Federally Funded Innovation Inducement Prizes

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Summary

Since at least the 18th century, philanthropic organizations, industry, governments, and nongovernmental organizations throughout the world have offered many different kinds of prizes with a variety of objectives to reward accomplishments in science and technology. In the United States, Congress authorized most of today's federally-funded innovation inducement prizes beginning with the 108th Congress (2003). This analysis focuses on federally-funded "innovation inducement prizes," which are sponsored by federal organizations and designed to encourage scientists and engineers to pursue scientific and technical societal goals not yet reached.

The objectives of such prizes are generally to identify new or unorthodox ideas or approaches to particular challenges; demonstrate the feasibility or potential of particular technologies; promote development and diffusion of specific technologies; address intractable or neglected societal challenges; and educate the public about the excitement and usefulness of research and innovation. They differ from "recognition prizes" such as the National Medal of Science, National Medal of Technology, and the Nobel prizes, which reward past S&T accomplishments.

The scientific and technological goals for federally-funded innovation inducement prizes include the full spectrum of research, development, testing, demonstration, and deployment. They are an alternative to more traditional ways of achieving societal objectives with S&T such as grants, contracts, fees, patents, and human or physical infrastructure investments that some think are too costly, risk-averse, and bureaucratic. Some believe that prizes, if designed well, can enhance the ability of science and technology to solve societal problems, by reaching a wider community of problem solvers, encouraging risk-taking, and focusing the attention of policymakers, entrepreneurs, the public, and researchers on the goals of an innovation program. Concerns about prizes are that they may inhibit the exchange of information among researchers and innovators due to the very nature of competitions, be challenging to design and finance, and result in duplicative work which may not be the best use of limited intellectual and financial resources.

Prizes differ in their intentions, objectives, sources of funding, competition mechanisms, reward structure, and other variables. The prizes themselves may take the form of recognition and publicity, cash, marketing monopolies, or other means. When a cash award is provided, most range from $250,000 to $2 million, can go up as high as $10 million, and have exceeded $500 million when the winner provides a service such as a vaccine. Some experts view the non-compensation portion of prizes such as recognition and publicity, as important, and sometimes more important, than the potential financial reward.

Members of Congress interested in federally-funded innovation inducement prizes may wish to consider several policy options including creating new prizes, and modifying or increasing oversight of current prize programs. In the 111th Congress, policymakers may make decisions that influence whether or not current prize programs will be funded, and existing programs modified. Some policymakers have proposed new prizes on technologies such as self-powered farms, voting systems designed for persons with disabilities, energy technologies, nanotechnology, cybersecurity, and automotive energy efficiency.

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National governments throughout the world have offered prizes to encourage innovation since at least the late 1700s. For example, Napoleon's government offered a 12,000 franc prize for technologies that would enhance the preservation of food to better feed advancing military troops. This lead to the process of preserving food in bottles, which shortly thereafter led to the process of canned foods, and then broad use by consumers.[1]

In the United States, Congress authorized most of today's federally-funded innovation inducement prizes beginning with the 108th Congress (2003). The purpose of this report is to gain a better understanding of these prizes to provide guidance for Members of Congress who are interested in creating new prizes, modifying current prize programs, or increasing oversight of current prizes.

This report discusses the status of current federally-funded innovation inducement prizes, addresses the different types of prizes, analyzes when prizes may be appropriate and effective, and summarizes assessments that have been made of their effectiveness. The report also provides the lessons that may be learned from completed competitions, and policy options for those Members of Congress interested in taking action regarding federally-funded innovation inducement prizes. The report concludes with an overview of 111th congressional activities regarding prizes.

This report does not discuss prizes funded by non-federal organizations nor does it discuss recognition prizes that reward past accomplishments other than to distinguish them from innovation inducement prizes (see discussion of this issue in the following section, "What Are the Different Kinds of Prizes?").

What Are the Different Kinds of Prizes?

Philanthropic organizations, industry, governments, and nongovernmental organizations offer many different kinds of prizes with a variety of objectives to reward accomplishments in science and technology (S&T).[2] Some prizes, such as the Nobel prizes and U.S. National Medal of Science and National Medal of Technology, reward past accomplishments and do not have a specific scientific or technological goal. These have been called "recognition prizes." Other prizes, called "innovation inducement prizes," are designed to attain scientific and technical goals not yet reached, often in response to perceived market failures.

Objectives of these prizes include both technological and non-technological goals:

- Identify new or unorthodox ideas or approaches to particular challenges;
- Demonstrate the feasibility or potential of particular technologies;
- Promote development and diffusion of specific technologies;

[1] Dale Blumenthal, "The Canning Process: Old Preservation Technique Goes Modern," *Food and Drug Administration Consumer Magazine*, September 1, 1990, at http://www.fda.gov/bbs/topics/CONSUMER/CON00043.html.

[2] For lists of some existing prizes, see Knowledge Ecology International, *Selected Innovation Prizes and Reward Programs*, KEI Research Note 2008:1 at http://www.keionline.org/misc-docs/research_notes/kei_rn_2008_1.pdf; and McKinsey & Company, *And the Winner is ... Capturing the Promise of Philanthropic Prizes*, 2009 at http://www.mckinsey.com/clientservice/socialsector/And_the_winner_is.pdf.

- Address intractable or neglected societal challenges; and
- Educate the public about the excitement and usefulness of research and innovation.[3]

This report focuses upon federally-funded "innovation inducement" prizes that have these goals.

The scientific and technological goals for prizes include the full spectrum of research, development, testing, demonstration, and deployment. They are an alternative to more traditional ways of achieving societal objectives with science and technology such as grants, contracts, fees, patents, and human or physical infrastructure investments that some think are too costly, risk-averse, and bureaucratic. Some believe that prizes, if designed well, can enhance the ability of science and technology to solve societal problems, by reaching a wider community of problem solvers, encouraging risk-taking, and focusing the attention of policymakers, entrepreneurs, the public, and researchers on the goals of an innovation program. Concerns about prizes are that they may inhibit the exchange of information among researchers and innovators due to the very nature of competitions, be challenging to design and finance, and result in duplicative work which may not be the best use of limited intellectual and financial resources.[4]

Prizes differ in their intentions, objectives, sources of funding, competition mechanisms, reward structures, and other variables. There is also a wide spectrum of participants in prize competitions from individual citizens with and without scientific or technical expertise, school districts, governments, universities and other nonprofit organizations, and small and large companies. The prizes themselves may take the form of recognition and publicity, cash, marketing monopolies, or other means.[5] Some experts view the non-compensation portion of prizes as important, and sometimes more important, than the potential financial reward. From a competitor standpoint, key considerations are the degree of flexibility in the competition rules, and the financial and nonfinancial risks and incentives.[6]

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

[4] National Academy of Engineering, *Concerning Federally Sponsored Inducement Prizes in Engineering and Science* (Washington, DC: National Academy Press, 1999) at http://www.nap.edu/catalog.php?record_id=9724; National Research Council, *Innovation Inducement Prizes at the National Science Foundation* (Washington, DC: National Academy Press, 2007); Richard G. Newell and Nathan E. Wilson, *Technology Prizes for Climate Change Mitigation*, RFF DP 05-33, Resources for the Future, June 2005 at http://www.rff.org/documents/RFF-DP-05-33.pdf; McKinsey & Company, *And the Winner is ... Capturing the Promise of Philanthropic Prizes*, 2009, at http://www.mckinsey.com/clientservice/socialsector/And_the_winner_is.pdf; Thomas Kalil, *Prizes for Technological Innovation*, The Brookings Institution, December 2006 at http://www.brookings.edu/views/papers/200612kalil.pdf; Liam Brunt, Josh Lerner, and Tom Nicholas, *Inducement Prizes and Innovation*, CEPR Discussion Paper No. DP6917, July 2008 at http://ssrn.com/abstract=1307507.

[5] Knowledge Ecology International, *Selected Innovation Prizes and Reward Programs*, KEI Research Note 2008:1 at http://www.keionline.org/misc-docs/research_notes/kei_rn_2008_1.pdf.

[6] Barry J. Nalebuff and Joseph E. Stiglitz, "Prizes and Incentives: Towards a General Theory of Compensation and Competition," *The Bell Journal of Economics* 14(1): 21-43, Spring 1983.

What Is the Status of Federally-Funded Innovation Inducement Prizes?

The following federal agencies have science and technology (S&T) programs that conduct prize competitions: the Department of Energy (DOE), the Department of Defense (DOD) including the Defense Advanced Research Projects Agency (DARPA), the Department of Health and Human Services' (HHS) Biomedical Advanced Research and Development Authority (BARDA), and the National Aeronautics and Space Administration (NASA). Each of these agencies have the statutory authority to offer prizes. **Table 1** provides an initial overview, and the text that follows provides more in-depth information.

