University of Victoria
EcoCAR 2 – Plugging in to the Future
EcoCAR and EcoCAR 2

- Government and Leading Industry Sponsored Elite Student Design Competition (15 Universities Selected in US/Canada)

- Development of Future Hybrid Electric Vehicle (HEV) Technology by Designing, Modeling, Simulating, Testing, and Retrofitting a 2013 GM Malibu with a Newly Developed Hybrid Powertrain

- Open to Both Undergraduate and Graduate Students

- Getting Training and Experiences on Advanced HEV Technology, Mechatronics and Project Management

- Working with Leading Experts Worldwide through Direct Contacts with Major Industrial Sponsors

- Closely Supervision by Faculty Members with Related Background and Interests
Why It Is Unique and Exciting?

- Urgently Needed, Advanced Technology
- Well Funded Developments:
  - Federal (US, Canadian) and Provincial Supports
  - Extremely Strong Industrial Industry Sponsorship
- Integrated to Academic Program
  - Open to Undergraduate and Graduate Students
  - 3 Year Development Program
- Advanced Research and Training
  - Mechatronics, Hybrid Vehicle, Control, Modeling, System Design, Simulation, Instrumentation, Embedded Systems, CAD/CAE/CAM, Team Work, Project Management, etc.
- Hands on Experiences
  - Advanced Software Tools
  - Advanced Hardware Tools
- Great Career Opportunities in High-tech and HEV Industry
Sponsors and Supports

- US Department of Energy
- General Motors Corp.
- Natural Resources of Canada
- Argon National Laboratory, US
- The MathWorks
- dSPACE
- A123
- SIMENS
- National Science Foundation, US
- University of Victoria / Faculty of Engineering
## What We Do

<table>
<thead>
<tr>
<th>YEAR &amp; OBJECTIVE</th>
<th>MECHANICAL</th>
<th>ELECTRICAL</th>
<th>CONTROLS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Year 1: Design</strong></td>
<td>Lifecycle analysis, vehicle architecture selection and performance modeling</td>
<td>CAD - Component</td>
<td>Control System Design</td>
</tr>
<tr>
<td></td>
<td>Define Electrical Requirements</td>
<td>CAD - Routing and Integrations</td>
<td>HIL Design/Setup</td>
</tr>
<tr>
<td></td>
<td>Simple Control and SIL/Prelim HIL</td>
<td>Vehicle Modification</td>
<td>Vehicle Harness/Systems Design</td>
</tr>
<tr>
<td></td>
<td>Finalized Component Selection</td>
<td>Vehicle Harness/Systems Design</td>
<td>HIL Finalization &amp; Communication Setup</td>
</tr>
<tr>
<td></td>
<td>Component Integration</td>
<td>Vehicle Harness Setup</td>
<td>HIL Testing - Safety and Fault Mitigation Implementation</td>
</tr>
<tr>
<td><strong>Year 2: Mule Vehicle</strong></td>
<td>Controls Integration and Vehicle Troubleshooting</td>
<td>Aero and Lightweighting, R&amp;H, NVH</td>
<td>Refinement and Optimization</td>
</tr>
<tr>
<td></td>
<td>Refinement and Optimization</td>
<td>Refinement and Optimization</td>
<td>99% Buyoff - Vehicle Ready for Production</td>
</tr>
</tbody>
</table>
Major Groups

- Modeling/Simulation/System Design
- Mechanical Design, Analysis and Manufacturing
- Power Electronics and Electric Machines
- Control and Embedded System
- Programming
- Prototyping and Retrofitting
- Project Management
- Business Outreach

http://www.ecocar.uvic.ca
Related Courses and Training (Rewards)

- **MECH459 - Fundamental of Hybrid Electric Vehicles (for 3B Students)**
- **MECH580 Selected Topics in ME (Open to All Grad. Students)**
  5:30 - 8:20 pm; Wednesdays; ECS104
  ELEC496 Selected Topics in Electrical Engineering;
  CENG496 Selected Topics in Computer Engineering;
  SENG480 Selected Topics in Soft Computer Engineering;
  Instructor: Dr. Z. Dong (Open to Team Members with Home Chair Approval)
- **MECH497 Green Vehicle Technology Project (3 Units, Crawford & Dong)**
- **MECH499 Design Project** (ME Faculty Members)
- **ECE499 Design Project** (Dr. K. Li)
- **ENGR466 Mechatronics System Design** (Dr. D. Constantinescu)
- **MECH499 Honour Thesis** (3 Units, ME Fac.)
- **EcoCAR 2 Co-op Terms**
- **EcoCAR 2 Trainings (at Sponsors’ sites) and EcoCAR 2 Developments**
- **Graduate Studies at M.A.Sc. And Ph.D. Levels**
New UVic Green Vehicle Research, Testing and Training Centre

