EcoCAR 3

The 11th DOE Advanced Vehicle Technology Competition Series

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Argonne National Laboratory
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Project ID #T1070

Overview

Timeline

- OEM RFP released: July 2012
- OEM selected: Dec 2012
- Univ. NOPI released: Feb 2013
- Univ. RFP released: April 2013
- Universities selected: March 2014
- EcoCAR 3 Launch Workshop: April 2014
- Year 1: August 2014 – June 2015
- **Year 2: August 2015 – June 2016**
- Years 3-4: August 2016 – June 2018

Partners

- DOE, General Motors
- 30 other government & industry sponsors
- Managed by Argonne National Laboratory

**Budget does not include $915M of in-kind/cash support provided to universities or in-kind to competition*

Barriers

- **A.** Lack of trained engineers and scientists
- **B.** Lack of advanced vehicle technology curricula
  - Improving cross disciplinary collaboration at university administration level
  - Improving curriculum availability for automotive engineering education, model based design and validation methodologies

Budget*

Year	VT	Sponsors	Total
FY 2012	$1.871M	$1.163M	$3.034M
FY 2013	$1.891M	$919K	$2.81M
FY 2014	$1.917M	$2.26M	$4.177M
FY 2015	$2.49M	$2.23M	$4.72M
FY 2016	$2.5M (est.)	$2.09M	$4.59M

Project Objectives – Relevance

Objectives:

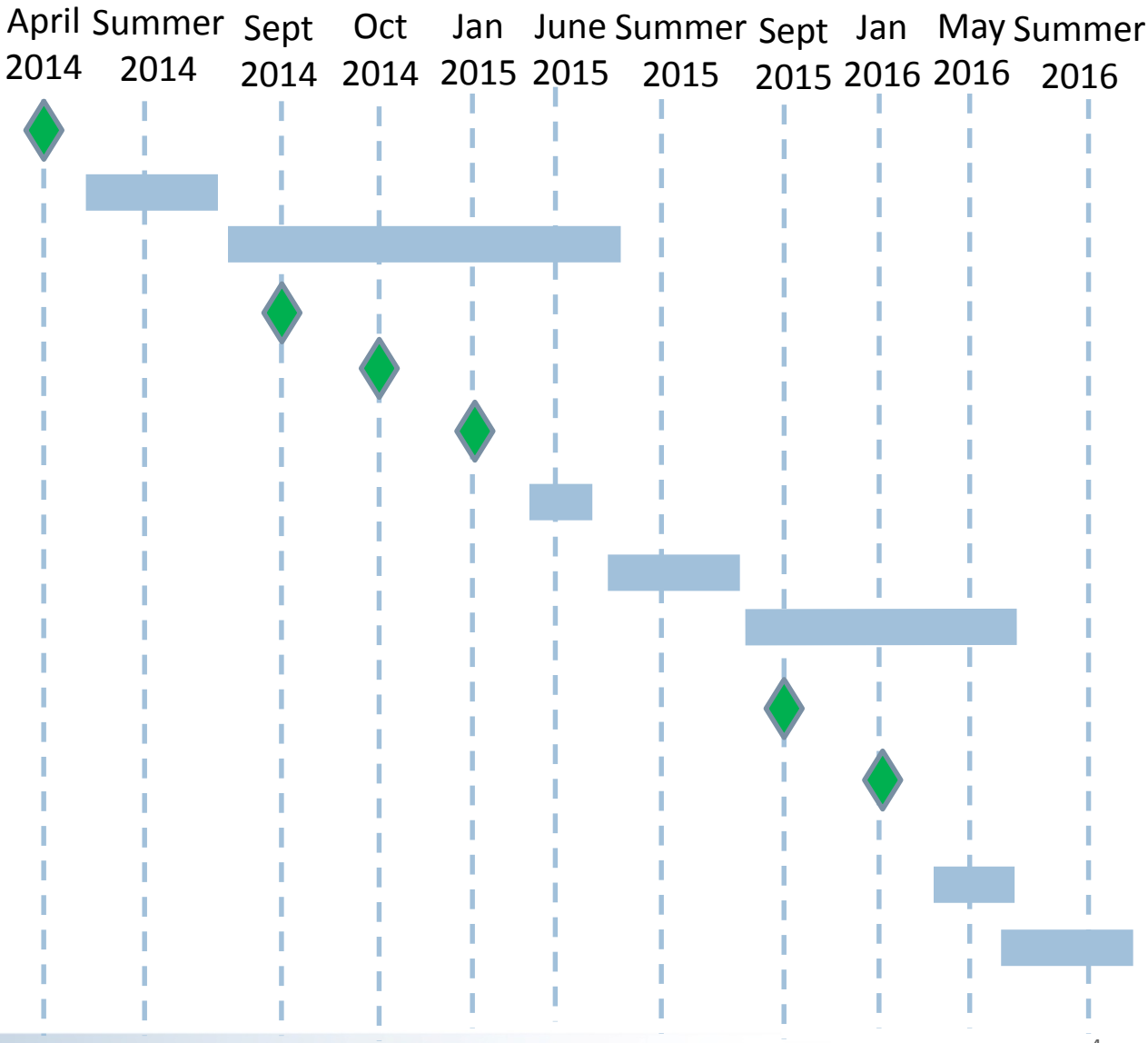
- Workforce Development: seed industry with engineers, business leaders and communicators with real-world experience in advanced vehicle technologies
- Demonstration of energy-efficient powertrains, alternative fuels and innovative technologies and their impact on reducing environmental impact
- Develop and execute a safe, efficient and fair competition (ANL Ideology)
- Ensure the technical integrity of AVTCs, aligning with industry standards