Table 1. Federally-Funded Innovation Inducement Prizes

Agency	Competition	Technological Target	Total Prize	Status
Department of Defense (DOD)	**DOD Wearable Power Prize**[a]	Long-endurance, lightweight power pack for warfighters in the field.	$1.75 million.	Prizes awarded. A new competition is being considered.
	DARPA Grand Challenges[b]	Autonomous operation of unmanned ground combat vehicles	$3.5 million.	Competitions held in 2004, 2005, 2007. Awards given in 2005 and 2007. No future competitions are planned.
Department of Energy (DOE)	**DOE Grand Challenges**	Breakthrough achievements in research, development, and commercial application that have potential for application to performance of DOE's mission.	$1-10 million.	The three DOE Grand Challenge competitions, the Freedom Prize, H-Prize, and L-prize, are described in the following rows.
	• **Freedom Prize**[c]	Reduce country's dependence on foreign oil.	$1.5 million.	Competition expected to begin in 2009.
	• Hydrogen Prize (H-Prize)d	• Hydrogen storage, and advancements in technologies, components or systems related to hydrogen storage.	$1 million.	Competition expected to begin in 2009.
	• Bright Tomorrow Lighting Prize (L-Prize) e	Three competitions: Replacements for 60 watt (W) incandescent light and parabolic aluminized reflector (PAR) 38 Halogen lighting; and a 150 lumens/watt (lm/W) "21st Century Lamp."	$10 million for 60W incandescent lamp category; $5 million each for PAR 38 and 21st Century Lamp categories.	Ongoing 2009 competition for 60W and PAR 38 replacements. Future competition expected for 21st century lamp.

Agency	Competition	Technological Target	Total Prize	Status
	Progressive Automotive X PRIZE[f]	Clean, production-capable and super fuel efficient vehicles that exceed 100 MPG equivalent fuel economy. (MPGe)	$10 million from private sponsors; DOE provided $3.5 million for education activities.	Over 100 teams have registered for competition scheduled for 2010.
DOE and Environmental Protection Agency (EPA)	**American Le Mans Series (ALMS) Green Challenge Race**[g]	Encourage manufacturers to develop and introduce green technologies.	No financial prize. EPA and DOE provide in-kind support.	Two winners in 2008. In 2009, competition renamed Michelin Green X Challenge.
NASA	**NASA Centennial Challenge**[h]	Drive progress in aerospace technology of value to NASA's missions, and find the most innovative solutions to technical challenges.	$300,000 to $2 million.	Six ongoing competitions (described in rows below). Future competitions on other topics are planned.
	• Astronaut Glove Challengei	Improve glove design to reduce effort needed to perform tasks in space and improve the durability of the glove.	$250,000.	One competition held and won. Second competition in 2009.
	• General Aviation Technologyj	Demonstrate the performance of light aircraft that incorporate improvements to maximize fuel efficiency, reduce noise, and improve safety.	$300,000.	NASA awarded a total of $97,000 in prizes in 2008. Competition scheduled for 2011 announced in 2009.
	• Lunar Regolith Challengek	Design and build robotic machines to excavate simulated lunar soil.	$750,000.	Competition held in 2008 with no winner. New competition scheduled for 2009.
	• Northrop Grumman Lunar Lander Challengel	Build and fly a rocket-powered vehicle to perform simulated Lunar flight.	$2 million.	Level One of the competition completed in 2008, and $350,000 in prize money awarded. Level Two competition in 2009.
	• Power Beaming and Tether ("Space Elevator")m	Two competitions: Power Beaming - Wireless power transmission; Tether - Exceed current tether strength.	$2 million.	Competitions held in 2006-2008 with no winner. Competitions scheduled for 2009.
	• **Lunar Oxygen Production or MoonROx**[n]	Generate breathable oxygen from simulated lunar soil.	$1 million	Competition held in 2008 with no winner. Competition scheduled for October 2009.

Agency	Competition	Technological Target	Total Prize	Status
HHS	**BARDA Project Bioshield**[o]	Effective medical countermeasures (e.g., diagnostic tests, drugs, vaccines, and other treatments) against chemical, biological, radiological, and nuclear (CBRN) agents.	Contract that guarantees government will purchase results of research and development proposed.	Ongoing competition with annual awards of contracts beginning in 2005. Awards thus far have ranged from less than $1 million to almost $900 million.

Source: Congressional Research Service based on information cited for each competition.

a. For more information, see http://www.dod.mil/ddre/prize/topic.html. Personal communication, CRS with Karen Burrows, DOD Prize Manager, March 27, 2009.

b. For more information, see http://www.darpa.mil/grandchallenge04/sponsor_toolkit/congress_lang.pdf; DARPA, DARPA Grand Challenge 2005:Rules, October 8, 2004 at http://www.darpa.mil/grandchallenge05/Rules_8oct04.pdf; http://www.darpa.mil/grandchallenge04; http://www.darpa.mil/grandchallenge05/; http://www.darpa.mil/grandchallenge/index.asp; and Personal communication, CRS with John Jennings, DARPA, on March 26, 2009.

c. For more information, see http://www.freedomprize.org/prizes/history.php. Personal communication, CRS with Karen Hanson, Executive Director, Freedom Prize, March 27, 2009.

d. For more information, see http://www.hydrogen.energy.gov/news_hprize_foundation.html. Personal communication, CRS with Jerry Hinkle, Technical Director, H-Prize, Technology Transition Corporation, March 31, 2009.

e. For more information, see http://www.lightingprize.org/index.stm.

f. For more information, see http://www.progressiveautoxprize.org/;

g. For more information, see http://www.epa.gov/OTAQ/ld-hwy/420f08031.htm; and http://www.americanlemans.com/index_green.php

h. For more information, see http://centennialchallenges.nasa.gov/; NASA FY2009 and FY2010 Budget Requests.

i. For more information, see http://astronaut-glove.tripod.com/.

j. For more information, see http://cafefoundation.org/v2/pav_home.php.

k. For more information, see http://regolith.csewi.org/.

l. For more information, see http://space.xprize.org/lunar-lander-challenge.

m. For more information, see http://www.spaceward.org/elevator2010-pb and http://www.spaceflightamerica.org/.

n. For more information, see http://moonrox.csewi.org/.

o. For more information, see CRS Report RL33907, *Project BioShield: Appropriations, Acquisitions, and Policy Implementation Issues for Congress*, by Frank Gottron.

Department of Defense (DOD) Wearable Power Prize

The DOD Wearable prize was authorized by the John Warner National Defense Authorization Act of 2007 (P.L. 110-36), which stated that

> The Secretary of Defense, acting through the Director of Defense Research and Engineering and the service acquisition executive for each military department, may carry out programs to award cash prizes in recognition of outstanding achievements in basic, advanced, and applied research, technology development, and prototype development that have the

> potential for application to the performance of the military missions of the Department of Defense.

In response to this general authorization, DOD decided its first competition would be development of a long-endurance, lightweight power pack for warfighters in the field.

Competition Goals

The prize competition sought to inspire the use of ground-breaking and inventive approaches to solve technical problems; reach non-traditional DOD performers by lowering the barriers for participation; inspire students, academia, private inventors, and industry alike to leverage resources and compete using innovative ideas and approaches.[7] The winner of the contest was the lightest weight system weighing 4 kg or less at the weigh-in and meeting the total energy requirement as demonstrated in the competitive demonstration (bench plus field tests). **Figure 1** provides an overview of the prize's timeline, and may be illustrative of a typical prize timetable.

Of the completed competitions, the DOD Wearable Power Prize (which was managed by DOD with contractor support as needed) appears to have been the most successful in reaching a specific technological target for the federal government as well as enhancing its network of those interested in the topic, both internally within the services, and externally among possible contractors. DOD officials are discussing the next steps to advance the technology, not only with the winners, but the other participants as well.

