PRIZES FOR ADVANCED TECHNOLOGY ACHIEVEMENTS

Fiscal Year 2007 Annual Report

January 2008

Part 1 – DARPA URBAN CHALLENGE

Part 2 – WEARABLE POWER PRIZE

DIRECTOR OF DEFENSE RESEARCH AND ENGINEERING
Prepared for Members and Committees of Congress

Part 1 – DARPA URBAN CHALLENGE

DARPA URBAN CHALLENGE

Fiscal Year 2007 Report

January 16, 2008

Defense Advanced Research Projects Agency

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APPENDICES

1 BACKGROUND

Section 2374a of Title 10 of the United States Code authorizes the Secretary of Defense, acting through the Director, Defense Research and Engineering (DDR&E), and the Service acquisition executive of each military department, to conduct programs to award up to $10 million in cash prizes to recognize outstanding achievements in basic, advanced, and applied research; technology development; and prototype developments that are potentially applicable to the military missions of the Department of Defense (DoD) (see Appendix A). DDR&E delegated this authority to the Director of the Defense Advanced Research Projects Agency (DARPA) on November 3, 2006, to conduct the DARPA Urban Challenge program. The Under Secretary of Defense for Acquisition, Technology, and Logistics authorized a $3.5 million prize purse on December 4, 2006.

This document describes DARPA's FY 2007 activities under the delegated prize authority.[1]

The DARPA Urban Challenge was held on November 3, 2007. A total prize purse of $3.5 million was offered for the three fastest and safest vehicles that traversed a 60-mile urban course in moving traffic in less than 6 hours. Six vehicles completed the course, the fastest at an average speed of approximately 13 miles per hour. This achievement marks a significant landmark in the development of autonomous vehicle technology and represents a major advancement toward achieving the Congressional goal that by 2015 one-third of the Armed Forces' operational ground combat vehicles be unmanned[2].

2 PROGRAM GOALS

Addressing the Congressional goal for 2015 requires a breakthrough in vehicle technology and intelligence to ensure that autonomous vehicles can operate safely among other vehicles, both manned and unmanned, in all ground environments. Demonstrating this capability was the objective of DARPA's Urban Challenge.

Specifically, the program goals were to:

- Accelerate autonomous ground vehicle technology development in the areas of sensors, navigation, control algorithms, machine intelligence, and systems integration. These areas are essential to independent autonomous ground vehicle operations in urban areas.
- Demonstrate an autonomous vehicle able to operate independently in a realistic urban environment through a field of live traffic. A successful technology demonstration can shift perceptions within the technical and operational communities about the state of the art and accelerate development of autonomous ground vehicles for military

[1] Although the prizes were awarded in FY 2008, most program expenditures occurred in FY 2007.
[2] Section 220 of the Floyd D. Spence National Defense Authorization Act for Fiscal Year 2001, Public Law 106-398.

operations. Autonomous vehicles could be used in dangerous missions and remove American forces from harm's way.

- Attract and energize a wide community of participants to bring fresh insights to the problem of developing a truly robust autonomous vehicle and provide qualified performers to develop autonomous ground vehicles for DoD.

DARPA managed the Urban Challenge to meet these goals through the prize authority.

3 PRIZE AUTHORITY UTILIZATION

Previous experience, including that at DARPA, shows that a prize competition is effective in attracting considerable attention to solve a difficult technical problem important to DoD. Talented technical leaders responded to the challenge of forming and motivating teams to achieve technical goals in a competitive environment of resource constraints and tight deadlines. Attracting and energizing a wide community of participants is key to effecting long-term growth in U.S. technical communities needed by DoD to develop world-class autonomous systems, including autonomous ground vehicles. The DARPA Grand Challenges in 2004 and 2005 demonstrated that the prize competition format shapes the interests and influences the career paths of students and junior faculty at a formative stage, promising intellectual advances in related fields for years to come.

The prize format leverages commercial investments in related areas. The strong representation at the Urban Challenge of automobile manufacturers and suppliers working with universities, traditional Defense contractors, and commercial entities is an example of the use of the prize authority as a means to build a community and provide technical leadership to leverage military investment. Cross-fertilization with automotive suppliers promises potential cost savings as commercial, off-the-shelf components are developed and adapted for DoD applications. The prize format also attracted teams that would not have otherwise participated in a conventional contracted effort because the prize format allowed them to retain unencumbered rights to intellectual property developed in the program.

