

**NASA CONTESTS AND PRIZES:
HOW CAN THEY HELP ADVANCE
SPACE EXPLORATION?**

HEARING
BEFORE THE
SUBCOMMITTEE ON SPACE AND AERONAUTICS
COMMITTEE ON SCIENCE
HOUSE OF REPRESENTATIVES
ONE HUNDRED EIGHTH CONGRESS

SECOND SESSION

—————
JULY 15, 2004
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Serial No. 108-66

Printed for the use of the Committee on Science



Available via the World Wide Web: <http://www.house.gov/science>

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U.S. GOVERNMENT PRINTING OFFICE

94-832PS

WASHINGTON : 2004

For sale by the Superintendent of Documents, U.S. Government Printing Office
Internet: bookstore.gpo.gov Phone: toll free (866) 512-1800; DC area (202) 512-1800
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**NASA CONTESTS AND PRIZES: HOW CAN
THEY HELP ADVANCE SPACE EXPLORATION?**

THURSDAY, JULY 15, 2004

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

The Subcommittee met, pursuant to call, at 10:06 a.m., in Room 2318 of the Rayburn House Office Building, Hon. Dana Rohrabacher [Chairman of the Subcommittee] presiding.

COMMITTEE ON SCIENCE
U.S. HOUSE OF REPRESENTATIVES
WASHINGTON, DC 20515

Hearing on
**NASA Contests and Prizes: How Can They Help
Advance Space Exploration?**
Thursday, July 15, 2004
10:00 a.m. – 12:00 p.m.
2318 Rayburn House Office Building

WITNESS LIST

Rear Admiral Craig Steidle (Ret.)
Associate Administrator,
Office of Exploration Systems,
National Aeronautics and Space Administration

Honorable Robert S. Walker
Chairman,
Wexler & Walker Public Policy Associates

Dr. Peter H. Diamandis
Chairman & CEO,
X PRIZE Foundation

Dr. Molly K. Macauley
Senior Fellow,
Resources for the Future

Dr. Douglas Holtz-Eakin
Director,
Congressional Budget Office

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HEARING CHARTER

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

**NASA Contests and Prizes:
How Can They Help Advance
Space Exploration?**

THURSDAY, JULY 15, 2004
10:00 A.M.—12:00 P.M.

2318 RAYBURN HOUSE OFFICE BUILDING

1. Purpose

On Thursday, July 15, 2004, the Subcommittee on Space and Aeronautics of the Committee on Science will hold a hearing to examine whether and how the National Aeronautics and Space Administration (NASA) could use prizes to spur innovation.

NASA has requested permission to begin a small prize program and is seeking legislative authority to run an expanded program. (See details below.)

The type of prizes NASA would offer are known as “inducement prizes”—prizes offered to induce someone to undertake research with a particular goal—as opposed to prizes given for previous achievements (such as the Nobel Prize).

In its report issued last month, the President’s Commission on Implementation of United States Space Exploration Policy (also known as the Aldridge Commission for its Chairman, former Under Secretary of Defense Edward “Pete” Aldridge) recommended that NASA offer inducement prizes.

Inducement prizes have also been in the news recently because of the flight of Burt Rutan’s SpaceShipOne—the first privately financed flight into space—which was prompted by the X-Prize, a \$10 million inducement prize for a human sub-orbital space flight. The X-Prize is privately funded and administered by a private foundation that was set up for that purpose.

2. Witnesses

Rear Admiral Craig E. Steidle (Ret.) is the Associate Administrator at NASA for Exploration Systems, and oversees the Centennial Challenges program, NASA’s program of prize contests.

The Honorable Robert Walker is the Chairman of Wexler & Walker Public Policy Associates and former Chairman of the House Science Committee. He was also a member of the Aldridge Commission.

Dr. Peter Diamandis is the Chairman of the X-Prize Foundation, a non-profit organization dedicated to promoting the formation of a space-tourism industry through a \$10 million prize.

Dr. Molly Macauley is an economist and Senior Fellow with Resources for the Future. Dr. Macauley’s research interests include space economics and policy and the economics of new technologies.

Dr. Douglas Holtz-Eakin is the Director of the Congressional Budget Office.

3. Overarching Questions

The hearing will discuss the following topics:

1. What are the advantages and disadvantages of NASA using prizes to spur innovation?
2. Should prizes be offered for the development of specific, discrete technologies (such as the development of a better astronaut glove), or for large technological feats (such as sending a person into orbit), or should there be a wide range in the size of prizes?
3. To what extent should NASA rely on prize competitions for the development of important new technologies? Should NASA ever rely exclusively on prize

competitions for the development of a technology, and if not, how should it determine how to meld competitions with more traditional contracting?

4. How can NASA ensure that technologies resulting from a prize competition are safe, as well as relevant to NASA's objectives?

4. NASA's Proposal for Greater Prize Authority

As part of the Space Exploration Vision that the President announced on January 14, NASA proposed the "Centennial Challenges" program—a set of prize contests for designing particular technologies. NASA requested approval from the Appropriations Committee to begin the Centennial Challenges this fiscal year by transferring \$2 million from other programs into the prize effort. The Appropriations Committee denied the request, saying it "was not included as part of the fiscal year 2004 budget submission nor was the initiative approved in the appropriations Act."

This year's program was to award prizes up to \$250,000. NASA is also seeking statutory authority to expand the program to \$50 million annually and to allow it to award prizes of up to \$10 million (and greater amounts, up to \$50 million, with the approval of the NASA Administrator). NASA included the proposal in the reauthorization bill proposal it sent to Congress earlier this year. (See attached list of potential contest topics.)

5. Issues

Could prizes open new pathways to technological innovation for NASA?

Traditionally, NASA has used several tools to spur the development of technologies it needs to carry out its mission. It has awarded grants to universities and other non-profits, it has relied on its own in-house scientists and engineers, and it has drawn up specifications and then awarded contracts for the development or procurement of specific technologies.

Prizes would presumably involve less direction from NASA than would any of the traditional routes. Instead, NASA would offer a prize for the development of a particular technology or achievement, and then would wait to see what contestants produced. Proponents of prizes argue that this would be less costly and less bureaucratic, and might spur more creative thinking. In addition, they argue that inventors and entrepreneurs (as opposed to large aerospace corporations) would be more able to compete than they can under traditional processes, which involve more "red tape."

Some of these benefits are discussed in a 1999 National Academy of Sciences report, "Concerning Federally Sponsored Inducement Prizes in Science and Engineering." The report recommended that Congress encourage federal agencies to experiment more extensively with inducement prize contests in science and technology.

The report noted that traditional peer review processes tend to favor proposals that seem safe over those that may produce surprising and potentially more innovative results. The report also noted that the federal procurement system can be intolerant of risk, and can place costly bureaucratic demands on private-sector contractors.

In summary, the Academy cited prizes as having these benefits:

- the ability to attract a broader spectrum of ideas and participants by reducing the costs and other bureaucratic barriers to participation by individuals or firms;
- the ability of the Federal Government to shift much of the risk and the financial burden of technology development from the government to the contestants;
- the ability to educate, inspire, and mobilize the public for scientific, technological, and societal objectives.

What are the pitfalls of using prizes to spur technology development?

Prize contests can be less clear-cut than they first appear. Problems can develop in the design of the contest, the selection of a winner, and in the aftermath.

First, NASA would have to be careful in its design of prize contests. The goal for which the prize was being awarded would have to be clearly enough described that contestants (and NASA) had a firm sense of what NASA was seeking and why. On the other hand, too detailed a description by NASA would limit the kinds of ideas that a contest could yield. A very detailed description would not end up being much different than contract specifications.

The selection of a prize winner can also be difficult. Judges need to be open to unexpected ideas. There are historical examples of revolutionary ideas losing prize contests because the judges were not open to unexpected ways of achieving the stat-

ed goals. (See below.) On the other hand, NASA would also have to be careful to test prize entries carefully to ensure that there were no safety or other problems that might not be initially apparent.

Finally, in terms of the aftermath, NASA would have to decide how to put a winning idea into actual use. A prize winner might not have the financial wherewithal or even the technical capacity to actually turn their winning idea into a viable product.

The 1999 Academy report suggested these steps to avoid some of the pitfalls:

- Contest rules should be seen as transparent, simple, fair, and unbiased.
- Prizes should be commensurate with the effort required and goals sought.
- Treatment of intellectual property resulting from prize contests should be properly aligned with the objectives and incentive structure of the prize contest.

Finally, it is unclear whether prizes would necessarily be a less costly way of doing business once all the costs NASA would have to incur in running a successful contest are taken into account.

How dependent upon prizes should NASA be for the development of critical technologies?

If a technology is critical to a NASA objective—returning to the Moon by 2020, for example—should NASA depend on prizes for the development of relevant technologies? The timing of technology development may be easier to control through traditional means of doing business (although traditional programs have been plagued by delays at times). If NASA wanted to use both prizes and traditional grants and contracts to develop a technology, would those two paths be undertaken simultaneously? Would those with a contract have an unfair advantage? NASA and prize advocates have not yet made clear how they would answer such questions.

What kinds of goals are appropriate for prize contests?

NASA has proposed to use prizes primarily to develop specific, discrete technologies necessary to enable space exploration, such as the development of a better astronaut glove. However, the Aldridge Commission recommended a different type of prize program that would “accelerate the development of enabling technologies. As an example of a particularly challenging prize concept, \$100 million to \$1 billion could be offered to the first organization to place humans on the Moon and sustain them for a fixed period before they return to Earth.” (p. 33)

The Commission did not elaborate on the idea. It is unclear, for example, what responsibility NASA would have, if any, for ensuring the safety of participants—or even if NASA would have any role at all other than seeing if the expedition succeeded. Nor did the Commission discuss how NASA would evaluate the long-term viability of whatever technology was used on such a mission or how NASA would use any technology that resulted. In one view, NASA would just stand back and offer prizes to create incentives for a wholly private space endeavor. But then would the government take on any manned missions itself?

In general, the more complex the goal of a contest, the more complex NASA’s role would likely be. (For example, evaluating a set of technologies to go to the Moon is a more demanding undertaking than evaluating an astronaut’s glove.) At some point, the complexity might eliminate the advantage of a contest over traditional means of technology development.

6. Background

Recent events

The Defense Advanced Research Projects Agency (DARPA) has been a trailblazer in the use of alternative procurement mechanisms. In the 2000 Defense Authorization Act, Congress gave DARPA authority to offer prizes for “outstanding achievements in basic, advanced, and applied research, technology development, and prototype development” with military applications. DARPA has used that authority to establish its Grand Challenges program, which is offering prizes for a successful field test of autonomous ground vehicles over difficult terrain. In the first such test in the Mojave Desert this March, no one won the \$1 million award. The next field test will be held in October 2005 for a \$2 million prize.

On June 21, SpaceShipOne, the spacecraft built by Burt Rutan completed the first privately funded manned space flight in history. The flight was a preliminary test in preparation for an attempt Rutan plans to make later this year to win the X-Prize—a \$10 million privately-sponsored prize awarded to the first team to launch three humans up 100 kilometers (62 miles) into space, return them safely to Earth, and repeat the launch within two weeks with the same ship. The X-Prize has re-

sulted in increased attention to the role of prizes as an innovative way of attracting non-traditional players to the space industry. (See attached article.)

History

Inducement prizes have been used for centuries.

One well known example is described in the best-selling book *Longitude* by Dava Sobel. By the 17th century sailors had mastered the ability to determine their exact latitude at sea, but calculating their exact longitude proved to be more complicated. In 1714, through an Act of Parliament, the British Government offered a reward of £20,000 (millions of dollars in today's money) for a "practical and useful" method of accurately determining longitude at sea. The size of the prize reflected both the importance of the issue and the fact that no reliable method was within reach at the time. John Harrison, a working class man with little formal education, eventually solved the problem by developing the first accurate clock that kept time accurately even during a ship's pitching and rolling at sea. However, despite the proven test of his invention at sea, the group administering the prize (the Board of Longitude) refused to award him the prize money—which historians attribute to the Board's domination by astronomers who favored a rival, astronomy-based method of determining longitude. The longitude case illustrates both the ability of a large prize to draw serious proposals and the problems that can arise if the judges have conflicts of interest.

Other prize contests of this type have included privately sponsored prizes for feats of aviation in the early part of the 20th century. In 1919, Raymond Orteig, a New York hotel owner, offered \$25,000 to the first aviator to cross the Atlantic from New York to Paris (or vice versa) without a stop. Charles Lindbergh, an unknown airmail pilot, won the Orteig prize on May 28, 1927, 33 ½ hours after taking off from Roosevelt Field on Long Island. During this period, many skilled, famous aviators died attempting to win the prize. In fact, the study of aviation prizes (and early aviation in general) illustrates that fatalities were highly likely in the attempts at such prizes. This raises the issue of whether fatalities can be expected in the area of prizes associated with manned space flight. If such prizes are conducted and a fatality does occur, it is important to determine if this could impede the development of such contests and stifle the potential innovation that could result from inducement prize programs.

7. Questions for the Witnesses

The witnesses were asked to address the following questions in their testimony:

Questions for Admiral Steidle

1. How does NASA plan to design and administer prizes to induce the greatest possible innovation and advances in space technologies? Why has NASA decided to offer prizes for the development of specific, discrete technologies (such as the development of a better astronaut glove) rather than for large technological feats (such as sending a person into orbit)?
2. How does NASA plan to ensure that technologies resulting from a competition are safe, as well as relevant to NASA's objectives?
3. How involved does NASA plan to be in specifying either the technologies that must be developed (or the goal that must be achieved) to win a prize, overseeing the work of companies competing for prizes, and judging the outcomes of prize competitions? Are there any models NASA is using in designing its prize program?
4. What are the benefits and drawbacks of prizes over other ways the government can spur innovation within the private sector? Are prizes better at drawing participation from non-traditional players in private sector who are not normally involved in government contracts?

Questions for Mr. Walker

1. What are the benefits and drawbacks of prizes over other ways the government can spur innovation within the private sector? Are prizes better at drawing participation from non-traditional players in private sector who are not normally involved in government contracts?
2. To what extent should prizes supplement or replace the existing methods within NASA of developing new technologies, such as contracting, procurement and grants?
3. How can prizes be designed and administered to induce the greatest possible innovation and advances in space technologies? Should they be offered for

the development of specific, discrete technologies (such as the development of a better astronaut glove), for large technological feats (such as sending a person into orbit), or should there be a wide range in the sizes of prizes?

4. How involved should NASA itself be in specifying either the technologies that must be developed (or the goal that must be achieved) to win a prize, overseeing the work of companies competing for prizes, and judging the outcomes of prize competitions? Wouldn't NASA's involvement in prizes become more intrusive the larger the technological feat that is being encouraged?
5. How could NASA ensure that technologies resulting from a competition are safe, as well as relevant to NASA's objectives?

Questions for Dr. Diamandis

1. What key ingredients have made the X-Prize so successful in spurring participation by the private sector? To what extent has the X-Prize attracted interest from NASA's traditional contractors to participate in the competition?
2. How can prizes be designed and administered to induce the greatest possible innovation and advances in space technologies? Should they be offered for the development of specific, discrete technologies (such as the development of a better astronaut glove), for large technological feats (such as sending a person into orbit), or should there be a wide range in the sizes of prizes?
3. Might offering prizes encourage competitors to cut corners when it comes to safety? How could NASA ensure that technologies resulting from a competition are safe, as well as relevant to NASA's objectives?
4. Should NASA offer prizes or are they best offered only by private organizations such as yours? If you believe NASA should fund prizes, how involved should NASA itself be in specifying either the technologies that must be developed (or the goal that must be achieved) to win a prize, overseeing the work of companies competing for prizes, and judging the outcomes of prize competitions? Wouldn't NASA's involvement in prizes become more intrusive the larger the technological feat that is being encouraged?
5. What needs to happen to transition technologies from a prize winner to a successful ongoing concern? What are the steps the Federal Government can take to make that transition more likely?

Questions for Dr. Macauley

1. What are the benefits and drawbacks of prizes over other ways the government can spur innovation from the private sector? Are prizes better at drawing participation from non-traditional players in private sector who are not normally involved in government contracts?
2. Some have argued that either the design or administration of certain prizes (e.g., the Longitude Prize) was biased towards a particular technological solution. Are there lessons from the historical record of scientific and technological inducement prizes that could be learned to avoid potentially serious flaws in the design and administration of such programs?
3. How can prizes be designed and administered to induce the greatest possible innovation and advances in space technologies? Should they be offered for the development of specific, discrete technologies (such as the development of a better astronaut glove), for large technological feats (such as sending a person into orbit), or should there be a wide range in the sizes of prizes?
4. Should NASA offer prizes or are they best offered only by private organizations? If you believe NASA should fund prizes, how involved should NASA itself be in specifying either the technologies that must be developed (or the goal that must be achieved) to win a prize, overseeing the work of companies competing for prizes, and judging the outcomes of prize competitions? Wouldn't NASA's involvement in prizes become more intrusive the larger the technological feat that is being encouraged?
5. What needs to happen to transition technologies from a prize winner to a successful ongoing concern? What are the steps the Federal Government can take to make that transition more likely?

Questions for Dr. Holtz-Eakin

Please discuss your view of prizes with respect to the following issues:

1. How would prizes be scored for budgetary purposes?
2. What are the benefits and drawbacks of prizes over other ways the government can spur innovation from the private sector? Are prizes better at drawing participation from non-traditional players in private sector who are not normally involved in government contracts?
3. How can prizes be designed and administered to induce the greatest possible innovation and advances in space technologies? Should they be offered for the development of specific, discrete technologies (such as the development of a better astronaut glove), for large technological feats (such as sending a person into orbit), or should there be a wide range in the sizes of prizes? Wouldn't NASA's involvement in prizes become more intrusive the larger the technological feat that is being encouraged?
4. What is the experience private sector experience in the area of prizes, including the issues of risk and intellectual property?
5. What is the experience of the Federal Government in the area of inducement prizes? If Congress were to consider a program of inducement prizes for NASA, what issues does this bring up, and what are the options, for either the authorization or appropriations process?
6. What needs to happen to transition technologies from a prize winner to a successful ongoing concern? What are the steps the Federal Government can take to make that transition more likely?

8. Attachments

New York Times article, "Into Space, Without NASA" (August 26, 2003).

Summary of candidates for NASA Centennial Challenges prizes.

August 26, 2003

Into Space, Without NASA

By JOHN SCHWARTZ

MESQUITE, Texas — Russell Blink is squeezing into a spacesuit. It is the real thing, made for Russian astronauts. John Carmack, his fellow dreamer, bought it for \$5,000. Like the technologies for making rocket engines that showed up in industrial catalogs, it was, simply, out there.

"Isn't it amazing what you can get on eBay these days?" Mr. Carmack says with a wicked smile.

If the past of spaceflight lies with NASA, which is bracing for the Aug. 26 report into the Columbia shuttle disaster, the future of spaceflight may be starting here, in a cluster of office parks east of Dallas near body shops, heavy-equipment rental yards and flooring stores. In a high-ceilinged warehouse, a small group of dedicated hobbyists led by Mr. Carmack, a software millionaire, is trying to build a rocket from largely off-the-shelf components that the members fully expect will take Mr. Blink into space on the cheap.

Then again, the future may lie in a very different place: a high-tech shop in the Mojave Desert, Scaled Composites, where Burt Rutan, an innovative aviation designer, is putting together his own craft.

Or it could be in any of the other two dozen teams from five countries that are hoping to win the X Prize, a contest whose founders hope will jump-start a private space race and create a space tourism industry. The competition has garnered the interest of space freaks, tech zillionaires like the founder of Amazon.com, Jeff Bezos, and more. (Mr. Bezos declined to talk about his space research company, Blue Origin L.L.C., or to say whether he planned to participate in the X Prize competition.) None of the teams seem to be doing things the way that NASA does them, but that's the point -- to get to space in an entirely new way.

For now, only the governments of the United States and Russia launch humans into space; China plans to try later this year. The two space tourists so far have paid millions of dollars to fly on Russian craft. A private space industry would face many roadblocks.

"The environmental impact study is a big, big hassle," Mr. Carmack says, and the Federal Aviation Administration is still trying to determine what kind of process should be used to regulate the flights.

But advocates of space exploration say there has to be an alternative to what they see as the expensive, bureaucratic over-engineering of NASA. The American space agency would create "the plutonium-powered toaster," says Dr. Charles Lurio, a space consultant and advocate.

"There's no question that there are difficulties to be overcome and dangers, but that's why you want to have a bunch of different people try a lot of different things," he said.

The contest is modeled on the Orteig Prize, the competition that led to Charles Lindbergh's transatlantic flight in 1927 with his Spirit of St. Louis. What with inflation and the high cost of shooting things into space, the scale of the new prize is somewhat larger: \$10 million to the winner, instead of the Orteig's \$25,000.

The connection to the Orteig Prize is important to the creator of the X Prize, Dr. Peter H. Diamandis. "Since the age of 9, I wanted to be an astronaut," he said. "It's all I dream about."

He worked toward his goal, getting degrees in medicine and engineering, as well as certification in fields like

aviation and scuba diving. Along the way he realized that only a tiny number of astronaut applicants get the job, and only about half of those chosen get to fly. And even those who fly rarely get many missions.

So Dr. Diamandis decided to create a new industry in the private sector to send people -- or, as he calls them, "self-launching carbon payloads that come with their own money" -- into space.

"I was convinced that the marketplace was real, that the technology was readily available," he said. "The only thing missing was the vehicles to jump-start the market."

In 1994, a friend and fellow space advocate, Gregg E. Maryniak, gave him a copy of Lindbergh's memoir, "The Spirit of St. Louis." Dr. Diamandis realized that competitions had been an important spur to commercial aviation. The two friends enlisted several other enthusiasts and established the X Prize Foundation in St. Louis, with plans to build a monitoring center in the St. Louis Science Center.

The Lindbergh connection does not stop there. Erik R. Lindbergh, Charles and Anne Lindbergh's grandson, is a trustee and vice president of the foundation. "I kind of got in under the grandfather clause," he said.

Mr. Lindbergh said at first he asked, "Isn't there a better way to spend \$10 million on earth?"

But Dr. Diamandis reeled him in. Mr. Lindbergh talked with Dr. Byron Lichtenberg, a former astronaut and a co-founder of the prize, about the "overview effect" astronauts describe in seeing the world all at once, that "it changes them." It could be a powerful experience for a larger group of people.

"I said: 'Oh -- there's something more here. It's not just about money and excitement and sex appeal.'" Mr. Lindbergh said. "There's something much, much bigger here. And that is what got me involved."

Still, fund-raising was slow and the prize money was only secured late last year.

Old NASA hands say it's not quite as easy as it looks to the newcomers.

"We're coming up on 50 years of human spaceflight and we're still learning every day," said Jay Honeycutt, the president of Lockheed Martin Space Operations and a former director of the Kennedy Space Center. "I just hope they all do understand how hard it is."

Still, he said he loved the idea of the prize. "I think it's dynamite," he said.

Each team is approaching the prize in its own way. Mr. Rutan's company, Scaled Composites, is the most closely watched. It is Mr. Rutan who designed Voyager, the first airplane to fly around the world without refueling. His X Prize entry has two stages: a sleek, twin-turbojet carrier aircraft, the White Knight, and a second-stage rocket, SpaceShipOne. Some competitors speculate that Microsoft co-founder Paul Allen is backing the project, though neither Mr. Allen's people nor Mr. Rutan's crew is talking. In any case, from his site in the Mojave Desert, Mr. Rutan has already flown the plane that will launch the space vehicle, and this month he did a drop test of the space-going component to show that it could be piloted and landed safely.

Another well-regarded team, Canadian Arrow, fulfills a lifelong dream of its founder, Geoff Sheerin. An industrial designer, Mr. Sheerin is creating a rocket that would make Buck Rogers comfortable. He will launch it on an offshore barge in the Great Lakes system for a straight-up, straight-down flight, and he plans to recover the capsule from the lake.

Mr. Sheerin said the prize was part of his own business plan to foster space tourism. "We intend to collect the X Prize on the way to becoming the industry," he said.

Since he was a teenager in Niagara Falls, Ontario, he realized it was possible to create rockets that could launch people into space for a reasonable fee. But he found no one willing to finance such a venture.

The X Prize, he said, brought out backers more comfortable with sponsoring a competitor than a business -- adventure capital, as opposed to venture capital, began to flow. "Without the prize there would be no Canadian Arrow," he said.

Backers still take some convincing, however. "There's an initial skepticism," Mr. Sheerin said, "until we show up and they find we're not wearing tinfoil on our heads."

Other groups have decided to make a run at space without participating in the X Prize.

Jeff Greason, the president of Xcor, a California company close by Mr. Rutan's, said the conditions of the X Prize contest weren't compatible with building the vehicle that would lead to commercial spaceflight.

"We are very focused on getting the cost required to enter the market down as small as possible," he said. "That leads us to a smaller vehicle that will not carry three people."

He added, "We're not in a rush to be the first to do it; we want to be the first to make real money doing it."

That focus on cost is what could start the next space industry, said Mr. Maryniak, now executive director of the X Prize. Historically, he said: "Space engineers sort of worship at the altar of high performance. In the real world what people have to optimize to is low cost."

Setting the bar intentionally low should also make a difference, he said. X Prize calls for launching people just over 60 miles high into suborbital space, the middle frontier surpassed early in the American space program. Any passengers would still feel weightless, and the physics of launching to that level is far simpler than those needed to achieve orbital flight, Mr. Maryniak said. "It's possible for modern-day Orvilles and Wilburs to do this task," he said.

Selecting the teams has been a challenge, Dr. Diamandis said. "I can't tell you the number of e-mails I've gotten that say, 'Forward me a million dollars and I would be pleased to build my antigravity ship and win your X Prize.'" At the same time, he said, "You don't want to turn away those pesky bicycle mechanics from Dayton, Ohio."

What thrills him, Dr. Diamandis said, is that so many people are excited by the competition. "We're allowing people to dream again," he said.

He does not deny that the endeavor has risks.

"These are pioneers," he said. "Much of the stagnation in our space program is because of our inability to take risks -- we're not allowed to fail any more. There can't be new frontiers opened without embracing some level of risk."



Candidate Challenges

	By Type	By Enterprise	By Estimated Purse Size
	<ul style="list-style-type: none"> • Technology Demonstration <ul style="list-style-type: none"> - Autonomous Drill - Astronaut Glove - Extreme Environment Computer - In Situ Life Detector - Lunar Resource Processing - Nanotube Tether - Planetary Power Transmission - Power Storage Breakthrough - Precision Lander - Three-Dimensional Detector - Very Low Cost Launch for Suborbital Science • Robotic Capabilities <ul style="list-style-type: none"> - Robotic Insect - Robotic Triathlon - Rover Survivor • Spacecraft Missions <ul style="list-style-type: none"> - Lunar Landing - Mars/Asteroid Micromissions - Micro Reentry Vehicle - Modular Spacecraft Demonstration - Solar Sail Race 	<ul style="list-style-type: none"> • Aeronautics (R) <ul style="list-style-type: none"> - Nanotube Tether - Robotic Insect • Bio. & Phys. Research (U) <ul style="list-style-type: none"> - Micro Reentry Vehicle • Exploration Systems (T) <ul style="list-style-type: none"> - Astronaut Glove - Lunar Landing - Lunar Resource Processing - Modular Spacecraft Demonstration - Planetary Power Transmission - Robotic Triathlon - Telerobotic Construction Race • Space Science (S) <ul style="list-style-type: none"> - Autonomous Drill - Power Storage Breakthrough - Extreme Environment Computer - In Situ Life Detector - Mars/Asteroid Micromissions - Precision Lander - Rover Survivor - Solar Sail Race - Three-Dimensional Detector - Very Low Cost Launch for Suborbital Science 	<ul style="list-style-type: none"> • \$250K and Below <ul style="list-style-type: none"> - Astronaut Glove - Lunar Resource Processing - Rover Survivor • \$250K to \$1M <ul style="list-style-type: none"> - Extreme Environment Computer - In Situ Life Detector - Nanotube Tether - Micro Reentry Vehicle - Precision Lander - Three-Dimensional Detector - Very Low Cost Launch for Suborbital Science • \$1M to \$10M <ul style="list-style-type: none"> - Autonomous Drill - Planetary Power Transmission - Power Storage Breakthrough - Robotic Insect - Robotic Triathlon - Telerobotic Construction Race • \$10M and Above <ul style="list-style-type: none"> - Lunar Landing - Mars/Asteroid Micromissions - Modular Spacecraft Demonstration - Solar Sail Race

Note: Additional challenge ideas, especially in aeronautics, Earth observation and bioastronautics, to be solicited at 2004 workshop. Final challenges to be selected after 2004 workshop and other external inputs and internal review and approval.