Impacts:

- Seeded the industry with more than 17,000 graduates since 1988
- AVTC graduates are better prepared to contribute to the automotive industry
  - 80% of graduates go to work in the automotive industry
    - *Key contributors to products such as Chevy Volt/Bolt, Nissan Leaf, Tesla S Model, etc.*
  - 53% of GM hired AVTC alumni have credit for at least one piece of protected intellectual property within two years of working in the company
- Diverse fleet of student-built prototype vehicles
  - Provides valuable data for academic research, publications, and student education
- Strong collaboration of more than 30 government and industry sponsors
  - Highly leveraged support from outside sponsors, expands R&D, scope and educational reach

Milestones

Task
EcoCAR 3 Launch Workshop
Y1 Internal Deep Dives/Planning
Year 1 Execution: Academic 2014/2015
Y1 Kick Off Workshop (Novi, MI)
Y1 Fall Workshop (MathWorks)
Y1 Winter Workshop (Freescale/NXP)
Y1 Competition Finals (Seattle)
Y2 Internal Deep Dives/Planning
Year 2 Execution: Academic 2015/2016
Y2 Fall Workshop (MathWorks)
Y2 Winter Workshop (Freescale/NXP)
Y2 Competition Finals (GM Desert Proving Ground – Yuma, AZ; San Diego)
Y3 Internal Deep Dives/Planning

