UNIVERSITY OF MICHIGAN-DEARBORN

GATE Center for Electric Drive Transportation at the University of Michigan - Dearborn

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Project ID #
TI020

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Overview

Timeline

- Project start date: 9/1/2011
- Project end date: 9/30/2016
- Percent complete: 40%

Budget

- Total project funding: $1,249,977
  - DOE share: $999,981
  - Contractor share: $249,996
- Funding received in FY13: $199,423
- Funding for FY14: $209,948

Barriers

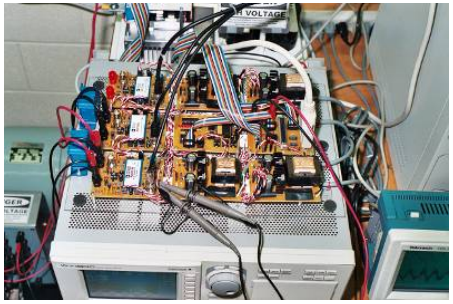
- Barriers addressed
  - Lack of trained engineers and scientists
  - Lack of advanced technology curricula
  - Automotive industry in high demand of knowledgeable and experienced workforce

Partners

- Chrysler, Ford, ANSYS, EDTA, Mathworks, DENSO, Hp Pelzer, dSPACE, PSIM, GaN Systems
- Project Lead: Univ. of Mich. Dearborn

Relevance/Objectives

- Establish concentrations in electric drive transportation in MS and Ph.D programs in Automotive Systems Engineering (ASE) at UM-Dearborn
- Develop and offer seven new courses
- Develop and offer a series of short courses
- Offer five graduate fellowships per year
- Enhance research in seven thrust areas
- Establish an Industry Consortium on EDV to support the above initiative



