



RDECOM



TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

ARC Accomplishments & Collaborations **Pursuing Challenges with Vision and Focus**

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- Develop simulation and modeling tools for discovering and assessing critical ground vehicles technologies

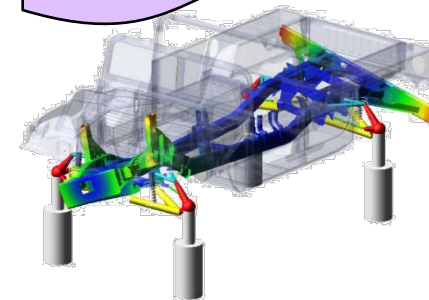
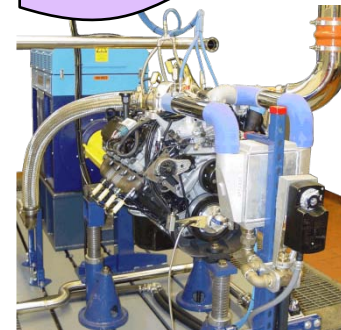
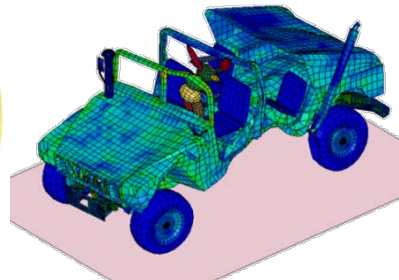
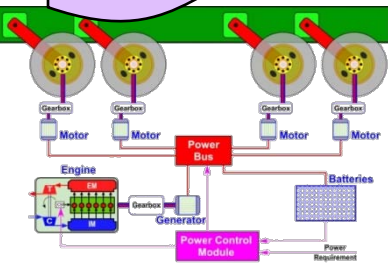
**Thrust Area 1
Intelligent
Vehicle
Dynamics
and Control**