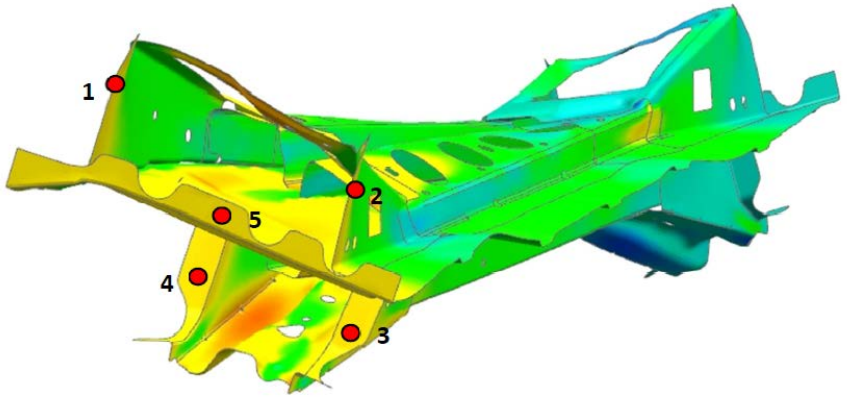


Approach/Strategy for Deployment

- **Design and execute North America's premier collegiate Advanced Vehicle Technology Competition program**
  - Replicates real-world, hands-on, production-intent automotive industry experience in an academic environment, spur innovation and enhance education experience
  - Follows multi-year Vehicle Development Process (VDP) modeled after auto industry
  - Utilizes industry-leading engineering tools, methodologies and practices
  - Provides comprehensive automotive engineering education, training, and mentoring, matching students with subject matter experts from multiple areas of industry
- **Addressing Technical Barriers**
  - Enable teams to develop their vehicles with limited university resources by establishing a 30+ sponsor network providing $940M of support to teams
  - Model Based Design Curriculum and Applied Auto Engineering Curriculum projects to spread educational reach to larger academic community
  - Business program evolved into Project Management to equip teams/students for engineering project management and sponsor development
- **Integration with other VT programs:**
  - Clean Cities University Workforce Development Program (funds ~114 interns/yr.)
  - Other DOE programs (M&S, Vehicle Systems) – secured SMEs and judges to participate in workshops, competition and score reports and team deliverables

Accomplishments/Progress: Safety

- **Improved structural modification "Waiver" process:**
  - Teams submit analysis showing vehicle modifications do not compromise vehicle safety
  - Analysis is reviewed by GM subject matter experts: teams now submit analysis results files directly to GM
  - Process is more thorough & streamlined



- **Team Facility inspections**
  - All team facilities inspected for safety and compliance to program requirements
- **New Systems Safety activity**
  - Required activity for all teams
  - Systems-level hazard identification, risk assessment, risk mitigation
  - Analyzes overall effect at vehicle level (including operator and environment)
  - Result: team vehicles are more safe and better prepared for on-road testing
  - Result: students are exposed to systems engineering concepts used in industry

Accomplishments/Progress: Vehicle Integration

Year 2 Competition Goals

- Full vehicle integration
- Pass safety/technical inspection
- Stretch goal: basic vehicle functionality
- Years 3-4: full vehicle functionality & refinement

Program Progress

- Teams received engines Sep 2015
- Teams received ESS hardware Dec 2015
- Teams received Camaros Dec 2015

Team Progress as of April 28

- All teams completed ESS design review
- 5 teams with commissioned ESS
- 8 teams with powertrain integrated

Accomplishment / Key Milestone

- Dynamic vehicle demonstration at an GM Desert Proving Ground (May 16-21, 2016)

Accomplishments/Progress: New ADAS Activity

New in EcoCAR 3: Stereo vision-based ADAS

- Integrating stereo vision sensors on Camaros
- Executing computer vision algorithms on newest NXP sensor fusion board
- Using data to improve vehicle efficiency

Teams only introduced to ADAS 6 months ago. Since then, have developed programs to:

- Import stereo video from two cameras
- Identify signs and vehicles
- Generate 3D maps and use them to estimate distance to traffic elements
- Begin executing programs in real-time on NXP hardware

Long-term goal: build a foundation for future CAVs activities in EcoCAR 3 and beyond

Accomplishments/Progress: New Innovation Activity

Major Innovation Initiative added in EcoCAR 3 in partnership with NSF

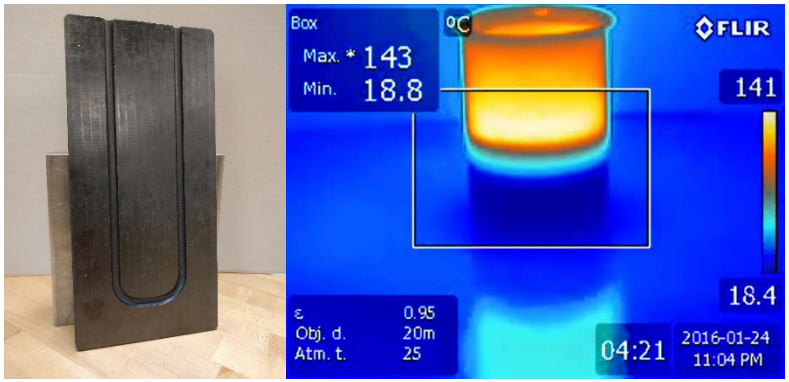
- Designed to spur R&D development at universities on topic of their choosing
- Each year, teams can continue with prior topic or select new one
- Significant support from NSF