Chairman ROHRBACHER. Good morning. This hearing will be called to order. And welcome to today's hearing entitled *NASA Contests and Prizes: How Can They Help Advance Space Exploration?*

Earlier this week, I collaborated with the American Institute of Aeronautics and Astronautics in holding a roundtable discussion, which Bob Walker, of course, was moderator, on how commercial space transportation activities can be utilized to enhance and facilitate the national space exploration initiative. Not surprising, the topic of competitive prizes dominated the discussion. The panel participants agreed that prizes provide a potentially critical near-term solution for re-invigorating the Nation's civil and commercial space capabilities. Today's hearing will continue that discussion, but we will continue that discussion on the record by examining whether and how federally-sponsored prizes inspire private sector innovation and encourage the development of advanced technologies for space exploration.

Space entrepreneurs are anxious for policies that encourage further commercial activities and for future opportunities in space transportation. I was particularly pleased that the Aldridge Commission recommended prizes as a significant means for increasing the private sector's involvement in space exploration. The good efforts of the Commission and the X-Prize have given us the historic opportunity to do space in a smarter way. In particular, the organizers of the X-Prize contest never wavered in their belief that non-traditional players some day would make a tremendous impact on space transportation. Indeed, last month Burt Rutan's hybrid spacecraft design successfully achieved suborbital flight and safely returned a human to Earth. In performing this monumental task, he demonstrated that space travel is no longer the sole domain of government. This is compelling. It is a compelling example that a revamped national space program fueled by inspired market-based creativity and innovation holds promise for America in the exploration and utilization of space.

As we go forward in further study of this concept, critical issues will need to be addressed. What are the difficulties in establishing a process to oversee the management of space prizes on behalf of NASA? Should these prizes be within NASA or outside of NASA? Is a separate space foundation the best way to go? How do we determine the appropriate level for space prizes? What space exploration missions or objectives are suitable for competitive prizes? Our expert witnesses will provide us today and we hope with some very useful thoughts and some creative ideas of their own when it comes to these issues and how to make these things real.

We will celebrate the 35th anniversary of Apollo 11, that mission to the Moon, next week on July 20. In recognizing the courageous achievements of Armstrong and Aldrin, and Collins, let us not forget that equally dedicated and courageous individuals are now coming forward to write a second chapter of America's space experience. These new pioneers are to be applauded for their efforts in charting our future in the—in space. I think of them sort of, as I mentioned at the roundtable, as, perhaps, the Hans Solos of this generation, maybe inspired by that film of the last generation.

So I am encouraged that today's hearing will help us move forward and will help us see if this concept can be made real in terms of space prizes.

[The prepared statement of Chairman Rohrabacher follows:]

PREPARED STATEMENT OF CHAIRMAN DANA ROHRABACHER

Earlier this week, I collaborated with the American Institute of Aeronautics and Astronautics in holding a roundtable discussion on how commercial space transportation activities can be utilized to enhance and facilitate the national space exploration initiative. Not surprising, the topic of competitive prizes dominated the discussion. The panel participants agreed that prizes provide a potentially critical, near-term solution for reinvigorating the Nation's civil and commercial space capabilities. Today's hearing will continue that discussion by examining whether and how federally sponsored prizes inspire private sector innovation and encourage development of advanced technologies for space exploration.

Space entrepreneurs are anxious for policies that encourage further commercial activities and for future opportunities in space transportation. I was particularly pleased that the Aldridge Commission recommended prizes as a significant means for increasing the private sector's involvement in space exploration. The good efforts of the Commission and the X-Prize have given us the historic opportunity to do space smarter. In particular, the organizers of the X-Prize contest never wavered in their belief that non-traditional players some day would make a tremendous impact on space transportation. Indeed, last month Burt Rutan's hybrid spacecraft design successfully achieved sub-orbital flight and safely returned a human to Earth. In performing this monumental task he demonstrated that space travel is no longer the sole domain of government. This is a compelling example that a revamped national space program, fueled by inspired market-based creativity and innovation, holds the promise of America exploring space.

As we go forward in further study of this promising concept, critical issues will need to be addressed. What are the difficulties in establishing a process to oversee the management of prizes on behalf of NASA? Is a separate space foundation the best way to go? How do we determine the appropriate level for prize awards? What space exploration missions or objectives are suitable for competitive prizes? Our expert of witnesses will provide us with their views and opinions on these and other critical issues.

We will celebrate the 35th anniversary of the Apollo 11 mission to the Moon next week on July 20th. In recognizing the courageous achievements of Neil Armstrong, Buzz Aldrin, and Mike Collins, let us not forget that equally dedicated and courageous individuals are now coming forward to write the second chapter of America's space experience. These new pioneers are to be applauded for their efforts in charting our future in space. I am encouraged that today's hearing will help us move towards that future.

Chairman ROHRABACHER. Now Mr. Lampson, you may have a few words to say.

Mr. LAMPSON. Thank you, Mr. Chairman.

And I was most curious to know about your house full of babies and how well they are doing, and I am anxious to meet them one of these days.

Chairman ROHRABACHER. Technology helps there, too.

Mr. LAMPSON. Well, good morning, everyone. And I also want to welcome our witnesses this morning to today's hearing, including Bob Walker, the former Chairman of the Science Committee.

We are here today to examine the role that government-sponsored prizes might play in promoting the development of needed space technologies and, equally important, how such prize programs would need to be structured to be both effective and efficient. While there are numerous precedents for prizes offered by individuals and organizations in the private sector, there has been little experience today with governmentally-supported incentive prizes or contests. The often-cited Longitude Prize, first offered by the British Government in 1714, provides a historical example of

the potential value of incentive prizes. On the other hand, it took decades and some politics for that prize finally to be awarded to the inventor of the first accurate marine chronometer. In addition, the winning inventor was, in fact, “sustained for many years by research grants from the group administering the prize.” That is a quote from a 1999 National Academy’s report. And that is a fact that is not often acknowledged.

The most recent government-sponsored prize appears to be the DARPA Grand Prize Challenge, which has not yet produced a winner. Nonetheless, DARPA indicates that it is pleased with what has been accomplished to date. I think we need to take a serious look at prizes, strip away the hyperbole, and determine a few things: when such prizes make sense; what it would cost to provide adequate prize incentives; and thirdly, how the rules governing the prizes should be structured.

There is no question that the recent success of SpaceShipOne in reaching the edge of space has generated a lot of excitement. I applaud Burt Rutan’s achievement, as mentioned by the Chairman. I wish all of his X-Prize competitors the best with luck.

The development of a healthy commercial space sector is important to the future of this country, and it is something that I have long supported. It can also provide valuable capabilities to aide the Nation’s civil space program, and perhaps prizes could have and could play a role in increasing the involvement of the private sector, and I look forward to hearing from our witnesses on that particular point.

However, the establishment of incentive prizes should not be viewed as a substitute for adequate and sustained investment by the Federal Government in aeronautics and space R&D. We need to support a robust NASA budget this year and in the years to come. I hope that today’s focus on prizes will not divert from the importance of continuing that critical federal involvement in space exploration and utilization.

I want to offer an apology to our panel. I have a conflict. I am going to not be able to stay for the entire period. I will, indeed, look at all of what your comments and the questions and answers are, so forgive me for not—I assure you, this is one of the things that my greatest interest, as the Chairman knows, and I find it difficult for me to place a higher priority than this, but sometimes it just has to be done.

So again, I welcome you and thank you very much for coming. I look forward to learning more about your testimony, and I yield back my time, Mr. Chairman.

[The prepared statement of Mr. Lampson follows:]

PREPARED STATEMENT OF REPRESENTATIVE NICK LAMPSON

Good morning. I’d like to welcome the witnesses to today’s hearing, including in particular Bob Walker, the former Chairman of the Science Committee. We are here today to examine the role that government-sponsored prizes might play in promoting the development of needed space technologies and equally importantly, how such prize programs would need to be structured to be both effective and efficient.

While there are numerous precedents for prizes offered by individuals and organizations in the private sector, there has been little experience to date with governmentally-supported incentive prizes or contests. The oft-cited “Longitude” prize first offered by the British government in 1714 provides a historical example of the potential value of incentive prizes. On the other hand, it took decades and some poli-

tics for that prize finally to be awarded to the inventor of the first accurate marine chronometer. In addition, the winning inventor was in fact “*sustained for many years by research grants from the group administering the prize*” [to quote a 1999 National Academies report], a fact not often acknowledged. The most recent government-sponsored prize appears to be the DARPA “Grand Challenge” prize, which has not yet produced a winner. Nonetheless, DARPA indicates that it is pleased with what has been accomplished to date.

I think we need to take a serious look at prizes, strip away the hyperbole, and determine:

- *when* such prizes make sense,
- *what* it would cost to provide adequate prize incentives, and
- *how* the rules governing the prizes should be structured.

There is no question that the recent success of SpaceShip One in reaching the edge of space has generated a lot of excitement. I applaud Burt Rutan’s achievement, and I wish all of his X-Prize competitors the best of luck. The development of a healthy commercial space sector is important to the future of this country, and it’s something I have long supported. It can also provide valuable capabilities to aid the Nation’s civil space program. And perhaps prizes could have can play a role in increasing the involvement of the private sector—I look forward to hearing from our witnesses on that point.

However, the establishment of incentive prizes should not be viewed a substitute for adequate and sustained investment by the Federal Government in aeronautics and space R&D. We need to support a robust NASA budget this year and in the years to come. I hope that today’s focus on prizes will not divert from the importance of continuing that critical federal involvement in space exploration and utilization.

That said, I again want to welcome our witnesses, and I look forward to your testimony.

Chairman ROHRABACHER. Well, thank you very much. And you know, no one can doubt your commitment. You are the ultimate activist in these things, so I hope you are successful in your—okay.

Today we have some fine witnesses with us, and I would like to introduce them at this time. And we have with us, of course, the Chairman of the Full Committee, Mr. Boehlert. Would you—Chairman Boehlert, would you like to have an opening statement of any kind?

Mr. BOEHLERT. No, Mr. Chairman. I applaud you for following through on your commitment to this. It is an idea that we are all enamored with, and we want to develop it to its maximum potential, and you have got great witnesses. Let us hear from them.

Chairman ROHRABACHER. All right. Thank you very much.

So we do have great witnesses. We have Rear Admiral Craig Steidle, who is NASA’s Associate Administrator for Exploration Systems. He oversees the Centennial Challenges Program, NASA’s program prize contest. And Admiral, we appreciate having you here. We will be—and we have had many good meetings together.

Rear Admiral STEIDLE. Certainly.

Chairman ROHRABACHER. And the Honorable Bob Walker, Robert Walker, who is the Chairman of Wexler & Walker Public Policy Associates, and of course, as we have mentioned, former Chairman of the House Science Committee, my former boss, also a member of the Aldridge Commission, which recommended that NASA offer large prizes in order to spur innovation. Peter Diamandis, Chairman of the X-Prize Foundation, a non-profit organization dedicated to promotion and promoting the formation of space tourism through a \$10 million prize and a man who is now basking in the spotlight of success, and everyone is patting him on the back. And when someone succeeds, they get pats on the back in politics, and when

they fail, there are knives in the hands of the people who are patting you on the back. And then Dr. Molly Macauley, an economist and Senior Fellow with Resources for the Future. Dr. Macauley's research interests include space economics and economic policies for new technologies. We will all appreciate hearing from you. And Dr. Douglas Holtz-Eakin is the Director of the Congressional Budget Office, Chairman and someone whose expertise is important for us, because every decision in terms of policy also is a decision about budget, which we know.

Chairman ROHRABACHER. So our witnesses should know that they—we know you have a lot to say, but we would hopefully hear only about five minutes at—in your opening statement, and then we will get to questions and answers.

Ms. Johnson from Texas.

Ms. JOHNSON. Thank you very much, Mr. Chairman, and Ranking Member, who just stepped out, Mr. Lampson, for holding this hearing. And let me welcome Mr. Walker, who chaired this committee. It is good to see you.

I understand the purpose of this hearing is to examine NASA's proposed Centennial Challenges Prize Program and the role that prizes might play in encouraging technological developments. At a time when NASA's space program is at a virtual standstill because of the unfortunate accident in February of 2003 and budget shortfalls, it is increasingly necessary that this agency be extremely careful in setting priorities for the future.

With that in mind, I have two major concerns about this prize program proposed: safety and fairness. The safety of all participants must remain a primary concern since space travel is inherently dangerous. Under no circumstances should we allow the desire for profit to ever interfere with the responsibility of maintaining safety. NASA should also strive for higher standards of fairness. This proposed program would award a prize upon delivery of a desired technological development. Unfortunately, no funding will be provided to the participants in advance. While such an approach may bring in some entrepreneurs who might not otherwise participate in technology development for NASA, it may also eliminate participation of researchers from universities or not-for-profit organizations who typically are dependent on research grants to support themselves and their graduate students. I strongly urge that this prize proposal includes stipulations requiring the inclusion of small and/or minority-owned businesses and educational interests, otherwise, entire segments of our business community will be unfairly excluded from participating in financially lucrative NASA activities.

With that being said, I am hopeful that Congress and NASA can work together amicably to devise an effective and inclusive program. I look forward to hearing the testimony of our distinguished witnesses today.

Thank you, Mr. Chairman, and I yield back.

[The prepared statement of Ms. Johnson follows:]

PREPARED STATEMENT OF REPRESENTATIVE EDDIE BERNICE JOHNSON

Thank you, Mr. Chairman. I would like to thank you and Ranking Member Lampson for holding this Subcommittee on Space and Aeronautics hearing today on Space Prizes.

The purpose of this hearing is to examine NASA's proposed "Centennial Challenges" prize program and the role that prizes might play in encouraging technological developments.

At a time when NASA's space program is at a virtual standstill because of the unfortunate accident in February of 2003 and budget shortfalls, it is increasingly necessary that this agency be extremely careful in setting priorities for the future.

With that in mind, I have two major concerns about this prize program proposal: safety and fairness.

The safety of all participants must remain a primary concern since space travel is inherently dangerous. Under no circumstances should we allow the desire for profits to ever interfere with the responsibility of maintaining safety.

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With that being said, I am hopeful that Congress and NASA can work together amicably to devise an effective and inclusive program. I look forward to hearing the testimony of our distinguished witnesses today.

Mr. Chair, I yield back my time.

Chairman ROHRABACHER. Thank you very much.

Now we have heard the yin and the yang, so—Admiral Steidle, you might—you may proceed.

STATEMENT OF REAR ADMIRAL CRAIG E. STEIDLE (RET.), ASSOCIATE ADMINISTRATOR, OFFICE OF EXPLORATION SYSTEMS, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Rear Admiral STEIDLE. Yes, sir. Thank you very much, sir.

Mr. Chairman, Members of the Subcommittee, thank you for the opportunity to appear today to discuss the past accomplishments and the future promise of prize competitions.

Prize competitions are proving to be an important tool for innovation, not only for NASA in our Centennial Challenges Program, but for private efforts, like the X-Prize, and other federal agencies, like the Defense Advanced Research Projects Agency and their Grand Challenges competition. Congress's attention and support will be important in the months and years ahead for all of these efforts.

I would like to take just a few minutes, sir, to do a—to describe NASA's new prize competition program, Centennial Challenges, including how it supports NASA's new direction, the program's goals, the past prize competitions that Centennial Challenge is modeled on, and the recent developments. And I will close by outlining future directions for Centennial Challenges and describing how Congress can help to support this exciting new program.

On the 14th of January, President Bush visited us at NASA Headquarters and announced a new Vision for Space Exploration. Embodied within the vision are many difficult technical challenges. Meeting these challenges will require us to unleash the best innovative talents our nation has, recognizing that NASA needs a dy-

dynamic mechanism for tapping the ingenuity of the Nation, wherever it may be, we created Centennial Challenges.

Centennial Challenge is a very different approach from how NASA and nearly all federal R&D agencies have traditionally gone about technical innovation. Instead of soliciting proposals for a grant or contract award, NASA will set a technical challenge, the prize amount to be awarded for achieving that challenge, and a set of rules by which teams will compete for that prize. Through this particular program, we hope, first of all, Ms. Johnson, to be fair and safe. We hope to stimulate innovation in ways that standard federal procurement can not. We hope to enrich NASA's research with these new innovations and innovators. We hope to address traditional technology development obstacles. And we hope to achieve returns that significantly outweigh the program's investment. And also, we hope to educate, inspire, and motivate the public to participate with us.

Centennial Challenge is modeled on and grows from the successes of prior programs, some of which Congressman Lampson alluded to this morning. These prior successes demonstrate the important advantages of prize competitions, that being the ability to reach out to new inventors, innovators, and risk-takers and have them apply their experience, thinking, and resources toward the development of novel and unorthodox solutions. It is exactly these kinds of unexpected winners and their ingenious solutions that we hope to identify and leverage.

The science and engineering community has long recognized the value of prize competitions. In 1999, the National Academy conducted a blue ribbon workshop entitled "Concerning Federally-sponsored Inducement Prizes in Engineering and Science." The central recommendation of that workshop was that Congress should encourage federal agencies to experiment with—extensively with inducement prize contests in science and technology.

We recognize the need to obtain external inputs on our future prize competitions. To obtain these external inputs, we held our first annual Centennial Prize Workshop here in DC last month. This two-day workshop was a significant success. We had over 200 attendees that participated, including representatives from both established and emergent aerospace companies, representatives from other industry sectors, researchers from universities, non-profit organizations, members of various financial institutions, educators, students, and hobbyists. It was a tremendous success, and we saw an overwhelming support for this program.

About 30 managers from NASA's field centers and from other federal R&D agencies and from the X-Prize Foundation moderated these particular workshops for us. Keynote speakers included a Member of Congress, the President's Science Advisor, and the Captain of the Aerospace Industry. Together these participants provided invaluable inputs, which are being summarized in a report on our website, CentennialChallenges.NASA.gov.

Simultaneously with this workshop, the President's Commission on implementation, thanks to Mr. Walker, the House Space Exploration Policy released its report entitled "A Journey to Inspire, Innovate, and Discover." Among the many important recommendations included, Congress increased the potential for commercial op-

portunities related to the Nation's space exploration vision by creating significant monetary prizes for the accomplishment of these space missions.

I would like to take just a second, sir, if I could to introduce to you Mr. Brant Sponberg who is sitting behind me right here. Brant is my assistant at NASA and is NASA's manager of the Centennial Challenges Program. He and his staff are currently working extremely hard at revising their program plans based on these inputs from these workshops, other studies, and the Commission's report in developing specific prize competitions. Examples of the kind of challenges that we are examining include: complete robotic and human space missions, key technologies, leveraging partnering opportunities, educational enrichment programs. In all of these competitions, it will be important to review the proposed rules to ensure that it is safe and fair, that the objective is transparent, that they can not be gained by competitors, that they will attract a strong field of competitors. Depending on the size of the prize purse, we plan to subject the draft rules for each competition to independent internal and external review. In the case of the largest prizes, we will likely have a public comment period to obtain additional inputs on these draft rules and processes.

With the exception of these prize competitions targeted at students, we plan to make all challenges open to any U.S. competitor who is not a federally employed. The Program Manager is committed to keeping overhead costs as low as possible so that the maximum amount of funding is available for these prizes and purses. And we will shortly release a request for information nationally to solicit inputs on how to structure the Centennial Challenges support and maintain this low overhead.

And so Congress is extremely important to the success of this Centennial Challenges program. We have requested specific authority from Congress to conduct large prize competitions with purses up to \$50 million in size and to retain funding in prize purses over multiple years. Both of these authorities are important to maximize the agility of the Centennial Challenges Program. NASA's fiscal year 2005 budget request for Centennial Challenges is \$20 million, and NASA has requested a \$2 million reprogramming change in fiscal year 2004 to start and kick-off the Centennial Challenge Program.

This program is exciting and is an integral part of NASA's new direction and significantly a part of the Exploration Initiative. It represents an opportunity to reach new communities of innovators to find novel solutions to hard technical problems that we face in the future. And I greatly look forward to our future prize competitions, the new approaches that they will inject into our programs, the new ways of doing businesses and processes, and I look forward to that day where I can shake hands with the first prize winner.

I thank you, sir, for the opportunity that the Committee has provided us today, and I look forward to your questions.

[The prepared statement of Rear Admiral Steidle follows:]

PREPARED STATEMENT OF REAR ADM. CRAIG E. STEIDLE, USN (RET.)

Mr. Chairman and Members of the Subcommittee, thank you for the opportunity to appear today to discuss the past accomplishments and future promise of prize competitions. Prize competitions are proving to be an important tool for innovation,

not only for NASA and our Centennial Challenges program, but also for private efforts like the X-PRIZE and for other federal agencies like the Defense Advanced Research Projects Agency and their Grand Challenge competition. Congress's attention and support will be important in the months and years ahead to all of these efforts.

I would like to take a few minutes to describe NASA's new prize competition program, Centennial Challenges, including how it supports NASA's new direction, the program's goals, the past prize competitions that Centennial Challenges is modeled on, and recent developments. I will close by outlining future directions for Centennial Challenges and describing how Congress can help support this exciting new program.

Centennial Challenges and the Vision for Space Exploration

On January 14th, President Bush visited NASA Headquarters and announced a new Vision for Space Exploration. The Vision lays out a strategy for sustained, long-term human and robotic exploration of our solar system and the worlds that lay beyond. Embedded within the Vision are many difficult technical challenges, from autonomy and communications to power and propulsion to structures and spacecraft. Meeting these challenges will require us to unleash the best innovative talents our Nation has to offer. Recognizing that NASA needs a dynamic mechanism for tapping the ingenuity of our Nation, wherever it may lie, we created Centennial Challenges.

Centennial Challenges is a very different approach from how NASA, and nearly all federal R&D agencies, have traditionally gone about technical innovation. Instead of soliciting proposals for a grant or contract award, NASA will set a technical challenge, the prize amount to be awarded for achieving that challenge, and a set of rules by which teams will compete for that prize. Through Centennial Challenges, we hope to:

Stimulate Innovation in Ways That Standard Federal Procurement Cannot—By specifying technical goals but not pre-selecting the best way to achieve them, a large number of approaches to a problem will be developed, including unorthodox approaches that would likely not be pursued in a traditional procurement.

Enrich NASA Research With New Innovators—Centennial Challenge winners will be judged and earn awards based on actual achievements, not proposals. Using this approach, we hope to reach new innovators who would not normally work on NASA issues and find novel or low-cost solutions to NASA engineering problems that would not be developed otherwise.

Help Address Traditional Technology Development Obstacles—In each Challenge, multiple teams will be developing, integrating, testing, or flying various approaches to the same technical goal. With multiple teams and multiple approaches, Centennial Challenges will help transition new technologies into operation and address other traditional technology pitfalls.

Achieve Returns That Outweigh the Program's Investment—History shows that the total resources spent by teams to win prize competitions usually exceeds the value of the prize many times over. By having multiple teams bring varied resources and knowledge to bear on a problem, we will get more solutions developed and tested.

Educate, Inspire and Motivate the Public—Highly visible Challenges will draw substantial public, educator, and student interest in NASA, the competitors, and the technical field of the Challenge itself.

Short History of Prize Competitions

Centennial Challenges is modeled on and builds on the success of prior prize competitions in stimulating technological innovation, scientific discovery, and new exploration achievements.

As early as the 18th century, the British government offered the Longitude Prize, a competition for a navigational solution to the accurate determination of longitude on the high seas. At the time the prize was set, it was assumed that the solution laid in using star maps as navigational aides and that the winner would be an astronomer.

The solution was actually achieved by a London clock maker and his invention, the marine chronometer.

In the early 20th century, numerous prizes were offered for new achievements in aviation by governments, the U.S. airmail service, wealthy individuals, and even newspapers in both the United States and Europe. Perhaps the most famous of these aviation prizes was the Orteig Prize for the first crossing of the Atlantic Ocean by air. Again, at the time the prize was set, many assumed that a famous Arctic explorer of that age would win. Instead, a relatively unknown airmail pilot named Charles Lindbergh won the Orteig Prize and went down in history as the first person to cross the Atlantic in an airplane, opening a new avenue of transcontinental transportation.

These two historical examples demonstrate an important advantage of prize competitions—the ability to reach out to new inventors, innovators, and risk-takers and have them apply their experience, thinking, and resources towards the development of novel and unorthodox solutions. It is exactly these kinds of unexpected winners and their ingenious solutions that we hope to identify and leverage through Centennial Challenges.

More recently, the privately funded X-PRIZE Foundation has demonstrated the tradition of prize competitions in stimulating innovative solutions to technical challenges. Established in 1996 with the goal of demonstrating private, reusable, sub-orbital human space flight, the X-PRIZE spurred Mike Melvill's June 21st test flight above 100 kilometers, making him the first astronaut to fly a vehicle developed by the private sector to space. The achievements of Burt Rutan and Scaled Composites, the team behind Melvill's flight, are a remarkable private sector engineering achievement. We at NASA are looking forward to a winning X-PRIZE team, hopefully later this year.

The science and engineering community has long recognized the value of prize competitions. In 1999, the National Academy of Engineering conducted a blue ribbon workshop titled "Concerning Federally Sponsored Inducement Prizes in Engineering and Science." The central recommendation of this workshop's report was that:

"Congress should encourage federal agencies to experiment more extensively with inducement prize contests in science and technology."

The workshop's report also includes a number of important recommendations regarding how agencies should structure and conduct prize competitions.

The Defense Advanced Research Projects Agency (DARPA) is the first federal agency to pursue the Academy's recommendations and establish a major prize competition. The DARPA Grand Challenge is an annual race aimed at developing autonomous vehicle capabilities for the battlefield, and the first race was held earlier this year in the California desert. We at NASA have a great deal of interest in autonomous systems and robotics and are eagerly anticipating next year's Grand Challenge race.

Recent Developments

Building on this successful history and recognizing the potential value of prize competitions to augment our ability to implement the Vision for Space Exploration and ongoing NASA programs, we conducted an internal study to gather ideas for NASA prize competitions. Two of the founders of the X-PRIZE, including Dr. Peter Diamandis who is with us here today, assisted with this study. We collected almost 130 prize competition concepts and winnowed the list to 15, which was the basis for the initial formulation of Centennial Challenges.

However, we also recognized the need to obtain external inputs on our future prize competitions. Since the teams competing for a particular Challenge will come from outside NASA, we felt it was important to understand what Challenges outside organizations would be interested in competing for and to get their thoughts on how to structure these competitions. To obtain these external inputs, we held the first annual Centennial Challenges Workshop here in Washington last month. The two-day workshop was a great success, both in terms of the attendance and the inputs we received. Over 200 attendees participated, including representatives of both established and emergent aerospace companies, representatives from other industry sectors, researchers from universities and non-profit organizations, members of various financing communities, educators and students, representatives of space advocacy groups, and even hobbyists and interested members of the public. About 30 managers from NASA's field centers, from other federal R&D agencies, and from the X-PRIZE Foundation helped moderate the workshop. Keynote speakers included a member of Congress, the President's Science Advisor, and a captain of the emergent aerospace industry. Together, these participants provided invaluable inputs. They identified excellent prize competition concepts that were missed by our internal study and gave us important feedback on goals and rules for specific competitions. The inputs from the workshop are summarized in a report that is available through a link on our website at www.centennialchallenges.nasa.gov.

Simultaneous with our workshop, the President's Commission on Implementation of U.S. Space Exploration Policy released its report titled "A Journey to Inspire, Innovate and Discover." Among the many important recommendations made by Chairman Pete Aldridge and the Commission is that:

Congress increase the potential for commercial opportunities related to the national space exploration vision. . . by creating significant monetary prizes for the accomplishment of space missions. . .

The Commission goes on to state, “NASA should expend its Centennial prize program to encourage entrepreneurs and risk-takers to undertake major space missions.” We have taken the Commission’s words to heart and are actively exploring ambitious prize competition concepts.

