Recovery Act – An Interdisciplinary Program for Education and Outreach in Transportation Electrification

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Michigan Tech
Michigan Technological University

Overview

Timeline

- Start: Nov 2009
- Finish: Oct 2012
- Status: 55% Complete

Budget

Funding	Total
• DOE:	$2.978M
• Industry:	$0.750M

Technical Targets

- Graduate and Undergraduate Interdisciplinary Engineering Instruction
- Targeted to on-campus and distance-learning
- Hands-on laboratories for all participants

Barriers and Risks

- Lack of established curriculum
- Lack of established books & reference materials
- Industry needs not clearly defined

Partners

- Project Lead
  - Michigan Technological University
- Industry
  - 3M
  - AVL
  - Argonne National Laboratory
  - Carter Bothers
  - Detroit Diesel
  - Halibrand
  - Eaton
  - EMP Engineered Machine Products
  - Engineering Society of Detroit
  - GM
  - Horiba
  - Kohler
  - MathWorks
  - Michigan Green Jobs
  - National Instruments
  - Pace
  - Phoenix International
  - Schweitzer Engineering Laboratories
  - Wineman Technologies
  - Woodward

Introduction

Hybrid Electric Drive Vehicle Engineering

Primary objectives:

- Development of an **interdisciplinary curriculum** that can lead to a professional master's degree with a focus on preparing students to work in industry and train those already in industry.

- **Undergraduate and graduate certificates** in Advanced Electric Vehicle Engineering; with the graduate certificate focused on **distance learning for engineers working in industry and displaced engineers**.

- Development of a **mobile laboratory** that includes subsystem learning stations, electrified vehicle software and hardware in the loop systems, a portable vehicle chassis dynamometer, and will utilize HEV's provided by GM. **This laboratory serves as a key enhancement to the distance learning laboratories and to established university outreach activities.**

Curriculum Development and Outreach

Hybrid Electric Drive Vehicle Engineering

Program Goals:

1. Develop courses that lead to an Undergraduate Certificate
2. Develop courses that lead to a Graduate Certificate
3. Develop a Program of Study Leading to a Professional Masters with a certificate in Hybrid Electric Drive Vehicle Engineering (M.Eng.)
4. Design and Fabricate a Mobile Laboratory for Instruction and Outreach

The Interdisciplinary Curriculum is Offered Both On-Campus and Through Distance Learning

Objectives

Three-Year Objectives:

- Develop a master of engineering degree, and graduate and undergraduate certificate programs in Advanced Electric Drive Vehicles
- Target enrollment of **120** graduate students with an expected 50% split of on campus and distance students
- Address work force needs and competencies in emerging electric vehicle technologies for US based industries
- Promote and raise awareness for transportation sustainability through electric propulsion systems with outreach programs

Year 2 Objectives:

- Curriculum Development: Course development and course modifications
- Mobile Laboratory: Completed, learning stations integrated, and ready for Summer 2011
- Collaborate with industry partners to identify work force needs and potential students
- First round of courses delivered and course assessments
- Delivery of “Introduction to Propulsion Systems for Electric Vehicles **Laboratory**” course on campus Spring 2011 via Mobile Laboratory Summer 2011
- Develop Outreach (Public Education) materials and begin outreach activities

VT ARRA Program Relevance

Relevance to VT program goals:

- Create an education program to **retrain the existing workforce and create the next generation of engineers** to:
  - Develop energy efficient and environmentally friendly technologies
  - Develop EDV to reduce dependence on fossil fuels and increase energy security,
- Conduct outreach to K-12 to attract youth to engineering and science education
- Educating the public on the technologies and benefits of vehicle electrification

Relevance to the ARRA goals include the creation of new jobs as well as save existing ones, spur economic activity and invest in long-term economic growth:

- Electric Drive Vehicle related Engineering & Design jobs (TBD)
- GRA's - 18 person years of employment (new jobs)
- Other university positions – 9 person years of employment (existing jobs saved)
  + 3 person years (new job)

This program is directly relevant to and will impact the VT ARRA program:

- Retrain displaced engineers
- Educate incumbent engineers in **Vehicle Electrification Technologies,** which will impact jobs in transportation related industries.
- Educate the next generation of engineers trained in innovative vehicle technologies

Milestones

Month/Year	FY10 Milestones	March Status
Dec-2009	Pilot Course taught to 96 distance students	Complete
Aug - 2010	Modifications Complete for on-campus “Propulsion Systems for Electric Drive Vehicles Laboratory” courses	Complete
Aug - 2010	Development and Modification Complete for 7 courses	Complete

Month/Year	FY11 Milestones	March Status
Dec - 2010	First Round of Teaching Courses Complete	Complete
Dec - 2010	Mobile Lab 2nd Stage Simulators	50%
Dec - 2010	Senior Design Teams (1-4) Completes HEDV projects	Complete
May - 2011	Mobile Laboratory Complete/Commissioned	80%
May - 2011	Development of Outreach Materials for 1st year	50%
May - 2011	Senior Design Team Completes HEDV project	50%
Aug -2011	Course Development Complete	65%

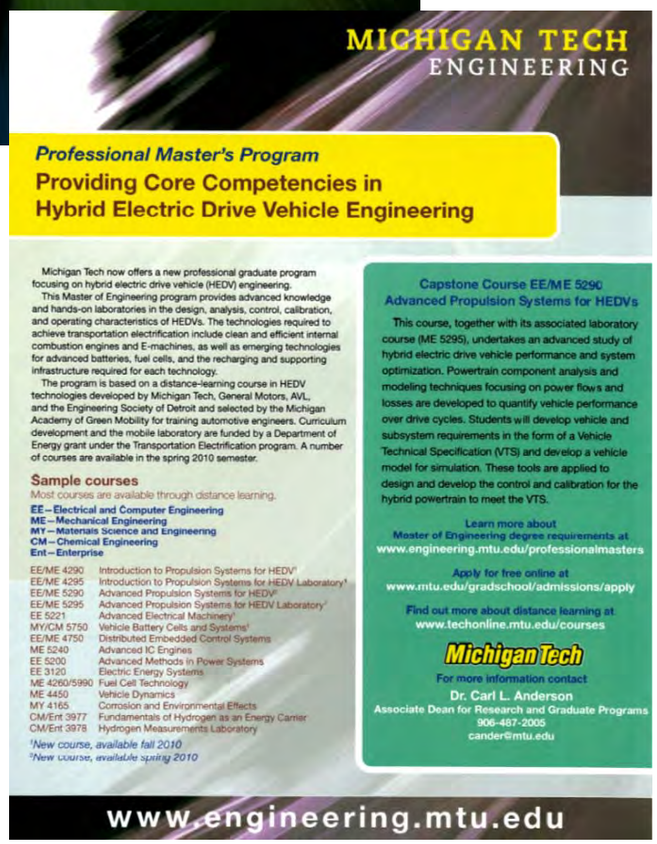
Overall Project Approach

Curriculum Development for Advanced Electric Drive Vehicles

- Create 8 New Courses
- Modify 9 Existing Courses to integrate HEV content
- Leverage Existing Courses
- Deliver courses both on-campus & distance learning

Mobile Laboratory

- Develop a Mobile Laboratory that includes HEV subsystems to full vehicle development process.
- Develop instruction and outreach activities with universal educational platforms for hands-on discovery based learning.