**Thrust Area 2
Human
Centered
Design
Simulation**

**Thrust Area 3
High
Performance
Structures &
Materials**

**Thrust Area 4
Advanced
and Hybrid
Powertrains**

**Thrust Area 5
Vehicle System
Integration,
Optimization
and Robustness**



University of
Michigan

Oakland
University

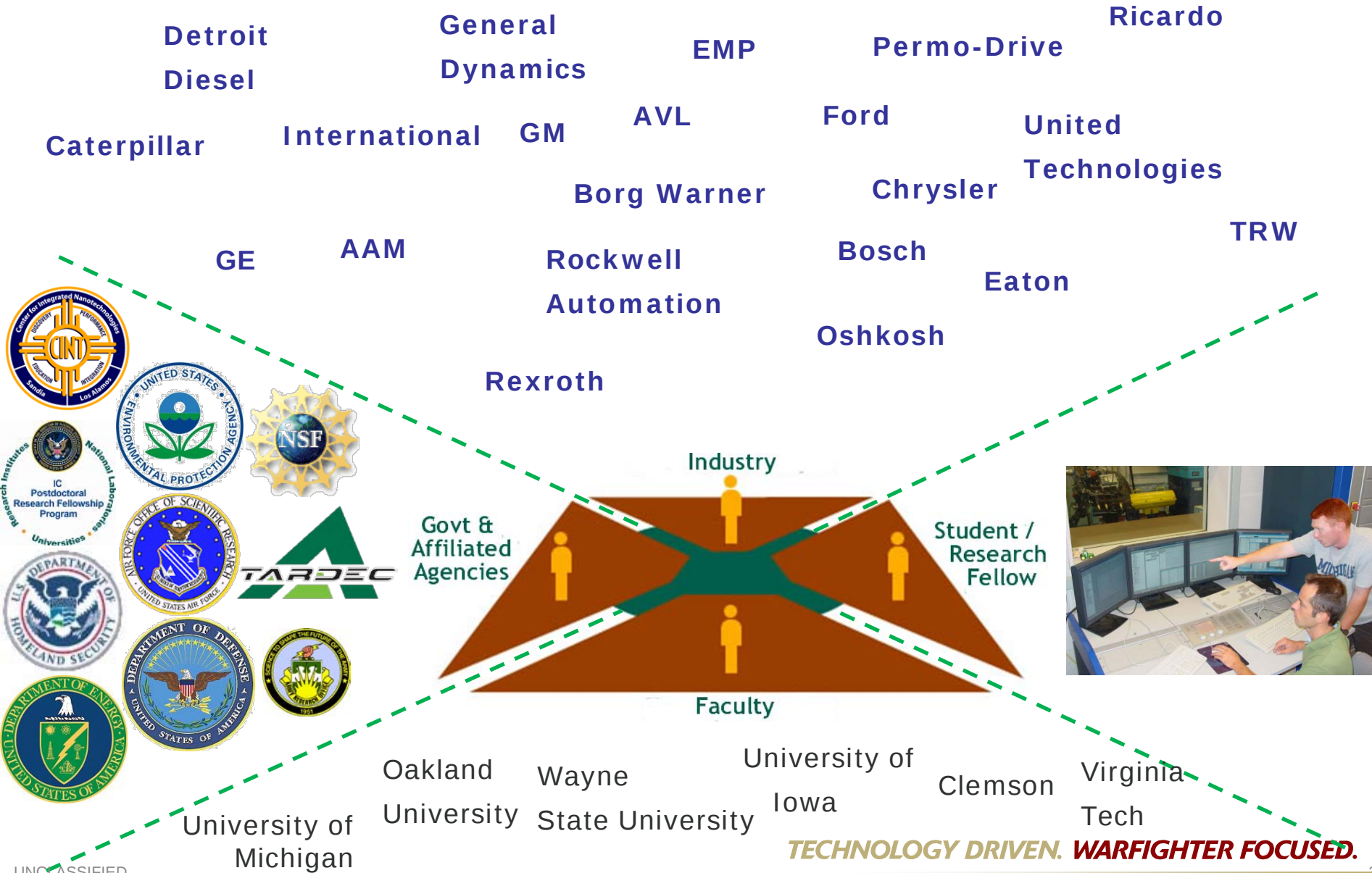
Wayne
State University

Universit
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Iowa

Clemson

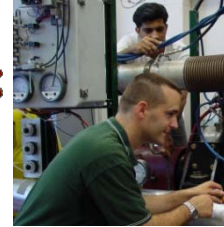
Virginia
Tech

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.



- A string of graduate students that earned their MS degrees in the ARC, went on to teach at West Point and then moved to positions of responsibility in the Army:

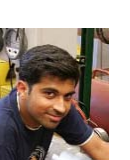
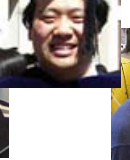
- **Sam Homsy**
- George Seaward
- Chad Jagmin
- Wesley Williamson



- Many ARC graduates went on to take prominent positions in the Army, Industry and Academia:

- Dr. Matthew Castanier
- **Dr. Scott Fiveland**, Caterpillar
- Dr. Tim Jacobs, Texas A&M
- **Mr. Sam Homsy**, Navistar Defense LLC
- **Dr. Joe Lin**, Eaton
- Dr. Young Jae Kim, GM Hybrid Powertrain Eng.
- Dr. Bin Wu, Mercedes-Benz Hybrid LLC
- Dr. Vasilios Tsourapas, Eaton
- **Mr. Hakan Yilmaz**, Bosch
- Mr. Gerald Fernandes, Bosch
- Dr. Burit Kittirungsri, Cummins
- Dr. Jonathan Hagena, PACCAR
- Dr. Ian Darnell, Lawrence Livermore National Labs
- Dr. Jinzhong Wang, MSC software
- Dr. Geunsoo Ryu, Hyundai
- Dr. Kyung Won Suh, Hyundai
- Dr. Andreas Malikopoulos, GM R&D
- Dr. Jin Ming Liu, GM R&D
- Dr. Jeongwoo Han, Argonne National Laboratory

Texas A&M Paccar Bosch GM
 Cummins
 Lawrence Livermore International
 National Laboratory Argonne Hyundai
 MSC Software
 Caterpillar
 Eaton



