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The Advanced Vehicle Power Technology Alliance (AVPTA):

The Story Behind a Successful Federal Agency Collaboration

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The Advanced Vehicle Power Technology Alliance (AVPTA):

The Story Behind a Successful Federal Agency Collaboration

Abstract

The United States Department of Energy and the Department of Defense each had a significant research effort in energy use reduction for commercial or military vehicles, respectively. In 2010, the two Agencies formed an Alliance known as the Advanced Vehicle Power Technology Alliance (AVPTA) to co-fund research of value to both partners. A great deal of effort went into developing a Charter to create the guidelines and structure of the Alliance. AVPTA has now been in existence for a decade and is considered a model for such relationships. This paper describes the history of the Alliance, the technical areas covered, and the issues involved with interagency collaboration.

Keywords: Vehicle Lightweighting, fuel economy, AVPTA, DOE, DOD, Collaboration

Introduction

The U.S. Department of Energy (DOE) has had many successful programs with the commercial automotive industry. The United States Council for Automotive Research (USCAR) was formed in 1992 and has worked closely with the DOE. Many programs were spawned from that collaboration, such as a Partnership for a New Generation of Vehicles (PNGV) and the 21st Century Truck Partnership (21CTP).

Meanwhile, the Department of Defense (DOD) was addressing similar issues for military vehicles as DOE was for commercial vehicles, but without a structure to share information and leverage their combined resources. DOD and DOE decided to address this situation through the formation of the Advanced Vehicle Power Technology Alliance (AVPTA). Many lessons were learned throughout the formation and life of the Alliance and problems overcome. One early lesson was that although there were many similarities in the need for improved fuel economy, there were also significant differences between commercial and military requirements. Part of the challenge to the Alliance was to sort out these differences and select areas of common interest and goals.

This paper will review the history and impetus for forming AVPTA, the eventual structure that was successful and some of the successes and challenges along the way.

History

The auto industry had significant structured interactions with DOE, whereas the military's interactions with the DOE were mostly ad hoc, uncoordinated interactions. Yet both groups, the DOE in cooperation with the commercial auto industry and the DOD primarily through the Army, had strong motivations to significantly reduce fuel consumption. The commercial auto industry had to meet increasingly stringent fuel economy standards (or CAFÉ, Corporate Average Fuel Economy). Although the military did not have to meet CAFÉ standards, the DOD operates the largest fleet of vehicles in the world, about 470,000 at the start of AVPTA, 58% tactical and 42% combat (Bochenek, 2011). The burdened fuel cost during wartime was about five times the commodity price for a total of $30B in 2010. Over 70% of the cargo shipped in convoys was fuel and water and 18% of US casualties were related to convoy resupply (Gorsich, 2014).

In the US DOD Quadrennial Defense Review Report (Quadrennial, 2010), two points were made that related to this discussion; a strategic approach was needed to reduce energy consumption and interagency partnerships needed to be strengthened. This eventually led to a Memorandum of Understanding (MOU, 2010) between the DOE and DOD titled "Concerning Cooperation in a Strategic Partnership to Enhance Energy Security" signed July 22, 2010 by Deputy Secretaries of Energy (Daniel B. Poneman) and Defense (William J Lynn III). This was the first official document for the formation of the AVPTA. It acknowledged that the DOE was the lead federal agency responsible for the development and deployment of advanced energy technologies whereas the DOD would need to invest in many of the same technologies.

The advantages of forming the Alliance were the following: (Bochenek, 2011)

- Partnership with true collaboration to enhance national energy security
- Demonstrate federal government leadership
- Provide shared capabilities and access to resources
- Accelerate technology development
- Drive innovation
- Increase the value of research investments
- Address national energy needs

With the MOU in place, work began to develop a framework for the AVPTA culminating in a workshop 18-20 July 2011 (Bochenek et al., 2011). The workshop was held in Detroit and was attended by the Michigan Congressional Delegation, and senior executives and subject matter experts from industry and academia. The lead organizations were the Army's Ground Vehicle Systems Center (GVSC) (formerly the Tank-Automotive Research, Development and Engineering Center (TARDEC)) and the DOE's Vehicle Technologies Office (VTO).

A 5-year Charter was written and signed on 18 July 2011 by Dr. Steven Chu, Secretary of Energy and Dr. Joseph W. Westphal, Undersecretary of the Army (Charter, 2011). It laid out a general framework for the Alliance and specifically outlined six Technical Focus Areas (TFAs):

- advanced combustion engines and transmissions
- lightweight structures and materials
- energy recovery and thermal management
- alternative fuels and lubricants
- hybrid propulsion systems (including batteries/energy storage)
- analytical tools.

