a 200-mile drive to see Voyager land in the Mojave Desert, and that was one of the great moments of my life to see that aircraft come in. It is just really terrific. I try to explain its significance to my son when we see it at the Air and Space Museum. He is less than completely impressed right now, but I think—he is seven, and——

Mr. RUTAN. I believe the Voyager pilot is with us in the audience today, too, my brother, Dick.

Mr. WU. Well, you flew it really nice, straight, and level all of the way in. And you did walk away from the landing, which is a very good thing. Thank you. It is very, very impressive.

I really want to ask you all a couple of questions apart from commercial space and what you have been working on, because, you know, sometimes in the course of your work and your extensive background, you can shed valuable light on other organizations and other processes. And the two things I wanted to check with you about are really NASA and federal programs.

As you know, the launch window for the next Shuttle opens approximately May 15, and I was wondering if either of you, particularly Mr. Rutan, but either of you, have any commentary as you have observed. I mean, I know you all have been very busy, but if you have observed the NASA return to space—return to flight efforts, if you have any observations to share with us. And then I have one other question after that.

Mr. RUTAN. Well, I feel very privileged to have an appointment this afternoon with the new NASA Administrator, even though he has only been on the job a couple of days. So I believe there is likely going to be major changes on what we believe is ahead, and I would prefer to not guess, at least until I have had a chance to give him my thoughts and to have a better idea of what is likely to happen at NASA. But I believe there will be major changes in what NASA's activities were otherwise going to be because Mike Griffin is on board. So I really don't think it would be appropriate for me to guess on that until I have a little more information.

Mr. WHITEHORN. I would like to make a general comment.

I think it is incredibly important for the future of space that NASA returns to space flight. I think there is an enormous psychological impact. And you know, one of the comments that was made earlier was about in education. When I was brought up as a young lad in Scotland, my parents told me that I would probably go to space when I grew up and that they wouldn't be alive to see it, but I would. The generation beyond my generation grew up not believing they would ever go to space. They ceased to believe it, because the whole attitude to space became, "Robots will do it, because robots are going to be cheaper," and scientists decided that robots

were where space was going. And to be honest with you, the psychological impact of that around the globe was that people actually stopped believing in the whole idea of the exploration of space, because why do human beings want to pay through their tax dollars to fund something that they are never going to get the chance to ever experience themselves? However, science has moved on. Our understanding of our own planet has moved on enormously in the last 20 years, and people have realized that our tenure on this planet is pretty limited, that you know, there will be catastrophic events that could damage civilization itself, and that they happen on a more regular, say, precept than we had thought of 30 or 40 years ago.

So the idea that we can't ever leave this planet is a psychologically damaging one to the whole concept of civilization, development, and science and technology itself. So not only is this private sector venture incredibly important, but also NASA's return to space flight is incredibly important, and I think we should laud them for, hopefully, what will be a great event around May the 15th or shortly afterwards. And it was interesting, my son went to see SpaceShipOne the Christmas before last. And he went back to his school in England, and the schoolteacher was asking, "What did you do in the Christmas holidays?" of all of the boys in the class and the girls in the class. And he said he had been to see the spaceship and his dad might be building one. And the science teacher sent him out of the class. And the difference between two years ago and now is that he has had a letter of apology about that and—thanks to Burt succeeding in the X–Prize, and also, you know, if you look at the attitude to space at the moment, the interest there was in the Mars mission, because this government announced that you were going to intend to go to Mars with human beings, and the worldwide coverage of the Mars Explorer last year was dramatically different to the previous coverage of the early missions to Jupiter, for example, in the late '80s and early '90s, which didn't attract that much public interest or attention. The fact that human beings are going out beyond this planet is the incredibly important principle that NASA has to re-establish and it is doing so now, which is to be lauded.

Mr. WU. Thank you very much.

And Mr. Chairman, with your forbearance, if I can get out my second question.

The—if—and I look forward to hearing, Mr. Rutan, your observations in private after you have had your meeting. And Mr. Whitehorn, I completely agree with you about the importance of NASA's return to flight. It has tremendous symbolic as well as real significance, and I think the whole Nation, the whole world, will be holding its breath. And that is why it is so important.

NASA AERONAUTICS

The other thing that gets a whole lot less attention and that is that we talk all of the time about space, but we forget about the aeronautics mission of NASA. And I was wondering if either of you have views about whether NASA has under-emphasized its aeronautics mission perhaps at the expense of either American competitiveness or world aviation.

Mr. RUTAN. Well, before NASA, there was NACA. And NACA did, indeed, support the industry by providing wind tunnels and providing basic research, really very well focused on the kinds of things that a manufacturer would need in order for him to go out and build an airplane and compete and to build the industry. NACA never did run an airline. NASA now is running the only airline that America has in space. So it is a considerably different thing. I don't think just by throwing more funding to NASA you are going to get help on the aeronautics. I think you are going to have to be specific, and you are going to have to identify the resources that NASA has for aeronautics, which one of the wind tunnels are critical, and the ones that are critical need to be—remain open so that the developers all of the way down to—all of the up from Boeing and all of the way down to Scaled Composites can use these facilities, because they are national assets that we have spent money for.

In general, though, in terms of the research done at the individual level, say, calculations and so on, at NASA, what has happened is because the airline industry and the military airplane development industry is so competitive, you will look inside Northrop and Boeing and so on and you will find better skills there of these technologies than you find looking inside the labs at NASA. So I am not a proponent of keeping a lot of that alive if it is not something that flows good information out to the U.S. manufacturers. I don't see a benefit there. But I think at least on the short term, we have got to make sure that the wind tunnels that are important and the assets that are important that the government owns, that they not be just thrown away.

Mr. WHITEHORN. I would agree with Burt's testimony.

I would also add that I think one of the issues that NASA has had to face over the last 45 years is that it really hasn't had a clear output specification of what it should be doing from government on behalf of the people of the States. I mean, it is, to me, very, very interesting that NASA had—if you look at the 1970s and 1980s, it was very direction-less for a long period of time. And it was also part of a Cold War that existed between the Soviet Union and the USA, and people forget that these days. It was forced to do things by government by using tax dollars, which were part of the Cold War itself, rather than part of the exploration of space. And I think NASA, for the first time in, probably, two decades, has a very clear direction at the moment, but it mustn't be thinking in that clear direction about the mechanics of achieving it using the ideas of the past. It mustn't get stuck into the rut of, "Well, we have got to do this so we have got to build this type of rocket, because that is the way you do it." It should really be thinking about, you know, if the best way to do it is to build something out of paper mache and send it into space, because that will work more effectively and be more cost-effective and safer, then that is the way we should think about doing it. And I think that attitude and that cultural change in NASA you can definitely see happening at the moment from the outside.

Chairman CALVERT. I thank the gentleman. I thank the gentleman for his questions.

Mr. WU. I thank the witness, and I thank the Chairman for his forbearance.

Chairman CALVERT. Okay. We are spending a little more time on this panel than we expected, but it is very interesting. Mr. Bartlett has joined us. Does the gentleman have any other questions or——

Mr. BARTLETT. I am sorry I couldn't have been here for the whole hearing. Thank you all very much for coming.

Are you making an argument, maybe, that you ought to be—we ought to be rethinking NASA and its mission when you note that the aeronautical area has—now has large companies, very competitive, that are able to attract skills that it is difficult for the government to match? I have a general philosophy that government needs to be only where they need to be, and if we don't need to be in an area, maybe we shouldn't be there.

Mr. RUTAN. Well, I don't think that it is NASA's role to do development, and I don't think it is NASA's role to run an airline or a spaceline. I think it is NASA's role to do basic research to discover—to allow the discovery of breakthroughs. The problem that we have is if you define research, like I think it should be defined, and that is if there is something out there that you are trying to achieve and you want to put funding in to achieve it, if half of the people that look at that goal look at it from the standpoint of, "Oh, man, that is tough. And, God, it would be neat if you could do it, and I think you can do it." And then the other half of the technologies looked at—technologists look at that and they say, "Well, hell, that is impossible." Okay. I believe at that level, then to go after it, you are doing research. But if everybody says, "Oh, yeah, that will work, and we are just here to kind of refine it," then all you are doing is development. And that is my argument with this exploration program now is they are not out there looking for the breakthroughs. They are not out there looking for things that can make big differences. They are really—NASA is doing development, because NASA, in general, and it may be somewhat of things imposed by them by accident committees. It may be some things that are imposed on it by you folks who pass out their money. But they just flat are scared to death of failure, and if they are scared to death of failure, you are incapable of doing research. I think NASA ought to be funded to do research to support America's airline industry and America's military development industry, and that means that most of what they do are things that are expected to fail. And that takes a whole different culture and a whole different idea. That is what NASA ought to do.

Mr. BARTLETT. I come from a science background. I appreciate very much your understanding that there is no unsuccessful experiment.

Mr. RUTAN. Right.

Mr. BARTLETT. If it doesn't work, that is a success. You learn——

Mr. RUTAN. Right.

Mr. BARTLETT.—that it doesn't work, so you have got to try something else next time.

Mr. RUTAN. And if you are afraid to fly it, you never learn anything.

Mr. BARTLETT. That is right. You know, and people who don't come from a science background have a lot of trouble under-

standing that, that there is no unsuccessful experiment. If it didn't work, it didn't work, so we will try something else next time.

But for people who are—who want to avoid failure, they see an experiment that—where you didn't prove your hypothesis, where the data did not support your hypothesis, they see that as a failure, and so they don't want to do it. And when you have that kind of timidity, you are not going to push the envelope very far very fast.

Mr. RUTAN. The X–34 is a very good example. Here is something that was funded all of the way through, essentially ready to fly, and then was not flown because it was deemed to be risky. And you know what happened shortly after we had some failures in some Mars missions, and they decided, "Listen, we don't like it, because it is risky, so we don't fly it." And that is, essentially, what happened. If they had have flown that and made a smoking hole in the desert, you would learn something from it. When you don't fly it, you have wasted all of your money and you have defined certain failure of your goals.

Mr. BARTLETT. I appreciate your concern.

Thank you very much, Mr. Chairman.

Chairman CALVERT. I thank the gentleman.

I certainly thank this panel. Mr. Rutan, again, congratulations for your accomplishments.

Mr. Whitehorn, thank you for putting some risk capital behind this, and that is what entrepreneurship is all about.

I am going to have a question—a couple of questions, one that I will—because we—in the interest of time, about the long-term prospects for space tourism on full orbital flights. And if I can put that in writing to you and get a written response what kind of technologies need to be developed and what do you see is a timeline for something like that.

With that, again, thank you very much for your testimony. It is very interesting. We have spent more time on this than we thought, but you were very kind to stay here, and it was very interesting for us. Thank you very much.

Mr. RUTAN. Thank you.

Chairman CALVERT. Okay. Our next panel: Mr. Elon Musk is the CEO and Chief Technology Officer for Space Exploration Technologies, SpaceX; Mr. John W. Vinter is Chairman of the International Space Brokers, ISB; Mr. Wolfgang Demisch, the founder of Demisch Associates, LLC, Aerospace Financial Analyst; and Dr. Molly Macauley, Senior Fellow and Director of Academic Programs at Resources for the Future.

Of course, Mr. Musk is known for inventing, what is it, PayPal and very successful and now is investing his money in something that is even more interesting, and that is space exploration.

With that, Mr. Musk, we are going to try to stay on our traditional schedule now of five minutes of testimony and five minutes for questions. We kind of let that go with the last panel, but we are going to stick to it this time.

So Mr. Musk, thank you very much for coming, and you may begin your testimony.

Panel II:

STATEMENT OF MR. ELON MUSK, CHAIRMAN AND CEO, SPACE EXPLORATION TECHNOLOGIES (SPACEX)

Mr. MUSK. All right. Thank you. There we go. All right.

Chairman Calvert, distinguished Members of the Committee, thank you for having me here. It is an honor to be here.

I will address the questions as directly as possible.

The first one is: "What is the SpaceX business plan?"

SpaceX is dedicated to improving the reliability and cost of access to space for the greater purpose of helping us become a spacefaring civilization one day. Without dramatic improvement in those two inseparable metrics, cost and reliability, we will never exceed the great deeds our Nation accomplished for all humanity with the Apollo program.

Although the ultimate goal of SpaceX is to provide heavy-lift, super-heavy lift, in fact, and manned launch vehicles, we have chosen to focus our initial efforts on a small rocket capable of launching satellites to low-Earth orbit. This vehicle, the Falcon I, is effectively a sub-scale technology test bed, ensuring that the inevitable areas of development occur at a small scale and without people on board.

However, the Falcon I, which has the lowest cost per flight in the world, and is entirely American built, is also showing strong market demand in its own right. We already have three firm contracts for launch and expect to close another two before Falcon I performs its maiden flight later this year. Once Falcon I has a few flights under its belt and the satellite producers have time to adjust, I think it is quite possible that there will be more flights of Falcon I than any other orbital launch vehicle in the world.

It is also worth noting that the Falcon I is the only semi-reusable rocket in the world, apart from the Space Shuttle. However, reusability is not currently factored into the price. As we refine that process, we may be able to make further cost reductions and hope to make further cost reductions in the cost per flight of Falcon I. As far as reliability is concerned, the Futron Corporation, which is used extensively by NASA and the FAA, concluded that the Falcon I, despite being low cost, had the second highest design reliability of any American rocket. It was tied with the most reliable version of the Boeing Delta IV and Lockheed Atlas V. The highest design reliability rank was held by our Falcon V design, which will be the only American rocket that can lose any engine or motor and still complete its mission, which I think is really quite crucial.

The Falcon V, scheduled for first flight next year, is a medium-lift rocket designed to carry people as well as satellites. As such, the design margins will meet or exceed the NASA requirements for manned spacecraft. In fact, my current instruction to the design crew is that they exceed the NASA specs. My hope is that this vehicle will provide the United States with an all-American means of transporting astronauts to orbit and ensure that we are beholding to no one once the Space Shuttle retires.

All in all, I see an increasingly positive future for commercial space activities over the next five to 10 years.

But what should the government do or not do to encourage the nascent commercial space industry?

The most important thing that the government should do is adopt a nurturing and supportive attitude towards new entrepreneurial efforts. In particular, the government should seek to purchase early launches as well as offer prizes for concrete achievements. Evidence for the tremendous power of prizes can be found throughout history, most recently, obviously, with the X–Prize and the best evidence being the prior panel.

Regarding purchasing early launches, the Defense Department has been very supportive and has done the right thing at every level, purchasing two of the four launches we have sold to date. But regrettably, NASA has not yet procured a launch and has provided less financial support than the Malaysian Space Agency, who has bought and paid for a flight on Falcon I.

However, I am very much heartened by the recent confirmation of Dr. Griffin as the new NASA Administrator. I am confident that his outstanding technical ability, dedication, and diverse experience will invigorate our space program. With a finite budget and entrenched interests to fight, Dr. Griffin will be forced to make some difficult decisions in the year ahead. I urge Congress to give its full support to Dr. Griffin when he does so.

As far as what the government should not do, I think it is important to minimize the regulatory burden required for space launch activities. And a comment made by Mr. Rohrabacher early on regarding the ITAR rules and having ITAR apply only to certain countries and not to others with—you know, we are in close military alliance, I think makes a lot of sense. But right now, we have the greatest difficulty just dealing with people from New Zealand and from the UK and from Canada. I mean, for goodness sake, it just becomes a bit silly. I really think we need to—there is an urgent need for reform in that area. I think, unfortunately, the American industry is really being harmed by this. And so it—but in general, we should do no more than is necessary to protect the uninvolved public, I think, as far as regulation is concerned. It sometimes seems to me that our society is paving the road to hell one regulation at a time.

And are there implications for the commercial space industry as you see it in the President's announced Vision for Space Exploration?

Well, the NASA budget is unlikely to see significant increases in years ahead, and in fact, will face severe pressure from entitlements just when we really need to spend money on the moon and Mars in, say, 10 or 20 years. Compounding the problem, U.S. launch prices have been increasing every year. So this places NASA in a financial vice, a continually tightening financial vice.

Unless we can reverse the trend of rising costs, we are going to accomplish less and less every year. So therefore, the only way that our country can meet the President's Vision, or really, any interesting objectives in space, is to encourage the development of new, low-cost access to space. If we can't afford to get there, the Vision will remain—or will become nothing more than a mirage.

[The prepared statement of Mr. Musk follows:]

PREPARED STATEMENT OF ELON MUSK

Chairman Calvert and distinguished Members of the Committee, thank you for inviting me to testify today on *Future Markets for Commercial Space.* It is an honor to be here.

What is the SpaceX Business Plan?

SpaceX is dedicated to improving the reliability and cost of access to space for the greater purpose of helping us become a true space-faring civilization. Without dramatic improvement in those two inseparable metrics, we will never exceed the great deeds our nation accomplished for all humanity with the Apollo program.