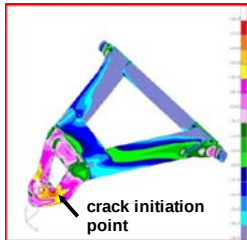
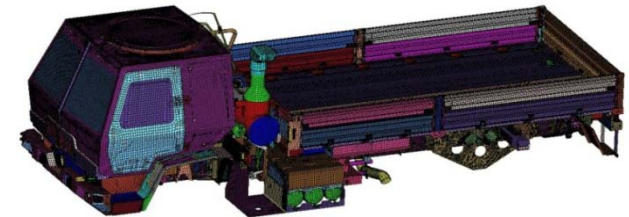
Current Participation

6 Universities
33 projects
27 professors
13 research scientists or postdocs
37 graduate students

Scholarly Output: Last 5 years

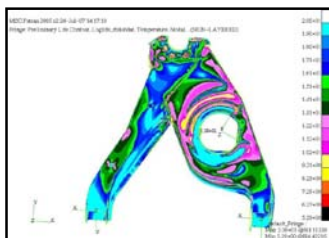
- Graduated 18 MS and 23 PhD
- Published 315 journal and conference papers
- 4 best paper awards (SAE, ASME, IEEE)
- 44 plenary, keynote, and distinguished lectures
- Fellows: 3 SAE, 4 ASME, 1 AAAS, 1 IACM, 3 IEEE
- 8 external Research and Educational Awards
- 8 University Awards
- 2 Young Scientists/Young Innovator awards
- 25 Presidents, Chairs, and Executive Board Members of large technical societies

- Parallelized Reliability-Based Design Optimization Software System has been developed and installed on TARDEC HPC to improve the design of complex mechanical systems, such as Army vehicle systems, for durability and weight reduction. Examples:
 - High-mobility trailer drawbar
 - Stryker A-arm
 - HMMWV A-arm
 - FMTV frame for new engine and transmission



