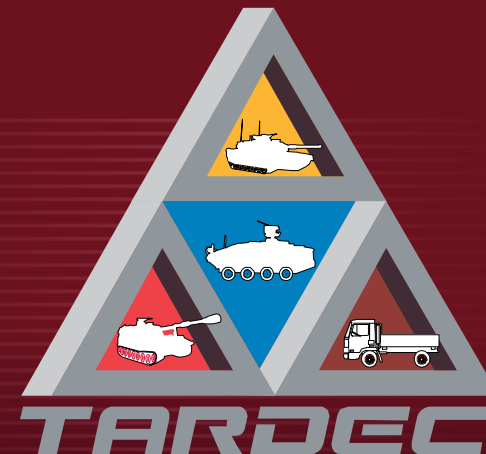




RDECOM



TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

An Army Discussion on Ground Vehicles and the ARC

May 20, 2008

Report Documentation Page				Form Approved OMB No. 0704-0188	
Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.					
1. REPORT DATE 20 MAY 2008		2. REPORT TYPE N/A		3. DATES COVERED -	
4. TITLE AND SUBTITLE An Army Discussion on Ground Vehicles and the ARC				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S) Pete Schihl				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) US Army RDECOM-TARDEC 6501 E 11 Mile Rd Warren, MI 48397-5000				8. PERFORMING ORGANIZATION REPORT NUMBER 18880	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSOR/MONITOR'S ACRONYM(S) TACOM/TARDEC	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S) 18880	
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release, distribution unlimited					
13. SUPPLEMENTARY NOTES Presented at the 14th Annual ARC Conference May 20-21, 2008, Ann Arbor, Michigan USA, The original document contains color images.					
14. ABSTRACT					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT SAR	18. NUMBER OF PAGES 23	19a. NAME OF RESPONSIBLE PERSON
a. REPORT unclassified	b. ABSTRACT unclassified	c. THIS PAGE unclassified			

- Introduction to Army Ground Vehicles
- TARDEC Strategic Thrust Areas
- Mobility and Propulsion Synergy with TARDEC
- Conclusions



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

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

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



Background - Army Ground Vehicles



COMBAT VEHICLES

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

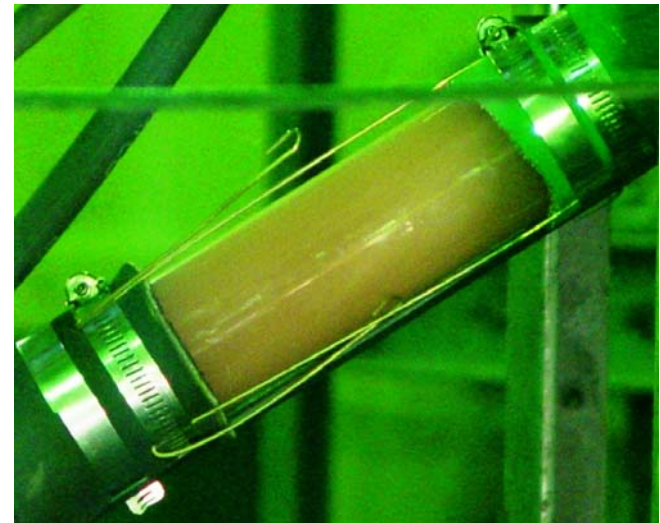
TACTICAL VEHICLES

- **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)**
- **FMTV (Cat C-7)**

LEGEND: **black:** two-stroke diesel **red:** four-stroke diesel **blue:** gas turbine

- Highly mobile
 - Transient response; high load capability; operate in high and low temperature regions; accommodate particle laden environments
 - Grade-ability; side sloping
- Survivable
 - Resist all attacks; penetrators, IEDs, EFPs, etc.
- Intelligent
 - Collect and integrate situational awareness information for decision makers
 - Unmanned vehicle use

- Power and Energy
- Survivability
- Condition Based Maintenance
- Intelligent Systems



- Power and Energy
 - complex power and energy management systems
 - high temperature operation, thermal management
- Survivability
 - Safety, rollover protection, driver training
 - advanced materials for addressing RBG and IFD threats
- Condition Based Maintenance
 - Health monitoring and prognostic capability
- Intelligent Systems
 - Unmanned ground vehicles (power/energy management, terrain interaction)

