



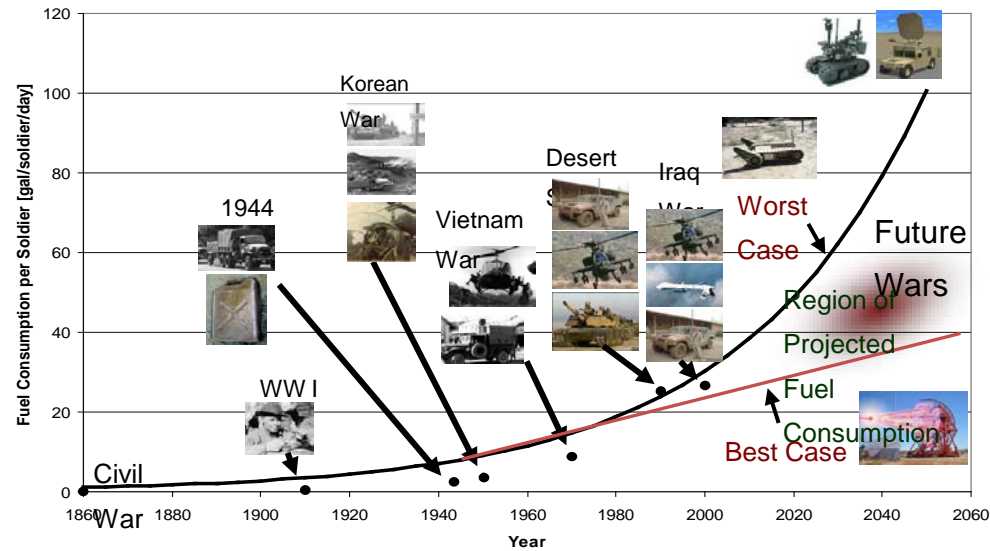
TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

Ground Vehicle Power & Mobility
17 November 10

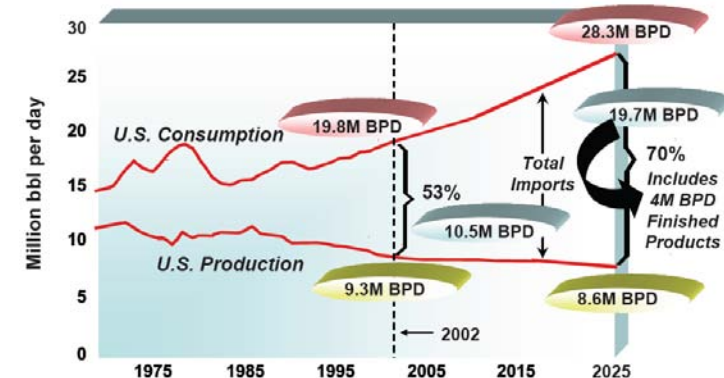
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The Challenges

- Battlefield consumption of energy increasing
 - New C4ISR technologies
 - IED Defeat Systems
 - New weapons
- Energy security problematic
 - Increasing dependence on foreign oil
 - Alternative sources sought – wind, solar, bio-mass, waste to energy
- Operational issues
 - Battery usage & limitations – energy & power density
 - Demand for auxiliary power on-board vehicles
 - Emphasis on silent (“quiet”) watch
 - Unmanned vehicles (air/ground)
 - Unattended sensors
 - Inefficient management/ distribution of power
 - Demand for soldier-wearable power
- Increased emphasis on system power metrics (KPPs, low consumption components)



