

Commercial Vehicle & Power Systems Research

Professor Greg Shaver

School of Mechanical Engineering

gshaver@purdue.edu

Jan. 10th. 2024

PURDUE
UNIVERSITY®

RAY W. HERRICK
LABORATORIES

Collaborators & funders:



Shaver Research Group

19 Active Graduate Students (13 Phd, 6 MSME)

Ethan Brown Yuchen Song Alec Vucsko Shubham Ashta Michael Adekanbi Zar Ahmad Raghav Kakani Bharath Natarajan Daniel Litowitz



Benjamin Mathews Audrey Willoughby Anushka George Doni Thomas Adil Shaikh Reynolds Manion Shreyas Supe Chisom Emegoakor Jared Davis Vidal Tchato



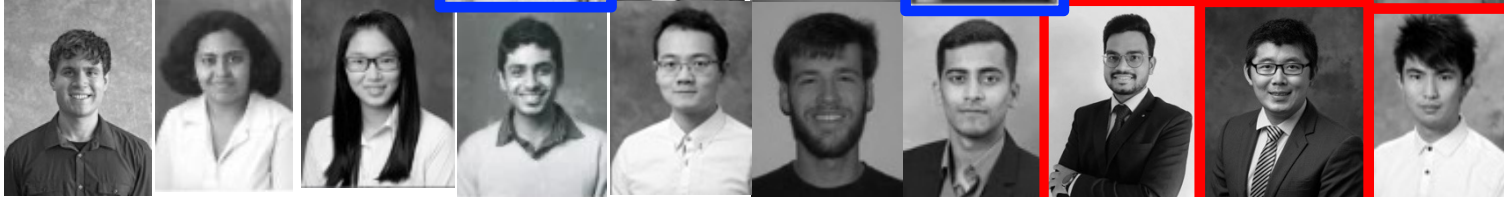
Greg Shaver, PhD
Faculty Lead

Employed at industry partner companies.

Tenure-track faculty.



57 Former Graduate Students
(24 PhD, 33 Masters)



Ongoing Projects

Hydrogen Engine Powered Excavator (w/ A. Vacca)

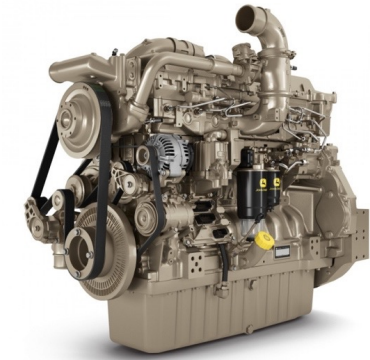
- DOE is funding
- Collaboration w/ Cummins, Komatsu, & Bosch-Rexroth
- eBoosted engine testing at Purdue
- Vehicle testing at Purdue
- Purdue is leading engine/powertrain control algorithm & fluid power system development



Reduce CO₂ emissions by 100%

Ethanol/Biodiesel Blends as a low CO₂ Diesel Replacement for Off-road Engines (w/ E. Holloway)

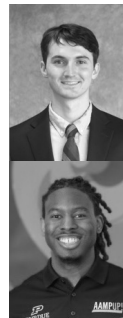
- Funders: Deere & Fuels Groups
- Determine if fuel-adaptive control strategies are required for ethanol/biodiesel blends



Reduce CO₂ >50% through use of a low CO₂ fuels

Natural Gas Engine Controls for Low-Methane Engines

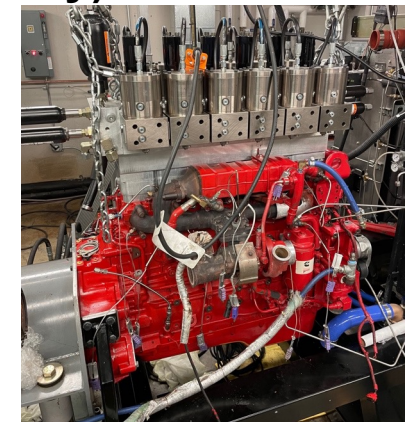
- Caterpillar is funding
- Control strategies to allow reduced NO_x and methane emissions
 - Gas compression
 - Power generation



Reduce methane emissions (a harmful global warming gas)

Natural Gas Engine VVA/CDA (w/ C. Goldenstein & E. Holloway)

- Cummins is funding
- Knock and throttling reduce performance & eff.
- Study merits of VVA/CDA In-cyl mass & composition estimation
- Engine testing at Purdue