Mobility and Propulsion Discussion



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

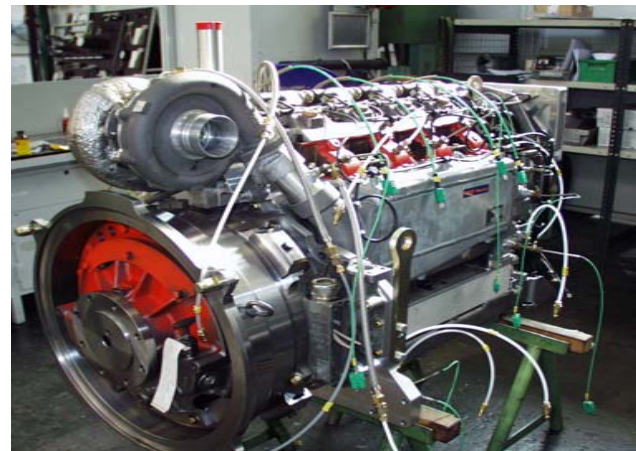


The Army vehicle cooling point is high tractive effort to weight under desert-like operating conditions (ex. 5 ton wheeled vehicle ~ 0.6 while 15 ton tracked vehicle ~ 0.7 both at 120 F ambient)

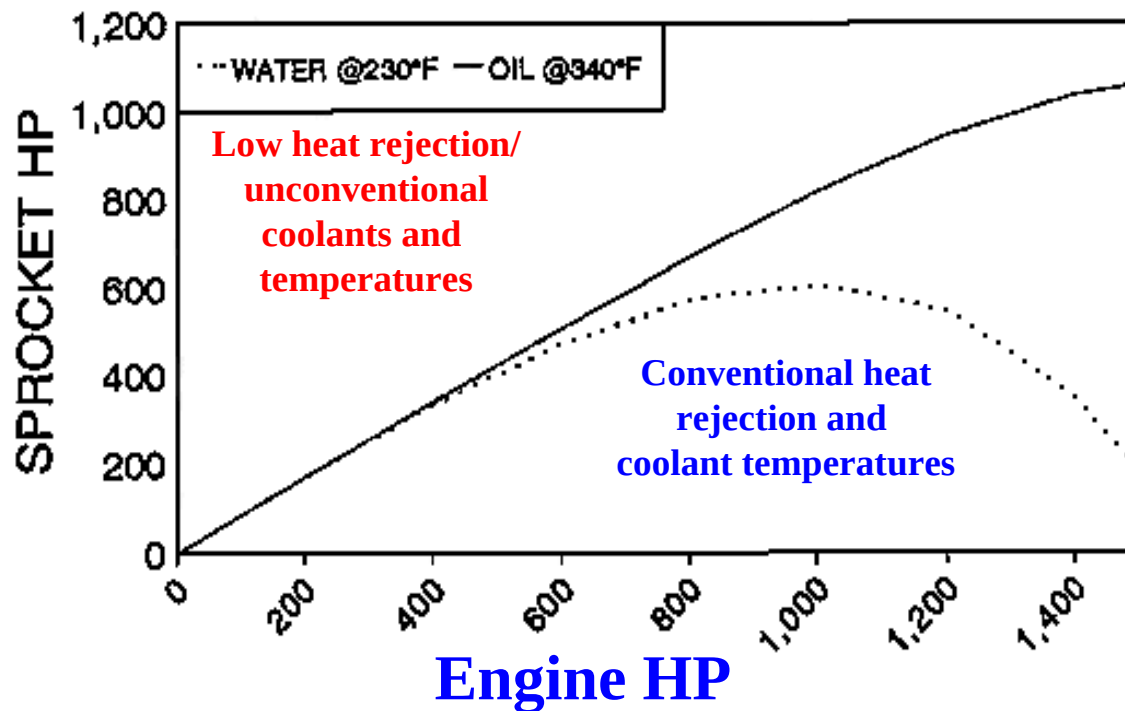


- Army definition of Propulsion System **Power Density (PD)**:
 - $PD = \text{sprocket (wheel) power} / \text{total propulsion system volume [bhp/ft}^3\text{]}$
 - Air filtration requirements, thermal management system, transmission, engine (fuel), ducting requirements

