EcoCAR 2: Plugging In To The Future

The 10th DOE Advanced Vehicle Technology Competition

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Sponsored by Connie Bezanson

Project ID #TI013

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Overview

Timeline

- NOPI sent out September 2010
- RFP sent out November 2010
- Universities selected March 2011
- Project kickoff April 2011
- Year 1 began August 2011
- Year 2 began August 2012
- Year 3 begins August 2013

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 model based design and validation methodologies

Budget

Year	VT	Clean Cities	Non-DOE	Total
FY 2011	$2.00M	$1.425M	$835K	**$4.260M**
FY 2012	$1.99M	$1.475M	$463K	**$3.929M**
FY 2013 (exp)	$2.00M	$1.175M	$519K	**$3.694M**

Partners

- DOE, General Motors
- 29 additional automotive industry sponsors
- Managed by Argonne National Laboratory

Project Objectives – Relevance

Objectives:

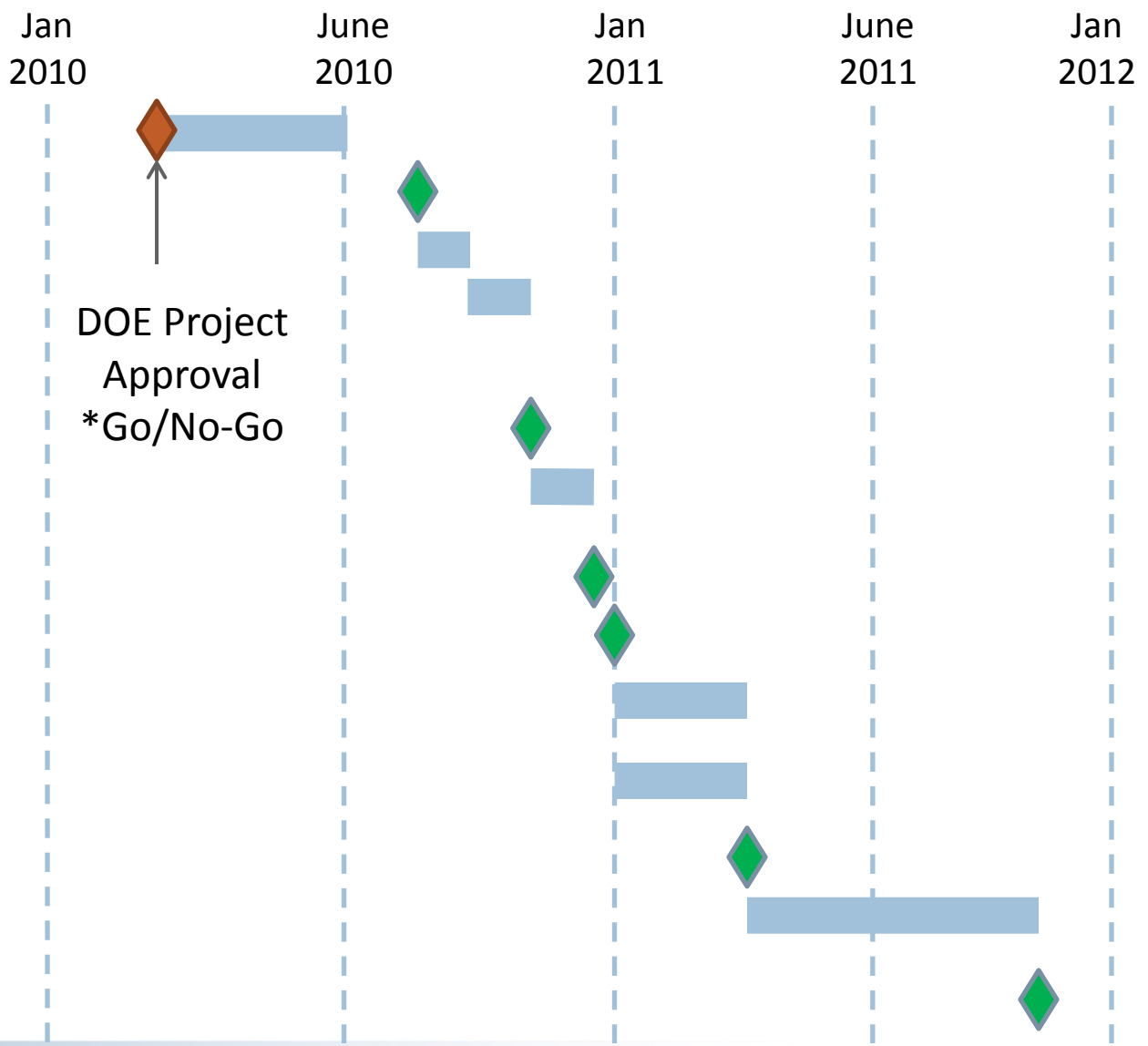
- Workforce Development – seed the industry with engineers/communicators with hands-on/real-world experience in advanced vehicle technologies
- Develop and execute a safe, efficient and fair competition (ANL Ideology)
- Ensure the technical integrity of AVTCs, aligning with industry standards

