

# DARPA FANG Mobility/Drivetrain Challenge

Fiscal Year 2013 Report

February 3, 2014



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Defense Advanced Research Projects Agency

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## 1 BACKGROUND

Section 2374a of Title 10 of the United States Code authorizes the Secretary of Defense, acting through the Assistant Secretary of Defense for Research and Engineering (ASD(R&E)) and the service acquisition executive for each military department, to carry out programs to award up to \$10 million in cash prizes in recognition of 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). ASD(R&E) (formerly the Director, Defense Research and Engineering [DDR&E]) delegated this authority to the Director of the Defense Advanced Research Projects Agency (DARPA) and authorized the conduct of the DARPA Adaptive Vehicle Make (AVM) Design Challenges totaling \$5.01M (see Appendix B). Only two portions of that authorization have been executed to date: the Vehicle Crowd-sourcing Challenge (VCC), which featured a total of \$10,000 in cash prizes for the winning designs (carried out under the renamed eXperimental Crowd-sourced Vehicle Challenge [XC2V]) in FY 2011; and the Infantry Fighting Vehicle Mobility and Drivetrain Design Challenge, which awarded a \$1,000,000 cash prize for the winning design (carried out under the renamed Fast Adaptable Next-Generation Ground Vehicle [FANG] Mobility/Drivetrain Challenge, or FANG-1 Challenge).

This document describes DARPA's FY 2013 activities under the delegated prize authority.

The DARPA FANG-1 Challenge was initiated on January 14, 2013, and lasted 13 weeks. A total prize purse of \$1,000,000 was offered to the team whose design submission best achieved established requirements for performance, lead time, and cost using the META design tools and the VehicleFORGE collaboration environment.

The Ground Systems team - James Nees, Eric Nees, and Brian Eckerly - was awarded the \$1,000,000 prize based on its final design submission, which received the highest score when measured against the established requirements for system performance and manufacturability.

## 2 PROGRAM GOALS

Initiated in 2010, the AVM portfolio of programs has conducted significant research in the area of design and verification flow for the make process of complex systems and the development of an integrated software tool suite that implements this new process. Early in 2013, AVM sponsored the FANG-1 Challenge in an effort to run a focused test of the first release of these tools. Building on the lessons learned from the FANG-1 Challenge, AVM is now refining and adding to the tool suite in preparation for future design events that will focus on increasingly more complex systems.

The AVM portfolio of programs aims to compress the development timelines for new complex cyber-physical systems by at least five fold. With AVM, DARPA is pursuing the development of several elements of enabling infrastructure that are aimed at radically transforming the systems engineering / design / verification (META), manufacturing (iFAB), and innovation (VehicleFORGE) components of the overall "make" process for modern defense systems. Each

of these infrastructure capabilities is largely generic and applicable to any cyber-physical or cyber-electromechanical system. This approach is highly dependent on the generation of high-fidelity component, context and manufacturing process models. To exercise these capabilities in the context, of a relevant military system, AVM also includes the FANG program, a design and development effort for a new amphibious infantry fighting vehicle (IFV) that was implemented for the purpose of demonstrating the efficacy of AVM tools and processes.

FANG represents the fully inclusive application space of the entire AVM portfolio of tools and facilities, both virtual and brick-and-mortar, that is used to design and build a relevant product example. FANG is responsible for staging the design and build activities for progressively more complex subsystems. While FANG is DARPA's chosen method of implementing and testing META and iFAB, neither tool suite is dependent upon it. End users can apply META and iFAB in part or whole, based on their needs.

The FANG program is structured around testing AVM products on successive systems of increasing complexity. The FANG-1 Challenge focused only on the design stage using the META tradespace exploration and design analysis tools and the iFAB manufacturability feedback tools. FANG is working to manufacture the winning FANG-1 Challenge design using an iFAB foundry, thus testing the efficacy of iFABs foundry configuration tools. FANG will also test the manufactured vehicle system in order to gauge the accuracy of the performance predictions developed during META design.

The goals of the FANG-1 Challenge were to test, at scale, a revolutionary set of collaborative design tools and processes produced by the three research components of the AVM portfolio (META, iFAB and VehicleFORGE), produce a design for a new heavy amphibious IFV with functional requirements that mirror the unclassified requirements for the Marine Corps' Amphibious Combat Vehicle, and to leverage the META design tools and the VehicleFORGE collaboration environment to significantly change the design experience and open the aperture for design innovation.