Overall Project Approach

- Development of two key **Interdisciplinary Courses in Propulsion for HEDV**: Create and implement these courses to provide students with background knowledge in propulsion systems
- Development of two associated **Laboratories**: Create and provide learning opportunities through hands-on laboratory experiences
- New Course Development: **New courses** pertaining to electro-mechanical systems, energy conservation, and battery management in electric vehicles
- Enhancing Existing Courses: **Improving current courses** in electrical, chemical, materials, and mechanical engineering to provide cross access to respective departmental students

Objective-Specific Approaches
Curriculum Development

- An **Interdisciplinary team** of faculty and staff in four engineering departments to develop and teach the courses.

- Courses are dual listed among four departments to attract a **diverse** student pool

- **Industry guided curriculum development:**
  - Partnered with Michigan Academy for Green Mobility Alliance (MAGMA) a organization lead by the automotive industry in partnership with the state and training providers
  - MTU persons serve on the directors, advisory, curriculum and funding committees
  - MTU certificate program was the first of the DOE sponsor programs that received full MAGMA approval for our certificate as assessed by industry experts

www.sae.org/training/magma/

  - MAMGA has and is identify students, both incumbent and displaced engineers to participate in the program. Funding for tuition covered through State/Federal Grants
  - Preparing short courses with hands-on laboratories to be delivered on-sight via the mobile laboratory (HEV introduction, E-Machines, Batteries, Embedded software, …)

Objective-Specific Approaches
Curriculum Development

Schedule of new course development, modifications and delivery

New Courses				10	10	10	11	11	11	12	12	12
Name	**Dept.**	**Number**	**Credits**	**Spng**	**Sum**	**Fall**	**Spng.**	**Sum.**	**Fall**	**Sp**	**Su**	**Fall**
Intro. To Prop. Systems for EDV	EE/ME	4295	3			**T(DL)**		T(DL)	T(DL)			T(DL)
Adv. Prop. Systems for EDV	EE/ME	5295	3	T(DL)			T(DL)			T(DL)		
Intro. To Prop. Systems for EDV Laboratory	EE/ME	4296	1	M	M	**T**		T(DL)	T (2CR)		T(DL)	T (2CR)
Adv. Prop. Systems for EDV Laboratory	EE/ME	5296	1	T	M	**M**	T	T(DL)		T	T(DL)	
Advanced Electric Machines	EE	5221	3		D	**T(DL)**			T(DL)			
Vehicle Battery Cells and Systems	MY/CM	5760	3	D	D	**T(DL)**			T(DL)			T(DL)
Vehicle Dynamics	ME	4450/5450	3						D	T(DL)		
Distributed Embedded Control Systems	EE/ME	4750/5750	3	T	M		T			T(DL)		
Distance Learning Enrollment				**64**		**29**	**6**					
Traditional Campus Enrollment				**22**		**92**	**51**					

Modified Courses				10	10	10	11	11	11	12	12	12
Name	**Dept.**	**Number**	**Credits**	**Spng**	**Sum**	**Fall**	**Spng.**	**Sum.**	**Fall**	**Sp**	**Su**	**Fall**
Intro. to Motor Drives	EE	3221	4	T	M		T	M		T		
Power Electronics	EE	4227	3			**T(DL)**		M	T(DL)			T(DL)
Power Electronics Lab	EE	4228	1			**M/T**			T			T
Power System Operations	EE	5230	3					M	T(DL)			T(DL)
Power System Protection	EE	4223/5223	3			**M**	T(DL)					
Power System Protection Lab	EE	4224/5224	1			**M**	T					
Distribution Engineering	EE	4225/5250	3	T(DL)					M	T(DL)		
Intro to IC Engines	ME	4220	3		M		T(DL)			T(DL)		T(DL)
Internal Combustion Engines II	ME	5250	3	T				M	T(DL)			
Distance Learning Enrollment				**9**		**15**	**38**					
Traditional Campus Enrollment				**105**		**40**	**196**					

KEY				
Status:	*D = Develop*	*T = Teach*	*M = Modify*	*DL = Distance Learn.*
Depart:	*EE = Elect. Eng.*	*ME = Mech. Eng*	*CM = Chem Eng.*	*MY = Mat.Sci & Eng.*
Level:	*3XXX = UG*	*4XXX = UG Tech Elect*	*5XXX = Grad.*	ENT = Enterprise