Impacts:

- More than 16,000 trained engineers have graduated from AVTCs to date
- AVTC graduates are better prepared to contribute to the automotive industry
  - 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, technical publications, and student education
  - Demonstrates unique technologies and powertrain configurations of interest to DOE and automotive industry
- Strong collaboration of more than 30 government and industry sponsors
  - More than $940M of support to EcoCAR 2 teams

Milestones

Task
OEM Selection
Deep Dive #1
Competition Philosophy Development
Notice of Program Interest (NOPI) Development
NOPI Released
Request for Proposal (RFP) Development
RFP Released
Proposals Due
Team Selection
Competition Administrative Content Development
EcoCAR 2 Launch Workshop
Competition Technical Execution Development
Kickoff Workshop (August 2011)



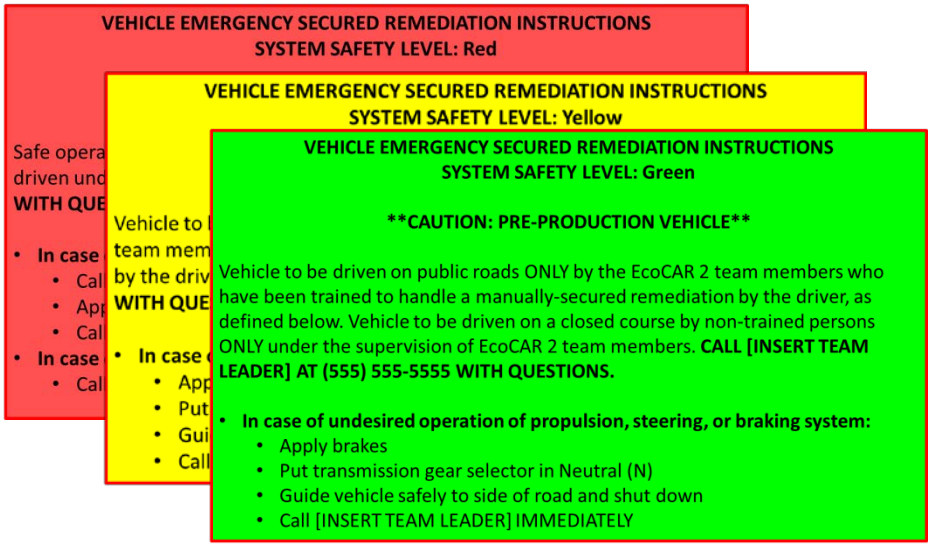
Approach/Strategy for Deployment

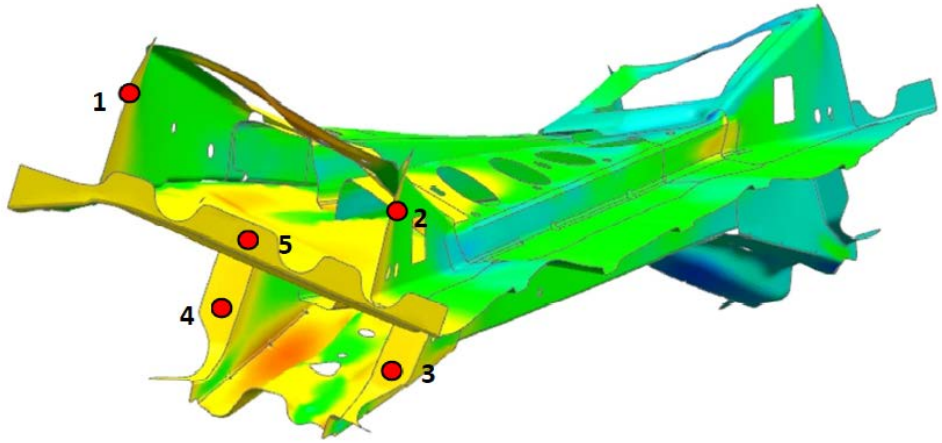
- **Design and execute North America's premier collegiate Advanced Vehicle Technology Competition program**
  - Replicates real-world, hands-on, production-intent automotive industry experience in an academic environment
  - Follows a structured, multi-year Vehicle Development Process (VDP) modeled after 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 Project to develop automotive modeling curricula
  - Business program added to emphasize project management, sponsor development
- **Integration with other VT programs:**
  - Clean Cities University Workforce Development Program
  - Other DOE programs (M&S, Vehicle Systems) – secured SMEs and judges to participate in workshops, competition and score reports and team deliverables