Future Directions for Centennial Challenges

My Centennial Challenges Manager, Mr. Brant Sponberg, and his staff are currently hard at work revising their program plan based on the inputs from our internal study, the June workshop, and the Commission report and are developing the specific prize competitions that NASA would like to begin in FY 2004 with a few small (\$250,000) prizes and then expand the effort in FY 2005. Examples of the kinds of Challenges they are examining include prize competitions:

For Full Missions—These would be prize competitions for the successful completion of a challenging robotic or human space mission by a private sector organization. The size the purses for these kinds of prize competitions would be in the single to few tens of millions of dollars and competitors will likely include aerospace companies and university teams. Examples include Challenges for: the first private robotic soft landing on the Moon, the return of samples from near-Earth asteroids, or even the first private orbital human space flight.

For Key Technologies—These would be prize competitions for the successful development and demonstration of a technological capability that is important to future space exploration or other NASA programs. The size of the purses for these prize competitions would range from hundreds of thousands of dollars to a few million dollars and competitors will likely include industry researchers, university researchers, and other inventors. Examples include Challenges for: a more dexterous astronaut glove; an aerocapture mission demonstration; a highly accurate descent and landing system; autonomous robots capable of retrieving science samples from Earth environments that are analogous to those on other worlds; a highly-efficient and low mass power distribution system for robotic or human bases on other worlds; and highly efficient lunar resource processing techniques.

To Leverage Partnering Opportunities—These would be prize competitions for technical goals and capabilities that are common between NASA and other organizations. The size of the purses for these prize competitions would range from hundreds of thousands of dollars to a few million dollars. Partners would cost-share the purse with NASA or be responsible for competition administration. Partners could include: professional organizations, corporations and non-profit research organizations, other federal R&D agencies, hobbyist organizations, and public space advocacy groups. Examples include Challenges for: an autonomous, low mass drilling system for accessing underground science samples and resources on other worlds and on Earth; an improved power storage system for rovers and for various Earth-based applications; a fully autonomous unmanned aerial vehicle for cargo delivery; high strength-to-weight materials; and a solar sail mission to provide space weather data for various government customers.

For Educational Enrichment—These would be prize competitions to excite and encourage college and secondary school students to pursue educations and careers in science, technology, engineering, and math. The size of the purses for these kinds of prize competitions would range from the thousands to tens of thousands of dollars. Examples include a robot “survivor” contest and a contest for a model rocket that must launch after being dropped from a certain height and re-land.

In all of these competitions, it will be important to review the proposed rules to ensure that: they are fair, objective and transparent; that they cannot be “gamed” by competitors; and that they will attract a strong field of competitors. Depending on the size of the prize purse, we plan to subject the draft rules for each competition to independent internal and/or external review. In the case of the largest prize competitions, we will likely have a public comment period to obtain additional inputs on draft rules.

With the exception of those prize competitions targeted at students, we plan to make all Challenges open to any U.S. competitor who is not a federal employee. My program manager is committed to keeping overhead costs low so the maximum amount of funding is available for prize purses. We will shortly release a request for information (RFI) to solicit inputs on how to structure Centennial Challenges support and maintain low overhead.

Congressional Support Is Key

Congress is important to the success of Centennial Challenges. NASA has requested specific authority from Congress to conduct large prize competitions with purses up to \$50 million in size and to retain funding for prize purses over multiple years. Both of these authorities are important to maximize the utility of Centennial

Challenges. Without them, the ability of Centennial Challenges to conduct prize competitions for space missions or significant technology demonstrations and to partner with other NASA programs will be greatly diminished. NASA's FY 2005 budget request for Centennial Challenges is \$20 million, and NASA has included a \$2 million reprogramming change in the FY 2004 Operating Plan to undertake a few small (\$250,000) prizes.

Centennial Challenges is an exciting and integral part of NASA's new direction. It represents an opportunity to reach new communities of innovators and to find novel solutions to hard technical hurdles. I greatly look forward to our future prize competitions, the new approaches that they will inject into our programs, and to one day shaking the hand of our first Challenge winner. Thank you for the forum that the Committee provided today. I look forward to responding to your questions.

Chairman ROHRABACHER. Thank you very much, Admiral. And it is getting into the details and see how this Centennial Challenge works. And it is going to be a very interesting new innovation to watch. It is, clearly, a step in the right direction, and a step in the direction that some of us have been advocating.

But now Mr. Walker may think that it is only one step in the right direction. He may want to go maybe 150 or 300 steps in another direction. So Mr. Walker, you may proceed.

Mr. WALKER. Thank you, Mr. Chairman.

I am delighted to be with you. And thank you for your kind words and Mrs. Johnson for her kind words. And I am delighted to be back in the room.

Chairman ROHRABACHER. Mr. Walker, could I—can I sort of take the prerogative of the Chair at this moment? Mr. Burgess has joined us and has a request to make.

Mr. BURGESS. I thank you, Mr. Chairman, and appreciate the indulgence of the members of—the witnesses who are here today. But I wanted to take a moment to introduce a guest to this committee. This is Taghreed Qaraghuli, a member of the Iraqi Women's Delegation. And Mr. Chairman, I ask for unanimous consent that she be allowed to sit at the dais for today's Subcommittee hearing. The Iraqi Women's Delegation is visiting Congress to learn firsthand how American democracy works.

Chairman ROHRABACHER. With unanimous consent, hearing no objections, so ordered.

And let me express—Ms. Johnson, you have a guest as well? Would you like to have her join us as well? Would you like to introduce her to us?

Ms. JOHNSON. She is one of the leaders of the delegation from Iraq.

Chairman ROHRABACHER. Well, we have two ladies who are joining us. And let me note that we want to welcome both of them to our hearing, and with unanimous consent, hearing no objection, we will have them join us today. And let me note this to our guests. We wish you all of the success in the world, and we hope that Iraqi women will be a role model for women throughout the Islamic world and show how democracy and freedom can work and how everyone will be included in a democratic society. And so we are very, very pleased to have you both with us today. And as we talk about technology and talk about the prizes.

So excuse me, Mr. Walker. You may proceed.

**STATEMENT OF HONORABLE ROBERT S. WALKER, CHAIRMAN,
WEXLER & WALKER PUBLIC POLICY ASSOCIATES**

Mr. WALKER. Thank you, Mr. Chairman. And I am delighted to be back in the room.

As a matter of fact, one of the things I was going to mention as I started here is that some people asked me about the Connestoga wagon that is in the portrait that—of me that stares so ominously down on this room back there. And they wonder how it—how a Connestoga wagon got in there. And I can explain to them the reason why it is there is because the Connestoga wagon was invented in my old Congressional District, and it was, in fact, the high-tech of its era. Now some of it—my constituents still cling to that high-tech, even to this day, but I thought it was a nice symbol, also, for the reason why we are here talking about prizes today, because the Connestoga wagon became symbolic of Americans moving on to the new frontier of the west.

And in large—the large reason why they went was for a prize of some sort. Now it wasn't a specifically designated prize. Often, it was Sutter's gold. It was opportunity of one kind or another. But in some cases, they went for 180 acres of land that was being offered by the Government. And those were, in fact, real incentives that inspired people to do things that they wouldn't otherwise do. I would suggest to you that the reason why you want to do prizes is because you will get people involved to win prizes who would never dream of pursuing a government contract. What you will do is encourage people to take risks that they might find unacceptable if there wasn't a prize out there, and certainly take some risks that the Government inside of its regular institutions would probably find unacceptable. So what you will end up with prizes is people willing to do things that are outside the box, that you won't necessarily have RFPs or specs. You will have a goal. And if there will be people who will take that desire to pursue that goal and extend it in ways that we can't even imagine.

Now I don't suggest that this should be NASA's sole way of pursuing space technology for the future. NASA has a lot of contributions to make on the high-tech arena or in the high-tech arena. And this should simply be a mechanism by which NASA reaches out beyond what it can traditionally do to get new thinking into the mix. I think that NASA can play a role in helping some of these people who are pursuing prizes by being a high-tech advisor to them along the line and give them ideas where they run into places where they might otherwise stumble. But it should be a part of a totality of a program, not just the only piece of the program.

In my mind, the prizes here should be big. I think that you ought to have a couple of these prizes that are very large so that smaller developments are done in the wake of that big goal. And I would offer you one example. I sit on the Board of a company called Space Dev. Space Dev has a technology called "hybrid rocket technology." It is not new. It is not a new idea. In fact, this company bought it from a company called Amroc that went out of business some years ago. For years, this little company has tried to get people interested in hybrid rocket technology. The Government wasn't interested. NASA wasn't interested. The Defense Department wasn't interested. Nobody was particularly interested.

But Burt Rutan was going after the X-Prize, and he needed a rocket. And he needed a rocket he could buy pretty cheap. And it doesn't cost you very much to make hybrid rockets, because they are made out of rubber and laughing gas. So our rocket went out, and they tested it about three or four times on the ground, and then they put a man on it, and he flew. And he flew a couple test flights, and then just the other day, he went suborbital on that technology.

Now since that time, because it is the first new human-rated rocket in 25 years, there has been lots of interest in it, and it all came about, because there was somebody willing to invest in Burt Rutan's idea of how you pursue a prize. That is the wake of technology that you can begin to build behind the prize. And so Space Dev may end up with a technology that will have broad application that does not necessarily even reference the prize in the end.

So it seems to me that you do want to have a big enough goal so that you get this technology in the wake and maybe a goal big enough that you can't even write specs for it. The way in which this can really begin to have an impact is if you set a goal so big that people can't sit around and write a lot of specifications for it, you simply give people the opportunity to move ahead.

Now in my mind, one of the things that you have got to be very careful of as you do this is how much risk you are willing to accept. I would suggest to you that the idea behind these prizes should be to increase the amount of risk that you are willing to accept. But you can not absolutely ensure safety if you are pursuing some of these prizes. The prizes are a risk-taking mechanism. And risk toward reward should be something that should be very inherent in what you do. And so I would hope that as you develop your mechanisms, maybe you need to go off-line and establish a charter or a foundation that offers some of these prizes so that Government doesn't have to get involved in the questions before appropriation committees every year about why did this fail, because in all honesty, you will probably get as much failure in these programs as you will get success, but that will be a good thing. Risk has to be a part of the end results that you want out of a prize program.

Thank you, Mr. Chairman.

Chairman ROHRBACHER. Mr. Diamandis.

**STATEMENT OF DR. PETER H. DIAMANDIS, CHAIRMAN & CEO,
X-PRIZE FOUNDATION**

Dr. DIAMANDIS. Mr. Chairman and honorable Members, thank you. I am thrilled to be here.

And I wish to speak on three subjects: the X-Prize to give everybody an update; the—our support and interest in Centennial Challenges; and third, to echo Mr. Walker's remarks, the need to embrace increased levels of risk fundamentally.

We kicked off the X-Prize because there is an inherent interest in the U.S. public to go and fly into space. Over 60 percent of the people consistently say they would like a chance to go. But you know, up until recently, it has been very rare that you can go. In 1995, after reading "The Spirit of St. Louis," I proposed the idea

of a \$10 million cash prize we now have named the Ansari X-Prize. And we have now 27 teams from seven countries building private spaceships to compete to win this \$10 million. And they are spending in excess of probably \$100 million, some say as much as \$400 million, I will say, for the record, over \$100 million to go and win this. And the beautiful thing is we don't pay \$1, not a single dollar, until someone does it, unlike traditional government procurements where you will spend the money inherent—you know, independent of whether someone does it or not. And in fact, they may never reach the design goals they desire. We don't spend \$1 until it is actually won. And that is the beauty of the competition.

The other element is we have been able to attract people that would never look at a government contract, as Mr. Walker said. The—this is a way of, in one essence, getting fixed-price science or fixed-price engineering. You put out the goal. It is a challenging goal. And once that is put out there, if enough money and time is given, it will be achieved. And you are bringing levels of entrepreneurship and levels of intelligence and levels of motivation you can not buy with a contract. There is no way you can secure that through a traditional mechanism.

We are getting people thinking about this around the world during shower time, during, you know, time when they are at dinner. This is bringing out the human spirit, the need to achieve that greatness, that goal, to do something that is meaningful with their lives. And the U.S. Government and NASA can do that and capture that level of enthusiasm and get the world excited. You know, I want to see kids getting on the Net and looking at the prizes to help shape what they do in their careers. What do people say out there is exciting to do? What can I go after? Because right now, if you want to be an astronaut, you know, the last 40 years have told you the chances are 1 in 1,000. And even if you become an astronaut, your chances of flying are 50 percent. And people say, "Well, space isn't really something I can do." Well, this makes it available for everybody.

Now I want to address the issue of risk. I feel fundamentally that unless we embrace risk, especially as Americans, we will not have the innovation. The price of going to orbit has gone up over 40 years, arguably, not down, and it has not become less risky. We need to embrace risk to offer new breakthroughs. The day before something is a breakthrough, it is a crazy idea. If it is not a crazy idea or an idea that is not—it is not a breakthrough, it is a small incremental improvement. So how do we allow breakthroughs if we don't allow risk? I mean, we are Americans. 500 years ago, thousands of people risked their lives to cross the Atlantic. And we are thankful for that. And then 200 years ago, they risked their lives to cross the Americas right now in Los Angeles. I mean, why would I want to stop taking risks now as we are on the verge of the greatest frontier ever? Please, don't say we shouldn't go with risk. You know, that old motto, "Failure is not an option," well, if we can't fail, we can't have breakthroughs. We have to allow mechanisms to do that.

One of the issues that have made X-Prize a success so far—and I appreciate your kind words, Mr. Chairman, but until we write that \$10 million check, we have not yet succeeded, but we hope to

do that in the next three months. The key ingredients here are the rules. The rule-making process will determine whether there is a success or there is a failure, whether you get garbage or you get nothing at all. We have spent 80 percent of our time up front thinking about the key rules. That is fundamental. The second thing that is important is it has got to be romantic and exciting. It has got to capture the hearts and minds of nine-year-old boys to CEOs of companies. And the third part that has made the X-Prize successful is the back end, the potential marketplace, the fact that there is a \$1- to \$3 billion-a-year space travel marketplace that will materialize out of that.

Those three components, the rules, the excitement of the concept, and the fact that there is someplace it can go, and it doesn't have to be someplace you can go, necessarily only to government, and government—it isn't government's job to make sure there is a business market there. But if the rules are properly written, like we did with the X-Prize where we said three people versus one person, we—and reusable, that inherently said the vehicles coming out of this could service a marketplace. And that was our—that was the important thing that we set out there.

I want to—in the—my last minute here, give my support to the Centennial Challenges Program. I think it is the most fundamentally critical thing that NASA could be doing. The level of excitement. And rather than \$20 million or \$25 million a year, I would love to see, you know, a good 10 percent of the NASA budget put toward prizes. Why not for every contract that is—let there be a series of prizes attached to those to allow people who would never go after the same things that Lockheed and Boeing did? In fact, you know, when asked why isn't Lockheed and Boeing going for the X-Prize, well, the fact of the matter is the current procurement methods have ruined the large contractors. They do not take the risks. They don't build the 777 until they know there is enough orders there. They don't go and build any new launch vehicle until they know the government is prepared to pay—foot the bill. It is really only the small entrepreneurial companies, the university people, the people who could never go after this that are willing to take the level of risk. So there has to be both sides of the equation. And I think prizes could enable that.

Thank you, Mr. Chairman.

[The prepared statement of Dr. Diamandis follows:]

PREPARED STATEMENT OF PETER H. DIAMANDIS

Chairman Rohrabacher, Members of the Subcommittee, it's an honor to be here. Today I wish to brief you on three subjects: First, the X-PRIZE Competition; Second, the critical need to support NASA's plans for the Centennial Challenges; and third, the need to embrace an increased level of risk in our exploration of space.

X-PRIZE:

There is little doubt that there is a large and vibrant marketplace of individuals willing to pay for the opportunity to fly into space. Surveys consistently indicate that over 60 percent of the U.S. public would welcome the opportunity to take such a trip, and the most recent Futron Corporation study quantifies this public space flight market at over \$1 billion dollars per year during the next twenty years.

Unfortunately, the private spaceships needed to service this market do not yet exist. To solve this challenge, in 1995 I proposed the idea that a prize be offered to the first private team to develop such a ship. In May 1996, in St. Louis under the Arch, with then NASA Administrator and 20 astronauts, the X-PRIZE was an-

nounced. Ten million dollars was offered to the first team able to privately build a ship and fly three people to 100 kilometers altitude, twice within a two-week period.

Today we have twenty-six teams from seven nations competing and we expect a winner of the X-PRIZE in the next three to four months.

The results of this competition have been nothing short of miraculous. For the promise of \$10 million, more than \$50 million has been spent in research, development and testing. And where we might normally have expected one or two paper designs resulting from a typical government procurement, we're seeing dozens of real vehicles, motors and systems being built and tested. This is Darwinian evolution applied to spaceships. Rather than a paper competition with selection boards, the winner will be determined by the actual ignition of engines and the flight of humans into space. Best of all, we don't pay a single dollar until the result is achieved. The bottom line is that prizes work!

I'm also very proud that the X-PRIZE has played a roll with NASA in the creation of the newly announced Centennial Challenges. These annual NASA prizes will help encourage out-of-the-box thinking that is sorely needed in our risk averse space community. While the annual budget for NASA's Centennial Challenges is only \$25 million today, I imagine a future where 2.5 percent of the NASA budget, some \$400 million, would be offered each year. Entrepreneurs will 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 they offer NASA the passion and dedication of the entrepreneurial mind that cannot be purchased at any price.

I encourage the Congress to fully embrace and support the use of prizes by NASA. Admiral Steidle and all of Code T are to be congratulated for their efforts in launching the Centennial Challenges and should be fully supported to encourage this new way of doing business within the Agency.

DETAILS ABOUT PRIZES:

What are the key ingredients that have made the X-PRIZE so successful?

I would attribute our success to three key components. First, the rules were well thought through and clearly presented. You'll hear me speak of this over and over again—writing the rules is more than 80 percent of the battle. Our second key to success was the romance and excitement involved with the prize topic. Sub-orbital space flight included the human element, the potential to create heroes and a personal message to every viewer of the competition, that message being "You can go next!" The third key component was the existence of a business or market to support the teams after the prize was won. The potential for a billion dollar space tourism market has helped teams justify their investments and fuel their enthusiasm.

To what extent has the X-PRIZE attracted interest from NASA's traditional contractors to participate?

None of the traditional contractors have demonstrated any interest in the X-PRIZE competition. In fact, shockingly, none have had any interest in supporting us as a non-profit educational organization, even though, in my opinion, these large corporations may be one of the greatest beneficiaries from our activities.

The current contracting methods have spoiled the incumbents. They are paid for paper designs and are paid in cost-plus contracts whether they deliver or not.

But luckily, it is not the traditional contractors who we seek to attract with these competitions. They lack the ability to take the risks involved in achieving breakthroughs and to achieve low-cost solutions.

How can prizes be designed and administered to induce the greatest possible innovation?

Writing the prize rules is the most critical step to achieving this goal. Well written rules will deliver breakthroughs, diversity and innovation. Poorly written rules will result in no entries, or worse yet, trivial solutions.

In addition the competing teams must believe that there is an even playing field without bias for a preferred technology or company. Judging must be independent of the offering agency and teams must be left alone to the maximum extent possible.

Should prizes be offered for discrete technologies, or for large technological feats?

The answer is, of course, both. However in the case of discrete technologies, they need to be wrapped into a competition which makes for good theater in some fashion. Remember that teams must create sufficient interest from a group of potential financiers to underwrite their effort. As such what they are doing must fall into one of the following areas:

- It must be great theater; likely to involve the human element in some fashion.
- It needs to inspire youth and educate the public
- It must attract the attention of the global press
- It must portend a large and vibrant marketplace

For example a device able to detect a bacterium or virus in a 100 grams of soil might be boring, but dress it as a life-detection prize or better yet, a home-land defense pathogen detection prize and the concept will get the attention of the media and corporate sponsors.

Might offering prizes encourage competitors to cut corners when it comes to safety? How can NASA ensure that the technologies resulting from a competition are safe and relevant to NASA's objectives?

I will speak more about risk at the end of this testimony. Safety is a relative issue. It is balanced against many factors. Would you preclude two personally funded bicycle mechanics from Dayton Ohio from building a self launching powered aircraft? Did they cut corners? Who can judge them? If the government attempts to regulate safety issues related to teams competing for prizes, it will kill the potential for innovation.

The goal for the technology resulting from competition is not to put them directly into production or use, it is to explore new approaches or ways of thinking. The idea is to invent the transistor not to perfect the process leading to a Pentium Chip. We should not expect technologies resulting from a competition to be safe—we should expect the technologies to be different and full of potential and possibilities.

Should NASA offer prizes or are they best offered by private organizations such as the X-PRIZE?

NASA should most definitely be offering prizes! This is in addition to private organizations, or in cooperation with private organizations like the X-PRIZE.

As a taxpayer I cannot think of a better thing NASA can be doing with my money than offering prizes.

How involved should NASA be in specifying the technologies that must be developed?

The most dangerous thing NASA could do is to over-specify the rules or specify what technologies should be used. The rule making process will determine the success or failure of a competition. Writing these rules is an art form requiring specifying just enough, but not so much as to limit the creativity of the contestants.

How involved should NASA be in overseeing the work of companies competing? How involved should they be in judging the competition?

Again, oversight of the teams competing needs to be very carefully managed. It needs enough agency involvement to support team needs, clarify rules and must support the credibility of the prize effort with potential sponsors, but should NOT direct their creative approach in any fashion. Teams need to be allowed to explore non-traditional approaches which might seem 180-degrees out of phase with current accepted practices. This is the only way to bring about true breakthroughs.

What needs to happen to transition technologies from a prize winner to a successful ongoing concern? What can the government do to support this transition?

The best way to achieve this lies once again in the writing of the rules. As an example, the X-PRIZE chose to require a three-person vehicle rather than a one-person ship. The reason for this was to allow for the creation of a capability that would most easily make the transition to a revenue generating spaceship.

ACCEPTING RISK:

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

There is no question that there is risk involved in winning the X-PRIZE, as well as risk in going to the Moon or Mars or opening any portion of the space frontier. BUT, this is a risk worth taking!

As American many of us forget the debt we owe to early explorers. Tens-of-thousands of people risked their lives to open the 'new world' or the American west. Thousands lost their lives and we are here today as a result of their courage.

Space is a frontier and frontiers are 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 future generations. In a time when people are risking their lives in motor sports or bungee jumping, it seems a bit shallow to be concerned about the risk involved exploring space.

It is also critical that we take risk in our technology development and that we allow for failure. Without risk and without room for failure we can not have 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 isn’t a breakthrough, is it? It would have simply been 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.

I urge both this committee and NASA to take steps which will help the American people understand that space exploration is intrinsically risky, yet a risk worth taking. Let’s make space explorers heroes once again.

Chairman ROHRABACHER. Tell us how you really think.
Great. Thank you very much for that testimony.
Dr. Macauley.

**STATEMENT OF DR. MOLLY K. MACAULEY, SENIOR FELLOW,
RESOURCES FOR THE FUTURE**

Dr. MACAULEY. Thank you, Mr. Chairman, and Members of the Committee. It is an honor to be here and for our guests, our Iraqi guests, it is an honor for me to be here with you. And I notice that your joining Congresswoman Johnson has increased the participation of women up there 50 percent, so thank you very, very much.

In my short answer to are prizes a good idea is yes, but being the researcher that I am, I have a couple of buts to add with that, so let me go ahead and mention those. First of all, we are not working with a clean slate. We have a heavy hand of government in space R&D already through procurement contracts and through peer-reviewed research, which hasn’t been mentioned a lot yet, so we have to think of prizes as a tool in an already existing portfolio. But with that in mind, you know, peer-reviewed research and contracts have a lot of imperfections, as do prizes. But some of them offset each other, so taken together, these are all a set of tools that I think we can effectively use to marshal innovation in our space program.

In my written statement, I look at the history of prizes, because we are forging somewhat new territory here both by bringing back prizes and having them governmentally sponsored. So one question is what can we learn from the history of prizes, and there is a rather large history. We can look at prizes in aviation, automobiles, and rocketry, and I think very important for discussion of the Centennial Challenges, which may involve innovation in technologies that may be unique to NASA that may not have commercial payoff, that may not have an enduring relationship with government as customer. These may be very specific technologies that further space exploration per se. And interesting from the history of prizes, those are still good candidates.

If you look at the history of aviation prizes, Curtiss, Bleriot, Sigorsky, and Farman were among aviators winning prizes, but there were many, many dozens of others. The thing about those four individuals is they did end up developing a product line of aircraft. But dozens of others who were successfully competitive for prizes didn’t. Apparently they were motivated just by the thrill, and that is my point that we can also see prizes given for solving mathematical theorems. And there was a prize offered by the

French Academy of Sciences in 1790 for producing a soda alkali from salt. So again, the point is if some of the Centennial Challenges are addressing very unique, maybe NASA-specific innovations, they still may be fair game for prizes if one of the motivations is the thrill of invention and not necessarily the lure of a market.

However, these inventors were often interested in patenting their innovation. So NASA prizes don't necessarily have to target innovation for commercial profitability but the assignment of property rights to the inventor may be necessary to attract participation.

Also, the heyday of prizes in our U.S. history took place during an era of very limited government. These aviation prizes and these prizes for automobile races were taking place largely even before we had the personal income tax or corporate taxes. It was the heyday when the private sector owned a lot of the mass transit, the railways, the trolley cars, the private sector-owned electricity companies and water companies. It was the era of innovation spurred by Carnegie, Rockefeller, J.P. Morgan, Jay Gould, Vanderbilt. Today's culture is very, very different I would assert. We have the very heavy hand of government both in tax policy and in R&D policy, and I think that it is fair to say we can't look at prizes as the silver bullet that is going to reinvigorate enthusiasm for space like prizes seemed to do in the early decades of the 1900's.

Times have changed, and so I don't want to unfairly burden with prizes as being that silver bullet that will all of a sudden encourage the Appropriations Committee to begin spending a lot more money on space. I think we need to realistically look at the bowl of prizes here. They can, nonetheless, complement existing approaches to contracts and peer review, et cetera.

As mentioned, another advantage of prizes is the financial risk rests largely with the competitors and those whom they find to fund their work. That is an advantage for the taxpayer, because the risk is allocated somewhere else in our economy, but this can have some problems. For example, if the prize is offered for a technology that is a tent pole, absolutely critical for one of NASA's ideas, and we find out we are unable to award the prize because we simply find that our best and brightest can't do it, then we may be delayed in the pursuit of that technology and government may end up spending more money to find a substitute or a work-around. So offering a prize for something that is a critical tent pole in our pursuit of our objectives, we have to think a little bit about that. And of course, grants and peer-reviewed research have no guarantee of success, either, but again, for tent pole technologies, we might have to think a little more carefully about prizes.

There is another advantage of prizes that is particularly important in Centennial Challenges, and that is that an unawarded prize, a prize that we offer but we find no winner, is still important. Failure can be very important, because we learn from that. What we would learn from offering a prize for which there is no winner is that our best and brightest right now, given the current state of technology, simply can't do it, and that is very important information for managers of innovation in something that is unique and interesting. So failure, in and of itself, is not necessarily bad.

It brings us information. Albeit it brings us delay and we figure out a work-around, but it is important information.

A couple of disadvantages of prizes, as mentioned earlier, a cash flow problem for those entrepreneurs who want to step up to the plate but really are going to have to spend some time finding funding to underwrite the effort. And also there is a lot of economics research about possibly wasteful effort if you have got a lot of folks competing for a prize. From a broad, societal perspective, some economic theories have suggested that can be very wasteful. There is a duplication of effort in some of those cases.

Now problems with government-sponsored prizes, I know that Doug to my left here will address these, but one of them is committing to a prize across Administrations, Congresses, and fiscal years. Another problem is how we want to allocate property rights. In my testimony, I have a note that the government, in 1960 or so, ended up paying Mrs. Robert Goddard and the Guggenheim Foundation a large settlement for government use of more than 200 of Robert Goddard's patents. Mr. Goddard died in 1945. So that is an example of where figuring out in advance how we want to handle property rights is very important.

I also think involving an outside board of experts to judge the prize is very desirable, appropriate, and perhaps even necessary. I think eligibility for the prize should be broad and include government employees and FFRDCs. So here I differ a bit with the present structure of Centennial Challenges. A lot of our Nation's talent in space does rest with some of the FFRDCs and the NASA centers, and I think it is important that eligibility be very broad, but that is why we have an outside Board of Directors completely unrelated to NASA serving as judges and other administrators of the prize.