Although the ultimate goal of SpaceX is to provide super-heavy lift and manned launch vehicles, we have chosen to focus our initial efforts on a small rocket capable of launching satellites to low-Earth orbit. This vehicle, the Falcon I, is effectively a sub-scale technology test bed, ensuring that the inevitable errors of development occur on a small scale and without people on board.

However, the Falcon I, which has the lowest cost per flight in the world for a production rocket and is entirely American built, is also showing strong market demand in its own right. We already have three firm contracts for launch and expect to close another two before Falcon I performs its maiden flight later this year. Once the Falcon I has a few flights under its belt and the satellite producers have time to adjust, I think it is quite possible that there will be more flights per year of Falcon I than any other vehicle in the world.

It is also worth noting that the Falcon I is the only semi-reusable rocket in the world, apart from the Space Shuttle. However, reusability is not currently factored into the price. As we refine that process, the cost of Falcon I will decline over time. As far as reliability is concerned, the Futron corporation, which is used extensively by NASA and the FAA, concluded that Falcon I had the second highest design reliability of any American rocket. It was tied with the most reliable version of the Boeing Delta IV and Lockheed Atlas V. The highest design reliability rank was held by our Falcon V design, which will be the only American rocket that can lose any engine or motor and still complete its mission.

The Falcon V, scheduled for first flight next year, is a medium lift rocket designed to carry people as well as much larger satellites. As such, the design margins will meet or exceed NASA requirements for manned spacecraft. My hope is that this vehicle will provide the United States with an all American means of transporting astronauts to orbit and ensure that we are beholden to no one once the Shuttle retires.

All in all, I see an increasingly positive future for commercial space activities over the next five to ten years.

What should the government do or not do to encourage the nascent commercial space industry?

The most important thing that the government should do is adopt a nurturing and supportive attitude towards new entrepreneurial efforts. In particular, the government should seek to purchase early launches as well as offer prizes for concrete achievements. Evidence for the tremendous power of prizes can be found throughout history, most recently with the X–Prize.

Regarding purchasing early launches, the Defense Department has been very supportive and has done the right thing at every level, purchasing two of the four launches we have sold to date. Regrettably, however, NASA has not yet procured a launch and has provided less financial support than the Malaysian Space Agency, who has bought and paid for a flight on Falcon I.

However, I am very much heartened by the recent confirmation of Dr. Griffin as the new NASA Administrator. I am confident that his outstanding technical ability, dedication and diverse experience will invigorate our space program. With a finite budget and entrenched interests to fight, Dr. Griffin will be forced to make some difficult decisions in the years ahead. I urge Congress to give its full support to Dr. Griffin when he does so.

As far as what the government should not do, I think it is important to minimize the regulatory burden required for space launch activities. We should do no more than is necessary to protect the uninvolved public. It sometimes seems to me that our society is paving the road to hell one regulation at a time.

Are there implications for the commercial space industry as you see it in the President's announced Vision for Space Exploration?

The NASA budget is unlikely to see significant increases in coming years and in fact will face severe pressure from entitlements in the next decade. Compounding the problem, U.S. launch prices from existing contractors are increasing every year, sometimes significantly.

Unless we can reverse the trend of rising costs, NASA will be placed in a continually tightening financial vice, accomplishing less and less each year. Therefore, the only way that our country can meet the President's Vision in a meaningful way is by encouraging the development of new, low cost access to space. If we can't afford to get there, the Vision will become nothing more than a mirage.

BIOGRAPHY FOR ELON MUSK

Elon is the CEO & Chief Technology Officer of Space Exploration Technologies (SpaceX), which is developing a family of launch vehicles intended to reduce the cost and increase the reliability of access to space ultimately by a factor of ten. The company officially began operations in June 2002 and is located in the heart of the aerospace industry in Southern California.

SpaceX is the third company founded by Mr. Musk. Prior to SpaceX, he co-founded PayPal, the world's leading electronic payment system, and served as the company's Chairman and CEO. PayPal has over sixty-five million customers in 38 countries, processes tens of billions dollars per year and went public on the NASDAQ under PYPL in early 2002. Mr. Musk was the largest shareholder of PayPal until the company was acquired by e-Bay for $1.5 billion in October 2002.

Before PayPal, Mr. Musk co-founded Zip2 Corporation in 1995, a leading provider of enterprise software and services to the media industry, with investments from The New York Times Company, Knight-Ridder, MDV, Softbank and the Hearst Corporation. He served as Chairman, CEO and Chief Technology Officer and in March 1999 sold Zip2 to Compaq for $307 million in an all cash transaction.

Mr. Musk's early experience extends across a spectrum of advanced technology industries, from high energy density ultra-capacitors at Pinnacle Research to software development at Rocket Science and Microsoft. He has a physics degree from the University of Pennsylvania, a business degree from Wharton and originally came out to California to pursue graduate studies in high energy density capacitor physics & materials science at Stanford.

Chairman CALVERT. I thank the gentleman for his testimony.

Mr. Vinter.

If the gentleman would turn on his microphone.

STATEMENT OF MR. JOHN W. VINTER, CHAIRMAN, INTERNATIONAL SPACE BROKERS

Mr. VINTER. Yes.

Good morning, Mr. Chairman. Thank you. Members of the Subcommittee, good morning as well.

My name is John Vinter, Chairman of International Space Brokers. Our office is in Rosslyn, and we have subsidiary offices in London and Paris. I am pleased to testify before the Subcommittee.

My company represents a "who's who" of satellite users, including, in the U.S., Intelsat, XM Satellite Radio, Worldspace, AT&T, Bigelow, Kistler, and SpaceX. Additionally, we represent SES Astra in Luxembourg, Telesat Canada, New Skies Satellites in the Netherlands, Optus in Australia, Star One in Brazil, and Singapore Telecom. We have also managed the third-party liability program for the Shuttle when they were flying commercial missions.

I am also the Chairman of COMSTAC, the DOT's Commercial Space Transportation Advisory Committee.

You have asked me today to address three questions: "What kind of activities does your company include for insurance purposes in its definition of commercial space?" "As insurance brokers, what do you see as the outlook for commercial space activities in the next five years, 10 years? How do you think we should avoid exaggerated expectations in the industry, such as those that occurred in the low-Earth orbit market in the late 1990s?" and finally, "What, if anything, should the government do or not do to encourage commercial space endeavors?"

With respect to commercial space, we include any space activity which does not directly involve the U.S. Government as an insured. We address satellite insurance and risk management needs from "cradle to grave."

For us, commercial space begins with the arrival of people or equipment at the various launch sites, continues through launch, deployment, testing, and on-orbit operations of satellites through the end of their expected lives. These are the areas of risk where we spend the majority of our time and where satellite owners spend the majority of their insurance money. The launch itself is generally the riskiest and most expensive phase of any commercial space endeavor. In simple terms, our objective is to cover the risk of loss or damage to the satellites, including failure of the launchers or failure of the satellite to work according to the specifications. In general, as a comment, the market wishes to see successful first flights before insuring.

We also provide liability coverage for damages to third parties caused by launch and related activities and accidents. Again, commercial space insurance begins with arrival of equipment or people at the launch site and continues through on-orbit operations. As with the satellite coverage above, activities prior to arrival at the launch site are best covered in non-space insurance markets.

We also insure persons, for example, astronauts, tourist visitors to the Space Station, and individuals who have flown on the Shuttle. We also can insure various contingencies such as acts of governments, and yes, we could probably even insure a space prize.

As insurance brokers, what do you see the outlook for commercial space in the next several years?

We see space activities evolving and growing, albeit not very fast. The world's satellite manufacturers and launch vehicle providers have considerable excess capacity. There does not seem to be sufficient demand to absorb this excess in the near future. For the next several years, we think there will be approximately 15 to 20 commercial launches a year. We see, however, more human activities in space, the X–Prize being the first, and no doubt the America's Prize will be the second. And other incentive programs I am sure will generate an increase in activities.

I hope Mr. Rutan and Mr. Whitehorn, the other gentleman from Virgin Galactic, are widely successful and very active. The insurance community will be there for them, but it still remains to be seen.

What, if anything, should the government do?

Well, with respect the government involvement to encourage space endeavors, I offer the following. I would suggest the government maintain the current liability risk-sharing regime of private insurance, government indemnification in excess of private insurance, and cross waivers. This regime was established in the late '80s and was renewed last year for an additional five-year period. This system, in my judgment, is working very well. It has been adopted by non-U.S. launch organizations. I know there are doubters, but I believe this is very essential to the commercial launch business in the U.S.

I also would recommend we take another look at the International Traffic in Arms Regulations as regards to commercial

space to see if they really achieve what they are meant to achieve. We handle these matters for some of our clients, and the people who review the matters for licensing and monitoring are doing an excellent job and in a very timely fashion. The practical impact is not so clear. From the insurance point of view, this is an essential area, because ⅔ of the insurance market is located outside the country, and it appears that the same underwriters show up on every program, but they have to be individually cleared for every program. I believe that the U.S. industry would benefit if the process can be streamlined. I should also point out the whole process is pushing satellite business overseas as non-U.S. operators find it increasingly difficult to cope with the whole process.

I believe the use of government ranges and government purchases of commercial space services, where feasible, seems to be working well. I would, of course, defer to others, such as Mr. Musk, for their comments.

In this age of deficit spending, I would be hesitant to recommend additional public spending, but perhaps it could be considered by way of providing seed money for promising new technology.

This concludes my testimony. I will, of course, be pleased to answer any questions. Thank you.

[The prepared statement of Mr. Vinter follows:]

PREPARED STATEMENT OF JOHN W. VINTER

My name is John Vinter, Chairman of International Space Brokers, Inc. My office is in Rosslyn, VA, and we have subsidiary offices in London and Paris. I am pleased to testify before the House Committee on Science, Subcommittee on Space and Aeronautics.

My company represents a "Who's Who" of satellite users, including the following: In the U.S., Intelsat, XM Satellite Radio, Worldspace, AT&T, Bigelow, and SpaceX. Additionally, we represent SES Astra in Luxembourg, Telesat Canada, New Skies Satellites in the Netherlands, Optus in Australia, Star One in Brazil, Singapore Telecom in Singapore, and others. We also have managed the Shuttle third party liability insurance program for NASA.

I am also the Chairman of COMSTAC, the Department of Transportation's Commercial Space Transportation Advisory Committee, advising the FAA's commercial space transportation office. In my career, I have been fortunate, in separate career phases, to work for both a satellite company having the need for insurance as well as an underwriter company providing insurance coverages. Today, I am a broker representing the above mentioned clients, and others, in the purchase of insurance from the international space insurance market. You have asked me to address the following questions:

1. What kind of activities does your company include for insurance purposes in its definition of "commercial space"?
2. As insurance brokers, what do you see as the outlook for commercial space activities in the next five years? Next 10 years? How do you think we should avoid exaggerated expectations for the industry, such as those that occurred in the low-Earth orbit (LEO) market in the late 1990s?
3. What, if anything, should the Government do or not do to encourage commercial space endeavors?

What kind of activities does your company include for insurance purposes in its definition of "commercial space"?

With respect to "commercial space" activities, we include any space activity which does not directly involve the U.S. Government as an insured. We address satellite insurance and risk management needs from "cradle to grave."

For us, commercial space begins with the arrival of people or equipment at the various launch sites, continues through launch, deployment, testing, and on-orbit operations of satellites through the end of their expected lives. These are the areas of risk and insurance where we spend the majority of our time and where satellite

owners spend the majority of their insurance money. The launch itself is generally the riskiest and most expensive phase of any commercial space endeavor to insure. In simple terms, our objective is to cover risks of loss or damage to the satellites, including failure of the launchers, or failure of the satellite to work according to its specifications.

We also provide liability coverage for damages to third parties caused by launch related and satellite operational accidents. Again, commercial space insurance coverage begins with the start of launch site activities and continues through on-orbit operations. As with the satellite coverage above, activities prior to arrival at the launch site are best covered in non-space insurance markets.

We also ensure persons, for example, the lives of various astronauts and tourists/visitors to the Space Station, including individuals who fly or have flown on the Shuttle.

From time to time, we also insure contingencies such as acts of government, and other causes, that could affect the ability to launch for various reasons.

As insurance brokers, what do you see as the outlook for commercial space activities in the next five years? Next 10 years? How do you think we should avoid exaggerated expectations for the industry, such as those that occurred in the low Earth orbit (LEO) market in the late 1990s?

As brokers, we see space activities evolving and growing, albeit not very fast. The world satellite manufacturers and launch vehicle providers have considerable excess capacity at the moment. There does not seem to be sufficient demand to absorb this excess in the near future. For the next several years, it would appear there will be approximately 15 to 20 commercial launches per year. We see, however, more human activities in space, the X–Prize being the first of what is expected to be a significant increase in the number of humans going into space. I have no doubt that the America's Prize, and, hopefully, other incentive programs will generate an increase in activities, although it is hard to determine how long this will take.

Going into space is expensive and involves significant risk. The implications of the low-Earth orbit projects in the late '90s adversely affected the financial markets. I have no doubt that the financial community will demand sound business plans before advancing significant sums of money. As it is well known, space is very exciting and will be the subject of much discussion. Unfulfilled expectations can't be avoided. I do not know whether a solution will exist to deal with the ups and downs of expectations. Perhaps getting together with the insurance industry for their opinions may be of value in minimizing the potential financial risks.

What, if anything, should the government do or not do to encourage commercial space endeavors?

With respect to government involvement to encourage space endeavors, I offer the following thoughts.

I would suggest the government maintain the current liability risk sharing regime of private insurance/government indemnification in excess of private insurance and cross waivers. This regime was established in the late 1980s and was renewed last year for an additional five-year period (P.L. 108–428). This system, in my judgment, is working very well and has been adopted by non-U.S. launch service organizations. I know this regime has doubters but failure to maintain this regime, I believe, in the long run could significantly harm the U.S. commercial launch business.

I would also recommend that the International Traffic In Arms Regulations, as regards to commercial space activities, be reviewed to see if they really achieve what they are meant to achieve. We handle these matters for some of our clients and the people who review such matters for licensing and monitoring are doing an excellent job and in a very timely fashion. The practical impact of these regulations should be noted. From the insurance point of view, it is important to recognize that two thirds of the market is located outside of the country and the same underwriters appear on most of the programs. It could benefit U.S. industry if the ITAR process can be streamlined. However, I should point out the whole process is pushing satellite business overseas as non-U.S. operators find it increasingly difficult to cope with the process, particularly, in a tough competitive environment.

I believe the use of government ranges and government purchases of commercial space related services, where feasible, seems to be working well. I would defer to others for their comments in this regard.

In this age of deficit spending, I would be hesitant to recommend additional public expenditure for commercial space projects but perhaps it could be considered by way of providing seed money for promising new technology and so forth.

This concludes my testimony. I would, of course, be pleased to answer any questions. Thank you for this opportunity.

BIOGRAPHY FOR JOHN W. VINTER

Professional Background:

John Vinter is Chairman of International Space Brokers, Inc. (ISB). He has been involved with virtually all aspects of satellite business for over thirty years. Mr. Vinter was appointed to the Department of Transportation's Commercial Space Transportation Advisory Committee (COMSTAC) in January 2000. In July 2003, he was appointed as COMSTAC Chairperson by FAA Administrator, Marion Blakey and assumed the official duties of Chair at the last meeting in October 2003.

Mr. Vinter founded ISB in February 1991, in conjunction with three prominent insurance brokerage organizations. Since its founding, ISB has consistently maintained a 30–40 percent market share in this business.

From March 1984 to February 1991, Mr. Vinter was responsible for the space underwriting activities for INTEC (now AXA Space). INTEC was the underwriting manager for CIGNA and a large number of insurers and re-insurers worldwide. As Executive Vice President, Mr. Vinter was lead underwriter for many of the world's major programs. His underwriting activities were such that INTEC was able to achieve an underwriting profit six out of seven years and a market share of 20–25 percent.

From August 1976 until February 1984, Mr. Vinter held a variety of positions with Satellite Business Systems where he was Director of Administration, Contracts and Procurement. In this capacity he was responsible for Satellite Business Systems' business transactions involving contractual relationships with its customers, contractors, insurers and launching agencies. He was also responsible for the risk management function of the company. In connection with this activity he negotiated the contract for the first HS–376 satellite as well as the first commercial Shuttle launch services agreement with NASA for which he then purchased the first Shuttle third party liability and launch insurance.

From July 1968 to August 1976, Mr. Vinter held a number of management positions within Communications Satellite Corp. in which he was responsible for the negotiation, procurement and administration of major satellite and ground system procurements.

Education:

John Vinter has an A.B. degree in Economics from Georgetown University and a M.S. degree in Telecommunications Operations from George Washington University.

Chairman CALVERT. I thank the gentleman.

Mr. Demisch, you may begin your testimony.