The US: Our Increasing Reliance on Fossil Energy Imports

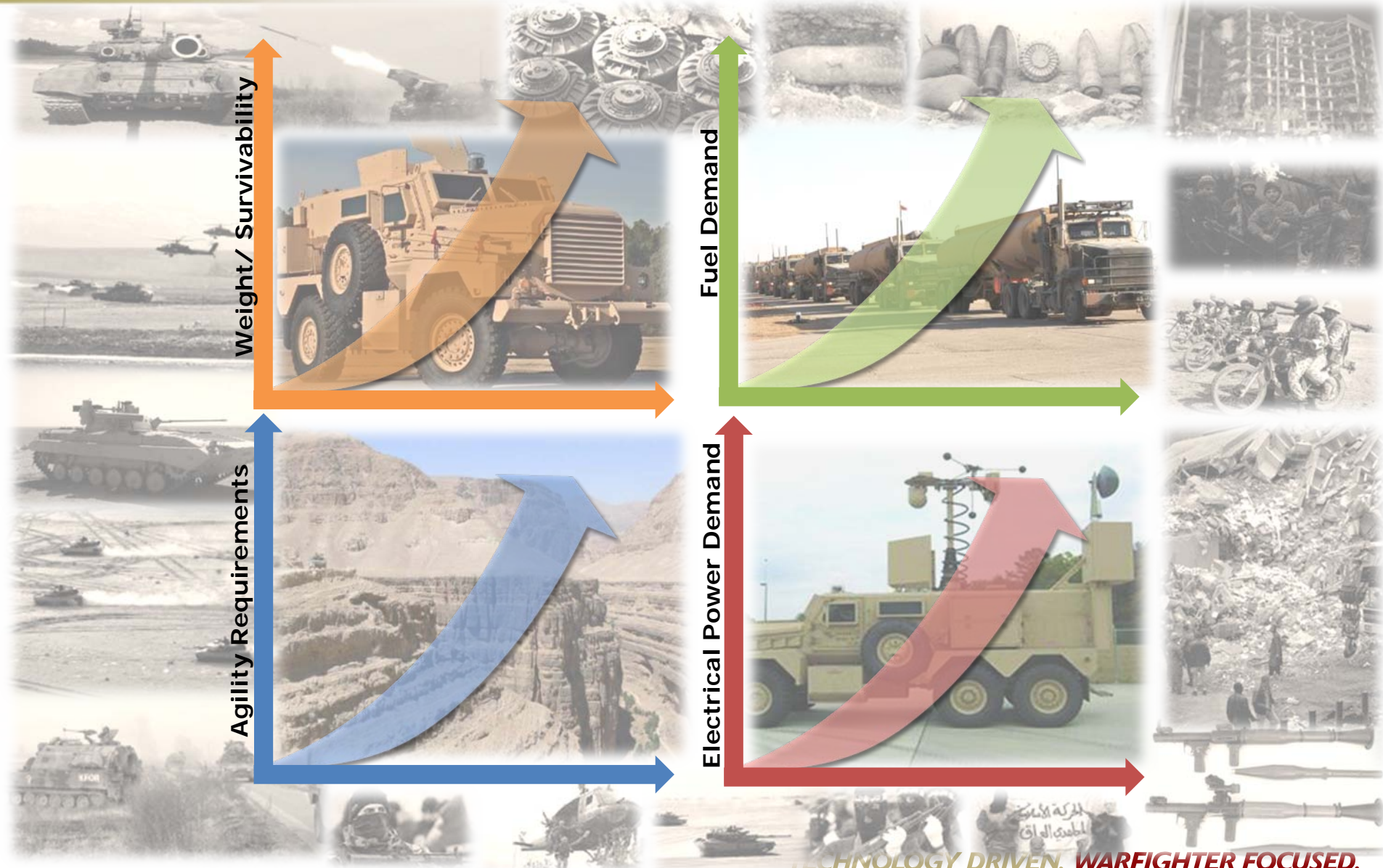


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Vision: GVPM will be the DoD's first choice for ground systems power and mobility solutions

Mission: Research, develop and deliver ground systems power and mobility technology solutions to the current and future force