- **First Class Green Vehicle Development and Testing Facilities**
  - Computer Modeling, Design and Simulation
  - Hardwire in Loop Testing
  - Advanced Battery Pack Development
  - 4WD, Active Braking Enabled Chassis Dynamometer
  - Engine Dynamometer
  - Emission Measurement

- **Hands on Shop**
  - Automotive Shop
  - Small Machine Shop
  - Small Electronics Shop
University of Victoria
EcoCAR – the NExT Challenge
2009-2011

- Team Leaders
  - Jeremy Wise and Jeffery Walden
- Faculty Advisors
  - Dr. Zuomin Dong (zdong@uvic.ca)
  - Dr. Curran Crawford (ccrawford@uvic.ca)
- Website and contact: http://www.ecocar.uvic.ca
UVic EcoCAR 1 – Push the HEV Technology Boundary

- THS
- 2-Mode
- GM 2.4 L EcoTec E85 Fuel
- GM 2-Mode FWD Transmission
- 2 x 50kW Traction Motors
- UQM 145kW Rear Traction Motor
- A123 21 kWhr HV Battery Pack
- 2-Mode Plus
What We Do – Mechanical
What We Do – Electrical/Controls/Software
UVic 4WD 2-Mode Plus EcoCAR Control System

- **GM**
  - Driver
  - Accelerator
  - Brake
  - CS, EDS Switch

- **UVic (Added)**
  - UQM Motor Controller
    - Motor Torque, Speed, Temp, Capability
    - Battery V, I, SOC Temp
  - UQM Soft Start Relay
  - UQM Soft start V, I Sensors
  - UQM Motor Torque
  - Analog
  - RS-232
  - Vehicle PC Data Logging, Display
  - Auxiliary Sensor
  - UVic Can 2.0 @ HS

- **TPIM**
  - HCP
  - MCP
  - ECM
  - Constraints
  - Actual
  - Gear/Mode
  - Eng Torque, Speed; Capacity;

- **GMLAN**
  - GMLAN @ HS

- **A123 Battery Controller**
  - A123 Systems

- **Analog & Digital**
University of Victoria
EcoCAR 2 – Plugging in to the Future

- Team Leader
  - Daniel Prescott (dprescott@uvic.ca) (Year1: Stefan Kaban)
- Faculty Advisors
  - Dr. Zuomin Dong (zdong@uvic.ca)
  - Dr. Curran Crawford (ccrawford@uvic.ca)
- Website and contact: http://www.ecocar.uvic.ca
UVic EcoCAR2 through Optimization

**Goals** - Minimize emissions and energy consumption (Y2 & Y3 points; E&EC performance)

**Powertrain design and prototyping** - advanced powertrain architecture, sizing and control System
  - Support flexible multiple mode vehicle operations
  - Enable optimal vehicle operation for different demands

**Leading-edge powertrain control technology**
  - Real-time optimal control to maximize efficiency/performance
  - Optimal/intelligent energy management (fuel economy and life)
  - Integrated Infotainment system (improved utility and efficiency)

**Design for manufacturing, maintenance and reliability**
  - Essential to have a fully functional vehicle
  - Lesson from EC1
Multiple Mode AWD
Series–Parallel
PHEV
2.4L GM EcoTec LE9 Engine

