The University Senate of Michigan Technological University
Proposal 14-17

(Voting Units: Academic)

"Graduate Certificate in Automotive Systems and Controls"

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1. General Description and Characteristics of Program:

The Departments of Mechanical Engineering-Engineering Mechanics and Electrical and Computer Engineering propose the establishment of an interdisciplinary "Graduate Certificate in Automotive Systems and Controls." Students completing this certificate will develop competencies in controls, systems engineering, and systems integration, encompassing multiple aspects of mechanical and electrical engineering with a primary focus on automotive applications.

The Certificate will be available to degree-seeking students enrolled in the Graduate School at Michigan Technological University, as well as non-degree seeking students at MTU. Students enrolling in this certificate program must have an undergraduate degree in Electrical Engineering, Mechanical Engineering, or a degree in a closely related field. The Certificate will be offered both to traditional on-campus students and online students. This Certificate requires a minimum total of 15 credits.

Students must earn a grade of B or higher in each of the courses counting toward the Certificate. A maximum of 6 credits is allowed in courses at the 4000 level.

The Director of Graduate Studies in each of the ME-EM and ECE departments will oversee the certificate program for students in their departments.

Catalog Description -The Graduate Certificate in Automotive Systems and Controls provides graduate students and non-degree seeking students with at least a bachelor's degree in a STEM discipline with advanced knowledge of the design, integration, and control of electro-mechanical components, subsystems, and complex multi input-output powertrains. It is expected that students beginning this Certificate program have a working understanding of i) control theory equivalent to that gained in EE 3261 or MEEM 4775, and ii) computer programming or simulation tools (e.g. MATLAB)

2. Rationale:

Based upon recent industry partners' input and feedback on new and emerging technologies in the automotive industry, and the associated new job functions and hiring requirements, it is critical that students and incumbent engineers develop high-level skills targeted to meet the growing need for engineers to design, develop, integrate and control electro-mechanical components, subsystems, and complex multi input-output powertrains.

Michigan Tech has received support from OEMs in the automotive industry for this curricular development and the creation of several new courses in this area. Michigan Tech should offer recognition to students who complete a set of new and existing courses in this area in order to give them a credential indicating their knowledge in this emerging field.

This program will build on an existing successful ***Graduate Certificate in Hybrid Electric Vehicles,*** but this new program will expressly ***focus on controls.***

It is anticipated that this Automotive Systems and Controls graduate certificate will be even more popular and successful as the course content applies to a broader industry constituency rather than just the HEV aspect. It cuts across the entire automotive industry from OEMs to suppliers. Although titled "automotive", the content will be applicable to the commercial transportation and off-highway industries as well.

The Graduate Certificate in Automotive Systems and Controls is designed to:

1. Develop and apply engineering design, analysis and controls to a complex system incorporating numerous embedded systems controlling a dynamic system;
2. Deepen systems integration knowledge including requirements, design, technical, safety and economic analysis for mobility systems;
3. Enhance students' interdisciplinary skills in approaching complex systems.

Students who complete this Certificate will be able to demonstrate that they understand systems engineering and controls from an interdisciplinary perspective that includes a dynamic networked system encompassing the functions of a vehicle from the larger perspective of mobility.

3. Related Programs:
This proposed Certificate is related to the established Graduate Certificate in Hybrid Electric Vehicles, but is also uniquely different with respect to the focus on the vehicle as a connected mobility platform including interconnected autonomous vehicles with human-machine interfaces. The HEV certificate focuses specifically on the powertrain.

There are several graduate certificates available at other universities in Hybrid Electric Vehicle topics, but a graduate certificate at this level in Automotive Systems and Controls could not be found.

The University of Michigan offers a MSE in Automotive Systems Engineering, a 30 credit hour degree program with similar courses, and The University of Michigan offers a 4 module sequence of 4-6 hour sessions on a Certificate in Emerging Automotive Technologies. The program at University of Michigan is more focused on powertrain similar to the MTU Hybrid Electric Vehicle program. http://isd.engin.umich.edu/degree-programs/automotive-engineering/curriculum.htm

The Ohio State University Center for Automotive Research offers a Certificate in Powertrain Modeling & Control which consists of two graduate credit courses and two non-credit seminars that can be completed in one academic year. This program is the most similar to this proposal,

however the MTU program is more comprehensive in that it is a minimum of 15 credits required. https://car.osu.edu/partial-list-expertise-area-courses-gs-ase

The proposed Certificate has a strong focus on controls in order to encompass students not only in powertrain, but also in chassis, and other vehicle systems, which will be a differentiator that will make this program more appealing. This certificate has more of a focus on the mobility needs than just the vehicle as a transportation device.

4. Projected Enrollments:
Based upon historical enrollment statistics and the expanded area of focus for this proposed certificate, it is estimated that the steady state online student enrollment is expected to be 20-25 students in the Certificate program.