~10% fuel savings w/ low-CO₂ fuel

Ongoing Projects

Autonomous Roadside Mowing (w. J. Evans)

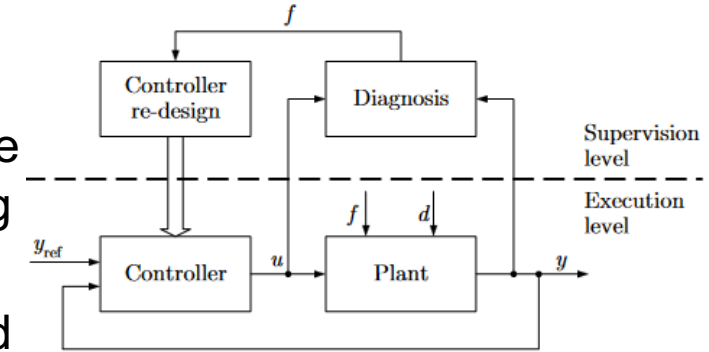
- Funded by Indiana Department of Transportation
- Designing obstacle avoidance & path planning algorithms
- Unreal Engine to simulate photorealistic environment
- Pre-built mowing robot to be retrofit for testing



Save lives & reduce injuries

Control and Sensing Resiliency in Navy Marine Diesel Engines

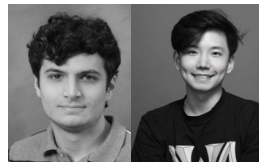
- ONR is funding
- Reduce downtime due to control and sensing failures
- Develop model-based diagnosis and fault tolerant control algorithms



Increase up-time of US Naval assets

Indy Autonomous Challenge (w/ D. Williams, S. Sundaram & S. Labi)

- Develop software to autonomously race the car
 - Perception
 - Planning
 - Motion control
- Racing on top tracks (Indy Motor Speedway, Monza-Italy, etc.)



Demonstrate Purdue/State of IN technical motorsports excellence; Develop high speed vehicle automation

Energy Harvesting from Class 8 Truck Trailers (w. J. Gibert, A. Arrieta & J. Evans)

- Wabash is funding
- Design & test harvesting methods from trailer suspension, skin flex and aerodynamics



Reduce CO₂ and power advanced safety systems

Ongoing Projects

Automated Class 8 Truck Docking (w. D. Williams)

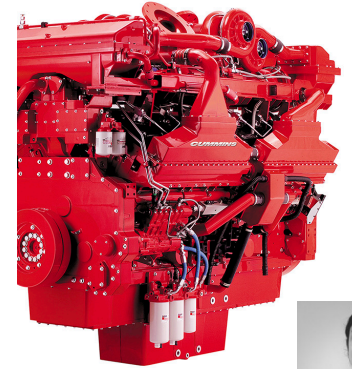
- ZF engineer doing thesis research
- Use machine-learning to improve the safety and speed of docking



Reduce trailer/dock damage & improve efficiency

Modeling Strategies for Engines & Integrated Systems

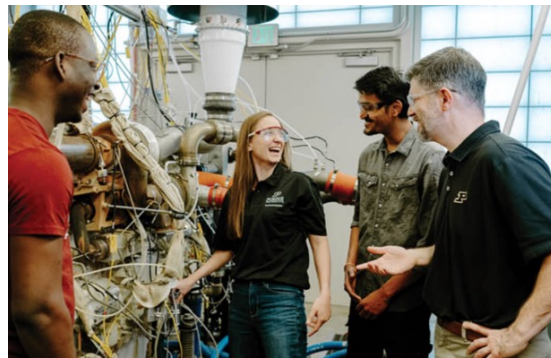
- Cummins is funding
- Focused on large engines use for power generation, mining & marine applications, including:
 - Marine vehicle & propulsion system modeling
 - Field data utilization for improving model fidelity



Improved models for system design and control

High Efficiency Off-Road Engines (w/ E. Holloway)

- Funders: Deere & Eaton
- Cylinder deactivation & EGR pumping
- Project close-out/publications