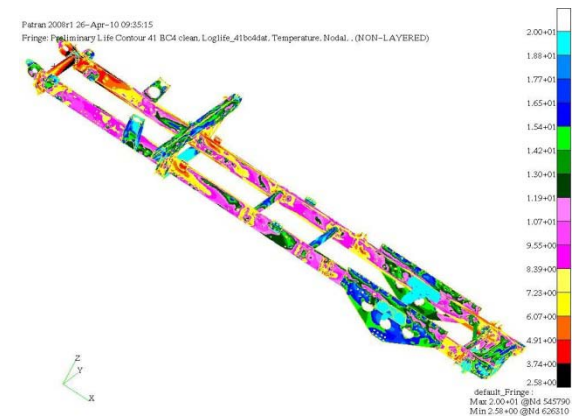
Stryker Left-Front A-Arm

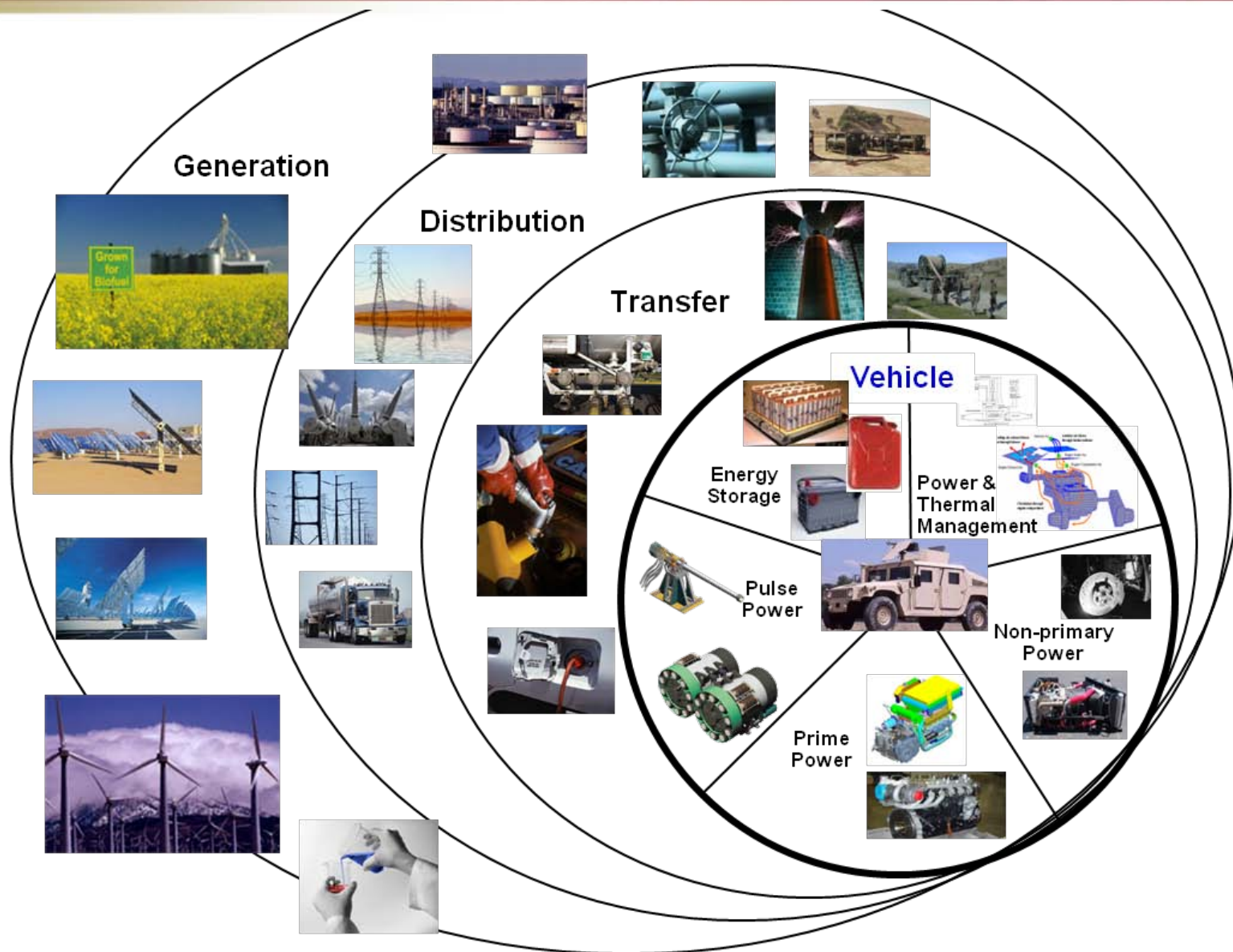
- Obtain **2-sigma RBDO** design: probability of failure less than **2.275%**.
- Significant weight savings of 10.38 lbs from total weight of 53.0 lbs (**19.6% reduction!**).
- Improving probabilistic fatigue life **10.8 times**.