The 2011 Workshop began with VIP briefings on the critical energy needs of the US military and industry, including presentations by Sen. Carl Levin, Dr. Chu, Dr. Westphal, General Motors VP Dr. Alan Taub, GVSC Director Dr. Grace Bochenek, and DOE Program Manager Mr. Patrick Davis (**Figure 1**). Following the general session, the technical experts broke into six working groups to cover the six topics above. A workshop summary report was written covering the output of the working groups (Bochenek et al., 2011). At a high level, DOD and DOE Strategic Goals and Strategic Drivers were delineated. In some cases, they were very similar such as the goal to reduce fuel usage. In other cases, they diverge such as the DOD driver to lighten the logistics requirements, thereby saving lives.

Eventually the six topics expanded to seven with batteries and energy storage separating from hybrid propulsion systems. A technical lead was assigned from each agency for each of the seven topic areas. The two leads for each area developed a Coordination Plan including opportunities for joint meetings, project integration, and possibilities for joint endeavors.

Structure

Despite the strong start, it took time to develop a viable working structure. In the first phase, DOE's Vehicle Technologies Organization (VTO) and the Army lab, GVSC, identified already established projects of mutual interest. These projects were upgraded with additional subject matter experts (SMEs) and resources. By 2013, new projects of mutual interest to the Army and DOE were being initiated.

The six Technical Focus Areas (TFAs) that were delineated in the 2011 Charter continued throughout with relatively few changes (**Figure 2**). Hybrid propulsion systems was separated into two TFAs: electrified propulsion systems and energy storage and batteries. Typically there would be about 30 subprojects each year divided among these seven areas. The most active TFAs with the most subprojects were Lightweight Structures and Materials, Alternative Fuels and Lubricants and Energy Storage and Batteries.

A new category labeled "Extended Enterprise" was added in FY17 and included projects technically "endorsed" by DOE, but not directly aligned with its Funding Opportunities Announcement Areas of Interest. GVSC funded the projects, but DOE representatives had meeting access and received technical reports. The Extended Enterprise projects centered on fuel cells and a lightweight steel, FeMnAl (Berube and Rogers, 2018).

GVSC SMEs were invited to attend the VTO Annual Merit Review during which GVSC personnel were exposed to the complete VTO project portfolio while also participating as review panel members. Joint participation in the review helped to formulate areas of mutual technical interest for future new-start projects.

A new project needed approval from both parties, the DOE VTO and the Army's GVSC, to become an AVPTA project. GVSC had a very rigorous internal project review/approval process to initiate a new project. Proposed projects were submitted to a Technical Council that heard briefings by SMEs proposing the respective project(s). Each project had to have an identifiable path to deployment with an accompanying timeline, and a work product consistent with GVSC's 30-Year Strategy. Then an Alliance new-start project review and selection process occurred during the VTO's annual project selection meeting, which was jointly attended by GVSC and VTO Directors and subject matter experts.

Selected projects were publicized based upon VTO's annual Advanced Vehicle Technologies Research Funding Opportunity Announcements process and timeline. The process leveraged DOE's National Energy Technology Laboratory Contract Office to rapidly obligate and efficiently track project funding by individual performers. Funded investigators included the auto companies, auto suppliers, defense industry OEMs and suppliers, DOE National Laboratories, universities and colleges, and other businesses. Millions of dollars were jointly contributed to the Alliance, with a resulting level of effort and output that neither agency would have realized alone.

Challenges

As the MOU and Charter were being written, the common goal of reducing energy usage for ground vehicles was obvious. But as the participants began developing project ideas, it also became obvious that major differences existed between the commercial market and military vehicles. **Figure 3** shows the divergent paths for commercial and military in the areas of fuel economy, emissions and electrical power. The industry drivers are emissions, CAFÉ, and profit. The Army drivers are survivability, mobility, lethality, and operational energy. Even the fuels are different, commercial using gasoline and diesel, the military using diesel and JP-8, a jet fuel, and diesel.

As shown in **Table 1**, the goals, materials, applications, and manufacturing processes are similar between the commercial and military markets, but as shown in **Table 2**, significant differences are in play. "Developing programs that are of mutual benefit requires a detailed understanding of the technologies, and constant coordination between the subject matter experts to ensure maximum benefit to both organizations" (Polsen, 2014).

Examples of successful AVPTA projects

Numerous research projects were initiated and conducted under the AVPTA umbrella. Some examples are below, showing the diversity, depth and breadth of the projects.