Objective-Specific Approaches
Curriculum Development

Schedule of course delivery for existing courses

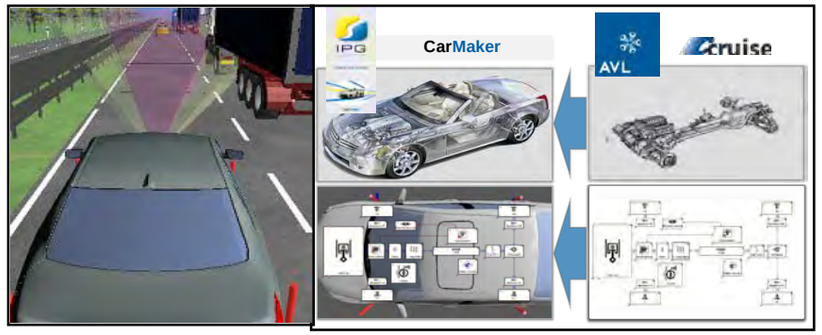
Existing Courses				10	10	10	11	11	11	12	12	12
Name	**Dept.**	**Number**	**Credits**	**Spng**	**Sum**	**Fall**	**Spng.**	**Sum.**	**Fall**	**Sp**	**Su**	**Fall**
Electric Energy Systems (EE/Non EE)	EE	3120	3	T(DL)		**T**	T(DL)	T(DL)	T(DL)	T(DL)		T(DL)
Power System Analysis 1	EE	4221	3			**T(DL)**			T(DL)			T(DL)
Power System Analysis 2	EE	4222	3	T(DL)			T(DL)			T(DL)		
Advanced Methods in Power Systems	EE	5200	3			**T(DL)**		T(DL)	T(DL)			T(DL)
Classical Control Systems	EE	4261	3			**T**			T			T
Thermodynamics/Fluid Mechanics (Non ME)	ENG	3200	4	T		**T**	T		T	T		T
Principles of Energy Conversion	ME	4200	3	T		**T(DL)**				T		
Dynamic Systems and Controls	ME	4700	3(DL)/ 4	T(DL)		**T**	T	T	T	T	T	T
Advanced Thermodynamics	ME	5200	3			**T(DL)**			T(DL)			T(DL)
Experimental Design in Engineering	ME	5670	3			**T**		T	T		T	T
Optimization	ME	5680	3				T(DL)			T		T
Dynamic Systems and Signal Analysis	ME	5700	4			**T(DL)**			T			T(DL)
Linear Systems	ME	5715	3	T			T(DL)		T			
Fuel Cell Technologies	ME	4260/5220	3			**T(DL)**			T(DL)			
Senior Capstone Design (4 Projects, Avail DL)	EE/ME	4901/4911	2 & 2	1		**1, 2**	2, 3		3, 4	4		3, 4
Fuel Cell Fundamentals	CM/ENT	3974	1			**T**			T			T
Hydrogen Measurements Laboratory	CM/ENT	3978	1	T			T			T		
Enterprise Courses	ENT	29XX-49XX	1	T		**T**	T	T	T	T	T	T
Distance Learning Enrollment				**46**		**73**	**59**					
Traditional Campus Enrollment				**348**		**520**	**215**					

Objective-Specific Approaches
Mobile Laboratory

Summer 2011

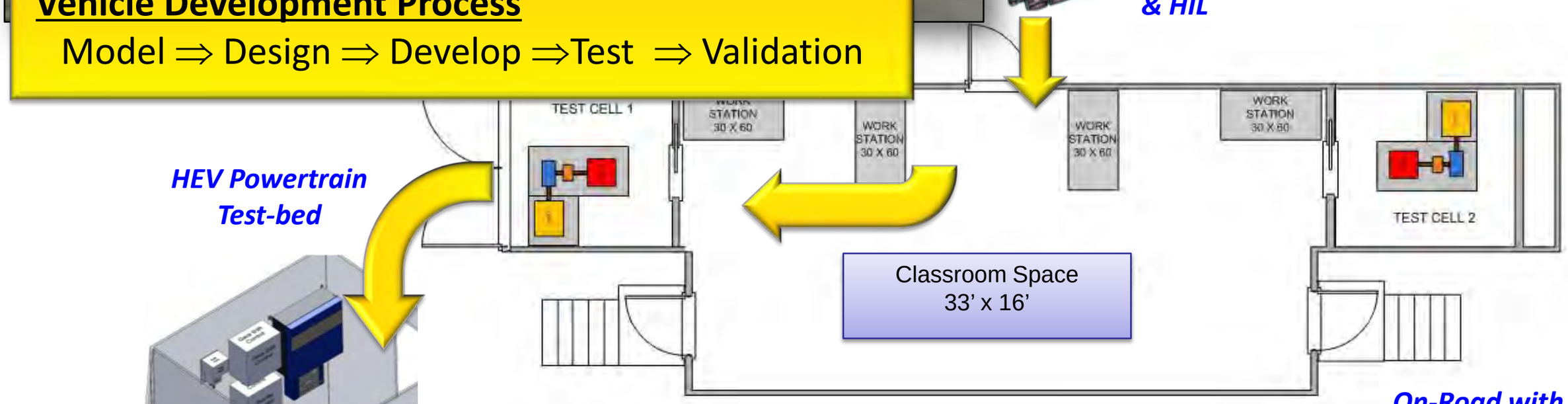
Vehicle Development Process

Model ⇒ Design ⇒ Develop ⇒Test ⇒ Validation

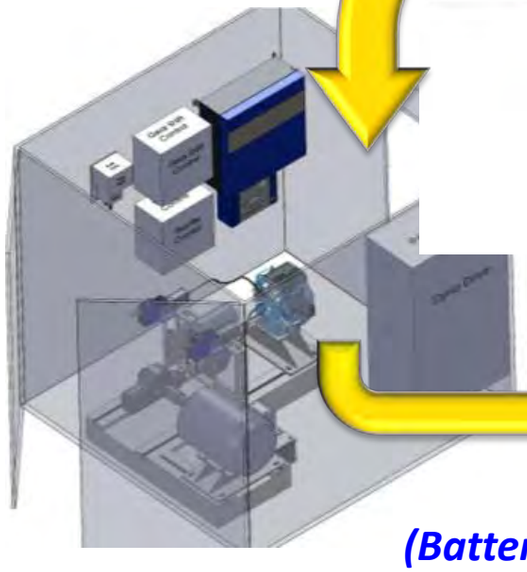


Powertrain & Vehicle Simulation

PCM SW & HIL



HEV Powertrain Test-bed



Powertrain HIL (Batteries, E-Machine, Engine, etc.)