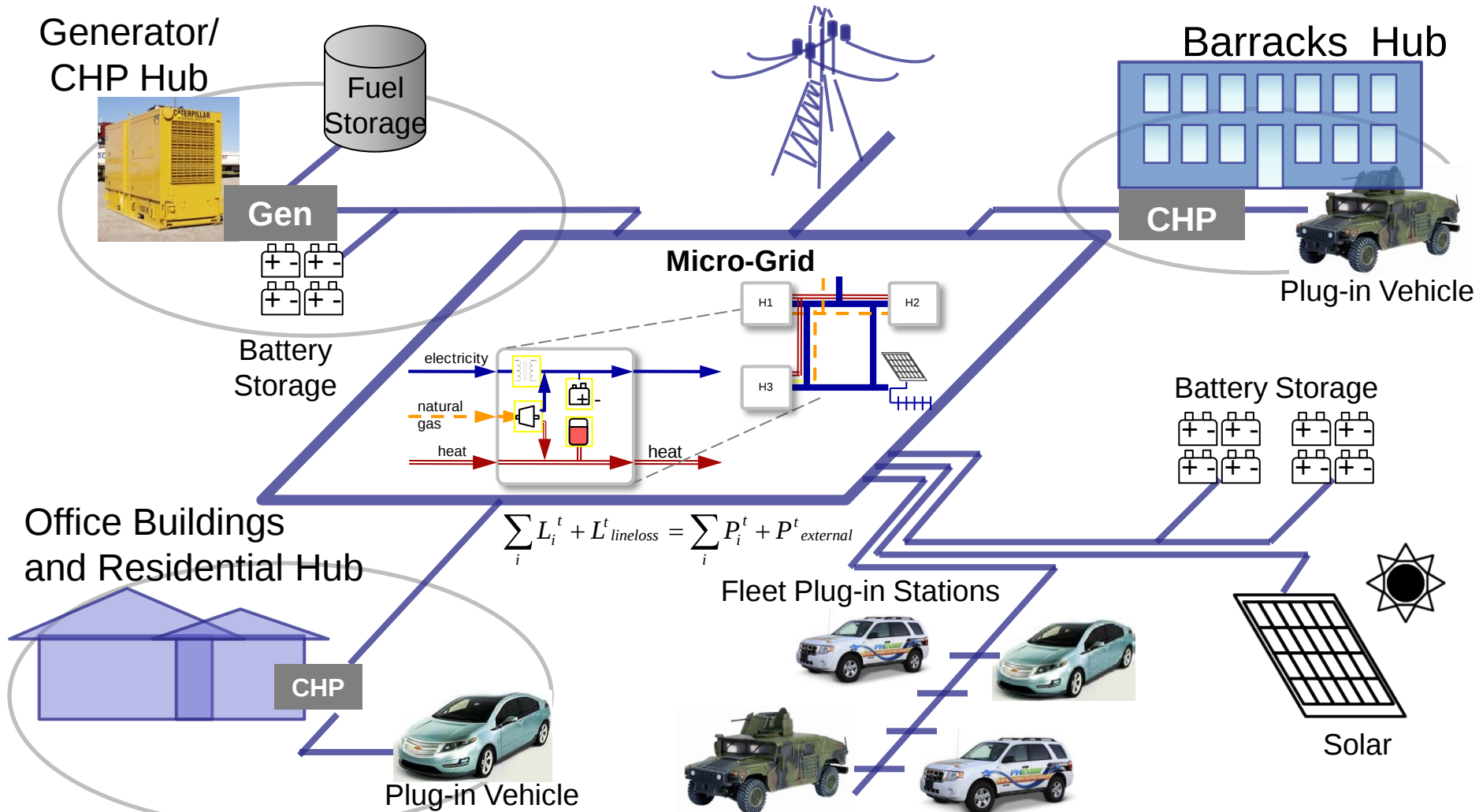
HMMWV Left-Front A-Arm

- 328K** DOF, used **16 HPC Parallel Processors**.
- 2-sigma RBDO** design.
- Improve fatigue life **2084 times**.
- For **95% confidence level**, the optimum weight is increased from **106.9 in³** to **184.56 in³**.





Optimal Sizing and Control of Vehicle Supported Military MicroGrid



"Vehicles designed today will be in military service 50 years from today"

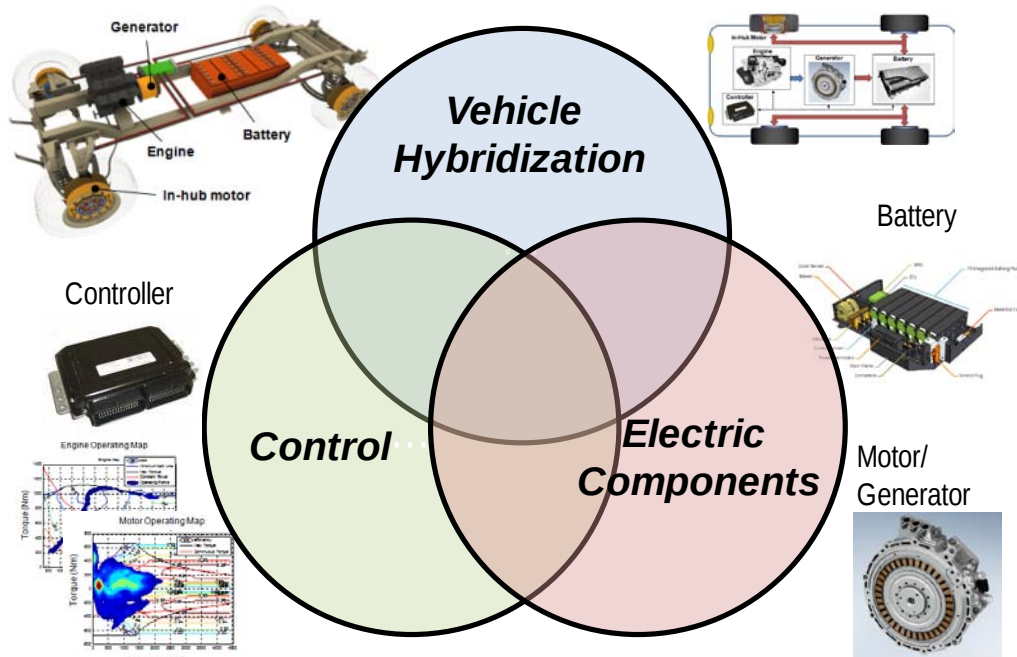
Impetus for improving efficiency

- Energy security and cost of fuel
- Steady increase of battlefield energy consumption



