

# The University of Tennessee's GATE Center for Hybrid Systems

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# History of GATE at UTK

- One of nine original GATE Centers established in 1998
- Focus on *hybrid drive trains and control systems*
- Housed in the College of Engineering
- Nine faculty members from three departments involved in the GATE Center



# History of GATE at UTK

- Two classifications of UTK GATE students
  - GATE Fellows
    - Fourteen students received fellowships and ten graduated
  - GATE Research Assistants
    - Nine students received assistantships and seven graduated
- Students employed in industry
  - Ford Motor Company
  - Oak Ridge National Laboratory
  - National Renewable Energy Laboratory
  - The University of Tennessee
  - Southwest Research Institute®
  - Lynx Motor Technologies
  - Volpe Transportation Center
  - Detroit Diesel
  - Electric Transit Vehicle Institute
  - EPRI-PEAC



# GATE Goals and Objectives

*“The goal of GATE is to overcome technology barriers preventing the development and production of cost-effective, high-efficiency vehicles for the U.S. market by training a future workforce of automotive engineering professionals who are knowledgeable about, and experienced in, developing and commercializing advanced automotive technologies.... GATE Centers of Excellence are an opportunity to equip a new generation of engineers and scientists with knowledge and skills in advanced automotive technologies.”*

*Funding Opportunity Announcement DE-PS26-05NT42381*



# UTK GATE Objectives

- Integrate updated and expanded courses into existing curriculum
- Provide fellowships for students that will be successful in their degree programs and engineering careers



# UTK GATE Program

- Program Focus- Advanced Hybrid Propulsion and Control Systems
  - Enhancing hybrid systems based on IC engines and transitional engine technologies
  - Developing optimal strategies for powertrain control and systems integration respective of fuel efficiency, emissions, energy management and dynamic performance
  - Developing objective performance measures and mitigation strategies for powertrain performance issues unique to hybrid vehicles that represent barriers to customer acceptance
  - Providing metrics for an objective comparison of advanced hybrid vehicles based on detailed performance measures of optimally-controlled systems



# Current Courses

- ME 588 Introduction to Hybrid Electric Vehicles (3). Series, parallel, and dual configurations. Sizing and analysis of typical HEV components: motors, auxiliary power sources, on-board energy storage, and fuels. Steady-state HEV force and power modeling schemes. Powertrain design using various computer simulation tools.
- ME 523 (3) Special Topics in Thermodynamics. – Advanced Internal Combustion Engines. Combustion and computer modeling of internal combustion engine processes. Alternative fuels, emissions and emission controls, valve timing.
- ME 642 (3) Advanced Internal Combustion Engines. This course covers several aspects of current engines supplied in on-road vehicles. The course focuses on the operation of the engine as a sub-system within the vehicle. Advanced engine designs with emphasis on those designs that offer improved emissions and fuel economy performance



# Planned Courses

- ME 589 Hybrid Electric Vehicle Control Systems Design and Analysis (3). Dynamic modeling, simulation and analysis of complete HEV systems. Linear control design techniques and discrete logic design applied to HEV power trains and operating mode controls. Digital and real-time controls and hardware issues of automotive systems. Design and human factors engineering issues of vehicle controls and displays.
- ME 5XX Special Topics (3). This is a new course to be developed which will address drivability and human factors in vehicle engineering. Planned rollout Spring 2010.



# Current GATE Students

- GATE Fellows
  - One student has completed his MS degree in mechanical engineering
    - Scott Curran is employed at Oak Ridge National Laboratory. His research involved on-road evaluation of the emissions effect of student-produced biodiesel on modern aftertreatment systems.
    - Sean Peterson has left the program for full-time employment.
- GATE Research Assistants
  - One student has completed his PhD degree in mechanical engineering
    - David Smith is employed at Oak Ridge National Laboratory. His research involved characterizing PHEV Engine Emissions Impacts on Control Strategy



# Recent Activities Completed

- Current Research Projects
  - PHEV Engine Emissions Impacts on Control Strategy
    - Address the issue of engine emissions from a plug-in hybrid electric vehicle.
      - Detailed modeling to create a suitable supervisory control strategy
      - Further investigation of a candidate hybrid powertrain installed on a dynamometer for complete testing and evaluation.
  - UT Biodiesel Model for Sustainable Biodiesel Production
    - Investigate a model for closed loop, sustainable biodiesel production for both universities and businesses
    - Examine the economics of production, the environmental impact of the process, on-road emissions, and the behavior of the fuel with advanced diesel aftertreatments.



