Power & Energy from an Army Ground Vehicle Perspective

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Agenda

• Army Ground Vehicles Introduction
• War Fighter Outcomes and Power/Energy Needs
• Army Ground Vehicle Challenges
• Engine Emissions Policy
• Networked Energy Concept
• Future Directions
Army Ground Vehicles

300,000 + tactical and combat vehicles (150 – 1500 BHP)
240,000 + trucks – class 2 thru class 8 + (150 – 500 BHP)
40,000 + 2-stroke powered vehicles (200 – 500 BHP)

MRAP - Mine Resistant Ambush Protected

PLS – Palletized Loading System

HEMTT – Heavy Expanded Mobility Tactical Truck

*FVPDS (Jan. 2000)
Fielded Vehicle Performance Data Systems
COMBAT VEHICLES

- M1 Abrams (AGT-1500)
- M109/M110 Self Propelled Howitzer (8V71T)
- M2/M3 Bradley (VTA-903)
- M88 Medium Recovery Vehicle (TCM-1790)
- M578 – Light Armored Recovery Vehicle (LRC) – (8V71T)
- M60 family (TCM-1790)
- Chaparral Missile Launcher (6V53T)
- FAASV – Fast Assault Ammunition Supply Vehicle (8V71T)
- M551 Sheridan Assault Vehicle (6V53T)
- Stryker (3126/C7)

TACTICAL VEHICLES

- HET Heavy Equipment Transporter (8V92TA)
- HEMTT Heavy Expanded Mobility Tactical Truck (8V92TA)
- PLS Palletized Loading System (8V92TA)
- 2.5 Ton Truck (LD-465/LDT-465)
- M939 5 Ton Truck (NHC 250/6CTA8.3)
- M915/M916 Line Hauler (NTC400/S-60)
- M917, M918, M919 Tractor (NTC 400)
- HMMWV (GM 6.2/6.5 IDI)
- CUCV Commercial Utility Cargo Vehicle (GM 6.2/6.5 IDI)
- Family of Medium Tactical Vehicles (C7)

LEGEND: black: four-stroke diesel  red: two-stroke diesel  blue: gas turbine
10 Comprehensive Warfighter Outcomes

- Battle Command Network
- Counter IED and Mine
- **Power and Energy**
- Human Dimension
- Training
- Force Protection
- Battlespace Awareness
- Force Application
- Logistics
- Unmanned Systems Operations
- Provide enhanced ability to operate worldwide by reducing by half, the weight and volume of fuel associated with powering the force.

- Combat platforms require up to 30 MJ of pulsed power for lethality and 20 percent increase in continuous power to enable superior tactical mobility, speed and an excess capacity for on/off board electrical power use while increasing fuel economy by 40 percent.

- Emerging electrical components and systems require dismounted Soldiers to possess a fourfold increase of available power, above current 12.3 Watts-Hr, at half the tactical weight.
$10 per barrel increase in oil increases DoD costs by ~$1.3B per year
<table>
<thead>
<tr>
<th>Description</th>
<th>Quantity</th>
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<tbody>
<tr>
<td>Kuwait/OIF/OEF Fuel to FOB (Million gallons/yr)</td>
<td>431</td>
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<tr>
<td>Fuel trucks needed</td>
<td>140,075</td>
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<td>Convoys needed</td>
<td>9,332</td>
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<tr>
<td>Soldiers per convoy trip (Fuel trucks, protection, other support)</td>
<td>120</td>
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<tr>
<td>Soldier trips</td>
<td>644,360</td>
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<tr>
<td>Fewer Soldier trips (Resulting from 1% Fuel Savings)</td>
<td>6,444</td>
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On Board Electrical Power

- Growing need for countermeasures, protection, sensors, ad hoc HVAC, etc.
- Silent watch need; minimal noise
  - In-line starter generators
  - Auxiliary power units
  - Hybrid propulsion architecture
  - Fuel cells
  - Batteries
- Can’t impede mobility
  - Dash speed, top speed on grade, high tractive effort to weight cooling
- One solution does not fit all vehicle applications
Army Ground Vehicle Propulsion

Challenges

1. Cooling
2. Cooling
3. Cooling
4. Fuel Effects
5. Filtration

The Army vehicle cooling point is high tractive effort to weight under desert-like operating conditions (ex. 5 ton wheeled vehicle ~0.6 while 15 ton tracked vehicle ~0.7 both at 120 F ambient)
High Power Density Propulsion Systems – Combat Vehicles