Technical Accomplishments and Progress: Safety

Progress

- Improved process for safe vehicle development and commissioning:
  - Includes both vehicle hardware and software
  - Prescribes restrictions for vehicle activity based on known and proven safe functionality
- Improved Waiver process:
  - Modifications to vehicle structure are required to package components
  - Teams must submit analysis proving the modification does not compromise vehicle safety
  - Analysis is reviewed by industry subject matter experts





Technical Accomplishments and Progress: Safety

Progress (cont.)

- Refined safety and technical inspections process:
  - All vehicles receive a comprehensive inspection by a team of experienced government and industry engineers
  - Vehicles are not permitted to run dynamic events until they have passed inspection

Accomplishments

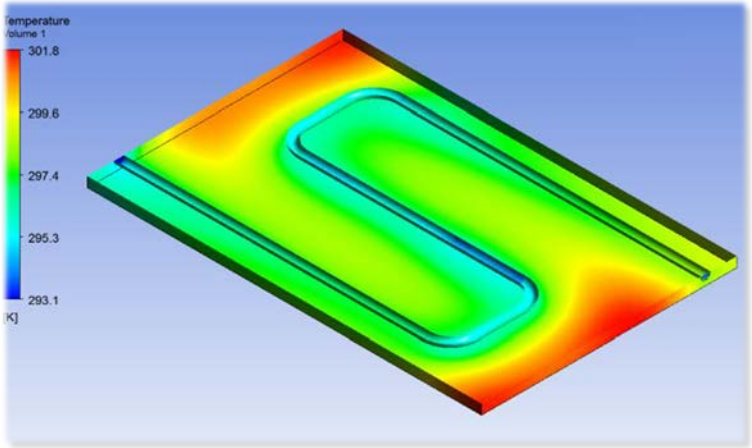
- No recorded safety incidents at competition events
- Two inspections per year allows for more thorough inspection of vehicles
- Clearly defined system safety level process equips teams to develop vehicle hardware and software safely

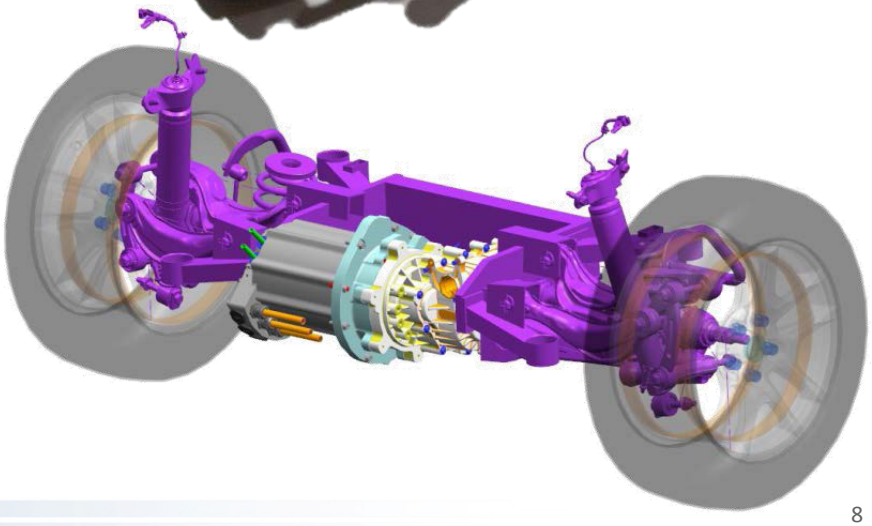
Technical Accomplishments and Progress: Model Based Design