Ex. Bradley FIV: $PD = 3$
FCS MGCV target: $PD = 6$
Research target: $PD > 8-10$

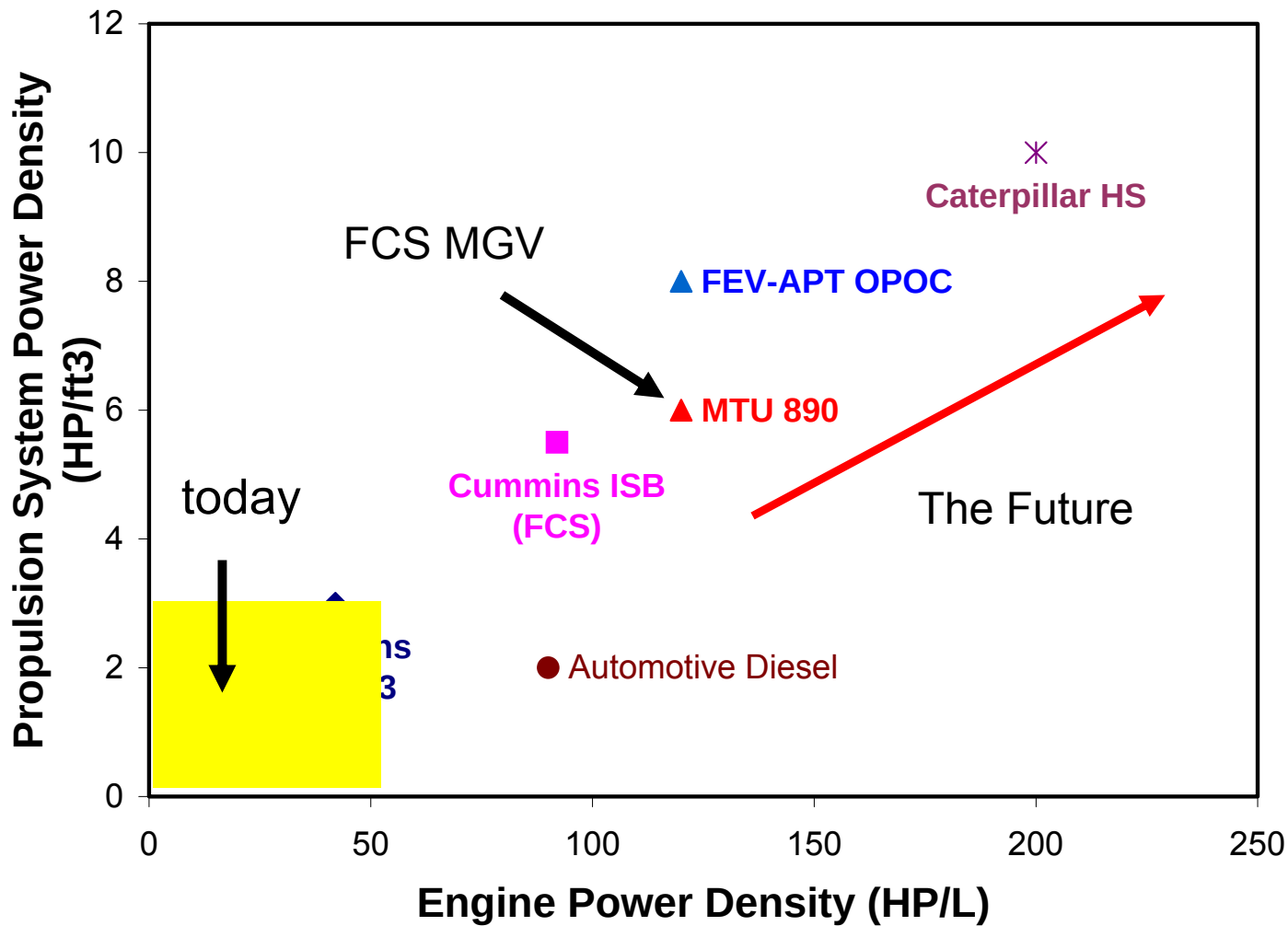


Sprocket Hp vs Engine Hp Ambient Air 120°F



Excess fan power eats up engine power

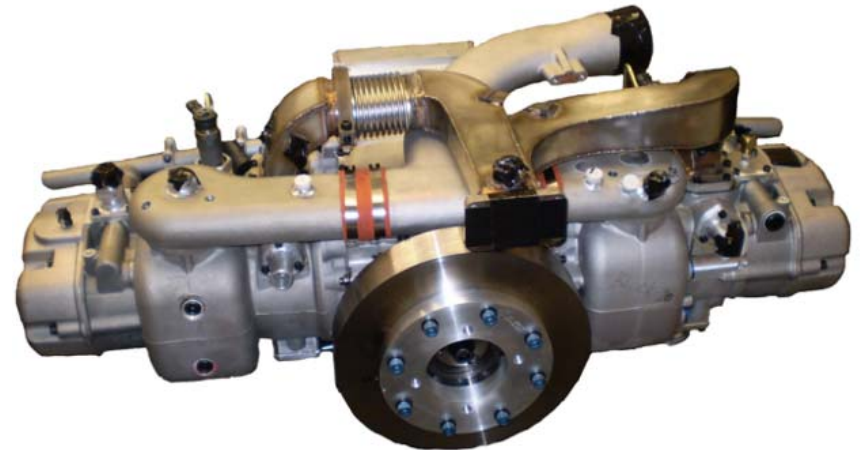
High Power Density Military Engines





High Speed Combustion Targets

- Rated speed: 6000 rpm
- Engine Power Density
 - 200 BHP/L
- Engine Heat Rejection
 - 25 BTU/bhp-min (0.6 kW/kW)