A hybrid programmatic structure was employed for the Urban Challenge that combined the strengths of an open competition for prize money with those of a more conventionally contracted effort. Seed funding for vehicle development was competitively awarded to 11 teams by soliciting and evaluating proposals to find those most likely to produce a competitive vehicle. This group, referred to as "Track A," received milestone-based funding up to $1 million, with the payout dependent on performance. Both Federal procurement contracts and Section 845 Other Transaction Authority for Prototypes were used, as requested by the teams to best meet their composition and capabilities. Seventy-eight additional teams, referred to as "Track B", did not receive Government funding, but were attracted by the intellectual challenge and incentivized by the cash prizes. Of the 11 teams that qualified to compete in the final Urban Challenge event, 7 were from Track A. Of the six teams that completed the course, five were Track A teams.

4 CASH PRIZES AWARDED

Prizes were awarded at the program finish on November 3, 2007 (during FY 2008).

Tartan Racing from Pittsburgh, Pennsylvania, was awarded $2 million for first place; the Stanford Racing Team from Stanford, California, was awarded $1 million for second place; and Victor Tango from Blacksburg, Virginia, was awarded $500,000 for third place. All three teams are university-led groups with strong industrial participation and previous experience with the DARPA Grand Challenge.

5 SOLICITATION AND EVALUATION METHODS

The Urban Challenge was announced on May 1, 2006, in a press release that was widely reported in the media and on the Internet. Information was distributed extensively via email and a website linked to the heavily visited DARPA homepage to ensure all interested parties were afforded an opportunity to participate. The announcement was published in FedBizOpps and attracted substantial media coverage.

At the Urban Challenge Participants Conference on May 20, 2006, in Reston, Virginia, potential entrants met directly with DARPA representatives to discuss all aspects of the event. The conference attracted more than 500 members of the public, and an even larger number watched over the live webcast. After formal presentations by DARPA officials, attendees asked questions and offered suggestions on various aspects of the rules and event outline.

By the October 13, 2006, deadline, DARPA accepted 89 teams from across the United States, representing major automakers, major Defense contractors, universities, and teams with very diverse backgrounds—including two high schools (Appendix B).

During 2007, the Urban Challenge teams underwent a rigorous evaluation process designed to select the teams best fit to compete in the final event:

- April 13: Track A teams submitted publication-quality technical papers detailing their technical approaches and vehicle designs. Track B teams submitted 5-minute videos demonstrating vehicle capability on a standardized test course. Three DARPA technical personnel evaluated each video.
- June 1: Track B teams submitted publication-quality technical papers detailing their technical approaches and vehicle designs. All technical papers were evaluated by DARPA and published after the event (www.darpa.mil/grandchallenge/rules.asp) to encourage technical information sharing and cross-fertilization.

- June 11–July 20: Fifty-three teams received site visits (listed in Appendix C) by teams of three DARPA officials, which evaluated the performance of the vehicles on a standardized course at each Urban Challenge team's home test course. Vehicles were required to perform maneuvers such as U-turns and to negotiate basic intersections with moving traffic present.
- October 26–31: Thirty-six teams were selected and 35 teams participated as semifinalists in the National Qualification Event (NQE) at the former George Air Force Base in Victorville, California (see Appendix D). Vehicles were tested on their ability to pull smoothly and safely into moving traffic, come to a complete stop at intersections in the presence of two-way traffic, park amid other vehicles, drive a narrow road in the presence of parked cars, and replan a route in the presence of a blocked road.
- November 3: On the basis of their performance at NQE, 11 teams were selected to compete in the Urban Challenge Event:

Ben Franklin Racing Team	Philadelphia, Pennsylvania
CarOLO	New York, New York
Intelligent Vehicle Systems	Dearborn, Michigan
MIT	Cambridge, Massachusetts
Stanford Racing Team	Stanford, California
Tartan Racing	Pittsburgh, Pennsylvania
Team AnnieWay	Palo Alto, California
Team Cornell	Ithaca, New York
Team Oshkosh Truck	Oshkosh, Wisconsin
Team UCF	Orlando, Florida
Victor Tango	Blacksburg, Virginia

The evaluation process provided a rigorous but fair selection of teams for the final. The event was the culmination of 18 months of intense effort by approximately more than 700 scientists and engineers from the robotics community.

The 11 vehicles selected for the final event operated on the course simultaneously with 30 other manned and unmanned vehicles and performed normal driving maneuvers—passing moving vehicles and negotiating intersections. Each vehicle conducted three simulated supply missions in a mock urban area to complete the course. The Urban Challenge final event represented the first full-scale demonstration of autonomous vehicles operating together in traffic.

6 RESOURCES USED

The Urban Challenge was a complex event requiring considerable planning, coordination, and technical expertise to be a success. The event was managed by a Government program manager utilizing contractor support, as required, for execution. The FY 2006[3] funding provided

[3] All funding for the event was RDT&E.

