CHANGING WHAT'S POSSIBLE

Next-Generation Energy Technologies for Connected and Automated On-Road Vehicles (NEXTCAR)

The projects that make up ARPA-E's NEXTCAR Program, short for "NEXT-Generation Energy Technologies for Connected and Automated On-Road Vehicles," are enabling technologies that use connectivity and automation to co-optimize vehicle dynamic controls and powertrain operation, thereby reducing the energy consumption of light-, medium- and heavy-duty vehicles. By using onboard sensing and external connectivity such as Vehicle-to-Vehicle (V2V), Vehicle-to-Infrastructure (V2I) and Vehicle-to-Everything (V2X) communications, NEXTCAR technologies will allow a vehicle to "know" with some certainty its future actions in its operating environment. Whereas current powertrain control is reactive, with drivers and vehicle systems responding to events after they happen, control technologies developed under the NEXTCAR Program will demonstrate the potential of predictive powertrain and vehicle control on vehicle energy efficiency, both individually and collectively.

PROJECT DESCRIPTIONS

General Motors LLC – Detroit, MI

InfoRich Vehicle Dynamics & Powertrain Controls – $4,200,000

General Motors (GM) and their team will develop and incorporate innovative, predictive, "InfoRich" vehicle dynamic and powertrain (VD&PT) technologies for conventional internal combustion engine vehicles in four application areas: approach to a stopping event, departing from a stopping event, travel routing to maximize energy efficiency, and intelligent cruising that takes into account upcoming road and speed conditions. The GM team draws on experience in engine technologies and connected and autonomous vehicles to expedite the project development process.

Michigan Technological University – Houghton, MI

Connected and Automated Control for Vehicle Dynamics and Powertrain Operation on a Light-Duty Multi-Mode Plug-in Hybrid Electric Vehicle – $2,801,390

The Michigan Technological University team and its partners will develop a mobile connected cloud computing center, a vehicle dynamics and powertrain (VD&PT) model-based predictive controller (MPC) using real-time connected vehicle (V2X) data, traffic modeling, predictive speed, and eco-routing to improve the energy efficiency of plug-in hybrid electric vehicles (PHEVs). Key innovations include the development and implementation of the MPC controller, a connected and automated traffic simulation system to provide optimal eco-routing and speed profiles, a real-time virtual toolkit for developing and optimizing VD&PT control strategies, and the integration of a mobile laboratory for on-the-fly traffic simulation.

Oak Ridge National Laboratory – Oak Ridge, TN

Ultimately Transformed and Optimized Powertrain Integrated with Automated and Novel Vehicular and Highway Connectivity Leveraged for Efficiency – $3,357,191

The Oak Ridge National Laboratory team and its partners seek to develop and implement control technologies to exploit connectivity between vehicles and infrastructure to optimize concurrently vehicle-level and powertrain-level operations. The project will use a plug-in hybrid electric vehicle (PHEV) to achieve the following: compute optimal routing to bypass bottlenecks, accidents, special events, and other conditions that affect traffic flow; accelerate and decelerate optimally based on traffic conditions and the state of the surrounding roads; and optimize on-board the efficiency of the powertrain.

UPDATED: 1/4/2017

The Ohio State University – Columbus, OH

Fuel Economy Optimization with Dynamic Skip Fire in a Connected Vehicle – $5,000,000

The Ohio State University team with its partners will develop a transformational vehicle dynamics and powertrain (VD&PT) controls solution that leverages a novel ignition and air-management control technology to significantly improve vehicle energy efficiency. This solution comprises a unique combination of engine controls and hardware, enabling selective fuel-efficient cylinder deactivation at any time. The vehicle will be further augmented with a hybrid-electric system to broaden the engine control technology operating range. The powertrain control system will take advantage of connectivity and level 2 automation by using knowledge of the upcoming driving environment to maximize vehicle energy efficiency for a range of driving conditions. Vehicle demonstration will leverage the Smart City infrastructure in Columbus.

The Pennsylvania State University – State College, PA

Maximizing Vehicle Fuel Economy Through the Real-Time, Collaborative, and Predictive Co-Optimization of Routing, Speed, and Powertrain Control – $3,000,000

The Pennsylvania State University team aims to develop a comprehensive VD&PT system that will operate in a tightly integrated manner to improve vehicle energy efficiency for a heavy-duty diesel truck. Key innovations include using V2V and V2I communications to anticipate traffic congestion and signals; developing technologies for coordinated activities like truck platooning and coordinated intersection arrival and departures; optimizing vehicle routing and speed trajectories; and optimizing powertrain operation including engine start/stop decisions, cylinder deactivation, driveline engagement and disengagement, and gear shifting.