# Current Activities and Plans

- Current Research Projects
  - Development and Evaluation of Legacy Engine
    - Development of a high power density heavy fuel engine
      - Modeling
      - Control system development
      - System integration
      - Testing and Evaluation
  - Hydrogen Fueled Vehicle Demonstration Project
    - Supports Tennessee Hydrogen Initiative
    - Convert production vehicle to HICE operation
    - Support for graduate student(s)
    - Senior design project

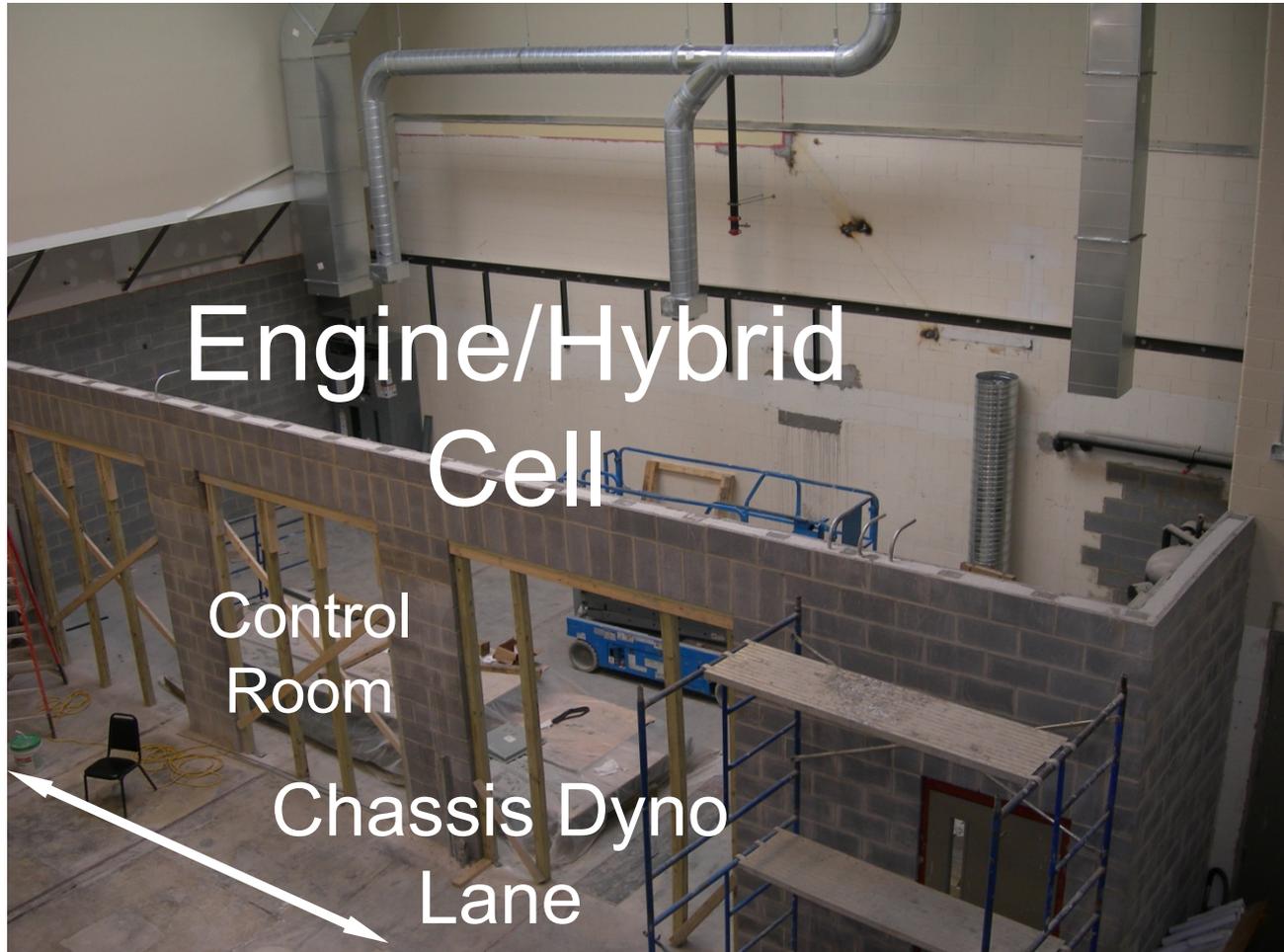


# Current Activities and Plans

- Continuing work on APCSI lab
  - Laboratory relocated temporarily to lease facility in Oak Ridge
  - All dynamometer test cells relocated to available facility on campus Fall 2009
  - Construction should be completed Summer 2009
- Website development
  - Updated website online now
  - Content being added
- Course development
  - Controls class to be updated and offered Fall 2009
  - Drivability/Human Factors course to be developed and offered Spring 2010
- Interaction with government and industrial partners
  - Collaborative research
  - Adjunct appointments for ORNL and ANL colleagues
  - Proposal for major partnership with industry partner



# APCSI Construction



# Resources & Industry Interaction

- Resources resulting from the UTK GATE program
  - \$2 million in grants and contracts from government and industry
  - \$250K from the university in cost sharing and providing facilities
- Industry Interaction
  - DOE Advanced Vehicle Technology Competitions
  - DOE Clean Cities Program
  - ExtEngine
  - Delphi
  - 3M
  - State of Tennessee
  - National Transportation Research Center
  - Power Source Technologies
  - Sentech
  - Argonne National Laboratory
  - Idaho National Engineering Laboratory
  - Denso Foundation



# Advanced Vehicle Technology Competitions



- Team Tennessee finished 7<sup>th</sup> overall in 2008
- Two GATE Fellows served as team leaders



# Outreach

- GATE outreach activities leveraged with Challenge X hybrid vehicle



Earth Fest 2008



Dean Ride & Drive



Run for Clean Air

# Summary

- Research facilities should be restored for AY 2009-10
- Increased course offerings involving ORNL staff
- New College of Engineering administration supportive of GATE activities
- Goal to increase research activity
- Continuity of student recruitment should improve with increased research funding