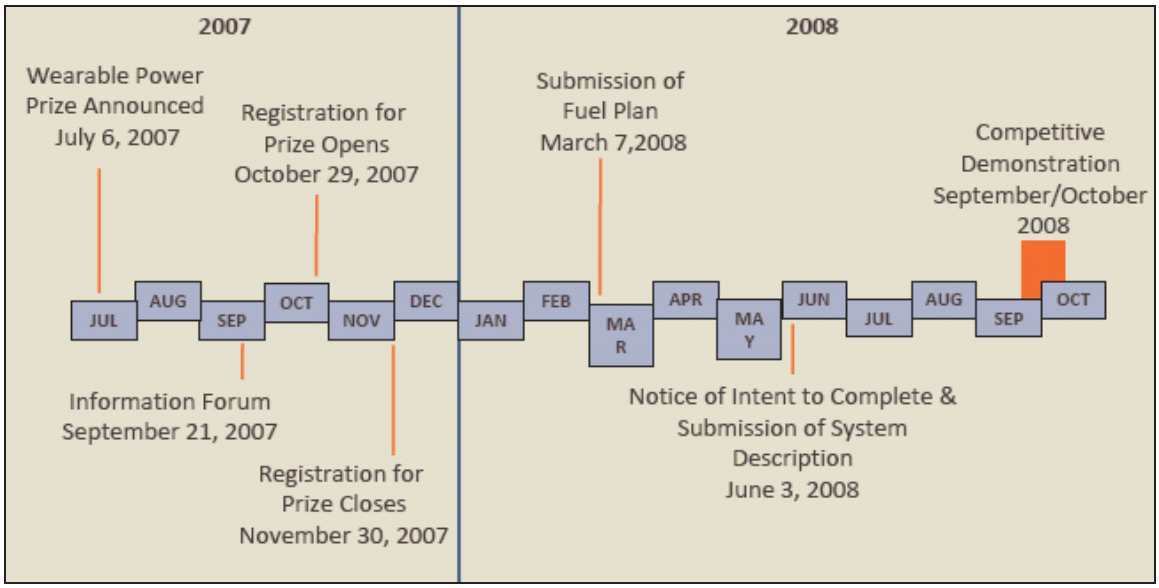
DOD Assessment of Program

DOD has assessed the benefits of the program for itself and to prize competitors, and found that the competition provided several benefits. It helped validate the status and appropriateness of DOD investments, identify new approaches, create a national awareness of the importance of wearable power, facilitated the Pentagon and military Services working together to identify a joint direction for this technology before and after the competition, and identified seven organizations and groups new to working with DOD.[8]

[7] For more information, see http://www.dod.mil/ddre/prize/topic.html.

[8] John W. Hopkins, Project Manger, Army Research Laboratory and Karen S. Burrows, Defense Research & Engineering Prize Manager, Wearable Power Prize Competition, "Wearable Power Prize Competition," powerpoint presentation, December 11, 2008.

Figure 1. DOD Wearable Power Prize Timeline



Source: DOD Wearable Power Prize Information Forum, powerpoint presentation, September 21, 2007 at http://www.dod.mil/ddre/prize/doc/WPP_IF_Brief9_21_07.pdf.

DOD's assessment concluded that there were benefits to competitors, such as those participating in the competition were able to have access to DOD-paid and validated laboratory grade testing in close-to-operational conditions, and to DOD civilian and military professionals who provided direct feedback and real-time technical assessments. Competitors were also able to interact with other teams, which enhanced collaborative discussions and networking opportunities on topics of common interest. In addition, competitors received heightened national and international publicity through news reports and web activities.

Lessons for Future

DOD analyzed its competition to identify lessons learned for future competitions. According to DOD staff, among these lessons are—

- Choosing a topic or a competition goal that will attract the broadest public interest and ability to participate;
- Involving stakeholders (e.g., possible customers and competitors) from the beginning;
- Recognizing that setting competition metrics is critical;
- Deciding if topic addresses joint-service need (or not) and executing accordingly;
- Lowering competition entry and participation barriers to enable broadest involvement;
- Deciding if screening to determine whether concepts not deemed worthy of further consideration is prudent;
- Dedicating resources for media campaign and competitor communications (from program start to finish);

- Recognizing that a final public event requires significant resources; and
- Developing a post-competition plan that addresses expectations after the competition.[9]

This competition is concluded, but DOD is currently discussing at least one additional competition on a different technological challenge as part of its overall DOD prize program.[10]

Defense Advanced Research Projects Agency (DARPA) Grand Challenges

The DARPA[11] Grand Challenges were authorized in the Bob Stump National Defense Authorization Act for Fiscal Year 2003 (H.R. 4546, Sec. 2374b), which stated

> The Secretaries of the military departments and the heads of defense agencies may each carry out a program to award cash prizes in recognition of outstanding achievements that are designed to promote science, mathematics, engineering, or technology education in support of the missions of the U.S. Department of Defense.[12]

In response to the Floyd D. Spence National Defense Authorization Act for Fiscal Year 2001 (S. 2549, Sec. 217), which stated, "It shall be a goal of the Armed Forces to achieve the fielding of unmanned, remotely controlled technology such that by 2015, one-third of the operational ground combat vehicles of the Armed Forces are unmanned," DARPA decided to focus on autonomous robotic ground vehicles.[13]

Competition Goals

According to DARPA, the Grand Challenges sought to promote innovative technical approaches that would enable the autonomous operation of unmanned ground combat vehicles. These autonomous ground vehicles were to navigate from point to point in an intelligent manner to avoid or accommodate obstacles including nearby vehicles and other impediments. For the contest, DARPA held field tests of autonomous ground vehicles over realistic terrain and set specific performance goals for distance and speed. DOD planned to make three awards, first place for $2 million, second place for $1 million, and $500,000 for third place.[14]

The intent of the Grand Challenge program was to encourage participation by nontraditional partners so they might offer new, innovative ways of thinking that can lead to breakthroughs in various scientific or technological challenges. The cost of developing, fielding, and insuring entered vehicles was the sole responsibility of the individual teams. DARPA did not provide

[9] Ibid.

[10] Personal communication, CRS with Karen Burrows, DOD Prize Manager, March 27, 2009.

[11] DARPA is located at the Department of Defense. For more information, see CRS Report RL34497, *Advanced Research Projects Agency - Energy (ARPA-E): Background, Status, and Selected Issues for Congress*, by Deborah D. Stine.

[12] For more information, see http://www.darpa.mil/grandchallenge04/sponsor_toolkit/congress_lang.pdf.

[13] Autonomous vehicles are "driverless vehicles," where a human does not need to be inside the vehicle to operate it.

[14] DARPA, DARPA Grand Challenge 2005:Rules, October 8, 2004 at http://www.darpa.mil/grandchallenge05/Rules_8oct04.pdf.

funding for the purpose of Grand Challenge entry or participation. Teams underwent a qualification process that included submission of the application, submission of an acceptable vehicle specification sheet and video demonstration, successful performance at the site visit, selection for the National Qualification Event (NQE), submission of an appropriate technical paper and successful performance at the NQE. The NQE was the final qualification featuring a course that measures and tests vehicle capabilities where semifinalists vie for selection for the Grand Challenge Event.

Competitions

In 2004 and 2005, DARPA held Grand Challenges, and in 2007, DARPA hosted the Urban Challenge—an autonomous vehicle race through traffic. In 2004, participants were to develop vehicles that will navigate a course. No team entry successfully completed the designated route, and no award was made.[15]

In 2005, the DARPA Grand Challenge was similar to that in 2004. However, the test was in a different location that included 132 miles in desert terrain. Five teams completed the course, and first, second, and third place were awarded.[16]

In 2007, the DARPA Urban required teams to build an autonomous vehicle capable of driving in traffic, performing complex maneuvers such as merging, passing, parking and negotiating intersections. Eleven teams qualified and there were three winners.[17]

DARPA currently has no plans to hold an additional Grand Challenge event at this time. Should an additional challenge be held, it would likely focus on a different topic.[18]

DARPA Assessment of Program

According to DARPA, its Urban Challenge showed "breakthrough advances in autonomous vehicle capability and demonstrated for the first time autonomous vehicle operation in traffic," which is "being absorbed by the community, as expectations have been raised regarding autonomous vehicle capability and performance."[19] Teams that participated in the competition have begun identifying transition targets and partners. For example,

> Oshkosh Truck, which fielded Team Oshkosh Truck, has planned logistics demonstrations for the U.S. Army and U.S. Navy on vehicle platforms such as the Medium Tactical Vehicle Replacement, Palletized Load System, and Heavy Expanded Mobility Tactical Truck, and will demonstrate their vehicle for U.S. Army's Tank-Automotive Command Life Cycle Management Command.[20]

DARPA made the following overall assessment of its program:

[15] Personal communication, CRS with John Jennings, DARPA, on March 26, 2009.

[16] For more information, see http://www.darpa.mil/grandchallenge04/.

[17] For more information, see http://www.darpa.mil/grandchallenge05/.

[18] For more information, see http://www.darpa.mil/grandchallenge/index.asp.

[19] DARPA, *Prizes For Advanced Technology Achievements: Fiscal Year 2007 Annual Report*, January 2008 at http://www.darpa.mil/GRANDCHALLENGE/docs/DDRE_Prize_Report_FY07.pdf.

[20] Ibid.