Less bounded than traditional AVTC activities

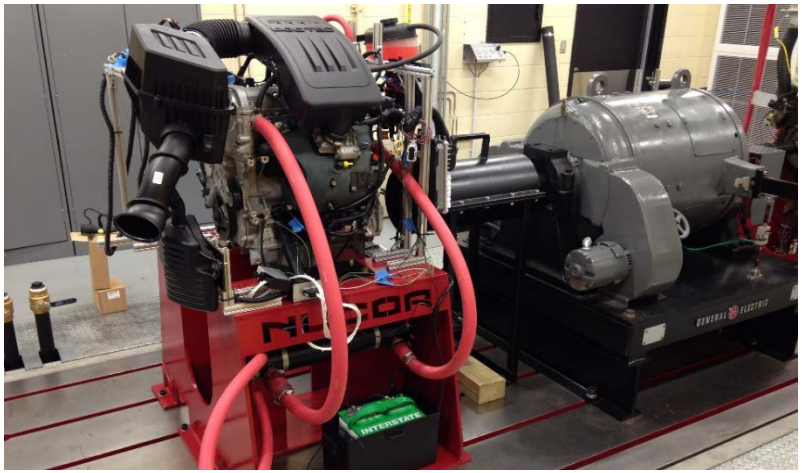
- Advances research in topics beyond hybrid system integration
- Embraces diversity of university backgrounds

Wide breadth of topics:

- V2X-based PHEV powertrain control
- EcoRouting for PHEVs
- Realtime cloud-based efficiency optimizations
- Additive manufacturing of mounts/driveshafts



Embry Riddle: Battery cooling plate using phase change composite material



Alabama: HCCI/SI E85 engine dyno cell

Accomplishments/Progress: Project Management and Communications Programs

- **Project Management Program:**
  - Revamped: new focus specifically on project management
  - Each team has funded Project Manager (PM)
  - Training provided to PMs to execute role
    - Manage/execute project schedule, timeline management, risk management, fundraising, budgeting and purchasing efforts
    - EcoCAR experience qualifies PMs to pursue CAPM certification
  - 11 PM-field-related papers published in EcoCAR 3 (Y1)
- **Communications Program:**
  - Program has been established for 6 years and is fully integrated as a multi-disciplinary aspect on each team. Level of execution improves every year.
  - Each team has funded Communications Manager (CM)
  - Training provided to CMs to execute role
    - Media relations and interviewing, video production, strategic social media, website development, personal branding, recruitment tools, educational and influencer campaigns

Accomplishments/Progress: Media/PR

EC3 to date:
1352 placements - 385M impressions
287 Local stories secured by teams

autoblog

OFFICIAL Apr 10th 2015 at 4:02PM

A Chevy Camaro hybrid? That's what EcoCAR3 could bring

GM, DOE Team Up For Round Three Of Innovation Competition

GLAMOUR INSPIRED

The Conversation

This Woman-Led Collegiate Team Is Building an Eco-Friendly Hybrid Camaro

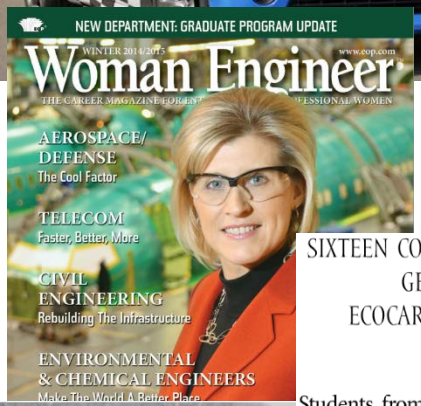
By Danica Lo - FEBRUARY 8, 2015

The Educated Mom

The official blog of Mindprint Learning

Not your Typical College Day: Transform this Camaro

MARCH 19, 2015



SIXTEEN COLLEGES NATIONWIDE GEAR UP FOR ECOCAR 3 COMPETITION

By John Aguilera

Students from 16 colleges around the nation are gearing up for year one of the four-year EcoCAR 3, Advanced Vehicle Technology Competition (AVTC). The competition, which began in 2008 as a program sponsored by the Department of Energy (DOE) and General Motors (GM) and managed by the Argonne National Laboratory, aims to encourage the best and brightest to come up with novel automotive solutions to problems such as gas consumption and aerody-namics.