Let me also say that NASA often uses these kinds of success measures: create jobs, attracts students to science and math. Prizes will not necessarily create jobs. Prizes will not necessarily attract students to science and math. Prizes will not necessarily increase the number of engineers and scientists or broaden participation of underrepresented minorities or prop up a group of suppliers, say, of space transportation to protect that industry. And again, those are often objectives that we have used in our space program. And prizes are not necessarily going to further those. We can argue whether those are appropriate success metrics, but prizes are likely not to be well aligned with those.

And then finally I want to echo some comments that have already been made about the issue of safety and risk. Again, if we look at the history of prizes in aviation, my research assistant, Maria Shriver, seated behind me, has not only looked at the history of prizes but the history of fatalities during that era of the heyday of aviation prizes. And aviators were dying left and right each year, and yet the prizes continued to be offered, and many continued to be awarded. It was a very different attitude toward loss of life and risk sharply in contrast to our responses to *Apollo I*, *Challenger*, and *Columbia*. And I would assert that we really need to rethink attitudes toward and public policy for fatalities in the space program.

And I think I will stop there and look forward to your questions.

[The prepared statement of Dr. Macauley follows:]

PREPARED STATEMENT OF MOLLY K. MACAULEY

Advantages and Disadvantages of Prizes in a Portfolio of Financial Incentives for Space Activities

Mr. Chairman and distinguished Members of the Committee, thank you for inviting me to meet with you today. My name is Molly K. Macauley and I am a senior fellow at Resources for the Future, a nonpartisan research organization established in 1952 upon the recommendation of the presidentially appointed Paley Commission. Researchers at RFF conduct independent analyses of issues concerned with natural resources and the environment. I emphasize that the views I present today are mine alone.¹ Resources for the Future takes no institutional position on legislative, regulatory, judicial, or other public policy matters.

My research interests are space policy issues with a focus on economics. My areas of study include: space transportation and space transportation vouchers; economic incentive-based approaches, including auctions, for the allocation of the geostationary orbit and the electromagnetic spectrum; management of space debris; the public and private value of remote sensing information; the roles of government and the private sector in commercial remote sensing; and the economic viability of satellite solar power for both terrestrial power generation and as a power plug in space for space-based activities. This research has taken the form of books, lectures, and published articles. My research on these topics is funded by grants from the National Aeronautics and Space Administration, the Federal Aviation Administration, and Resources for the Future. My comments on today's discussion of space prizes are funded solely by my discretionary budget at Resources for the Future.

Before offering my comments I'd like to make two introductory points.

The first is that for years, we have searched for the "silver bullet" that would propel our nation back into space by way of the Shuttle and Space Station for the multiple pursuits of scientific exploration on one hand and a vibrant commercial space industry on the other. There is no lack of ingenuity in ideas for both of these goals. But critics of NASA's plans—regardless of the specific details involved—assert that they take too much time and money away from more pressing societal needs. And, critics of commercial space activities assert that such projects carry unique risks, take too much time to develop, and take too much time before they earn any money.

Obviously, priority determines the allocation of budgets in both the private and government sectors of the economy. There is "ample" money in general but competing priorities for spending it. Risk, long lead times, and long payback periods cannot be blamed as a death knell of space because significant investment takes place in other high risk, highly uncertain industries including pharmaceutical development, information technology-related hardware and software, and hybrid autos.

A second introductory comment summarizes my conclusions. Prizes, although not a silver bullet for invigorating enthusiasm for space or elevating its priority in spending decisions, could nonetheless complement government's existing approaches to inducing innovation—procurement contracts and peer-reviewed grants. Even if an offered prize is never awarded because competitors fail all attempts to win, the outcome can shed light on the state of technology maturation. In particular, an unawarded prize can signal that even the best technological efforts aren't quite ripe at the proffered level of monetary reward. Such a result is important information for government when pursuing new technology subject to a limited budget.

The remainder of my testimony addresses these topics: previous experiences of using prizes to encourage innovation, including prizes in aviation, automobiles, and rocketry; use of prizes in the current era of heavy government involvement in R&D (most experience with prizes pre-dated "big government"); and advantages and disadvantages of prizes compared with procurement contracts and peer-reviewed research grants. The concluding sections draw from these observations to offer comments about NASA prizes.

I. Observations about the history of using prizes to encourage innovation

Prizes have a long history of encouraging innovation, and a look back at these contests can offer insights into what might be expected from NASA prizes. The following examples highlight use of prizes in basic and applied research in chemistry,

¹I thank Maria Schriver for excellent research assistance, particularly in collecting and organizing information about the history of aviation prizes. Responsibility for opinions and errors in this testimony rests exclusively with the author.

autos, and aviation. Another example, rocketry, is a case in which prizes were scarcely used.

Soda alkali. One of the earliest documented uses of prizes took place in the 1780s when the French Academy offered 100,000 francs to whomever could produce a soda alkali from sea salt. The competition successfully led to a process that became the basis of the modern chemical industry.²

Autos. Prizes also figured prominently in the development of the automobile, with dozens of popular, well-publicized auto races beginning in the 1890s, mostly in Europe. One of the notable contests in the United States—the “Great Chicago Auto Race”—is credited with giving birth to the American auto industry. In 1895, H.H. Kohlstaad, publisher of the *Chicago Times-Herald*, sponsored this competition to test the overall utility, cost, speed, economy of operation, and general appearance of cars.³

Kohlstaad was surprised at the number of letters and telegrams he received expressing interest in participating in the contest. The auto business had seemed centered in Europe, yet he found that there were widespread efforts underway in the U.S. Most of the inventors were simply unaware of the work of the others. Unlike previous road races, the contest placed only secondary emphasis on the outcome of the race itself—rather, the awards were for evaluating performance of characteristics of the cars. Entrants included individual inventors as well as the R.H. Macy Company and the De La Vergne Refrigerating Company. Macy’s had been importing German-built Benz cars and hoped to sell them in Chicago after publicity from the race.

Only six cars ultimately participated—many competitors were discouraged by a large snowstorm the night before the race. Two cars finished the race, but four entries won cash awards: the first place finisher, inventor Frank Duryea, earned \$2,000 (about \$50,000 in 2004 dollars) for his auto’s speed, power, compactness, and overall race performance; the other finisher won \$1,500 for performance and overall economy. The Macy entry, which did not finish the race, and another entrant won \$500 each for general performance. A fifth entrant got a special gold medal for safety; the absence of noise, vibration, heat or odor; and general excellence of design and workmanship. Duryea later went on to become the biggest producer of autos in the U.S., building 13 cars in 1896 (the cars were hand-built; mass production of autos was years away).

*Aviation.*⁴ Another notable and frequent use of prizes—and much of the inspiration for the X-Prize—was in the early history of aviation. Between roughly 1908 and 1915, the heyday of privately sponsored competitions for distance, elevation, and speed jumpstarted the aviation industry. Three dozen or so individual prizes during this period—at roughly the rate of four or more annually—fostered innovations that decidedly gave birth to the industry. Some general observations about aviation prizes include:

1. Prizes were usually offered for incremental improvements. For example, the first couple of prizes were for flights of 25 meters and 100 meters, then for over 1,000 feet in elevation. Subsequent prizes were for longer distances, higher elevation, and faster time.
2. Prizes were almost without exception offered by private individuals and companies, not by governments. Sponsors were mostly wealthy entrepreneurs such as Raymond Orteig, a New York hotel owner; Jacques Schneider, a wealthy French industrialist; Ralph Pulitzer, the son of newspaper publisher Joseph Pulitzer; James D. Dole, a Hawaiian planter; Eduoard and Andre Michelin, executives of what was to become the Michelin Tire Company; and James Gordon Bennett, the publisher of the *New York Herald*. Prizes were also offered by the French Aero Club, which undertook private fundraising to obtain the prize money; the French Champagne industry; the Harvard Aeronautical Society; the Daniel Guggenheim Fund; the *Daily Mail* of London; and the *New York World*. Governments funded military planes to race in competitions after World War I but didn’t supply the prize money.

²See Joel Mokyr, *The Lever of Riches* (New York: Oxford University Press), 1990.

³See Paul A. Hughes, “A History of Early Electric Cars,” at [http://www. Geocities.com/Athens/Crete/6111/electcar.htm](http://www.Geocities.com/Athens/Crete/6111/electcar.htm) (accessed July 2004) and Richard Wright, “A Brief History of the Automobile Industry in the United States,” at <http://www.theautochannel.com/content/mania/industry/history/chap10.html> (accessed July 2004).

⁴The history of prizes in this section is drawn from M. Josephy Jr., editor in charge (1962), *The American Heritage History of Flight* (American Heritage Publishing Company); “The History Buff,” at <http://www.ehistorybuff.com/uwrightals.html> (accessed July 2004); and Gregg Maryniak (2001), “When Will We See a Golden Age of Spaceflight?” Pre-publication draft at <http://www.xprize.org/papers/XP-CATO-Maryniak.5Mar01.doc> (accessed July 2004).

3. Big air meets were popular during 1909–1911 but then they either continued without much publicity or became less profitable. Many meets continued as annual races into the 1930s—the meets were not competitions for “be the first to . . .” but were for speed and demonstrations of skill.
4. There were prizes that were never awarded or that were awarded only after a long extension of the competition deadline. For example, the Orteig prize, awarded to Charles Lindbergh in 1927, was originally offered in 1919 for a period of up to five years, but the deadline was extended.
5. Prizes were offered for generally specified objectives like distance, speed, or minimum number of refueling and maintenance stops. Prize guidelines typically did not include stipulations about the technological approach or other engineering characteristics.
6. In at least one documented instance, a company underwrote a competitor in exchange for advertising the company’s product (consumer soft drinks) on his plane.
7. Prize amounts varied widely—in 2004 dollars, the amounts ranged from about \$200,000 to over \$1 million. The typical amount was around \$300,000. Later prizes were almost always for more difficult achievements, but prize monies didn’t increase accordingly. The amounts do not seem correlated with the difficulty of the achievement required to win—but this observation may be biased by the paucity of detailed information about the prizes.
8. Accidents and fatalities were common—but did not lead to standdowns in holding competitions.
9. Whether contestants sought commercial gain from their innovation is not clear from the available records about the prizes. Some winners—but by far the minority—became founding fathers of a product line of aircraft—such as Louis Bleriot, Glenn Curtiss, Henri Farman, and Igor Sigorsky.

Rocketry. The success of prizes in fueling innovation in autos and aviation sharply contrasts with the history of rocketry and space travel.⁵ With one exception, the earliest efforts in rocket development never attracted prize money. Research grants rather than prizes typically financed studies of rockets—although even research grants were rare in the early decades. Konstantin Tsiolkovsky, Robert Goddard, and Hermann Oberth—the fathers of space travel—worked independently in self-financed home-based or academic laboratories. Tsiolkovsky received a grant of 899 rubles in 1899 from the Russian Academy of Science. Goddard, after making multiple requests (with the urging of Lindbergh), was given grants of \$5000 and later, \$3,500, from the Smithsonian Institution during 1917–1920.

In 1927, some forty years after the first serious, scholarly articles on rocketry had been published, Robert Esnault-Pelterie, a well-known airplane inventor, and his friend, banker Andre Louis-Hirsch, established a 5000-franc prize. The prize was to be awarded annually to the author of the most outstanding work on astronautics.

Public interest in rocketry was generally cool to lukewarm—in fact, “talk of rockets and space travel was viewed as crackpot by the public and as unscientific by most scientists.”⁶ Newspaper reporters, seizing upon some of Goddard’s writing about how rockets could get to the Moon, sensationalized the statements and referred sarcastically to Goddard as the “moon man.” The American Interplanetary Society—a professional organization that was a forerunner of the American Institute of Aeronautics and Astronautics—changed its name to the American Rocket Society because interplanetary travel was so ridiculed.

For a long time, the early rocket scientists were unaware of each other’s work, separated by geography and language. Beginning in the 1920’s and 1930’s, rocket and interplanetary societies formed in Western Europe and the U.S., researchers began regularly to report results in professional journals, and many experimental studies of rockets began under the auspices of defense agencies abroad (but not in the U.S). At this time, research in rocketry was best organized in Russia, where the Soviets created a government bureau for interplanetary flight, staged an exhibition on rocket technology, and published conference papers and a nine-volume encyclopedia. Research programs in Germany and France were also active in both theoretical studies and experimental testing of rocket components.

In the U.S., the Guggenheim Foundation was funding some of Goddard’s research, but as late as 1940 the Army and Navy remained generally uninterested (although the Army was conducting some limited research on rocket propellants). The Air

⁵ See Wernher von Braun and Frederick I. Ordway III (1975), *History of Rocketry and Space Travel* (New York: Thomas Y. Crowell Company)

⁶ See von Braun and Ordway.

Corps responded to one of Goddard's proposals for support by writing that the Corps "was deeply interested in the research work being carried out. . . under the auspices of the Guggenheim Foundation (but) does not, at this time, feel justified in obligating further funds for basic jet propulsion research and experimentation."⁷ By 1945, the U.S. government rocket program was more fully developed, with large expenditures and production facilities coordinated across the military services by President Roosevelt's National Defense Research Committee.

Some observations. These experiences show the usefulness of prizes in fundamental research (soda alkali) and in advancing technology (autos and aviation). Of course, the counterfactual question of "would innovation have come about in the absence of prizes," and if so how fast and at what cost, is equally important—but hard to answer. These experiences also took place before the rise of government's heavy hand in R&D (more on this in a later section below).

The absence of prizes in rocketry also raises questions. Several reasons could explain the difference between the role of prizes in spurring aviation and the virtual absence of prizes in the early development of space technology. The industrialists and media who funded aviation prizes appeared to be responding to an enthusiastic public in seeking publicity for derring-do involving human flight, and at least in one case (maybe more, if documentation were more complete), the chance to use a plane as a flying billboard by advertising consumer products on the fuselage. Public perception of rocketry was incredulous, less enthusiastic and as noted, even marked by ridicule.

Rocketry, perhaps more so than aviation, was the "stuff" of science fiction. Visible success—a rocket that successfully launches high and far—was also more difficult to achieve than success in aviation during these formative years. In addition, far fewer individuals were experimenting with rockets—thus, many fewer contestants might have stepped up to rocketry prizes were they to have been offered. Finally, a reason for using prizes in aviation might at first glance be the potential for commercializing the technology, but as noted earlier, this motive is far from obvious. A commercial profit motive in competing for aviation prizes per se (as distinguished from using the plane as a flying billboard for consumer products) is not evident in the written record—most of the competitions were "one-shot" (although, again as noted, some aviation product lines were spawned). More generally, the technological advances encouraged by aviation prizes were each incremental but taken together built a foundation for the evolving commercial aviation industry.

II. What's different now—an era of government-sponsored R&D

The climate for aviation prizes to reward technological advance pre-dated today's complex relationship between the private and government sectors in general and in space-related R&D in particular. The heyday of prizes was about 1900 to 1917—two decades in which aviation feats made the news for an attentive public interested in the new technology, thrilled by its daredevils, and newly enamored of all modes of transportation as the era of the auto began. The period was undoubtedly one of the most distinctive periods in the history of innovation. The private sector reigned in almost all economic sectors. For instance, almost 100 % of public transit systems—street railroads and trolleys—were privately owned, and individuals or private syndicates held about 85 percent of electric companies and 50 percent of water companies.

Economic growth was also rapid. Per capita income roughly doubled just after the turn of the century due to an economy-wide increase in output. It was the era of modernization in steel mills, the beginning of skyscrapers, and rapid urbanization. It was also the chapter of the great industrialists—Andrew Carnegie in steel, John D. Rockefeller in oil, J.P. Morgan in finance, and railroad magnates like Jay Gould, Edward Harriman, Collis Huntington, and Cornelius Vanderbilt. These entrepreneurs and their companies did the bulk of R&D.

Not surprisingly, government began to grow rapidly with the advent of personal and corporate income taxes in 1913 and a corporate excise tax enacted in 1909. Government spending increased from about \$500 million in 1902, to about \$900 million in 1913, then to \$1.8 billion in 1922 (all amounts are adjusted for inflation). Per capita government spending increased 2½ times from its level in 1902 to its level in 1922. World War I, the Depression, and World War II brought further large increases in federal spending. Most expenditures before 1915 were for defense, the postal service, and veterans services; by 1920, expenditures included these activities plus growing interest on debt and financing of air and water transportation.

Increased government expenditure during this time was not, however, directed towards R&D. About the only role of government in innovation—albeit an important

⁷ See von Braun and Ordway.

role—was protecting invention by way of the very active patent system. The large expansion of government R&D that characterizes today’s public sector began after World War II in the form of procurement contracts and peer-reviewed research grants to universities. At the same time, a new, so-called social contract between government and researchers evolved to provide for freely sharing the results of research in exchange for funding.⁸

Government involvement now extends well beyond protecting intellectual property to include direct subsidies and R&D tax credits as well as carrying out research at government laboratories or other facilities, often in partnership with the private and academic sectors. Government’s influence is far wider because a host of other policies, although not directed toward R&D, also significantly affect the rate and direction of innovation. These include safety and health regulation, mandatory labor practices, and environmental protection. Analyses evaluating the fruits of government-sponsored R&D reveal a mixed record. The supersonic transport, the Clinch River Breeder reactor, synthetic fuels from coal, and the photovoltaics commercialization programs are among “failures” according to most analysts.⁹ In other cases, government investment seems to have paid off. For example, a recent National Research Council study of fossil energy research supported by the U.S. Department of Energy found that a least a handful of R&D initiatives ranging from electronic ballasts in compact fluorescent tubes to atmospheric fluidized-bed coal combustions were “well worth it” in that the estimated net realized economic benefits were positive.¹⁰

III. The tight coupling of government R&D funding and aerospace

Government stepped in to fund and manage civilian space activity in response to Sputnik and the Cold War—putting a “government in charge” imprimatur on space activities. Government involvement continues—of all federal R&D money flowing to industry, about a third goes to the aerospace sector, and of that, 98 percent goes to nine companies.¹¹ Two-thirds of R&D funding in aerospace is federally financed.¹² Not all space developments have been publicly funded, however. There have been some important exceptions in which large amounts of private money were invested in developing space technology. NASA and the Department of Defense jointly funded a small amount of the development costs of the Hughes Aircraft Company to design the Syncom satellites (the first commercial geostationary communications satellites), but most of the funding came from the Comsat Corporation using money from common carriers and from a public stock offering.¹³ Private money also contributed to underwriting the cost and risk of developing the launch vehicle Pegasus and portions of the Sea Launch system. Like any industry, however, for every profitable success there are many more financial failures. There have been unsuccessful attempts to privately finance new space transportation systems, low-Earth orbit communications networks, and some commercial Earth-observations satellite systems.

IV. Prizes, procurement contracts, and peer-reviewed research grants in the 21st century

As government grew, prize offerings tailed off not only in aviation but also in other fields. There may be no causal link, or maybe there is one. The answer would shed some light on whether reinstating prizes now can be successful in inducing innovation. Part of the answer also rests with whether prizes are compatible with or offer significant advantages compared with the ingrained contracting and grant-making relationships between government and the private sector in space R&D. In any case, neither prizes nor, for that matter, other traditional approaches to R&D

⁸See historical discussion and references in US Congress, Office of Technology Assessment (1991), *Federally Funded Research for a Decade* OTA-S&T-490 (Washington, DC: U.S. Government Printing Office).

⁹The edited volume by Linda Cohen and Roger Noll (1991) *The Technology Pork Barrel* (Washington, DC: Brookings Institution) discusses these examples.

¹⁰National Research Council (2001) *Energy Research at DOE: Was it Worth It?* (Washington, DC: National Academy Press).

¹¹Federal funding of R&D increased from about \$ 50 billion in 1960 to over \$80 billion in 1990 (all figures in 2002 dollars), growing rapidly during the “golden years” for research after the launch of Sputnik and the commitment to land on the Moon. Federal R&D funding in recent years has been around \$105 billion.

¹²Tables A-9 and A-15, National Science Foundation, *Research and Development in Industry: 2000*, at <http://www.nsf.gov> (accessed July 2004).

¹³At the time, the public held half of Comsat’s stock and communications companies like AT&T, ITT, RCA, and Western Union held the other half. For more on the development of commercial communications satellites see John L. McClucas (1991) *Space Commerce* (Cambridge, MA: Harvard University Press).

sponsorship by way of peer-review or procurement contracts guarantee “success” in bringing about innovation.

Much of the preceding discussion has emphasized the historical success of prizes but they have some disadvantages. These include:

- no provision for up-front cash flow to defray expenses;
- duplication of research effort if many individuals or groups compete;
- uncertainty about whether the innovation can succeed; and
- delays in the pace of innovation if a lot of time elapses before it is determined that there are no winners.

In addition, prizes are unlikely to meet other social objectives that government sponsorship in general, or NASA sponsorship in particular, has traditionally pursued. For example, prizes do not necessarily further these goals that NASA has frequently set forth as success measures in its R&D policy:

- increase the number of academic researchers;
- increase the number of scientists and engineers;
- create jobs;
- influence political support by way of job creation;
- broaden the participation of traditionally under-represented groups in science and technology; and
- prop up a particular supplier or group of suppliers to ensure choice (say, to ensure that a range of capacities is available in space transportation by dividing business among companies that offer different classes of vehicle lift)

In addition, there are some disadvantages of *government-sponsored* prizes compared with privately sponsored prizes:

- Government typically cannot commit to funding beyond a fiscal year, thus limiting the timing of the prize competition and cutting short the time that might be required for the technical achievement it awards.
- Any uncertainty about whether the prize will actually be awarded due to government budgets or changes in administration will weaken if not eliminate incentives to compete.
- Intellectual property rights to the achievement may need to reside with the competitor to induce participation, even though the taxpayer, by financing the prize, could fairly claim rights. It is interesting to note that after contentious deliberations, in 1960 the U.S. government awarded the Guggenheim Foundation and Robert Goddard’s widow \$1 million in settlement for government use of more than 200 of Goddard’s patents (Goddard died in 1945).¹⁴

Some of these disadvantages are also an outcome of traditional grants and procurement contracts. And, grants and contracts offer some advantages over prizes. What follows summarizes some of the differences:

Asymmetry of information. The engineer/entrepreneur may have a better idea of the technical riskiness of the R&D than the government. In this case, offering an award upon completion of rather than in advance of research lessens the cost to the government of pursuing highly risky innovation.

Information and uncertainty. While prizes put the burden of proof on competitors, grants and procurement contracts, by requiring up front information, can more promptly reduce (although not eliminate) uncertainty about whether the innovation is feasible. Prizes may go un-awarded for the duration of the competition, and only then, after this delay, might it be concluded that the technology is not yet feasible (although other reasons may explain the lack of a winner). Using prizes can thus delay a determination that a technology is infeasible and delay pursuit of alternative paths that might have been more quickly pursued under a grant or contract.

Cash flow. Grants and contracts, by providing funding up-front, underwrite early stages of innovation. Prizes, by providing an award only upon completion, could create cash-flow problems for contestants or require them to spend time and resources to find financial support during the competition.

Who bears financial risk. Financial risk rests largely with the taxpayer under grants and contracts and projects can fail or be terminated before providing any return to the taxpayer. Prizes do not guarantee success but the financial risk rests with competitors and their funders rather than the taxpayer.

¹⁴ See von Braun and Ordway.

Safety risk. The early history of aviation is replete with accidents and fatalities in pursuit of innovation, but efforts continued with scarcely a hiccup. The government's approach to safety risk is wholly different, as illustrated by the lengthy shutdown of U.S. human space flight activities in the wake of the *Apollo 1*, *Challenger*, and *Columbia* fatalities.

Duplication of effort. A prize rather than a research grant made to one firm may have the advantage that “two (or more) chances are better than one” if there are several independent research programs. On the other hand, from a broad view of the Nation's resources as a whole, there may be wasteful duplication of effort if there are simultaneous research programs all pursuing the same goal.¹⁵

Awardees' incentives. Most peer-reviewed grants result in publications and sometimes, patents. By and large, grants are not intended for nor do they typically result in commercial products or services. Procurement contracts can satisfy government-unique requirements or lead to commercial feasibility. The motives for competing for prizes are less clear—in the history of aviation prizes, only a few entrants themselves followed up with commercial product lines, but they may have collected patents (the data about the long-term pay-offs to aviation prizes are sparse). Typically an award recipient, whether it is an individual competing for a prize or a corporation winning a procurement contract, capitalizes any expected commercial value of the research or innovation into their decision whether to compete.

Basic research, technology development, and commercialization. All three approaches can underwrite basic research, technology development, or commercialization. For example, a university researcher with access to a laboratory may be as interested in competing for a prize as in competing for a research grant. A private inventor may compete for an award for modest improvements in technology or may be inspired to research more radical innovation, irrespective of commercial potential. Prizes have been awarded for solving mathematical problems (the Wolfskehl Prize for proving Fermat's last theorem¹⁶) as well as for technology development with commercial potential—the motives for pursuing an award seem varied.

Failure. All three approaches provide an opportunity to learn what “doesn't work.” The Defense Advanced Research Projects Agency (DARPA), for example, had no winner in its recent, \$11 million Grand Challenge race for robotic navigation of a 142-mile stretch of the Mojave Desert. DARPA admitted that it was pessimistic about a successful finish because the technology is not yet that advanced, but also pointed out that learning from mistakes is a way to advance technology. The agency plans to hold the competition again in 2006. Similarly, a recent government contract for a follow-on Earth observation satellite system for the Landsat program was not awarded to any bidder because proposals did not meet all the criteria. In these cases, failing to find a winner signaled that the technology, cost, or both was not yet up to the expected par. The chance to learn more than this—that is, to learn more about details of engineering design, engineering cost, and so forth—is limited, however, unless competitors are required to share information about their approach rather than keep the information proprietary.

Because of these differences in prizes, grants, and contracts, all three approaches, taken together, can provide a good portfolio of tools to encourage innovation. As an additional note, in all three approaches, ownership of intellectual property needs to be determined and will affect the public and private pay-off to the innovation.

V. NASA prizes

The candidate Centennial Challenges identified by NASA for prize awards range from very low cost spacecraft missions, to breakthrough robotic capability, to revolutionary technology demonstrations.¹⁷ There is precedent in the history of prizes for awards to address all of these types of innovations. However, the specific candidate challenges that NASA has identified do not include prizes for Earth science—even though the language accompanying the Challenges preamble embraces Earth science. Innovation in Earth sciences might be a good prospect for prizes given the rapid pace of new sensor development and the manifested interest of the private sector in Earth observations.

It is hard to outline a formula for determining the size of the prizes—awards set too low may just miss inducing an innovation; awards set too high result in taxpayers paying more than necessary to induce the innovation. Not all competitors

¹⁵ Researchers have investigated the problem of “patent races” and whether simultaneous pursuit of a new technology leads to wasteful duplication. For example, see discussion in Jean Tirole (1988) *The Theory of Industrial Organization* (Cambridge, MA: MIT Press), Chapter 10.

¹⁶ See National Academy of Engineering (1999) *Concerning Federally Sponsored Inducement Prizes in Engineering and Science* (Washington, DC: National Academy Press).

¹⁷ See “Centennial Challenges Program” at <http://centennialchallenges.nasa.gov/workshop.htm> (accessed July 2004).

will necessarily be pursuing commercialization or an ongoing supplier relationship, if the history of aviation prizes is a guide to motives for participation. For this reason, potential commercial profitability may not figure in competitors' participation decisions or be relevant to government's procedures for determining the size of the prize.

In any case, if a prize is offered but not awarded, the outcome may signal that the technology is simply not yet mature enough at that price—important information for government R&D managers. For “tent pole” technology development—that is, technology that is essential in furthering a goal—the uncertainty of success in a prize competition weakens the usefulness of prizes (although grants and contracts do not necessarily guarantee success either).

Shortcomings of government prize sponsorship, as noted earlier, include commitments to funding across fiscal years, political administrations, and different Congresses. Problems also involve determining an appropriate allocation of rights to intellectual property developed with taxpayer support but possibly of commercial proprietary value. It would be useful for competitors to share results even if their attempt is unsuccessful (learning by doing), but so doing could undermine expected private value and thus come full circle to discourage participation in the competition.