Program Progress

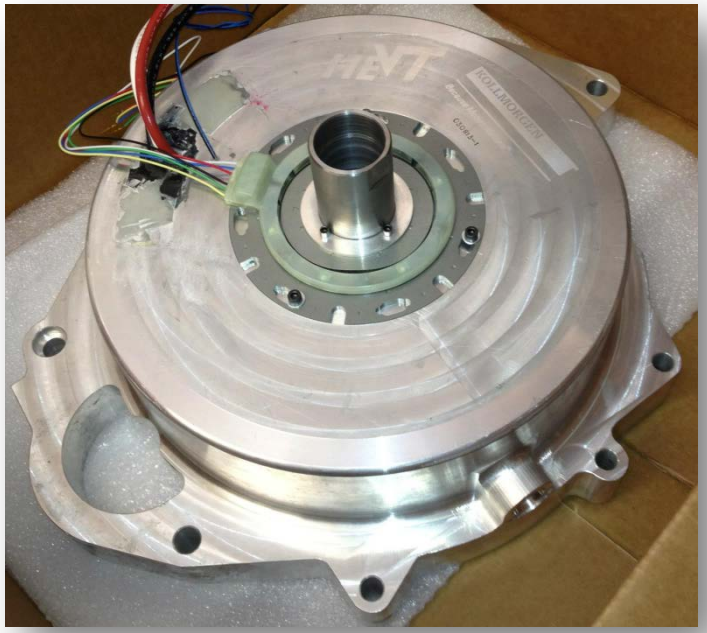
Students use industry recognized model-based design tools throughout the program

- Computer Aided Design (CAD) & Finite Element Analysis (FEA) – Siemens NX
- Computational Fluid Dynamics (CFD) – CD Adapco STAR CCM
- Math and physics based powertrain component and vehicle simulation modeling – MATLAB®/Simulink®
- Supervisory control (system of systems) design and validation – MATLAB®/Simulink®



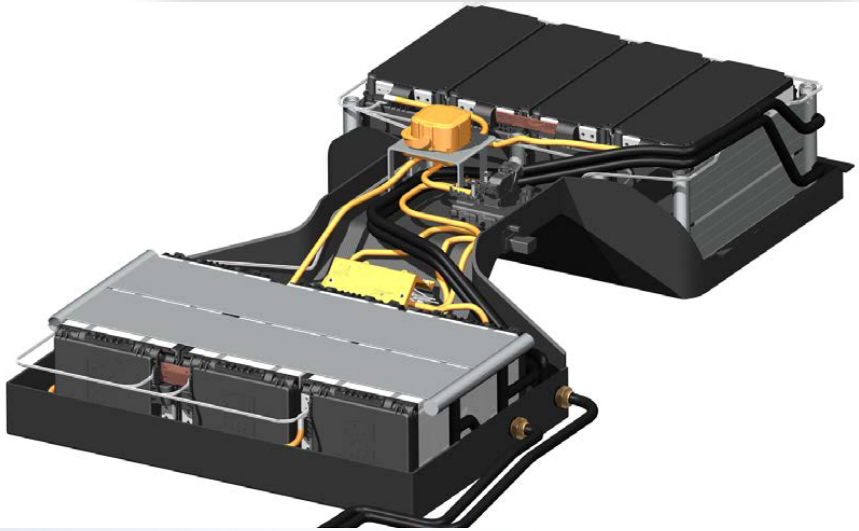


Technical Accomplishments and Progress: Model Based Design



Student Accomplishments

- Completed vehicle simulation models for control system development
- 15 student-designed and built Energy Storage Systems (ESS)
- Student designed structural modifications are reviewed by industry subject matter experts
- Computer Aided Manufacturing (CAM) used by students to build functional prototypes



Technical Accomplishments and Progress: Vehicle Integration

Program Progress

- Teams received vehicles Summer 2012
- Teams received sponsored powertrain components Summer/Fall 2012

Team Progress as of March 28

- All vehicles have received initial safety inspection
- 8 teams have a fully-integrated and commissioned ESS
- 11 teams have demonstrated powertrain component functionality on the bench
- 3 teams demonstrated powertrain functionality in-vehicle

Accomplishment / Key Milestone

- Dynamic vehicle demonstration at an OEM proving ground (May 13-23, 2013)

Technical Accomplishments and Progress: Controls, Modeling, and Simulation

Program Progress

- Safe software design through closed loop development and testing methodology
- Control design process adapted to include Software In-the-Loop (SIL) validation
- Heavier emphasis on fault detection and mitigation
- Students follow standardized control development process by simulating physical systems in a virtual environment before prototypes are built
- Improved consistency of deliverables/expectations for Years 2 and 3