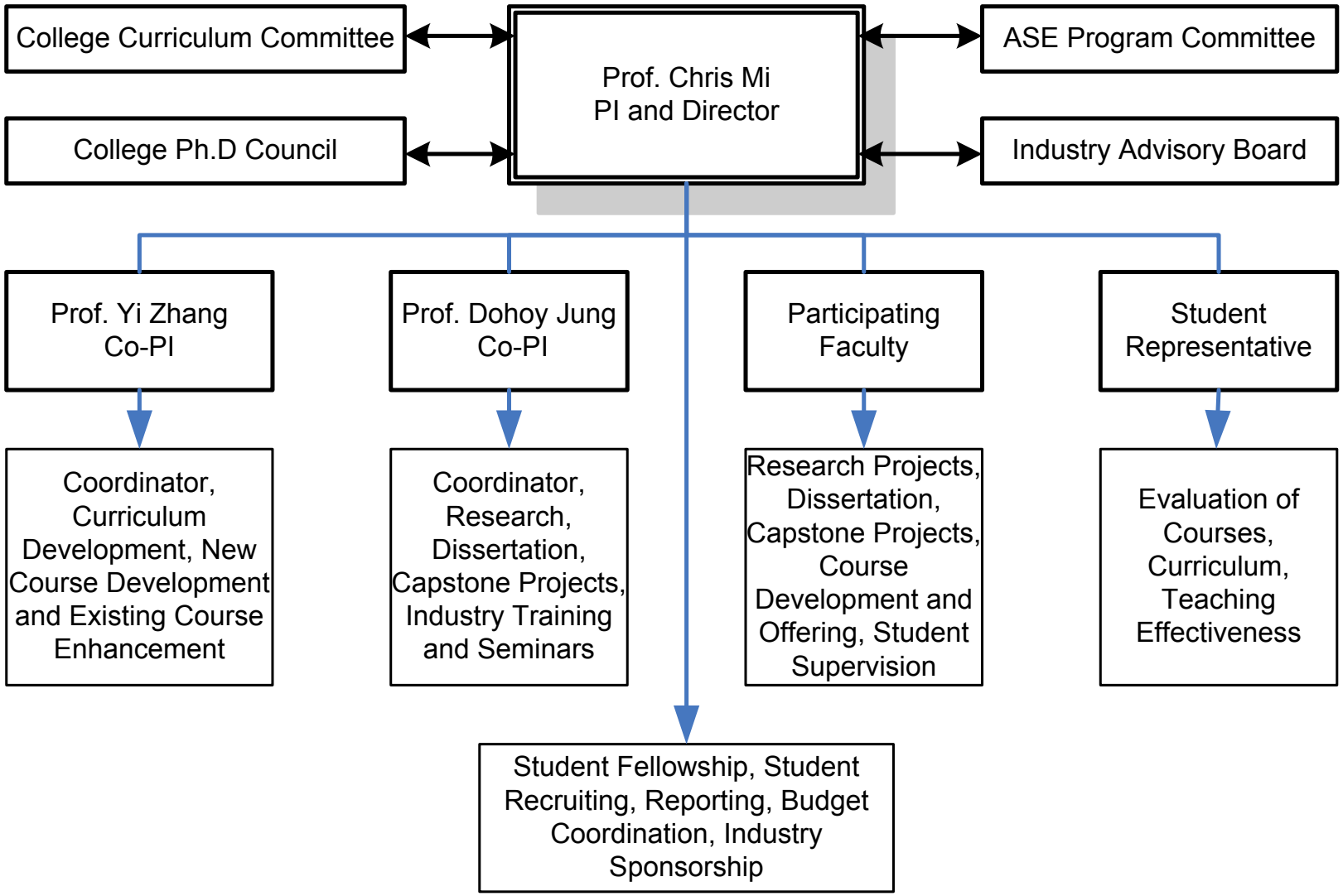
Milestones – Year 2

Second Academic Year (09/01/2012-08/31/2013)	
Milestones	Results
Offer three additional new courses	Offered 3 new courses
Recruit four to six graduate students	Total 8 students
Implement laboratory improvements	Improvement of two labs
Offer three revised existing courses	Offered 3 revised courses
Offer industry training programs	Offered 3 tutorials/short courses
Publish conference and journal papers	Published five papers
Approve dissertation proposals	One dissertation was passed
Organize Center Annual Conference	IAB meeting and workshops

Milestones – Year 3

Third Academic Year (09/01/2013-08/31/2014)	
Milestones	Results
Offer the last two additional new courses	Offered 2 new courses
Refine and offer the new/revised course	Offered 5 courses
Recruit four to six graduate students	Total 8 students
Offer industry training programs	Offered 3 tutorial/short course
Publish conference and journal papers	Published five papers
Annual IAB Meetings	Two meetings per year
Organize Center Annual Conference	Offered WPT workshop

Approach - Center Management



Ph.D Concentration in Electric Drive Transportation

- Required Courses
  - ASE502: Modeling of Automotive Systems
  - ENGR799: Doctoral Dissertation
  - ENGR798: Seminar
- Elective Courses: select 4 concentration courses listed below and 3 additional elective courses
  - ASE502 Energy Storage Systems
  - ECE5462 Hybrid Electric Vehicles
  - ASE566 Vehicle Thermal Management
  - ASE5791 Vehicle Power Management
  - ECE646 Adv. Electric Drive Transportation
  - ASE501 Energy Conversion Systems
  - ASE557 Powertrain NVH Analysis
  - ISE567 Reliability Analysis
  - ECE517 Advanced Electric Drives
  - ASE548 Automotive Powertrains II
  - ECE615 Adv. Power Electronics

MSE Concentration in Electric Drive Transportation

- Required Courses
  - ASE 698 Capstone Project or ASE 699 Master's Thesis
  - ASE500 Automotive Systems Engineering
  - ASE587 Automotive Manufacturing Proc
- Elective Courses: select 4 concentration courses listed below and 2 additional elective courses
  - ASE 502 Energy Storage Systems
  - ECE 5462 Hybrid Electric Vehicles
  - ASE 566 Vehicle Thermal Management
  - ASE 5791 Vehicle Power Management
  - ECE 615 Adv. Power Electronics
  - ECE 646 Adv. Electric Drive Transportation
  - ASE 557 Powertrain NVH Analysis
  - ISE 567 Reliability Analysis
  - ECE 517 Advanced Electric Drives
  - ASE 548 Automotive Powertrains II
  - ASE 515 Vehicle Electronics II
  - ECE 532 Automotive Sensors & Actuators

Accomplishments: Development of New Courses

Third Academic Year (09/01/2013-08/31/2014)		
Course #	Course Name	Results
ESE501:	Energy Conversion Systems	Offered multiple times
ESE502:	Energy Storage Systems	Offered multiple times
ECE615:	Advanced Power Electronics	Offered
ECE646:	Advanced Electric Transportation	Offered multiple times
ECE5791:	Vehicle Power Management	Planned
ECE517	Advanced Elec. Drives	Offered multiple times
ASE 557:	Powertrain NVH - Offered	Offered
ASE 566:	Vehicle Thermal Management	Offered multiple times

Accomplishments: Enhancement of Four Existing Courses

Third Academic Year (09/01/2013-08/31/2014)		
Course #	Course Name	Results
ASE548	: Automotive Powertrains II	Offered multiple times
ECE5462	Hybrid Electric Vehicles	Offered multiple times
ECE517	Advanced Electric Drives	Offered multiple times
ISE567	Reliability Analysis	Offered multiple times
Short courses, trainings, and seminars		Offered multiple topics and multiple times