Involving a broad range of expertise, including outside experts, may be an advantage in structuring government-backed prizes. For instance, it may be desirable for a board of directors consisting of experts outside of government to administer and judge contests. Because a prize can “ferret out” new ideas, eligibility to compete should also be broad (the Centennial Challenges prohibit federal employees and employees of federally funded research and development centers (FFRDCs) from competing, but much talent in aerospace is at NASA centers and FFRDCs).

VI. Conclusions

The history of prizes is attractive enough to warrant experimenting with their use in NASA activities. Further review of the structure of previous contests (their guidelines, funding, and results) and in particular, their assignment of property rights would provide helpful “lessons learned” as plans proceed. But prizes cannot fully substitute for peer-reviewed grants and procurement contracts. Even though these funding mechanisms are far from perfect, they balance some of the disadvantages of prizes. Taken together, all of these forms of financial support make up a portfolio of tools for encouraging innovation.

BIOGRAPHY FOR MOLLY K. MACAULEY

Dr. Macauley is a Senior Fellow with Resources for the Future (RFF), a research organization established upon the recommendation of the presidentially appointed Paley Commission in 1952. Dr. Macauley's research at RFF includes the valuation of non-priced space resources, the design of incentive arrangements to improve space resource use, and the appropriate relationship between public and private endeavors in space research, development, and commercial enterprise. Dr. Macauley has been a visiting professor at Johns Hopkins University, Department of Economics, and at the John Hopkins School of Advanced International Studies. She has also been a visiting professor at Princeton University in the Woodrow Wilson School of Public Affairs. Dr. Macauley has testified before Congress on the *Commercial Space Act of 1997*, the *Omnibus Space Commercialization Act of 1996*, the *Space Business Incentives Act of 1996*, and space commercialization. She has served on many national level committees and panels including the congressionally mandated Economic Study of Space Solar Power (Chair), the National Research Council's (NRC) Aerospace and Space Engineering Board's steering committee on issues of technology development for human and robotic exploration and development of space, the NRC Space Studies Board steering group on space applications and commercialization, and the NRC Space Studies Board task force on priorities in space research. In 1994, she was selected as one of the National Space Society's “Rising Stars,” and in 2001 she was voted into the International Academy of Astronautics. Dr. Macauley has published extensively with more than 70 journal articles, books, and chapters of books. She has served on the Board of Directors of Women in Aerospace and is President of the Thomas Jefferson Public Policy Program, College of William and Mary. Her Ph.D. in economics is from Johns Hopkins University and her undergraduate degree in economics is from The College of William and Mary.

Chairman ROHRABACHER. Well, thank you very much for your provocative testimony. And I am sure we will get around to some dialogue, maybe even interpanel dialogue, on some of the issues

you have brought before us today. Just to remind you, however, someone did say that the era of “big government” is over. I don’t know what happened after that, but I remember somebody said that.

So Mr. Holtz-Eakin—now pronounce it for me.

Dr. HOLTZ-EAKIN. Holtz-Eakin.

Chairman ROHRABACHER. Holtz-Eakin. Mr. Holtz-Eakin. Dr. Holtz-Eakin.

**STATEMENT OF DR. DOUGLAS HOLTZ-EAKIN, DIRECTOR,
CONGRESSIONAL BUDGET OFFICE**

Dr. HOLTZ-EAKIN. Mr. Chairman, Members of the Committee, international guests, the CBO is delighted for the chance to appear today. We have submitted our testimony for the record.

Let me simply make four points that will reflect some of the comments that have been made by the panel members before me. In some circumstances, prizes—inducement prizes and incentive prizes are an effective means to acquire new technologies, and thus, as Dr. Macauley said, would be a useful addition to the portfolio of tools that NASA has to pursue its objectives in aeronautics and space. However, prizes are not a panacea. While at the level of individuals, it will alter the mix of risk and rewards and may induce new entrants: those with a greater taste for risk, those who are currently curtailed by the barrier from federal procurement compliance. This may induce these new entrants into the pursuit of accomplishment. At the aggregate level, the use of prizes does not change the ultimate technological challenges or the research requirements. And for that reason, if they are deployed in the pursuit of great and risky challenges, they will require correspondingly large prizes in order to be successful.

And the prizes are more than the money. As has been emphasized before me, the rules in pursuit of the prize must be clear and consistently employed. That—an important consideration in thinking about setting out the rules is what constitutes the timing in pursuit of the prize, who will be eligible to participate, and when is new participation cut off. What will be the rules for the transfer of the ultimate technology at the end of the pursuit of this prize, and who will have the rights to that will be an important part of the incentives provided by the prize. And finally, the prize payoff must be assured, which will, in fact, in this context, largely depend on the budgetary treatment.

Now that budgetary treatment in the end will depend on how Congress chooses to write any such legislation. And the two examples that exist at the moment, I believe, show some of the outer boundaries of the possibilities. The DARPA prize that was mentioned earlier is financed out of annual appropriations. In 2004, when it was not awarded, the \$1 million was reprogrammed and used for other purposes. The \$1 million was not large, relative to the overall budget, and was relatively assured in the eyes of the competitors. Larger prizes might not be suitable in that circumstance because of the possibility that a large prize would be subject to rescinding or reprogramming. In those circumstances, what NASA has requested in this—for the Centennial Challenges, is an authorization of appropriation of now-year money. Money

that will be available in whatever year in which the prize might be awarded, it would be subject to appropriation, but once appropriated, that budget authority would remain present until the prize was used and would provide some assurance to competitors that the resources would ultimately be there upon completion of the technological objective.

Those are the four major points in the testimony. They are reflective, I think, of the issues that have been surfaced by the panel members before me. We look forward to answering your questions. [The prepared statement of Dr. Holtz-Eakin follows:]

PREPARED STATEMENT OF DOUGLAS HOLTZ-EAKIN

Mr. Chairman, Congressman Lampson, and Members of the Subcommittee, thank you for this opportunity to present the Congressional Budget Office's views on the basic economics and budgetary treatment of cash prizes, or inducement prizes, like those that would be included in the Administration's Centennial Challenge prize program proposed in the 2005 budget for the National Aeronautics and Space Administration (NASA). In my remarks today, I would like to make four points:

- In some circumstances, inducement prizes are an effective means of acquiring technologies that the government deems desirable but that are unlikely to be provided by private markets. But there is no free lunch. Innovators and researchers must be paid for what they do. Inducement prizes have to be very large if the objectives sought are risky and expensive.
- Prizes can be most useful when the government seeks participation in research efforts by people or firms that might not participate in the traditional procurement process. Contests offer the advantage of lowering the barriers to entry typically posed by the government's procurement procedures.
- The rules and structure of contests can make a difference in the level of effort put forth by participants and in the payoff to the government.
- Inducement prizes entitle successful competitors to a future payment. To fulfill that type of commitment, the sponsoring agency needs to have sufficient budget authority to cover the potential payment before offering the prize. As a general rule, money needs to be appropriated up front for the full cost of the prize.

No Free Lunch

An inducement prize is one among many means that the government can use to spur the development of innovative technologies. Like direct production, contracting for specific systems, and research grants, cash prizes have characteristics that make them a more or less effective way to do business depending on the circumstances. But prize competitions do not change the underlying factors that determine risks and rewards. An individual or business choosing to participate in a government-sponsored contest will address those risks and their cost in deciding whether to enter and, once entered, in deciding how much effort to undertake. Large and expensive technical risks will require large prizes if they are to induce effort.

Charles Lindberg won a \$25,000 prize when he succeeded in flying from New York City to Paris in 1927. Inflated to 2005 dollars, that prize amounts to a little over \$260,000—a very small amount measured against the scale of NASA's major programs. Advocates suggest that inducement prizes are more likely than traditional contracting to produce revolutionary technical changes that reduce costs because they bring new players and new ideas to the playing field. That may be the case, but the point remains that the large scale of the projects that dominate NASA's programs—for example, the Crew Exploration Vehicle is currently estimated to require development expenditures of over \$12 billion (in 2005 dollars)—would probably require prizes of the same order magnitude as the current cost estimates, if they were to produce the desired results.

Prizes are not new; there are examples from the United States and abroad currently in effect and stretching back to the 18th century.¹ Before Lindberg won his prize, Glenn Curtis won prizes of \$2,500 in 1908 and \$10,000 in 1909 for achieving

¹See Steering Committee for the Workshop to Assess the Potential for Promoting Technological Advance Through Government-Sponsored Inducement Prizes in Engineering and Science, *Concerning Federally Sponsored Inducement Prizes in Engineering and Science* (Washington, D.C.: National Academy of Engineering, November 1999), Appendix A.

a set of firsts in wheeled takeoffs and flight distances.² In the early 1700s, the British Parliament offered a substantial prize to the developer of a means to gauge longitude at sea. As this Subcommittee is well aware, the privately funded Ansari X-Prize offers \$10 million to the first team able to fly a vehicle carrying one person, but capable of carrying three, to an altitude of 62 miles above the Earth and return safely, twice within a 14-day period. And in 2004, the Defense Advanced Research Projects Agency's (DARPA's) Grand Challenge offered a prize to the first developer of a robotic rover capable of completing a challenging desert obstacle course.³ Although no contestant succeeded this year, the competition will again be run in October 2005.

Prizes and Participation

What is different about prizes, and what advantages may they offer? Experience from both the Ansari X- and DARPA prize contests suggests that inducement prizes will draw untraditional participants and ideas that the usual contracting procedures will not. Thus, the prize mechanism may be most valuable when the government is seeking to achieve a specified objective but has little idea of how to do so, and therefore wants to encourage a wide variety of approaches.

Probably the main reason that prize competitions induce wider participation than other lures the government can use is that they impose few contracting and accounting requirements. Such requirements pose significant barriers to entry by newcomers, especially small firms, in traditional competitions for government contracts.

A second factor that might play a role in inducing wider participation is the prestige associated with winning an open competition. Relatively unknown entrants might find a well-publicized competition more attractive than an equivalent procurement contract if winning would provide a larger boost to their credibility in the marketplace. They might also value the resulting prestige more than established firms would and therefore be more inclined to participate.

Rules and Structure

The rules and structure of a contest matter and are likely to be critical to the government's getting its money's worth for the prize offered. My testimony touches on only a few of the major points from the substantial body of literature on the subject.

Most important, the contest's rules must be adhered to. Awarding a prize for performance that falls short of the designated finish line establishes a precedent that contestants may use in future competitions to claim rewards for less than complete success. To successfully make repeated use of contests, the government must establish a reputation for following the rules that it establishes.

Clarity in the rules is also essential. Unclear or unenforceable rules are an invitation to conflict, and the government will bear a cost of adjudication when disputes arise. Conflicts over rules in the Federal Communications Commission's auctions of licenses to use the radio spectrum and in its Pioneer's Preference policy (which granted spectrum license rights to the developers of innovative technologies or approaches to using the radio spectrum) are relevant illustrations. In both cases, unclear rules led to prolonged and expensive legal disputes between the government and private parties.

A cash award contest could be structured as a tournament or race, each of which offers advantages and disadvantages. A tournament, which specifies an objective and a time limit, guarantees an award to the party that has made the most progress toward meeting the objective. It encourages participation—parties with substantial uncertainty may enter on the basis of partial insights—but can impose high costs on the government for evaluating many participants' relative progress toward the goal. In contrast, a race specifies a goal and may or may not specify a time period, but an award is made only if a party achieves the goal. Participation may be less than if partial success is rewarded, but the government pays only for meeting the specified objective and is likely to incur lower evaluation costs because unequivocal success is more easily judged than progress toward the goal.

Rules governing entry and elimination, if the contest has phases, are also important. A competitor for a cash prize makes decisions about whether to enter and how much effort to expend mindful of the odds both of achieving the goal and of achieving it before competitors do. More entrants worsen the odds of being first and lead to decreased effort. Fewer entrants, however, may deny the government the benefits

²U.S. Centennial of Flight Commission, "Glenn H. Curtiss" available at www.centennialofflight.gov/essay/Explorers—Record—Setters—and—Daredevils/Curtiss/EX3.htm.

³The DARPA Grand Challenge is described at www.darpa.mil/grandchallenge.

of capturing a wide array of novel approaches—one of the main reasons for choosing a contest over other forms of acquisition.

The designers of a government-sponsored contest face the problem of structuring the competition so that rewards are sufficient to offer a good prospect of success but take account of the subsequent benefits of spreading technological innovation to the larger economy. A competition that limits the patent rights of a successful winner will attract fewer entrants and less effort but at the same time allow for the rapid diffusion of technology. In some cases, offering a larger prize to attract more entrants and greater effort in exchange for intellectual property rights may make sense for the government.

In many circumstances, cash awards may be outstanding for a number of years. For example, the \$10 million Ansari X-Prize was first offered in 1996. To provide the same inducement today, the prize would have to have grown to over \$12 million. Government-sponsored competitions could maintain a constant level of real incentives by indexing the value of prizes to the rate of inflation. Also, in the interest of matching rewards and effort, contest rules could specify increasing rewards at the government's discretion. For example, DARPA is increasing its challenge award from the \$1 million offered in 2004, when no competitor completed the course, to \$2 million for the 2005 race. Elimination rounds could also be used to intensify the competitive effort. As the number of competitors decreases, their improved prospects of finishing first increase the expected value of the prize and prompt greater effort.

Financing and Federal Budgetary Treatment

Policy-makers have several alternatives for the financing of prize money. To best encourage successful competition for advancement in space travel and exploration, however, the government would have to make clear that the funds to reward the winners were available and were not contingent on future legislative actions. That approach would mean providing the budget authority up front—appropriated by the Congress and accounted for in the federal budget. Were funds to be appropriated later, a degree of uncertainty would probably limit participation.

Practices in the private sector also suggest that a sponsor may tailor its financing to the nature of the prize. For example, recipients of performance awards like the Nobel Prize have no fixed expectation of receiving the prize, so the sponsor has no obligation to fund a specific number or size of awards. In contrast, individuals or businesses vying for an inducement prize are opting to compete on the basis of a promise of a specified payment. As a result, the sponsor must guarantee that it will be able to pay the amount promised at the time promised. The Ansari X-Prize Foundation is being funded by private donations, but the amount and timing of the payment are backed by an insurance policy, making it clear to competitors that the funds will be there for a successful entrant.

Most existing federal prizes are used to recognize past performance—for instance, the Malcolm Baldrige National Quality Award and the Vannevar Bush award for public service activities in science and technology. Such awards typically are in the form of medals and other non-cash compensation, but agencies still need funding to cover the cost of the prizes and the programs. Such programs are funded by annual appropriations, so the level of funding can fluctuate from year to year depending on federal priorities.

DARPA's 2004 competition illustrates the approach of appropriating the full cost up front. The budget authority for the \$1 million prize was included as part of the agency's \$2.8 billion appropriation for 2004. When DARPA announced the competition, it reserved the \$1 million needed to cover the potential payment. Once the competition ended without a winner, DARPA released those funds and was able to use the money for other authorized purposes. Had there been a winner, the agency would have incurred an outlay when it paid the prize.

Very large cash prizes may require additional measures to secure a future federal payment. Given the amount and short time horizon of the DARPA prize, competitors may be confident that the agency will be able to pay the \$1 million. Competitors may have less confidence, however, if the promise to pay extends several years into the future, especially if the prize represents a much larger share of an agency's budget. Funds appropriated for a payment that is in the future but have yet to be obligated can be rescinded or otherwise limited by subsequent legislative action, especially if federal policies toward the program's objectives change.

Proponents of prizes valued at hundreds of millions or billions of dollars must consider ways to balance contestants' need for assurance about the funding with the cost of ensuring payment. As mentioned, the sponsors of the X-Prize purchased an insurance policy to guarantee the prize money. Alternatively, federal funds could be put in a private escrow account, but such a transaction would involve making the payment—that is, a budget outlay—at the time the money was put in the escrow

fund; if there was no winner, unclaimed funds would be returned to the government, but that receipt would not occur until after the competition was over.

The budgetary impact of any award program ultimately depends on policy-makers' choices about the terms. Specifying the amounts authorized to be appropriated is the key element of Congressional control, but other terms are important as well. NASA has requested authority for a permanent award program, not a pilot program. Individual awards would be limited to \$10 million (although the Administrator or his or her designee could increase that sum), and any appropriated funds would be available indefinitely (as so-called no-year money). That approach would give the agency latitude in setting the duration of competitions without risk that the authority would lapse, and it would allow the agency to reuse any unclaimed (and therefore unobligated) funds for other competitions.

DISCUSSION

Chairman ROHRABACHER. Well, thank you very much. And that was a very good summary, I might add, so I appreciate that.

We have—Ms. Jackson Lee has joined us. Thank you very much.

We now will go into some questions and answers. And I—first a little bit about—I think the risk issue has been pretty well addressed by the testimony. And there—you know, two points of view on how much risk—you let us know that Charles Lindbergh and, as you mentioned in your testimony, there were people dying before Charles Lindbergh took off, and he took off anyway. And the question is was that a good thing that Charles Lindbergh took off and ended up flying across the Atlantic and accomplished his mission. I think it was historic. I think it did something for the spirit of the American people. And it was a risk. There was no doubt about that to the people that died beforehand. But did that do great things for America and for the world? I think it did.

If anyone disagrees with that, I—please feel free to jump in. We don't want to attack the memory of Charles Lindbergh here. Okay. All right.

I think all—what we hear also is this—the testimony about hybrid rockets and how the fact that they were ignored by the establishment. There is no doubt that this idea about awards and prizes is an idea that is trying to get around the fact that our establishment seems to be stuck in a morass. And is—and the established institutions in our society that are supposed to be leading us on technologically and upward into space are not working. It is not happening that way. There is too much—and whether it is private sector or public sector, there is too—the bureaucracy and politics that has developed over the years like slag on a rocket nozzle is keeping us down. And it is preventing us from taking advantage of ideas that are already here. How long did you say the hybrid rocket has been around? Which—was it Bob who mentioned that?

Mr. WALKER. Yeah. I—the Amroc technology goes back into the '60's, I think. I am not exactly certain of that, but I think Amroc—it was the '60's or the '70's when they first came up with the concept that is today being used in the hybrid rockets that Space Dev is building.

Chairman ROHRABACHER. So we need to make sure that we have a system that will—in much—be able to reach out and be able to use these new technologies, which are now being cut off. Let me ask about how we see the—and by the way, there is a mention of duplication of effort as—might be a cost in this. Yes, there is a—you know, there is analysis that can have a down side to every-

thing, but I know that we were up against a system that eliminated all of the duplication of competition. We were up against that system for 50 years. And by the end of that 50 years, that system couldn't produce toilet paper. And I remember going into stores in communist countries, and they had eliminated all of the competition in toothpaste, for example. You go into a communist store and it said "toothpaste." And that is all it had, "toothpaste." It didn't have "gleam" or didn't have these various, you know, "all bright" or whatever kind of toothpaste. You go into a store now, we have got toothpaste of every kind and variety you could imagine. But what struck me about the toothpaste in communist countries is it was awful. It was really bad. And yeah, there is some duplication when you have competition, but I have a feeling that it actually is worth it. And that is just a thought.

ORGANIZATION OF PRIZES

About how we would organize this idea of prizes, what structure we would use if we accept that it is an idea—a good idea. If, in the end, the downside is looked at the upside and we all—and we come to a consensus in our society that it is a good thing to move forward on this idea, where will we put it and who will make the determinations? A lot of these questions have been talked about today. Let me ask, is it a better idea to create a separate foundation? Can this be done within NASA? The Chair would personally suggest that it might be a good idea to establish something like the National Endowment for Space Technology and Innovation, something like that, which would put a group of people outside of the current structure in a position to offer the prizes, oversee the prizes, and to make sure that they were paid. But that is just an idea. Maybe if we go down the panel of how you would see the—can it work within NASA? And if it can't, what is the best alternative?

Rear Admiral STEIDLE. Sir, I thank you, sir. I, of course, from the perspective of where I am, feel that it is in the right place, sir, right where it is now, and that—and for this reason.

Chairman ROHRBACHER. I thought you might say the Navy would be the best place to put it. But—

Rear Admiral STEIDLE. Yes, sir, a year ago, I would have said that. Yes, sir. But what has to be done is the focal point of these particular challenges. There needs to be a focal point on where are we headed with this, what are the requirements, what are the particular aspects that we hope to achieve and the expectations. The President's Vision right now gives us those particular directions and focus and vision around which we can place the Centennial Challenge Program. It also gives us a scope in the programs that we have from our traditional procurement processes and RFPs and RFIs through small business innovative research into technical transfer programs to another aspect called Centennial Challenges. So I think if it was put somewhere else other than this, you must have, I think, some sort of a link back to the visions and the expectations that you need. And for that reason, I think where it is right now, focused on the Exploration Vision that the President provided, it is a perfect addition.

Chairman ROHRABACHER. We are going to be watching the Centennial Challenge and how it works and note its successes and failures. And you will be a good guide for us. Thank you very much.

Mr. Walker.

Mr. WALKER. Mr. Chairman, I think that the testimony from the CBO may have given you a guideline here. It seems to me that it is entirely appropriate that the—NASA would have some discreet kinds of technology that it would utilize prizes for and that they would be for fairly nominal sums inside an appropriation cycle that everybody understood it—what was manageable. But if you want to go for a really big prize, the kind of thing that I was talking about, you may want to reach outside NASA. I mean, if you are going for a \$100 million prize or a \$200 million prize, something along those lines, you may want to have a separate foundation that you charter and you may put some government money into it or you may provide the kinds of tax incentives that would allow that chartered foundation to raise the money. But that may be a more appropriate mechanism if you go for a very big kind of concept.

Chairman ROHRABACHER. Perhaps even having a tax credit—

Mr. WALKER. A tax credit might be another way of doing it to assure that someone with a large amount of wealth that wants to be intimately involved with such a program would have the ability to get in it.

Chairman ROHRABACHER. Right.

Dr. DIAMANDIS. Mr. Chairman, I would like to go on the record to say—

Chairman ROHRABACHER. You need to push a button on that. Okay.

Dr. DIAMANDIS. Thank you. I would like to go on the record to say I don't think there is a need to charter any kind of a new organization or foundation. Organizations, like my organization, X-Prize Foundation as a private foundation, would be thrilled to work in partnership with NASA. In fact, our very existence has been to pull together the global expertise to manage and run prizes, I would say, on an efficiency that is not seen elsewhere. One of the things that a private foundation can do in managing it is be innovative, such as go take NASA funds. Of course, the rules need to be set in concert. The objectives need to be set in concert with NASA. NASA is the customer—or the American people are the customer through NASA's eyes and vision. But a private, outside foundation can do things such as go and match that money from outside private corporate money, make deals with media companies to bring media attention and their capital. I think it is not unlikely that NASA money could be matched 4:1 with outside capital, so a \$10 million prize becomes a \$40 million prize. And you have a level of, also, independence that I think is critical to getting teams to compete.

I promised to read an e-mail here from Burt Rutan today, because he was unable to come out. So I will read this. I agree with some of what he says, not necessarily all of it, but I am going to read it nonetheless. It says, and this is with all due respect to NASA, and Burt is sometimes outspoken, so my apologies in advance. It says, "The Congress must direct NASA to conduct the prizes in the only way that they can work, to allow innovation and

provide an atmosphere that will result in breakthroughs. That was done by Kremer and Orteig and X-Prize, i.e., the dollars were offered and guaranteed, but the offer had nothing to do with how the applicant approached the problem and had nothing to do with what risks the applicant should take. In fact, there should be no information passed until the applicant is ready to fly for the record. The DARPA \$1 million prize for robotic vehicles was not run correctly. DARPA spent \$6 million to monitor the applicants, six times the prize amount, and DARPA's work all tended to dissuade innovation. I have no faith that NASA knows how to run a technology prize. They must be directed by Congress to do it right." I do know that, you know, we have a 10:1 ratio in the other way in terms of the amount of money we spend to run the prize on an annual basis versus the prize amount. And we have been able to go out and attract a lot of innovators and benefactors, which I think could also be done to leverage NASA's dollars.

Chairman ROHRABACHER. Let us note that I think it was Mr. Rutan that said that this—his project cost, what, \$20 million to come thus far, and he said that had this been done totally within NASA, that it would be—that would have been paying for the blueprints.

Mr. WALKER. Mr. Chairman, what he has said is it cost at least \$20 million.

Chairman ROHRABACHER. At least 20 million? So I would suggest that this is a very low estimate on the part of Mr. Rutan that if it had gone through NASA it would have been—the blueprints would have been more like \$50 million and to complete the project, it would have been a \$500 million project. \$500 million for what was done in the private sector for \$20 million. Now people can disagree with that, but I think that that is not totally—that is not an outlandish thing to guess on my part.

Finally, the last two witnesses on how we should structure it, and then we will do Ms. Jackson Lee.

Dr. MACAULEY. Mr. Chairman, you suggested a National Endowment for Space Technology and Investment—Space Technology Investment. And I have a problem with that, because the acronym is NESTI, and I think we should do better than that, so let us go back to the drawing board on the name. But I think it is absolutely essential that the money and the administration and the rules and the judging be outside of NASA for a number of reasons. One is, as I indicated in my testimony, I think eligibility needs to extend to the talent we have at NASA centers and FFRDCs. The only way to avoid a conflict of interest there is to decouple the administration, judging, et cetera from NASA.

Secondly, I can already see the kinds of administrative legally and regulatory required burden that is going to be put on a NASA-administered prize. And to whatever extent we can decouple it through a quasi-private/public instrument or a colleague of mine suggested, because we already have a government relationship with them, the Smithsonian Institution, but it has its own set of problems. But also, our community is so insular; we talk with ourselves and among ourselves. And we have got to engage the Vanderbilts and the Carnegies that are the titans of other than space industry. And we can do that if we have them work on this

as part of a Board of Directors for this prize. Our space community talks to itself. We are too insular. We have got to reach out and engage the titans of our industry and other industries. And that is—a nice vehicle to do it is to have them to be involved in this prize situation.

Chairman ROHRABACHER. Thank you. Let us note that we have people—the space industry and this X-Prize actually reaching out to titans of other industries, other entrepreneurs, people who were in the dot-com industry and the—and in the Internet. And there are people with huge resources there that are very interested in this arena. And that is what this private alternative has actually mobilized.

Mr. Holtz-Eakin and then Ms. Jackson Lee.

Dr. HOLTZ-EAKIN. Well, statutes preclude me from making specific recommendations, so I won't offer up the CBO as the location for this, but I will suggest that there are two kinds of considerations that would offer—enter into the decision. The first is what institution is best suited to pick the objectives for such prizes. The formal research literature on the use of prizes suggests that they are most effective in situations that are characterized by great uncertainty about how to literally get from point A to point B and not situations in which the risks are level of effort, management, or financial risks, the costs come in higher than you expected. So finding those kinds of situations and using prizes for them is really the threshold question. What are we trying to do?

The next consideration would be which institution is best suited to create the certainty in the rules, not changing the rules in the middle of the game, and in the payoffs and the final ownership of the technologies. And those are the things that should decide it, not the labels on government versus non-government.

Chairman ROHRABACHER. Okay. Well, thank you very much.

Ms. Jackson Lee, thank you for giving the Chair a little extra time.

Ms. JACKSON LEE. Thank you, Mr. Chairman. Thank you very much, Mr. Chairman.

And it is a pleasure to be able to have the distinguished former Chairman of this distinguished Committee before us. And we thank you for the work you have done during your tenure here in Congress and certainly the commitment that you continue to have in the business of science in America. When you were Chairman, and I still continue to say, but we have moved into a new century, and isn't that terrible to be able to say. That will be good for your book. But I have said always that science is the—then the work of the 21st Century. I will continue to say that science does create opportunities for this century and centuries to come. So this is an important hearing from the perspective of, I think what Dr. Holtz-Eakin just mentioned. It—this hearing speaks to the question of getting from A to B with a great deal of uncertainty or the issue would be one of, at this point, so problematic that we didn't even know what we were discussing. So you are sort of reaching far into the unknown is what I think you are suggesting that prizes might be the best for.

Mr. Chairman, you know that I have been, hopefully, a passionate advocate for space exploration and certainly space and aer-

onautics and certainly the cutting-edge research. And so this hearing is important for that reason. I don't think I have a particular stake, at this point, in whether it is government or private, but I do wish to raise some issues. And I ask unanimous consent, Mr. Chairman, for my entire statement to be put into the record at this time.

Chairman ROHRBACHER. Certainly, with no objection.

Ms. JACKSON LEE. Thank you.