Configurable HEV's

On-Road with Production HEV's

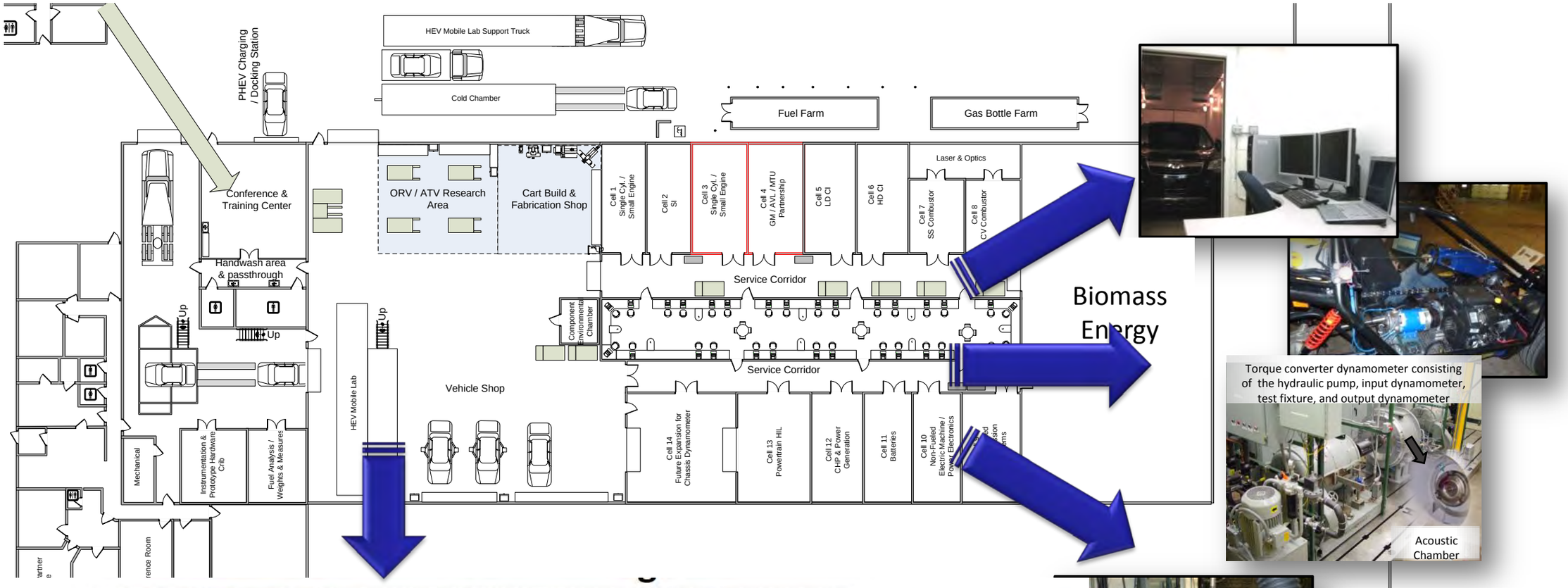
Objective-Specific Approaches
Mobile Laboratory

Mobile Laboratory Development:

- Four Universal Learning Stations for hands-on laboratories in subsystems
- Two HEV Powertrain laboratories: ICE+E-Machine+Battery+Drives with embedded software development
- Configurable hybrid vehicles with full model-based software development and calibration and rapid hardware modifications – Full HEV Development cycle
- Production HEVs couple with Mobile Chassis Dynamometer
- HEV Simulation Gaming for outreach and education
- HEV Themed outreach displays and demos

Advanced Propulsion Research and Education Center

Michigan Technological University 2011 Merit Review



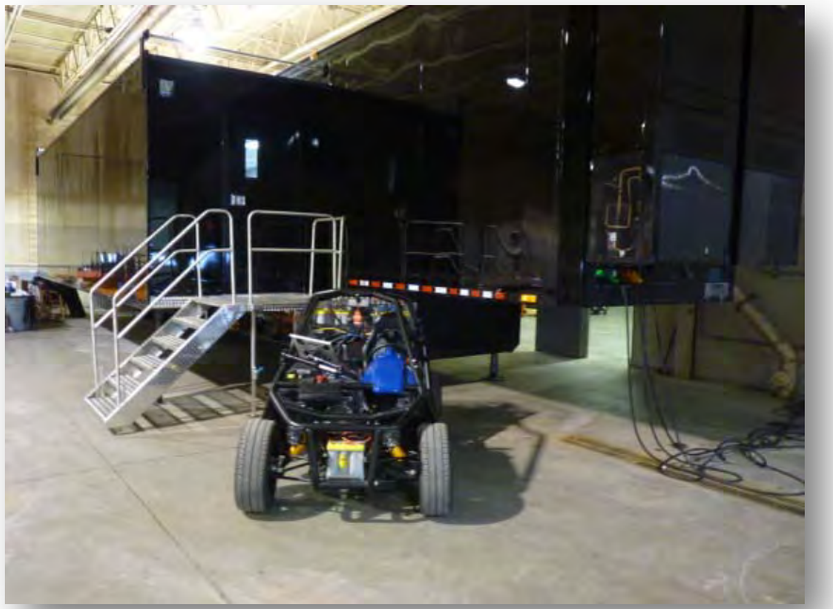
Mobile Lab: HEVs to Grid

55,000 sq ft Center

Objective-Specific Approaches
Mobile Laboratory

Mobile Laboratory Development:

- Senior Design Teams: Developed Configurable Hybrid Electric Learning Vehicles (CHELV) as learning stations within the mobile laboratory. This vehicle is an integral part of EDV Laboratory experiments at both undergraduate and graduate levels.



Mobile Lab set up in the APSRC with the CHELV

Completed Configurable Hybrid Electric Learning Vehicle which was designed and built by Senior Design students

- Enterprise Teams: Developing an interactive software and game package to serve as education tools for electric vehicle technology and operation.

Objective-Specific Approaches
Outreach

Mobile Laboratory is our key to outreach and educational activities:

- Simulation, Embedded Software, Subsystem and System laboratories for on-campus and distance learning students

Development of outreach and educational materials

- Implement an outreach program with audio and visual material developed by Senior Design and Enterprise Engineering students
- Develop an interactive hybrid electric drive vehicle software and game package to serve as educational tool for electric vehicle technology and operation

Outreach Activities

- Secondary School Visits
- Summer Youth Programs
- NSF Research Education for Undergraduates
- NSF Research Experiences for Teachers
- Short Courses for training displaced and incumbent engineers

Outreach at the SAE Clean Snowmobile Competition at the Mall

Objective-Specific Approaches
Course Delivery

A interdisciplinary team of thirteen experienced educators and researchers with different but complimentary technical expertise to:

- Establish innovative, effective and engaging teaching and delivery methods for current and developing courses

- Work closely with OEMs and suppliers to ensure the program meets work force needs