> The Urban Challenge program achieved its program goals and stimulated interest in the programs and projects of interest to the DoD Science and Technology (S&T) community. It was successful in attracting considerable joint investment by the participants and their sponsors, effectively leveraging Government investment in the program. The technical challenge was carefully defined and staged to bring coherence to the community and increase the chance for cross-fertilization among competing groups. The solicitation and qualification process was successful in attracting a large pool of strong teams with participation from the defense industry, automotive industry, academia, as well as a number of smaller organizations. This investment in expanding the community will continue to pay dividends as DoD benefits from a strengthened commercial sector autonomous vehicle technical community. The program has been successful in attracting many young people to work on S&T problems in areas affecting national security, and benefits are expected to accrue for many years as this group enters the work force.
>
> The DARPA Grand Challenges in 2004 and 2005 made significant strides toward a day when autonomous robotic vehicles will perform hazardous tasks on the battlefield that today put America's fighting force in harm's way. In addition to saving lives, the technology will reduce stress on manpower requirements by requiring fewer support people. The DARPA Urban Challenge continued the acceleration of autonomous ground vehicle technology, making possible deployment on the battlefield within the timelines established by Congress.[21]

Department of Energy (DOE) Grand Challenges

The DOE Grand Challenges were authorized by the Energy Policy Act of 2005 (P.L. 109-58, Title X, Sec. 1008; EPACT 2005), in a section entitled "Prizes for Achievement in Grand Challenges of Science and Technology." This act states that "The Secretary may carry out a program to award cash prizes in recognition of breakthrough achievements in research, development, demonstration, and commercial application that have the potential for application to the performance of the mission of the Department." The Freedom Prize was created in the same act. The Energy Independence and Security Act (EISA) amended EPACT 2005 to create two additional prizes, the Hydrogen Prize (H-Prize) and the Lighting Prize (L-Prize). These prizes are scheduled to begin their activities in 2009.

Freedom Prize

The purpose of the Freedom Prize, authorized in EPACT 2005, is to encourage and recognize the development and deployment of processes and technologies that will improve America's national security, economic prosperity, and health by reducing the country's dependence on foreign oil.[22] The prize is to reward innovative deployment of existing technologies in five broad categories which include industry, military, schools, government and community. The first Freedom Prize competition, focused on school districts, is scheduled to begin in 2009. The Freedom Prize Foundation plans to give several awards, with total of $1.5 million in prizes.[23]

[21] DARPA, *Prizes For Advanced Technology Achievements: Fiscal Year 2007 Annual Report*, January 2008 at http://www.darpa.mil/GRANDCHALLENGE/docs/DDRE_Prize_Report_FY07.pdf.

[22] For more information, see http://www.freedomprize.org/prizes/history.php.

[23] Personal communication, CRS with Karen Hanson, Executive Director, Freedom Prize, March 27, 2009..

Hydrogen Prize (H-Prize)

The purpose of the H-Prize, authorized in EISA 2007 (Sec. 654), is to

> competitively award cash prizes in conformity with this subsection to advance the research, development, demonstration, and commercial application of hydrogen energy technologies…. The Secretary shall establish prizes under this subsection for—
>
> (i) advancements in technologies, components, or systems related to—
>
> (I) hydrogen production;
>
> (II) hydrogen storage;
>
> (III) hydrogen distribution; and
>
> (IV) hydrogen utilization;
>
> (ii) prototypes of hydrogen-powered vehicles or other hydrogen-based products that best meet or exceed objective performance criteria, such as completion of a race over a certain distance or terrain or generation of energy at certain levels of efficiency; and
>
> (iii) transformational changes in technologies for the distribution or production of hydrogen that meet or exceed far-reaching objective criteria, which shall include minimal carbon emissions and which may include cost criteria designed to facilitate the eventual market success of a winning technology.[24]

The 2009/2010 competition is to focus on storage materials for hydrogen in mobile systems for light-duty vehicles with a $1 million prize to the winner. Private contributions are expected to augment prize funds. The tentative schedule is to give notice of the competition in the *Federal Register* in Summer 2009, take entries by Fall 2009, and have a judging panel test and evaluate in Summer 2010. The $1 million prize is expected to be awarded in Fall 2010. The Hydrogen Education Foundation administers the prize on behalf of DOE.

Bright Tomorrow Lighting Prize (L-Prize)

The goal of the L-prize, authorized in EISA 2007, is to spur development of ultra-efficient solid-state lighting products to replace the most widely used lighting, the 60-watt incandescent lamp and the PAR 38 halogen lamp, and to develop a "21st Century Lamp" that delivers more than 150 lumens/watt (lm/W). On June 24, 2009, DOE announced the beginning of the competition in a Federal Register notice.[25] Awards include cash prizes, subject to the availability of appropriated funds, of $10 million for the first successful product in the 60-watt incandescent lamp category and $5 million for the first successful product in each of the PAR 38 and 21st Century Lamp categories. In addition, there are opportunities for federal purchasing agreements, utility programs, and other incentives.

[24] For more information on the H-prize, see http://www.hydrogenprize.com/indexNew.asp.

[25] Department of Energy, "Bright Tomorrow Lighting Competition," 73 *Federal Register* 35680, June 24, 2008.

In this competition, companies do not enter the competition officially until they have 2,000 samples of the product ready for laboratory testing. The results of the testing will then be judged by a technical review committee, whose members may include utilities, lighting designers, and light-emitting diode (LED) technology experts, to determine the winning entry.[26] As of June 2009, it is expected that 5-10 companies are developing products for submission to the competition.[27] If no submissions are received by June 2010, then DOE has the option of either closing the competition or revising the standards under which it operates.

A unique feature of the L-prize is that there are a number of partners. Partners are organizations such as utilities and energy efficiency groups that have agreed through a memorandum of understanding to aid in marketing winning technologies. As of June 2009, there are approximately 23 partners who are active in 29 states.[28]

Progressive Automotive X PRIZE

The goal of the Progressive Automotive X PRIZE, managed by the X PRIZE Foundation with financial sponsorship by the Progressive Casualty Insurance Company, is "to inspire a new generation of viable, super-efficient vehicles that help break our addiction to oil and stem the effects of climate change."[29]

As noted earlier, when the federal government offers a prize, it frequently does so with the help of another organization who administers the prize either for a fee or at no cost through the provision of in-kind support. In this situation, another organization offers the prize and it is the federal government who provides support. An alternative approach is for the federal government to support a competition managed by a private or philanthropic organization, rather than administering the prize and acting as the primary sponsor itself.

A purse of $10 million in prizes would be awarded to the team(s) that develop a clean, production-capable and super fuel efficient vehicles that exceeds 100 MPG equivalent fuel economy (MPGe). This competition is focused on development of cars that would be made available for purchase, rather than concept cars. No technology is specified, but plans are to provide clear technical boundaries (i.e., for fuel-efficiency, emissions, safety, manufacturability, performance, capacity, etc.). In addition, the competition hopes to attract both existing automobile manufacturers and newcomers, and a balanced array of private investment, donors, sponsors, and partners to help competitors succeed (e.g., manufacturing assistance, testing resources, etc.). Beyond technological innovation, the prize sponsors plan to publicize the results, provide a cash award, and educate the public on key issues.

Over 100 teams representing 136 vehicles with 14 different fuel sources have passed the first judging stage allowing them to participate in the competition. The next stage is the judging of the vehicle designs to assess the vehicle's features, production capability, safety, and business plans. In the final stage, teams will compete in a long distance stage competition to assess vehicle performance and determine if their vehicles can exceed 100 MPGe. Both the competition events

[26] Personal communication, CRS with James Broderick, Department of Energy, June 10, 2009.

[27] Ibid.

[28] For a list of the current partners, see http://www.lightingprize.org/partners.stm.

[29] Progressive Automotive X Prize, "Prize Details," webpage at http://www.progressiveautoxprize.org/prize-details.

and the announcement of winners, which will take place after the event results have been analyzed, are expected in 2010.

DOE's Office of Energy Efficiency and Renewable Energy provided a $3.5 million grant to the Progressive Automotive X PRIZE for educational activities related to the competition. This includes a website, Fuel Our Future, developed with the X PRIZE Foundation and Discovery Education, that serves as an "interactive online portal offering stimulating science, technology, engineering and math (STEM) lessons and resources for students, teachers and families as the unique and engaging Progressive Automotive X PRIZE competition unfolds."[30] Additional plans for the funds include a national high school student contest, and educational events in host cities of the Progressive Automotive X PRIZE race series.[31]

American Le Mans Series (ALMS) Green Challenge Race

The Environmental Protection Agency's (EPA) Office of Transportation and Air Quality, DOE's Argonne National Laboratory, and the Society of Automotive Engineers (SAE) proposed a competition that incorporated "green" principles[32] into auto racing to encourage manufacturers to develop and introduce "green" technologies.[33] As with the Progressive Automotive X PRIZE discussed in the previous section, a non-federal organization sponsors the actual competition while federal agencies and others co-sponsors in-kind support. The Green Challenge Award sponsored by the American Le Mans Series (ALMS) with EPA, DOE, and the SAE as co-sponsors, is for the fastest car with the smallest environmental footprint.[34] It is described further below.

The ALMS Green Challenge provides incentives for improved efficiency, use of renewable fuels, and reduced greenhouse gas emissions; allows any technology or fuel; and uses life-cycle analyses to assess both the on-track impacts and the upstream environmental and energy impacts of the fuel. These technologies were tested as part of the 1,000-mile Petit Le Mans race in the 2008 racing season.