Accomplishments: Industry Partners

- Chrysler Group, LLC.
- Ford Motor Company
- DENSO International
- ANSYS, Inc.
- The Mathworks
- dSPACE
- Hp Pelzer
- EDTA
- PSIM
- GaN Systems

- Member benefits
  - Non Exclusive, royalty free IP for internal use
  - Access to recent, not-yet-published GATE Center research
  - Access to GATE Center prepublications and presentations
  - Early access to intellectual property by GATE Center
  - Access to the GATE Center facility
  - Serve on the Industry Advisory Board
  - Attend GATE Center annual conference , free or discounted attendance of seminar, short course, training
  - Networking opportunities
  - Jointly proposals to federal programs,
  - Priority access to students for internships
  - Guest lectures & seminars for GATE Center

Accomplishments: Workshop on Wireless Power for EV Applications

- March 13, 2014 at GATE Center of Dearborn
- 100 attendees
- 8 plenary speakers
- A 6-people panel moderated by Matt Roush of CBS News
- Co-Sponsored by
  - GATE Center for Electric Transportation
  - IEEE Transportation Electrification Initiative and IEEE Future Directions Committee
  - IEEE Distinguished Lecture Program
  - ANSYS Corporation

Accomplishments: GATE Fellows

- One MS student graduated
- Eight full time Ph.D
- Three part time Ph.D students
- Three passed qualify
- One dissertation proposal exam passed
- Fall 2014, three applications

Accomplishments: Five-year Education Plan for Course Offerings

Course #	Course name	Faculty	Year 1	Year 2	Year 3	Year 4	Year 5
ESE501	Energy Conversion	Ratts		X	X	X	X
ESE502	Energy Storage	Mi	X	X	X	X	X
AE557	Powertrain NVH	Cherng		X		X	
AE566	Vehicle Therm. Man.	Jung, Li		X	X	X	X
ECE5791	Power Management	Murphey			X		X
ECE646	Adv. Power Elec.	Mi		X	X		X
ECE517	Electric Drives	Kim		X		X	
ECE5462	Hybrid Vehicles	Kim	X	X	X	X	X
AE548	Powertrain II	Zhang	X	X	X	X	X
ISE567	Reliability	Xi		X	X		X
Total courses offered per year			3	9	8	7	8

Accomplishments: On Out Reach and Professional Seminars

- **Prof. Chris Mi is Invited to Give Lectures at APEC, March 17, 2014**
  - **Topic**: Wireless Power Transfer
- **Prof. Chris Mi is invited to give lectures at IEEE ITEC Asia Pacific, August 31, 2014**
  - **Topic**: Wireless Power Transfer
- **Prof. John Cherng is Invited to Give a Seminar at Ford Motor Company, April 19, 2013**
  - **Topic**: NVH Characteristics of Electrical Vehicles
- **Professional online course for General Motors and Siemens, as well as APEC and ECCE**
  - **Topic**: Battery Management Systems
- **Keynote speech and industry session at ECCE, VPPC, IEVC**
  - **Topic**: Wireless power transfer
- **Special issue of IEEE TPEL and JESTPE on Wireless Power**
- **Workshop on wireless power by IEEE**

Short Course - Optimal Design of Electric Machines - 4/18-19, 2013

- Fundamental Concepts for Electric Machines and Drives
- Electric Machines and Drives for State-of-the-Art and Future Generations HEV and EV
- FEA Models for Large Scale Optimization Studies
- Design Optimization – Robust Design and Differential Evolution
- Magnetic Materials and Losses
- Advanced Simulation Concepts: PM Modeling, System Modeling, Steady State Parameter Extraction
- Faults and Condition Monitoring
- Non-rare Earth Alternatives and Other Non-PM Machines
- Hands on training in the computer lab

Nominal Cost $199 for general attendee and free for partners

IAB Curriculum Committee

- Curriculum committee formed in August, 2012
- Meet twice a year
- Committee Members
  - Industry Member
    - Wensi Jin (Chair, Mathworks)
    - Ming Kuang (Ford)
    - Zed Tang (Ansys)
    - Mark Zachos (DG Technologies)
    - Mahendra Muli (dSpace)
  - Faculty Member
    - Chris Mi (Director, ECE)
    - Dohoy Jung (ME)
    - Yi Zhang (ME)

- Purpose:
  - ✓ Make the graduates' skills relevant for the industry
  - ✓ For IAB members to interact around the curriculum between the bi-annual GATE meetings
  - ✓ Make sure the curriculum covers relevant subsystems outside powertrain.
  - ✓ Make sure the curriculum reflects how software engineering and systems engineering are done in the industry
  - ✓ Help shape the curriculum as a way to influence students' directions
  - ✓ Find ways to involve industry speakers in the GATE teaching activities
  - ✓ Help identify short and long term needs and prioritize courses based on them