DARPA managed the FANG-1 Challenge to meet these goals through the prize authority.

### **3 PRIZE AUTHORITY UTILIZATION**

To execute the DARPA FANG-1 Challenge, an inducement scheme was required to incentivize designers and enthusiasts to create and submit vehicle designs that met the requirements of the challenge and enabled the testing of AVM tools. As a result, a prize payment was made to the team that created the winning design. Prize authority made it possible to work with more than 1,000 individuals comprising more than 200 teams, many of whom had never worked directly with DoD. The target audience for participation included small automotive and technology enthusiasts, businesses, mechanics, academics, designers, manufacturers, vehicle designers within established industrial concerns, and hobbyists. Accessing this population efficiently and effectively enough to exercise the AVM tools on a mobility and drivetrain design for an amphibious vehicle in less than 3 months would not have been possible with standard authorities such as contracts, grants, or cooperative agreements.

## **4 CASH PRIZES AWARDED**

The FANG-1 Challenge concluded on April 14, 2013. The winner was announced and the prize was awarded on April 22, 2013.

Ground Systems, a three-person team with members in Ohio, Texas, and California, was awarded the \$1,000,000 prize based on its final design submission, which received the highest score when measured against the established requirements for system performance and manufacturability.

## **5 SOLICITATION AND EVALUATION METHODS**

The DARPA FANG-1 Challenge was announced on October 2, 2012. Each individual registered for the program and completed a verification process to prove that they were a qualified “U.S. Person” and eligible to view material that could have some restricted release requirements. The competition officially began on January 14, 2013. The long registration period allowed ample time for interested participants to hear about the Challenge, register, and provide identifying documents.

The FANG-1 Challenge received publicity through a series of communications products, including an independent microsite at [vehicleforge.org](http://vehicleforge.org), posts on the DARPA Facebook page and Twitter feed, an email newsletter, short videos on the concepts behind the FANG-1 Challenge, and several media events led by the DARPA program manager, such as a presentation at Maker Faire 2012 in San Mateo, California.

To enable broad participation in the program, the Challenge competition utilized a custom-built online collaborative design environment, VehicleFORGE. This purpose-built site was based on open-source software from the popular SourceForge online platform. VehicleFORGE provided opportunities for teaming and access to relevant design/collaboration tools to help nontraditional participants successfully compete in the design competition. The site also allowed geographically-separated team members to collaborate, both in real-time and asynchronously, on the vehicle design.

The FANG-1 Challenge was divided into three distinct portions intended to narrow the field of participants to an ultimate winner. All registered and verified participants completed an initial design exercise with a mass-spring damper (MSD) component. This activity verified each participant’s ability to load the required software, manipulate models appropriately, and upload a final design to the VehicleFORGE servers.

Of almost 1,200 registrants, more than 1,060 passed the “U.S. Person” verification and were accepted as participants. Thirty-four participants completed the MSD exercise successful, and 18 teams submitted one or more completed designs at the first design review. Nine teams submitted one or more final, complete designs by the end of the 13-week design challenge. All designs received a score based on various software simulations against a set of system performance requirements. The three top scoring designs were given additional scrutiny and deeper

evaluation. The design submitted by the Ground Systems team received the highest verified design score.

## 6 RESOURCES USED

The DARPA FANG-1 Challenge was conducted over 13 weeks starting January 14, 2013. Ricardo, Inc. (a performer specifically selected to execute the Challenge and following vehicle data package validation), Government staff members, and support contractors carried out the event. When feasible, existing travel plans were used to minimize travel costs.

Prize funds were drawn from the Program Elements (PE) and Projects as follows:

| PE     | Project | Title  | FY13      | Total              |
|--------|---------|--|-----------|--------------------|
| 62702E | TT-04   | Fast Adaptable Next-Generation Ground Vehicle (FANG) | 1,000,000 | 1,000,000          |
|        |         |  |           | <b>\$1,000,000</b> |

## 7 TECHNOLOGY TRANSITION

The DARPA FANG-1 Challenge was a successful demonstration of the AVM toolset, models, and collaboration platform for the compositional design and testing of an amphibious vehicle mobility and drivetrain system. DARPA is pursuing a dual track of validating the predicted performance for the winning system while continuing development of the AVM tools.

DARPA is building a full-scale test article to verify the software predictions made by the AVM tools based on the winning design from the FANG-1 Challenge. These real-world test and evaluation results will provide firm data points for assessing the accuracy of the software simulation tools.