TM4 80kW BAS

Magna E-Drive

A123 6s x 3s15p Lithium-Ion Battery
### Vehicle Technical Specifications

<table>
<thead>
<tr>
<th>SPECIFICATION</th>
<th>PRODUCTION MALIBU</th>
<th>COMPETITION REQUIREMENT</th>
<th>TEAM TARGET</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acceleration (0-60 mph)</td>
<td>8.2 seconds</td>
<td>≤ 9.5 sec</td>
<td>5.8 sec</td>
</tr>
<tr>
<td>Acceleration (50-70 mph)</td>
<td>8.0 seconds</td>
<td>≤ 8.0 sec</td>
<td>4 sec</td>
</tr>
<tr>
<td>Braking (60 –0 mph)</td>
<td>43.7 m</td>
<td>≤ 43.7 m</td>
<td>43.5 m</td>
</tr>
<tr>
<td>Highway Grade Ability (20 min)</td>
<td>10+ % at 60 mph</td>
<td>3.5% at 60 mph</td>
<td>8% @ 60 mph</td>
</tr>
<tr>
<td>Cargo Capacity</td>
<td>16.3 ft³</td>
<td>7 ft³</td>
<td>12.7 ft³</td>
</tr>
<tr>
<td>Passenger Capacity</td>
<td>5</td>
<td>≥ 4</td>
<td>5</td>
</tr>
<tr>
<td>Mass</td>
<td>1589.6 kg</td>
<td>&lt; 2250 kg</td>
<td>&lt; 2250 kg</td>
</tr>
<tr>
<td>Starting Time</td>
<td>&lt; 2 seconds</td>
<td>&lt; 15 seconds</td>
<td>&lt; 5 sec</td>
</tr>
<tr>
<td>Ground Clearance</td>
<td>155 mm</td>
<td>&gt; 127 mm</td>
<td>&gt; 127 mm</td>
</tr>
<tr>
<td>Range</td>
<td>736 km (CAFE)</td>
<td>332 km</td>
<td>332 km</td>
</tr>
<tr>
<td>Criteria Emissions</td>
<td>Tier 2 Bin 5</td>
<td>Tier 2 Bin 5</td>
<td>Tier 2 Bin 5</td>
</tr>
<tr>
<td>Charge Deplete Mode Range</td>
<td>N/A</td>
<td>N/A</td>
<td>63.1 km</td>
</tr>
<tr>
<td>UF Weighted Electrical Consumption</td>
<td>N/A</td>
<td>N/A</td>
<td>165.6 Wh/km</td>
</tr>
<tr>
<td>UF Weighted Fuel Consumption</td>
<td>8.83 Lge / 100km</td>
<td>7.12 Lge / 100 km</td>
<td>4.86 Lge / 100 km [432.7 Wh/km]</td>
</tr>
</tbody>
</table>
New Challenge Now
An Entirely New AWD EREV Powertrain Modeling and Design
New to EcoCAR 2: Infotainment System

- Android and Ca-Fi: 6.2 inch touch screen LCD, powered by The Freescale™ Cartex™ A8 i.MX5x processors running at 1.2 GHz; music and other audio with output connections for camera, USB and antennas, designed to be compatible with all sorts of car.
- Mercedes-Benz A-Class concept
- Toyota Entune in-car infotainment system
- Other electronics and embedded systems: solar roof Prius, etc.
UVic EcoCAR 2009 Competition Awards

• 2nd Place Overall
• 1st Place First Year Technical Reports
• 1st Place, MathWorks Modeling Award
• Best Electrical Systems Presentation
• 2nd Place, Hardware-in-Loop Evaluation
• 3rd Place, dSPACE Embedded Success Award
• Best Media Relations Program

Faculty Advisors: Zuomin Dong and Curran Crawford
UVic EcoCAR 2010 Competition Awards

- 4th Place Overall Award
- Best Technical Reports Award
- US National Science Foundation Outstanding Incoming Advisor Award (Drs. Dong and Crawford)
- Ron Stence Spirit of Challenge Award
- Dr. Don Streit Sportsmanship Award
- Modeling and Simulation (dSPACE) - 3rd Place Award
- Energy Storage System Design (A 123Systems) - 3rd Place Award
- Spirit of Outreach Award
UVic EcoCAR 2011 Competition Awards

- 1st Place MathWorks Award - Optimal Powertrain Design and Control
- 1st Place dSPACE Award - Hardwire in Loop Testing and Vehicle Dynamics Modeling
- Fastest 0-60 miles/h Acceleration (6.3 seconds)
- Fastest 50-70 miles/h Acceleration (3.5 seconds)
- Best Engineering Workmanship Award (Overall Appearance and Design for Service)
- 3rd Place A123 Workmanship Award - 21 kWh Li-ion Battery Pack Design and Prototyping
- Best EcoCAR Website Award (http://www.ecocar.uvic.ca)
UVic EcoCAR2 2012 Competition Awards

• First Place - Mechanical Design Award
• First Place MathWorks (Modeling, Simulation and Optimization) Award
• Third Place A123 Battery System Award
• Third Place Infotainment System Award
Become a Member of UVic EcoCAR2 Team

- No automotive experience necessary!
- All disciplines welcome!
Contacts

Website and contact: http://www.ecocar.uvic.ca

- Team Leader
  - Dan Prescott (dprecott@uvic.ca/)
    ~ Stefan Kaban (Y1 TL) & Hassib Hasanzadeh (Outreach/Prj)

- Faculty Advisors
  - Dr. Curran Crawford (ccrawford@uvic.ca)
  - Dr. Zuomin Dong (zdong@uvic.ca)
    - Mechanical Engineering
  - School of Business Faculty Contact: Dr. Adel Guitouni
  - ECE Faculty Contact: Dr. Subhasis Nandi and Dr. Ashoka Bhat
  - SENG/CS Faculty Contact: Dr. Mantis Cheng
Reception and Open House at “Q-Hut”