11 competitively awarded research contracts and agreements as well as the rules and course development, logistics and event planning, and the Urban Challenge Participants Conference. The FY 2007 funding provided Event logistics, command and control, and operations. The prize award funding for first, second, and third place was FY 2008 funding. The funds were drawn from the Program Elements (PE) and Projects as follows:

PE	Project	Title	FY06	FY07	FY08	Total
0601101E	CCS-02	Information Sciences	928,908	1,053,241		1,982,149
0602304E	COG-02	Cognitive Computing	1,000,000	3,595,957	3,500,000	8,095957
0602702E	TT-13	Network Centric Enabling Technology	11,800,680			11,800,680
0603764E	LNW	Future Combat Systems	2,099,922	739,982		2,839,904
					Grand Total	**$24,718,690**

Program managers and other officials reviewed 65 proposals, reviewed 46 videos and 53 technical papers, conducted 44 site visits, and tested 35 teams at the NQE. At the Urban Challenge final event on November 3, 2007, DARPA staff members assisted in judging the event as course officials and safety monitors.

The event venue was configured to ensure a realistic urban test environment and safety for all participants and spectators. A communications and tracking system and command center monitored all vehicles on the course to ensure full situational awareness and positive control of all autonomous vehicles.

7 TECHNOLOGY TRANSITION

The DARPA Urban Challenge showed breakthrough advances in autonomous vehicle capability and demonstrated for the first time autonomous vehicle operation in traffic. This result is being absorbed by the community, as expectations have been raised regarding autonomous vehicle capability and performance. The technology is new and is being rapidly matured for future use in military platforms, and teams have begun identifying transition targets and partners.

The Robotics Institute at Carnegie Mellon University (CMU), which fielded Tartan Racing, is a performer on the U.S. Army's Future Combat System (FCS) Autonomous Navigation Subsystem (ANS) program. CMU is considering the potential transition of DARPA Urban Challenge technologies for use on the FCS ANS program.

The General Motors Corporation said they intend to pursue the production of a driverless car, which would provide DoD with a U.S. supplier of autonomous ground vehicles. In press statements the company said the Urban Challenge competition significantly advanced its understanding of what is needed to make driverless vehicles a reality.

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 at Fort Eustis in April 2008.
The Ben Franklin Racing Team, cosponsored by Lockheed Martin, has strong ties to the contractor community, and technology from this program is expected to appear in future offerings to DoD.

8 CONCLUSION

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.

APPENDIX A

PRIZE AUTHORITY STATUTE

The prize authority statute, section 2374a of U.S. Code Title 10 was amended by Section 257 of the National Defense Authorization Act of 2006 and Section 212 of the National Defense Authorization Act of 2007 as follows:

§ 2374a. Prizes for advanced technology achievements

(a) Authority. 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.

(b) Competition requirements. Each program under subsection (a) shall use a competitive process for the selection of recipients of cash prizes. The process shall include the widely-advertised solicitation of submissions of research results, technology developments, and prototypes.

(c) Limitations.

(1) The total amount made available for award of cash prizes in a fiscal year may not exceed $10,000,000.

(2) No prize competition may result in the award of more than $1,000,000 in cash prizes without the approval of the Under Secretary of Defense for Acquisition, Technology, and Logistics.

(d) Relationship to other authority. A program under subsection (a) may be carried out in conjunction with or in addition to the exercise of any other authority of an official referred to in that subsection to acquire, support, or stimulate basic, advanced and applied research, technology development, or prototype projects.

(e) Annual report.—
‘‘(1) In general.—Not later than March 1 of each year, the Secretary shall submit to the Committee on Armed Services of the Senate and the Committee on Armed Services of the House of Representatives a report on the activities carried out during the preceding fiscal year under the authority in subsection (a).
‘‘(2) Information included.—The report for a fiscal year under this subsection shall include, for each program under subsection (a), the following:
‘‘(A) A description of the proposed goals of the competitions established under the program, including the areas of research, technology development, or prototype development to be

promoted by such competitions and the relationship of such areas to the military missions of the Department of Defense.
''(B) An analysis of why the utilization of the authority in subsection (a) was the preferable method of achieving the goals described in subparagraph (A) as opposed to other authorities available to the Department, such as contracts, grants, and cooperative agreements.
''(C) The total amount of cash prizes awarded under the program, including a description of the manner in which the amounts of cash prizes awarded and claimed were allocated among the accounts of the Department for recording as obligations and expenditures.
''(D) The methods used for the solicitation and evaluation of submissions under the program, together with an assessment of the effectiveness of such methods.
''(E) A description of the resources, including personnel and funding, used in the execution of the program, together with a detailed description of the activities for which such resources were used and an accounting of how funding for execution was allocated among the accounts of the Department for recording as obligations and expenditures.
''(F) A description of any plans to transition the technologies or prototypes developed as a result of the program into an acquisition program of the Department.
(3) **Suspension of the authority for failure to include information**.—For each program under subsection (a), the authority to obligate or expend funds under that program is suspended as of the date specified in paragraph (1) if the Secretary does not, by that date, submit a report that includes,
for that program, all the information required by paragraph (2). As of the date on which the Secretary does submit a report that includes, for that program, all the information required by paragraph (2), the suspension is lifted.