STATEMENT OF MR. WOLFGANG H. DEMISCH, PRESIDENT, DEMISCH ASSOCIATES, LLC

Mr. DEMISCH. Thank you, Mr. Chairman.

Mr. Chairman, Members of the Subcommittee, and honored guests, thank you for the opportunity to appear before you today. My name is Wolfgang Demisch. I am a principal in Demisch Associates LLC, a financial consultantcy in the aerospace sector.

You have asked me to address the outlook of the commercial space launch business as well as to forecast when space would attract classic risk-reward investors to succeed the "angel" investors, such as Paul Allen, who funded SpaceShipOne that we see today. The goal is to help the Committee recommend what the Congress could or should do to encourage commercial space endeavors as called for in the NASA charter.

Your hearings come at a challenging time for commercial space. The benefits of commercial space are just embedded in the economy. They are taken for granted by anybody who goes for a hike with a GPS, for instance, but they just haven't been well rewarded in the financial area. To highlight the issue, over the last four

years, essentially all of the world's civil communications fleet has changed hands for an aggregate price roughly equal to one-year NASA budget. That has been a disappointing return for the investors, and that is without factoring the costs of things like Iridium or Beale or Kistler. The only consolation is the buyers are probably a roll call of the smartest investors in the world, people like KKR and Carlyle and Apollo, and clearly, they see outstanding risk-reward in space right now, and but notably in the space communication segment.

The fact that there are smart buyers for space communication doesn't change the reality that access to space remains too costly for most commercial endeavors. Price per pound to low-Earth orbits in the $10,000 class, essentially unchanged from the $1,000 a pound achieved by the Saturn V in the 1970s. That translates, incidentally, on a tourism basis, directly into the $20 million a head paid by the guys who flew on the Russian boosters, and I might note that that was a bargain. They didn't pay for life support. If NASA were to do the same thing, if Congress was encouraging them, they would probably have to charge five to eight times as much.

So I think the message is space launch is on a much lower productivity track than microelectronics or computing, and that is despite Congress's long-term funding support of new space launch technology: the reusable Shuttle, the commercially-derived EELV. No savings were achieved. I am unaware, regrettably, of any credible proposal for substantial cost reductions. The propulsion breakthrough, which I think would be necessary in the technical basis to achieve such a breakthrough, isn't in sight. I think it would be prudent to set policy on the basis that no substantial launch cost reductions are to be expected.

It will stay expensive until we get something like the proposed space elevator that Clarke, among others, has written about. I think that is a plausible technology, and so I enthusiastically applaud NASA's Centennial Challenge program, which will help mobilize the need of talents and materials and power technology that would underpin that kind of a transformation. And I think that is worthy of your support, but in the interim, I think it will remain uneconomic to send up anything other than information up and down from space. Absent some astonishingly serendipitous discovery, a cancer cure, for instance, space access, I think, would grow in line with the general economy.

And I think the more promising approach to improving the efficiency of space flight is to accept that it is hugely costly; about 10 pounds of space payload is equal to one man year at current engineering rates, and at that price, it is really worthwhile to invest to shrink the payload weight that is needed to perform a specific task. NASA has used this technique with pretty good success to trim the mission costs of its interplanetary probes. And while it has limitations, because, you know, antenna size and also people don't scale down like they might, nevertheless, it is pretty powerful, especially when you combine several satellites in the station keeping system to ambulate the performance of a bigger platform. There is lots of space for better improvement: better batteries, better solar cells, lighter structures, more efficient communications, and has di-

rect spinout both to the military as well as eventually to the larger economy. I think that that kind of effort deserves your support.

In general, I have to say Congress has been consistently supportive of commercial space. It has shied away from the kind of direct operating incentives we saw in the beginning of the civil air transport industry, but nevertheless, Congress has been very generous. I consider, for instance, you know, the duopoly allocation for the satellite radio business or, for that matter, the enormous frequency allocation, which was granted Teledesic when they had their broadband project, and those kind of in-kind supports that is essentially the modern day equivalent of land grants to the railroads that financed the transcontinental railroads in the 19th century. I think it is important, but I think it is inadequate, to catalyze a major new industry of the scope and stability that is needed to transform commercial space into the kind of risk-reward investor as opposed to "angel" investor area that you are seeking. Commercial space today is centered on communications and broadcasts and the new broadcasts are being brought into service, like XM Radio and Sirius, and as that happens, existing services, like DirectTV, get forwarded into larger media powerhouses and the investment feasts on those enterprises is not controlled by the space investment. It is controlled by other factors.

I do think there are other drivers for commercial space initiatives that respond to Congressional mandates regarding national security, for instance. It is interesting that right now there is no effective surveillance of the millions of containers that flow across our borders. In fact, industry can't even find about ⅓ of them. So the TSA and Customs have begun to institute some monitoring. These are big boxes, you know, I mean, sort of house-sized, able to contain anything, germ warfare labs. The monitoring doesn't really watch these trailer-sized structures either while they are in transit or when they are in the U.S. There are proposals for satellites to offer that capability to maintain that watch worldwide. It requires each container be equipped with a suitable black box that checks its status and reports intrusions. And once that is there, there is also, of course, obvious commercial spin-offs from that. You can monitor the environment. You can monitor the temperature. You can check the—see that the product quality is maintained. When you have a container of beer and it goes to 160 degrees, it is probably not going to be good beer. But it also gives you a straight commercial payoff. You can include the documentation for fast Customs clearance.

That kind of monitoring, I think, will be routine in the decade, because it responds—is driven by a pressing security need. There are other initiatives, for example, to switch a lot more of the air traffic control to satellite-based navigation and communications. That will take longer. But I think that getting the infrastructure support, which provides steady and reliable revenues, that is the kind of thing risk-reward investors seek and will accept. I think that may begin the transition the Committee is talking about.

Thank you for your attention. I am available for any questions.

[The prepared statement of Mr. Demisch follows:]

PREPARED STATEMENT OF WOLFGANG H. DEMISCH

Mr. Chairman, Members of the Subcommittee, honored guests. Thank you very much for the opportunity to appear before you today. My name is Wolfgang Demisch, I am a principal in Demisch Associates LLC, a financial consultancy oriented towards the aerospace sector and I have been active in aerospace financial matters since the early 1970's.

You have asked me to address the outlook for the commercial space launch business, as well as to forecast when space would attract classic risk-reward investors to succeed the 'angel' investors we see today, investors such as Paul Allen, who funded the Spaceship 1 development. The goal is to help the Committee recommend what the Congress could or should do to encourage commercial space endeavors, as called for in the NASA charter.

Your hearings come at a challenging time for commercial space. While the benefits of commercial space are now so embedded in our economy that they are taken for granted by anyone who goes on a hike with a GPS, to give just one example, they have not been well rewarded in the financial arena. To highlight the problem, over the past four years, the bulk of the world's civil communications satellite fleet has changed hands, for an aggregate price roughly equal to one year's NASA budget. This represents a disappointing return to the industry sponsors; even without factoring in the additional losses on restructured projects such as Iridium or the costs of now quiescent launch ventures such as Beale or Kistler. The consolation, if any, is that the buyers, firms such as KKR, Carlyle and Apollo, are almost a roll call of the world's most astute investors. Their actions demonstrate that they see outstanding risk-reward value in commercial space, notably the communications segment, where substantial purchases could be made.

That commitment to space based communications however does not invalidate the painful reality that access to space remains too costly for most commercial endeavors.

At present, the price per pound to low Earth orbit is in the $10,000/lb class, depending on the vehicle. It is not much changed, on an inflation adjusted basis, from the roughly $1000/lb achieved by the Saturn V booster in the 1970's. Today's price translates readily into the $20 million fare paid to Russia by the first space tourists, who arguably got a bargain, as their life support and training was included. NASA would have to charge several times as much to cover its costs, if the Congress were ever to encourage such a use of NASA's fleet.

Clearly space launch costs are on a much lower productivity track than the microelectronics or computing sectors. This is so despite Congress' solid support of cost reduction efforts, first with the reusable Space Shuttle, then with the commercially derived EELV, neither of which achieved the savings anticipated. Regrettably, I am unaware of any credible proposal to achieve the desired substantial cost reductions. The propulsion breakthrough, which would be a prerequisite for a much better cost performance, is not in sight. Hence it would seem prudent to set policy on the basis that no substantial launch cost reductions are to be expected.

Access to space will stay expensive until we can achieve something like the proposed space elevator that Arthur C. Clarke, among others, has written about. This seems a plausible technology. Consequently, I enthusiastically applaud NASA's Centennial Challenge program, which will, I believe, help mobilize the needed talents to realize the materials and power technologies that underpin such a transformative capability. This effort, although still far from fruition, is worthy of your consideration in my view.

In the interim, perhaps for the next two or three decades, it will remain uneconomic to send anything other than information up into or back down from space. This suggests that absent some astonishingly serendipitous discovery, a cancer cure for instance, entry to space will grow about in line with the general economy, rather than some multiple thereof. It also suggests that there is not much to be gained from an effort to force feed the launch sector

A more promising approach to improving the economic efficiency of space flight, in my opinion, is to accept that space payload is hugely costly, 10 pounds per man-year at current engineering rates. At that price, it is worthwhile to invest to shrink the payload weight needed to perform the desired task. NASA has used this technique with considerable success to trim the mission cost of its interplanetary probes. While the approach has limitations, because of antenna size and power requirements, because of packaging constraints as well as because of people life support needs for manned systems, it is surprisingly powerful, especially when considering that several smaller spacecraft can cooperate to emulate the performance of a larger platform. There is plenty of scope for payload improvement, including better sensors, more efficient solar cells and batteries, lighter structures and more efficient

communications. The product applications exists in the broader defense market as well as in space, plus such improvements eventually find application in the larger economy. While unglamorous, such initiatives are well suited to the NASA culture and likewise deserve your continued support.

Congress has been consistently supportive of commercial space. While it has thus far shied away from the kind of aggressive operating incentives that early in the last century helped bring the national air transport system into existence, Congress has been generous, even beyond the massive launch vehicle investments. For instance, Congress allowed duopoly positions for the satellite radio business, just as it blessed the enormous frequency allocation granted Teledesic to support their space based broadband project.

Such in kind support, reminiscent of the land grants that financed the transcontinental railroads in the 19th century, remains an important component for commercial space ventures, but appears inadequate to catalyze major new industries of the scope and stability needed to transform commercial space into a risk-reward investor's area of interest. Commercial space enterprises are currently centered on the communications and broadcast sectors. While there have been new services brought into being here, most recently the direct radio broadcasters Sirius and XM Radio, others such as DirecTV have been acquired by larger media powerhouses. For these entities, space is a minor component of the overall investment thesis.

There may however be other drivers for commercial space, initiatives that respond to Congressional mandates regarding national security for instance. For example, there is not at present any effective surveillance of the millions of containers that flow across our borders. While the TSA and U.S. Customs have begun to institute some monitoring, both at the point of origin as well as at the port of entry, there is no watch on these trailer sized structures while in transit or while in the U.S. Satellites offer the capability to maintain that watch worldwide, provided each container is equipped with a suitable black box that checks its status and reports intrusions. This type of self-assessment is of course readily extended to include measurements of commercial interest, such as temperature or vibration, which then facilitates better product quality control, as well as of course electronic documentation for faster and easier customs clearance.

Such monitoring will, in my view, be a matter of routine within the decade, because it responds to a more pressing security need. Other initiatives, for instance to shift much more of the air traffic control responsibility to satellite based navigation and communications links, will take longer to achieve broad acceptance. However, services such as these, providing critical infrastructure support, appear to be the kind of reliable revenue generators that risk-reward investors eagerly accept. They may begin the transition the Committee asked about.

Thank you for your attention.

BIOGRAPHY FOR WOLFGANG H. DEMISCH

Mr. Demisch is an owner of Demisch Associates LLC, an aerospace financial consultancy. He has over 30 years experience as an analyst and banker in the Aerospace and Technology sectors. While a research analyst covering aerospace and computer technology, he frequently was ranked a leader in these fields by Institutional Investor Magazine. He later established and managed the U.S. Equity Research department for UBS. He subsequently moved to the investment banking side of the business, where he helped implement transactions such as the 2002 purchase of GE Americom by Societe Europeenne des Satellites. He has served on the NASA Advisory Council and numerous NASA panels, including small satellite technology, space station alternatives and commercial uses of space. In 2003 he established Demisch Associates LLC to provide advisory services for investors considering acquisitions in the aerospace and technology sectors. A frequent guest on financial TV and speaker at industry meetings, he is a member of Wall Street Week with Louis Rukeyser's Hall of Fame. He has served on the Board of Directors of SAIC, an employee-owned professional services company, since 1991. He is a graduate of Princeton University and the Harvard Business School.

Chairman CALVERT. Thank you.

Dr. Macauley, you may begin your testimony.

STATEMENT OF DR. MOLLY K. MACAULEY, SENIOR FELLOW AND DIRECTOR, ACADEMIC PROGRAMS, RESOURCES FOR THE FUTURE

Dr. MACAULEY. Thank you.

Good morning, Mr. Chairman, and Members of this subcommittee. Thank you for the opportunity to join you today.

Much of the discussion this morning has centered on getting things and people into space. I have been asked to broaden discussion a bit to consider these as well as other kinds of activities included in the commercial space industry. I have also been asked to discuss U.S. leadership in these activities, and probably most important, the role of government, including what government should not do in encouraging commercial space.

My written comments address all of these three topics, and they have some very specific discussion of past regulatory and legislative initiatives, the legislative initiatives taken and spearheaded by this subcommittee. And the testimony also has some detailed discussion about directions for the future.

So, in the interest of time, I will just summarize the general themes here.

And I offer my comments with a great deal of humility. I am not a pioneer in building space technology and making a business work like my colleagues this morning. So I offer my comments with humility. What I and other analysts try to do, though, is innovate in the case of public policy. And actually, in the past couple of years, there has been a great deal of innovation in public policy in the U.S. Government at the Federal, State, and local level, and these have direct applicability to space policy making.

Generally, they are incentive-based approaches. They generally work. They generally work well. In particular, what they try to do is to minimize the costs imposed on industry, but, at the same time, do some of the things government is supposed to do, such as protecting the environment to some degree, providing some reasonable amount of worker or consumer safety, generally provide opportunities but without dictating choice, and in short, to balance the interests of the taxpayer with specific interests of industry.

So some of these examples of policy innovations, say, in the last decade have been highly successful tradable permits in the case of industries that have to meet environmental regulation, auctions of portions of the electromagnetic spectrum by the Federal Communications Commission to improve access to and use of spectrum, vouchers to permit consumer choice, the move towards performance standards meeting a level of overall performance rather than government dictating exactly how every nut and bolt used by industry should comply with safety regulations, and of course the role of prizes and cash incentives.

I think it is very important to point out that government policy making for space in the form of Congressional legislation, again spearheaded by this subcommittee in the past, as well as some presidential policy directives and some regulation of various commercial space activities has, in many cases, already promulgated incentive-based policies like these. We already have on the books some provisions for space transportation vouchers. In some cases, we are moving towards performance standards. There are provi-

sions for government purchases of Earth and space science data and space transportation services and now, most recently, we are experimenting with prizes. In all cases, the statutory intent has been to support commercial space.

Now to be sure, not all of these initiatives have worked. The example perhaps most notable is the attempt to transfer to commercial operations. But the policy experiments are being attempted. And in terms of government's future role, I recommend that a philosophy of incentives like these and sometimes established as experimental or demonstration policy programs, the counterparts to technology pathfinders underlie future approaches.

In the interest of quickly summarizing my other comments, let me use two examples.

The first. Recently Google joined with a company called Keyhole to offer three-dimensional maps on our PCs and our BlackBerrys for finding things ranging from street directions to restaurants to ATM machines. For some neighborhoods, these maps are so detailed, you can see your neighbors' trashcans. But the real advantage of Google and Keyhole is that the maps are easy to use and they are very well annotated. Even though the underlying satellite imagery and aerial photography data can consist of many terabytes, they are very complicated to manipulate and geographically rectify these data, and they are very hard for a consumer not trained in photogrammetry, let alone map reading, to understand. The factors, then, are these: ease of use, low-cost ease of use, annotation, and a corporate partnership that brings with it, ready-made, a large consumer market.

The second example. A newcomer to commercial space is satellite radio, XM and Sirius. They had to obtain FCC licenses and frequency allocations, contract for commercial launch services and insurance, obtain permits for and then install and maintain an initial network of hundreds of terrestrial repeaters for ground coverage in drop-out areas. They also had to design and test radio antennae and in-car technology. Then they had to attract GM, Honda, Sony, Wal-Mart, Best Buy, Circuit City, and RadioShack for their supply and market chains. And they still weren't done. They needed programming. They needed content. So they are signing up Major League Baseball, NASCAR, CNN, Fox News, and Howard Stern, literally hundreds of kinds of programs.

The points of these examples are these.