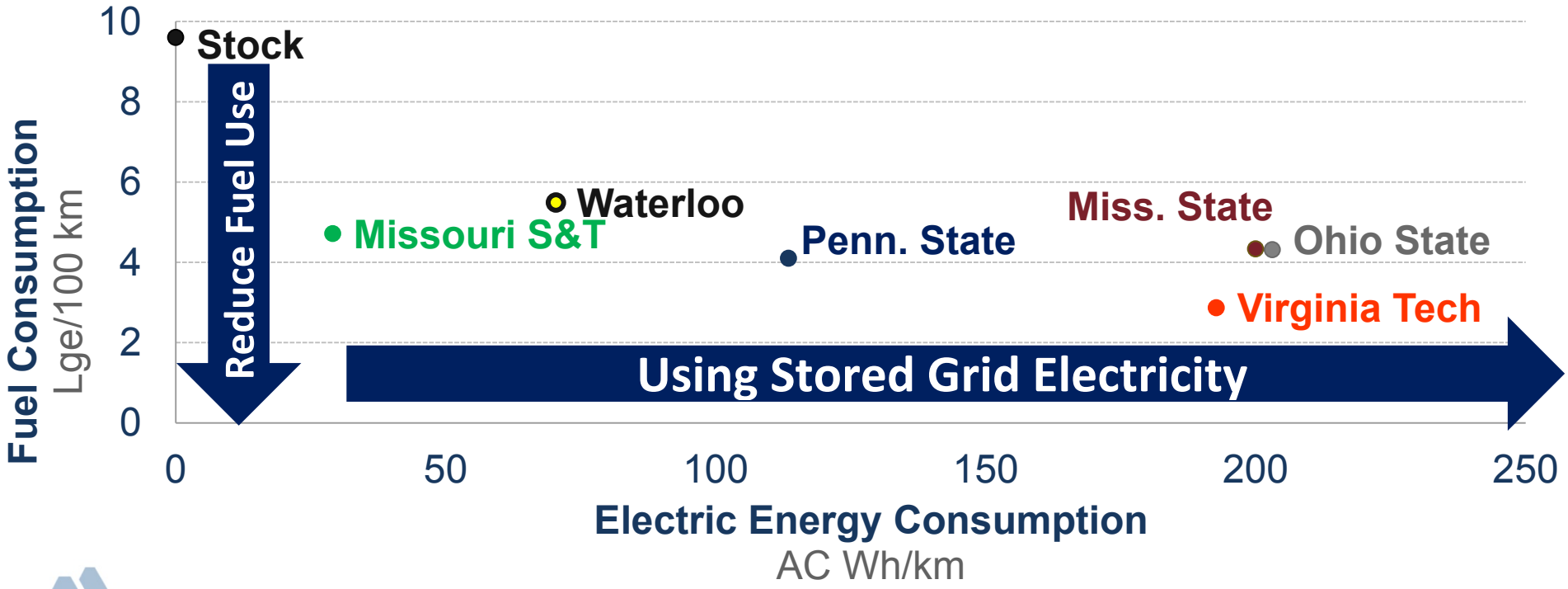
Student Accomplishments

Developed and validated control systems using industry practices such as Design Failure Mode and Effects Analysis (DFMEA) and Fault Tree Analysis (FTA), which resulted in:

- Fully implemented Hardware In-the-Loop (HIL) test benches
- Robust control code
- Safe torque delivery to powertrain components
- Quicker identification of failures for repair purposes

Technical Accomplishments and Progress: Energy Use and Environmental Impact

- **Broad technology demonstration and evaluation**
  - Lowest Fuel Consumption – won by **E85 PHEV**
  - Lowest Greenhouse Gases – won by **Biodiesel PHEV**
  - Lowest Petroleum Use – won by **H_2 Fuel Cell PHEV**
  - Lowest Tailpipe Emissions – tied by two **H_2 Fuel Cell PHEVs**



Technical Accomplishments and Progress: Business and Project Management

- **AVTC Business/Project Management Activities**
  - Equip teams to manage and execute fundraising, budgeting, risk management, and project management efforts
  - Equip Business Managers with professional development skills (risk analysis, FMEA, budgeting, sponsorship development, pitching, etc.)
  - Trains Business Managers for professional certifications (CAPM)
  - Requires teams to plan and execute sponsorship development plans
- **Student Accomplishment Highlights**
  - Many teams have secured hardware donation agreements from local sponsors such as Parker-Hannifin, UQM, Remy, etc.
  - $25,000 sponsorship from John Deere secured by Purdue University
  - Teams able to plan, maintain, and execute risk management strategies
  - Teams have developed and maintained complex project management plans

Technical Accomplishments and Progress: Communications Program

AVTC Communications Activities

- Equip teams to plan and execute outreach efforts, including congressional, community and education outreach events
- Requires teams to obtain local, regional, and national media coverage
- Equip Communications Managers with professional development skills, including media relations training

Accomplishments

- Collaboration with Clean Cities Coalitions nationwide
- Strategic social media activity on Facebook, Twitter, YouTube, Flickr, and more
- Engaging sponsor collaboration videos and blogs
- Strong media relations with more than **184** student-obtained media hits in Year One
- More than **258** public, youth, campus, influencer, and professional organization outreach events in Year One

Technical Accomplishments and Progress: Media/PR

To Date:

237 articles

169 M impressions

$200K in Ad Value

Driver's Seat

News, views, and advice about cars, auto safety, driving, and transportation.