Purdue University – West Lafayette, IN

Enabling High-Efficiency Operation through Next-Generation Control Systems Development for Connected and Automated Class 8 Trucks – $5,000,000

Purdue University, together with its partners, has a multi-pronged approach for the implementation of their heavy-duty diesel truck project, focusing on concepts including: transmission and engine optimization; more efficient maintenance of exhaust after-treatment systems using look-ahead information; cloud-based remote engine and transmission recalibration; cloud-based engine and transmission control; and efficient truck platooning. The most promising strategies will be evaluated and refined using a phased approach relying on a combination of simulations, development and real-world testing.

Southwest Research Institute – San Antonio, TX

Model Predictive Control for Energy-Efficient Maneuvering of Connected and Automated Vehicles – $2,900,000

The Southwest Research Institute (SwRI) team will outfit an internal combustion-engine vehicle with connectivity and automated controls to produce a fuel economy improvement of over 20 percent compared to the baseline vehicle. To do this, the SwRI team will develop a path planning tool that taps into vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) resources to determine future powertrain performance requirements, enabling more efficient control of the engine and transmission. Vectors for improving vehicle efficiency include automated eco-driving, improved thermal efficiency and engine down-speeding using electronic boost, engine start-stop, and powertrain optimization.

University of California, Berkeley – Berkeley, CA

Predictive Data-Driven Vehicle Dynamics and Powertrain Control: from ECU to the Cloud – $3,330,000

The University of California, Berkeley team and its partners will develop an innovative VD&PT control architecture based on a predictive and data-driven approach, which will optimize PHEV performance in real-world conditions, and facilitate efficient departure at intersections, predictive cruise and speed profiles, and learning-based eco-routing and tuning. The team’s proposed VD&PT control architecture will operate in a coordinated manner over short-, medium-, and long-term targets while being optimized in real time, based on the predicted behavior of the vehicle and inputs from the surrounding environment. The system will also crowdsource real-time and historical data on drivers' origins and destinations, traffic conditions, infrastructure, road grade, and road curvature to improve individual vehicle operating efficiency.

University of California, Riverside – Riverside, CA

An Innovative Vehicle-Powertrain Eco-Operation System for Efficient Plug-in Hybrid Electric Buses – $2,800,000

The University of California, Riverside team will design, develop, and test an innovative vehicle-powertrain eco-operation system for natural-gas-fueled plug-in hybrid electric buses. This system will use emerging connected and automated vehicle applications like predictive approach and departure at traffic signals, efficient adaptive cruise, and optimized stopping and accelerating from stop signs and bus stops. Since stop-and-go operation wastes a large amount of energy, optimizing these maneuvers for an urban transit bus presents significant opportunities for improving energy efficiency. Using look-ahead information on traffic and road grade, the team will optimize the powertrain operation by managing combustion engine output, electric motor output and battery state of charge in this hybrid application.

The University of Michigan – Ann Arbor, MI

Integrated Power and Thermal Management for Connected and Automated Vehicles (IPTM-CAV) Through Real-Time Adaption and Optimization – $1,500,000

The University of Michigan team will develop four technological solutions for their ARPA-E NEXTCAR project that include managing and optimizing propulsive power and auxiliary thermal load, predictive thermal management of electrified connected and automated vehicles, optimizing powertrain and exhaust after-treatment systems by anticipating future conditions, and integrating powertrain and vehicle thermal management systems. The proposed strategies are applicable for a range of vehicles powered by internal combustion engines, hybrid-electric, plug-in hybrid, and all-electric powertrains.

University of Minnesota – Minneapolis, MN

Cloud Connected Delivery Vehicles: Boosting Energy Efficiency Using Physics-Aware Spatiotemporal Data Analytics and Real-Time Powertrain Control – $1,400,000

The University of Minnesota team and its partners seek to improve the energy efficiency of medium-duty delivery vehicles through real-time powertrain optimization using two-way vehicle-to-cloud (V2C) connectivity. Large delivery fleet operators already use extensive data analytics to assign routes for minimizing energy consumption. The project team will further improve the energy efficiency of their series hybrid-electric vehicle by optimizing battery state of charge and engine operating strategy in coordination with intelligent eco-routing. Using cloud connectivity, the vehicle will periodically download the most-efficient powertrain calibrations based on external data like traffic and weather collected while the vehicle is en route.