- Army definition of Propulsion System Power Density (PD):
  - PD = sprocket (wheel) power / total propulsion system volume [bhp/ft$^3$]
  - Air filtration requirements, thermal management system, transmission, engine (fuel), ducting requirements

Ex. Bradley FIV: PD = 3
FCS MGV target: PD = 6
Research target: PD > 8-10
Excess fan power eats up engine power

Sprocket Hp vs Engine Hp
Ambient Air 120°F

Low heat rejection/unconventional coolants and temperatures

Conventional heat rejection and coolant temperatures

Excess fan power eats up engine power
• **Sulfur content:** max. 3000 ppm
• **Aromatics:** max. 25%
• **Specific gravity:** 0.775 – 0.84
• **Evaporation Characteristics:**
  – 10% recov.: max. 205 C
  – End point: max. 300 C
• **Net Heating Value:** min. 42.8 MJ/kg
• **Cetane Index:** none
JP-8 Cetane Index
Worldwide Trend in 2007

Mean regional CI
Middle East – 46
U.S. Pacific – 40.8

Mean Worldwide CI Value since 2003: 43 - 44
Engine Emissions Policy

• The Army cannot buy 2007 or Tier IV (> 75 bhp) compliant COTS engines and directly integrate into current and new heavy-duty vehicles.

• Combat vehicle: permanent armor/attached weapon system – National Security Exemption (NSE) via 40 CFR, 89.908

• ‘Tactical Vehicles’
  ✓ Without ARMOR – NSE from 2004 and 2007 standards (i.e. meet 1998) and Tier IV
  ✓ With ARMOR – NSE from ALL standards
Engine Emissions Solution
Pathways

• Near term
  – Modified on-road COTS minus cooled EGR and exhaust aftertreatment
  – TIER II or TIER III engines

• Mid term
  – Modified on-road COTS and TIER IV minus cooled EGR and exhaust aftertreatment
  – Tier II or TIER III engines

• Long term
  – unknown
Vision: Entities that share energy:
- From those that have it, to those that need it...
- Redundant energy sources = increased energy security

Improving energy capability through holistic power sharing - you’re in the fight...!
Ground Vehicle Power and Energy Future Directions

- **Advanced Propulsion System**
  - Low heat rejection and high power to weight ratio engines; propulsion materials
  - Heavy-fuel flexible and more efficient engines
  - More efficient transmissions
    - Longitudinal and cross-drive; wider ratio
  - Hybrid propulsion for mission specific applications
  - Energy Recovery Systems

- **On-Board Electrical Power**
  - In-line starter generators, auxiliary power units, fuel cells
  - High energy and power density batteries
THANK YOU!
BACK UPS
RDECOM Strategic Directions in Power and Energy

- Higher Energy Power Sources for Soldiers and Sensors
- Unmanned Air and Ground Platforms
- Intelligent Energy Management with Alternative Energy Sources
- Ground Platforms Auxiliary Power and Quiet Watch Capabilities
- High Energy Weapons

DDR&E Energy and Power Areas of Opportunity

- Tactical Energy Independence
- Autonomous Platform Power
- Grid Power Distribution & Control
- Platform Efficiency & Environmental Impact
- Electric Weapons & High Power Sensors
Strategy for Future Directions

Higher Energy Power Sources for Soldiers and Sensors

Unmanned Air and Ground Platforms

Intelligent Energy Management Coupled with Alternative Energy Sources for Reduced Logistical Burden (Combat Outposts)

Ground Combat & Tactical Vehicles Vehicle Auxiliary Power and Quiet Watch Capabilities

High Energy Weapons

Rucksack Portable Power System

Trojan Vehicle Fitted with Rolls-Royce APU

Reformed Methanol Hybrid Fuel Cell

High Energy Weapons
Power & Energy Technology Gaps

C4ISR & Soldier
High Density Storage for Soldiers and Platforms
Logistic Fuel Conversion for Auxiliary Power Sources
Efficient, High Density Alternative Energy Capture and Conversion

Ground
Power Sources and Conversion for Small Autonomous Systems
On Board Power-Higher Density, Higher Power Mechanical To Electrical Conversion
Intelligent, Scalable Power Management & Distribution
Integrated Power Management on Platforms

Air & Effects
Reliable Extended Shelf Life Power Sources for Munitions
High Temperature Power Electronics for Platforms