Businesses can succeed or fail despite of or independent of space policy. Commercial space success depends as much on the usual business challenges: strategy, customer relations, contracting practices, understanding consumer markets, as on challenges that are space unique. Space businesses also depend on innovation in non-space commercial markets, like electronics, information technology, entertainment, automobiles, retail services. And space businesses also face policies related to export restrictions, as have been mentioned earlier, national security concerns, and regulation in financial, environmental, occupational, and employment sectors.

And a good space policy, I think, will be familiar with these other pressures brought to bear on our U.S. industry to understand the big picture of what space business in this context is all about.

So in conclusion, I would just like to say that I think to confer with the titans of space industry, as we have done today, is essential for good policy making. It may also be useful to confer with titans in other types of U.S. industries that are directly related to the success of our space businesses. And finally, good space policy is necessary, but it won't always be sufficient for business success nor at fault for business failure.

Thank you.

[The prepared statement of Dr. Macauley follows:]

PREPARED STATEMENT OF MOLLY K. MACAULEY

Good morning, Mr. Chairman and Members of the Committee on Science, Subcommittee on Space and Aeronautics. I am Molly K. Macauley, a Senior Fellow at Resources for the Future (RFF), a research organization established in 1952 and located here in Washington, DC. RFF is independent and nonpartisan, and it shares the results of its policy analyses with members of all parties in the executive and legislative branches of government, as well as with business advocates, academics, members of the press, and interested citizens. My comments today represent my own views, it should be noted, and not those of RFF, which takes no institutional position on legislative or regulatory matters.

My training is in economics and I have worked as a space analyst for 20 years. I have written extensively about space economics and policy, serve on numerous NASA and National Academy of Science panels, and have had the opportunity to meet with your committee several times in past years. Thank you for the opportunity to meet with you today, Mr. Chairman. I am honored to be part of this distinguished panel. Moreover, I am grateful that you are seeking perspectives about the role of government in space commerce.

I've been asked to consider these topics: the kinds of activities included in "commercial space;" U.S. leadership in these activities and the outlook during the coming years for the industry; and the role of government, including what government should *not* do in encouraging commercial space.

My overall observation is that U.S. commercial space policy to date has been appropriately supportive of U.S. industry and sets a good precedent for the future. The interests of the taxpayer and industry are most likely to flourish mutually by way of a conservative approach to legislative and regulatory intervention, coupled with an innovative, incentive-oriented philosophy. I also recommend the usefulness of demonstration or pathfinder, experimental approaches to policy.

WHAT KINDS OF ACTIVITIES ARE INCLUDED IN "COMMERCIAL SPACE?"

Some of the promise of commercial space has been more than realized, accompanied by new and perhaps unexpected consumer markets. Some promise has been less successful, often for a variety of reasons independent of government actions.

Looking backward for just a moment is useful. A decade ago, the *Wall Street Journal* and *USA Today* had vastly expanded their geographic distribution by a new method: using satellites to transmit the papers to local printing presses across the country for early morning publication. The satellite distribution technology was so novel that the papers included at the top of their front page, *"Via Satellite,"* to impress upon readers that the news was hot off the press even if the news had originated thousands of miles away. A much more routine use of space by the commercial media was the satellite pictures of cloud cover and hurricanes on the daily TV news. In another routine use of space, telecommunications companies routed some long-distance telephone calls by way of satellite, although microwave or undersea fiber optic cable sent most calls. Satellites also enlarged the market for cable television. Sometimes to the dismay of neighbors, many consumers had erected large satellite dishes in their yards to receive cable TV. Reflecting the by-then wealth of experience of commercial satellite makers in serving these markets, *Fortune* magazine, in its list of "100 Things America Makes Best," included communications satellites by Boeing.

In another related market, the satellites supplying these services were commercially launched, fueling the commercial space transportation industry. In other markets, some bulky, expensive, and complex global positioning satellite (GPS) receivers were finding use in ground surveying and in navigation for civil aviation. The entrepreneurs proposing the first commercial remote sensing space system worked with policy-makers to forge entirely new regulatory and legislative policy to obtain li-

censes for their service and were preparing for launch. There were also business plans for markets in space burials and for commercial materials processing on the Shuttle and Space Station.

Today, just a decade later, the novelty of commercial communications satellites has worn off so that the newspaper covers don't remind readers of the transmission technology (although the technology is still essential and new comsats are routinely launched for existing and new services). Residential satellite dishes are much smaller and hardly noticeable perched on apartment balconies and corners of rooftops. There are now some thirty-two commercial satellite operators around the world. They support 176 million Americans for whom cell phones, pagers, BlackBerrys and high-speed connection to the Internet are as essential as a morning cup of coffee. Most of these services use at least some satellite relays in addition to terrestrial network technologies. Backpackers and passenger cars carry lightweight, increasingly lower cost, and highly capable GPS receivers. Satellite radio receivers are in cars, homes, and boats and hand-held satellite radios accompany joggers. XM Satellite and Sirius Satellite radio companies along with SpaceShipOne are the most prominent among new entrants in commercial space markets. XM has just announced that it is also joining with AOL for Internet radio service. Both XM and Sirius point out that after eighty years of AM radio and sixty years of FM radio technology, their digital technology offers the first new radio broadcast medium.

In the case of commercial space remote sensing, industry is struggling financially. For a variety of reasons, the industry has had trouble building a civilian consumer market and has instead relied heavily on sales to government, including contacts for data purchases by the National Geospatial Intelligence Agency and other national and foreign government security departments.

But the recent acquisition by Google of Keyhole Corporation, a California-based digital mapping company, is a new and promising direction for remote sensing. Keyhole uses satellite and aerial maps and, most important, easy-to-use software. A person (untrained in the complexities of photogrammetry) can zoom-in for detail on satellite and aerial pictures by way of a personal or laptop computer and even simulate 3D maps to find hotels, parks, ATMs, and subway stops at home or when traveling. One reviewer noted that in some cases a consumer can even zoom in enough to see a neighbor's trash cans. In remote sensing, then, companies are finally treating the market not as "users" but as "consumers." Keyhole, together with the innovative software known as Ajax that manages the complexity of all of the data and interfaces between hardware and software components, simplifies and annotates otherwise complicated digital imagery.

In the commercial space transportation industry, ideas and technology have moved from conventional rockets to an innovation like Sea Launch, and from unmanned commercial vehicles to the promise of SpaceShipOne in serving payloads in the form of people not packages.

These examples of satellite radio, the Google-Keyhole arrangement, and innovations in space transportation technology and markets represent a particular and significant development relevant to Congressional and public policy perspectives on commercial space. This development is the hard work of industry in blending space-based technology with existing technologies and markets on Earth, complete with having to comply with the regulations that govern *those* technologies and markets. In other words, commercial space is not a stand-alone industry and it can succeed or fail on market conditions and other public policy wholly independent of commercial space policy.

By way of illustration, satellite radio had to: obtain FCC licenses and frequency allocations; contract for commercial launch services and insurance; obtain permits for and then install and maintain an initial network of 800 terrestrial repeaters for ground coverage in drop-out areas; design and test radio, antenna, and in-car technology; attract GM, Honda, Sony, WalMart, Best Buy, Circuit City, and Radio Shack, among other companies, to build its supply and market chain; and sign up major league baseball, NASCAR, CNN, Fox News, Howard Stern, and other programming. No space technology has a stand-alone supply network or consumer market.

U.S. LEADERSHIP IN COMMERCIAL SPACE—STATUS AND OUTLOOK

Most experts contend that some of the best commercial space products as well as significant innovation continue to come from U.S. companies. But these observers also acknowledge that "U.S.-made" can be misleading. For instance, companies routinely employ foreign-born, U.S. trained engineering talent. In addition, increasingly, and due in part to export restrictions, markets are typically larger for U.S.-made components rather than entire finished products.

Space-related markets are markedly more competitive than in past decades. Space transportation markets now include suppliers in Europe, China, Russia, Ukraine, Japan, and India—all now offer commercial launch services. Israel and Brazil also have their own launch capability. According to data maintained by the Office of Commercial Space Transportation in the Federal Aviation Administration, in the past ten years, the U.S. share of the worldwide commercial launch market has averaged about 30 percent to 40 percent of total launches and about a third of total revenue (of a $1 billion total market in 2004, the U.S. share was about $375 million). The total number of launches in the past five years has been smaller than in previous years, largely due to longer-lived satellites and a decline in the number of small satellites launched to nongeostationary orbit. For example, in 2004, U.S. companies launched six out of a total of 15 worldwide commercial launches.

Joint arrangements between U.S. and foreign companies are increasing. For instance, Boeing has a share of launch revenue from its partnership in Sea Launch, which had three launches valued at $210 million in 2004. In commercial remote sensing, U.S. companies have entered into distribution agreements to market foreign data from SPOT and Radarsat.

The international mobility of engineering talent, increasing activity by other countries in commercial space launch markets, and joint arrangements such as those noted above are trends that are likely to continue in coming years. During 2004–2013, the Office of Commercial Space Transportation expects a total of about 23 commercial launches per year, on par with past years. Industry trends may include continuing coupling of space-based and ground-based technologies and markets—the "XM" model. Commercial companies have also proposed the first commercial deep space science mission and commercial space operations and telemetry, tracking, and control systems. In the case of Earth observations, a major initiative impelled by the G–8 heads of state in June 2003 has led to a ten-year plan for an integrated global Earth observation system (GEOSS) among the governments of more than 30 countries. A separately established organization is working closely with industry to identify opportunities to support GEOSS in the coming decade.

WHAT MIGHT GOVERNMENT DO (OR NOT DO) TO ENCOURAGE COMMERCIAL SPACE?

The Congress and executive branch have generally been extremely supportive of commercial space. The legacy of policy initiatives to nurture the industry is rich with examples. Table 1 lists key legislation, regulation, and policy directives that have included provisions specifically addressing commercial space. These initiatives have included (but not been limited to) a host of innovative, market-like approaches: vouchers to fund launch purchases by space science researchers, to enable them to choose a launch vehicle best tailored to their payload; government purchases of Earth and space science data and launch services; and most recently in the *Commercial Space Launch Amendments Act of 2004,* initial steps toward allowing private and commercial passengers to undertake space travel.

The twenty-year legislative and regulatory history of commercial space has generally and been responsive to industry concerns. To be sure, not all initiatives taken so far have worked in practice. For example, transferring the land remote sensing system (Landsat) to private operation or identifying a commercial company to build and operate a follow-on system (the Landsat Data Continuity Mission) did not work out for a variety of reasons. However, the policy emphasis on data buys has formed the basis for the purchases of commercial space remote sensing data under contracts worth about $1 billion with national security agencies. By way of the Centennial Challenges project, the National Aeronautics and Space Administration (NASA) is now offering prizes for space technology development. NASA also has funding in its FY 2006 budget request for commercial transportation of crew and cargo to the International Space Station.

Table 1. Key Legislation, Regulation, and Policy Addressing Commercial Space Activities*

Land Remote Sensing Commercialization Act of 1984
Established the process for the commercial operation of government owned, civilian land remote sensing satellites

Commercial Space Launch Act of 1984
Granted to the US Department of Transportation (DoT) licensing authority and safety regulation for commercial space transportation and provided that DoT would prescribe insurance requirements

Commercial Space Launch Act Amendments of 1988
Established government indemnification of commercial space transportation third-party liability and other provisions for sharing certain space launch risks between government and industry through 1993; subsequent legislation extended the provisions through 2004

Launch Services Purchases Act of 1990
Required that launch services acquired for deployment of NASA and NASA-sponsored payloads take advantage of all reasonable sources of U.S. commercial launch services

NASA Authorization Act FY 1991
Codified space shuttle use policy initially promulgated after the Challenger shuttle accident in 1986 and limiting the shuttle system to activities requiring the presence of man or other unique capabilities of the shuttle; explicitly precludes shuttle launch of most commercial payloads; calls for no increase in space debris from US space activities

Land Remote Sensing Policy Act of 1992
Transferred operation of the government-owned civilian land remote sensing satellites from industry back to the government

NASA Authorization Act FY 1993
Provided for a commercial space voucher demonstration program to award vouchers for the payment of commercial launch services for the purpose of launching small payloads funded by NASA

Commercial Space Act of 1998
Required the NASA Administrator to study feasibility of privatizing the space shuttle including consideration of ownership, operation, third-party liability indemnification, launch of commercial payloads, and potential cost savings; required NASA to acquire, where cost effective, space science data (such as data about the moon, planets, comets, solar storms) and earth science data from a commercial provider; continued space launch voucher demonstration program

U.S. Commercial Remote Sensing Policy 2003 (from NSPD-15)
Provided for the licensing and operation of U.S. commercial remote sensing space systems, U.S. government use of commercial remote sensing space capabilities, foreign access to U.S. commercial remote sensing space systems, and government-to-government relationships in U.S. commercial remote sensing space systems

Commercial Space Launch Amendments Act of 2004
Allowed licensing of private spacecraft on experimental bases and established liability guidelines, provided legal basis for allowing private and commercial passengers to undertake space travel and established concept of informed risk for space passengers; also required study of whether to continue indemnification of commercial expendable launch vehicles

* Note: List is not comprehensive.

In the future, consideration could be given to potentially strong incentive-oriented approaches when government oversight of commercial space activities is deemed necessary. These approaches include financial incentives, performance standards that nurture adoption of alternative technologies rather than requirements that specify technologies to achieve performance, rational pricing policy for access to government assets, and reliance on private markets for insurance when appropriate. Table 2 lists market-like policies that have been taken or are currently used, or that might be used in the future in designing space policy. These approaches include performance standards, prizes, private market insurance, auctions, voucher, and government purchases of commercially produced goods and services. The objective of

policy options such as these is to encourage flexibility, discourage government intervention when private institutions (such as insurance markets) could suffice, and ensure a "fair playing field" between government space and commercial space activities.

I know from Chairman Calvert's recent comments at the 21st National Space Symposium this month that there is concern about sectors of the U.S. space program working in isolation from the others. These sectors would include the civil, national security, and commercial space activities. This is a familiar problem. For instance, in the case of energy policy, the Department of Energy, the Federal Energy Regulatory Commission, the U.S. Nuclear Regulatory Commission, the National Highway Safety Administration, the Environmental Protection Agency, and the Minerals Management Service all have great influence on energy markets. These agencies' decisions affect what fuels are used to generate electricity, what fuel efficiency targets cars must meet, what mixtures of gasoline may be sold, and where oil and natural gas can be produced.

Our space and space-related agencies now range from the national security complex to NASA, the Department of Interior and the U.S. Geologic Service, the Department of Commerce and the National Oceanic and Atmospheric Administration, the Federal Aviation Administration, and the Federal Communications Commission. The Departments of State and Energy, together with the Department of Commerce, are key champions of the GEOSS program (described above). The Department of Energy also plays a role in space power systems.

To some extent, our space sectors have mutually benefited from this mix. For instance, GPS is owned and operated on the defense side but routinely used by the civil and commercial sectors. Remote sensing/Earth observation information was championed by NASA and the infrastructure, data, R&D, data validation, and information products from NASA's Earth science activities over four decades are routinely used by the defense and commercial sectors. Commercial satellite telecommunications were advanced markedly by industry but are routinely used by the defense and civil sectors.

Some steps could be taken to better integrate the large scale and scope of government space and space-related activity. For instance, establishing prizes for innovation of use to all three space sectors—civil, commercial, and national security—makes sense provided all three sectors have at least a few desirable innovations in common. These requirements could range from space transportation to space-based navigation for on-orbit activities that may include autonomous refueling and repair. They may also include developments in Earth science in mapping and meteorology, for which prizes could be offered for new and faster algorithms to turn data into actual information products for the battlefield or the oil field (for geologic exploration). These prizes could be jointly funded and developed by the civil and national security sectors with input from the commercial community.

Another step, and one that has been taken in the past, is establishment of a space-dedicated cabinet council. In the past, such an effort has been inadequate to overcome differences in goals, leadership and decision-making. Nor did previous interagency efforts adequately include provision for industry representation, which if optimally designed would include representatives from "other than the usual suspects" by seeking participation of non-space companies (perhaps WalMart, Microsoft).