Opposed Piston Opposed Cylinder (OPOC) Targets

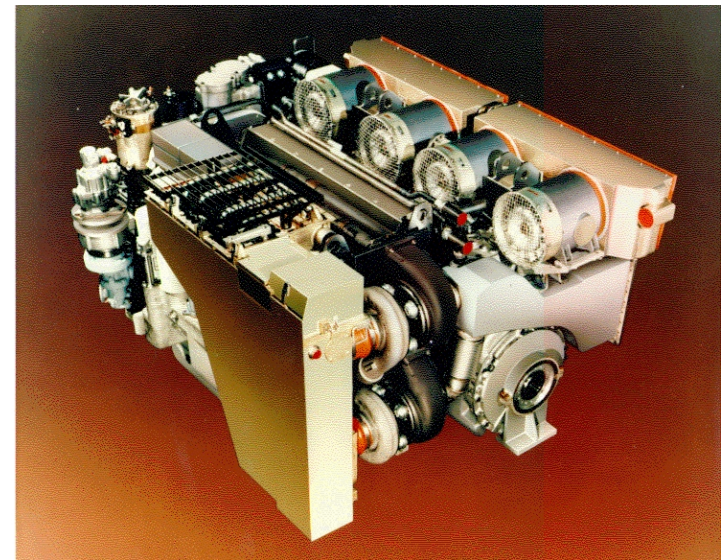
- Engine Power Density (125 BHP/L)
- Engine Heat Rejection
 - 18 BTU/bhp-min (0.43 kW/kW)

Current and Future Military High Power Density Needs

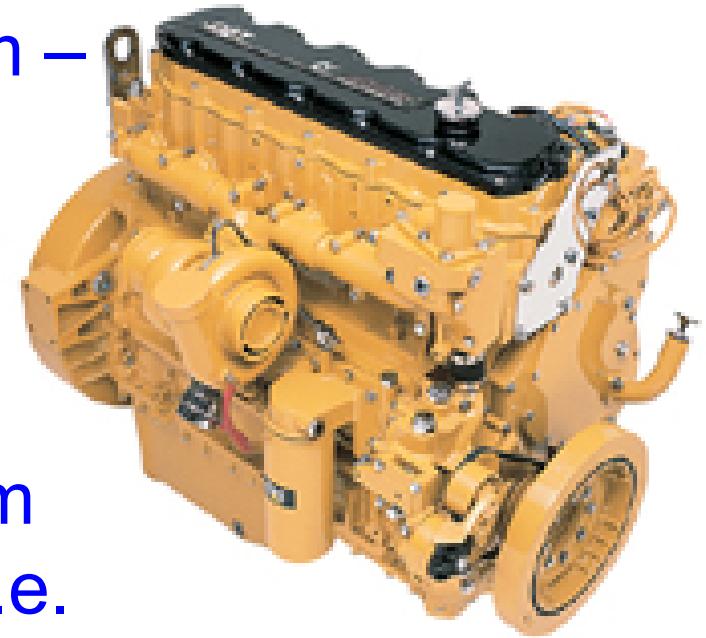
- High pressure ratio turbocharging: $PR > 5$
- High temperature in-cylinder package
 - Reduce CAC requirements (higher intake manifold temp.)
 - High oil sump temperatures
 - Combustion surface high temperature capability
- Advanced combustion systems with multi-fuel capability (DF-2, JP-8, JP-5, Jet A, Jet A1)
 - Closed-loop in-cylinder control
 - High pressure, flexible fuel injection systems with high volumetric delivery rate
 - Push toward high load, low air-fuel ratio heat release
- Strategic and innovate cooling strategies