Power Generation	 Diesel Engines  Rotary Engines  Transmissions  JP-8 Fuel Cells  Traction Motors  Integrated Starter & Generator  Turbine Engines  Alternators  Drivelines
Energy Storage	 Li-Ion / Ultracap Hybrid Energy Storage  Capacitors  Advanced Batteries  Fuels
Thermal Transport & Distribution	 Radiators  Thermal Interface Materials  Heat Recovery  Phase Change Cooling  Advanced Electronics Cooling  Thermal Architectures
Power Control & Distribution	 Power Controllers for Power Management  Power Converters/Inverters  Wide Band Gap Materials (SiC)  High Temperature SiC Modules  Pulse Power Switching  High Temp Inductors  High Temperature Capacitors
Track & Suspension	 Track Systems  Suspension Systems  Electronic Stability Control  Elastomer Research



GVPM Technologies for Vehicle Mobility & Energy Efficiency



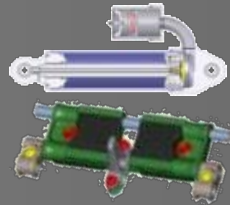
Increasing demands, operational flexibility, and inter-relationships
Requires a Systems Engineering approach and investments in key technology areas



Powertrain



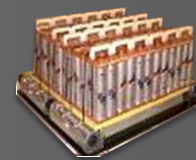
Thermal
Management



Track &
Suspension



Non-Prime
Power



Energy
Storage



Pulse
Power

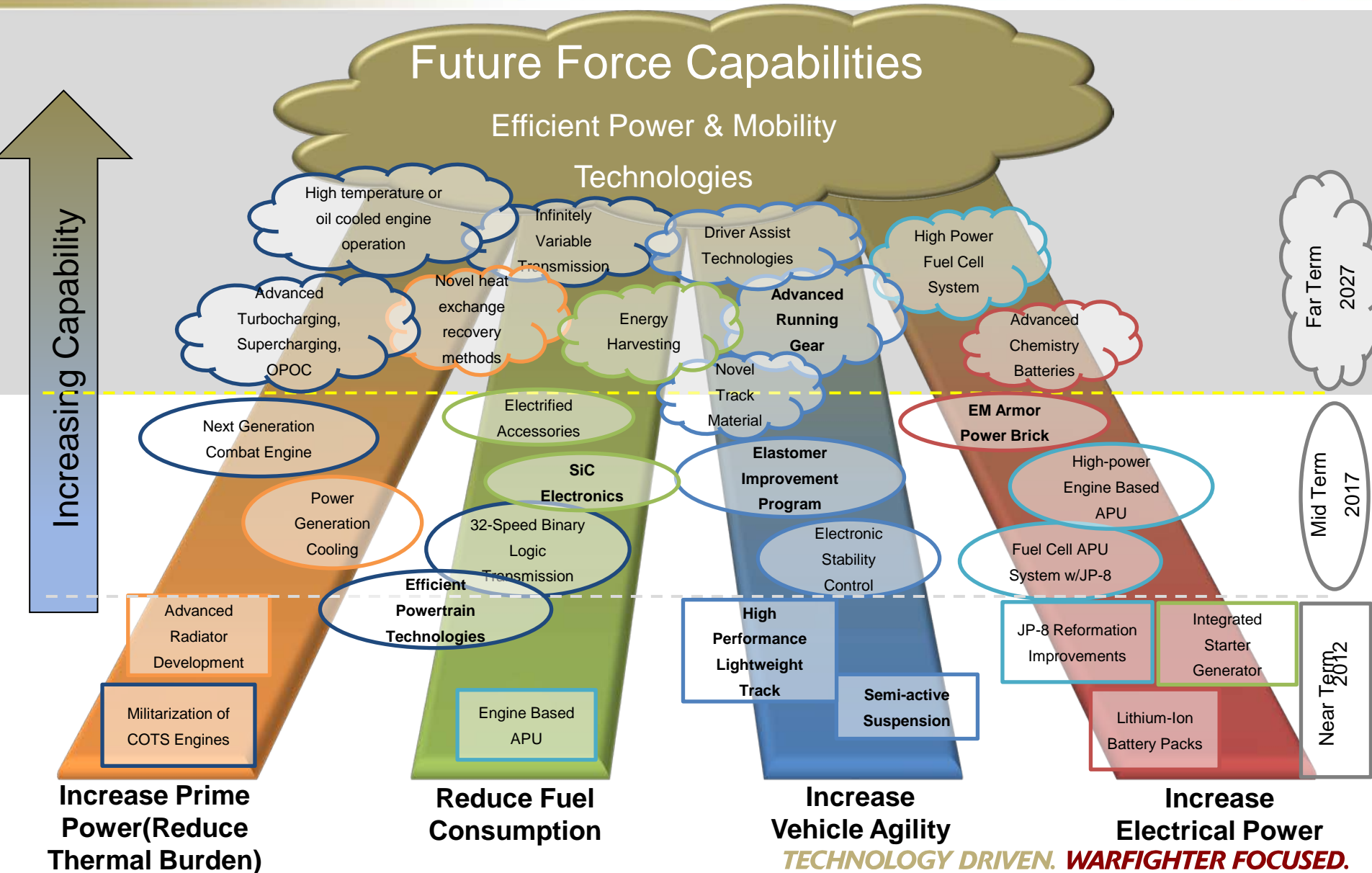


Advanced
Propulsion

Systems Level Analysis, Integration and Testing

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Capability Based Technology Strategy



• Powertrain Test Cells

- 6 test cells for performance and endurance testing of engines/drivetrains
- Dynamometers with absorption capability of 100-3000 horsepower

• Full Vehicle Environmental Test Cell