Table 2. Commercial Space: Flexible Approaches to Government Oversight

Approach	Examples	
	Previous/Current Use	Prospective Use
Auctions	Some regions of electromagnetic spectrum (FCC)	Access to/use of some operational assets; access to congested resources (e.g., tracking networks)
Government purchase of commercial services and products	Earth observation data buys; launch services	Space science data buys; space transportation
Performance standards	Commercial launch licensing safety requirements (FAA/AST)	Safety requirements; space transportation; earth observations science requirements
Pricing policy	Access to government launch facilities; access to ISS-like resources; government earth observation and science data	Access to/use of government facilities
Non-deterrence of commercial sector in pricing and disposal of tooling, equipment, and residual hardware, etc. at completion of government programs	Excess ballistic missiles	
Private market insurance	Commercial space transportation; payloads	Commercial space transportation; payloads including persons
Prizes	Centennial Challenge (NASA)	Innovation in technology development and testing
Tradable permits	Pollution mitigation (EPA)	Debris mitigation
Voluntary measures	Debris mitigation	Informed consent for private, first-party risk taking; GEOSS-like institutional arrangements
Vouchers	NASA-funded researchers' purchases of launch services	NASA-funded researchers' purchases of earth science data

SUMMARY OBSERVATIONS

Some of the alternatives outlined in Table 2 address different types of risk (financial and safety), export issues, and other topics not addressed at length in this testimony. With these omissions in mind, some general guidelines for public policy and commercial space include:

— Balance financial risk taken by industry compared with asking the public to underwrite risk (for example, in the case of upcoming deliberations on continuation of commercial launch indemnification)

— Balance personal risk taken by crew, passengers, and third parties in commercial space transportation

— Maintain familiarity with the non-space commercial markets upon which commercial space relies (for example, computing hardware, software, wireless connectivity, telecommunications capacity enhancements and cost reductions, consumer retail markets)

— Routinely seek out the opinions of non-space industry leaders in information technology, telecommunications technology, entertainment, automobiles, education, retail services, and other consumer markets to appreciate the larger context in which commercial space operates

— Intervene when necessary and appropriate in legislative and regulatory policy in non-space commercial markets upon which commercial space relies (for instance, spectrum and orbital access, environmental and occupational safety/health regulation)

— Balance export policy, national security concerns, and other restrictions on international trade in space goods and services

— Build or build-on inter-agency relationships among the myriad government offices that are involved directly or indirectly in space technology, policy, and operations

— Acknowledge that commercial space success depends at least as much if not more on normal business challenges (business strategy, customer relations) as on challenges that are space-unique or that pertain to government commercial space policy

— Accept that some commercial ventures will fail independently of supportive legislative, regulatory, or other policy

In conclusion, the supportive legacy of U.S. commercial space policy has set a good precedent for the future. The interests of the taxpayer and U.S. industry are most likely to flourish mutually by way of a conservative approach to legislative and regulatory intervention, coupled with an innovative, incentive-oriented philosophy amenable to demonstration or pathfinder, experimental approaches to policy.

BIOGRAPHY FOR MOLLY K. MACAULEY

Dr. Macauley is a Senior Fellow at Resources for the Future in Washington, DC. Her research focuses on economics of and policy issues in space transportation, Earth science and remote sensing, space risk, space debris, space power technology, and the roles of the government and private sectors in space. She has published over 50 articles, lectured widely, and testified before Congress on these topics. Dr. Macauley also chairs the Board of Advisors of the Thomas Jefferson Public Policy Program at the College of William and Mary and has served on the Board of Directors of Women in Aerospace. She is a member of the International Academy of Astronautics and the Aeronautics and Space Engineering Board of the National Academy of Sciences, and has been honored by the National Space Society as one of the Nation's "Rising Stars" in space policy. She has also received commendation from the National Aeronautics and Space Administration for contributions to development of commercial space remote sensing. In addition, Dr. Macauley spearheaded the Space Shuttle flight of replica of a standard of George Washington; that standard is now on display at Mount Vernon. Dr. Macauley has taught for many years in the Department of Economics at Johns Hopkins University and consults for a variety of aerospace and other companies. She has a Bachelor's degree in economics from the College of William and Mary and Master's and doctoral degrees from Johns Hopkins University.

DISCUSSION

COST OF ACCESS TO SPACE

Chairman CALVERT. Thank you. Thank you for your testimony.

Mr. Musk, as I was listening to the other testimony, I noticed an emotional response at one moment where Mr. Demisch said that we should set policy on the basis that no substantial launch cost reductions will be expected. And I know from discussions with you, you hope to reduce those launch costs through your business. So I thought I would give you an opportunity to comment on that.

And since you are one of the newest entrants into the launch market, based on your experience, how would you characterize the U.S. Government's regulation of the launch industry, in general? And what should the government possibly do to enable this industry to succeed?

So with that, I will——

Mr. MUSK. Certainly. Well, I think the fact that we are offering the Falcon I launch vehicle at a price of approximately $6 million, which, thanks to the current U.S. dollar, is quite a bargain on the international market. We are actually—we only cost, effectively, about three million pounds. The—this compares with the next best U.S.—or the next best U.S. launch vehicle being the Pegasus from Orbital Sciences, which has a NASA list price of about $30 million.

Our vehicle does 50 percent more payload, has a better payload environment, has more volume. In fact, on every meaningful dimension, it is superior and yet it is about 1/5 of the cost.

So I think that is, you know—clearly indicates that significant improvement is possible. We expect to do the same thing with our medium-lift vehicle, Falcon V, and we expect to make some announcements about a heavy-lift vehicle in the—later this year and with similar price reductions on the order of four to five over the current U.S. launch vehicle costs. And those we consider starting points. We are going to go down from there.

As far as the—what the U.S. Government can do as—from a regulatory standpoint, you know, I think there is currently a fairly large body of regulation regarding expendable launch. It is quite onerous. It adds quite a bit to our cost per launch. And I think the U.S. Government should do its best to minimize and constantly be trying to reduce that body of regulation. Regulation just tends to—it is like atrophy. It just keeps growing. Unless there is an active force to contain it, it just gets worse and worse every year.

And then to the point that I mentioned in my testimony, I think we really need to do something about ITAR. I think that is really harming the U.S. industry.

Chairman CALVERT. Yeah, I am going to give you the opportunity to answer a question.

There are people, and you have probably heard this, Mr. Musk, because of your own considerable personal wealth, I heard the phraseology "angel." You are probably considered one of those folks, and that—you know, you have more capability financially than most to do this that—are you in this for the business, or are you in this—because, you know, I am sure you heard this behind your back, are you in this for a hobby? So I want you to have the opportunity to answer this question for the record, because——

Mr. MUSK. Certainly.

Chairman CALVERT.—I think you should—you deserve that.

Mr. MUSK. I certainly—well, if it is a hobby, it is the most expensive hobby I could possibly conceive of. You know, in fact, the—I have—there is a joke in the space industry, which is how do you make a small fortune in the launch business, if you start with a large one? And I have heard that joke so many times that I started to—just for amusement, when people ask me why I started the company, I would say, "Well, you know, I had a large fortune, and I was trying to make it small very quickly, and this seemed like a good way to do it."

But the serious answer is that this really is a business, which I expect to be really quite profitable. I think we could hit a positive cash flow as soon as the—late this year or early next year, which would mean that, if we were able to do so, we would have achieved positive cash flow in our third or fourth year of operation, which is unusually good for any business, and I would say particularly good for the launch business.

So I think I am really quite convinced that there is a solid business there. You know, we are doing our best to solicit business throughout the world. You know, we—the Malaysian launch, we competed against the Russians for that and won. You know, that was a tough one. We have got a couple of other international

launches we expect to win. We are working hard to earn NASA business. So I am—we are trying to get as much business as possible in order to drive that cost even lower than it is today.

Chairman CALVERT. Thank you.

Mr. Rohrabacher.

Mr. ROHRABACHER. One thousand dollars a pound on Saturn V? Is that in today's dollars or then-dollars?

Mr. DEMISCH. Then-year dollars.

Mr. ROHRABACHER. Then-dollars? So it is——

Mr. DEMISCH. So adjustment for inflation, it is about $10,000.

Mr. ROHRABACHER. So it is about the same, then?

Mr. DEMISCH. Yeah, it hasn't—things haven't changed much. I think if Mr. Musk can achieve the kind of overhead reductions that I think are necessary to get the costs down to something which is a little bit closer to materials and engineering content, it would be a tremendous gain. It hasn't been possible for any of the other players, maybe perhaps because of regulatory issues, but——

Mr. MUSK. If I—this is an interesting point, which I suspect that members may not be aware of.

Do you know what the cost of propellant is on our rocket? Propellant is usually the dominating cost. It—you know, gas—jet fuel is the dominating cost in airliners. The cost of propellant for our rocket is $50,000 a launch. That shows you there is a huge amount of room for improvement. And we should be getting to the point where that cost actually matters as opposed to being an accounting error on the launchcrafts.

Mr. ROHRABACHER. Well, of course—Mr. Musk, how old are your children now?

Mr. MUSK. They are one.

Mr. ROHRABACHER. I am—you have two babies that are one, and I have three babies that are one week from being one. Now do you foresee our babies being able to go to college on the Moon?

Mr. MUSK. Well, I think college on the moon may be challenging, but if they can actually have the potential to go there at all, that is really part of what I am working hard to try to achieve is that there should be the possibility that, you know—that any citizen can go to space, go beyond orbit, even to the Moon and going to Mars. I think it would be really a very dismal future where that possibility was closed.

Mr. ROHRABACHER. I noticed when the other panelists were talking, there was a lot of—I am sorry. You did sound a little pessimistic, sir, but—about the development of technology and overcoming this, but I think that what we hear from Mr. Rutan and Mr. Musk, who are on the business end of this, is that the technology development will be there. They are confident. I mean, I noted confidence in both Mr. Rutan and Mr. Whitehorn in terms of technology. What they don't seem to be confident in is government policy that will permit them the type of technology development to overcome problems.

Mr. DEMISCH. I think that I will defer to Mr. Musk in one nanosecond, but the challenge really has been that there are—we are living with the same technology in space propulsion and have, really, since—probably the Shuttle is the most advanced engine of any space vehicle currently flying. And so that sets your underlying en-

gineering merit. And then the question is how cheaply can you build it. And that then becomes a question of how costly and complicated is it and what is your overhead weights on your people and all of the rest of these things.

Mr. ROHRABACHER. You know, I think every time that humankind has said that, they have been wrong. And let me just note, and Mr. Rutan is not on the stand now, but I will never forget when he talked about when he—I had a group of people there to hear a lecture by him in my District, when he talked about how he has changed the way that there is re-entry and how that the implications on that—of that. I mean, this is not just a mechanical change. It is actually a change of concept.

Mr. DEMISCH. I think Mr. Rutan is a genius in aviation. I think that that is—I bless his efforts, and I hope that this committee can encourage NASA to give people like him a lot more space in the aeronautics arena, because it—God knows it needs it, where industry would just be fading before our very eyes in terms of employment and so on. It would be nice if we had people like Mr. Musk in the space frontier. All I am saying is the underlying technical merit of the boosters hasn't changed. The only real way for drastic improvement is something completely different, like an elevator. That I think is technically doable over time. So it is not there yet, but at least it is conceptual.

Mr. ROHRABACHER. Well, that is—there is a revolutionary idea: the elevator into space. But let me know. I never looked at that.

Thank you.

Mr. Chairman, if you would just indulge me one more note, and that is that what we have heard today is that there are some things we can do, and the—Mr. Musk has made it very clear that export control is—as our witness of the first panel mentioned export control, I—and we are talking about people who understand the importance of freedom here and are not suggesting that we do anything that puts our country in jeopardy by making these technologies available to potential enemies. But I think it behooves us and the Subcommittee to become a force, as I have tried to be, in the international relationships to try to push these barriers aside for countries that are friendly to the United States and pose no future danger to us. And it is something that we could do that would really help these folks out. This is one of the regulations——

Chairman CALVERT. And I would be happy to work with you on this. I am on the Armed Services Committee, and you are on the International Relations Committee. We—and this committee. We—between that, we ought to be able to work out some streamlining to make this process work a little more simpler.

Mr. ROHRABACHER. And one on—other note is that Mr. Musk did, I would like to note, mention the concept of prizes as a means of developing new technologies. And I have a bill for that, and I would hope our new head of NASA, who we are all mystic about, he also takes a positive view towards that approach, and perhaps we could work something out, and move in that area as well in developing new technologies by prizes for them rather than having the government bureaucracy telling people how to turn the screws and seeing the actual development process.

So thank you very much, Mr. Chairman.

EMERGING SPACE-BASED MARKETS

Chairman CALVERT. I thank the gentleman.

I am going to have a question for all of the panelists.

And looking into the future, do you see evidence of newly emerging markets or products that will rely on space-based assets? And if so, what might they be? And we will put it another way. Are there products or services coming into the marketplace in the next five to 10 years that are likely to spur the additional space-based infrastructure?

And I think I will start with you, Mr. Musk, and just head on down the panel.

Mr. MUSK. Sure. I think that there are a couple trends that I see. One is in the small satellite arena of doing things with the smaller, lower-cost satellites rather than with gigantic, very expensive satellites. I think we are seeing that trend. We are certainly seeing that trend and the interest in our small launch vehicle. I think as the—as time goes by, there is greater and greater interest in more broadcast, more communications, more exploration. I see a—really a very positive future for space. And it is—for those that are pessimistic, I think it is—bearing in mind that space is a very cyclic business, and so when—and once—people are prone to become very optimistic at the top of the cycle and very pessimistic at the bottom of the cycle. And you need to remember that it is a cyclic business.

Chairman CALVERT. It sounds like real estate.

Mr. MUSK. Yeah. Buy low, sell high.

Chairman CALVERT. Mr. Vinter.

Mr. VINTER. Yes, sir.

I echo what Elon is saying about small satellites replacing big satellites. The big satellites have proved to be very, very difficult to produce, taking three and four years to get out of the factory, whereas the smaller ones could come out in a year or a year and a half. So that is definitely a trend.

There is also, I think, going to be a big interest in so-called KA band, and this is an application where there is interaction, you know, back and forth over the Internet. And we are seeing a number of people today who are really interested in KA band. And there are a couple of experimental packages that—and one operational package already flying with us. And I think that if it takes off, it will be—probably very interesting.

Mr. DEMISCH. I think that there is still a tremendous opportunity for growth, or just start off with trying to use your cell phone. I mean, the service is still terrible any way you slice it, and so there is need for a better service, and the only way you really get it is to have it coming down from above rather than from the buildings on the side. And the other thing is, of course, I think the kind of really high-speed mobile links, as you sort of start to see TV on your cell phone and so on, again, the best place to do it is from up above. I think the underlying concept that was behind Teledesic remains sound, and I don't know that their business plan is close to being resurrected, but a lot of work has been done there. And I think that that is going to see a lot more future. And the other thing is I just think that the combination of surveillance and track-

ing for monitoring and national security purposes is, in fact, going to be a large growth market over the course of the coming decade.

Dr. MACAULEY. I come from a research organization where my colleagues specialize in agriculture, energy, water, and I argue with them, and they are gradually coming to agree, that I think that space is every bit as an important and natural resource as those. And it is a natural resource that is really unique. It is an incredibly unique environment. It has fundamental attributes that make it a very difficult place to be for a long period of time, but nonetheless it is a resource that we are still learning a lot about. And I remember eight years ago when we would get *USA Today* or the *Wall Street Journal,* right under the headline, it said, "via satellite," which meant in order to get these newspapers to remote places around the world in time for people's morning coffee, the text of the newspapers was sent via satellite to regional printing presses. And now we don't see that underneath the *Wall Street Journal* or *USA Today.* They are still using that technology, but it is embedded so much in our way of life, and similarly with much of our communications activities. So space, as a place through which to bounce signals, is very much a part of our life. Will it ever be a place where we turn to the dreams of a decade ago of doing materials processing? I remember hearing, similar to those today, where we had entrepreneurs thinking about space as a unique environment in which to do some very interesting materials processing. And then what happened was when 3M and other companies stepped up to the plate to try it out, it took so long to get there, to get through the process of getting your assets into space and getting the experiments done that we had accomplished the innovation here on Earth much more quickly.

So once we get to space more quickly and can stay there for sustained periods of time routinely, we may see some of those visions, which were very visionary, recycle back. And then today, the extensive discussion about not just a place through which to bounce signals but a place to actually send us all and, perhaps, someday to live, if not visit. I think that—yeah, I think the future of space is very bright, subject to a lot of other things that have to happen in a business sense to make it work and subject to sound government role.

Chairman CALVERT. Well, thank you.

And I want to thank this panel. We are living in an exciting time, and I am looking forward to working with all of you in the future. And I am looking forward to, Elon, coming out to your launch here shortly, and I wish you all of the success in the world.

And I, again, thank this panel for coming today. We are adjourned.

[Whereupon, at 11:45 a.m., the Subcommittee was adjourned.]

Appendix 1:

Answers to Post-Hearing Questions

ANSWERS TO POST-HEARING QUESTIONS

Responses by Burt Rutan, Scaled Composites, LLC

Questions submitted by Representative Mark Udall

Q1. As you understand it, what steps will you have to go through to get the commercial version of your spaceship approved for commercial service by the FAA? Which office of the FAA will you be coordinating with?

A1. In my opening remarks I did outline what I believe the proper steps for government approval of commercial spaceships. My handout also included more detail on the subject and is attached for your reference. (See Attachment)

Q2. In your testimony you indicated that you have a number of proposed changes to the licensing process that you think would make sense. Please provide your proposed changes for the record.