Car Talk

Student Teams Build Green Camaros for Fun--and Good Jobs

Paste

Female-led Team at Wayne State Built a Hybrid Camaro for the EcoCAR 3 Challenge

Motorized Vehicle MANUFACTURING 2014-2015

Paving the Road to Automotive Advances with EcoCAR 3

Kristen De La Rosa
Director
Advanced Vehicle Technology Com
Argonne National Laboratory
Argonne, IL

Accomplishments/Progress: STEM Outreach & Community Involvement

- Partnership with National Science Foundation to support diversity
  - Diversity in Engineering Award to encourage diversity among EcoCAR teams, youth
- Partnership with Clean Cities Coalitions nationwide
  - 3 teams conducted Idle Box Reduction Campaigns in Y2
- **47** Middle & High School STEM events in Y1 – 25 to diverse student audience
- **115** Middle & High School STEM events in Y2. Nearly half to diverse student audience
- More than **250** community, campus, consumer, influencer, and professional organization outreach events

Prior Accomplishments & Ongoing Activities Still Bearing Fruit

- Safety and technical vehicle inspections
  - Vehicles inspected before operating – typically twice per year
- Clearly-defined system safety level process
  - Equips teams to develop vehicle hardware and software safely
- Model-Based Design concepts integrated into majority of competition activities
  - Rapid controls prototyping through In-the-Loop techniques (MIL-SIL-HIL)
  - CAD/CAM/CAE techniques used to build vehicle structural components
  - Industry-grade tools: Siemens NX, Matlab/Simulink/Stateflow, dSPACE simulators
- Cross-disciplinary and inter-disciplinary educational experience
  - EcoCAR technical activities span engineering disciplines: ME, EE, Computer/Software, Industrial/Process, etc.
  - Beyond engineering: significant communication and project management activities
  - Result: unparalleled real-world education experience unavailable elsewhere
- Additional educational initiatives to expand reach, educational experience
  - Model-Based Design Curriculum Project
  - Applied Automotive Engineering Curriculum Project

Collaboration: Universities and Industry Sponsors

Arizona State University
Cal State, Los Angeles
Colorado State University
Embry-Riddle Aeronautical University
Georgia Tech
McMaster University
Mississippi State University
The Ohio State University
Penn State University
University of Tennessee, Knoxville
University of Alabama
University of Washington
University of Waterloo
Virginia Tech
Wayne State University
West Virginia

Headline

U.S. DEPARTMENT OF ENERGY, GM

Visionary

MathWorks, NSF, California Environmental Protection Agency Air Resources Board, NXP, Clean Cities U.S. Department of Energy