5. Scheduling Plans:
No change in the regular scheduling of the existing courses is anticipated. The Departments delivering the new courses have agreed to fit them into their regular scheduling plans.

6. Curriculum Design: (**New courses in Boldface**)
In accordance with Senate policy, the requirements for the Graduate Certificate in Automotive Systems and Controls are a minimum 15 credits of coursework, including the required 9 credits of core courses and 6 credits of approved electives. Because this is an interdisciplinary graduate level certificate, a maximum of six credits can be earned at the 4000 level.

Required Coursework (A) 6 credits
*__EE/MEEM 5811 Automotive Systems__ (3)
*__EE/MEEM 5812 Automotive Control Systems__ (3)

Required Coursework (B) 3 credits - one of the following:
*MEEM 4220 Internal Combustion Engines I (3)
*EE4219 Intro to Electric Machines and Drives (3)
*MEEM 4450 Vehicle Dynamics (3)

Elective Coursework (C) - 6 Credits

Undergraduate Courses: (only one course can be taken from this list. Only 3 credits will apply)
*EE4219 Intro to Electric Machines and Drives (3)
*MEEM 4220 Internal Combustion Engines I (3)
+EE4252 Digital Signal Processing and Applications (4)
+EE4253 Real-Time Signal Processing (3)
EE4272 Computer Networks (3)
+EE 4735 Embedded Systems Engineering (3)
*EE4227 Power Electronics (3)
EE/MEEM4296 Experimental Studies for Hybrid Electric Vehicles Lab (3)
+MEEM 4450 Vehicle Dynamics (3)

Graduate Courses (at least 3 credits from this list)
*EE5227 Advanced Power Electronics (3)

EE5461 Mobile Networks (3)
EE5726 Embedded Sensor Networks (3)
EE5841 Machine Learning (3)
EE5900 Cyber-Physical Systems (3)
EE5900 Advanced Embedded Systems (3)
EE/MEEM 5275 Integration of Energy Storage in Sustainable Systems (3)
*MEEM5715 Linear Systems Theory and Design (3)
+EE/MEEM 5295 Advanced Propulsion Systems for Electric Drive Vehicles (3)
EE/MEEM 5296 Powertrain Integration in Hybrid Electric Vehicles Lab (2)
EE/MEEM 5750 Distributed Embedded Control Systems (3)
*MY/CM5760 Vehicle Battery Cells and Systems (3)
+MEEM5290 Principles of Energy Conversion (3)
+MEEM5440 Advanced Vehicle Dynamics (3)
+MEEM 5670 Experimental Design in Engineering (3)
*MEEM5250 Internal Combustion Engines II (3)
+MEEM 5255 Advance Powertrain Instrumentation and Experimental Methods (3)
+MEEM 5700 Dynamic Measurement /Signal Analysis (4)
*MEEM 5220 Fuel Cell Technology (3)
***EE 5455/MEEM 5300 Cyber Security of Industrial Controls** (3)
*EE 5900/MEEM5990 Cyber Security of Automotive Systems I (3)
+**MEEM 5201 Fundamentals of SI Engines (**1)
+**MEEM 5202 Fundamentals of Diesel Engines (**1)
+**MEEM 5203 I Engine Control Systems (**1)
+**MEEM 5204 Diesel Engine Control Systems (**1)
SU5010 Geospatial Concepts, Technologies, and Data (3)

*Courses already offered distance learning/online
+Courses will be adapted to distance learning/online

Online delivery:
All the core required courses and a majority of the approved elective courses are currently offered online. It is anticipated that courses designated to be adapted to online be will be ready to be offered by the 2017-2018 academic year. This will allow off-campus students to fully complete the Graduate Certificate in Automotive Systems and Controls with online offerings.

7. New Course Descriptions:

EE/MEEM 5811 Automotive Systems (3)
Automotive systems for light duty vehicles are examined from the perspectives of requirements, design, technical, and economic analysis for advanced mobility needs. This course links the content for the automotive systems graduate certificate in controls, powertrain, vehicle dynamics, connected and autonomous vehicles.

EE/MEEM 5812 Automotive Control Systems (3)
Introduction to automotive control systems. Modeling and control methods are presented for: air-fuel ratio, transient fuel, spark timing, idle speed, transmission, cruise speed, anti-lock brakes, traction, active suspension systems, and hybrid electric vehicles. Advanced control methodologies are introduced for appropriate applications.

MEEM 5201 Fundamentals of SI Engines (1)
A combination of lecture and hands-on activities. Options for transportation and lunch. Content; operation fundamentals, performance metrics, thermochemistry, combustion, Miller & Atkinson

cycle, fuel & air system, supercharging & turbocharging, exhaust systems, energy balance, variable valve actuation, simulation, and advanced concepts & trends.

