SYSTEMS ENGINEERING METHODOLOGY FOR FUEL EFFICIENCY AND ITS APPLICATION TO THE FUEL EFFICIENT DEMONSTRATOR (FED) PROGRAM

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Agenda

- Fuel Efficient Demonstrator (FED) Program
- Total Vehicle Fuel Economy® process
- Complex Systems Modeling & Simulation
- Results
- Conclusions
FED Background

- Initiative by Office of the Secretary of Defense to:
  - Improve vehicle technology to reduce fuel consumption on the battlefield
  - Reduce US dependence on oil


FED Objectives

- To demonstrate a tactical vehicle with significantly greater fuel economy than an M1114 HMMWV while maintaining tactical vehicle capability

Objective: 30% Fuel Economy Improvement
FED concept meets or exceeds M1114 HMMWV capabilities with 70+% better fuel efficiency
A robust process flow with thorough planning and complete analysis of results.
Successful and risk-managed strategy for product development.
• Unique military drive cycle developed for FED program with government input
• Criteria for quantitatively evaluating design alternatives
• Robust cycle
  – High & Low Speed
  – Flat & Grades
  – On & Off Road
  – Tactical Idle
• Focus on battle space
Prioritization Framework – Total Systems

- Energy Balance
  - Unique to vehicle & drive cycle

- Efficiency Measures
  - Mapping fundamentals

- Energy Balance

- Efficiency Measures
• Outreach efforts prioritized by energy balance results & subject matter expertise
• Opportunities primarily outside defense supply base
• Focus on key subsystem data to support modeling & simulation
Leverage for Improvements

- Requirements
- Architecture
- Technology
- Specifications
Surrogate model based technology selection & vehicle performance toolset

- Supplements traditional M&S tools by integrating them
- Supports multi-attribute trade-offs
- Real-time performance prediction & sensitivity
Design Space Exploration

• Surrogate models allow simulation of hundreds of thousands of feasible design configurations
  – Trade space definition
  – Filtering according to requirement scenarios
  – Generation of Pareto frontiers

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Composite FE

GVW
System Selection

- Pareto optimization
  - No optimal solution, only data driven trade-offs
- Normalization against requirement scenarios
  - Apples to apples comparisons
- Risk management
  - Unique issue for demonstration program
- Baseline concept development
  - Early mitigation of feasibility risks
Results

- Predicted 70% efficiency improvement vs M1114
- Roadmap to 110% identified for upgrades
  - Additional improvements outside drive cycle
Conclusions

- Critical for government staff to understand requirements sensitivities
  - “The realities of system development are that EVERY requirement has a cost to implement and deliver. Given limited resources and stakeholder values, bounding the solution space requires reconciling the cost of the desired requirements with the available resources.”


Conclusions

• Feasible solutions are available to address the fuel efficiency of the military ground vehicle fleet
  – Mix of improvements oriented toward both legacy fleets versus ongoing and future programs
  – Focus on relatively low risk solutions
  – More than just technology solutions