Once the competition was in place, EPA, DOE, and SAE created the rules, regulations, and technical specifications for the competition as part of a "Green Racing Work Group." The government provided staff support for these activities. The ALMS funded the competition. Auto companies participating in the competition funded the research, development, and deployment of the cars in the competition. Thirty-seven cars competed for a trophy. There was no financial prize. Two winners were announced for prototype and grand touring (GT)[35] classes. According to one

[30] Progressive Automotive X Prize, "FuelOurFutureNow.com Will Excite Students About Energy Efficiency," press release, February 3, 2009, at http://www.progressiveautoxprize.org/news-events/press-release/fuelourfuturenowcom-will-excite-students-about-energy-efficiency.

[31] For more information, see http://autoblog.xprize.org/axp/2009/02/progressive-automotive-x-prize-and-doe-launch-fuelourfuturenowcom.html.

[32] For more details as to how green principles are evaluated in this competition, see http://www.americanlemans.com/images/sponsors/09_MICHELIN_GreenX_Challenge_booklet.pdf.

[33] For more information regarding the Green Racing Initiative, see http://www.epa.gov/oms/ld-hwy/420f08031.htm. A fact sheet is available at http://www.epa.gov/oms/ld-hwy/420f08031.pdf.

[34] For more information regarding the Green Challenge Award, see http://www.epa.gov/oms/ld-hwy/420f08038.htm.

[35] GT vehicles generally include high-performance automobiles designed for long-distances.

analyst, the competition accurately foreshadowed the ability of diesel injection technology to reduce emissions through the use of particle filters while maintaining high performance.[36]

The competition, renamed the Michelin Green X Challenge competition and sponsored by ALMS and the Michelin corporation, is taking place again in 2009.[37] The competitions began in the Spring of 2009, and will take place at each ALMS race in the 2009 racing season.[38] At the end of the season, EPA, DOE, and SAE International will present Green Challenge awards to the vehicle manufacturers in each class with the highest scores during the entire racing season.[39]

National Aeronautics and Space Administration (NASA) Centennial Challenges

The NASA Centennial Challenges were authorized in Section 104 of the National Aeronautics and Space Administration Authorization Act of 2005 (P.L. 109-155) which stated that

> The Administration may carry out a program to competitively award cash prizes to stimulate innovation in basic and applied research, technology development, and prototype demonstration that have the potential for application to the performance of the space and aeronautical activities of the Administration.

According to NASA, the Centennial Challenges seek to drive progress in aerospace technology of value to NASA's missions; encourage the participation of independent teams, individual inventors, student groups and private companies of all sizes in aerospace research and development; and find the most innovative solutions to technical challenges through competition and cooperation.[40] Individual challenges are either "first-to-demonstrate" competitions, or "repeatable contests" with prizes that range from $300,000 to $2 million. Each challenge is a public/private partnership with co-sponsor organizations that contribute cash towards the prize purse and allied organizations that provide in-kind services to enhance the competition. NASA's current challenges are described below.

Astronaut Glove Challenge

The goal of the astronaut glove challenge, managed by Spaceflight America, is to improve glove design to reduce effort needed to perform tasks in space and improve the durability of the glove. The 2007 challenge consisted of two competitions. One for a $200,000 prize, won by an unemployed aerospace engineer, reached its technological target of meeting, or exceeding, the specifications of NASA's current Phase VI glove. The winner subsequently started his own company to produce spacesuit gloves, and has a contract to provide gloves to another company that is producing spacesuits for the emerging private suborbital spaceflight industry.[41] The other

[36] Robert Larson, Director Emeritus, Center for Transportation Research, Argonne National Laboratory, Presentation, April 15, 2009.

[37] For more information, see http://www.americanlemans.com/images/sponsors/09_MICHELIN_GreenX_Challenge_booklet.pdf.

[38] For more information, see http://www.americanlemans.com/index_green.php?sFile=12896.

[39] Ibid.

[40] For more information, see http://centennialchallenges.nasa.gov/.

[41] NASA, Innovative Partnership Programs, website at http://centennialchallenges.nasa.gov/cc_challenges.htm#glove.

$50,000 prize for a mechanical counter pressure glove went unclaimed.[42] The 2009 Astronaut Glove Challenge "is designed to promote the development of glove joint technology, resulting in a highly dexterous and flexible glove that can be used by astronauts over long periods of time for space or planetary surface excursions."[43]

General Aviation Technology

The general aviation technology competition, managed by the CAFE Foundation, involves a number of competitions with the goal of reducing the impact of aircraft on the environment, including demonstrating the performance of light aircraft that maximize fuel efficiency, reduce noise and improve safety. [44]

In 2007, NASA awarded $250,000 in prizes for personal air vehicles (PAV) that had the best performance as measured by a number of criteria including shortest runway, lowest noise, highest top speed, best handling qualities, and highest fuel efficiency, with $100,000 for the best overall performance. The 2008 General Aviation Technology Challenge included the Community Noise Prize ($150,000), Green Prize ($50,000), Aviation Safety Prize ($50,000), CAFE 400 Prize ($25,000)(a 400 mile cross-country air race), and Quietest Light-Sport Aircraft (LSA) Prize.[45] NASA awarded a total of $97,000 in prizes during this competition, with all but the Green Prize competitors receiving some level of financial award.[46] In 2009, draft rules were announced for the 2011 CAFE Aviation Green Prize with a proposed maximum purse of $1.7 million dollars.[47]

Lunar Regolith Excavation Challenge

The goal of the lunar regolith[48] excavation challenge, managed by the California Space Authority, is to design and build robotic machines to excavate simulated lunar soil. The winning team will receive a prize of $750,000. Twenty-five teams have registered for the competition. Sixteen teams competed in 2008, but no team was able to win the prize. The next competition is scheduled to take place on August 15, 2009.[49]

Northrop Grumman Lunar Lander Challenge

Competitors in the Northrop Grumman Lunar Lander Challenge, managed by the X PRIZE Foundation, with a total of $2.0 million in prize money available, must build and fly a rocket-

[42] Tariq Malik, "Homemade Space Glove Wins NASA Contest," Space.com, May 4, 2007 at http://www.space.com/businesstechnology/070504_astronaut_glove_win.html.

[43] For more information, see http://astronaut-glove.tripod.com/.

[44] For more information, see http://cafefoundation.org/v2/pav_home.php.

[45] For more information, see http://cafefoundation.org/v2/pav_gatchallenge.php.

[46] For the results, see http://cafefoundation.org/v2/pav_pavchallenge_2008results.php.

[47] For more information, see http://centennialchallenges.nasa.gov/, http://cafefoundation.org/v2/cafenews_home.php, and http://cafefoundation.org/v2/pdf_AGP/2009/AGP.TA.04.22.09.pdf/.

[48] Lunar regolith is the loose, fragmental material on the Moon's surface, commonly called "lunar soil." While regolith on the lunar surface is the product of meteoritic bombardment or rocks, regolith on Earth is due to weathering of rock. For more information, see http://www.spacegrant.hawaii.edu/class_acts/RegolithTe.html.

[49] For more information, see http://regolith.csewi.org/.

powered vehicle under conditions that simulate the flight of a vehicle on the Moon.[50] From 2006-2008, three competitions were held on fixed dates in fixed locations. In 2008, level one of the competition was won with the winner receiving $350,000. In 2009, competitors will seek to win the remaining $1.65 million in level two of the competition at a date and location of their choosing between July 20, 2009, to October 31, 2009. Nine teams have registered for level two of the competition including five veteran teams, and four new teams. Winners are determined by the X PRIZE Foundation.

Power Beaming and Tether

The Power Beaming and Tether prize, managed by the Spaceward Foundation, includes two competitions, which together are called the Space Elevator Games.[51] In the power beaming competition, the goal is for teams to provide a practical demonstration of wireless power transmission by building mechanical devices that propel themselves up a vertical cable while the power supply remains on the ground. Competitions were held in 2006, 2007, and 2008 with no winners of the prize purse of $2 million awarded. A 2009 competition is planned for July. In the August 2009 tether competition, an additional $2 million prize purse will be given to the team that develops the material for a tether that can exceed the strength of the best available commercial tether by 50% with no increase in mass.

Lunar Oxygen Production or MoonROx

The MoonROx Challenge, managed by the California Space Education and Workforce Institute, has a technological goal of developing a process to extract breathable oxygen from lunar regolith.[52] A competition was held in 2008 with no winners of the $1 million purse. The next competition is scheduled for October 2009.

NASA Assessment of Program

The targeted outcomes for the NASA Centennial Challenges are to drive progress in aerospace technology of value to NASA's missions; encourage the participation of independent teams, individual inventors, student groups, and private companies of all sizes in aerospace research and development; and find the most innovative solutions to technical challenges through competition and cooperation. In its FY2009 budget request, NASA stated that the outcome of the program is to be evaluated based on its ability to "demonstrate benefits of prize competitions by awarding at least one prize and communicating the resulting technology advancements."[53]

According to NASA,

> Overall, the amount of team diversity (representing small and large businesses, high school and university students, and enthusiastic hobbyists and garage mechanics) and the variety of technologies implemented exceeded Agency expectations. As the prize purses increase, the amount of participation and level of technical maturity and ingenuity will also increase. In

[50] For more information, see http://space.xprize.org/lunar-lander-challenge.