Research and Education in vehicle electrification

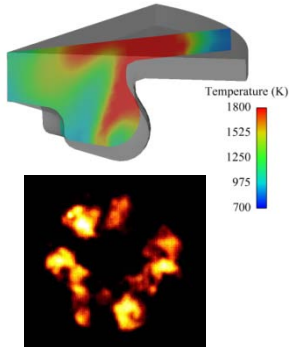
- Hybridization for efficiency
- Portfolio of Hybrid configurations
- Extra power for electronic equipment, navigation, active armor and weapons
- Silent watch capability
- Export-power capability



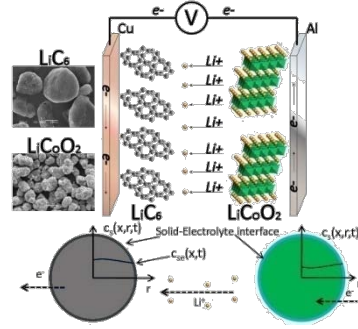
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Session 2C

- Basic research of fuel energy conversion and storage

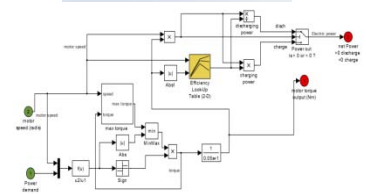
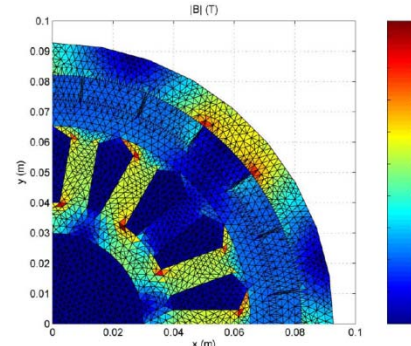


Diesel combustion, Alternative Fuels

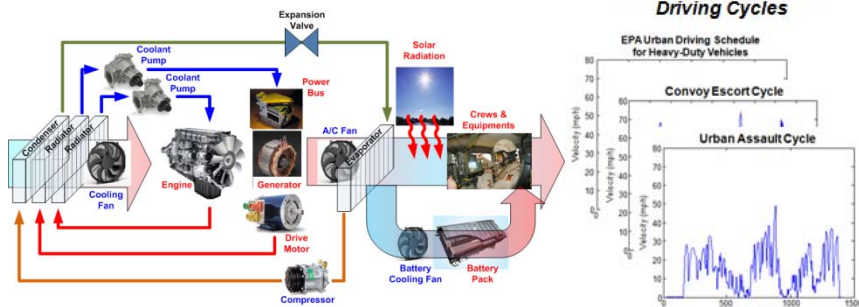


Battery chemistry, thermal and health management

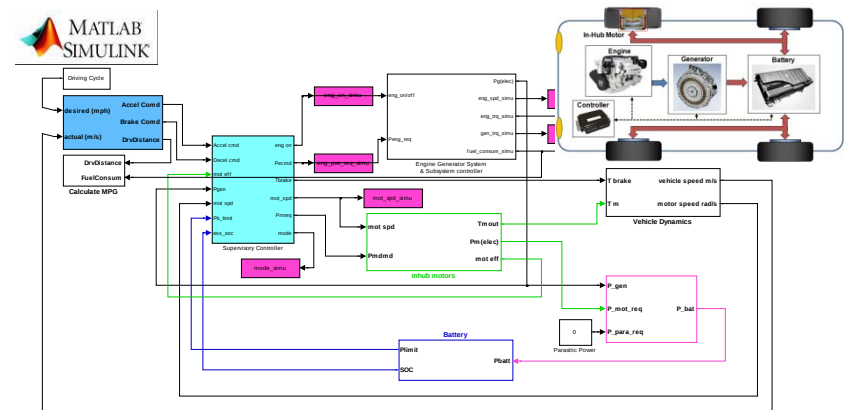
- Next-generation of electric motor models