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

PREPARED STATEMENT OF REPRESENTATIVE SHEILA JACKSON LEE

Thank you for calling what promises to be a provocative hearing. Contests and prizes seem to be a clever way of encouraging development of space technologies. It will be interesting to explore how this mechanism can be used to supplement our nation's space program.

However, Mr. Chairman I must question the choice of this subject for a hearing, at this moment in time. Just last year, we lost the Space Shuttle *Columbia* and her seven brave crew members. We got a tough report from Admiral Gehman and the CAIB, giving a laundry list of changes that need to be made at NASA to improve safety in the future. I have been pushing for a NASA safety hearing for six-months now, to find out what changes are being made and whether legislative action is necessary.

The CAIB reported that NASA's management practices and safety "culture" were partially to blame for the Shuttle disaster. Obviously, the same management and culture were responsible for developing the International Space Station. I have been expressing my concern for nine-months that the ISS may have its own hidden O-ring or falling-foam problem. Over the past six months, we have seen failing gyros, broken exercise equipment, faulty space suits, air quality monitoring devices, and our astronauts heard a crunching sound that is yet to be explained. We have not fully reinforced the ISS to shield it from micrometeoroids, and the small crew and grounding of the Shuttle may make it difficult to deal with other challenges in the future. It seems that having a hearing to talk about ISS safety issues could be fruitful.

I know other Members of this committee have been concerned for years about accounting and cost-overruns at NASA. As we are considering a bold new mission at NASA, it seems that delving into some of these financial matters might be prudent.

There are so many pressing issues at NASA. I am curious why we are discussing prizes today. Perhaps the latest activity surrounding the X-Prize has made this hearing more press-worthy, but I can't say that the hearing is particularly timely. These prizes have been around for centuries, and we don't have a legislative proposal before us to consider.

Mr. Chairman, you know I am a passionate advocate for space exploration and enjoy discussing ways to get our industries to lead in the field, and the American people more engaged in such noble pursuits. I just wish that as this Congress comes to a close, we can focus some of the Committee's energies on the truly pressing issues that face NASA and our space mission.

On today's subject, I would also like to note: prizes may well be an exciting and valuable tool to spark innovation in our space industry. However, there is no such thing as a free lunch, or free launch, I should say. There will be trade-offs: perhaps we will sacrifice the rights to royalty-free use of the technology later; perhaps we will lose the ability to monitor progress in the field; perhaps our universities and non-profit institutions will be cut out of the program; perhaps safety will suffer. I look forward to discussing the benefits and possible pitfalls of prizes and contests.

Thank you.

Ms. JACKSON LEE. As I have said, I appreciate this hearing, because I think it is important, because I think dreamers in America and inventors are part of what the American psyche is all about. And I would acknowledge to Dr. Macauley that I would in the issue of space prize is the progeny of a George Washington Carver could also be included and also as we seek to include and encourage more young women to get into math and science and certainly more Hispanics and African Americans and other minorities to do so as well.

So there lies my angst and my concern as we talk about prizes. Let me raise several points, and I would hope that my colleagues would welcome the dialogue.

First of all, as it relates to the government, let us not play cheap all ability to research and to discover. I think we have pinpointed the Internet to the Pentagon, some lowly government bureaucrats who—that they might be called, and others who pinpointed that beginning. And we appreciate very much their leadership on that issue. So we know that we have the ability to discover and to find great challenges or great resolve to the problems of America.

But I also raise the point of this hearing in that we have a number of other important issues that I think would be welcomed before the Science Committee, and I just want to share this with my colleagues. We still have to finish out the Columbia Accident Investigation Board's recommendation. The Gehman Report is extremely important. I have been a strong and long advocate of International Space Station's safety. And each day, we hear of matters that draw us to making sure that we have that hearing. We must as well fix cost overruns and accounting problems, and we also need to address the Aldridge Commission's recommendations.

I hope that, as we look at this exciting opportunity for prizes, we are not failing to address questions that will allow us to go into space safely. I think risk taking is something that Americans have always done. That is why we are the kind of Nation that we are. But, in fact, I think we must be concerned about safety, and I am still looking forward, Mr. Chairman, and you have agreed, and I must compliment you on that, that a safety hearing on both responding to the Gehman Report, but more importantly, the International Space Station is extremely important. I would love to have a prize dealing with how we make that entity safe to the extent that we feel very comfortable with it. And I know, again, that when you go into space it is a risk.

But let me pose these questions. And let me start with Dr. Holtz-Eakin on two aspects of your points that you made. And I would appreciate your response. First of all, you said the prizes do have their place. They are certainly useful for individuals who don't have a stomach for the procurement process and clearly want to be able to move more quickly than we would allow them to go. But how would you propose to score? How would CBO score prizes, and, for example, with the \$20 million requested for prizes in NASA, which we have already discovered may be a little too low, budget—be counted against the fiscal year 2005 budget or would it be counted against the year in which the prize is awarded? Would the way the rules are written for the prize affect the way it would be scored? And you sort of mentioned partly that, but if I could get a more enunciated position.

Let me also suggest that we have a number of programs that are going on, the Small Business Innovative Research Program, the SBIR program, which is described as a highly competitive, three-phase award system, which provides qualified small business concerns with the opportunities to propose innovative ideas that meet the specific research and development needs of the Federal Government. SBIR, in particular, seems to have goals similar to NASA's proposed Centennial Challenge Prize Program. What do you see as

the relative strengths and weaknesses? Can we utilize those? Are we being duplicative when we talk about these huge and large prizes?

Finally, let me say I am concerned with small businesses, minority-owned businesses. And as I look at the think tanks, I would be interested to know whether those folks are even included. As I tussle with the NASA procurement system, let me say that I am not very happy with what NASA has done. Johnson happens to be in my Congressional area or region. I still get calls often from small businesses and minority-owned businesses that they just can't break through, and their product is competitive. So we talk about prizes, although I know that is to reward people for their innovativeness in their research. Do we have any way to ensure that it is encompassing and open to everyone and give everyone an opportunity to be able to participate in a new scientific breakthrough?

BUDGET TREATMENT FOR PRIZES

With that, I would yield to Dr. Holtz-Eakin on those two specific questions on your \$20 million, and that seems like a small amount, but also any other side existing programs that might be useful in this effort.

Dr. HOLTZ-EAKIN. The budgetary treatment will be driven by the legislation as written, but the broad principle is that the budget should reflect the cost or the commitment that has been made of the taxpayers' money. And so in the specific case of the NASA request, as we understand it, there would be authorization of the appropriation of monies, \$20 million, and that appropriation would be now-year money, so there would be a commitment of budget authority of \$20 million that would last in principle and perpetuity that would allow NASA to award the prize. That would be a budget authority. It would be scored in the year in which it was award, 2005 say. When the monies are finally paid, in the event of a winner of the prize, then it would show up as an outlay in the federal budget, so there would be a large time difference between the budget authority being granted and the outlay being recorded on the budget.

There are lots of other possibilities, depending on the degree of certainty with which the funds are actually committed. If there was just a single-year appropriation with no ability to carry it from year to year, then there would be budget authority and, perhaps, no outlay in that year and it would disappear and be rescinded, and perhaps, reprogrammed. So it really will depend on how it is structured.

With regard to the SBIR, I don't know enough right now to give you a good answer. We would be happy to work with you on that and get back and look at comparisons.

Ms. JACKSON LEE. If I may, Mr. Chairman, for Dr. Macauley and Dr. Diamandis.

Dr. DIAMANDIS. Diamandis.

PRIZES AND DIVERSITY

Ms. JACKSON LEE. Thank you for correcting me.

Tell me about this concept of the prize and how it would be encompassing and take into account my concerns for the emerging populations of scientists and engineers and innovative thinkers? Science is not very diverse right now, frankly. And all I can see is the private prize, which again would be self-contained, dominated by people who are already in the field, and if you will, excluding by being a very select and exclusive club, leaving out thousands of my constituents.

Dr. MACAULEY. I did point out that the prizes are probably not going to address that kind of objective. And therefore, we need to think carefully about the other tools we have that might do that, whether it is, you know, instances in our contracting or peer-reviewed research that require diversity and require reaching out to all of these various groups. So it is a societal goal that needs to be taken into account. It is something that was not part of the early history of prizes in this country, so it is new territory to figure out how, from a public policy view, we accommodate those kinds of objectives. It is—this is new territory, and it is history in the making. And when we look back to try to learn lessons learned on that particular dimension, we don't have a lot to draw from.

Dr. DIAMANDIS. Actually, I thank you, Ms. Jackson Lee, for asking the question, because it allows me to bring up a point, which is it is exactly the opposite from what your presumption may be. Of the 27 teams going for the \$27 million Ansari X-Prize, none of them, other than Scaled Composites, are traditional contractors. In fact, all of them are small groups, groups out of universities. One is a woman-owned business and with a woman pilot. And they come—a diversity. They come out of the dot-com world. They come out of retired NASA employees. They come out of, literally, college kids who came together to make this dream happen.

So it is—by putting up the prize, it actually flattens the playing field, so the large, traditional players, who can only have the ability to go—have the contracting capability and understand government game, can apply. In fact, we—this encourages the non-traditional, smaller groups to get involved, the ones with the ideas that are really innovative that would never see the traditional light of day.

Rear Admiral STEIDLE. I wonder if you would allow me just to comment on that. In a set up of workshops that we just conducted here in Washington, we used the small and minority business programs at NASA to do the advertising for those particular workshops, and it was reflected in the over 200 responses and corporations that participated in our workshop just for Centennial Challenges. The Small Business Innovative Research and the university research programs, as well as technology transfer programs, are also in my directorate for—across NASA wide. I just went out—we just went out with a solicitation on the 7th of July. We—for small business, next phase, and we expect 2,600 responses. That is the indication from the notification of intent that we have. We are trying to change the way we do business. For instance, on some of our broad agency announcements, we are going to put it up on WEBCAST, because we know there are a lot of individuals and a lot of businesses that don't have access to Federal Biz-Ops and things of that nature. So we are trying to do things differently and

make sure we expand that horizon. And the Centennial Challenges will be another tool that will allow us to do that and incorporate other assets.

Ms. JACKSON LEE. Mr. Chairman, you have been very kind and, with your indulgence, I didn't know if Chairman Walker wanted to jump in.

Mr. WALKER. The only thing—the only comment I would make along these lines is that I think that any time you can expand opportunities, you do, in fact, reach out to people who are entrepreneurial, regardless of background. And the advantage of prizes is that this is an opening of opportunities that have never existed before in the space arena. We have tended to be very myopic in how we have done space over the years, and this does allow us to have a much broader horizon and, I think, will inspire many more people to take the opportunity to become involved in the space enterprise.

Ms. JACKSON LEE. Mr. Chairman, thank you for your indulgence. I knew if I asked the question, I would get some good answers, and——

Chairman ROHRABACHER. I think you got very provocative. It was a provocative question and good answers and the Chairman would note that before the era of “big government”——

Ms. JACKSON LEE. Yes.

Chairman ROHRABACHER [continuing]. Black Americans made enormous contributions in the field of technology. And I think Black America now is just coming to the realization of this heritage that they have got. And I—not just George Washington Carver. We are talking about people who—for example, you have got a guy who invented the way that we make shoes that made it possible for our—for us to have shoes. I mean, the bottom line people before this guy came along, and I don't—I can't pronounce his name. It was—but anyway, this fellow made it possible for people to have two pairs of shoes, for Pete's sake. And it was due to a very complicated invention, as well as, of course—I mean, we are doing things like “The Real McCoy,” that whole thing. People think it is an American expression from, you know, Kentucky or something. It is actually a fellow named McCoy who was a Black American who produced an important piece of technology that permitted us to have safe engines for railroads. And so I think we don't have anything to worry about there. I think that we don't need “big government” to ensure that there is going to be opportunity. We need opportunity to make sure that we don't need “big government.”

Ms. JACKSON LEE. Well, I thank you. I just want the thinkers out here to know that they need to reach out to those colleges and places where those individuals are.

Chairman ROHRABACHER. Sure.

Ms. JACKSON LEE. Thank you.

Chairman ROHRABACHER. Okay.

Mr. Forbes. We have 15 minutes. I think we can get a few more questions before we break and maybe——

SAFETY

Mr. FORBES. Thank you, Mr. Chairman, and I, too, thank you for having this hearing and thank all of you. It is exciting to listen to

what we can do when we combine the private sector with the public sector whether we are building spaceships or whether we are building naval ships. And one of the things that I hear as the number one request, I guess, from the applicants is, "We want as little monitoring as possible and let us alone. Let us just do what we do best and that is create this product." And sometimes that is the difference between the \$20 million price tag and the \$500 million price tag that we add so many other things on to it, that by the time we get finished, it costs \$500 million instead of \$20 million. But in a perfect environment, we could say, "Okay. We are just going to let the applicants go." But we don't always live in a perfect environment. There are two big components that we look at, especially in this committee. One of them is what we have heard mentioned earlier with the safety component. And the second one, and we have heard this eluded to as well, when we spend dollars on the space program, one of the things that compels me to do that more and more is not just the spin-off technology we get, but also the magnet that serves to attract math and science students across the country, which I just think is a huge goal for the dollars that we spend.

And so I would throw out two questions to you. First as to the safety aspect, where does the pendulum swing as far as any monitoring we have to do with the applicants, specifically since this could be a government-sponsored prize, at least in some part? What liability do we have to the applicants, and how much monitoring do we have to do there? And secondly, what, if any, monitoring do we do to the applicants to make sure that these dollars are reaching out as much as possible to serve as that magnet to draw more and more math and science students to the field? I still think it is a huge vulnerability for the country. So I would throw that out to the panelists.

Rear Admiral STEIDLE. I will start off with that, sir. First of all, we have designed and Dr. Diamandis has helped us significantly. And it wasn't known here. I don't think I mentioned that, but he has helped us design this particular program. And with the lessons learned that he has put his in, he has helped us with the Centennial Challenges, so we are headed down in that particular direction very similar to what he has done.

From a safety aspect, we have to define the expectations and what is to be expected and get out of the way, do not provide the technical solutions and technical processes and things. If we knew those things, we wouldn't need a prize in the first place. So the government has to move away from that. But we can provide our ranges and the FAA can possibly be there for that particular event when the prize is demonstrated. And I believe that is what the X-Prize is doing as well. And I think that is very, very appropriate. We plan to market, as best that we possibly can, through workshops, through WEBCAST, through websites to get a full, across-the-board participation from some large prizes down to smaller prizes and ones in the middle. So it is incumbent upon us to define those workshops and then spread the word on that.

Mr. WALKER. In my view on this, I mean, there are certain things that you are going to do to protect the public, obviously. You are not going to let Burt Rutan take off from the mall in Wash-

ington, DC. You are going to make certain that you have things that are in place to protect the public in these things. But where you have to allow the risk is if Bob Walker wants to get in Burt Rutan's craft and go flying, you ought not be preventing that. You ought to make certain that you have the kind of mechanisms that permit people to take a substantial amount of risk, as long as it is their own risk. So I think that is a real question.

I happen to believe that, with regard to math and science, the very fact that you are out doing exciting things will, in fact, inspire a lot of math and science enthusiasm. When the Aldridge Commission was meeting, one of the people who testified before the Aldridge Commission was the head of DARPA, Tony Tether. And he made a statement in the course of his testimony that said that the thing that caused the excitement about space in the 1960's was we all wanted to go. Well, if you do a prize program that gives everybody the sense that we are back in that era where we all might have a chance to go, Peter referenced this in his testimony, that will do more to inspire enthusiasm in math and science than nearly any other thing we could do.

Dr. DIAMANDIS. I appreciate Admiral Steidle's—referencing the work that we did with NASA. We are very proud of that. And in fact, safety is something which we believe can come out of existing rules and regulations. And we require teams to abide by all local, regional, and federal rules. So in the case of the FAA, that means they have to get a launch license and get proper insurance. But we don't try and create a new set of safety rules for them. These people are working within technologies and areas that are existing. And the concern is, again, I think, that the Centennial Challenge, as in any government prize, is the focus needs to be on the rule-making in the beginning. They have to be very clear and then allow them to go in a variety of different directions. Again, remember that you don't want to preclude those pesky bicycle mechanics from Dayton, Ohio from going and strapping on wings. You know. The solution is going to come out of very out-of-the-way locations if we really want those breakthroughs. So we can't confuse safety with risk too much.

On the education side, I think there are fundamental prizes that can be created that really have amazing implications for science and math. I will give you one example. I remember that much of the Mars data that we have collected over the years lays fallow. Only 10 percent ever gets looked at. Imagine, if you would, if you had prizes for kids to say put all of that data online and then prizes each year for the person who finds the most interesting discovery. I think you would have kids going back after high school, instead of watching TV, they would be mining the Internet looking for new discoveries on Martian data or Jovian data to win \$10,000 which would put them through college. There are very fascinating things you can do.

Mr. FORBES. Thank you, Mr. Chairman.

Chairman ROHRABACHER. Mr. Udall. And it is the intent of the Chairman, we have about eight minutes now before the vote, and Mr. Udall will have his questions and then we will probably adjourn.

PUBLIC VS. PRIVATE PRIZES AND RETURN ON INVESTMENT

Mr. UDALL. Thank you, Mr. Chairman.

I want to thank the panel. This has been fascinating and a really exciting topic. I was going to try and finish in time to leave Dr. Burgess a minute or two, but he seems to need to get to the Floor.

I was wondering, and the entire panel maybe wants to think about this, but if NASA were to go ahead and offer this significant—or have the option of offering these significant prize monies for a series of projects yet to be determined, would that perhaps dry up the private sector's interest in additional prize-based competitions? And that also—what is the ROI, the return on investment, for the people who have offered this prize? Is there a return on investment they determined? Is it a psychic return? Is it a “Let us create excitement”? Or is there actually a financial return that the organizers of this anticipate?

Dr. DIAMANDIS. I—to answer your first question, I think that, quite frankly, private industry would love to work with NASA to amplify. The more prizes, the more money, the better, especially if they are an organized fashion building toward larger and larger goals, as Mr. Walker suggested. So I think it would not dry it up at all. I think, in fact, it may be the role of private industry to help take on more of the risk that the government might not be able to in more audacious prizes.

The return is clearly psychic return and making their personal dreams come true. We have, on our board, a number of billionaires and multi-millionaires who have given us the funds to make this happen. I give, as an example, that the America's Cup each year, the average team on the America's Cup spends \$60 million to \$80 million per ship and for a zero cash prize. When Larry Ellison backs his vehicle, it is ego money. A prize basically credentials something as being worth doing. That is where—the more money, the more worth it is doing in the eyes of the public. And then it attracts two flavors of money. It attracts ego money and sponsorship money. There are \$20 billion a year spent each year in sponsorship, which goes to car racing and football and baseball and so forth. None of it goes toward building rockets, at least not until recently. So before, if you wanted to build a rocket, if Burt Rutan—he would have to go and prove a marketplace, prove a return on investment for that. Now, by putting up a prize, he doesn't have to have an ROI. He can say, “Paul Allen, do you want to be known for history—historical purposes,” yet again? Or in our case, we are in negotiations with other sponsors now. A lot of people, the Chairman of HP, who was on the Aldridge Commission report, came up to me after the presentation and said, “HP wants to be involved in the X-Prize in supporting the next follow-on activities. How can we get”—it is great. It will bring corporate America into the picture and allow us to have that fun and bring that excitement back to the public.

Mr. UDALL. Anybody else on the panel want to comment on that particular question?

I know Bob Walker and I think, you know, that must mean that people writing \$10 million checks, that is like a Member of Con-

gress writing a \$10 personal check. You know, they just dash off that \$10 million check—

Mr. WALKER. But, no, I would just echo what Peter just told you. I mean, I think that it is clear that there are people who, for reasons of personal satisfaction, of being a part of history, are prepared to make large investments if they think that it is a worthwhile activity. And the more of a worthwhile activity that you can put on this, and a prize does that, the more likely you are to attract that kind of investment into the marketplace.

Mr. UDALL. Similar to many other, and this isn't charity, per se, but charitable impulses we all have that the feelings you have about having supported something worthwhile with a mission that is beyond your own self interest is exciting.

Talk a little bit about the companies involved competing for the prize. Now what kind of return on investment are they looking for? Is it publicity? Is it actual opening of markets? How do you read that, Dr. Diamandis?

Dr. DIAMANDIS. Yes, thank you, sir.

I have been told by at least half of the teams out there that the X-Prize allowed them to take risks and do things they could not do before. When they went out after money to support their efforts, their dreams of private space flight, they were laughed at before. When the X-Prize—we had the support of NASA at our inception, 20 astronauts, the FAA. When we kicked off the X-Prize on May 18 of '96, we brought the government, private sector, the Lindbergh family all together and credentialed this idea and made it possible for these teams now to go out and go after it. Their long-term goal is a billion-dollar marketplace. Their long-term goal is to be the first Canadian, Argentinean, Romanian private launch into—or American, of course, private launch into space. So it is the history books married with the billion-dollar marketplace. What the X-Prize has done is said, "Hey, this is not silly. This is doable. This is worth going after." And so that is the—we are sort of a seed current, if you would.

Mr. UDALL. I see my time has expired. If I would, I would like to ask unanimous consent to ask further questions of the panel, and particularly just pursue how we keep the relationship between the researchers at the university and the non-profit sector engaged in the basic research we are doing as we also put these prizes forth.

So I want to thank the Chairman and thank the panel.

Chairman ROHRBACHER. Thank you very much.

And let me apologize personally to my fellow colleagues that myself and Sheila Jackson Lee took extra time in our questions and answers in the beginning and that time could have been used for other colleagues who—one of whom didn't get a chance to ask questions at all. And so, in the future, even the Chairman should understand that by not sticking to that five minutes, we are cutting other people off. And the Chairman will try harder next time. But this is, of course, a very—been a fascinating hearing.

And I want to thank the panelists for testifying today. And each one of you made a major contribution to our understanding of this issue.

If there is no objection, the record will remain open for additional statements and questions, as we just mentioned, from members of the panel. And we would hope that those questions would be given within—and answers would be given quickly back, but within two weeks. So without objection, so ordered.

And I now, again, thank you personally for your participation. And let us look to the future. And you have given us a lot of food for thought, but a lot of enthusiasm, and that is what it takes to build a better world. Thank you very much. The hearing is now adjourned.

[Whereupon, at 11:38 a.m., the Subcommittee was adjourned.]

Appendix:

ANSWERS TO POST-HEARING QUESTIONS

ANSWERS TO POST-HEARING QUESTIONS

Responses by Rear Admiral Craig E. Steidle, USN (Ret.), Associate Administrator for Exploration Systems, National Aeronautics and Space Administration (NASA)

Questions submitted by Chairman Dana Rohrabacher

Q1. Please describe how NASA plans to address the following issues related to conducting a program of prizes:

Q1a. How will issues of liability be treated? Will the Federal Government assume any legal risks associated with private companies competing for a prize?

A1a. NASA is seeking specific legislative authority in the Agency's FY 2005 authorization bill which was submitted to the Congress on March 19, 2003. This proposed authority would allow NASA to conduct contests for larger prizes, similar to the authority recently obtained by DARPA. Section 323 of the authorization bill is entitled, "Authority for Competitive Prize Award Program to Encourage Development of Advanced Space and Aeronautical Technologies." *Section 323 would require potential prize recipients to assume liability for all associated risks.*

NASA will also require all prize competitors to register. As part of the registration process, competitors will be required to sign waivers and disclaimers consistent with Section 323 described above.

Competitions requiring flight demonstrations will be regulated by the FAA, which will ensure public health and safety. These requirements will be published in the Challenge rules, and competitors will be required to adhere to those rules in order to fly.

Q1b. How will issues of intellectual property (IP) be treated? Will the IP rights for the technologies of a winning prize reside with the government, or with the prize winner?

A1b. The assignment or licensing of intellectual property rights will be specific to the rules of each prize competition.

When Challenges seek to encourage the development of private sector capabilities that NASA or other users can purchase in the future, most or all intellectual property ownership rights will remain with the competitors and no licenses will be required to be granted to the Federal Government.

When Challenges are aimed at developing novel innovations that NASA can incorporate in government systems, NASA will require the competitors, in the rules of the competition, to grant NASA a license to use those innovations (e.g., inventions and trade secrets) in NASA applications. Rights to use inventions and trade secrets in non-NASA applications will remain with the competitors.

Q1c. Why will NASA centers, FFRDCs, and federal employees not be allowed to compete for prizes?

A1c. NASA assumes as the baseline for all Centennial Challenge competitions that federal employees, including FFRDC employees, will be ineligible for competition. This means that all Centennial Challenges will be open to teams composed of members of industry, academia, non-profit organizations, students, and unaffiliated individuals (or any combination thereof).

There are several reasons for establishing this baseline. They include:

Program Goals and Effectiveness—A key goal of Centennial Challenges is to leverage new sources of innovation. NASA has multiple, existing mechanisms for tapping federal R&D talent.

Conflicts of Interest—Where federal employees are involved in the development or review of the rules for a particular prize competition or involved in the administration or judging of a competition, there is the potential for real or perceived conflicts-of-interest. Where federal organizations are involved in both competing for Challenges and in the formulation or administration of the same Challenges, potentially expensive and burdensome "firewalls" between the Challenge formulators, reviewers, and judges and the Challenge competitors would have to be erected. These would likely pose a large and unreasonable overhead burden to Centennial Challenges.

Fairness and Accountability—All competitors will be required to use their own resources to compete in a Challenge. They will not be allowed to use taxpayer funds they are receiving for other work, through contracts or grants, to compete in a Challenge. By their very nature, federal employees and facilities cannot meet this criterion—they are fully funded (or almost completely funded in the

case of some FFRDCs) by the taxpayer. Although theoretically a federal employee could contribute to a team during their non-work hours, ensuring the accountability of these federal employees would represent a large and unreasonable overhead burden to Centennial Challenges.

Unless transparently, fairly, and equitably distributed, the use of federal capabilities by winning teams could also open Centennial Challenges to charges by the losing teams that the winning team had unfair access to federal capabilities.

Prize Award—If a federal organization won a Challenge, it is not clear how the purse would be awarded. Claims could be made that the team members, their federal organization, and/or the Treasury should all receive the purse.

This baseline can and will be examined on a case-by-case basis during the development of rules for individual Challenges. Where access to federal expertise or facilities is deemed critical to winning a particular Challenge competition, it will be the responsibility of the Centennial Challenges Manager to work with the relevant federal organizations to make their capabilities available to competing teams on a transparent, fair, and equitable basis.

Q2. In his testimony, Dr. Diamandis said that the goal of a prize is not to develop technology to put directly into use in the space program, but rather to develop new ways of thinking—to invent the transistor, not to perfect the process leading to a Pentium Chip.” But presumably NASA must run its programs using mature technology.

Q2a. How does NASA plan to take a winning idea and turn it into a mature technology that the space program can use?

A2a. Centennial Challenges will include prize competitions that span the spectrum of technology development, from operational space missions, to atmospheric flight demonstrations, to ground demonstrations of major subsystems, to component-level technology breakthroughs.

Examples of candidate Challenges for operational space missions include competitions for: a lunar robotic soft lander, a micro re-entry vehicle, an orbital aero-assist demonstration, and a solar sail.

Examples of candidate Challenges for atmospheric flight demonstrations include competitions for: advances in general aviation, an autonomous unmanned aerial vehicle for cargo transport, a long duration unmanned aerial vehicle, and a hybrid airship.

Examples of candidate Challenges for ground demonstrations of major subsystems include: a precision planetary descent and landing system, an autonomous drilling system, a telerobotic construction system, a robotic Earth analog sample return system, and a human lunar all-terrain vehicle.

Examples of candidate Challenges for component-level technology breakthroughs include competitions for: a mobile power storage breakthrough, a radiation shielding breakthrough, advances in deployable telescope technology, an advanced astronaut glove, advances in lunar resource processing techniques, advances in beamed power technology, and advances in materials.

In all cases, relevant users of the capability to be demonstrated in a Challenge will have a role in the development of the winning criteria and rules for that Challenge. By design, all Challenges will be structured so that the resulting capability is ready for the next level of technology maturation.

Q2b. Does NASA plan to offer contracts to the winners of a prize, such as to develop his or her idea further to meet NASA’s specifications? Or would such a job more likely fall to one of the major aerospace contractors?

A2b. Winning a prize does not mean that someone will receive a contract. However, NASA may develop requirements based on information and ideas obtained from prize competitions that may be used to develop future solicitations. Any such Request for Proposals would comply with the requirements of the Competition in Contracting Act (CICA).