The utilization of the AVM software tools during the FANG-1 Challenge also informed the continued development of the AVM toolchain and models. Metrics on model use and re-use, predictive capabilities of the META tools, utilization of the VehicleFORGE platform, and experience in the utility of an open design challenge as a method for developing complex systems design are all feeding into the next set of research and development activities to improve and expand the AVM toolchain capabilities.

## 8 CONCLUSION

The DARPA FANG-1 Challenge achieved its goal of testing, at scale, the revolutionary set of collaborative design tools and processes produced by the AVM portfolio (META, iFAB and VehicleFORGE). The FANG-1 Challenge also produced a design for a mobility and drivetrain system on a large amphibious vehicle and leveraged the META design tools and VehicleFORGE

collaboration environment to change the design experience and provide a path to design innovation. The event attracted attention far beyond the participant pool and expanded the conversation around comprehensive systems design and manufacturing simulation.

## APPENDIX A

### PRIZE AUTHORITY STATUTE

The prize authority statute, Section 2374a of U.S. Code Title 10 states:

#### § 2374a. Prizes for advanced technology achievements

- (a) **Authority.** The Secretary of Defense, acting through the Assistant Secretary of Defense for 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, 2018.

## APPENDIX B

### Adaptive Vehicle Make Design Challenges Prize Authority Memo



DIRECTOR OF DEFENSE RESEARCH AND ENGINEERING  
3030 DEFENSE PENTAGON  
WASHINGTON, DC 20301-3030

ACTION MEMO

*Ash - Good concept*

FOR: UNDER SECRETARY OF DEFENSE (AT&L)

FROM: Director, Defense Research and Engineering *3N* DEC 08 2010

SUBJECT: Approval of Prize Awards for Defense Advanced Research Projects Agency (DARPA) Adaptive Vehicle Make (AVM) Design Challenges

- This request seeks authorization to offer prize awards for the DARPA AVM Challenges in total amount of \$5.01 million as detailed below. DARPA will coordinate with DDR&E staff to ensure the reporting requirements of the 10 U.S.C. § 2374a are met in regard to these competitions.
- The overall objective of the AVM Design Challenges is to exercise a new design and manufacturing approach that seeks to dramatically compress the development timeline for a complex military vehicle, shifting toward a make-before-buy development paradigm, and significantly broadening the innovation and participation pool in the design process. Five challenges are planned.
  1. The Vehicle Crowd-sourcing Challenge, planned to run in 2Q and 3Q FY11, is a small-scale pilot effort to identify the challenges of executing crowd-sourced vehicle design. The Challenge award is for the best design for the outer mold-line and structural body panels of a desert terrain vehicle. The winner of this Challenge will be awarded \$10,000.
  2. The Component Model Library Seed Challenge, planned to span 2QFY12 through 4QFY13, will focus on incentivizing contribution to the development of an open-source component model library that will facilitate the model-based design methods that underlie the AVM approach. This Challenge will consist of a series of one or more prize awards totaling \$1.0 million.
  3. The Infantry Fighting Vehicle Mobility and Drivetrain Design Challenge will occur in or around 4QFY12 and will award \$1.0 million to a winning design that, when subjected to model-based verification methods, maximizes an appropriate subset of metrics and attributes for the mobility and drivetrain subsystems of a next-generation infantry fighting vehicle.
  4. The Infantry Fighting Vehicle Chassis and Survivability Design Challenge will occur in or around 2QFY13 and will award \$1.0 million to a winning design that, when subjected to model-based verification methods, maximizes an appropriate subset of metrics and attributes for the chassis and survivability subsystems of a next-generation infantry fighting vehicle.

5. The Infantry Fighting Vehicle Total Platform Design Challenge will occur in or around 2QFY13 and will award \$2.0 million to a winning design that, when subjected to model-based verification methods, maximizes an appropriate subset of metrics and attributes for a complete next-generation infantry fighting vehicle.

RECOMMENDATION: USD(AT&L) delegate the authority and assign the responsibility of DDR&E to the DARPA Director to offer cash prizes not to exceed \$5.01 million for the AVM Design Challenges.

Approve:  \_\_\_\_\_ Disapprove: \_\_\_\_\_

PD. ACTION 2/27/10  
COORDINATION: NONE

Prepared by: Dr. Regina E. Dugan, DARPA, (703) 696-2400 (SACCP USA006617-10)

## APPENDIX C

### FANG 1 Mobility/Drivetrain Challenge Winning Design - by Team "Ground Systems"