A2. Our main emphasis is that FAA needs to staff the regulatory office with personnel experienced in the research testing and certification of commercial aircraft. These personnel are found at AVS, not at AST.

Questions submitted by Representative Sheila Jackson Lee

Q1. Some of those who have argued for an "informed consent" approach to safety for the emerging Personal Space Flight industry make an analogy to the "barnstorming" days of aviation when a formal structure for regulating safety did not yet exist but the aviation market continued to grow dramatically. It doesn't seem from your testimony that you agree with that analogy. Is that true? If you don't agree, why not?

A1. We are not among those who have argued that informed consent is adequate. Two things need to happen for a healthy, sustainable private space flight industry.

1. A level of safety at least as good as the early airliners.
2. Some form of FAA approval for the flight vehicle's safety as regards the paying passengers, not just the uninvolved public.

We believe the industry might be stillborn after the first fatal accident if these two items are not provided.

Questions submitted by Representative Jim Costa

Q1. One of the goals of previous hypersonic R&D programs such as the National Aerospace Plane was to cut travel times between widely separated locations such as the west coast of the United States and Asia. Would a commercial version of the sub-orbital spaceship you have developed be able to contribute to that goal? Why or why not?

A1. Sub-orbital rockets, flying parabolic missions will work nicely for flying people outside the atmosphere. However, they are limited to 300 or 400-mile trips. Air breathing, high altitude propulsion or space planes that skip along the atmosphere's extremities would be needed for travel between widely separated locations.

Attachment

REGULATION OF MANNED SUB-ORBITAL SPACE SYSTEMS
FOR RESEARCH AND COMMERCIAL OPERATIONS

A summary prepared by Burt Rutan, Scaled Composites

Safety Requirements for the Private Spaceline Industry

- New generic solutions for safety as compared to historic Government manned space operations will be mandatory
- Cannot run a Spaceline without a huge reduction of current risk

Safety Goals: Airline experience as a model

- Risk statistics, fatal risk per flight
  - First 44 years of manned space flight = one per 62 flights
  - First airliners (1927 & 1928) = one per 5,500 flights
  - Early airliners (1934 to 1936) = one per 31,000 flights
  - Current airliners = one per two to five million flights
  - Modern military fighters = one mishap per 33,000 flights
- Logical goal:
  - Better than the first airliners
  - < one percent of the historic government space flight risk

Different Systems Need Different Regulation Methods

- The AST Process
  - To show that the consequence of failure, i.e., the expectation of casualty (Ec) for the non-involved public (NIP) is low.
  - Deals with systems that are historically dangerous.
- The AVR (now AVS) Process
  - To show that the probability of failure (Pf) is low.
  - Assures safety of crew and passengers.
  - Deals with systems that need to be reliable.
- The risk method approach by AST
  - Risk is product of failure probability and consequence.
  - NIP risk with dangerous systems is assured only by selection of flight area.
  - Flight crew risk with dangerous systems can be addressed only by flight termination staging.
  - However, since Pf cannot be calculated for immature systems, AST has no acceptable process for new systems that have to be safe enough for commercial passenger service.
- AST Methods for Booster-like systems
  - Computer-flown or remote operation
  - Automation that requires backup via flight-termination systems
  - Ground-launched
  - Safety-critical rocket propulsion
  - Un-piloted stages dropped
  - High-scatter landing
- AVR Methods for Aircraft-like systems
  - Human Piloted flight
  - Expendable-like flight-termination systems are not appropriate
  - Runway takeoff
  - Rocket propulsion not safety critical

  - No "bombing" of hardware that presents risk to NIP
  - Horizontal aircraft-like runway recovery
- If the safety approach is based on failure consequence it should be regulated by AST.
- If the safety approach is based on failure probability it should be regulated by AVR or by staff experienced in aircraft safety assurance.
- If safety is based on both consequence and vehicle reliability, then consequence should be calculated by AST, but Pf must be accessed by those with aircraft safety regulation experience.

Experimental Research Testing of Airplane-like Systems

- Cannot be addressed by enforcing standards or guidelines—the important need is to allow innovation; to seek safety breakthroughs without regulatory hurdles. Regulators must not be expected to appreciate this need during a research test environment.
- Pf cannot be calculated, thus historic data must be a guide for approval of an adequate test area to meet Ec intent for NIP.
- Environmental requirements, like for aircraft are not needed, but they can be tolerated, with costs not the full burden of the developer.
- The AVR waiver method for all regulations is mandatory. The developer must be able to argue the equivalent safety justification for non-compliance to any regulation. This is critical, especially for an immature industry with indeterminate technical issues.
- The AST launch licensing process is not acceptable due to its costs, its hindrance of innovation and its negative effect on safety policy. The AVR-EAC (Experimental Airworthiness Certificate) method works and must be implemented. The system is based on respect for a developer's safety record and the expectation that he will follow the license rules.

Certification, or Licensing Spacecraft for Commercial Sub-orbital Passenger Operations

- The manufacturer and the operator cannot accept a scenario in which the FAA has no role in approving the safety of crews or passengers. His responsibility to do adequate testing to assure passenger safety must have acceptance by the FAA. Otherwise he has no unbiased defense at trial following an accident.
- Part 23 & 25 Certification are based on defining conformity. Then, by test and analysis showing adequate margins for the conformed vehicle. Subsequently the holder of the certificate can then produce and operate unlimited numbers of vehicles that conform. The main costs of certification are the issues related to conformity, not the specific tests to show margins.
- Any ethical manufacturer or operator must test to show margins, even in the absence of any government regulation.
- However, initially the manufacturer and operator will build and operate only a very small number of vehicles, thus making the detailed conformity process debilitating. Also, the intensity of the process would interfere with the need to solve new technical problems and to maintain a "question, never defend" posture while system technical status is not mature.
- Our proposal: an applicant seeking approval to fly passengers will be required to define the tests needed to show adequate margins for his design and define the required systems safety analysis. He must then obtain acceptance of the test plan by FAA regulators and later get acceptance that the tests were satisfactorily completed. The process will be design specific and repeated for each flight article.
- Conformity of the design, the tools, the systems or the manufacturing process will not be required.
- A manufacturer can select the conformity process as an option if he desires to avoid the individual tests of each production article.
- Conformity may be mandatory after the industry matures (the aircraft certification process).

Lessons from the Regulatory Process During the SpaceShipOne (SS1) Research Flight Tests

- The Tier1 test program involved 88 flights, 17 for the SS1 and 71 for the White Knight. 83 of those flights were licensed via an AVR–AIR–200 Experimental Airworthiness Certificate. Those flights were done under the authority of the EAC and directed via the information in its Operating Limitations list. The EAC was in effect for the duration of the program, July 2002 to October 2004.
- Five flights of SS1 were flown under the additional authority of an AST Launch License. License was in effect from March 2004 to October 2004.
- The 83 flights flown under the EAC involved the highest risk, both to the pilots and the NIP: first flights of unproven vehicles and nearly all envelope expansion, including first supersonic flight of SS1 to max-q.
- The EAC flights were regulated similar to the 1,800 research flights conducted by Scaled on 36 aircraft types over a 30-year period: we were expected to fly within the Ops Limits list, and were trusted to do so. The program allowed the innovation always present in aircraft research, and did not interfere with our 'question, never defend' safety policy.
- Development of the new safety innovations were done under the EAC: the new type hybrid rocket motor, the air launch and the 'care-free re-entry' feathered concept.
- The EAC process provided an efficient environment for exploratory testing and continued the historic research aircraft record of safety for the NIP.
- The AST Launch License process enforced on the remaining five flights of SS1 was a very different regulatory environment. We were assured streamlining from the certifications needed for commercial operations approvals but were kept in the dark on specifics. The process involved a 15 month, three party Ec analysis that failed to arrive at an adequate calculation for Pf, thus rendering the Ec determination to be useless. The process was misguided and inappropriate, at times resembling a type certification effort and left the applicant without the basic information needed to determine status. The regulators requested Ec analysis, then ignored those results without informing the applicant or allowing him to defend, to revise or to resubmit the data. The regulators refused to reveal the government's analysis method for Ec calculation. The 'shell game' continued for the majority of the program, resulting in a severe distraction to key test personnel as well as high costs and a disregard for our safety policy. The environment also precluded innovation.
- The Launch License process, as applied to the aircraft research test environment resulted in increased risk for our flight crews, the very people that bear the true risk in experimental flight tests.
- The AST office had no waiver policy, and answered our requests by a written denial from the Administrator without giving the applicant the opportunity to debate or negotiate the technical merits or to get an opinion from the EAC's regulatory staff.

Conclusions

- An applicant for approval to fly research flight tests of piloted, aircraft-like systems must have a defined process, one that allows him to plan his program staffing and financial needs. It is not acceptable to impose undefined, inappropriate forced oversight. The specific EAC process has served the industry well for decades and should be used and enforced by regulators familiar with research aircraft testing.
- The Ec process, developed for protection of population from the dangers of ground-launched, expendable rocket boosters, is not workable for application to piloted, aircraft-like systems during research tests and must be replaced by the AVR method of having test-experienced regulators select an appropriate flight test area for research tests. The Ec process might be justifiable for commercial operations, but it must be regulated by those experienced with commercial aircraft operations.
- Regarding licenses to conduct commercial flights that carry revenue passengers, it is not acceptable for FAA to ignore the approval or acceptance of the vehicle's ability to safely fly people. Regulation must be done by experienced (aircraft experienced) staff.

- The acceptance of the system's probable safety can be done via a vehicle-specific test requirement process for structures and safety analysis for systems, rather than the more expensive Type Certification process that includes full conformity assurance. These processes cannot be defined in advance by specification of standards or by design guidelines, since every new system will have unique features. The testing details and systems safety analysis process must be specific to the vehicle and its intended operation. This process does not have to be significantly more expensive than that which would be done by any ethical manufacturer in the absence of government regulation.

ANSWERS TO POST-HEARING QUESTIONS

Responses by Will Whitehorn, President, Virgin Galactic

Questions submitted by Representative Sheila Jackson Lee

Q1. It has long been my belief and contention that space exploration is something that should not be limited. This principle has generally applied to space exploration by nations, but today we face the prospect of space tourism where individuals would be the ones who get to explore space. I feel strongly that this opportunity should not just go to the rich, but also to others who have a passion for space exploration; especially students should at least have a chance at this. I believe in the long run this will be good for business and good for the science of space exploration because it will only increase the general public's interest in space. Does Virgin Galactic have any plans to provide the chance to explore space to even a select few individuals who may not have the means to pay for such a flight?

A1. Representative Jackson Lee, let me assure you that Virgin Galactic shares your concern that financial barriers alone should not limit commercial space travel to only the most financially able. Virgin Galactic is committed to making seats available on our spacecraft each year for individuals who cannot afford to pay the commercial price for this adventure of a lifetime. Our plans to accomplish this shared goal are in the early stages. I will provide more details to you and the Subcommittee as they crystallize. At this point, we are in discussions with the National Space Society to receive its input. Internally, we also are exploring opportunities to make tickets available every year for other charitable purposes. As our plans solidify, we will keep you and the Subcommittee advised.

Q2. You come from a background in the airline industry. As you look forward to operating commercial passenger-carrying spaceships, what aspects of your operations do you think will be similar to those of airlines, and what will be different? In particular, how will the safety and maintenance practices you plan to follow in your Virgin Galactic operation differ from those you follow in Virgin Atlantic?

A2. Lest there be any confusion, commercial operations for Virgin Galactic and Virgin Atlantic will differ markedly in many significant respects. Running a commercial space business is dramatically different than running a scheduled commercial airline. Differences aside, the most important common thread Virgin Galactic and Virgin Atlantic share is Virgin's unwavering commitment to safety. With respect to the airlines Virgin operates around the world and the passenger rail service we operate in the United Kingdom, the Virgin brand has become synonymous with safety. We have never lost a passenger. This fact is our proudest accomplishment. Similarly, safety will be Virgin Galactic's North Star.

Virgin Galactic will differ from Virgin Atlantic in a number of significant operational respects. For instance, it will not operate point-to-point service and it will not be subject to the Federal Aviation Administration's (FAA) customary regulatory structure for commercial carriers. These differences aside, the safety procedures we envision will bear some similarities to the lessons we have learned from our safe and successful airline ventures. For example, Virgin Galactic's pilots will be expected to develop a pre-flight safety check protocol similar to that used by our commercial airline pilots. Similarly, we intend to have maintenance practices and spacecraft check procedures similar to those jointly used by operators and manufacturers in the commercial airline industry. One key area of difference will be Virgin Galactic's pre-flight focus on the health, safety and security of our passengers. Working closely with the FAA's Office of Commercial Space Transportation, we plan to develop pre-flight guidelines that will be rigorously followed.

ANSWERS TO POST-HEARING QUESTIONS

Responses by John W. Vinter, Chairman, International Space Brokers

Questions submitted by Representative Mark Udall

Q1. In the past, we have heard the concern expressed that new commercial space ventures would not be able to find insurance because of the risk presented to insurers from potential launch failures. Is that still a concern?

A1. Underwriters are not unduly concerned about launch failures. They recognize that launch failures are part of the unique circumstances with respect to space ventures. What underwriters are concerned about is untried and unproven technology. Underwriters generally are quite willing to insure developed technology. Thus, in most cases, underwriters wait to see one or two successful launches before committing underwriting capacity for subsequent launches. The thesis being that a new launch vehicle or other untried technology should first be proven to work before seeking insurance. That said, occasionally the market will sometimes insure new technology but at a very much higher price.

Q2. How will the insurance market for commercial passenger-carrying spaceships differ from that for expendable launch vehicles that launch unmanned satellites?

A2. The market will consider the reliability for commercial passenger-carrying spaceships in much the same way that it does for expendable launch vehicles that launch unmanned satellites. The space market is primarily a property market. It will rate each spaceship and/or launch vehicle on its own merits. Thus, today whether we are discussing Space Shuttles, the Atlas or the Delta, the market will rate the launch system on its own merits. In due course as passenger-carrying spaceships prove themselves to be working, the likelihood is that eventually passenger-carrying spaceships will be treated very much like airline planes and their passengers are treated today.

Q3. As you look at the emerging commercial human space flight industry being described by Mr. Rutan and Mr. Whitehorn, how important will demonstrating adequate safety margins in advance of flight operations be if they want to get insurance? Are there any regulatory approaches to safety that would be more likely to make it easier to get insurance? Less likely?

A3. As stated in the answer to Question 1 above, the market would want to see successful demonstration of the vehicles carrying humans before making significant commitment to such vehicles. I should point out from the beginning that the market has insured humans on the Space Shuttle and indeed tourists on the Russian Soyez vehicle. A regulatory regime much like the FAA regime for aviation will most likely be rewarded by the market and the demonstration of successful flights will be the determining factor in these circumstances.

Q4. In your testimony you mentioned the potential impact of current export control policies on the U.S. commercial space industry.

- *Please elaborate on the nature of your concern with the present situation.*
- *What would you do to fix the problem?*

A4. The concern with the current ITAR arrangement is that non-U.S. satellite operators are favoring European suppliers of the satellites over U.S. suppliers in large measure because of the complication of the ITAR regime. The current ITAR regime limits the amount of information available to non-U.S. owners. Thus, all other factors being equal, a non-U.S. customer will buy a European satellite because it is much simpler to buy such satellite. I am aware of a number of instances where this happens to be true.

Please note I am talking of standard commercial communication satellites. With respect to launch vehicles and Earth observation satellites and new high technology equipment, I do not suggest any change to the current regime. In particular, launch vehicles and Earth observation satellites can be deemed weapons and as such, should be controlled to the maximum extent possible. With respect to standard communication satellites, however, I should point out that such satellites are in production in Europe without restrictions and nothing is gained from strictly controlling technical information with respect thereto.

With respect to these satellites, consideration should be given to removing such satellites from the Munitions List. If there is a particular technology, by all means this technology should be protected. If the concern is of a particular country such

as China, then it should be specified as such. The above comments are made as an observer of the current situation and it does not have an insurance connotation.

With respect to the non-U.S. underwriter community (approximately $\frac{2}{3}$ of the market is overseas), I suggest an annual license be adopted for each underwriter for all projects. A license is now issued to each underwriter for each launch to be insured or each satellite on-orbit, no matter how similar the satellites are. While the current government employees are very efficient in processing licenses, it seems a waste of time. A streamlined approach would be simpler.

ANSWERS TO POST-HEARING QUESTIONS

Responses by Wolfgang H. Demisch, President, Demisch Associates, LLC

Questions submitted by Chairman Ken Calvert

Q1. The Federal Government invests large sums of money in space and aeronautics research and development. From an economic perspective which has a greater return on investment for the U.S. economy, investments in space or investments in aeronautics? Are there specific areas within either space or aeronautics that have a particularly high return on investment?