(f) Period of authority. The authority to award prizes under subsection (a) shall terminate at the end of September 30, 2010.

APPENDIX B

URBAN CHALLENGE APPLICANTS

Albertabot	Austin, TX
American Industrial Magic	Traverse City , MI
The Artificial Automotive Group	Los Angeles, CA
Austin Robot Technology	Austin, TX
AutoTrek	Moorestown, NJ
AvantGuardium	Bethesda, MD
Axion Racing	Westlake Village, CA
base17 Robotics	Westfield, IN
Ben Franklin Racing Team	Philadelphia, PA
Berkeley-Sydney Driving Team	Berkely, CA
A Bunch of Dropouts	Kingman, AZ
BYUC	Provo, UT
Cakewalk	Whiteland, IN
California Institute of Technology	Pasadena, CA
CarOLO	New York, NY
Cincinnati Bearcats	Cincinnati, OH
CyberRider	Cambridge, MA
DOTMOBIL Team	Los Angeles, CA
Gator Nation	Gainesville, FL
The Golem Group	Santa Monica, CA
Grand Challenge NomadZ	Boulder, CO
Highlander Racing	Newark, NJ
I-Team	Campbell, CA
Indiana Robotic Navigation	Greenwood, IN
Insight Racing	Cary, NC
Intelligent Vehicle Systems	Dearborn, MI
Juxtopia	Baltimore, MD
LAAE	Hacienda Heights, CA
Magic Highway, U.S.A.	Topanga, CA
Magnolia	Ridgeland, MS
Martian Mentors	Goodrich, MI
Mexico	San Pedro, CA
MIT	Cambridge, MA
Natalythe Engineering	San Diego, CA
Oak Ridge Robotics	Oak Ridge, TN
Ody-Era	Carmel, IN
OSU-ACT	Columbus, OH
Palos Verdes High School Road Warriors	Palos Verdes, CA
Pegasus	College Station, TX
PHD (Programmers Hate Driving)	Phoenix, AZ
Princeton University	Princeton, NJ
Project Horizon	Melbourne, FL
"R" Junk Works	Palmdale, CA
Raytheon	Tucson, AZ
ROBOKAR	Spring Lake Park, MN

Roboride	Homewood, AL
ROWSG	Corvallis, OR
SciAutonics/Auburn Engineering	Thousand Oaks, CA
Space Cowboys	Pinckney, MI
Spring Light	East Lansing, MI
Spurrier's Hurriers	Mary Esther, FL
Stanford Racing Team	Stanford, CA
Sting Racing	Atlanta, GA
Tartan Racing	Pittsburgh, PA
Team 23 Racing	San Diego, CA
Team AnnieWay	Palo Alto, CA
Team Autonomous Solutions	Petersboro, UT
Team Banzai	Irvine, CA
Team Berlin	Houston, TX
Team CajunBot	Lafayette, LA
Team CART	Princeton, WV
Team Case	Cleveland, OH
Team Cornell	Ithaca, NY
Team Cybernet	Ann Arbor, MI
Team Grand Challenger	Houston, TX
Team Gray	Metairie, LA
Team Helios	Greenfield, WI
Team Jefferson	Crozet, VA
Team Juggernaut	Sandy, UT
Team-LUX	Woodstock, MD
Team Mojavaton	Grand Junction, CO
TeamNOVA	Chickasha, OK
Team Orange	San Jose, CA
Team Oshkosk Truck	Oshkosh, WI
Team Promethean	Pittsburgh, PA
Team Tebo	Irvine, CA
Team UCF	Orlando, FL
Team Urbanator	Littleton, CO
Team White Cougar	Las Vegas, NV
Team XAR	Irvine, CA
TROBO	Petal, MS
True Vision Robotics	Atascadero, CA
UBC Thunderbird Robotics	Seattle, WA
UD Team Grand Challenge	Dayton, OH
UMR Urban Challenge Team	Rolla, MO
University of Utah	Salt Lake City, UT
Urban Rangers	Indianapolis, IN
UU	Westminster, MD
Victor Tango	Blacksburg, VA