- Ambient temperature control to 160° F
- Solar load simulation
- Wind speeds up to 20mph in eight possible directions
- Two 2500 Hp dynamometers



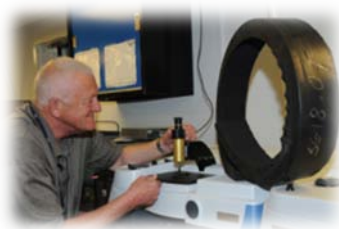
Engine Testing

• Air Flow/Cooling Lab

• Elastomer Improvement Program Lab

• Hybrid Electric Reconfigurable Moveable Integration Testbed (HERMIT)

• Ground Systems Power & Energy Labs (GSPEL)



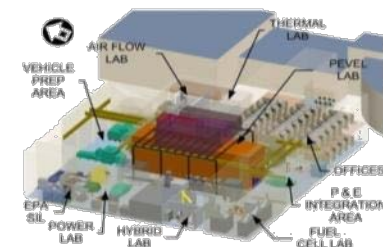
Elastomer Lab



HERMIT



Environmental Test Cell



GSPEL

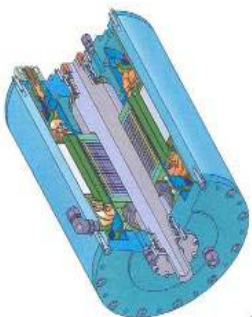
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Problem:

- Hybrid electric systems for combat and tactical vehicles are challenged to meet mobility requirements within the specified space and weight constraints
- The State Of the Art power electronics operate at low temperatures resulting in a large thermal burden, increasing the power needed from the prime mover to cool the system
- These challenges result in over sizing the engine/generator to gain power lost to the cooling system

Research Challenges:

- Research high temperature / high frequency compact power electronics
- Research high power / high torque density motor / generators



Traction Motor



DC-DC Power Converter



Integrated Starter Generator

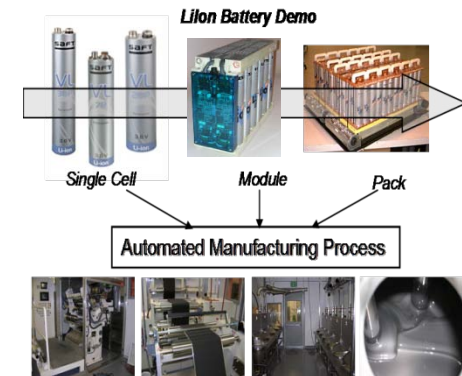
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•Problem:

- High power battery packs sized for combat hybrid electric vehicles are too large or extremely costly.
- High power advanced batteries for combat hybrid vehicle application must be safer and more reliable.