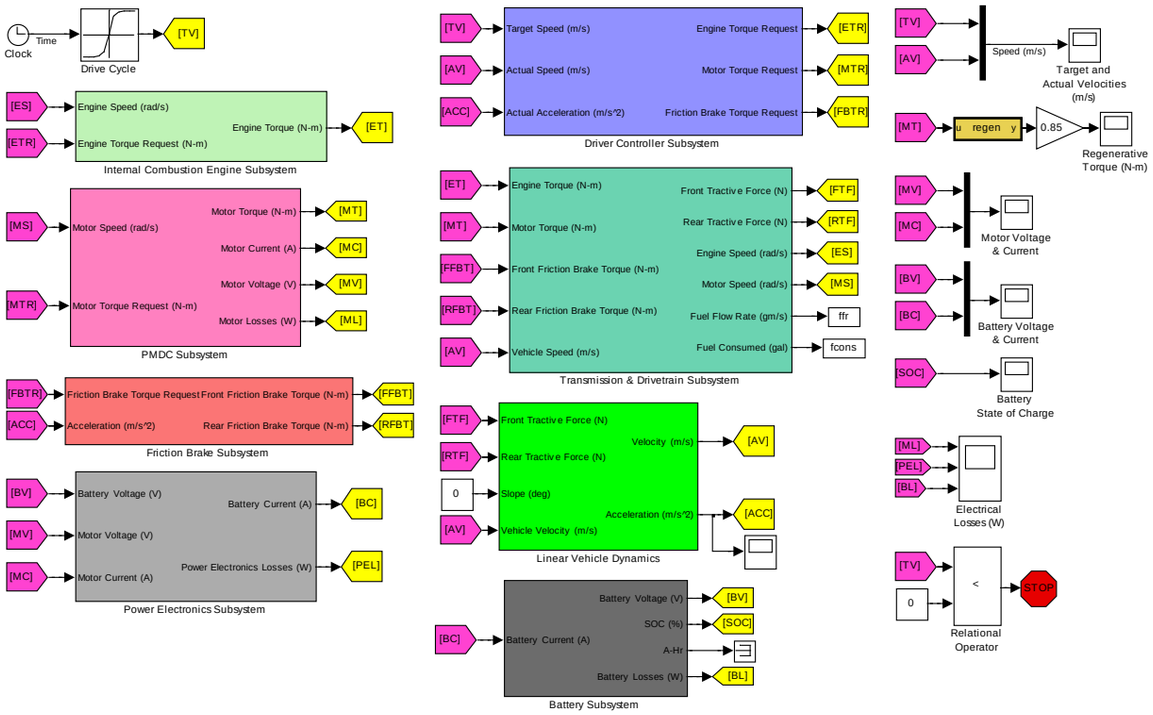
- Distance Learning courses delivered with the same material and quality of instruction as traditional classroom based courses

- Deliver hands-on instruction with simulators and laboratories at the subsystem and vehicle level

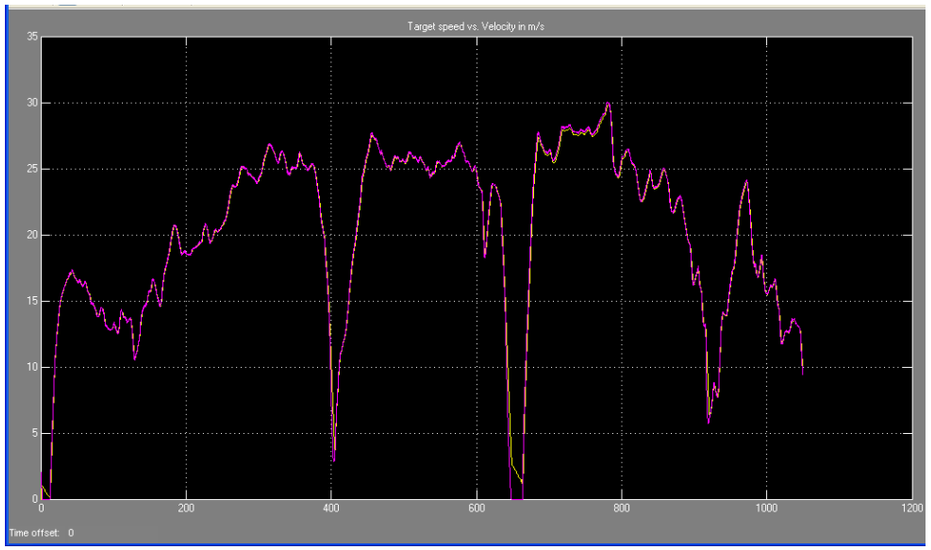
- Target to concentrated locations (e.g, South East Michigan) by partnering with Engineering Society of Detroit

ME/EM4295-4296 Intro to Propulsion for HEV

- Introduction to HEV/EV history, hybrid architecture for series and parallel systems
- Model based design in Simulink, IC engines, electric machines, electric drive systems, regeneration braking, power electronics, battery models as RC circuits,
- Introduction of drive cycles and driver controls, effects of road conditions and energy efficiency over a specified drive cycle.
- The final HVM included torque blending between the IC Engine and E-Motor, Engine-stop, transmission gear selection based on ICE torque request and fuel usage in each available gear, regeneration during braking and over-all fuel economy for a given drive cycle. The IC Engine model contained the torque, fuel flow rate and engine speed from a current production engine.



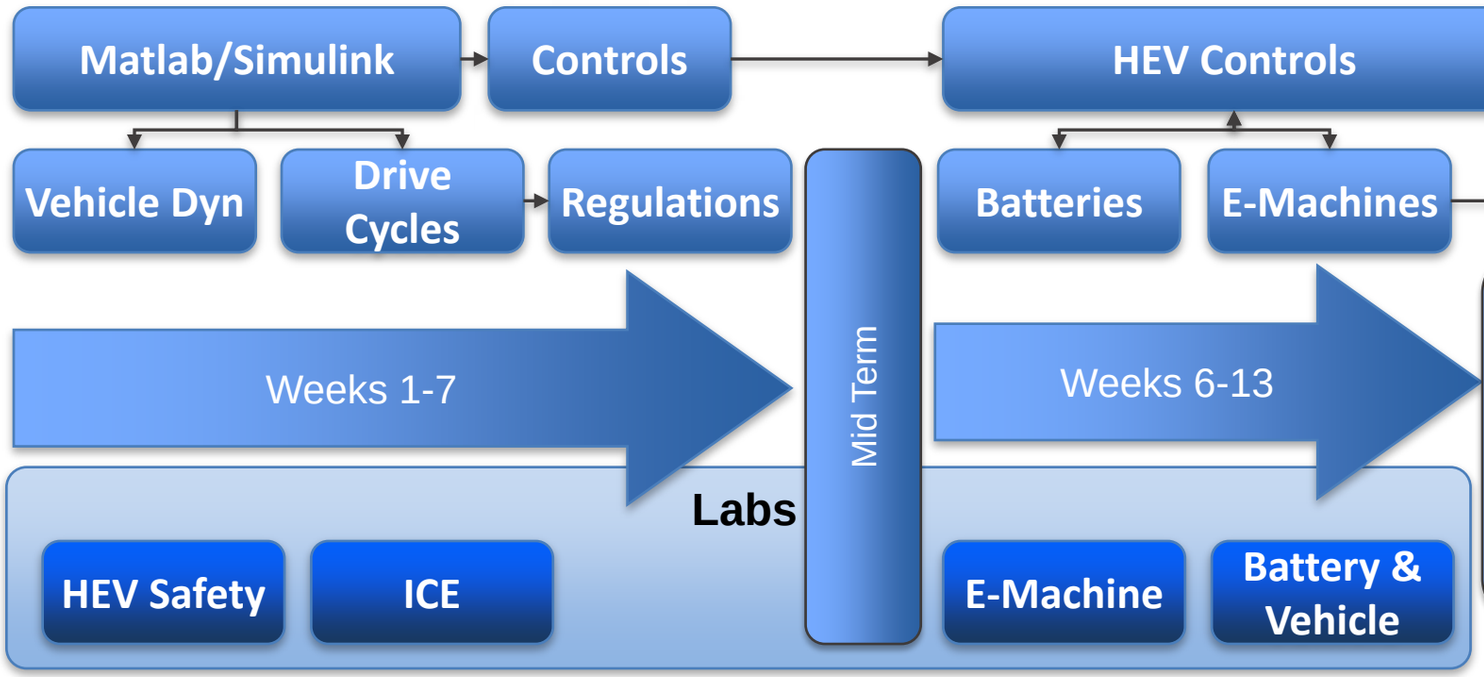
The HVM modeled in Simulink, this particular student included “extras” such as a Power Electronics module, a Friction Brake module with a complete front/rear brake bias algorithm for regeneration and determination of vehicle jerk for drive quality comparison.