USA TODAY

JUNE 10, 2011, 1:35 PM ET

GM Scouts For Talent At EcoCAR Competition

Article | Comments (4)

Email | Print | Like | Send | + More | Text

By Michael Ramsey

U.S. Government Work

An EcoCar competitor.

MILFORD, Mich. – General Motors Co. is nearing the end of a three-year interview process with about 200 of the best engineering students in the U.S. and Canada, with 39 committed to work for the auto giant this year, and more in the pipeline.

Nobody would call it that, but that's what the EcoCAR Challenge is. This week at GM's massive vehicle proving grounds in the exurbs of Detroit, teams of engineering students from 16 universities are getting final grades on their three-year projects to retrofit Saturn Vue crossovers (they now all carry the Chevy bowtie because Saturn bit the dust) donated by GM into advanced alternative powertrain vehicles for the competition.

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Jim Motavalli

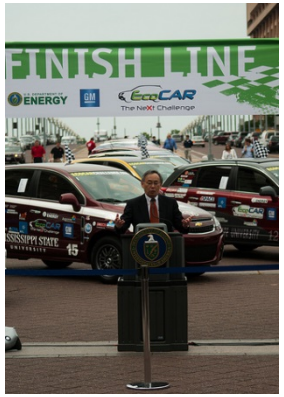
New York Times contributor blogs about green transportation

Behind the wheel at the EcoCAR college engineer competition

Sixteen teams from colleges across the country spent three years building hybrids, plug-in hybrids and even hydrogen cars. This week in Washington, they met in the final showdown. And some walked away with jobs at the Big Three.

THE WALL STREET JOURNAL.

Student teams to turn Chevrolet Malibus into EcoCars



The New York Times

REUTERS

WIRED

cnet

The Washington Post

Mississippi State University wins Year 1 of EcoCar 2 with plug-in hybrid Chevy Malibu