APPENDIX C

TEAMS THAT RECEIVED SITE VISITS

Austin Robot Technology	Austin, TX
AvantGuardium	Bethesda, MD
Axion Racing	Westlake Village, CA
The Ben Franklin Racing Team	Philadelphia, PA
Berkeley-Sydney Driving Team	Berkeley, CA
A Bunch of Dropouts	Kingman, AZ
BYUC	Provo, UT
CarOLO	New York, NY
California Institute of Technology	Pasadena, CA
DOTMOBIL Team	Los Angeles, CA
Gator Nation	Gainesville, FL
The Golem Group	Santa Monica, CA
Highlander Racing	Newark, NJ
Insight Racing	Cary, NC
Intelligent Vehicle Systems	Dearborn, MI
Martian Mentors	Goodrich, MI
Mexico	San Pedro, CA
MIT	Cambridge, MA
Mojavaton	Grand Junction, CO
Ody-Era	Carmel, IN
OSU-ACT	Columbus, OH
Pegasus	College Station, TX
Princeton University	Princeton, NJ
Raytheon	Tucson, AZ
SciAutonics/Auburn Engineering	Thousand Oaks, CA
Stanford Racing Team	Stanford, CA
Sting Racing	Atlanta, GA
Tartan Racing	Pittsburgh, PA
Team 23 Racing	San Diego, CA
Team AnnieWay	Palo Alto, CA
Team Autonomous Solutions	Petersboro, UT
Team Berlin	Houston, TX
Team CajunBot	Lafayette, A
Team CART	Princeton, WV
Team Case	Cleveland, OH
Team Cornell	Ithaca, NY
Team Cybernet	Ann Arbor, MI
Team Grand Challenger	Houston TX
Team Gray	Metairie, LA
Team Jefferson	Crozet, VA
Team Juggernaut	Sandy, UT
Team-LUX	Woodstock, MD
TeamNOVA	Chickasha, OK
Team Orange	San Jose, CA
Team Oshkosh Truck	Oshkosh, WI

Team UCF	Orlando, FL
Team Urbanator	Littleton, CO
TROBO	Petal, MS
True Vision Robotics	Atascadero, CA
UBC Thunderbird Robotics	Seattle, WA
University of Utah	Salt Lake City, UT
UU	Westminster, MD
Victor Tango	Blacksburg, VA

APPENDIX D

NQE SEMIFINALIST TEAMS

Austin Robot Technology	Austin, TX
AvantGuardium	Bethesda, MD
Axion Racing	Westlake Village, CA
Ben Franklin Driving Team	Philadelphia, PA
CarOLO	New York, NY
Gator Nation	Gainesville, FL
The Golem Group	Santa Monica, CA
Insight Racing	Cary, NC
Intelligent Vehicle Systems	Dearborn, MI
MIT	Cambridge, MA
Mojavaton	Grand Junction, CO
Ody-Era	Carmel, IN
OSU-ACT	Columbus, OH
Princeton University	Princeton, NJ
SciAutonics/Auburn Engineering	Thousand Oaks, CA
Stanford Racing Team	Stanford, CA
Sting Racing	Atlanta, GA
Tartan Racing	Pittsburgh, PA
Team AnnieWay	Palo Alto, CA
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Team CajunBot	Lafayette, LA
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Team Cybernet	Ann Arbor, MI
Team Gray	Metairie, LA
Team Jefferson	Crozet, CA
Team Juggernaut	Sandy , UT
Team LUX	Woodstock, MD
Team Oshkosh	Oshkosh, WI
Team UCF	Orlando, FL
Team Urbanator	Littleton, CO
University of Utah	Salt Lake City, UT
Victor Tango	Blacksburg, VA

Part 2 – WEARABLE POWER PRIZE

WEARABLE POWER PRIZE

Fiscal Year 2007 Report

January 14, 2008

Office of the Director Defense Research and Engineering
Deputy Under Secretary of Defense (Laboratories and Basic Sciences)

WEARABLE POWER PRIZE-Fiscal Year 2007 Report

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Wearable Power Prize–Fiscal Year 2007 Report

BACKGROUND

Section 2374a of title 10 United States Code as amended by Section 212 of the John Warner National Defense Authorization Act for Fiscal Year 2007 Public Law 109-364 requires the Secretary to report to the Congressional Defense Committees the activities carried out during the preceding fiscal year under the authority in that section by March 1st of every year. This report summarizes the activities carried out in Fiscal Year 2007 under this authority for the Wearable Power Prize competition.

The Director of Defense research and Engineering (DDR&E) used the authority to solicit novel and innovative solutions for wearable power systems for dismounted Warfighters. The Wearable Power Prize program directly supports the current and future demands of Warfighter Power and will help the DoD mature technologies such as fuel cells, batteries, and hybridized high power sources. The integration of these technologies into a lightweight wearable system is crucial and paramount to significantly reducing the weight of batteries Warfighters carry today. The power consumed by radios, computers, weapons, navigation systems and other mission equipment carried by dismounted Warfighters continues to grow placing even more importance on reducing the weight of power systems.