Q3. To what degree does NASA plan to depend solely on prizes for the development of technologies that are essential to exploration, such as technologies that would be required for either long-duration space flight or extended human missions to the Moon?

A3. There are no plans within NASA to depend on prizes for the development of immediate need “critical path” technologies that are essential to exploration.

Centennial Challenges is part of a portfolio of technology investments that support the Vision for Space Exploration and ongoing NASA missions. Prize competitions are a small part of that portfolio that allow NASA to tap new sources of inno-

vation and generate technical solutions that would go unexplored in standard procurement processes. Centennial Challenges complements, but does not replace, standard technology development mechanisms.

Q4. Dr. Macauley testified that prizes have been offered successfully in the past to develop incremental technologies, but that was before government began to invest so heavily in R&D.

Q4a. Is it better for NASA to offer both large and small prizes, or should it focus only on larger prizes? Would the cost of judging and otherwise administering small purse prizes outweigh the value of the prize itself and make such prizes not worthwhile?

A4a. NASA has many pathways for incremental technology development, including contracts, grants, and in-house development. Prize competitions should complement, not replicate, these existing procurement tools. Prizes should be focused on competitions that can produce advances and innovations that would otherwise go unexplored in standard technology development processes.

“Incremental technology” development does not necessarily equate with either a “small prize” or a “large prize.” Small prizes, if focused on breakthroughs in component-level technologies, can provide revolutionary advances. Therefore, even if the cost of judging and administering a small purse prize exceeds the dollar value of the prize, the value of the technological breakthrough to NASA may clearly justify the expenditure. An example of such a revolutionary innovation is the marine chronometer, which was developed to win the 18th century British Longitude Prize. Likewise, large prize purses for major subsystem ground demonstrations, atmospheric flight demonstrations, or operational space missions could, if not properly structured, result only in incremental advances.

Through Centennial Challenges, we intend to invest in both smaller prizes focused on component-level technology breakthroughs as well as larger prizes for major subsystem demonstrations, atmospheric flight demonstrations, and operational space missions that push innovation across a range of technologies. The response to question 2a) above covers each of these categories in detail.

The key to producing innovation in any prize competition is to define the winning criteria for the competition in a way that forces competitors to develop and demonstrate innovative capabilities to win the prize. For example, if NASA offered a prize competition for a soft lunar robotic landing where the winning criteria and purse size were very similar to the requirements and costs of NASA’s lunar Surveyor landers from the 1960s, we could expect relatively few innovations from competitors for that prize. However, if NASA offered a substantially smaller purse and required that the competitors also access another area of the lunar surface via penetrator, rover, reusable lander, or second lander, the competitors would have to develop new, innovative, and less costly approaches to lunar surface landings and access that are true breakthroughs over existing capabilities.

Q4b. How should it be decided whether prizes or contracts/grants are the appropriate tool for stimulating innovation for small, discrete technologies (such as the development of an improved astronaut glove)?

A4b. Prize plans must be coordinated with NASA’s overall approach to advancing the Agency’s mission goals. Other mechanisms include contract, grants, cooperative agreements, and Space Act agreements. NASA will regularly examine and update our planning for Centennial Challenges based on the procurement plans of other Agency programs. NASA will comply with all applicable statutes and regulations regarding the use of procurement contracts, including 31 USC 6303, which requires agencies to use a procurement contract if the “principal purpose” of the agreement is to acquire property or services for the direct benefit or use of the U.S. Government.

Identifying strong candidate Challenges involves other important criteria beyond the applicability of a prize competition to the technology or capability in question. Specifically, we are applying six base criteria when examining the suitability and relative strengths of candidate Challenges.

The Simpler, the Better—We are seeking Challenges with winning criteria that are objective, transparent, simple, and unbiased. Challenges that require complex rules, expensive testing and verification, or and/or qualitative judging are less desirable.

Relevance to NASA Programs—We are seeking Challenges where the capabilities that would be developed and demonstrated in the course of the competitions have strong relevance to programs in one or more NASA Mission Directorates.

Right Level of Difficulty—We are seeking Challenges where there are multiple pathways to developing the desired capability and where it would be hard to decide which pathway is the right one through a standard contract or grant selection process. Challenges that are too easy or impossible to achieve are not desirable.

Follow-On Opportunities—Historically, the most successful prize competitions are those that are aligned with some future economic opportunity for the competitors. All other things being equal, Challenges that will produce a capability that can be applied to a future NASA program, another aerospace market, or that have synergy with Earth-based applications are more desirable.

Competitor and Sponsor Interest—Interest from potential competitors and/or from potential sponsors of the competing teams is a strong indicator that a particular prize competition is good candidate and properly constructed. Interest from potential co-sponsors of the prize purse itself (i.e., other organizations in the government, industry, and academia with R&D interests coincident with NASA's) is another strong indicator.

Public Excitement—Historically, the most successful prize competitions produce excitement among the public, media, and educators that, in turn, incentivize competitors and sponsors to compete to earn their share of the fame associated with winning the prize. Challenges with greater potential to generate public excitement are more desirable.

No one Challenge will meet all of these criteria perfectly. However, NASA is using these criteria to cull the best candidate Challenges from the hundreds of ideas that have been generated internally and externally for future Centennial Challenge competitions. We intend to carefully develop the rules for each of our prize competitions using inputs from a variety of sources, including: Requests for Information (RFIs) to potential competitors, internal and external independent expert review boards, and inputs from workshops and other public venues. In fact, inputs from over 200 participants on over 30 candidate prize competitions from our first annual Centennial Challenges Workshop are available on the Internet at www.centennialchallenges.nasa.gov.

It is important to note that we have received more viable Challenge candidates than we will have the resources to pursue. At the end of the process, the Centennial Challenges Manager, in consultation with senior NASA management, must make judgments regarding the relative importance, attractiveness, and timing of candidate Challenges to achieve a relevant, strong and balanced prize competition program that can be implemented within available resources.

It is also important to note that NASA may want to pursue Challenges that overlap with but complement other procurements. For example, we are examining a candidate Challenge for a soft lunar robotic landing, which would complement our Lunar Exploration Program with entrepreneurial missions demonstrating innovative approaches to lunar surface access and exploration that might not otherwise be pursued.

Q5. How would a prize contest differ from NASA releasing a request for information (RFI), such as what was done for a Hubble robotic servicing mission? How should the decision be made as to whether a particular objective is better suited to a prize competition or to more traditional approaches? Would the largest difference between the two methods be the lead-time required for the development of a technology through a prize contest as compared to that of the traditional route?

A5. In the case of the Hubble robotic servicing mission, an RFI was used to obtain information from the private sector on what capabilities are present in the market place. A request for information (RFI) seeks information that the Government does not have that may be used by the Government to establish requirements or other aspects of a follow-on procurement, such as a Request for Proposals (RFP). An RFI may lead to a contract when the Agency requires an immediate need critical path technology, as was the case with the Hubble Robotic servicing capability.

A prize competition is a promise to deliver an award to a team or individual for the demonstration of a desired capability consistent with the competition rules. A prize competition does not inquire about existing capabilities present in the market place. Rather, a prize competition provides incentives for the creation of new capabilities.

Although a prize competition could lead to the development of a given capability in a shorter amount of time as compared to a standard procurement, that is not guaranteed and therefore is not a factor in deciding whether to pursue a prize competition versus a standard procurement. Two significant advantages of a prize com-

petition are that: 1) NASA only pays once the desired capability has been demonstrated, instead of paying for a proposal that may or may not result in the desired capability; and 2) all competitors are allowed to compete until the very end of the contest, which allows innovative approaches to be explored that would otherwise not be pursued in a standard procurement. NASA established Centennial Challenges not to achieve greater efficiencies in the procurement or development process (although that may happen). NASA established Centennial Challenges as a tool for tapping new sources of innovation and generating technical solutions that would go unexplored in standard procurement processes.

Questions submitted by Representative Nick Lampson

Q1. Who owns the intellectual property for developments achieved in the prize program?

A1. The assignment or licensing of intellectual property rights will be specific to the rules of each prize competition.

When Challenges seek to encourage the development, of private sector capabilities that NASA or other users can purchase in the future, most or all-intellectual property ownership rights will remain with the competitors and no licenses will be required to be granted to the Federal Government.

When Challenges are aimed at developing novel innovations that NASA can incorporate in government systems, NASA will require the competitors, in the rules of the competition, to grant NASA a license to use those innovations (e.g., inventions and trade secrets) in NASA applications. Rights to use inventions and trade secrets in non-NASA applications will remain with the competitors.

Q2. What criteria will you use to determine which technologies to leave to prize contestants and which to develop through more traditional methods, such as contracts?

A2. Prize plans must be coordinated with NASA's overall approach to advancing the Agency's mission and goals. Other mechanisms include contract, grants, cooperative agreements and Space Act agreements. NASA will use procurement contracts if the "principal purpose" of the agreement is to acquire property or services for the direct benefit or use of the U.S. Government. A prize competition is used where NASA wants to stimulate new ideas from external sources in the private sector and incentivize multiple competitors. Prize competitions will not be used when the Agency has an immediate need for a critical path technology essential to exploration.

Identifying strong candidate Challenges involves other important criteria beyond the applicability of a prize competition to the technology or capability in question. Specifically, we are applying six base criteria when examining the suitability and relative strengths of candidate Challenges.

The Simpler, the Better—We are seeking Challenges with winning criteria that are objective, transparent, simple, and unbiased. Challenges that require complex rules, expensive testing and verification, or and/or qualitative judging are less desirable.

Relevance to NASA Programs—We are seeking Challenges where the capabilities that would be developed and demonstrated in the course of the competitions have strong relevance to programs in one or more NASA Mission Directorates.

Right Level of Difficulty—We are seeking Challenges where there are multiple pathways to developing the desired capability and where it would be hard to decide which pathway is the right one through a standard contract or grant selection process. Challenges that are too easy or impossible to achieve are not desirable.

Follow-On Opportunities—Historically, the most successful prize competitions are those that are aligned with some future economic opportunity for the competitors. All other things being equal, Challenges that produce a capability that can be applied to a future NASA program, another aerospace market, or that have synergy with Earth-based applications are more desirable.

Competitor and Sponsor Interest—Interest from potential competitors and/or from potential sponsors of the competing teams is a strong indicator that a particular prize competition is good candidate and properly constructed. Interest from potential co-sponsors of the prize purse itself (i.e., other organizations in the government, industry, and academia with R&D interests coincident with NASA's) is another strong indicator.

Public Excitement—Historically, the most successful prize competitions produce excitement among the public, media, and educators that, in turn, incentivize competitors and sponsors to compete to earn their share of the fame associated with winning the prize. Challenges with greater potential to generate public excitement are more desirable.

No one Challenge will meet all of these criteria perfectly. However, NASA is using these criteria to cull the best candidate Challenges from the hundreds of ideas that have been generated internally and externally for future Centennial Challenge competitions. We intend to carefully develop the rules for each of our prize competitions using inputs from a variety of sources, including: Requests for Information (RFIs) to potential competitors, internal and external independent expert review boards, and inputs from workshops and other public venues. In fact, inputs from over 200 participants on over 30 candidate prize competitions from our first annual Centennial Challenges Workshop are available on the Internet at www.centennialchallenges.nasa.gov.

It is important to note that we have received more viable Challenge candidates than we will have the resources to pursue. At the end of the process, the Centennial Challenges Manager, in consultation with senior NASA management, must make judgments regarding the relative importance, attractiveness, and timing of candidate Challenges to achieve a relevant, strong and balanced prize competition program that can be implemented within available resources.

It is also important to note that NASA may want to pursue Challenges that overlap with but complement other procurements. For example, we are examining a candidate Challenge for a soft lunar robotic landing, which would complement our Lunar Exploration Program with entrepreneurial missions demonstrating innovative approaches to lunar surface access and exploration that might not otherwise be pursued.

Q3. What specific results does NASA expect to achieve with the prizes contemplated in the FY 2005 budget request? What metrics have been established to determine if the goals are accomplished?

A3. If NASA gets the requested legislative authority, NASA plans to initiate at least four, and up to eight, new prize competitions in FY 2005. These candidate Challenges include competitions for: advances in deployable telescope technology, a mobile power storage breakthrough, a radiation shielding breakthrough, an advanced astronaut glove, advances in lunar resource processing techniques, a precision planetary descent and landing system, and an autonomous unmanned aerial vehicle for cargo transport.

NASA also plans to announce three annual Challenges in FY 2005. These candidate Challenges include competitions for advances in power beaming, materials, and general aviation. NASA will also initiate a parallel outreach program that conducts small prize competitions to encourage primary and secondary students to pursue careers in science, technology, engineering, and mathematics.

Over the long-term, NASA plans to track and report on the funding leveraged by Centennial Challenges. Historically, competitors for a prize competition collectively spend at least several times the value of the prize purse in pursuit of the prize. On average, we should meet this historical performance. NASA will also track funding leveraged where it co-sponsors a prize competition with another NASA program or external organization (i.e., other organizations in the government, industry, and academia with R&D interests coincident with NASA's).

Over the long-term, NASA will track and report on the innovations and capabilities created through Centennial Challenge competitions as well as any competitions that we find to provide useful lessons for us. Although these qualitative assessments will be more anecdotal in nature, the lessons learned will be important to the development of future Challenges.

Questions submitted by Representative Mark Udall

Q1. NASA's Centennial Challenge prize program is aimed at developing technologies needed for NASA's exploration initiative.

A1. It is important to note that while the focus of Centennial Challenges is on supporting the Exploration Systems Mission Directorate, NASA does intend to pursue prize competitions that support other mission areas, including the Science Directorate and the Aeronautics Directorate.

Q1a. What happens if either no one is interested in competing for the prize or no one comes up with a winning approach? What will NASA do? When will NASA make a decision on whether or not to suspend a particular prize approach?

A1a. The rules for all prize competitions conducted under Centennial Challenges will include two expiration dates.

The first expiration date will allow NASA to end a prize competition if an adequate number of competitors have not registered by that date. For example, if we judge that at least two competing teams are needed to ensure a strong competitive field for a particular Challenge, but only one team has registered at the end of the first year of the competition, NASA would reserve the right to end the competition at the end of the first year.

The second expiration date will allow NASA to end a prize competition if no competitor has achieved the winning criteria within the time allowed for the competition. For example, if we offered a prize for a soft lunar robotic landing within five years, but no team had successfully placed a lander on the surface of the Moon at the end of five years, NASA would end the competition at the end of the fifth year.

These expiration dates will ensure that NASA has the flexibility to recover from a defective set of competition rules and redirect prize funding towards a new competition. However, it is our intention to never have to exercise these expiration dates. We intend to carefully develop the rules for each of our prize competitions using inputs from a variety of sources, including: requests for information (RFIs) to potential competitors, internal and external independent expert review boards, and inputs from workshops and other public venues. In fact, inputs from over 200 participants on over 30 candidate prize competitions from our first annual Centennial Challenges Workshop are available on the Internet at www.centennialchallenges.nasa.gov.

Q2. What do you consider the biggest impediments to carrying out a successful prize program?

A2. The single largest hurdle to an effective Centennial Challenges program is obtaining specific legislative authority to conduct competitions with large prize purses over multiple years. Without this authority, NASA's use of prize competitions will be severely limited and sub-optimized.

The number and type of prize competitions that NASA could pursue would be greatly decreased without this authority. Most of the candidate prize competitions we are considering for FY 2005 and beyond would require prize purses in the million-dollar range and above to attract a strong field of competitors. Most of these prizes will also require multiple years of competition before a winner emerges. (For reference, the ongoing X-PRIZE competition was started in 1996—a nine-year competition with a \$10 million purse, which was won on October 4, 2004.) Examples of candidate prize competitions requiring this authority include full space missions, such as competitions for: a lunar robotic soft lander, a micro re-entry vehicle, an orbital aero-assist demonstration, and a solar sail demonstration. Examples also include atmospheric flight demonstrations, major subsystem demonstrations, and component-level technology breakthroughs, such as competitions for: a mobile power storage breakthrough, a radiation shielding breakthrough, a precision planetary descent and landing system, an autonomous drilling system, a telerobotic construction system, a robotic Earth analog sample return system, a human lunar all-terrain vehicle, and a long duration unmanned aerial vehicle. With specific authority to conduct competitions with large prize purses and to treat prize purse funding as no-year funding, as was provided in 2002, NASA will be able to pursue a robust Centennial Challenges. Since FY 2001, in anticipation of enactment of prize authority, NASA's annual appropriations acts have included an administrative provision stating: "Funds for announced prizes otherwise authorized shall remain available, without fiscal year limitation, until the prize is claimed or the offer is withdrawn."

ANSWERS TO POST-HEARING QUESTIONS

Responses by the Hon. Robert S. Walker, Chairman, Wexler & Walker Public Policy Associates

Questions submitted by Chairman Dana Rohrabacher

Q1. If NASA were to establish a program of prizes, how should issues of liability be treated? Should the Federal Government assume any legal risks associated with private companies competing for a prize? Would your answer be different if an outside entity (such as a private foundation or an endowment) was in charge of designing, administering and judging prize contests, rather than NASA?

A1. Given the level of risk that must be assumed and that prize competitors would be willing to take, I do not believe the Federal Government should assume liability responsibility. Given the open-ended nature of prize competition, there would be an opportunity for fraudulent claims if such legal risks were assumed.

While I do not pretend to be an expert of how the X-Prize Competition has handled the issue of liability, clearly the use of an outside entity to sponsor the government's prize competition could use a similar approach.

Q2. If NASA were to establish a program of prizes, how should issues of intellectual property (IP) be treated? Should the IP rights for the technologies of a winning prize reside with the government, or with the prize winner? If with the prize winner, what rights, if any, should the government retain? Should the prize winners ever be required to share IP that NASA would need? Would your answer be different if an outside entity was in charge of prize contests?

A2. Part of the reason why possible prize competitors find such programs appealing is their ability to capitalize on their work even if they do not when or even if the prize money does not cover their actual expenses. Therefore, it is vital that intellectual property remain with the competitors, including the winner. NASA should have the ability to draw upon the expertise and technology based upon the inside knowledge gained with the prize program, but should properly pay for any technology actually included in NASA projects.

Q3. If NASA or another federal entity was in charge of running a program of prize contests, should the Federal Government be allowed to receive private funds in addition to federally appropriated funds? If so, what conflicts of interest might arise and how could they be prevented? Conversely, if a private foundation or outside entity was in charge of running such a program, should the Federal Government be allowed to contract with or provide funds to this entity?

A3. Multiplier money is very desirable whether the program is sponsored directly by NASA or by an outside entity. My preference would be to create an outside entity that clearly would be able to accept non-federal dollars, but would also be able to utilize appropriated money. Such an outside entity, probably a foundation, would avoid the conflict of interest issues.

Q4. What are the advantages and disadvantages for having either an outside private entity or a federal entity other than NASA in charge of running a program of prize contests, rather than NASA itself? What would the proper balance be between NASA's role and the outside entity's role in the designing, administering and judging of prize contests? Should NASA have any role in these areas?

A4. I would favor creating an outside entity, preferably a tax-free foundation, to administer any large prize program. For small prizes, aimed at limited technology development, it may be appropriate for NASA to directly offer prizes aimed at specific needs, but in general I believe a prize foundation is the best policy route. The advantages I see for the outside prize entity are as follows:

1. Eliminate most conflict of interest problems
2. Would be able to take both public and private money
3. Could be subjected to NASA oversight
4. Could accept risks not normally open to government agencies.

Q5. Should NASA centers, FFRDCs and federal employees be allowed to compete for prizes?

A5. Prize competition should be for non-federal personnel. In other words, I do not believe the centers, as presently constituted, should be included in prize competi-

tion. However, if the center transformed to FFRDCs, employees of the FFRDCs should be eligible for prize awards.

Q6. What recommendations do you have to minimize the possibility that the judging of a prize contest is not biased towards a particular solution? Do you believe NASA should or should not participate in the judging of such contests?

A6. The possibility of having prize awards dependent on judging decisions should be minimized as much as possible. The best way to accomplish this is to set prize criteria based upon clear objectives and with a specific time limit. No real judging is necessary if the winner is the first to meet the specified objectives within the timeframe indicated.

Q7. In his testimony, Dr. Diamandis said that the goal of a prize is not to develop technology to put directly into use in the space program, but rather to develop new ways of thinking—to invent the transistor, not to perfect the process leading to a Pentium Chip.” But presumably NASA must run its programs using mature technology.

Q7a. How could NASA take a winning idea and turn it into a mature technology that the space program can use?

Q7b. Should NASA offer contracts to the winners of a prize, such as to develop his or her idea further to meet NASA’s specifications? Or should such a job more likely fall to one of the major aerospace contractors?

A7a,b. Prizes are not meant to produce mature technologies. They produce unique ideas for addressing real goals. Therefore, NASA must see the outcome of prize competition as a variety of ways to address a specific goal with one winner, but multiple future choices. The winner should expect no more than to collect the prize—no guarantee of a future contract. But NASA should look upon the contest as a learning experience, which allows it to infuse new thinking into its more traditional contracting process.

Q8. What should NASA provide in order to attract participants to a prize contest? Should the winner of a prize contest expect to have a future business relationship with NASA? Should there be a guaranteed government contract for the winner of a prize, such as the delivery of cargo into orbit or to ISS? Is it necessary that there be some evidence of a future market for prizes to be effective?

A8. Prizes are not inherently a mechanism for developing contract relationships. Winners and participants in the contest should expect no more than the ability to retain the intellectual property they have created. On the other hand, NASA should not be precluded from forming a business relationship with prize contenders if they have something specific to offer to ongoing NASA efforts.

Q9. Dr. Macauley testified that prizes have been offered successfully in the past to develop incremental technologies, but that was before government began to invest so heavily in R&D.

Q9a. Is it better for NASA to offer both large and small prizes, or should it focus only on larger prizes? Would the cost of judging and otherwise administering small purse prizes outweigh the value of the prize itself and make such prizes not worthwhile?

Q9b. How should it be decided whether prizes or contracts/grants are the appropriate tool for stimulating innovation for small, discrete technologies (such as the development of an improved astronaut glove)?

A9a,b. While I am not opposed to the concept of small prizes for incremental technology development, I am concerned that the fairly precise nature of such prizes might end up looking more like a contract than a prize. I am more interested in large prizes with the potential for significant technology backwash that will be valuable even if no one actually wins the prize. For example, the announcement of a specific date for manned spacecraft race around the Moon with a substantial monetary prize could inspire the type of technology competition that would revolutionize the industry.

Q10. To what degree should NASA plan to depend solely on prizes for the development of technologies that are essential to exploration, such as technologies that would be required for either long-duration space flight or extended human missions to the Moon?

A10. The prizes NASA offers should seek to encourage development of technologies that fit the agencies exploration goals. But rather than specifying the technologies

NASA believes are relevant, the prizes should be broad enough to allow substantial innovation. Prizes should not be the sole approach to technology development but rather the high-risk component that creates unique technology pathways.

Q11. How would a prize contest differ from NASA releasing a request for information (RFI), such as what was done for a Hubble robotic servicing mission? How should the decision be made as to whether a particular objective is better suited to a prize competition or to more traditional approaches? Would the largest difference between the two methods be the lead-time required for the development of a technology through a prize contest as compared to that of the traditional route?

A11. RFI's tend to be a means of pinging the traditional NASA contractor and supply chain. Prizes are a way of getting entrepreneurial involvement, which does not want to be encumbered by federal rules and regulations. By putting time limits in the prize criteria, NASA should be able to encourage some early adopter activity that will benefit the whole of the space exploration programs, and come from the inventors, developers and financiers not normally involved in NASA procurement.

Questions submitted by Representative Nick Lampson

Q1. The Aldridge Commission report stated, "Given the complexity and challenges of the new vision, the Commission suggests that a more substantial prize might be appropriate to accelerate the development of enabling technologies. As an example of a particularly challenging prize concept, \$100 million to \$1 billion could be offered to the first organization to place humans on the Moon and sustain them for a fixed period before they return to Earth."

Q1a. How would such a prize work in practice, for example, should \$1 billion be put in a special account and the rest of NASA's budget for human exploration of the Moon be cut by an equivalent amount or even eliminated entirely?

Q1b. Given that small unmanned spacecraft missions currently cost a \$100 million or more, how credible is it to believe that any organization could carry off a human lunar mission for \$100 million—or even \$1 billion?

Q1c. By logical extension, should Congress consider curtailing the funding for the President's space exploration initiative and instead just put \$500 million to \$1 billion in a prize fund annually over the next decade as a prize for the first organization to land humans on Mars and return them safely?

A1a,b,c. The question of how to specifically designate money to the prize account was one that the Commission felt was better left to the Congress to determine. My personal view is that the creation of a foundation capable of receiving appropriated money would be the way to go. For large prizes the appropriations into the account could take place over several years and would not have to impact ongoing NASA programs in any substantial way. For NASA, the advantage would be that for modest investments on appropriated money for prize activity, technology development worth substantially more could be undertaken.

Another potential approach would be to appropriate money only once the prize criteria had been met. Clearly, this would involve a good faith commitment, but if no one achieved prize success, no money would have to be allocated. Meantime, the Nation would still benefit from the technology development in pursuit of the prize even with an unsuccessful outcome.

The Commission found that the value of the prize has little or no relationship to the amounts that will be spent in pursuit of it, providing that the goal is significant. Aviation prizes in the past and the X-Prize experience show a willingness to pursue big goals for the glory of the victory. Estimates range from between \$100–\$400 million spent in pursuit of the X-Prize. Burt Rutan will almost certainly have spent at least three times what the X-Prize is worth in his effort. Therefore, the prize is a device to encourage activity and the thought of the Commission was that the first \$1 billion dollar prize in history might just get considerable attention and substantial activity even toward a goal as big and expensive as a lunar mission.

Prizes should not be seen as a replacement of regularized NASA mission planning and execution. Instead, prizes are a means to achieve unique innovation with risks far larger than NASA is capable of taking. Curtailing NASA funding in lieu of prize competition would handicap the agency in favor of a total risk approach to space exploration. Prudence calls for a combined approach that accepts the risks inherent in prize competition but also preserves the inherent scientific and technological assets that NASA embodies

Question submitted by Representative Mark Udall

Q1. What do you consider to be the biggest impediments to carrying out a successful prize program?

A1. The biggest impediment to a prize program will be the reluctance to accept the substantial risks that must accompany the pursuit of prizes. Competitors are unlikely to fit the profile of typical NASA contractors, nor are they likely to want to be burdened by volumes of federal rules and regulations. In order for prizes to work, they must remain relatively unencumbered by standard government practices and therefore are likely to be technologically risky.

While financial risk should be mitigated by offering payment only upon success, the fact that government money is encouraging high-risk activity could become controversial.

The other problem I see is finding an appropriate funding mechanism. Since prizes do not easily fit inside the typical appropriations cycle, unique policies will have to be developed that assume appropriate budgetary restraints but also assure the availability of prize money when success is achieved.

ANSWERS TO POST-HEARING QUESTIONS

Responses by Dr. Peter H. Diamandis, Chairman and CEO, X-Prize Foundation

Questions submitted by Chairman Dana Rohrabacher

Q1. If NASA were to establish a program of prizes, how should issues of liability be treated? Should the Federal Government assume any legal risks associated with private companies competing for a prize? Would your answer be different if an outside entity (such as a private foundation or an endowment) was in charge of designing, administering and judging prize contests, rather than NASA?

A1. The government should not be accepting any additional liability risks. The existing FAA, DOT, and DOC licensing methods should be used where appropriate. The X-PRIZE Foundation utilizes liability release forms that must be signed by each team. The use of an outside administrative organization, like the X-PRIZE Foundation, could help to appropriately shield the government.

Q2. If NASA were to establish a program of prizes, how should issues of intellectual property (IP) be treated? Should the IP rights for the technologies of a winning prize reside with the government, or with the prize winner? If with the prize winner, what rights, if any, should the government retain? Should the prize winners ever be required to share IP that NASA would need? Would your answer be different if an outside entity was in charge of prize contests?

A2. The government should not claim any intellectual property rights from any of the teams. The teams need to be provided with the greatest impetus to commercialize their IP and inter-revenue generating business. At most, the government should request that prize winner agree to license the technology through NASA or the DOD. If agreed upon, this license should be issued at its best commercial rate.