Lightweight structures and materials. This TFA was probably the most active of all the groups and it advanced this research area at GVSC far beyond where it started. A primary challenge was to accomplish dissimilar metal joining, specifically a ferrous material (High-Strength Steel or Rolled Homogeneous Armor) to aluminum. The two metals have very different melting points so traditional welding is difficult. This becomes even more difficult when using thick sections as required for military vehicles. One group from Pacific Northwest developed a successful method known as friction stir dovetailing (Whelan, 2019), which uses a special tool with a spinning head that generates enough friction to heat and form aluminum into a dovetail that fits into a mechanically cut dovetail groove in a piece of steel.

Alternative fuels & lubricants. This TFA funded several groups to improve fuel efficiency through friction reduction using various methods, such as lubricant formulation, lubricant delivery and surface treatment of engine parts. Methods were also developed to measure and predict the relationship of friction to fuel economy. The investigators covered a range of organizations including George Washington U, Northwestern U., Ford Motor Company, Valvoline, and Oak Ridge National Lab. The goal was to improve fuel economy by 2% and the various efforts were successful in this attempt (for example, Hsu, 2019).

Energy storage and batteries. DOE had an on-going project with the National Renewable Energy Laboratory (NREL) on Computer-Aided Engineering for Electric-Drive Vehicle Batteries or CAEBAT. GVSC joined the effort through AVPTA in 2013 with the aim of using CAE to accelerate the development of Li-ion battery systems for military vehicles while reducing the need for expensive, time-consuming physical testing (Smith, 2019). Through CAEBAT, numerical design tools were developed to optimize batteries for improved performance, safety, long life, and low cost. The CAEBAT program allowed GVSC to leverage ~$20 million in DOE investments.

Electrified propulsion systems. Due to energy and environmental concerns, electric propulsion systems are becoming more common as well as the subject of research. One part of an electric system is the integrated starter-generator (ISG), which replaces the starter and alternator in a single electric device. GVSC led a project to replace traditional ISGs with ones that don't require rare earth magnets. The primary source of rare earths is China with the supply being subject to disruption. This project aimed to use different types of magnets or even eliminate permanent magnets. GVSC, in cooperation with the University of Akron and DCS Corporation, completed the design, build and testing of a Switched Reluctance Machine (SRM) that was superior to other non-rare-earth devices. The groups succeeded in reducing the torque ripple and acoustic noise, which were common problems in non-rare-earth systems (Tylenda et al., 2019).

Successes

In many cases, internal projects at DOE or GVSC were successful enough to expand to both organizations through AVPTA. One example was an internal GVSC Innovation Project on Engine Combustion Chamber Design. This evolved into an AVPTA project entitled "Physics-Based Computational Fluid Dynamics (CFD) Sub-Model Development" with the goal of developing more accurate sub-models for the processes occurring within the combustion chamber. An impressive array of scientists were on the project from eight different universities, each working on a different sub-model: U. Alabama, Boston U., Georgia Tech, U. Wisconsin, Michigan Tech, Ohio State, Penn State and U. Illinois (Aggarwal et al., 2019).

In July 2014, Secretary of Energy Ernest Moniz wrote Secretary of Defense Chuck Hagel seeking to explore major new collaborative efforts. As a result the Office of the Secretary of Defense Operations Energy Plans and Programs (OSD/OEPP) proposed a significantly expanded program for more energy efficient ground vehicles, called "Increasing the Fuel Efficiency of the Current Ground Tactical Fleet" (IFECGTF). The plan was to build on and strengthen existing AVPTA relationships/program/funding (Jennings, 2014). The program was awarded to GVSC by OSD/OEPP in April 2015. Approximately $25 million of 2015 Operational Energy

Capabilities Improvement Funds (OECIF) was allocated for four diverse IFECGTF projects: JP-8 Based Fuel Cell Power; Tactical Vehicle Electrification Kit (TVEK); Flame Spray Coating for Piston Friction Reduction; and Autonomy to Increase the Fuel Efficiency of Tactical Vehicles.

As shown above, there are many benefits to interagency programs. Resources can be leveraged on common problems; money isn't wasted repeating others' research. Research issues can be considered from a different point of view, which can be both illuminating and help drive innovation.

But investments in time and resources are required to achieve these benefits. Developing programs of mutual benefit requires a solid understanding of the operational requirements for each situation and a decision if cooperation even makes sense. Buy-in from high levels is needed to show the importance of the partnership and to secure funding. An organizational structure must be built; official documents such as MOUs and Charters need to be developed. After the guidelines are in place to initiate the partnership, internal structures at both agencies must be reorganized to manage the Alliance. At GVSC, one person worked full-time on the Alliance administration. Seven other SMEs were responsible for coordinating with DOE VTO counterparts in charge of the Technical Focus Areas. Each of the 20 to 30 projects per year had at least one GVSC person administering or contributing to it.