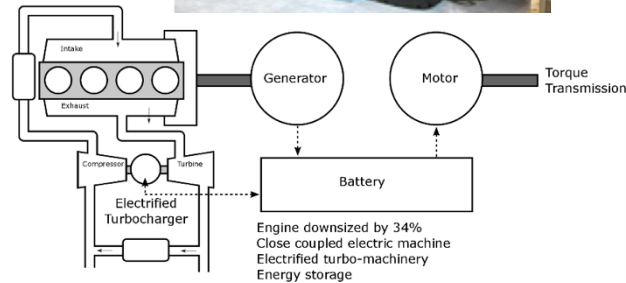


> 3% fuel/CO₂ reduction at high loads; > 30% at low loads

Examples of Recently Finished Projects

Heavy-duty Diesel Hybrid Electric Drivetrain

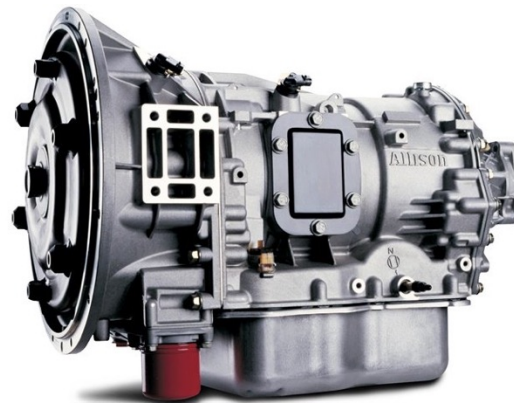
- DOE is funding
- Collaboration with U. of Wisconsin and Deere
- Engine testing at UW
- Vehicle testing at Deere
- Purdue is leading control algorithm development for engine & powertrain



> 10% fuel/CO₂ reduction on full-sized wheel loader

Improving Transmission Resilience to Driveline Resonance Through Detection & Control (w/ J. Evans & A. Bajaj)

- Allison is funding
- Analyze Allison data
- Simulate resonant conditions
- Develop mitigation techniques



Patent app. for validated algorithm to detect anomalies

Enabling Truck Platooning on Hilly Terrain

- collaborators: Peloton (start-up), Cummins, DOE & DOT
- COMVEC/etc. seminars + journal publications
- Co-PIs: Jain (ME), DeLaurentis (ABE), Bullock (CE)



12.3% fuel/CO₂ savings + improved truck gap control

Investigate methods to generate models for CTT Turbine maps using Artificial Intelligence

- Cummins Turbo Technologies is funding
- Turbine maps describe the product performance of turbines
- Use AI to enable evaluation of turbine performance at any speed & expansion ratio condition

Cummins Turbo Technologies

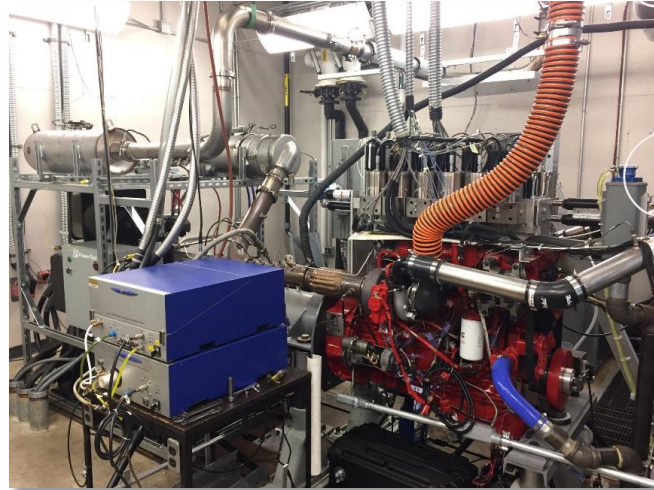


<1% error for turbo map model accuracy for flow & efficiency. 2.5x better than current approach.

Examples of Recently Finished Projects

Improving Diesel Engine Efficiency & Thermal Management via Variable Valve Actuation (VVA)