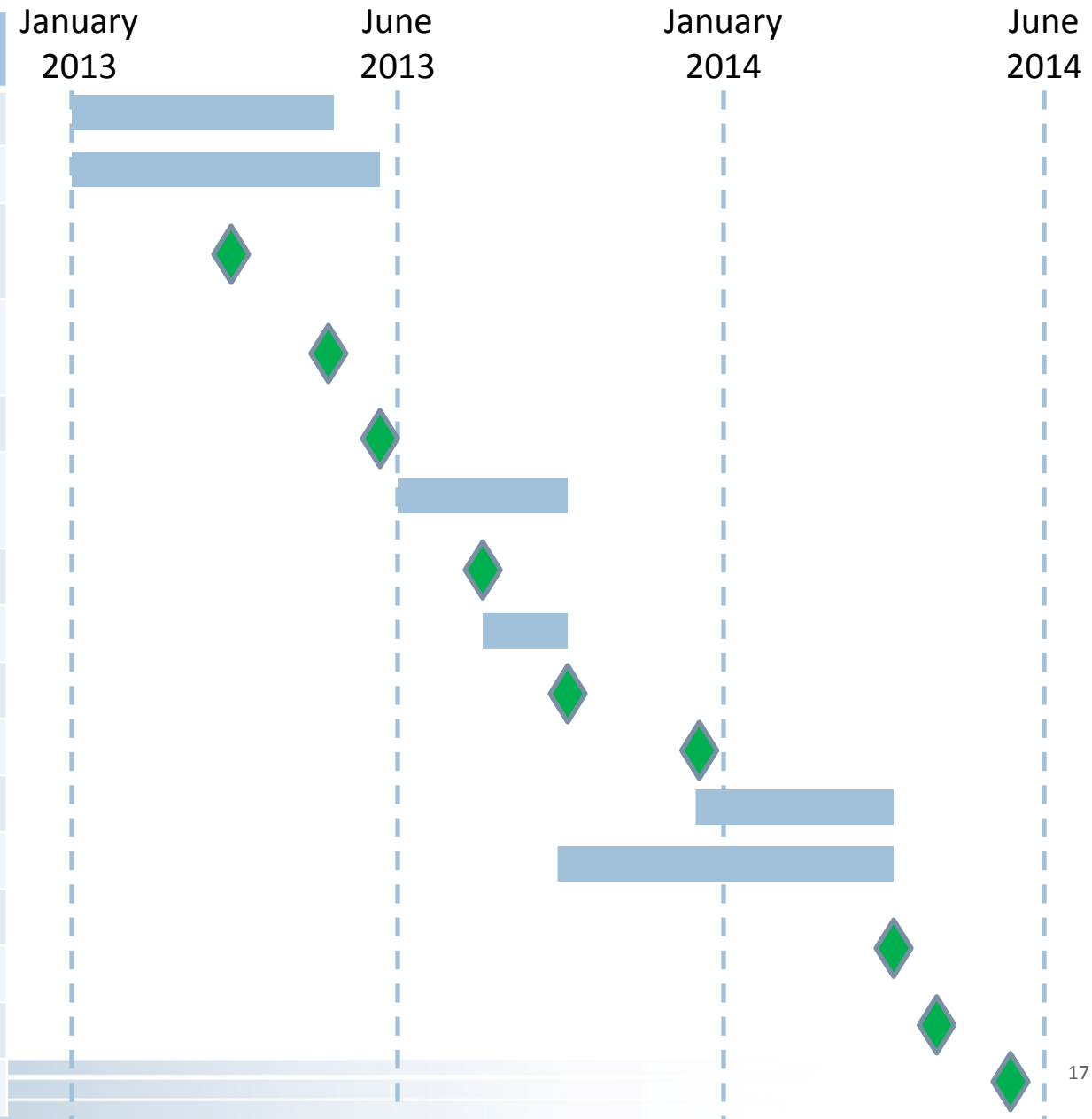
NATIONAL GEOGRAPHIC

Collaboration: Participating Teams and Industry Sponsors

Cal State, Los Angeles
Colorado State University
Embry-Riddle Aeronautical University
Mississippi State University
North Carolina State University
The Ohio State University
Penn State University
Purdue University
Rose-Hulman Institute of Technology
University of Tennessee, Knoxville
University of Victoria
University of Washington
University of Waterloo
Virginia Tech
Wayne State University

Future Work

Task
EcoCAR 3 Philosophical Development
Year 2 Competition Development
EcoCAR 3 Notice of Program Interest (NOPI) Released
EcoCAR 3 Request for Proposal (RFP) Released
Year 2 Competition
Year 3 Technical Execution Development
Year 3 Deep Dive
Year 3 Rules Development
Fall Workshop
EcoCAR 3 Proposals Due
EcoCAR 3 Team Selection
Emissions Workshop Development
Emissions Workshop
Year 3 Competition Development
EcoCAR 3 Launch Workshop
Year 3 Competition/Finale Event



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 16,000+ engineers and communicators
  - Provide students a real-world, hands-on educational experience using auto industry tools, methods, and practices
- 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
  - Model Based Design Curriculum Project develops automotive-focused powertrain modeling curricula

Leveraged DOE funding with significant collaboration and support from outside government, industry and academia

- Established a 30+ sponsor network providing $940M of support to teams for three-year EcoCAR 2 series
- Significantly leveraged DOE's three-year $10.65M investment with cash and in-kind support, technical mentoring and expertise

EcoCAR 2 Summary Video

CLICK PLAY BUTTON ON IMAGE FOR VIDEO!

Questions?

EcoCAR2

PLUGGING IN TO THE FUTURE

Technical Back-Up Slides

System Safety Level (SSL): Introduction

- Purpose: clearly identify the integration status of a prototype vehicle in development for **safety**
- Vehicle SSL provides the organizers documentation of your vehicle validation and verification
- If you follow the steps we lay out, the control system will be better tested, verified and documented by competition
- Minimum requirement to run dynamic events remains the same – passing competition Safety Technical Inspection
- SSL process compliments other competition events and processes to facilitate testing your vehicle at competition