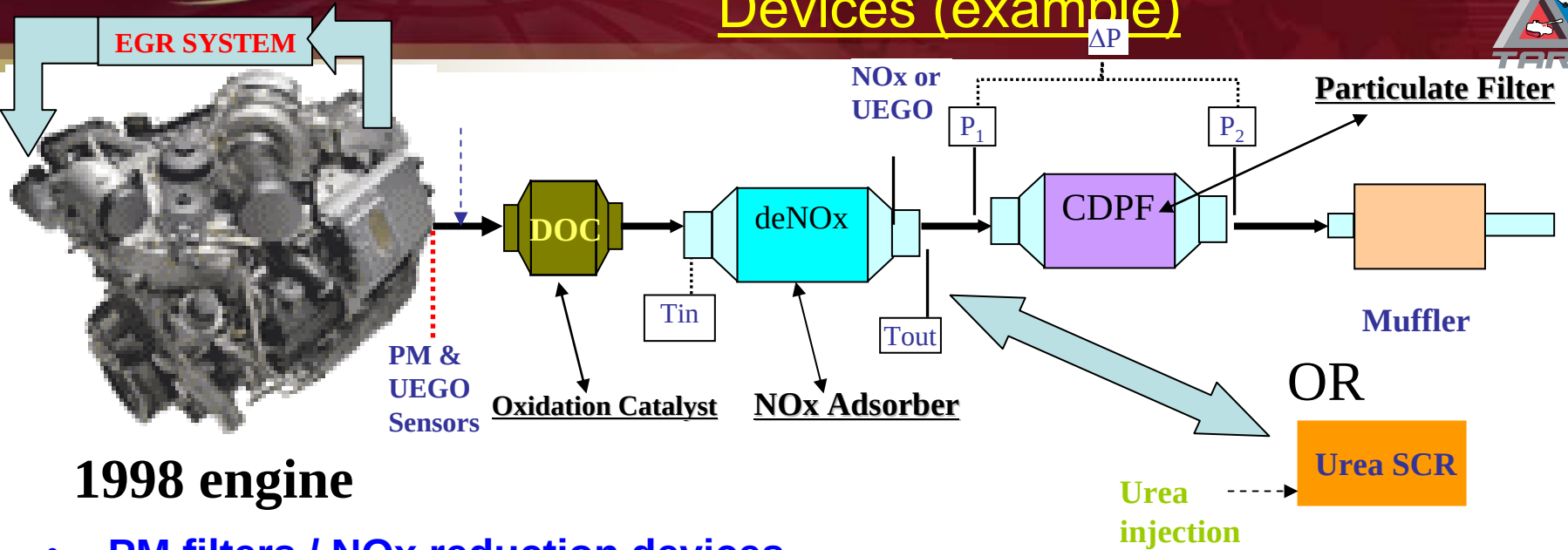


Advanced High
Pressure Fuel
Injection Small Hole Combustion Study



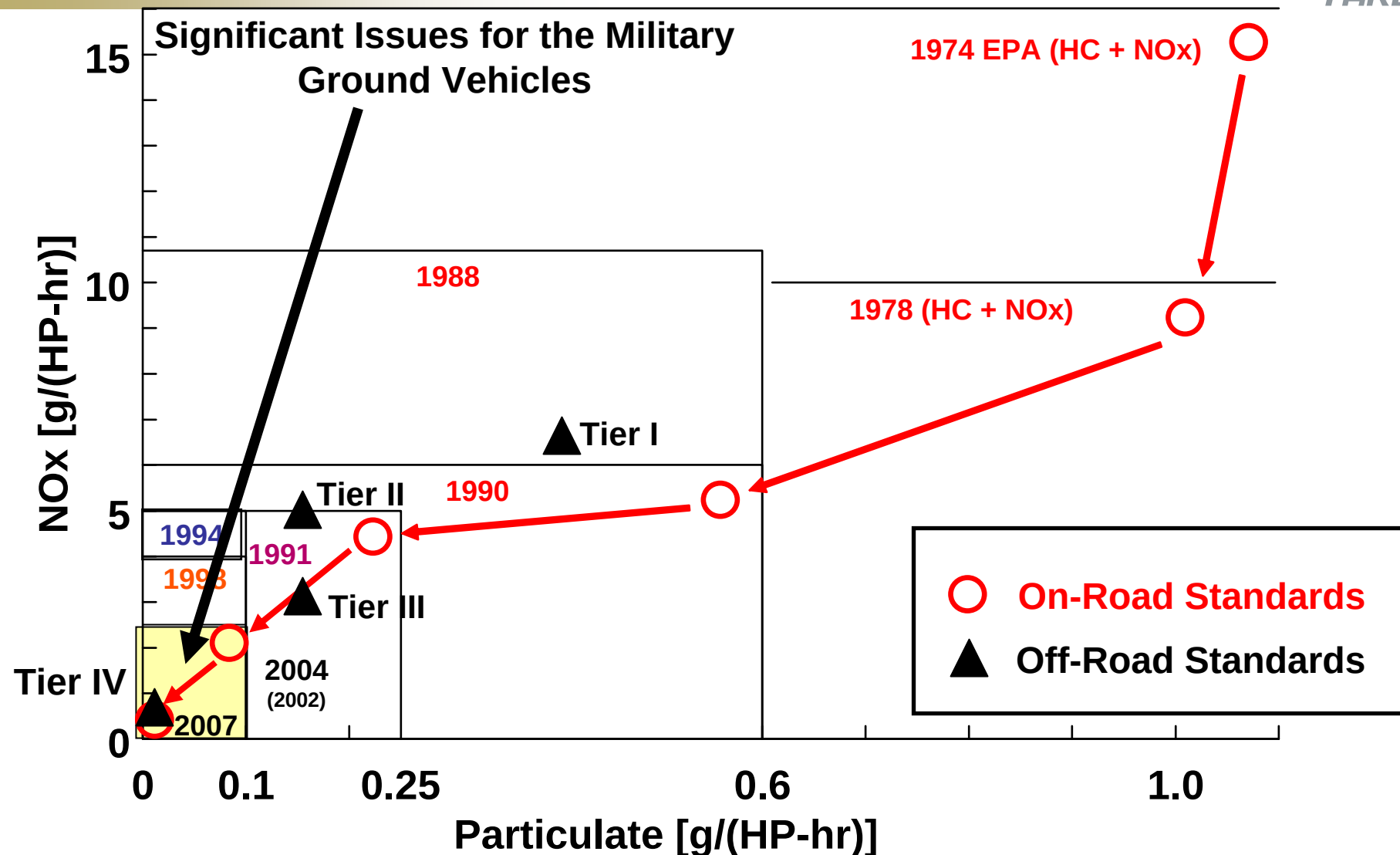
- Combat vehicle: permanent armor/attached weapon system – National Security Exemption (NSE) via **40 CFR, 89.908**
- ‘Tactical Vehicles’
 - ✓ Without ARMOR – NSE from 2004 and 2007 standards (i.e. meet 1998)
 - ✓ With ARMOR – NSE from ALL standards