[51] For more information, see http://www.spaceward.org/.

[52] For more information, see http://moonrox.csewi.org/.

[53] NASA FY2009 Budget Request, p. Cross-14 and p. 572.

> the past competitions where the prize purses were on the order of $300,000 each, it is estimated that the 10-15 participating teams represented an investment of $50,000 -$100,000 each. In the competition with a $2 million prize purse, teams invested on the order of $250,000 - $500,000 each.

In addition, NASA states that "Centennial Challenge competitions have spurred the creation of new businesses and products, including innovations in pressure suit gloves and reusable rocket engines."[54]

NASA makes the following assessment of the Centennial Challenge competitions:

> Prize programs encourage diverse participation and multiple solution paths. A measure of diversity is seen in the geographic distribution of participants (from Hawaii to Maine) that reaches far beyond the locales of the NASA Centers and major aerospace industries. The participating teams have included individual inventors, small startup companies, and university students and professors. An example of multiple solution paths was seen in the Regolith Excavation Challenge. NASA can typically afford one or two working prototypes but at this Challenge event, sixteen different working prototypes were demonstrated for the NASA technologists. All of these prototypes were developed at no cost to the government.
>
> The return on investment with prizes is high as NASA expends no funds unless the accomplishment is demonstrated. NASA provides only the prize money and the administration of the competitions is done at no cost to NASA by non-profit allied organizations. For the Lunar Lander Challenge, twelve private teams spent nearly 70,000 hours and the equivalent of $12 million trying to win $2 million in prize money. Prizes also focus public attention on NASA programs and generate interest in science and engineering. During the recent Lunar Lander Challenge, a live webcast had over 45,000 viewers and over 100,000 subsequent downloads. Prizes also create new businesses and new partners for NASA. The winner of the 2007 Astronaut Glove Challenge started a new business to manufacture pressure suit gloves. Armadillo Aerospace began a partnership with NASA related to the reusable rocket engine that they developed for the Lunar Lander Challenge, and they also sell the engine commercially.[55]

Future Competitions

NASA indicates that in selecting topics for future NASA Centennial prize competitions, it will consult widely within and outside of the federal government, and use selection criteria that include addressing common NASA and national technology needs; balancing the challenges across the fields of science, exploration, space operations, and aeronautics; and broadening the geographical distribution of competitor teams and host venues.[56] It is considering future challenges focused on revolutionary energy storage systems, solar and other renewable energy technologies, laser communications, demonstrating near-Earth object survey and deflection strategies, innovative approaches to improving the safety and efficiency of aviation systems, closed-loop life support and other resource recycling techniques, and low-cost access to space.

[54] NASA FY2010 Budget Request, p. SUM-10. NASA is requesting $4.0 million for the program in FY2010. No funding was provided in FY2009. In H.Rept. 111-149, the House recommended not providing this funding due to affordability considerations.

[55] NASA FY2010 Budget Request, "Cross-agency support," p. Cross-42, at http://www.nasa.gov/news/budget/index.html.

[56] Ibid.

Biomedical Advanced Research and Development Authority (BARDA) Project BioShield

BARDA[57] manages Project BioShield,[58] which is to accelerate the research, development, purchase, and availability of effective medical countermeasures (e.g., diagnostic tests, drugs, vaccines, and other treatments) against chemical, biological, radiological, and nuclear (CBRN) agents. Some view Project BioShield as a prize competition, where the prize is the award of a contract that guarantees the government will purchase the results of the research and development proposed.

Project Bioshield was authorized in the Project BioShield Act of 2004, which has three main provisions. One of these creates a government-market guarantee by allowing the HHS Secretary to obligate funds to purchase CBRN countermeasures while they still have several more years of development. However, companies may receive payment when development is complete and the product is delivered. The Pandemic and All-Hazards Preparedness Act (PAHPA; P.L. 109-417) modified the Project BioShield Act to allow for milestone-based payments for up to half of the total award before countermeasure delivery. Awards thus far have ranged from less than $1 million to almost $900 million.

HHS noted that several awards have resulted in products being added to the Strategic National Stockpile (SNS). However, HHS also noted that one award was cancelled and other opportunities have gone unfilled.[59] In 2007, Project Bioshield used the original Project BioShield 10% advance payment provision as well as milestone payment authorities provided by PAHPA. In 2008, BARDA issued a Request for Proposals (RFP), but had to cancel it in FY2009 due to the immaturity and excessive risk associated with awarding contracts to the organizations that submitted proposals, but later issued a different RFP.[60]

What Policy Options Might Members of Congress Consider?

Members of Congress interested in federally-funded innovation inducement prizes may wish to create new prizes, or modify or increase oversight of current prize programs. In discussing possible options, policymakers may wish to receive comments from the current or potential administering agency, and stakeholders in that prize including participants in the competition, sponsors of those competitors, organizations that partner with the agencies in the administration of a prize, and the users of the competition results from both a technological and educational perspective.

[57] Within the Department of Health and Human Services (HHS) is the Biomedical Advanced Research and Development Authority (BARDA), which is to provide an integrated, systematic approach to the development and purchase of the necessary vaccines, drugs, therapies, and diagnostic tools for public health medical emergencies. For more information on BARDA, see http://www.hhs.gov/aspr/barda/index.html.

[58] The information in this section is from CRS Report RL33907, *Project BioShield: Appropriations, Acquisitions, and Policy Implementation Issues for Congress*, by Frank Gottron.

[59] HHS, Office of the Assistant Secretary for Preparedness And Response, FY2010 Online Performance Appendix, p. 21-22 at http://www.hhs.gov/asrt/ob/docbudget/2010aspropa.pdf.

[60] Ibid.

Create New Prizes

Policymakers interested in exploring the possibility of additional prizes may be interested in the conclusions of several studies examining whether or not prizes are an appropriate policy mechanism to reach a particular societal goal relative to alternative research and development mechanisms; prize design, administration, and financing; and other possible considerations when developing prize legislation. Each of these issues is discussed further below.

Goals

As discussed earlier, prizes can have a number of goals. Although the primary focus may be achieving a scientific or technological goal including identifying new approaches to a challenge, some believe that the other aspects of competitions for a prize may be even more important. These subsidiary goals generally focus on the publicity surrounding prizes that may encourage the diffusion of specific technologies; bringing attention to intractable or neglected societal challenges; educating the public, particularly students, about the excitement and usefulness of research and innovation; and stimulating effort across the spectrum of research and innovations, including basic research, technology deployment and diffusion, and managerial/organizational innovation.[61]

Agencies also discussed the benefits of prizes for reaching goals such as expanding the network of academic and non-academic researchers willing to work with a federal agency, and enhancing communication among researchers who currently work with an agency and within an agency or between multiple agencies.

In considering legislation for prizes, policymakers may wish to take actions to identify broader goals such as these and encourage mechanisms for achieving them. For example, if policymakers are interested in using prizes as a mechanism for educating students about science and engineering, they may wish to state this goal specifically and encourage agencies to take actions that would enhance the ability of reaching this goal.

Appropriateness and Design

Policymakers interested in prizes may wish to consider the results of the following studies on innovation inducement prizes (both private and public sector), which focus on whether or not a prize is appropriate, and how a prize can be designed to best reach the sponsor's goal. These studies reached the following, sometimes contradictory, conclusions:

- *National Academy of Engineering:* Prizes, if designed well, can reach a wider community of problem-solvers than grants, and are useful when the desired output is not patentable. They are also useful when typical R&D funding mechanisms are too risk-averse, costly, or bureaucratic; or when there s an inadequate or nonexistent private market. Prizes can be tailored more precisely

[61] National Academy of Engineering, *Concerning Federally Sponsored Inducement Prizes in Engineering and Science* (Washington, DC: National Academy Press, 1999) at http://www.nap.edu/catalog.php?record_id=9724.

than other reward systems, though they may be challenging to design, determine awards, and finance.[62]

- *National Research Council*: Prizes can focus the attention of policymakers, entrepreneurs, the public, and researchers on the goals of an innovation program and reduce the administrative burden of grants and contracts. However, they may be less suited to attain certain societal goals than grants and contracts. For example, prizes may not be as suitable as grants and contracts in enhancing basic scientific and engineering understanding, and may put less emphasis on educating and training the next generation of researchers. In addition, prize competitions are likely, by their very nature, to inhibit the exchange of information among researchers and innovators at least for the duration of the project. Participation by would-be innovators also may be inhibited due to insufficient funds to participate in the prize competition.[63]
- *Resources for the Future*: Appropriate design is critical to prize success based on theoretical and historical evidence, so interested parties from both the public and private sectors should carefully consider how their specific resources and goals relate to the different prize design elements. If prizes are put into place on an experimental basis, it is important to understand the actual effectiveness and efficiency of the prize program, and how their design influences the results they achieve. Examples of design elements include the institutional setting (e.g., public or private sector), technological target relative to the sponsor's overall goals, financial award (e.g., prize should not be so large that it leads to excessive research, but not so small that researchers do not pursue), and victory conditions (e.g., "first past the post," where the first competitor to reach pre-determined award criteria wins the prize, which emphasizes speed and an explicit target; or "best in class," where everyone competes on the same day, which provides more flexibility for maximizing achievement in a given timeframe).[64]
- *McKinsey & Company*: When conducted in an open, competitive, and media-friendly way, prizes can be a unique and powerful tool that identifies new levels of excellence, encourages specific innovations, changes wider perceptions, improves the performance of communities of problem-solvers, builds individual skills, and mobilizes new talent and capital. However, designing and delivering successful prizes is hard work. Prizes may be most useful when there is a clear goal, a relatively large number of potential solvers willing to absorb some of the risk, and a range of success criteria that includes a clearly-defined societal benefit that can be translated into prize objectives that are significant, motivational, actionable, results-focused, and time-bound.[65]
- *Brookings Institution:* Prizes are especially suitable when the goal can be defined in concrete terms, but the means of achieving the goal are too speculative to be

[62] Ibid.