Curriculum Committee Activities

- Meeting twice in 2013 and in March 13, 2014
- Committee Feedback
  - In general, the committee feels the curriculum design looks good.
  - Since the GATE student body is rather small, new courses have to cover GATE students' needs as well as the needs of other students in ASE
  - Consider EV/HEV specific NVH issues in AE 557
  - Consider inviting IAB members to recommend topics for ASE 698 capstone project

Curriculum Committee Activities

- UMD presented detailed course development plans of two new courses (2nd Meeting)
  - Vehicle Thermal Management (ME538/AE566)
  - Powertrain NVH Analysis (AE557)
- Committee Feedback
  - Vehicle Thermal Management
    - The course to be developed not only for ASE, but also EE, MM and other students.
    - The course will cover waste energy recovery.
    - Addressing climate control and battery thermal management course.
    - The focus on developing and delivering a presentation is also very good.
    - Suggestion: IAB member companies for a guest lecturer
  - Powertrain NVH Analysis
    - The course outline seems quite comprehensive. Need to balance depth and breath.
    - Question: will battery related NVH such as cooling circuit noise and contact noise be covered? Yes.

Curriculum Committee Meeting (March 13, 2014)

- Review of Energy Conversion Systems (ESE 501/ME 577, Offered: Winter 2013)
  - Instructor: Prof. Eric Ratts
  - This course covers fundamental engineering principles for converting available energy sources, renewable and nonrenewable, into other energy forms of direct utility.
  - Committee Comments, Feedback and instructor responses
    - Consider including embedded systems
    - A lab component (or simulation) to help fortify the learning: Under consideration
    - Aware of other schools constructing a physical system to enhance learning (eg: McMaster U./NASA Glenn)
    - Does the course get into the math behind the various systems? Yes

Curriculum Committee Meeting (March 13, 2014)

- Review of Energy Storage Systems (ESE 502/ECE 503, Offered: Winter 2012/2014)
  - Instructor: Lecturer Gary Crosbie
  - This course covers basics of energy storage systems, battery basics, other energy storage systems, hybrid energy storage concepts and integrated energy storage Systems, battery management and requirements
  - Committee Comments, Feedback and instructor response
    - Exposed to different modeling approaches
    - Discussed students' hands-on learning
    - Good content overall, 4 lectures on BMS
    - Exposure to latest trends and incidents such as the B787 battery problem
    - Cover fly wheels
    - Monte-Carlo, SPICE type laboratory componenta

Proposed Future Work

- Actively recruit GATE Fellows
- Promote industry partners and secure additional membership
- Offer scheduled courses in the curriculum.
- Organize GATE Annual meeting and IAB meeting
- Promote GATE Center at related conferences
- Continue to offer industry training programs
- Develop capstone projects
- Present at conferences and publish results in journals
- Approve additional dissertation proposals
- Overcome limitations, increase visibility, enhance resource usage, leverage internal resources and external funding

Summary

- Developed and offered all new courses for the EDT concentration in the ASE program
- Revised and offered the contents of existing courses
- Offered all classes online for distance learning
- Recruited 8 graduate students for the GATE program fellowships and 4 part time students
- Signed 8 industry partners supporting the GATE Center
- Leveraged funding from college for lab upgrades
- Leveraged funding for projects involving GATE fellows
- Organized the annual industrial advisory board meeting
- Offered second 1-day workshop on wireless power transfer for electric vehicle applications

Project Personnel

- Chris Mi: PI, ECE, (313) 583-6434, chrismi@umich.edu
- Yi Zhang: Co-PI, Mechanical Engineering, (313) 593-5539, anding@umich.edu
  - Dohoy Jung, Mechanical Engineering
  - Yi Lu Murphey, Electrical and Computer Engineering
  - John Cherng, Mechanical Engineering
  - Ben Q. Li, Mechanical Engineering
  - Zhimin Xi, Industrial and Manufacturing Systems Engineering
  - Eric Ratts, Mechanical Engineering
  - Taehyung Kim, Electrical and Computer Engineering
  - Wencong Su, Electrical and Computer Engineering
  - Zlex Yi, Electrical and Computer Engineering

Answers to Reviewers

1. A laboratory component to the curriculum with physical hardware could also provide an additional level of understanding of the material.
   - Response: we have upgraded EV dynamometer laboratory with leverage funding to support activities in EV motor and battery testing and experiments
2. The reviewer observed good effort on development of the academic activities, but noted that the project needed more effort on marketing.
   - We have increased our effort in offering workshops, advertizing in conferences, and through IAB members
3. The future work appeared to be business as usual; not necessarily a bad plan, but it did not seem to incorporate fine-tuning for future strategic needs
   - We have increased our effort in lab upgrades, research effort, and seek improvement of courses through IAB curriculum committee