- Integrate accessories, develop representative duty-cycles, analyze power budgets



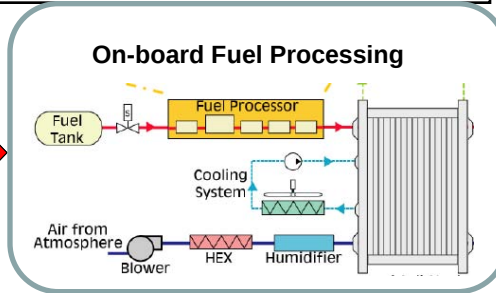
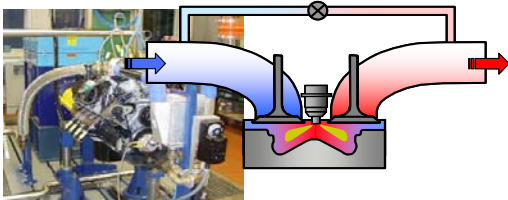
- Flexible hybrid electric vehicle system simulation in SIMULINK



JP8, Diesel, Bio-fuels, Synthetic fuels

Session 1C

Controlled
Combustion



Adapt Regional Energy Sources

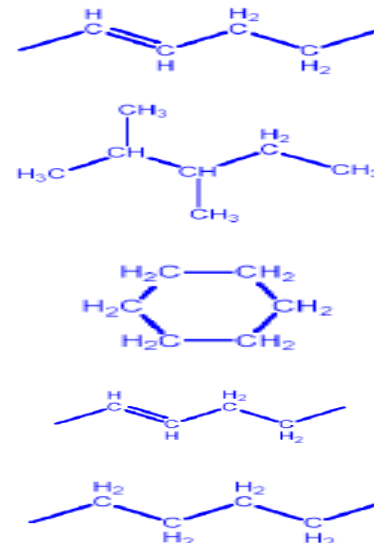
- Reaction paths and mechanisms
- Ignition Experiments
- Combustion Control and Adaptation
- Virtual Sensing and Diagnostics
- Fuel Processing & De-sulfurization
- Cold Start , Emissions, Efficiency

Motivation and constraints:

- Cost of Fuel
- Logistics
- Single Fuel Forward, but local supplies may dictate alternatives

Goal: Develop strategies for using a wide range of alternative fuels in future diesels

- Robust and reliable performance
- Fuel tolerant designs
- Diagnosability & Maintenance
- Visual signature



Session 1B, 2B

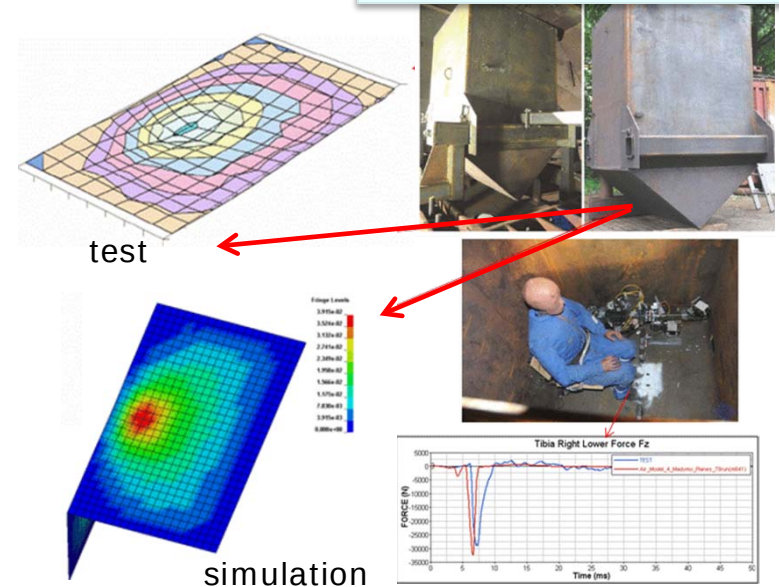
Challenge: Design material properties at the micro-scale to alleviate the tradeoff between protection to impulsive loads and the weight reduction.