[63] National Research Council, *Innovation Inducement Prizes at the National Science Foundation* (Washington, DC: National Academy Press, 2007).

[64] Richard G. Newell and Nathan E. Wilson, *Technology Prizes for Climate Change Mitigation*, RFF DP 05-33, Resources for the Future, June 2005 at http://www.rff.org/documents/RFF-DP-05-33.pdf.

[65] McKinsey & Company, *And the Winner Is ... Capturing the Promise of Philanthropic Prizes*, 2009 at http://www.mckinsey.com/clientservice/socialsector/And_the_winner_is.pdf.

reasonable for a traditional research program or procurement. Prizes also offer the potential for allowing government to establish a goal without being prescriptive as to how that goal should be met; and can stimulate philanthropic and private sector investment that is greater than the cash value of the prize and attract teams with fresh ideas who might not otherwise do business with the federal government. Prizes, however, have significant limitations including the challenges faced by entrants in having or raising funds to compete, or the difficulty of clearly specifying in advance the victory conditions and quantifiable fundamental research outcomes. In addition, competitions lead to multiple research teams working on the same project, which may not be the best use of limited intellectual and financial resources.[66]

- *Centre for Economic Policy Research*: Innovation inducement prizes can be a powerful mechanism for encouraging competition, and prestigious non-financial prizes can be particularly effective at encouraging innovation, but may have high administrative costs.[67]

Administration

Administering a prize includes not only the scope of the prize as discussed above, but such issues as deadlines, prize administrators, prize financing, competitor selection, judging procedures, intellectual property,[68] liability,[69] and public relations.[70] The cost of administering a prize may exceed the financial reward given to winners of the prize.

In developing legislation, policymakers may wish to consider whether or not they want a federal agency to administer a prize on its own, to have a separate organization such as a nonprofit organization administer a prize on behalf of the federal agency, or to support the prize competition of another organization.

Some experts believe that a growing prize industry, familiar with prize administration, may provide enhanced outcomes as it professionalizes the prize process by bringing more formal knowledge and experience into the design and management process.[71] However, there are also some challenges in taking this approach as an organization may have less control over the quality of the judging. This approach may also make it more difficult for organizations to integrate prize activities with other supporting activities such as related science and technology activities as well

[66] Thomas Kalil, *Prizes for Technological Innovation*, The Brookings Institution, December 2006 at http://www.brookings.edu/views/papers/200612kalil.pdf.

[67] Liam Brunt, Josh Lerner, and Tom Nicholas, *Inducement Prizes and Innovation*, CEPR Discussion Paper No. DP6917, July 2008 at http://ssrn.com/abstract=1307507.

[68] For more information, see CRS Report RL34559, *Intellectual Property in Industrial Designs: Issues in Innovation and Competition*, by John R. Thomas.

[69] For more information, see discussion of Federal Torts Claim Act in CRS Report RL34131, *Federal Liability for Flood Damage Related to Army Corps of Engineers Projects*, by Cynthia Brougher.

[70] Alex Schroeder, *The Application and Administration of Inducement Prizes in Technology*, IP-11-2004, Independence Institute, December 2004 at http://www.keionline.org/misc-docs/IP_11_2004.pdf.

[71] McKinsey & Company, *And the Winner is ... Capturing the Promise of Philanthropic Prizes*, 2009 at http://www.mckinsey.com/clientservice/socialsector/And_the_winner_is.pdf.

as lectures, student activities, and other public events that may be managed by other parts of the sponsoring organization.[72]

Financing

The financing of a prize includes both the prize purse that may be provided to competitors, and the cost of administering the prizes. In some cases, the cost of administering a prize can exceed the cost of the prize awarded to the competitor. Note that in some cases there is no financial reward, so the only cost is the administration of the prize.

Prizes are financed through a variety of mechanisms. Some prizes are totally funded and staffed by the federal agency. Other prizes are funded by a federal agency, but staff support (sometimes for no or limited cost) is provided by outside, nonprofit organizations. In other cases, prizes are funded by a private organization, and the federal agency provides staff support.

Competitors, in general, receive no funding from either the federal agency or private organizations involved in the prize competition. They must seek financial sponsorship. In cases where a large company is competing for a prize, this may not be a major issue. In situations where universities, small companies, or nonprofit organizations are competing, the degree of financing available to them may determine whether or not they can compete, or the level at which they compete.

Although a prize may be authorized by Congress, unless there is a specific appropriation, the competition may not take place. A related issue is whether holding the prize competition is an option or a requirement. An authorized prize competition may not occur if an agency does not request specific funding for a prize, or Congress does not make a designated appropriation. In some cases, agencies set aside funding from existing programs or solicit it from programs throughout the agency. The higher the financial reward, the more challenging such actions are to take.

Difficult economic conditions may raise additional financial policy issues regarding the previously discussed in-kind or financial sponsorship for competitors. Such conditions may limit the availability of non-governmental partners willing to provide low or no cost management for the prizes. Similarly, these conditions may make it more difficult for competitors to find financial sponsors.

Another financial consideration for prizes is what occurs to funding set aside for a financial prize when no competitor meets the technological conditions necessary to win the prize within a specified timeframe. Does the prize funding move to a new competition for the following year? Or does a policy decision need to be made as to whether the competition should end, or should the technological conditions be revised so that competitors potential of winning a prize is enhanced? Some competitions provide an option to revise conditions and prize funding each year.

[72] Ibid.

Legislation Considerations

In sum, policymakers may want to consider their responses to the following questions when developing legislation for a federally-funded innovation inducement prize:

- Should the legislation be general, providing federal agencies with an overview of the prize goals, or specific, detailing instructions to the agency regarding the prize competition? Such details may include the goals of the program, timeframe, award, participant eligibility, administration, contest rule determination, competition judges, intellectual property, liability, and program evaluation.
- How much flexibility should the agency have in determining the prize goals and in the administration of the prize?
- What should be the prize topic? Who should select it? (See **Box 1.**)
- What should be the goals of the program? What is the relative importance, for example, of technological advancement, education, and public awareness?
- Should there be a timeframe associated with the prize?
- Should there be a monetary award associated with the prize? If so, for how much? If not, is the publicity associated with winning the prize sufficient to encourage quality contestant participation? Should there be intermediary prizes?
- Who should be eligible to participate in the competition? For example, should employees of federal agencies or Federally Funded Research and Development Centers (FFRDCs) or Government-Owned, Contractor-Operated (GOCO) laboratory employees be allowed to compete? If so, can they use federal funds and facilities? Should foreign entities, such as non-U.S. citizens, corporations, or U.S. subsidiaries of foreign-owned corporations, be allowed to compete?
- Who should administer the program? For example, should a federal agency administer the program independently, do so in partnership with other federal agency or non-federal organizations, or act as a financial or non-financial partner in a competition administered by a non-federal organization?
- Should the competition be "first-past-the-post" or "best in class"?
- What happens to a financial prize if there is no winner?
- Who should determine the contest rules?
- Who should judge the competition? Should there be an appeal process?
- What are the criteria for the program to be considered successful?
- Should the program be evaluated? If so, by whom? When should that organization become involved?

Answering some of these questions may be challenging for policymakers without the guidance of the science and technology community and those experienced in the administration of prize competitions. In addition, the constantly changing nature of science and engineering due to new discoveries and innovation may also influence the need to provide sufficient flexibility in prize legislation.

Modify Current Prize Programs

Congress may decide that an existing program needs modification to meet national goals. The legislation authorizing prizes varies. Some legislation is specific in terms of how the prize is managed and how the winner is determined, while in other cases, the legislation is general and leaves such decisions up to the agency administering the prize. In addition, some prizes are authorized for only a specific period of time, and Members of Congress may wish to modify that timeframe.

Members of Congress may wish to modify the management and conditions under which a prize is given based on information they receive from stakeholders. Examples of possible stakeholders include organizations and individuals from universities, schools, science and engineering societies, trade associations, business, industry, venture capital groups, early-stage investors, philanthropic organizations, nongovernmental organizations, and foundations.