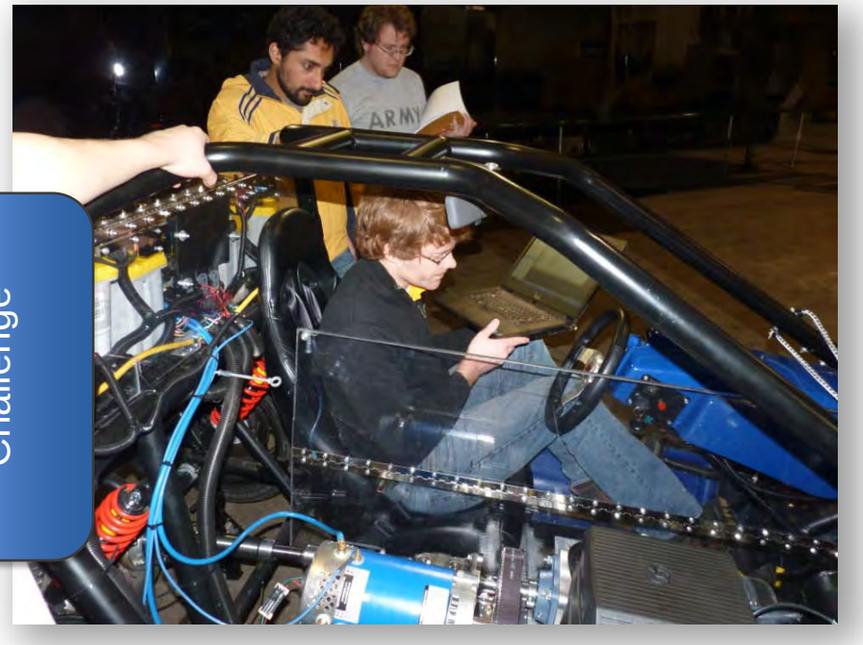
The target velocity (drive cycle) and the vehicle velocity for a HEV with torque blending, a finite ratio transmission and a shift criteria to minimize fuel usage. The vehicle modeled is a large SUV.

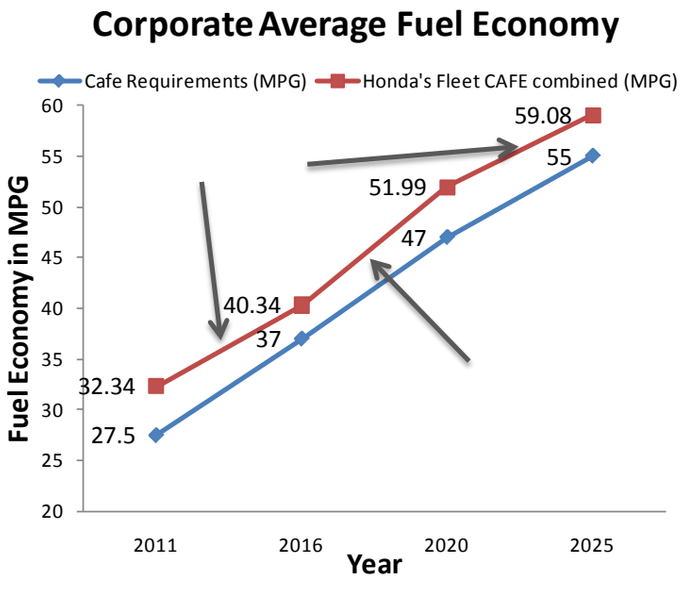
ME/EE 5295/5296 Advance Propulsion for HEV

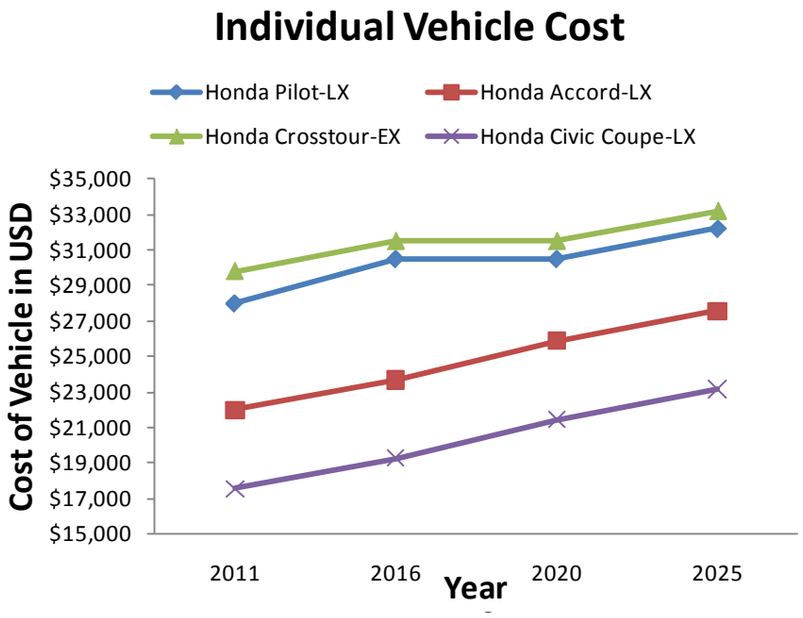
Model Based: Analysis ➡ Design ➡ Control