The competition has captured the interest of a diverse and broad group individuals, teams, and institutions. Beginning September 22nd 2008 at the Marine Corps Air-Ground Combat Center, Twentynine Palms, California, competitors will demonstrate their prototype systems culminating on October 4th in a "Power Wear Off", where the finalists power a variety of electronic equipment on a field test course. The top three winning teams will be announced with the first place team winning $1 million dollars for the lightest weight system that generates 20 watts average power continuously for 96 hours.

PROGRAM GOALS

Batteries have been the primary source of power for the Warfighter for over 100 years. Batteries (primary and rechargeable) have low energy density compared to liquid fuels, are expensive to procure, and create a significant logistic and disposal burden. Evolving Warfighter capabilities will consume significantly more power exacerbating the existing challenges of using batteries. The DoD estimates that future Warfighters will carry approximately 9 kilograms (almost 20 pounds) of

batteries to complete a 96 hour mission. To date, the payoff in the investment in separate component technologies for Warfighter power within the DoD has been very successful. The Wearable Power Prize competition advances the technology toward a more system-centric focus.

The goals of the Wearable Power Prize competition are to:

- Advance current DoD investments in Warfighter power technology such as high power batteries, fuel cells, small engines, and the hybridized versions of these technologies.

- Create broad interest and participation in the development and integration of technologies and the demonstration of prototype systems which meet the DoD's future portable energy requirements. A successful demonstration of the Wearable Power Prize competition objectives will be acclaimed as a leap-forward in long-duration, lightweight power technology.

To be eligible for cash prizes, the top three competitors must demonstrate under realistic operational scenarios a wearable system that produces 20 watts average power continuously for 96 hours and weighs less than 4 kilograms (~8.8 lbs).

PRIZE AUTHORITY UTILIZATION

Prize competitions are considered complementary to traditional research grants, cooperative agreement, and procurement contracts.[4] These traditional instruments have been used extensively to invest primarily in component-level technologies, such as fuel cells and batteries. Technology investments have had a significant payoff in advancing the state-of-the-art in these component areas.

A competition that showcases technologies for Wearable Power compliments the current DoD focus on energy efficiency and affordability. While investments in component technologies have been successful, system-focused projects in the DoD to hybridize, integrate, and demonstrate Warfighter hybrid prototypes for field use have lagged considerably. The Wearable Power Prize competition brings focused public attention to the need for wearable, long lasting, lightweight power for dismounted Warfighters.

The dual-use aspect of this competition is apparent with technology applications in outdoor recreation sporting (e.g., camping, hiking, fishing, hunting) where the

[4] National Academy of Engineering, *Concerning Federally Sponsored Inducement Prizes in Engineering and Science, 1999.*

need to power small, lightweight, portable systems is growing. The application of this competition's technologies for use by first responders is also relevant.

The efficacy of using the prize authority approach for attracting a broader spectrum of participants is favorably highlighted in the *Solicitation and Evaluation Methods* section of this report where the number of registered competitors, many of whom are self-identified as individual private inventors, far exceed the number of corporate-affiliated teams. Unlike traditional contract vehicles covered by federal acquisition regulations, the intellectual property (IP) associated with the competition's entries remain the property of the competitors. This is being done to stimulate participation and access by smaller, non-traditional participants thus, alleviating concern for unauthorized and uncompensated use of IP.

CASH PRIZES AWARDED

No prize awards were made in Fiscal Year 2007 for the Wearable Power Prize competition. The competition will be held September 22nd through October 4th, 2008. The Wearable Power Prize will offer a first place prize of $1,000,000 for the lightest weight prototype system meeting the competition requirements, and $500,000 and $250,000 for the second and third place prototype systems, respectively.

SOLICITATION AND EVALUATION METHODS

Prize Announcement and Solicitation of Interest.

In Fiscal Year 2007 the Wearable Power Prize was announced on July 5th 2007 via a *Defense Link* press release. *Defense Link* has over 80,000 subscribers many of whom are targeted audience members in industry and academia and reaches both traditional and non-traditional defense components alike. At the time of the press release, the public website was available (www.dod.mil/ddre/prize) and provided details of the competition, its objectives, and competition rules. The public had the opportunity to email questions to the website and receive answers about the Wearable Power Prize and the DDR&E Prize competition in general. Over 550 email inquiries were received during this time. Statistics show the DDR&E-Wearable Power Prize website was the second most visited website[5] in the DDR&E organization during July through December of 2007 with more than 40,000 webpage page visits. A Google™ word search of the Wearable Power Prize-related links rendered the following number of links shown below. This was a significant increase from July 2007 where the number of links were only a few dozen.