Box 1. Criteria for Selection of Prize Topics

A National Research Council committee identified the following criteria for selecting prize topics:

Criteria Related to Government Encouragement of Innovation

• The contest goal is widely judged to be worth pursuing and is in fact among the most important challenges facing the nation.

• If a prizewinning innovation is developed and put into practice, it will offer substantial practical benefit not only to its producers and users but also to the nation as a whole.

• Pursuit of the innovation should be perceived as a high-risk but high-reward activity.

• Without government intervention the market is unlikely to produce the innovation in a timely or effective manner, that is, the usual arguments from market failure for an affirmative federal involvement in the innovation process should apply to prize programs just as they do to other programs and policies intended to encourage innovation.

Criteria Related to the Use of the Inducement Prize Mechanism

• The prize goal should represent an ambitious effort, well beyond the current state of the art.

• It is expected that the contest objective can be achieved within a reasonable time frame for a prize program; on the order of 2 to 10 years.

• It will be possible to determine in a relatively objective manner whether a particular contestant's innovation has in fact achieved the contest objective.

• It will be feasible to define a plausible contest objective that is a suitable surrogate for the test of innovative success that is usually applied in the marketplace.

• The contest will encourage a wide range of types of contestants, including those not ordinarily active in the research grant and contract world, to participate.

• The goal is unlikely to be achieved, at least not in a reasonable time, using traditional grant and contract modes of encouragement alone.

Criteria Related to Broad Outreach and Engagement

• The goal should be reasonably meaningful to the general public and understandable by a wide range of potential contestants.

• The methods and tools required to compete effectively should be available to a reasonably large number and wide range of potential contestants.

• The process of competing for the prize should encourage formation of new social networks among individuals, firms, government laboratories, financial institutions, and others, who can contribute to future innovative activities.

Criteria Related to Political and Social Constraints

• Achieving contest objectives should not require use of classified information or technologies nor should it result in inadvertent creation of same.

• Pursuing the prize should not pose unreasonably large risks to contestants, [the federal government,] or the larger society.

Source: National Research Council, *Innovation Inducement Prizes at the National Science Foundation* (Washington, DC: National Academy Press, 2007).

Increase Oversight of Current Prizes

If policymakers are interested in increasing oversight of a federally-funded innovation inducement prize, they may wish to focus on whether or not the goals of the prize were achieved and its objectives clearly communicated, and how well the program was administered. There have been few external studies of prize effectiveness relative to alternatives, particularly federally-funded prizes. The prizes currently in place, therefore, provide an opportunity for policymakers to determine through their oversight mechanisms whether existing prizes should be discontinued or enhanced, and new prizes authorized. Possible prize evaluation criteria, by category, for evaluating the program include whether the contest—

Supply of Technology

- enhanced advanced innovation, or led to related innovations;
- identified new or unorthodox ideas or approaches to particular challenges;
- demonstrated the feasibility or potential of particular technologies;
- solved a challenging, well-defined problem requiring innovation;
- highlighted a range of best practices, ideas, or opportunities within a field;
- focused attention on, set standards in and/or influence perception of a particular field or issue;

Demand for Technology

- promoted development and diffusion of specific technologies;
- emulated market incentives, driving down costs through competition and exposing latent demand;

Scientific and Technical Community

- educated and changed behavior of participants through the prize process;
- celebrated and strengthened a particular community;
- registered large numbers of contestants, and those from a more diverse group than the traditional constituency for that agency;

Public Awareness

- educated the public about the excitement and usefulness of research and innovation.
- enhanced public awareness of and interest in the issue or federal agency

Prize Administration

- addressed intractable or neglected societal challenges;
- attracted private sources of funds to support the research activities of contestants, augment the prize purses, or provide in-kind services;

- functioned well with appropriate prize rules and processes.[73]

Activities in the 111th Congress

This section describes the activities in the 111th Congress regarding federally-funded innovation inducement prizes.[74]

In the Omnibus Appropriations Act, 2009 (P.L. 111-8), Congress indicated that funds for announced, authorized prizes at NASA shall remain available, without fiscal year limitation, until the prize is claimed or the offer is withdrawn. During the FY2010 appropriations process, NASA, requested $4.0 million for its Centennial Challenges program. No funding was provided in FY2009. In H.Rept. 111-149, the House recommended not providing this funding due to "affordability considerations."

Several Members of Congress have also introduced legislation in the 111th Congress that would establish prizes on several science and engineering topics.[75] Each of these is described below.

H.R. 41 would provide for federal research, development, demonstration, and commercial application activities to enable the development of farms that are net producers of both food and energy, and for other purposes. It would direct the Secretary of Energy to enter into an arrangement with the National Academy of Sciences to evaluate the feasibility of a prize and best practices award programs as tools to promote self-powered farms and, if feasible, make recommendations for carrying out such programs.

The Voting Integrity and Verification Act of 2009 (S. 48) would require the Director of the National Institute of Standards and Technology (NIST) to establish a program to award cash prizes competitively to eligible persons that advance the research, development, demonstration, and application of voting systems specifically designed to enhance accessibility and provide independence for persons with disabilities during the voting process.

The New Manhattan Project for Energy Independence Act (H.R. 513) would award a prize for the development and manufacturing of energy technologies that meet a number of economic, technical, and societal criteria including a plug-in hybrid vehicle, alternative fuel vehicle, electric vehicle, hydrogen fuel cell vehicle, or other alternative technology vehicle; an energy efficient residential or commercial building; a large scale solar thermal power plant or solar photovoltaic power plant; biofuels; carbon capture and storage system for a large scale coal-burning power plant; validated process for remediation of radioactive waste; or sustainable nuclear fusion reaction. The DOE would administer a prize program with monetary awards to advance the

[73] Adapted from National Research Council, Innovation Inducement Prizes at the National Science Foundation (Washington, DC: National Academy Press, 2007); National Academy of Engineering, Concerning Federally Sponsored Inducement Prizes in Engineering and Science (Washington, DC: National Academy Press, 1999); McKinsey & Company, And the Winner is ... Capturing the Promise of Philanthropic Prizes, 2009 at http://www.mckinsey.com/clientservice/socialsector/And_the_winner_is.pdf.

[74] For the most recent information on the status of these bills, see the Legislative Information System at http://www.congress.gov/.

[75] During the 110th Congress, several bills proposed prizes for greenhouse gas mitigation, farms that are net producers of both food and energy (H.R. 80), space and aeronautics (H.R. 4916), advanced technology achievements (S. 701), climate technology challenge (S. 280), and medical innovation (S. 2210), and innovation (S. 1371).

research, development, demonstration, and commercial application necessary to achieve these goals with a prize for each. Other goals include broad participation by researchers, large and small businesses, institutions of higher education, and any other qualified applicants, including veterans. In developing the prize, DOE is to consult with other federal agencies, including NSF; and may consult with other experts such as private organizations, including professional societies, industry associations, and the National Academy of Sciences and the National Academy of Engineering.

The Nanotechnology Innovation and Prize Competition Act of 2009 (S. 596) directs the Secretary of Commerce, through the NIST Director to establish a program to award prizes for achievement in the applications of nanotechnology for: (1) improvement of the environment, consistent with Twelve Principles of Green Chemistry of the Environmental Protection Agency (EPA); (2) development of alternative energy that has the potential to lessen the dependence of the United States on fossil fuels; (3) improvement of human health, consistent with regulations promulgated by the Food and Drug Administration (FDA); and (4) development of consumer products. The bill would appoint a board to oversee the program and require it to submit an annual report to Congress. It provides the board with the option of contracting with a private organization to administer the prize. That board could either make a financial award to the first competitor to meet criteria established by the board, or recognize individuals for superlative achievement in one or more of these nanotechnology applications and recommend to the Secretary of Commerce that the President award the National Technology and Innovation Medal (which would not have a financial award).

The Cybersecurity Act of 2009 (S. 773) would require the NIST Director to establish cybersecurity competitions and challenges with cash prizes to attract, identify, evaluate, and recruit talented individuals for the Federal information technology workforce, and stimulate innovation in basic and applied cybersecurity research, technology development, and prototype demonstration that have the potential for application to the federal information technology activities of the federal government. The program would target its competitions and challenges to different groups including high school students, undergraduate students, graduate students, and academic and research institutions. Competition topics are to be developed by the NIST Director based on consultations with organizations both within and outside the federal government, and may establish advisory committees to provide additional guidance. To carry out this program, $15 million would be authorized to be appropriated to NIST for each of FY2010 through FY2014.

The New Options Petroleum Energy Conservation Act of 2009 (H.R. 1794) would require that the Secretary of Energy establish a program to award a $1 billion prize to the first automobile manufacturer incorporated in the United States to manufacture and sell in the United States 60,000 midsized sedan automobiles that operate on gasoline and can travel 100 miles per gallon.

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