Leadership

AVL, BOSCH Invented for life, ETAS, PACCAR, dSPACE

Sustaining

Snap-on, SIEMENS, GKN, TRC

Supporter

DENSO, CHAMPLAIN CABLE, WOODWARD, PROTERRA, RICARDO

Contributor

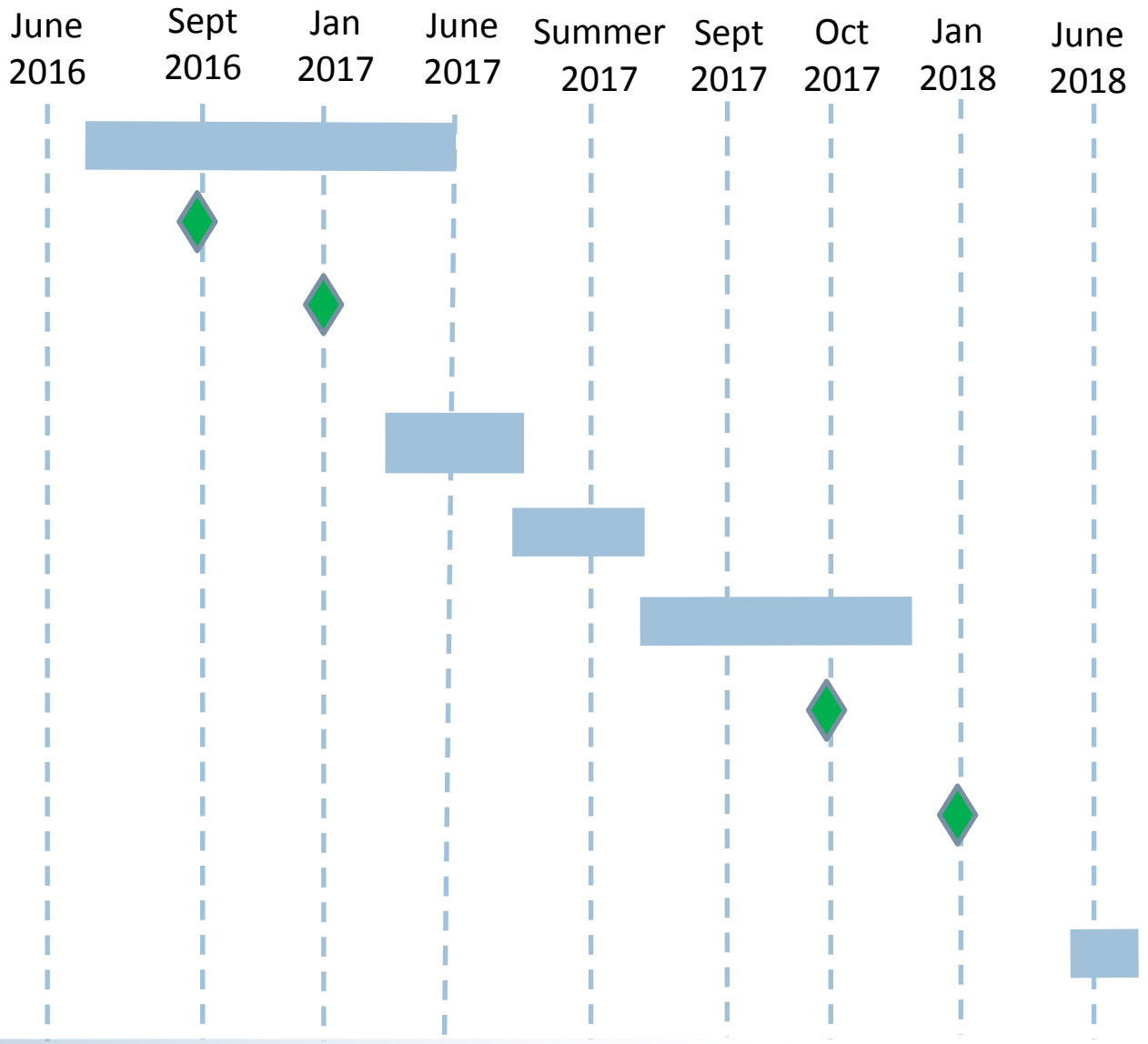
Mentor Automotive, New Eagle, tesa great to work with, VECTOR, DELPHI Foundation, EM empowering, EPRI ELECTRIC POWER RESEARCH INSTITUTE, A123 SYSTEMS, FLEXTRONICS

Collaboration: Universities

- 16 University Teams (including 2 Canadian schools)
- Every American time zone represented

Future Milestones

Task
Year 3 Execution: Academic 2016/2017
Y3 Fall Workshop (MathWorks)
Y3 Winter Workshop (Freescale/NXP)
Y3 Competition Finals (Milford Proving Ground; DOE HQ – Washington, DC)
Y4 Internal Deep Dives/Planning
Year 4 Execution: Academic 2017/2018
Year 4 Emissions Testing (TRC)
Y4 Winter Workshop (MathWorks/NXP)
Y4 Competition Finals & Over the Road Event (TBD)



Summary

The AVTC program is successfully addressing the following barriers:

- Lack of trained engineers and scientists
  - Over 25 years, AVTCs have seeded the automotive industry with 17,000+ engineers, business leaders and communicators who are making significant contributions to the industry immediately upon entry
  - Provides students a real-world, hands-on educational experience using latest auto industry tools, methods, and best practices to better prepare them for future careers as leaders of the automotive industry
- Lack of advanced vehicle technology curricula
  - Program provides automotive engineering education, training, and mentoring, matching students with subject matter experts from multiple areas of industry
  - Program drives teams to create new multi-disciplinary curricula at their university focusing on systems-level engineering
  - Model Based Design Curriculum Project provides in-depth modules across the academic community and public to teach the fundamentals of hybrid vehicle powertrain modeling
  - Applied Automotive Engineering Curriculum project provides several short modules - each provide basic 'startup' knowledge for automotive principles