•Research Challenges:

- Research thermal runaway process and its control.
- Research power vs. energy trade-off design optimization.
- Research manufacturing process development and cost control.
- Research thermal management.
- Research cell & system, safety & reliability.
- Research system control & cell and battery management systems.
- Research alternative electrochemical improvements, including alternative chemistries and battery materials.



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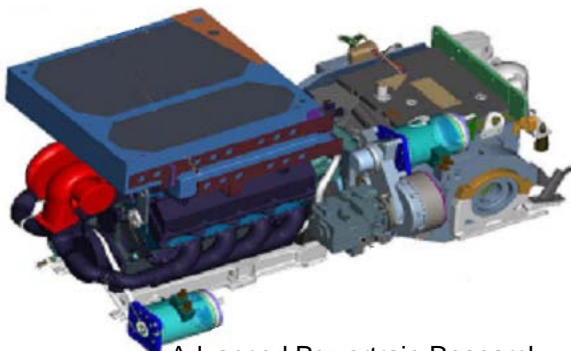
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Problem:

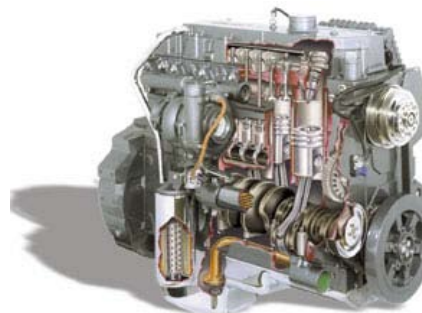
- Current high power commercial engines/powertrains are not compact enough for future manned ground combat platforms.
- Future ground combat vehicles will require lighter and more efficient powertrains that occupy less space, improve vehicle mobility, reduce fuel consumption and thermal load.
- Current state of the art engines require significant development to operate on one fuel forward (JP-8) and meet future vehicle power and mobility needs.

Research Challenges:

- Diesel combustion research to increase physical burn time.
- Propulsion system research to increase power density and efficiency.
- Propulsion system thermal management research.
- Research combustion optimization strategy for JP-8 military version of an emission compliant commercial. Engine control strategy for maintaining power with alternative heavy fuels.



Advanced Powertrain Research
And Development



Advanced Engine Research



Advanced Combustion
System Research

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Problem:

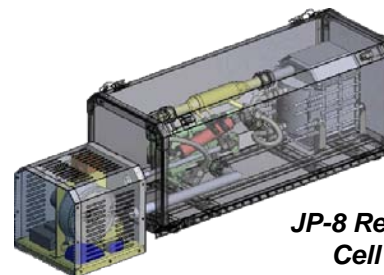
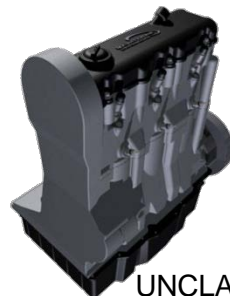
- Current non-primary power approach in field is inadequate for silent watch.
- Lead-acid batteries store insufficient energy to meet War Fighter requirements for vehicle silent watch (main engine off). Silent watch requirements vary from several hours to 24 hours. Current approach requires restarting of main engines during silent watch to recharge batteries, causing excessive fuel use, acoustic and thermal signatures.