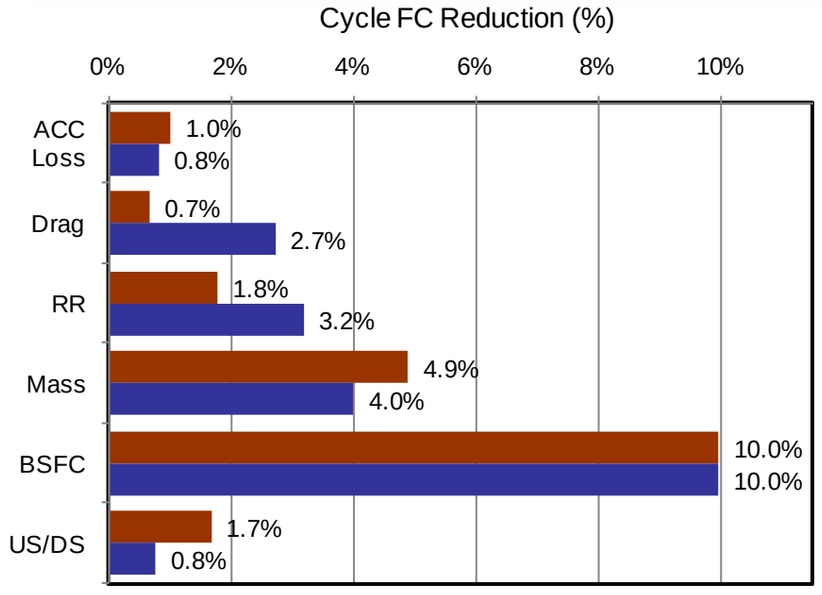


Lab: Students testing software on configurable HEV









Objective-Specific Approaches
Course Delivery

Course Delivery Fall 2010

New Courses

- EE/ME 4295 (9 DL / 42 Campus) Intro Propulsion Systems for HEDV
- EE/ME 4296 (13 Campus) Intro Propulsion Systems for EDV Laboratory
- EE 5221 (15 DL / 30 Campus) Advanced Electric Machines
- MY/CM 5760 (5 DL / 7 Campus) Vehicle Batteries, Cells, and Systems

Modified Courses

- EE 4227 (15 DL / 26 Campus) Power Electronics
- EE 4228 (14 Campus) Power Electronics Laboratory

Existing Courses

- Thirteen existing courses; of those six were taught via **distance learning** in addition to on campus. (73 DL / 520 Campus)

Total Enrollment Fall 2010: 117 DL / 652 Campus

Objective-Specific Approaches
Course Delivery

Course Delivery Spring 2011

New Courses

- EE/ME 5295 (6 DL / 20 Campus) Advanced Propulsion Systems for HEDV
- EE/ME 5296 (4 Campus) Adv. Propulsion Systems for EDV Laboratory
- EE/ME 4750/5750 (27 Campus) Distributed Embedded Control Systems

Modified Courses

- EE 3221 (56 Campus) Intro to Motor Drives
- EE 4223/5223 (29 DL / 26 Campus) Power System Protection
- EE 4224/5224 (16 Campus) Power System Protection Lab
- EE 4224/5250 (11 Campus) Distribution Engineering
- ME 4220 (9 DL / 87 Campus) Intro to IC Engines

Existing Courses

- Seven existing courses; of those four were taught via **distance learning** in addition to on campus. (59 DL / 215 Campus)

Total Enrollment Spring 2011: 103 DL / 462 Campus

Technical Accomplishments & Progress - FY11

Task 1

- New course content / material developed
- Industry guided curriculum based on workforce needs
- Enrollment of students into Certificate Programs, student recruitment

Task 2

- Mobile Lab trailer completed and delivery of class 8 tractor
- Mobile Lab learning stations configured and assembly in progress
- Mobile lab scheduled to launch May 2011

3-Year Project Technical Tasks
1. Curriculum Development
2. Mobile Laboratory Development
3. Outreach Development & Execution
4. Course Delivery & Evaluation

Task 3

- Four Senior Design teams developed a Configurable Hybrid Electric Learning Module
- Enterprise teams developing first phase of Learning Station Software

Task 4

- First round of course delivery completed
- Course and instructor evaluations completed

Technical Accomplishments & Progress - Task 1 Curriculum Development

- Course content and materials developed for 7 of the 8 new courses

- Course content and materials developed for 5 of the 9 modified courses
  - Improving courses to integrate HEV material and provide interdisciplinary access to the respective departmental students
  - Collaboration with MAGMA and industry to identify current and future workforce needs,
  - Working with industry and state to identify distance learning students.

- Undergraduate and Graduate Certificates in place, actively recruiting new students both on campus and distance learning
  - Graduate certificate focused on distance learning for engineers working in industry and displaced engineers.

Technical Accomplishments & Progress - Task 2 Mobile Laboratory Development

- Mobile Lab Trailer built by Kentucky Trailer Technologies (a Michigan company) and delivered to Michigan Tech Dec 2010.
- Detroit Diesel provided, on a 10 year no charge consignment, a class 8 Freightliner Tractor for towing mobile lab
- Tractor bed extended by G-Tech of Dearborn, MI to accommodate Kohler 80 kW generator which has also been installed
- Mobile Lab Team has finalized configuration and started assembly of learning stations. Mobile lab launch Summer 2011.
- Four Senior Design Teams completed design and build of the prototype **Configurable Hybrid Electric Learning Module (CHELM)** for the Mobile Laboratory. The vehicle operates as an HEV with torque blending between the motor and engine, regenerative braking, and engine auto-stops.
- Two Hybrid Enterprise Teams engaged to develop **Interactive Electric Drive Vehicles Software** for Education and Outreach activities. Teams have created a project management plan, acquired an open-source vehicle gaming engine, and have begin incorporating various HEV solid and physics based vehicle models into the game.

Technical Accomplishments & Progress - Task 3 Outreach (Public Education)

The Mobile Laboratory is our key to established outreach activities, maximizing the educational experience with hands-on learning experiences for all levels of students (K-12, Undergrad & Graduate).