Unique collaboration of government, industry and academia

- Demonstrates the benefits of sustainable vehicle solutions to address our current energy and transportation challenges

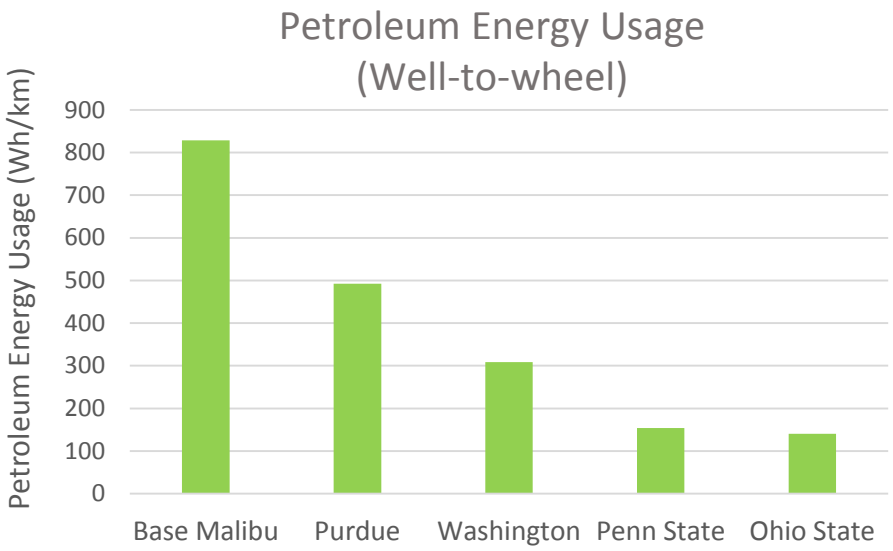
Questions?

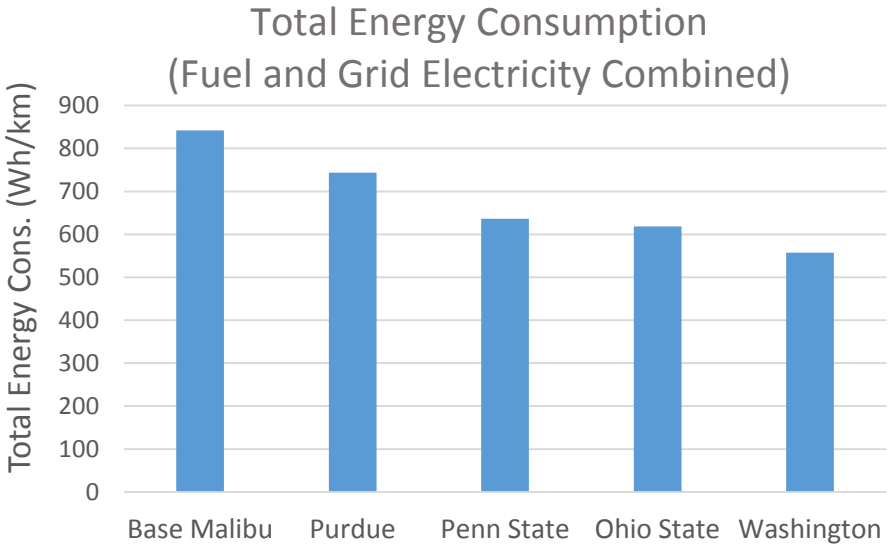
EcoCAR3
Advanced Vehicle Technology Competition

Technical Back-Up Slides

Accomplishments and Progress: Energy Use and Environmental Impact in EcoCAR 2

- Significant energy consumption reductions over stock vehicle:





- Multiple fuel types and many hybrid powertrain layouts evaluated:

Best petroleum energy usage

Best criteria emissions

Best energy consumption

Best GHG emissions