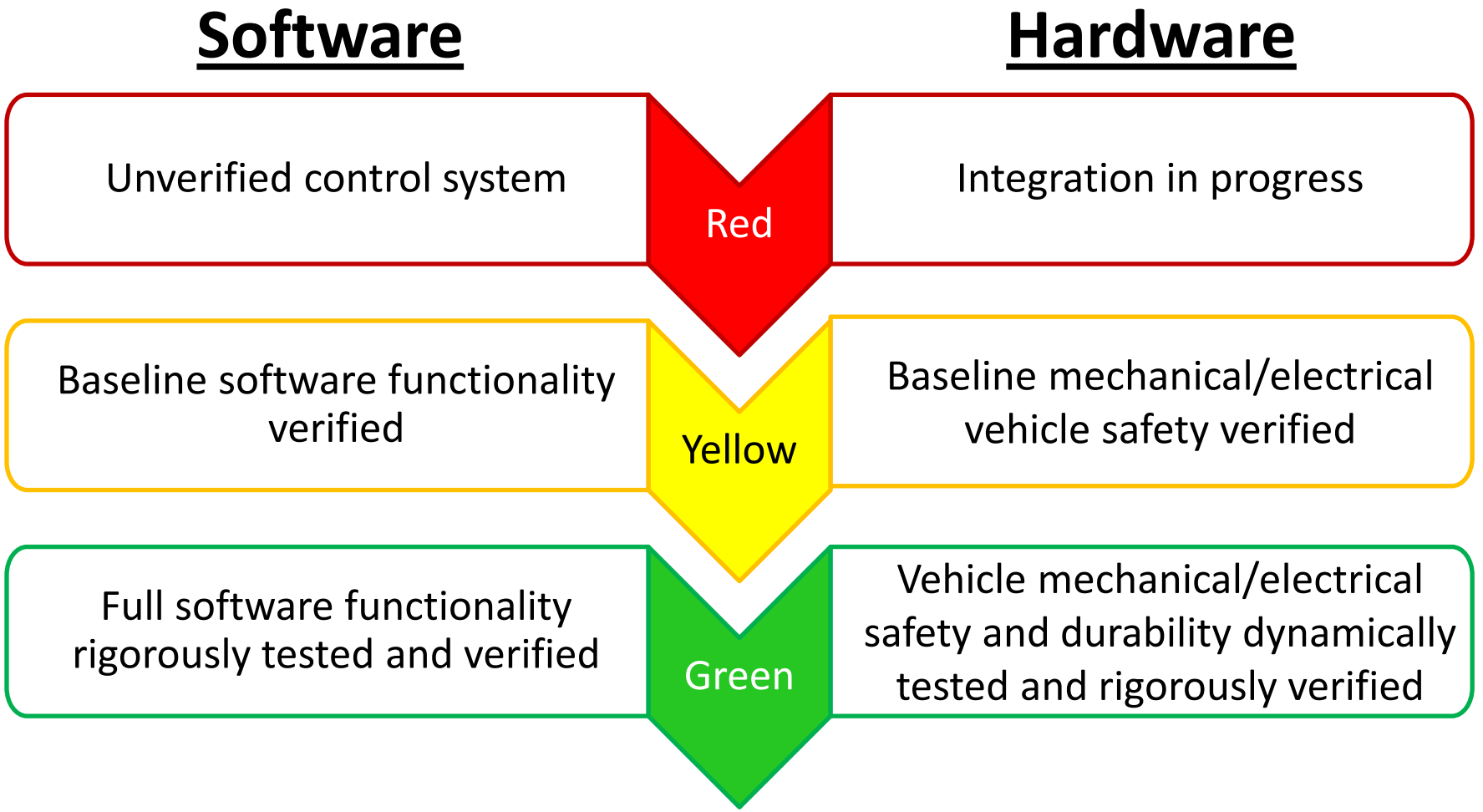
Why SSL is Important

- Conveys the status and safety level of the vehicle to team members, the organizers and the general public
- With multiple people working on the vehicle, you cannot assume that everyone always knows what state the vehicle is in
- Following SSL promotes an incremental integration strategy that ensures safety throughout development
  - Also reduces errors and troubleshooting downstream
- SSL works within the VDP for vehicle integration and validation and with the V diagram for controller validation

Overall Vehicle SSL

- Red – Not drivable
- Yellow – Drivable on closed course by an approved “technical community” or approved team driver, with functional E-Stop
- Green – Drivable on public roads by approved “technical community” driver and on closed course by the press
- The technical community is defined as members from the competition steering committees and qualified drivers at GM proving grounds.

Dual Paths to Verification



Your worst level determines your overall vehicle status

Requirements to Progress: Software

Default

1. Minimum of 50% credit earned in controls section of any progress report
2. Verified torque control via lift testing

AT COMPETITION:
Completion of specified dynamic events at competition. Final decision is at the discretion of the organizers

Requirements to Progress: Hardware