Q3. If NASA or another federal entity was in charge of running a program of prize contests, should the Federal Government be allowed to receive private funds in addition to federally appropriated funds? If so, what conflicts of interest might arise and how could they be prevented? Conversely, if a private foundation or outside entity was in charge of running such a program, should the Federal Government be allowed to contract with or provide funds to this entity?

A3. The idea of obtaining private funds to supplement a government prize purse is extremely important. The best way to accomplish this is to allow an outside private entity, such as the X-PRIZE Foundation or its equivalent, to run the competition and solicit sponsors that would co-fund a prize jointly with the government. A private entity with expertise in this area would be far more effective than the government in leveraging sponsor dollars.

Q4. What are the advantages and disadvantages for having either an outside private entity or a federal entity other than NASA in charge of running a program of prize contests, rather than NASA itself? What would the proper balance be between NASA's role and the outside entity's role in the designing, administering and judging of prize contests? Should NASA have any role in these areas?

A4. There are numerous advantages to allowing an outside private entity to run the competition. These include:

- A) The competition would be viewed as being judged more fairly if the government was not running it. An outside party would not be biased to any pre-conceived technology solutions. This will result in more teams joining the competition.
- B) An outside private entity can more aggressively market the competition through co-promotions with sponsors, television programming and public relation campaigns. NASA is limited by law on its ability to promote itself and its programs.
- C) A private entity, like the X-PRIZE Foundation, which is already administering prize programs, could significantly benefit from economies of scale in using its pre-existing skill set. This includes experiences and/or skills in the following arenas: public relations; team/participant management; judging panel selection and procedures; rules development; web and television marketing; sponsorship solicitation, etc. These could all be applied to promote and develop the government prizes as well as existing prizes.

Q5. *Should NASA Centers, FFRDCs and federal employees be allowed to compete for prizes?*

A5. Yes. They should be allowed to compete for the prizes. However, they should neither be using government funds nor be restricted by government rules and regulations. The whole concept of the prize is to allow non-traditional solutions to be achieved at a low cost. The employees of an FFRDC should be allowed to form teams and compete, but they should be privately funded.

Q6. *What recommendations do you have to minimize the possibility that the judging of a prize contest is not biased towards a particular solution? Do you believe NASA should or should not participate in the judging of such contests?*

A6. The best way to prevent a bias towards a particular solution is twofold:

- 1) Set clearly defined rules that state the end goal without inclusion of any bias towards a particular technology solution.
- 2) Design the managing and judging entity to be independent of the government.

I think it is appropriate to have one judge from NASA on the judging panel, but it is paramount that the judges be comprised of a mix of individuals from private industry or universities. Potential judges should also be selected from experts in the appropriate technology arena.

Q7. *In your testimony, you said that the goal of prize is not to develop technology to put directly into use in the space program, but rather to develop new ways of thinking—"to invent the transistor, not to perfect the process leading to a Pentium Chip." But presumably NASA must run its programs using mature technology.*

Q7a. *How could NASA take a winning idea and turn it into mature technology that the space program can use?*

A7a. The way that NASA can turn a winning idea into mature technology is to set the prize rules to meet that specific objective. For example, instead of a challenge involving a lunar rover that might be tested on Earth, establish a prize that requires a lunar rover to be tested on the Moon. Require it to be tested to the extent that NASA needs it. The challenge could be something like, "Go 10 miles in two days," for example. Allow the end result of the prize to demonstrate the functionality of the technology. A good example of this is Burt Rutan's demonstration of hybrid rockets as human-rated propulsion systems.

Q7b. *Should NASA offer contracts to the winners of a prize, such as to develop his or her idea further to meet NASA's specifications? Or should such a job more likely fall to one of the major aerospace contractors?*

A7b. NASA should offer the prize winners either a contract to provide the technology or an offer to license it from them for development by an existing contractor. That decision should rest with the prize winner. After all, they have just demonstrated the technology that NASA would like to make use of. Why not give them an opportunity to do it again and continue to learn? The alternative of turning it over to larger prime contractors would only result in higher cost; it is also likely that they will not have as much experience as the prize winner themselves.

Q8. *What should NASA provide in order to attract participants to a prize contest? Should the winner of a prize contest expect to have a future business relationship with NASA? Should there be a guaranteed government contract for the winner of the prize, such as the delivery of cargo into orbit or to ISS? Is it necessary that there be some evidence of a future market for prizes to be effective?*

A8. Many of the teams that would compete for NASA prizes, quite frankly, would not want to do business with the government. They are pursuing the prize for two reasons: 1) the cash prize and 2) the publicity. Also, they most likely view it as an opportunity to demonstrate the technology for personal business reasons. The best thing that NASA could offer would be a substantial cash prize and very high visibility. The contract or option to license the technology is important, but I think secondary to the first two. NASA must allow the team to retain all the intellectual property. This would be a non-starter if NASA tried to take ownership of any of the technology.

Q9. *Dr. Macauley testified that prizes have been offered successfully in the past to develop incremental technologies, but that was before government began to invest so heavily in R&D.*

Q9a. Is it better for NASA to offer both large and small prizes, or should it focus only on larger prizes? Would the cost of judging and otherwise administering small purse prizes outweigh the value of the prize itself and make such prizes not worthwhile?

A9a. As the X-PRIZE Foundation recommended in its study to NASA in 2003, it is our belief that NASA should offer a full range of prizes. These should include, at any one time, two to three grand prizes for such things as private flight to orbit, robots landing on the Moon, or asteroid sample return missions. There should be a full spectrum of prizes funneling down to the high school level. For example, students could do mining research based on Mars Lander data stored on computer archives. The goal here should be to get entrepreneurs and entrepreneurially minded companies to begin looking at prizes as a way to both supplement their income and create excitement and publicity for the space arena.

Q9b. How should it be decided whether prizes or contracts/grants are the appropriate tool for stimulating innovation for small, discrete technologies (such as the development of an improved astronaut glove)?

A9b. Not all technology challenges make good prizes. A technology challenge that make a good prize must have a human story involved with it. Heroic challenges and even the potential for failure intrigues the public. The topic must be of interest to the television-minded audience and the media world. Therefore, a challenge must be created in the context of a human feat. For example, an improved astronaut glove used while participating in a competitive sport or the use of teams competing against each other using these gloves to accomplish certain objectives. Regardless of the actual technology challenge being presented, the human factor must be incorporated to attract human attention.

Q10. To what degree should NASA plan to depend solely on prizes for the development of technologies that are essential to exploration, such as technologies that would be required for either long-duration space flight or extended human missions to the Moon?

A10. NASA needs to take dual courses with regards to critical technology.

It is completely reasonable that NASA should always continue to utilize a prime contractor for its mission critical technologies. However, for each of these technology areas that are most expensive and lacking innovation, it is appropriate for NASA to set aside some percentage (five or ten percent of the budget) for prizes. If, for example, a new landing technology to land on the Moon is required, rather than just contract with Boeing, NASA should initiate a Lunar Landing Prize with specific mission parameters. This would allow certain companies that could never compete against Boeing, in the contractual sense, to gain an opportunity at proving new ideas.

Q11. How would a prize contest differ from NASA releasing a request for information (RFI), such as what was done for a Hubble robotic servicing mission? How should the decision be made as to whether a particular objective is better suited to a prize competition or to more traditional approaches? Would the largest difference between the two methods be the lead-time required for the development of a technology through a prize contest as compared to that of the traditional route?

A11. This is perhaps the most important element. The difference between a prize and an RFI lies in the fact that in a prize, NASA does not get to judge which approach makes sense or which approach has the best technology. It simply judges who completed the task first successfully. The existing mature bureaucracy in NASA (and I say that in the kindest way) will prejudge which technology is too risky and what is most likely to work. Contracts will be awarded to the latter. NASA would never have allowed for *The Spirit of St. Louis* or *SpaceShipOne* with that type of selection process.

The most important thing NASA can do here is to set a very clear and concise set of rules independent of technology and then to judge who does it first. Providing the largest cash prize possible will serve to motivate the most number of creative approaches to engage the challenge.

Regarding what should be attacked as an RFI versus a prize: Prizes are most suited to fit those concepts which have very complex and multi-variable solutions. Good prize candidates are also those that have the opportunity for media, publicity, heroism, and a follow on line of business once the technology has been proven. RFIs can be used for soliciting solutions for known problems or known technologies where a price capability is sought that is well within the state of practice.

Question submitted by Representative Mark Udall

Q1. What do you consider to be the biggest impediments to carrying out a successful prize program?

A1. NASA needs to provide cash, use of its name and logo, and allowance for a flexible entrepreneurial approach that might seem contrary to NASA's existing way of doing business. There needs to exist an opportunity for Nike©, Apple© and Virgin Atlantic© to exploit a prize competition. Reality television shows should be generated that captures the minds and hearts of 50 million Americans. This blatant commercialism will make the difference between a prize program being stagnant, boring and nonfunctional to one that will capture the attention of nine-year-old kids and media CEOs across the country, if not the world.

ANSWERS TO POST-HEARING QUESTIONS

Responses by Dr. Molly K. Macauley, Senior Fellow, Resources for the Future

Questions submitted by Chairman Dana Rohrabacher

Q1. If NASA were to establish a program of prizes, how should issues of liability be treated? Should the Federal Government assume any legal risks associated with private companies competing for a prize? Would your answer be different if an outside entity (such as a private foundation or an endowment) was in charge of designing, administering and judging prize contests, rather than NASA?

A1. The issue of liability is indeed important and because (unlike the X-Prize), a NASA-sponsored prize involves both (1) government as sponsor and potential user and (2) the private sector or others (maybe government labs, for instance) as competitors, liability rules probably need to be developed by a mix of government and private sector attorneys. Models are probably available as used for other government contracting or peer-reviewed research awards. Liability of course has many aspects. For instance, there is liability for safety, performance, and property right infringement, and among these categories, concerns such as safety liability during development of the innovation (presumably this would rest with the inventor) or safety liability during use (presumably this would rest with the government when it makes use of the invention, or with other parties when they are making use of the invention). From an economics perspective, the assignment of liability can add cost to the competitor or add cost to the taxpayer, and the assignment confers different incentives for bearing risk. I'd be happy to work with any legal teams who become involved in designing liability guidelines.

Q2. If NASA were to establish a program of prizes, how should issues of intellectual property (IP) be treated? Should the IP rights for the technologies of a winning prize reside with the government, or with the prize winner? If with the prize winner, what rights, if any, should the government retain? Should the prize winners ever be required to share IP that NASA would need? Would your answer be different if an outside entity was in charge of prize contests?

A2. As the case with liability addressed in question (1) above, issues of IP also bring with them differences in "who bears the cost" and in incentives created for competitors and the government. Perhaps a workable solution is for IP to rest with the inventor, and the government or other customers use the invention under a fee-for-use or royalty payment. In other words, the prize money itself is a one-time award made to the winner for success, and any subsequent use by government or other customers requires a fee. The fee could be a one-time payment if the invention is a one-shot process or product, or it could be a per-use fee for a product or service with multiple uses.

Q3. If NASA or another federal entity was in charge of running a program of prize contests, should the Federal Government be allowed to receive private funds in addition to federally appropriated funds? If so, what conflicts of interest might arise and how could they be prevented? Conversely, if a private foundation or outside entity was in charge of running such a program, should the Federal Government be allowed to contract with or provide funds to this entity?

A3. There are examples of successful public-private cooperation in other development activities—for instance, in some (but not all) urban redevelopment projects, or in the early days of the Communications Satellite Corporation, which was a quasi-private sector entity. Perhaps a useful rule of thumb is to garner as much private sector involvement as possible, in funding as well as in administration of the prize. This rule would enable the government to act strictly as customer during the competition and once the prize is awarded.

Q4. What are the advantages and disadvantages for having either an outside private entity or a federal entity other than NASA in charge of running a program of prize contests, rather than NASA itself? What would the proper balance be between NASA's role and the outside entity's role in the designing, administering and judging of prize contests? Should NASA have any role in these areas?

A4. As suggested in the answer to question (3) above, making as much use of the private sector as possible probably best maintains the spirit and, as important, the desirable incentive structure of the prize, in order to bring out as many new ideas as possible, unencumbered by too much administration or restrictions. NASA must

play a role, since the agency is spending taxpayers' money, but that role can be limited to specifying the goal of the prize, the prize amount, and the time limits on the competition; providing the prize money; and judging the competition (again, since the agency is responsible for managing taxpayers' money).

Q5. Should NASA centers, FFRDCs and federal employees be allowed to compete for prizes?

A5. A significant amount of creative, entrepreneurial talent resides at the centers, FFRDCs, and among federal employees. For this reason, a prize designed to find the "best and brightest" competitors should have as few restrictions on participation as possible.

Q6. What recommendations do you have to minimize the possibility that the judging of a prize contest is not biased towards a particular solution? Do you believe NASA should or should not participate in the judging of such contests?

A6. As noted in question (4), since NASA is serving as steward of taxpayers' money, the agency needs to play a role in judging. If there is a concern about possible bias in judging, competitors will need to take this into account in their decisions to compete. In all fairness, even the private sector can bring bias to judging.

Q7. In his testimony, Dr. Diamandis said that the goal of a prize is not to develop technology to put directly into use in the space program, but rather to develop new ways of thinking—"to invent the transistor, not to perfect the process leading to a Pentium Chip." But presumably NASA must run its programs using mature technology.

Q7a. How could NASA take a winning idea and turn it into a mature technology that the space program can use?

A7a. It seems that both process technology (say, a new algorithm) and product technology is required for furthering space exploration, and since the history of prizes suggests an interest on the part of competitors in competing for both "basic" research development as well as product development, perhaps prizes should not be limited to only "mature" technology.

Q7b. Should NASA offer contracts to the winners of a prize, such as to develop his or her idea further to meet NASA's specifications? Or should such a job more likely fall to one of the major aerospace contractors?

A7b. The contracting mechanism that is used after a successful competition probably doesn't matter for the integrity of the prize.

Q8. What should NASA provide in order to attract participants to a prize contest? Should the winner of a prize contest expect to have a future business relationship with NASA? Should there be a guaranteed government contract for the winner of a prize, such as the delivery of cargo into orbit or to ISS? Is it necessary that there be some evidence of a future market for prizes to be effective?

A8. The history of prizes suggests that none of these provisions matters except for the prize itself (the award money).

Q9. You testified that prizes have been offered successfully in the past to develop incremental technologies, but that was before government began to invest so heavily in R&D.

Q9a. Is it better for NASA to offer both large and small prizes, or should it focus only on larger prizes? Would the cost of judging and otherwise administering small purse prizes outweigh the value of the prize itself and make such prizes not worthwhile?

A9a. NASA might consider experimenting with a variety of sizes of prizes—the overarching objective might simply be to provide an incentive for creative approaches to a variety of NASA requirements. A couple of disadvantages of prizes are that they don't provide up-front money, so competitors are limited in the cash flow or need to find financial backers, and that if a prize is not awarded, NASA has "lost time" during the duration of the prize competition. However, an unawarded prize may mean that the technology is simply not ready, and wouldn't be ready even if NASA had funded the technology development by means of traditional contracts or research awards. Prizes don't necessarily remedy the inherent uncertainty of innovation.

Q9b. *How should it be decided whether prizes or contracts/grants are the appropriate tool for stimulating innovation for small, discrete technologies (such as the development of an improved astronaut glove)?*

A9b. The history of prizes suggests that prizes may be useful for all kinds of innovation—so, NASA can experiment with prizes, with the caveats noted in the answer to question (9), above.

Q10. *To what degree should NASA plan to depend solely on prizes for the development of technologies that are essential to exploration, such as technologies that would be required for either long-duration space flight or extended human missions to the Moon?*

A10. See answer to question (9), above. Prizes don't provide initial cash to inventors, and prizes don't guarantee innovation. For critical technologies, NASA may need to provide cash up-front—and even then, success isn't guaranteed.

Q11. *How would a prize contest differ from NASA releasing a request for information (RFI), such as what was done for a Hubble robotic servicing mission? How should the decision be made as to whether a particular objective is better suited to a prize competition or to more traditional approaches? Would the largest difference between the two methods be the lead-time required for the development of a technology through a prize contest as compared to that of the traditional route?*

A11. As I understand it, an RFI doesn't imply funding, whereas a prize does promise an award if the competition is successful. Perhaps I misunderstand the RFI process. As noted in answers to previous questions, prizes might be offered for a wide range of types of innovation—discrete products, new processes, etc.

Questions submitted by Representative Mark Udall

Q1. *An area of focus for NASA's proposed prize program is seeking "revolutionary advances in fundamental technologies." On the one hand, a prize program might attract innovators who haven't traditionally been involved in NASA R&D activities. On the other hand, a prize program might wind up eliminating the participation of researchers from universities or other not-for-profit associations, who typically are dependent on ongoing research grants to support themselves and their graduate students' research activities.*

Q1a. *Are you concerned that an R&D approach built on prizes could potentially limit the opportunities for university researchers?*

A1a. Prizes have the disadvantage of not providing up-front cash for an inventor. A university researcher may find this *less* of a disadvantage than a private-sector entrepreneur not affiliated with a university, if the university researcher can do the research for the prize as part of research covered by university overhead or teaching allocations.

Q2. *What factors other than the size of the prize are likely to attract potential investors to participate in an inducement prize offering? For example, is winning the prize sufficient (because of the publicity involved) or must there be a market for the product that results from the competition?*

A2. The history of prizes suggests that the prize alone is sufficient. The challenging decision is *how much* to offer as the prize—presumably, the amount reflects the value of the potential innovation to NASA.

Q3. *What do you consider to be the biggest impediments to carrying out a successful prize program?*

A3. Perhaps the biggest impediment is figuring out how large to make the prize (the amount of prize money). The calculation involves figuring out how much the innovation "means" to NASA—and such valuation questions are always challenging.

ANSWERS TO POST-HEARING QUESTIONS

Responses by Dr. Douglas Holtz-Eakin, Director, Congressional Budget Office

Questions submitted by Chairman Dana Rohrabacher

Q1. If NASA were to establish a program of prizes, how should issues of liability be treated? Should the Federal Government assume any legal risks associated with private companies competing for a prize? Would your answer be different if an outside entity (such as a private foundation or an endowment) was in charge of designing, administering and judging prize contests, rather than NASA?

A1. General and sector-specific health and safety regulation, the criminal code, and the civil tort system all provide private firms with incentives to take care in their activities. In this context, the activities of prize competitors, whether overseen by the government, an outside agent acting on the government's behalf, or a private entity, would be unlikely to merit extraordinary treatment with regard to liability. The activities that propose the greatest risk, those associated with space launch, are already the subject of direct federal regulation and licensing.

Q2. If NASA were to establish a program of prizes, how should issues of intellectual property (IP) be treated? Should the IP rights for the technologies of a winning prize reside with the government, or with the prize winner? If with the prize winner, what rights, if any, should the government retain? Should the prize winners ever be required to share IP that NASA would need? Would your answer be different if an outside entity was in charge of prize contests?

A2. A prize competition intends to call forth effort to achieve program goals. In that context, whether National Aeronautics and Space Administration (NASA) or an outside entity were conducting a prize competition, the question of how intellectual property rights are treated is a question about how risks and rewards are divided between the government and prize seekers. One approach applied to rights created under government contracts is for the government to obtain a royalty-free license for use of those rights necessary for governmental purposes and for the contractor to retain the rights for other uses. An array of other arrangements are also possible. Broadly speaking and with all other rewards held constant, if more of the intellectual property rights to inventions or innovations made in the pursuit of a government-sponsored prize remain with the successful contestant, then contestants' incentive to expend effort is increased. If the government lays claim to more of the intellectual property rights, then the contestants' incentive to expend effort is less.

Q3. If NASA or another federal entity was in charge of running a program of prize contests, should the Federal Government be allowed to receive private funds in addition to federally appropriated funds? If so, what conflicts of interest might arise and how could they be prevented? Conversely, if a private foundation or outside entity was in charge of running such a program, should the Federal Government be allowed to contract with or provide funds to this entity?

A3. There is no reason why federal and private funds should not be commingled when a voluntary agreement can be reached between the government and the private sector. Conflicts of interest arise out specific facts to which a complex set of both federal laws and agency practices apply. It is not possible to comment on how such conflicts might be avoided in a NASA-sponsored prize competition without a specific set of facts outlining the details of an arrangement between NASA and a participating private entity.

Q4. What are the advantages and disadvantages for having either an outside private entity or a federal entity other than NASA in charge of running a program of prize contests, rather than NASA itself? What would the proper balance be between NASA's role and the outside entity's role in the designing, administering and judging of prize contests? Should NASA have any role in these areas?

A4. CBO is aware of no particular advantage or disadvantage inherent to the choice between the government or a private entity to run a prize competition. Any difference likely would derive from different objectives and rules.

Q5. Should NASA centers, FFRDCs and federal employees be allowed to compete for prizes?

A5. Permitting NASA centers and other federal employees or federally funded research and development centers (FFRDCs) to participate in government-sponsored

prize competitions likely will affect the incentives of both would-be private and governmental participants. Private participants would likely be discouraged by the addition of more competitors and any perception that a government entrant would enjoy an edge in both resources and evaluation in a close finish. Were governmental entities permitted to compete, they would also be subject to an incentive effect, perhaps a positive one. Some people have long advocated forcing government agencies to compete with private entities in the provision of specific services as a way to both improve the performance of government and reduce the cost of government-provided goods or services.

Q6. In his testimony, Dr. Diamandis said that the goal of a prize is not to develop technology to put directly into use in the space program, but rather to develop new ways of thinking—to invent the transistor, not to perfect the process leading to a Pentium Chip.” But presumably NASA must run its programs using mature technology.

Q6a. How could NASA take a winning idea and turn it into a mature technology that the space program can use?

Q6b. Should NASA offer contracts to the winners of a prize, such as to develop his or her idea further to meet NASA’s specifications? Or should such a job more likely fall to one of the major aerospace contractors?

A6a,b. Inserting new technology into NASA’s enterprise depends very much on the specifics of NASA’s programs and the technologies that they require. This problem is separate from the origins of the technology. As is the case with intellectual property, the prospect (or lack thereof) of future government contracts to develop an innovation will have an incentive effect on prize competitors.

Q7. What should NASA provide in order to attract participants to a prize contest? Should the winner of a prize contest expect to have a future business relationship with NASA? Should there be a guaranteed government contract for the winner of a prize, such as the delivery of cargo into orbit or to ISS? Is it necessary that there be some evidence of a future market for prizes to be effective?

A7. The simplest answer is cash. Although the government may offer rewards in a variety of forms—future business, development contracts, and favorable intellectual property rights—each of those forms has an equivalent cash value. The larger that cash value is, the stronger the incentive effect of the prize contest.

Q8. Dr. Macauley testified that prizes have been offered successfully in the past to develop incremental technologies, but that was before government began to invest so heavily in R&D.

Q8a. Is it better for NASA to offer both large and small prizes, or should it focus only on larger prizes? Would the cost of judging and otherwise administering small purse prizes outweigh the value of the prize itself and make such prizes not worthwhile?

Q8b. How should it be decided whether prizes or contracts/grants are the appropriate tool for stimulating innovation for small, discrete technologies (such as the development of an improved astronaut glove)?

A8a,b. CBO reviewed Dr. Macauley’s testimony with interest. Her research shows that recent experience with using prizes as a means to induce innovation is very limited. In that context, prudence might suggest a limited and experimental use of prizes to see how they work in the current configuration of governmental, academic, and private entities involved in meeting NASA’s demand for new technologies. Regarding the size of prizes, it must be recognized that achieving large, technically complex objectives will require commensurately large awards. Consistent with an overarching principle of contest design, prizes are likely to be most effective when the objective of the contest can be clearly established and success can be observed in black-and-white terms (for instance, crossing the finish line first) rather than in shades of grey (for example, subjective evaluation of technical merit.)

Q9. To what degree should NASA plan to depend solely on prizes for the development of technologies that are essential to exploration, such as technologies that would be required for either long-duration space flight or extended human missions to the Moon?

A9. Our limited recent experience with prize contests suggests experimentation should precede broad use. In that context, NASA’s objectives might be better achieved by using traditional contracting to develop technologies essential to its major missions.

Q10. How would a prize contest differ from NASA releasing a request for information (RFI), such as what was done for a Hubble robotic servicing mission? How should the decision be made as to whether a particular objective is better suited to a prize competition or to more traditional approaches? Would the largest difference between the two methods be the lead-time required for the development of a technology through a prize contest as compared to that of the traditional route?

A10. In issuing a request for information for the Hubble robotic servicing mission NASA took the first step in what is likely to be a traditional procurement of the goods and services necessary to accomplish the mission. An RFI is intended to solicit ideas and interest from the private sector and a precursor to a request for proposal or bid and, ultimately, a competitive award (a sole-source award may be an alternative in some circumstances). NASA's interest in or acceptance of the ideas or concepts submitted in response to an RFI provides the participants no immediate reward.

Continuing with the Hubble servicing example, a prize contest that made awards for actual performance would of course leap over an RFI and all of the other intermediate steps, but require the government to accept risks that it might not be prudent to take. The prize money might be too little or too much, the best solution may require joint action with the government, or a wide open competition could conceivably lead to attempts to service the Hubble that damaged the instrument. A contest that made awards for the "best" idea(s) is an alternative but has the problem of making an award based on very subjective evaluation in the presence of incomplete information.

Concerning lead times, the basics of the technologies required to accomplish a mission rather than the form of acquisition are likely to drive those spans.

Questions submitted by Representative Nick Lampson

Q1. What methods other than prizes or contests do you believe would be useful in stimulating investment in new technologies—whether space-related or not?

A1. The success of the United States economy in producing and developing technical innovations is well established. That success is built on a foundation of intellectual property rights and allowing private markets allocate resources. When government ventures into private markets, policy-makers must be keenly aware of how a wide array of actions, including direct spending for goods and services, tax policy, income transfer programs and regulation, affect the innovative process that has contributed so much to our standard of living. At the most basic level, the best method to stimulate investment in new technology is to allow market processes to work, intervene only when absolutely necessary, and even then to be aware of the unintended consequences that are often associated with government's attempt to improve market outcomes.

Q2. Typically the Federal Government seeks a royalty-free license to use any technology developed with federal funds.

Q2a. Would it be appropriate to require royalty-free licenses to the government as part of a NASA prize competition?

Q2b. Would a royalty-free license requirement affect the size of the prize that would have to be offered?

Q2c. If the government didn't require royalty-free licenses, how would that affect the relative benefit to the government of prizes versus contracts or grants?

A2a,b,c. Whether the government enjoys a royalty-free license to use the technology developed in a government sponsored prize competition is a question of how risks and rewards are divided between the government and prize seekers. If the government agrees to pay license fees to use inventions or innovations made in the pursuit of a government sponsored prize, contestants' incentive to expend effort is increased. If the government stipulates that it will not pay such fees, contestants' incentive to expend effort is less.

Questions submitted by Representative Mark Udall

Q1. NASA already has several existing means of attracting innovative R&D approaches. These include performance-based contracts, grants, and acceptance of unsolicited proposals. In addition, NASA participates in the Small Business Innovative Research (SBIR) program, which is described as a "highly competitive

three phase award system which provides qualified small business concerns with opportunities to propose innovative ideas that meet the specific research and development needs of the Federal Government.” *SBIR in particular seems to have goals similar to NASA’s proposed Centennial Challenge prize program.*

Q1a. What do you see as the relative strengths and weaknesses of each of the approaches (grants, unsolicited proposals, performance-based contracts, SBIR, and prizes) in encouraging innovative technologies?

Q1b. How much emphasis should NASA give to prizes versus these existing approaches?

A1a,b. CBO has not undertaken a detailed review of the Small Business Innovative Research (SBIR) program, which is within the National Aeronautics and Space Administration (NASA). Broadly speaking, however, it seems that the SBIR intends for NASA to have more involvement with contractors than would likely be the case for a prize competition and, unlike a prize competition open to all comers, is restricted to small businesses only. That the most effective prize competitions are open is a defining characteristic of the prize approach to encouraging innovation. That suggests that where objectives like increasing small business or minority participation in NASA’s program are sought, prize competitions are less effective than other alternatives.

Q2. What do you consider to be the biggest impediments to carrying out a successful prize program?

A2. A successful competition must have a very clear and unambiguous finish line and clear and well-thought-out rules. As I indicated in my testimony, failure to have either diminishes the prospect of a successful contest.