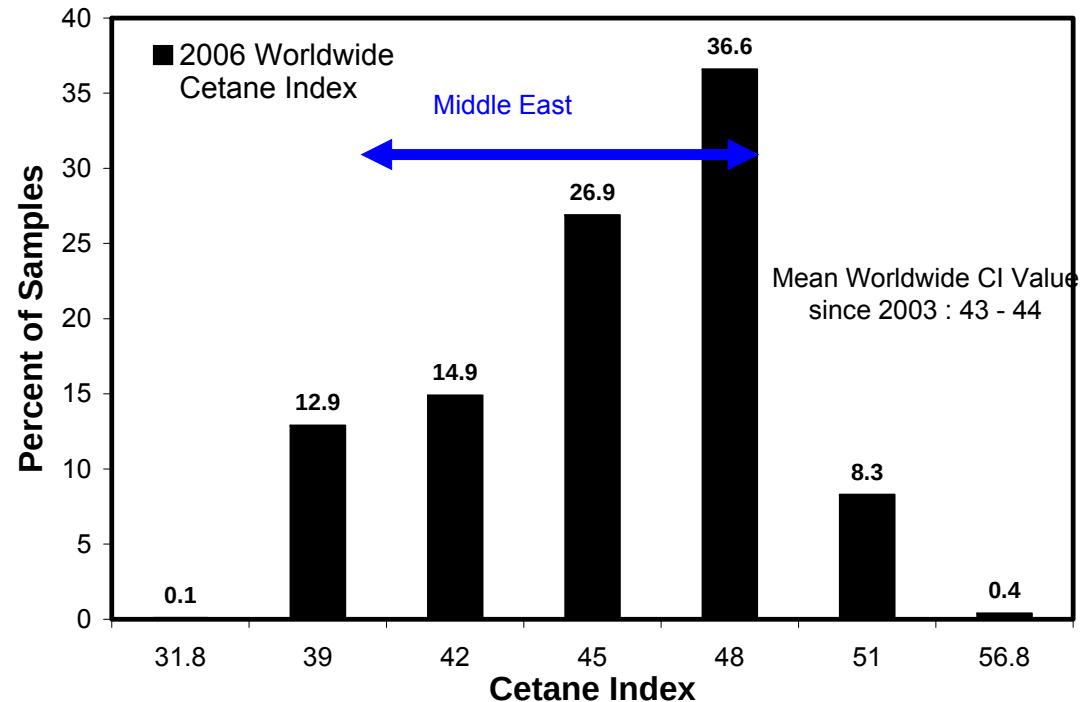


- **PM filters / NOx reduction devices**
 - ✓ Catalyzed filters (DOC + CDPF)
 - ✓ NOx trap (adsorber) vs. Urea SCR (selective catalytic reductant)
 - ✓ Additional space claim , **conservatively 5 x engine displacement**
- **NOx trap requires < 15 ppm fuel sulfur level**
- Likely to include high levels of EGR in addition to NOx aftertreatment device
 - ✓ higher heat rejection (~ 60% increase vs. MY1998)
- Oil formulation to extend CDPF lifetime
- Urea SCR requires on-vehicle, urea storage tank