Summary

This paper summarizes the Alliance between DOE and DOD on transportation energy reduction known as the Advanced Vehicle Power Technology Alliance or AVPTA. In 2016, the original charter was renewed/extended for five additional years and signed by the Honorable

Elizabeth Sherwood-Randall, Deputy Secretary of Energy and Honorable Patrick J. Murphy, Undersecretary of the Army. A third charter for five more years is planned for 2021.

AVPTA is a success from the point of view of interagency cooperation, from the impressive number of publications and patents that were generated through the program and from the cost avoidance through leveraging. Between 2011 and 2020, DOE and DA contributed a total of $150 million towards jointly-funded Alliance projects. The result was a level of effort that neither agency could achieve on their own.

After nearly ten years, the benefits of the collaboration have outweighed the investments in time and resources. The Honorable Katherine Hammack, former Assistant Secretary of the Army, commented that AVPTA has far exceeded all expectations for technical performance and has become the reference model for interagency collaboration. The Alliance is the prototype after which other programs have been structured (Berube and Rogers, 2017).

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Tables

Table 1. Examples of similarities between commercial and military vehicles.

Goals	Reduce fuel usage Reduce vehicle weight
Materials	Advanced High Strength Steels Aluminum Composites
Applications	Vehicle structure Diesel Engines Advanced Batteries Energy Storage
Manufacturing Processes	Welding (Friction stir welding, MIG, TIG) Multi-material joining Forming Casting

Table 2. Examples of differences between commercial and military vehicles.

Commercial	**Characteristic**	**Military**
Gasoline	Fuels	JP-8
2 tons	Vehicle Weight	Over 70 tons (tank)
Thin sheet metal	Materials	Thick armor
High volume	Volume	Low volume
Crash	Built to Withstand	Blast, Ballistic

Figures

Figure 1. Senator Carl Levin (D-MI), Dr. Steven Chu (Secretary of Energy) and Dr. Joseph Westphal (Under Secretary of the Army) in discussions prior to the 2011 Workshop.

Figure 2. Project areas at the start of Alliance.

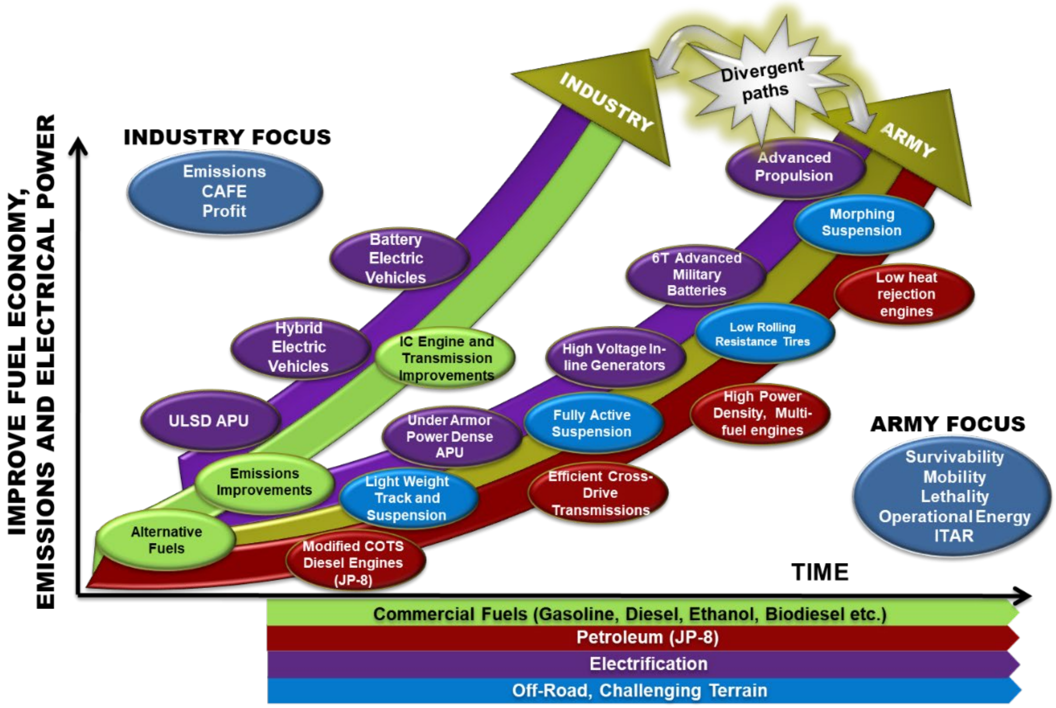

Figure 3. Divergent paths of commercial industry and military.