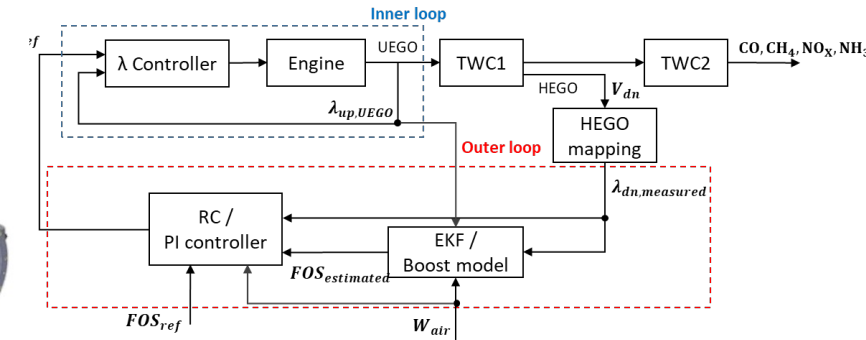
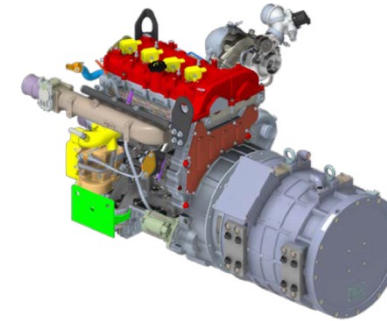
- Prior effort funded by Cummins, Eaton & DOE
- 7 papers cited by California Air Resources Board
- 3 papers cited by United States EPA



Helped drive new emissions regulations for CO₂ and NO_x

Robust Control of Nat. Gas Engine Aftertreatment

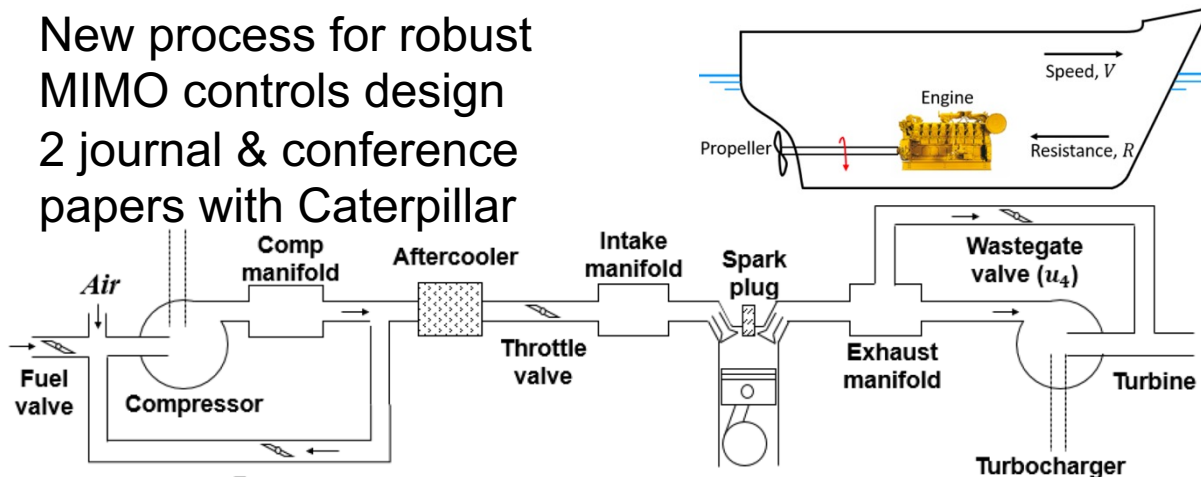
- DOE funded
- Collaboration with Cummins
- 2 journal papers with Cummins



Reduce CO₂ emission by 30% + ultra-low NO_x

Robust Natural Gas Marine & Genset Engine Controls

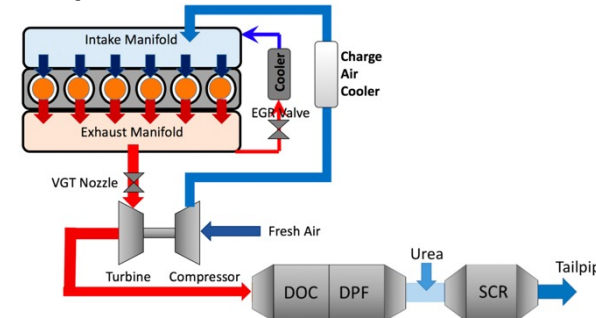
- New process for robust MIMO controls design
- 2 journal & conference papers with Caterpillar



Improve performance to get hard work done.

Biodiesel Impact: Hvy-Duty Engine/Aftertreatment

- Demonstrated some issues w/ NO_x and torque
- Can likely be mitigated via Purdue developed controls
- Sponsor: National Biodiesel Board



Identified challenges that need to be met for biodiesel

Examples of Recently Finished Projects

Auto-Unload of Grain while Harvesting is Occurring

- Sponsor/Collaborator: Deere
- Co-PIs: Evans (ABE), Vyn (Agronomy)
- Experiments done at Purdue



Two patents with Deere & multiple journal papers