[5] DDR&E Public Website - Most Visited

Wearable Power – 1,750,000 links
Wearable Power Competition – 516,000 links
Wearable Power prize – 261,000 links
Wearable Power contest – 185,000 links
Wearable Power pack – 275,000 links

Various media outlets proliferated the Wearable Power Prize press release and generated related stories in the following on-line publications:

Slashdot.org	*MSN.com*	*CNN.com*
The Wall Street Journal	*United Press International*	*Reuters*
The Conservative Voice	*TreeHugger.com*	*Physorg.com*
Wired.com	*IEEE Spectrum*	

One-on-one interviews with the competition sponsor, Dr. William S. Rees, Deputy Under Secretary of Defense for Laboratories and Basic Sciences were held with *CNN*, *MSN*, and the *Wall Street Journal*.

Wearable Power Prize Information Forum.

Prior to the opening of the prize registration, a public information forum was held in Washington, D.C. on September 21st 2007. The purpose of the forum was to provide an opportunity for the attendees to receive additional information and to ask questions about the upcoming competition. Briefings were given by the Wearable Power Prize program managers on the plans, objectives, rules and procedures for the prize competition with complementary briefs provided by the U. S. Army and U.S. Marine Corps program offices. The information forum was well attended by over 110 persons representing academic institutions, private citizens, small businesses, and large corporations. Proceedings from the forum were posted to the public website.

Figure 1. A PEO Soldier representative discusses current Soldier power requirements and future challenges.

Figure 2. Information Forum attendees view standard Soldier equipment.

Prize Registration and Assessment of Effectiveness.

Although a Fiscal Year 2008 activity, the registration for the Wearable Power Prize opened October 29th 2007 and closed on November 30th 2007. To attract the broadest group of non-traditional competitors and to remove perceived barriers to the competition by would-be contestants, the registration requirements were established in a manner that anyone meeting the competition's eligibility requirements shown in Table 1 could register.

	Team Leader (includes single-persons or Individuals)	**Team Member**
Citizenship	Must be U.S. Citizen	U.S. Citizenship not required
Age	21 years minimum	18 years minimum
Employment Status	Cannot be current employee of the Federal Government (Civilian or Military). Included are employees of FFRDCs.	
Other	U.S.- or Foreign-owned Companies permitted to enter provided team leader meets age and citizenship requirements.	
	State/Local government organizations and public universities are permitted.	

Table1. Wearable Power Prize Eligibility Requirements

At the close of registration on November 30th 2007, a total of 169 individuals and teams had registered. The majority of registered competitors are self-described private individuals and inventors. Registration demographics shown in Tables 1 and 2 highlight the broad range and background of participants. Registered teams are from 37 states and have international membership from 4 countries. Also included in the group of registered teams are major DoD contractors, representative organizations from power technology industrial firms, as well as teams with U.S. and foreign university affiliations.

Organizational Affiliation of Registered Individuals/Teams	*Quantity*
Private Individual	72
Industrial Firm	38
Other (not specified)	34
Educational Institution	11
None (no information provided)	9
Not for Profit Organization	2
Foreign Business	2
Foreign Educational Institution	1

Table 1. Organizational Affiliation of Registered Teams as of 30 November 2007

Number of Persons on Teams	*# Teams*
1	82
2	34
3	28
4	7
5	4
6	5
7	5
8	1
10	1
11	1
13	1