A1. The economic contribution of the aeronautics sector substantially exceeds that of the space segment, both in terms of direct sales as well as when factoring in the associated business activity. Moreover, because a substantial fraction of the federal space funding is committed to support manned space operations, an investment whose goals are primarily social rather than economic, the returns on space spending are further diluted. Historically, the Congress has not wavered in its steadfast support of advanced technology development, with aerospace a leading beneficiary. Experience has shown that advanced technology brings enormous social benefit through the new industries and jobs that it makes possible. Hence at the national level it has been the Congress's choice to support ambitious new technology and leave marginal improvements to industry. To achieve a better return on its aerospace investment, the Congress may find it useful to take a wider perspective on the challenges facing the aeronautics and space communities. In civil aeronautics, the aerodynamics and structures technology is mature.

One limiting factor is the need for manual control of each individual flight. This is both economically burdensome, (crew costs, along with fuel and capital, are one of the three largest elements in the air carriers direct operating cost) and a safety/reliability issue, particularly in general aviation. A more aggressive push to achieve automatic fight, with increased safety standards from what we now accept, should be a national goal Deployment would presumably start with the cargo carriers, but should spread very quickly as it would transform airline economics and greatly improve the utility of general aviation. Achieving this capability requires at the very least seamless cooperation between the FAA and NASA, plus superior software integration, but the payoff is very large.

Feasibility is clearly demonstrated by the growing numbers of military UAVs now routinely deployed in the U.S. and abroad.

In the military aerospace segment, strategists are seeking much higher speed flight vehicles and very long endurance systems. Much better materials and more efficient power sources are prerequisites for these efforts. unfortunately, although NASA has much experience in these issues, the NASA effort in these areas is small and shrinking. The success of the X–43 program last year is not being pursued, even though the return on investment from operational hypersonics for the country appears compelling.

The returns on space investments are often smaller simply because of time. The most promising commercial space businesses are communications and Earth observation both substantially regulated and hence subject to long delays before new technology can be brought to market. For instance, the Ka band communications now beginning to be offered were demonstrated in the 70s by NASA's experimental and very successful ATS III satellite. To rebuild the Nation's technology reserves and to restore NASA to its proper role as a technology generator for the national economy, in my opinion, it would be beneficial to encourage really challenging goals, objectives that cannot be met with off the shelf systems. one such goal could be deep space, to send probes out towards nearby stars, recognizing that such a mission would last perhaps centuries. The task would set new standards for advanced propulsion, ultra light structures, sensors and power systems, plus extreme reliability. Another goal might be comprehensive and ongoing multi-spectral Earth observation. To properly assess the implications of the geyser of environmental, economic and military data such a system would generate represents the data management challenge of the century, but the rewards are proportionate.

ANSWERS TO POST-HEARING QUESTIONS

Responses by Molly K. Macauley, Senior Fellow and Director, Academic Programs, Resources for the Future

Questions submitted by Chairman Ken Calvert

Q1. The Federal Government invests large sums of money in space and aeronautics research and development. From an economic perspective which has a greater return on investment for the U.S. economy, investments in space or investments in aeronautics?

A1. I appreciate the importance of this question, as the answer should guide budgetary allocations for both of these fields. However, I have not and do not know of any economic analyses comparing these investments on an apples-to-apples basis (that is, with comparable methods, time periods, and other modeling criteria).

Q2. Are there specific areas within either space or aeronautics that have a particularly high return on investment for the overall economy?

A2. Although I am not aware of studies that can provide an answer, the field of economics usually argues that government investment, as differentiated from private sector investment, has the higher return and the less potential to crowd out private investment when made on innovation that is generic, hence hard for private investors to capture a return.

Questions submitted by Representative Mark Udall

Q1. What future markets do you see for the commercial remote sensing industry?

A1. I see at least three markets. One market is providing services to operational civil and military government agencies, as implemented by funding awards to the commercial industry from the National Geospatial Intelligence Agency. On the civil side, the Federal Government has yet to provide a "one-stop" agency through which government can arrange for imagery purchases to support activities of the EPA, DOI, Dept. of Agriculture, Dept. of Energy, and other agencies. Yet the market seems to be there. For instance, while not a federal agency data purchase, the State of Hawaii has recently arranged to buy Quickbird imagery from DigitalGlobe to map rainy terrain in Kauai County. It is key that the imagery had to be of adequate resolution to meet the requirements of FEMA's Digital Flood Insurance Rate Map (see *Space News,* 6 June 2005, p. 13). It is also worth noting that the products that the commercial remote sensing industry provides are derivatives of sensor instrumentation and spacecraft bus designs pioneered by NASA's four decades' of remote sensing science and technology.

A second market is sales to commercial markets—agribusiness, real estate, utilities, etc. Here, the commercial markets are still coming up to speed in terms of having the expertise and technology in place for making use of imagery. At the same time, the commercial imagery world needs to better develop and market its products for the commercial sector. The commercial imagery world still is quite provincial in producing products with limited general appeal.

A third market yet to be tapped is that of providing imagery and other data from space assets for the purpose of monitoring compliance with domestic environmental regulation and international environmental agreements.

Q2. What do you consider to be the biggest obstacles to growth and sustainability of the commercial remote sensing industry?

A2. I see the biggest obstacles to be:

— failure to market more consumer-oriented, easy to use and understand products. This calls for better annotation of imagery as well as a Microsoft-approach to product design.

— failure to think outside the government procurement mechanisms to exercise more mainstream, consumer-oriented pricing and marketing

— a possible concern about innovation and R&D, typically the role of NASA. Cutbacks in the Earth science budget may not ensure that our remote sensing industry remains state-of-the-art.

Appendix 2:

Additional Material for the Record

STATEMENT OF HERBERT F. SATTERLEE, III
CHAIRMAN AND CHIEF EXECUTIVE OFFICER, DIGITALGLOBE, INC.

Mr. Chairman, Mr. Ranking Member, and Members of the Subcommittee, I would like to thank you for the opportunity to discuss the future market for commercial space and specifically as it pertains to the remote sensing and satellite imagery industry. I am the Chairman and Chief Executive Officer of DigitalGlobe, a commercial remote sensing and satellite imagery and information company based in Longmont, Colorado.

There are three commercial imagery companies currently operating in the United States, each with one satellite on orbit. Launched in 2001, DigitalGlobe's QuickBird satellite offers the world's highest resolution imagery commercially available at 61 centimeter resolution. Thornton, Colorado-based Space Imaging and Dulles, VA-based ORBIMAGE operate the IKONOS and OrbView3 satellites respectively, both at approximately one meter resolution. All three companies provide unclassified, high resolution satellite imagery to government and commercial customers worldwide for a variety of market applications such as defense and intelligence, homeland security, agriculture, forestry, oil and gas, environmental assessment, disaster planning, mitigation and recovery, flood insurance mapping, transportation and more.

Despite the vast range of potential markets for commercial satellite imagery, the industry has been slower to develop than originally anticipated. Still, the industry sees steady commercial growth with each fiscal quarter, and increased interest and demand from government and commercial customers. Strong U.S. Government anchor-tenant commitments have helped this industry maintain momentum as it develops commercial markets, and a continued commitment from the U.S. Government will be necessary until the full commercial market develops. These markets will not fully develop until we address the expensive and risky nature of the commercial space business which inhibits the realization of the industry's full potential. The cost of access to space has been a tremendous barrier to entry, and will continue to stifle industry's progress in making this business profitable. In order for the U.S. commercial satellite imagery industry to remain competitive with foreign and other domestic competitors and achieve its maximum potential, the cost of access to space needs to be significantly reduced.

Access to Space is a Competitive Discriminator

DigitalGlobe, clearly the leading commercial satellite imagery company in the remote sensing industry, has been in operation since 2001 with the launch of our QuickBird satellite. DigitalGlobe won the industry's largest-ever U.S. Government contract in 2003, and just recently signed the biggest, most prominent commercial contract the industry has ever seen. However, in recognizing these accomplishments and celebrating our successes, we must not forget the long, tumultuous road we've traveled and the challenges that lie ahead for DigitalGlobe and the entire industry.

Because of the tremendous cost associated with launching and operating commercial satellite imaging systems, it is an extremely risky business. One of the most significant challenges in successfully getting three companies to orbit has been the cost of access to space (including the consequent insurance premiums). All three of the commercial U.S. operators struggled to enter the market, each having experienced at least one launch or on-orbit failure. Approximately fifty percent of the cost to put DigitalGlobe's QuickBird system in orbit was related to launch and insurance costs, totaling tens of millions of dollars. Access to space in the past has been one of biggest barriers to building a successful commercial industry, and it will continue to be a major discriminator in the future.

Although the commercial satellite imagery industry has several benefits over its market rival, the aerial photography industry, it nevertheless experiences a major competitive disadvantage. The cost to develop and fly a commercial aerial photography sensor in an airplane is far less expensive than the cost to build and launch a commercial imaging satellite; yet, to stay viable, commercial satellite imagery providers must offer pricing competitive to that of the aerial photography companies.

Not only does our industry see competition from domestic competitors, but also from foreign satellite imagery providers. Foreign competitors are gaining a foothold in the global marketplace, and subsidization from foreign governments is a significant contributing factor. The U.S. companies make up the only truly commercial industry, having launched three satellites, all financed through private capital. Foreign providers enjoy partial or full subsidization from their governments, enabling them to more quickly realize a profit.

As the Commission on the Future of the Unites States Aerospace Industry identified, "the cost to orbit is an essential ingredient for progress." The cost of access to

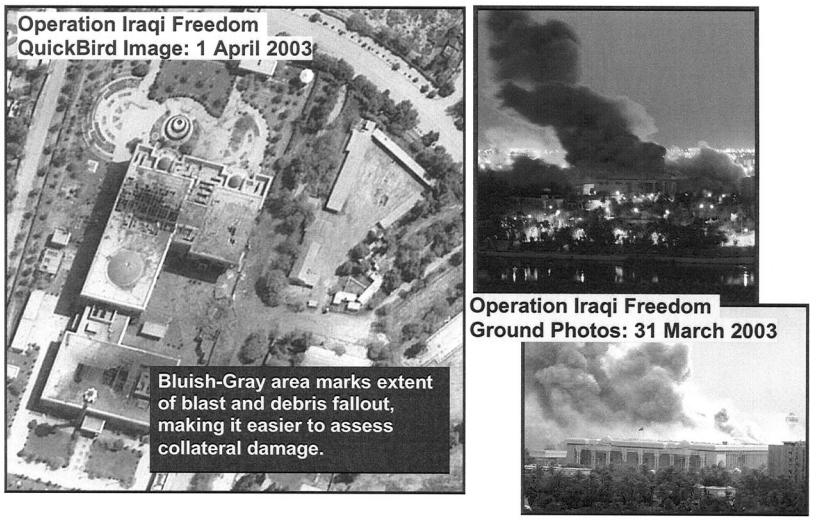
space needs to be significantly reduced in order for the U.S. commercial satellite imaging industry to remain competitive with foreign and other domestic competitors.

The U.S. Government–Industry Partnership: A Mutual Reliance

In part because of the high cost for access to space, the commercial satellite imagery operators have had to rely on significant U.S. Government contracts to sustain the industry while we grow the commercial markets. Long-term U.S. Government commitments such as the National Geospatial–Intelligence Agency's ClearView and NextView contracts have been key factors in allowing the industry to attract the private investment necessary to serve fixture commercial markets. Industry seeks a similar level of commitment from the U.S. civil government agencies to help grow our businesses and markets.

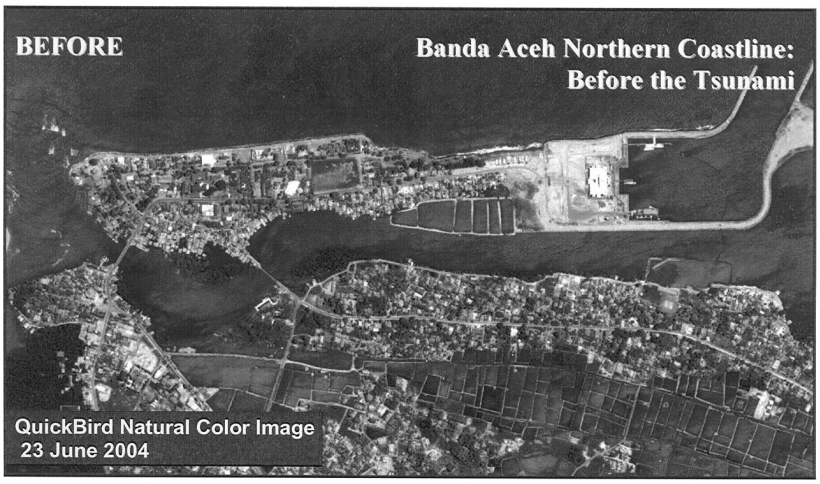
While the U.S. Government has made a significant investment in the industry, it receives tremendous value in return. As President Bush's 2003 Commercial Remote Sensing Space Policy recognized, a robust commercial satellite imagery sector will "advance and protect U.S. national security and foreign policy interests," "foster economic growth, contribute to environmental stewardship, and enable scientific and technological excellence." To this end, the President directed U.S. Government agencies to "rely to the maximum practical extent on U.S. commercial remote sensing space capabilities" and "develop a long-term, sustainable relationship between the United States Government and the U.S. commercial remote sensing space industry." By entering into long-term partnerships with industry and increasing its reliance on commercial satellite imagery, the U.S. Government is able to realize increased cost savings, streamline requirements among agencies and reduce duplication of efforts.

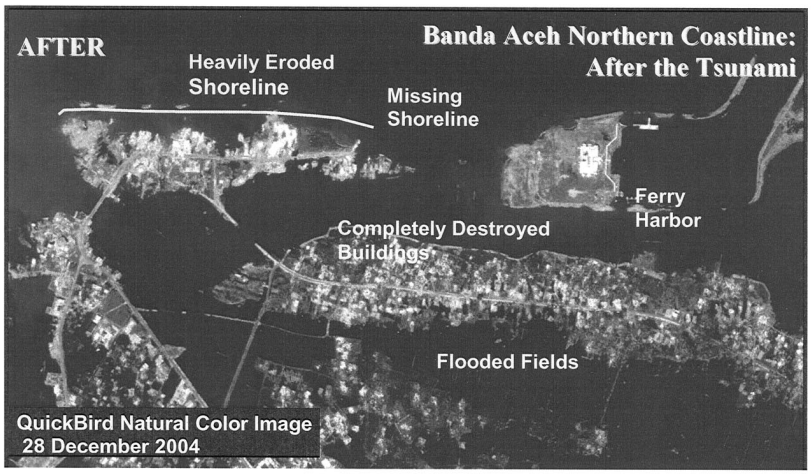
U.S. Government reliance on commercial satellite imagery drives further demand for and consumption of the technology. For example, as the industry entered into the marketplace several years ago, the initial demand from the defense and intelligence community was slow to materialize. However, the reliance on commercial imagery during military operations in Afghanistan and, even more so, in Iraq demonstrated that commercial products and services were of even more value than many had previously imagined. The ability to share unclassified commercial imagery with coalition troops and allies was invaluable, and the capacity of the industry to provide imagery to troops on the ground sometimes within a few hours of collection was remarkable. Because the use of commercial satellite imagery in these two campaigns was proven to be highly successful, the defense and intelligence communities have accelerated the convergence of commercial technology with national imagery architectures, and will increasingly rely on commercial sources to meet their mapping and intelligence needs.



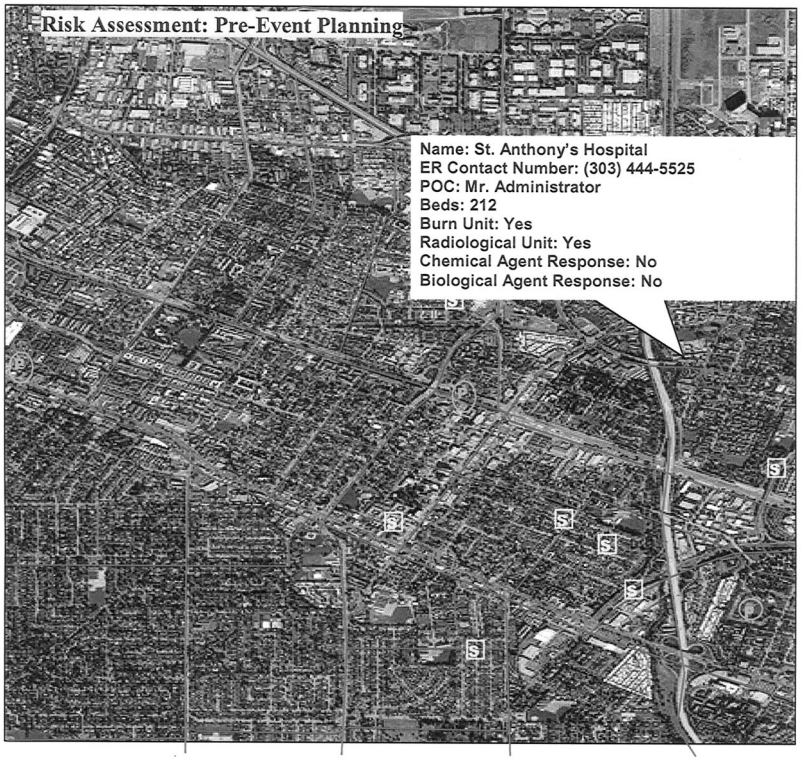
Another area where commercial satellite imagery was a significant factor in helping to complete a vital mission for the U.S. Government and others throughout the

world was during the Southeast Asian tsunami crisis in December of 2004. Within hours of the event, commercial satellite imagery of the devastated areas flowed via Internet connection to U.S. and global emergency relief organizations. DigitalGlobe offered newly collected imagery along with archived data of the same geographic areas from our ImageLibrary, enabling relief workers to assess the magnitude of the damage, navigate the altered landscape, determine where infrastructure and medical facilities previously existed or needed to be constructed, and decide on their next courses of action.