MEEM 5202 Fundamentals of Diesel Engines (1)
A combination of lecture and hands-on activities. Options for transportation and lunch. Content; fundamentals of operation, performance metrics, thermochemistry, combustion, fuel injection and spray, air systems and turbocharging, EGR, energy balance, heat transfer, diesel engine simulation, and advanced concepts and trends in diesel engines.

MEEM 5203 SI Engine Control Systems (1)
A combination lecture & hands-on. Options for transportation & lunch. Content; review engine operation, regulations, intro to engine control, sensors & actuators, causality effects; combustion phasing, lambda, valve timing, load, control of; throttle, knock, turbo, fuel, emissions control, algorithm & calibration, OBD, controller communications.

MEEM 5204 Diesel Engine Control Systems (1)
A combination of lecture and hands-on activities. Options for transportation and lunch. Content; review diesel operation, regulations, intro to engine control, diesel engine actuators, load control, Start of Injection, Rail Pressure, Turbo Control, EGR & Engine Out Emissions, aftertreatment, algorithm & calibration, OBD, controller communications.

EE 5455/MEEM 5300 Cyber Security of Industrial Controls (3)
General introduction to cybersecurity of industrial control systems and critical infrastructures. Topics include NIST and DHS publications, threat analysis, vulnerability analysis, red teaming, intrusion detection systems, industrial networks, industrial malware, and selected case studies.

8. Model Schedule Demonstrating Completion Time:
It is anticipated that degree-seeking students will take at a minimum one course each semester toward the certificate, since certificate credits can be counted towards a degree. It is expected that students will take additional courses each semester so that the certificate is completed within 3-4 semesters. It is also anticipated that the majority of non-degree seeking students will be online students who will take one course each semester toward the certificate, hence it is expected that these students will complete the certificate in five semesters. Courses are offered on the following schedule:

Fall	Spring	Summer	On Demand
EE/MEEM 5812	EE/MEEM 5811	EE 4735	EE 5726
EE 4252	MEEM 4220	EE 4227	EE 5900 Cyber Physical Syst.
EE 4272	EE 4219	EE 5461	EE 5900 Adv. Embedded Syst.
EE 4227	MEEM 4450	EE/MEEM 5296	EE 5455/MEEM 5300
EE 5227 (even years)	EE 4253	MEEM 5670	
MEEM 5715	EE 4272	MEEM 5700	
EE/MEEM 4296	EE 4735	MEEM 5201 (odd years)	
MY/CM 5760	EE 5461	MEEM 5202 (even years)	
MEEM 5290	EE 5841	MEEM 5203 (odd years)	
MEEM 5440	EE/MEEM 5275 (even years)	MEEM (even years)	
MEEM 5670	EE/MEEM 5295		
MEEM 5250 (odd years)	EE/MEEM 5296		
MEEM 5700	EE/MEEM 5750		
MEEM 5220	MEEM 5255		

9. Library and other Learning Resources:
Students in this program will need only the Library resources presently available to all enrolled students.

10. Faculty Resumes:
The following faculty contributed to the development of this proposal and will serve this program.

Jeffrey Naber	http://www.mtu.edu/mechanical/people/faculty/naber/
Jeffrey Burl	http://www.mtu.edu/ece/department/faculty/full-time/burl/
Bo Chen	http://www.mtu.edu/ece/department/faculty/full-time/chen/
Mahdi Shahbakhti	http://www.mtu.edu/mechanical/people/faculty/shahbakhti/
Jeremy Worm	http://www.mtu.edu/mechanical/people/staff/worm/
Jeremy Bos	http://www.mtu.edu/ece/department/faculty/full-time/bos/
Wayne Weaver	http://www.mtu.edu/ece/department/faculty/full-time/weaver/
Aurenice Oliveira	http://www.mtu.edu/ece/department/faculty/full-time/oliveira/

11. Equipment:
No additional equipment will be required. The Michigan Tech Mobile Lab will be used for the one credit courses, MEEM5201, MEEM5202, MEEM5203, and MEEM5204. The expense of the operation of the mobile lab and associated lab supplies for these courses will be recovered with approved lab fees.

12. Program Costs:
The new courses developed and courses adapted to online platforms, have been funded with a Jackson Learning Grant of $5,000 awarded April 2016, and through ME-EM and ECE department cost sharing. The remaining courses are presently being taught on a regular basis and expect to be able to cover the demand. Resources, such as on-line software, are already provided and available to instructors.

13. Space:
No additional space is required.

14. Policies, Regulations, and Rules:
Credits earned for this certificate may also be applied toward a single graduate degree at Michigan Technological University.

15. Accreditation Requirements:
None

16. Internal Status of the Proposal:
Approved by the College of Engineering

17. Planned Implementation Date:
Fall semester 2017