Approach: Robust and transparent numerical integration of simulation tools from the micro scale to the vehicle level; enable simulation and optimization of a vehicle design process

(Simulations of explosive threats; blast load and high velocity projectiles)

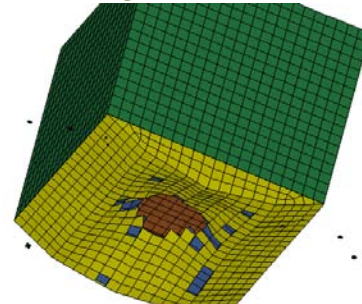
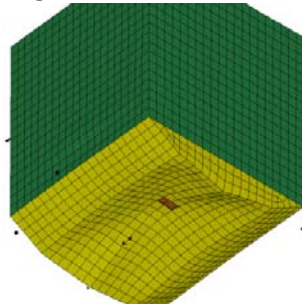
ImMAC from NASA Glenn

(Integrated Multiscale Micromechanics Analysis Code)



All-steel structure
Weight = 1631.2 Kg

Steel-composite structure
Weight = 1360.2 Kg



- Failure of outer floor
- No permanent damage in inner floor

Weight savings of 16.6 %

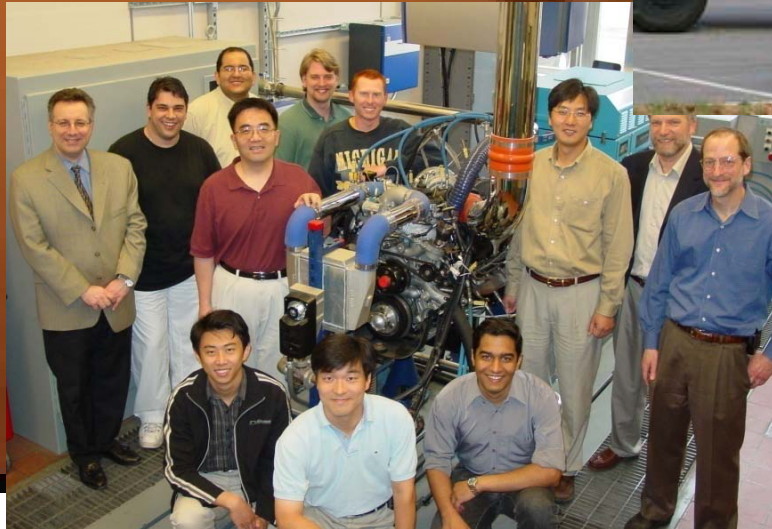
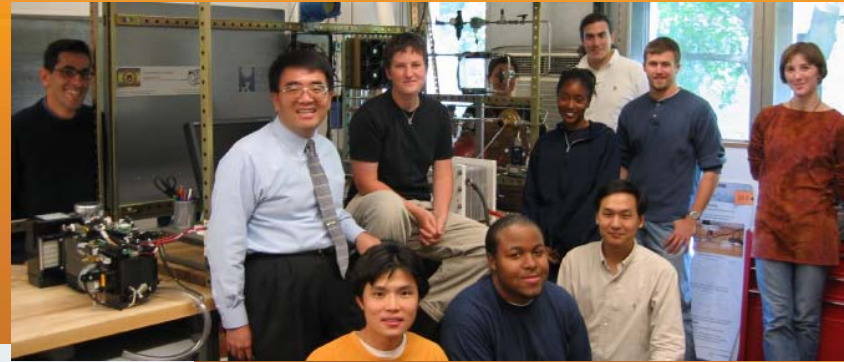
- Failure of outer floor
- No permanent damage in inner floor
- Same levels of deformation of inner floor with all-steel structure

FIBER = SiC1 (SCS6);
MATRIX = Ti-6Al-4V

Explosive threat:
6kg of C4 + steel projectiles



ARC's Commitment to our Soldiers and Students



*Pursuing Challenges with
Vision and Focus*

Dr. Grace Bochenek
Director
U.S. Army Tank Automotive
Research, Development and Engineering Center

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