- Enhancement of NSF **Research Experiences for Undergraduate Students** (EEC-1062886):3 year program for undergraduate research on Advanced Propulsion and Fuel Technology for Sustainable Transportation - **Starts summer 2011**

- Enhancement of NSF **Research Experiences for Teachers** (EEC-10009617): 3 year program providing high school teachers research educational activities in Sustainable Transportation Technologies - **Starts summer 2011**

- Undergraduate student teams involvement in Outreach Development:
  - Four Senior Design Teams completed building **Configurable Hybrid Electric Learning Module** for the Mobile Laboratory.
  - Hybrid Enterprise Teams developing **Interactive Electric Drive Vehicles Software** for Education and Outreach activities. The program is specifically targeted at 8^{th} – 12^{th} grade students, general public, community college, and non-degree seeking undergraduates to raise awareness for hybrid vehicles.

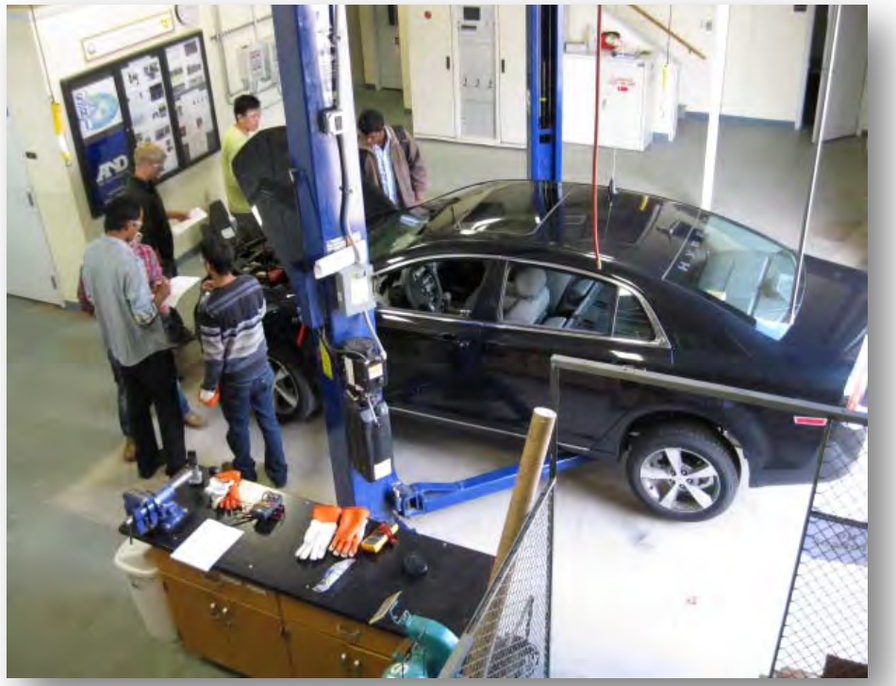
Technical Accomplishments & Progress - Task 4 Course Delivery and Evaluation

- Course delivery to date:
  - 7 Newly developed courses
  - 8 Modified courses
  - 19 existing courses that are program electives delivered

- Enrollment to date:
  - 339 distance learning
  - 1589 traditional on campus

- Distance Learning conducted with the same content and quality of materials as on campus courses.

- Courses taught by interdisciplinary team of faculty
  - *Mechanical, Electrical, Materials Science & Engineering, and Chemical Engineering Departments.*



Technical Accomplishments & Progress - Task 4 Course Delivery and Evaluation

- Traditional MTU survey of teacher effectiveness for each course taught each semester for both on campus and distance learning students

- Additional surveys were given –
  - Permission obtained from Michigan Tech's Institutional Review Board for program survey under protocol M0672
  - Survey distributed Fall 2010
  - 3 classifications of questions
    - Introduction and general questions (4 questions)
      - *Students had prior knowledge of hybrid and electric vehicle systems, which improved over the duration of the course*
    - Course-based questions (6 questions)
      - *Students were highly supportive of classroom content, teaching methods, and laboratory experiences*
    - Program-based questions (4 questions)
      - *Significant numbers liked distance learning component*
      - *Students expressed strong interest in graduate certificate*

Team Collaborations

- Project Lead
  - Michigan Technological University –*Education Provider, Program Developer*
- Industry
  - 3M – g*raphic package for mobile laboratory*
  - AVL - *HEDV instrumentation, HIL components, controls expertise*
  - Argonne National Laboratory - *graduate student internships*
  - Carter Bothers – *chassis for CHELM*
  - Detroit Diesel – *class 8 2006 Freightliner tractor*
  - Halibrand - *CHELM components, engineering support*
  - Eaton - *power management software and controls, battery technology expertise*
  - EMP Engineered Machine Products – *engineering support and coolant pumps*
  - Engineering Society of Detroit - *marketing, student recruitment, classrooms*
  - GM - *vehicles/vehicle components, student recruitment*
  - Horiba - *automotive test systems and expertise*
  - Kohler - *engines, engineering support*
  - MathWorks - s*oftware and software expertise*
  - Michigan Green Jobs - *marketing, student recruitment*
  - National Instruments - *hardware for the data acquisition and control of the test cells*
  - Pace - *computers and monitors for mobile lab*
  - Phoenix International - *electric motor, motor drives, engineering support*
  - Schweitzer Engineering Laboratories - *electric power systems and expertise*
  - Wineman Technologies - *software for the data acquisition and control*
  - Woodward - *energy controllers, controller software and controls expertise*

Future Work

Remainder of FY11

- Finalize development of remaining 1 new course (August, 2011)
- Finalize modifications to 5 courses (August, 2011)
- Launch Mobile Lab (May, 2011)
- Delivery of MEEM 4295 Intro & 5296 Adv. Propulsion for EDV Laboratory via mobile lab (Summer, 2011)
- Begin outreach activities with Mobile Lab (June, 2011)
- Enterprise teams integrate first stage simulators into mobile laboratory (May, 2011)
- Enterprise teams continue development of 2nd Stage Simulators (ongoing)
- Continue marketing HEV certificates and recruiting students at both undergraduate /graduate level (ongoing)
- Course Assessments and continuous improvements (ongoing)

Goals for FY12

- Enterprise teams integrate final stage simulators to Mobile laboratory and provide web versions (May, 2012)
- Final outreach during funding period complete (August , 2012)
- All course modifications including DL portions and courses and repeating outreach, senior design, and enterprise activities have been taught at least once. (August, 2012)
- Program running in a sustainable mode. (August , 2012)

Summary

- Full Curriculum offering and certificates approved
- Enrollments to date: 1589 on campus, 339 distance learning
- Mobile lab for course delivery and outreach rolls out this summer