Data stored in the ImageLibrary is not only valuable for before-and-after assessments such as this, but also for assistance in pre-event emergency planning. For example, archived, yet current satellite imagery could be extremely useful in emergency response planning for future tsunamis, earthquakes, hurricanes, forest fires, or other disasters. Satellite imagery together with digital geographic information systems (GIS) containing features such as key infrastructures like roads, airports and utilities, and key installations like hospitals, shelters, fire departments, and schools can be helpful in planning evacuation and emergency scenarios.



Satellite imagery can assist city, county, & state officials in establishing detailed geographic information systems (GIS) containing:

-- Key Installations
- H Hospitals
- P Police Stations
- F Fire Departments
- Shelters (e.g., Schools)

-- Key Infrastructure
- Roads, Rails, Bridges, Airports, Utilities, Ports

Each data point can be attributed with critical information officials will need in the event of an emergency, including:

-- Number of personnel by type
-- Number of hospital beds
-- Capabilities of facilities to handle emergencies

Cultivating Commercial Markets

The global exposure that the tsunami and military operations provided the commercial satellite imagery industry has not only been instrumental in increasing the U.S. Government reliance on the technology, but also in cultivating new commercial markets. For example, the news media's use of commercial satellite imagery during Operation Iraqi Freedom captured the attention of the oil and gas industry, which is now investigating the use of the technology for vulnerability assessment, infrastructure security and exploration purposes. And, State and local governments have focused more of their attention on satellite technology for emergency planning and relief, and homeland security purposes. Agriculture is another example of a market with huge growth potential for our industry. By utilizing new and archived commercial satellite imagery to assess crop and soil conditions and detect change, growers can make faster, better informed and more accurate crop management decisions, resulting in greater productivity and higher revenues. The insurance industry can benefit from utilizing high resolution commercial satellite imagery and elevation data to determine flood, fire or other hazardous zones. Even professional consumers such as realtors can use commercial satellite imagery and other GIS technology to

map and identify potentially lucrative land development opportunities by being able to analyze traffic patterns, population growth, census data, and key infrastructure placement. And in addition to commercial businesses, satellite imagery has even reached the individual consumer market with the recent deal made between DigitalGlobe and the Internet search engine Google to provide Internet surfers with current satellite imagery of almost any researched location on Earth. The list of potential commercial and consumer markets for commercial satellite imagery goes on and on: forestry, environmental assessments, transportation, port and airport security, economic development, etc.

Conclusion

After experiencing many bumps along the road, the U.S. commercial satellite imagery industry is experiencing steady growth and success. However, the industry has had to put its future into the hands of the U.S. Government. Without long-term U.S. Government commitments, U.S. companies' plans to begin their next generation systems might still only be ideas and briefing charts. Instead, the C1earView and NextView programs have turned those charts into hardware for both DigitalGlobe and ORBIMAGE by allowing our companies to attract the hundreds of millions of dollars in private investment required to build and launch our future generation systems.

Having more commercial satellite imaging assets in space multiplies the benefit for both the U.S. Government and the vast array of potential commercial customers. However, with launch and insurance costs remaining extraordinarily excessive, government budgets facing deficiencies, and foreign and domestic competition looming, the U.S. commercial imagery industry still faces significant challenges. More must be done to lower the cost of accessing space, or the commercial satellite imagery industry will be challenged to realize its full potential and provide the innovative solutions on which its government and commercial customers have begun to rely.

BIOGRAPHY FOR HERBERT F. SATTERLEE, III
CHAIRMAN AND CHIEF EXECUTIVE OFFICER,
DIGITALGLOBE®

Mr. Satterlee joined the DigitalGlobe team in 1998, bringing more than 25 years of experience in business and finance management for space, defense and remote sensing programs. In the face of two satellite failures prior to the successful launch of QuickBird in 2001, Satterlee rebuilt DigitalGlobe by refocusing the management team, boosting employee morale and confidence, leading the company out of near bankruptcy and securing the financing necessary to move forward with plans to build and launch QuickBird. Under Satterlee's direction, DigitalGlobe became fully operational and began serving customers in 2002. Also under Satterlee's leadership, DigitalGlobe was granted a quarter-meter imaging license by the U.S. Government, and was awarded the NextView contract by the National Geospatial–Intelligence Agency in 2003. Satterlee will help lead DigitalGlobe and the commercial remote sensing industry into the next generation of imaging with the construction and launch of the WorldView system no later than 2006. Satterlee is member of board of directors for USGIF, on the advisory committee for National Satellite Land Remote Sensing Data Archive, The National Oceanic and Atmospheric Administration's (NOAA's) Advisory Committee on Commercial Remote Sensing (ACCRES), and a member of MAPPS and ASPRS.

Satterlee previously served as CEO of RESOURCE21 LLC, a Denver-based remote sensing information products company. There, Satterlee led the development of aircraft-derived imagery information products for the agriculture industry. Prior to that, Satterlee spent 19 years working for Boeing Company, where he held several senior management positions. He received a Bachelor's degree in business administration, with a specialization in finance, from Washington State University, and an executive Master's of business administration degree from the University of Washington.

About DigitalGlobe

DigitalGlobe is an Earth imagery and information company located in Longmont, Colorado. With superior image resolution and unmatched customer service, DigitalGlobe makes it easier than ever to use spatial information to improve decisions in markets such as agriculture, civil government, environment, infrastructure, exploration, visualization-simulation, and intelligence.

DigitalGlobe offers the world's highest resolution commercial satellite imagery, the largest image size, and the greatest on-board storage capacity of any satellite imagery provider. In addition, the company's comprehensive ImageLibrary houses

the most up-to-date images available. DigitalGlobe established market leadership with the 2001 launch of its QuickBird satellite, and will continue its legacy with the construction and launch of WorldView—the industry's next-generation commercial satellite imaging system.

DigitalGlobe's comprehensive geo-information product store—at digitalglobe.com—delivers data for many types of project requirements. Through this online store, customers can access a wide variety of imagery and derivative information products, including 61-centimeter panchromatic and 2.4-meter multi-spectral imagery—the highest resolution satellite imagery commercially available.

In addition to technical superiority, DigitalGlobe distinguishes itself through its commitment to quality, fairness and customer satisfaction, and prides itself on being the most reliable and responsive provider of satellite imagery and information products for commercial and government applications.

DigitalGlobe's Basic Imagery products are designed for users with advanced image processing capabilities. DigitalGlobe supplies QuickBird camera model information with each Basic Imagery product, permitting users to perform sophisticated photogrammetric processing such as orthorectification and 3D feature extraction. Basic Imagery is the least processed image product of the DigitalGlobe product suite.

Standard Imagery products are designed for users with knowledge of remote sensing applications and image processing tools and require data of modest absolute geometric accuracy and/or large area coverage. Each Standard Image is radiometrically calibrated, corrected for sensor and platform-induced distortions, and mapped to a cartographic projection.

Orthorectified Imagery products are designed for users who require imagery products that are GIS-ready or have a high degree of absolute geometric accuracy for analytical applications. Each Orthorectified Image is radiometrically calibrated, corrected for sensor, platform-induced, geometric and topographic distortions, and mapped to a user-specified cartographic projection. Additionally, customers may choose to have these imagery products digitally mosaiced, edge-matched, and color-balanced to create seamless wide-area coverage. The panchromatic, natural color, and color infrared versions of Orthorectified Imagery are well suited for visual analysis and as backdrops for GIS and mapping applications, while the multi-spectral version is best used for image classification and analysis.

In addition to imagery products, DigitalGlobe provides product solutions for environment/natural resources, civil government, visualization-simulation, infrastructure, agriculture and other markets. The products include cloud-free mosaics, vegetation maps, bundled and merged products. DigitalGlobe also partners with industry leaders to provide value-added imagery and information products.

PREPARED STATEMENT OF PETER H. DIAMANDIS,
PRESIDENT AND CEO, X PRIZE FOUNDATION

Chairman Calvert and Members of the Committee, thank you for permitting me to submit this testimony on market development for personal space flight.

Today I wish to brief you on three subjects pertinent to your discovery of the marketplace for space and our ability to meet the needs of that market in the near future: First, the X–Prize Competition; second, the critical need to support an emerging new crop of space entrepreneurs; and third, the need to embrace an increased level of risk in our exploration of space.

The X–Prize Competition:

The Power of a 'Prize' to drive the market

There is a large and vibrant marketplace of individuals willing to pay for the opportunity to fly into space. Recent surveys consistently indicate that more than 60 percent of the U.S. public would welcome the opportunity to take such a trip. The Futron organization quantifies this public space flight market at more than $1 billion per year, over the next 20 years.

On October 4, 2004, Burt Rutan and the Mojave Aerospace team, supported by private financing from Mr. Paul Allen, won the ANSARI X–Prize Competition—proving to the world that sub-orbital flight was possible to develop in the private sector, safely, and at low cost. But, this is one vehicle. I support the notion that the market will not be served until there are multiple vehicles offering a diversity of competing spaceships serving this market.

The X–Prize Competition

In 1995, I proposed an idea that would spur the industry into motion to develop these myriad spacecraft. We funded the $10 million X–Prize and it was offered to the first private team to privately build a ship and fly three adults to 100 kilometers altitude, twice within a two-week period. The prize was purposefully funded to support the development of a spaceship capable of meeting the current market demand.

We announced the X–Prize Competition in May 1996 in St. Louis, under the Arch with then NASA Administrator Dan Goldin and 20 astronauts, business leaders and visionaries. Twenty-seven teams from seven nations signed up to compete over the next eight years. During this time, 150 individuals deposited funds to reserve a ride on the winning vehicle. The market for private space flight was born.

The result of the X–Prize competition was a miraculous rise in the public's demand for space flight, coupled with the private sector stepping forward with private funding to develop the vehicles. Additionally, the prize maximized investment. For the promise of a $10 million prize, more than $50 million was spent by the competing teams in research, development, and testing. Dozens of real spacecraft were actually built and tested. Compare this to a $10 million investment from a government procurement program, which historically has resulted in one or two paper designs.

This is Darwinian evolution applied to spaceships. Rather than paper competition with selection boards, the winner was determined by the ignition of engines and flight of humans into space. Best of all, we didn't pay a single dollar until the results were achieved.

The bottom line is that prizes work!

NASA's Centennial Challenges

I'm also very proud of the critical role that the success of the X–Prize Competition played in inspiring NASA to create the newly announced Centennial Challenges. These annual NASA prizes will help encourage out-of-the-box thinking that is sorely needed in our risk-adverse space community. While the annual budget for NASA's Centennial Challenges is only $25 million today, I imagine and ask for the Committee's support for a future where 2.5 percent of the NASA budget, some $400 million, would be offered each year. And, what would be truly exciting is to see NASA combine its efforts in research with the development efforts of the private sector—resulting in a two-tiered system of space flight.

Entrepreneurs can solve the problems that large bureaucracies cannot. Prizes offer NASA and the U.S. Government both fixed-cost science and fixed-cost engineering. More importantly, prizes offer NASA the passion and dedication of the entrepreneurial mind that cannot be purchased at any price.

I encourage the Committee to fully embrace and support the use of prizes for NASA's future Orbital, Moon and Mars initiatives.

Public Support drives the economic engine

As a result of the ANSARI X–Prize Competition, the front pages of *Forbes, Investors Business Daily, Wall Street Journal, Wired, The Washington Post* and the *New York Times* began to report on a new breed of space entrepreneurs. Companies representing the X–Prize teams, XCOR, SpaceX, Zero Gravity Corporation and Space Adventures captured both public attention and investor interest. For our space community, these companies were the early versions of Apple, Microsoft and Netscape. These companies embodied the entrepreneurial "can-do" spirit of America. When the X–Prize was won, it was the number two story of the year in 2004, headlining more than 300 newspapers and media outlets worldwide.

Most of the new space companies, including Zero Gravity Corporation which I founded, are focused on one specific market: Personal Space Flight. Many of us believe that it is the only commercial market that makes near-term sense. Call it space travel or barnstorming, the fact is that the public will pay for a chance to fly into space. This is a mass market that can yield a profit while developing breakthroughs in launch operations. These two areas are the very essence of what is most needed to develop a hearty industry.

The reason that space flight is so expensive today is simple—there just isn't enough of it. The commercial launch market for satellites is pathetically small, only 15–25 per year. The number of human space launches is even smaller: four Space Shuttle flights and four Soyuz flights.

What we need is not dozens, but thousands of space flights per year. Flights that teach us about launch operations—how to refuel, re-tool and re-launch a fleet of reusable vehicles.

I recognize that the vehicles resulting from the X–Prize are only sub-orbital ships, only one-thirtieth the size of today's orbital ships, but the lessons we will learn from these vehicles are critical. We will learn about operations, an area in which we are sorely lacking.

Everyone knows that the reason the Space Shuttle costs so much to operate is not the fuel, but its dependence on a standing army of 10,000-plus professionals. We have people, watching people watching people in order to increase safety margins.

In stark contrast, the reason that a crew of six can turn around a Boeing 737 for its next flight in 20 minutes is the operational robustness achieved through millions of flights conducted during the first 50 years of aviation. Flights that began with 10-minute hops across farmers' fields grew over time to transatlantic journeys. Our space program has in essence skipped the learning stages of these 10-minute hops and went straight to orbital shots. We need to practice and learn, but we cannot achieve the flight rates and experience base we need with the Space Shuttle or the Crew Exploration Vehicle or any other large government program.

The next generation of X–Prize vehicles will soon be competing in the X–Prize Cup—an annual competition for rocket-powered aircraft and future spacecraft. The X–Prize Cup is a partnership established between the X–Prize Foundation and the State of New Mexico under the vision of Governor Bill Richardson—specifically to support the new generation of space entrepreneurs. During X–Prize Cup week, there will be an Education Day with thousands of students learning about space, rocket demonstrations and eventually races, and an exposition of space-related technologies. In 2005, we will "Countdown to the X–Prize Cup" at the Las Cruces International Airport from October 6–9.

I urge the Committee to join our efforts to recognize the need to support the creation of personal space flight, if for no other reason than to enable a high flight-rate and teach us about low-cost, safe and frequent operations of rocket powered vehicles. NASA and the DOD should embrace this new generation of sub-orbital vehicles to learn all they can. Fly them frequently. Learn. Support America's space entrepreneurs.

ACCEPTING RISK:

Finally I'd like to address the issue of risk. In contrast to individuals who speak about reducing risk, I want to speak in favor of taking more risk.

There is no question that the ANSARI X–Prize Competition involved risk—so does going to the moon or Mars or opening any portion of the space frontier. BUT, this is a risk worth taking!

As Americans, many of us forget the debt we owe to early explorers. Tens of thousands of people risked their lives to open the 'new world' and the American West. Thousands lost their lives crossing the ocean and then the plains—but we are here today because of their courage.

Space is a frontier and crossing new frontiers is inherently risky! As explorers and as Americans, we must have the right to take risks that we believe are worthwhile and significant. We owe it to ourselves and to future generations. It is also critical

that we take risk to develop technology. It is critical that we allow for failure. Without risk and without failure, we cannot initiate and realize the very breakthroughs we so desperately need.

A breakthrough, by definition, is something that was considered a "crazy idea" the day before it became a breakthrough. If it wasn't considered a crazy idea, then it really wasn't a breakthrough, but an incremental improvement. Remember those immortal words, "Failure is not an option". . .if we live and work in an environment where we cannot fail, than breakthroughs may not be an option either.

In summary, I urge the Committee to support those efforts that will allow us to realize our dreams of space exploration. Support prizes as the most efficient mean to foster and enable breakthroughs in technology and embrace risk. Help the American people understand that space exploration is risky—but a risk worth taking.

Let's let space explorers be heroes once again.