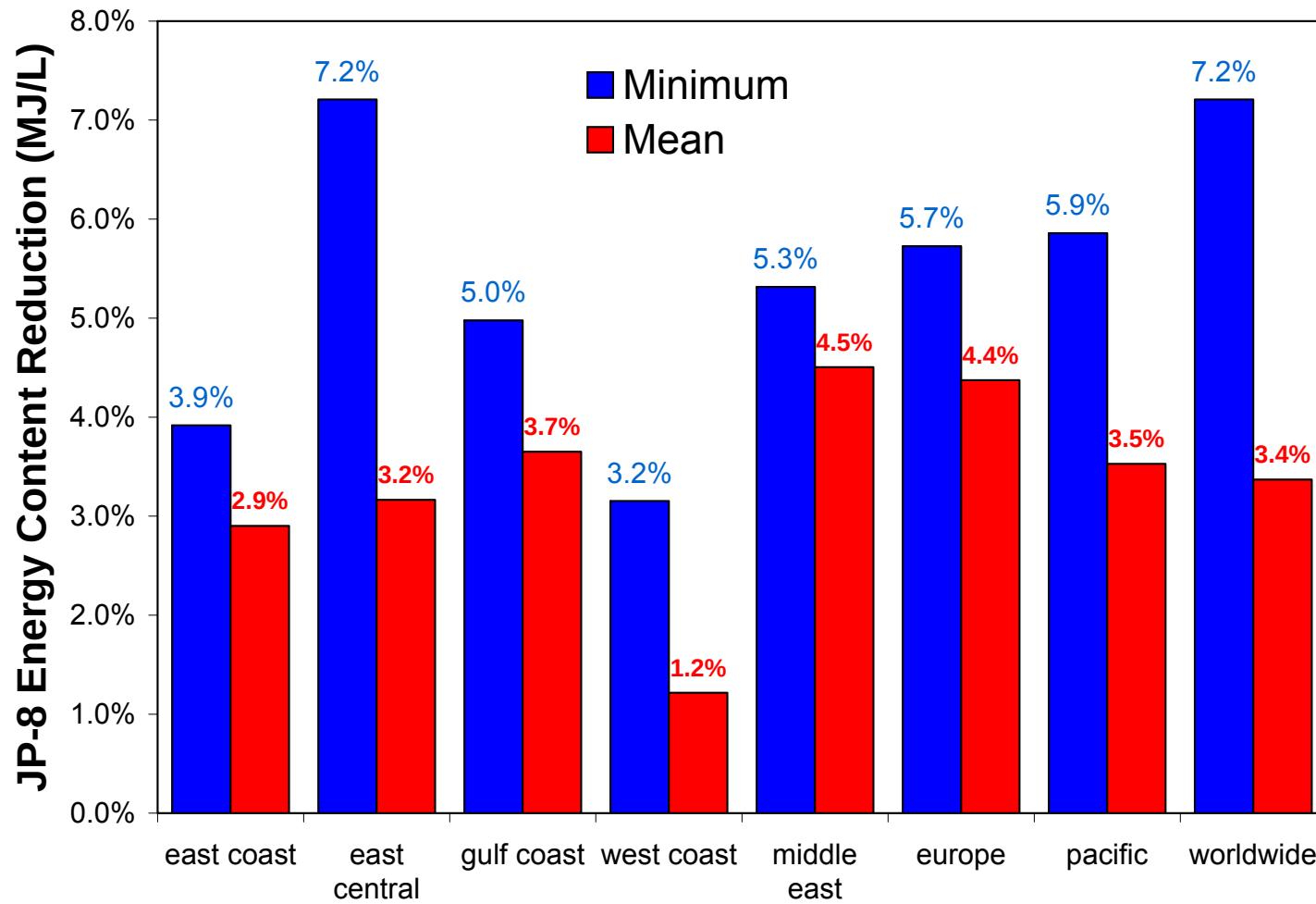
Evolution of the U.S. Diesel Emission Standards