Table 2. Team Size as of 30 November 2007

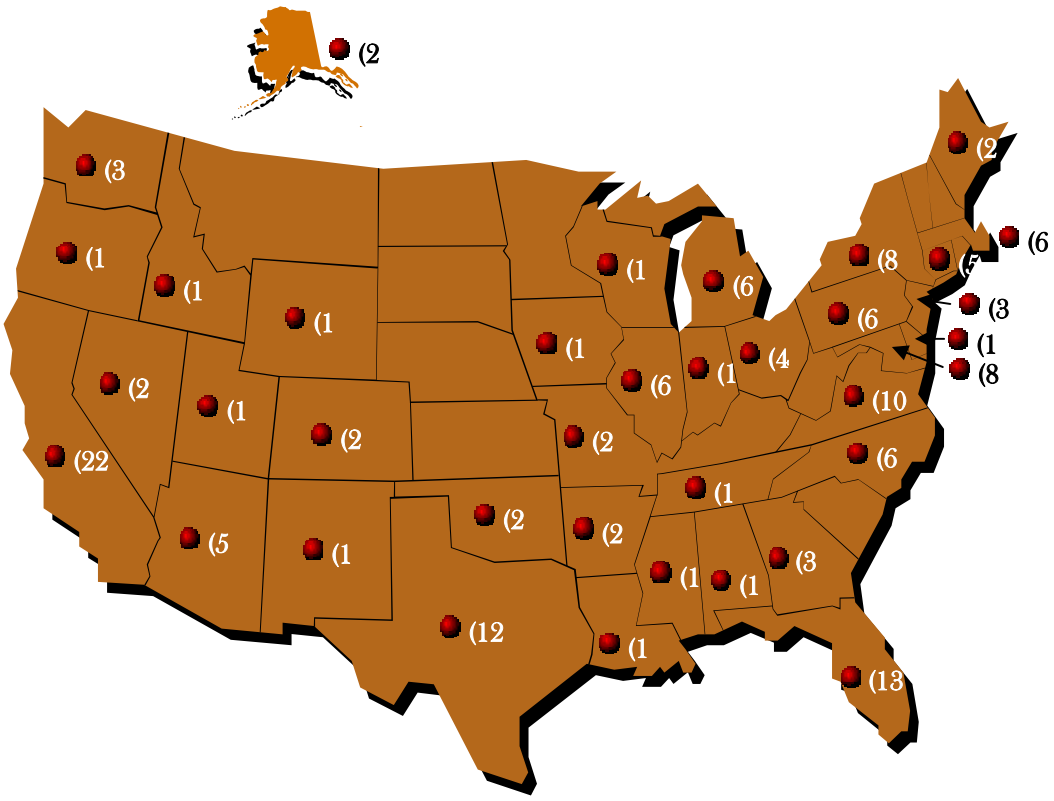

Figure 3. Wearable Power Prize Team Registrations (As of 30 November 2007)

Evaluation of Submissions.

In Fiscal Year 2008, the registered teams will be required to submit a fuel plan and a system description for each entry. These submissions will be reviewed by senior-level government personnel who are subject matter experts in DoD power and energy technologies. Given the diverse population of competitors ranging from individual inventors to traditional DoD Contractors, the competitors' entries will be evaluated for completeness of required technical data and safety of proposed solution. It is expected the number of competitors will be reduced as the competition nears. Many individuals and teams will self-disqualify due to their inability to bring their proposed solutions to fruition or they will fail to submit required data in accordance to the competition rules.

RESOURCES USED

In Fiscal Year 2007, the Wearable Power Prize expended $250,000. FY07 RDT&E funding came from program administrative withhold/tax under program element 0603618D82 - Joint Electronics Advanced Technology. Funding was used by program personnel which included a full-time government program manager, a part-time contractor, and part-time DoD civilian and military personnel. Government personnel were used prior to the Wearable Power Prize announcement to develop the competition goals, objectives, guidelines, and rules. Funding used prior to the competition announcement was sourced from existing DoD RDT&E program funds related to power and energy programs. Many of these personnel currently work projects in the army, navy, and air force related to DoD power and energy technology initiatives. Contractor personnel were used for competition technical and event planning support, and public website development. The Wearable Power Prize competition execution team is led by the Army Research Laboratory and includes the Office of Naval Research and the Air Force Research Laboratory.

TECHNOLOGY TRANSITION

The Wearable Power Prize competition will be the first DoD-sponsored program that brings together and demonstrates a wide array of power/energy sources, low-power electronic and power management technologies. It is anticipated that many of the technologies demonstrated will not be ready for immediate transition into service use, i.e., meeting full military performance and operational requirements. Many of the technology solutions demonstrated as a result of this competition will be considered for further evaluation under separate acquisition program agreements within the DoD. Competition awareness and involvement is being coordinated throughout the DoD's program offices, such as the U. S. Army Program Executive Office (PEO) – Soldier, the U. S. Army PEO – Land Warrior,

the U.S. Air Force 670th Aeronautical Systems Squadron – Battlefield Air Operations Program Office, and the Navy/Marine Corps Program Manager Expeditionary Power Systems. Many of the representatives from these offices have direct involvement with this competition and will be invited to attend the competition in the fall of 2008.

CONCLUSION

Prize competitions are unlikely to replace the traditional acquisition process in the DoD, but for specific technology problems, it is a method that has demonstrated to be tremendously useful for stimulating and incentivizing a broad spectrum of individuals to offer solutions to problems of significant interest to our Nation's Warfighters.

The Wearable Power Prize competition has indeed attracted a broad spectrum of participants to its competition. On September 22nd 2008 a head-to-head competition between private inventors, students from universities, international participants, and corporations vying to win the top prize of $1 million dollars will begin. The methods used to solicit interest in this prize have yielded favorable results and again validates the capacity of this and other federally-sponsored inducement prize competitions to "inspire, educate, and involve the public."[6]

The DoD will continue to rely on the dismounted Warfighter for many diverse and challenging missions while continuing to equip them with new and innovative capabilities that will require more power. As these capabilities evolve and are fielded, the DoD must be prepared to employ all authorities and acquisition instruments to the broadest and best community of inventors, researchers, engineers, and scientists this Nation has to offer to provide our current and future Warfighters with the lightest possible power systems.

[6] National Academy of Engineering, *Concerning Federally Sponsored Inducement Prizes in Engineering and Science, 1999.*