Research Challenges:

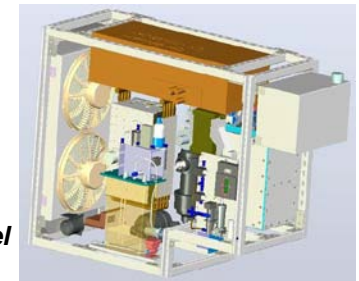
- Research engine-generator technologies with high power densities and low acoustic signatures.
- JP-8 reformation and desulfurization necessary for battlefield fuel cell application.
- Integration of fuel cells with JP-8 reformers to create APU system compatible with combat vehicle requirements
- Research fuel cell system optimization with batteries and ultra-capacitors.



Power Dense APUs



JP-8 Reformed Fuel Cell Systems



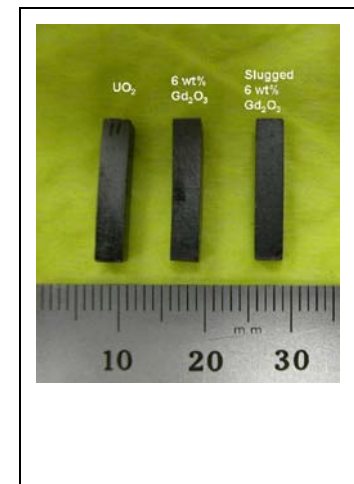
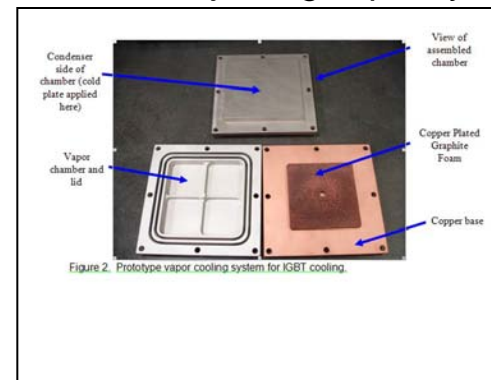
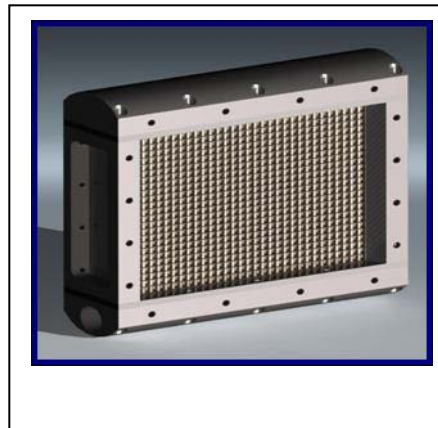
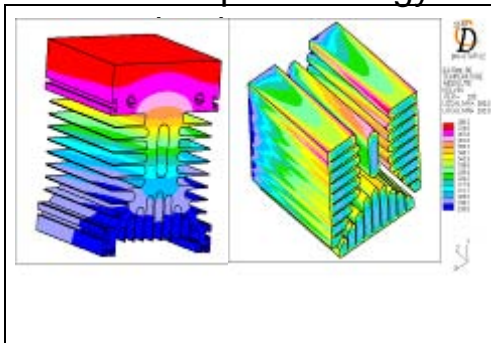
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Problem:

- Cooling systems are insufficient to meet mobility requirements of future combat vehicles.
- Vehicular space claims limit additional heat rejection ability
- Increased demands for electrical power significantly impacts vehicle's cooling system sizes and weights
- Thermal degradation has direct impact on component life and reliability.
- Lack of intelligent control strategies for power system adds to thermal burden.
- Insufficient data exists on the efficiency benefits of emerging technologies applied to vehicle power electronics

Research Challenges:

- Intelligent thermal (heating/cooling) management system have not yet been explored
- Develop technology that requires less volume and greater heat rejecting capacity than current



- **High power and temperature capable Power Electronics.**
- **Advanced component and system Thermal Management systems.**
- **Advanced component and system Power Management systems.**
- **Military adaptable, high power density, efficient, Diesel Engines.**



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