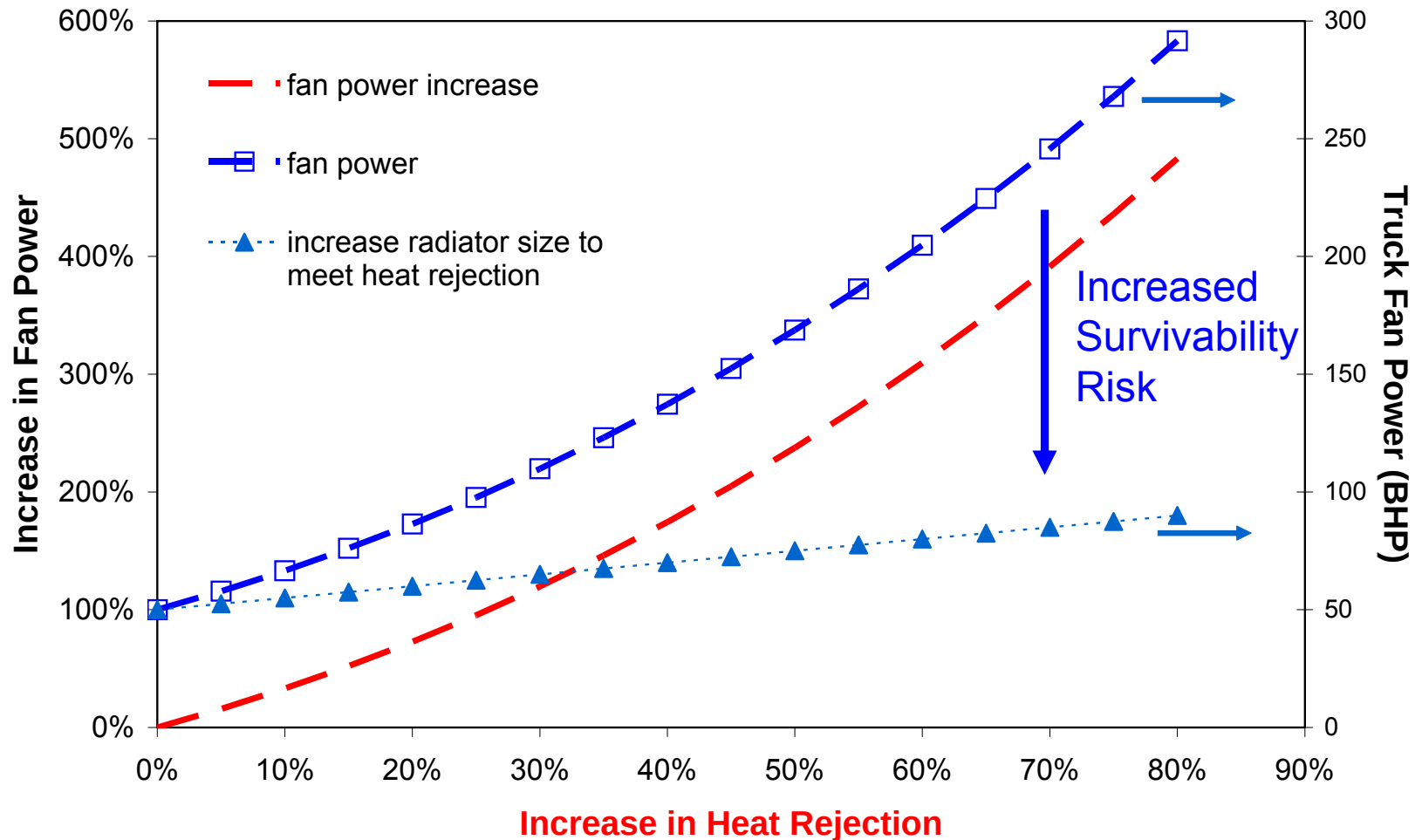


- **Sulfur content: max. 3000 ppm**
- Aromatics: max. 25%
- Specific gravity: 0.775 – 0.84
- Evaporation Characteristics:
 - 10% recov.: max. 205 C
 - End point: max. 300 C
- Net Heating Value: min. 42.8 MJ/kg
- **Cetane Index: none**



JP-8 Energy Density Question





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



Conclusion

- ARC will continue to support Army and TARDEC 'needs' in key thrust areas
 - Power and Energy (Mobility)
 - Survivability
 - Condition Based Maintenance
 - Intelligent Systems
- Continual increase in focus on Power and Energy based on Army ground vehicle needs

THANK YOU!