Modeling and Simulation of an OBVP Enhanced Vehicle to Improve Fuel Economy\On-Board Vehicle Power: Past, Present and Future”

Presented to

2011 Joint Service Power Expo

Session 16, May 4, 2011

by

Gary Grider, DRS

Mike Mimnagh, ONR

Eric Mog, DRS

Hybrid Assist Program

OBJECTIVE:

Upgrade the existing ONR OBVP vehicle by adding bi-directional power converter and energy storage.

MILITARY RELEVANCE/OPERATIONAL IMPACT:

The hybrid assist capabilities can improve fuel consumption and can augment the capabilities of the vehicle during mobility. The added energy storage will significantly extend silent watch capabilities.

NAVAL S&T FOCUS AREAs ADDRESSED:

Platform Mobility and Power & Energy

TECHNICAL APPROACH:

The existing ONR OBVP vehicle will be upgraded by replacing the boost-converter power supply with a state-of-the-art Generator Controller (GSC) and Li Ion energy storage. The internal combustion engine control will be upgraded to support using the generator as a motor to assist the vehicle mobility to improve fuel consumption. The hybrid control algorithm will be developed using modeling and simulation and validated with vehicle tests

SCHEDULE:

TASKS	FY09	FY10	FY11	FY12
Conceptual Design				
Modeling and Simulation				
SIL Integration				
SIL Tests				
Vehicle Upgrade				
Vehicle Testing				

Proposed Mild Hybrid Architecture

Engine

Generator

Transmission

Coolant

Cooling System

Accelerator Pedal

Speed Controller

Generator Controller

240VDC to 400 VDC

Inverter

3-Phase Output

Power Output Panel

Battery System

CAN Communications

System Controller

Sensors/ Other Comm

User Interface

OBVP-I, OBVP-II, and Mild Hybrid

OBVP-II, and Mild Hybrid

Mild Hybrid

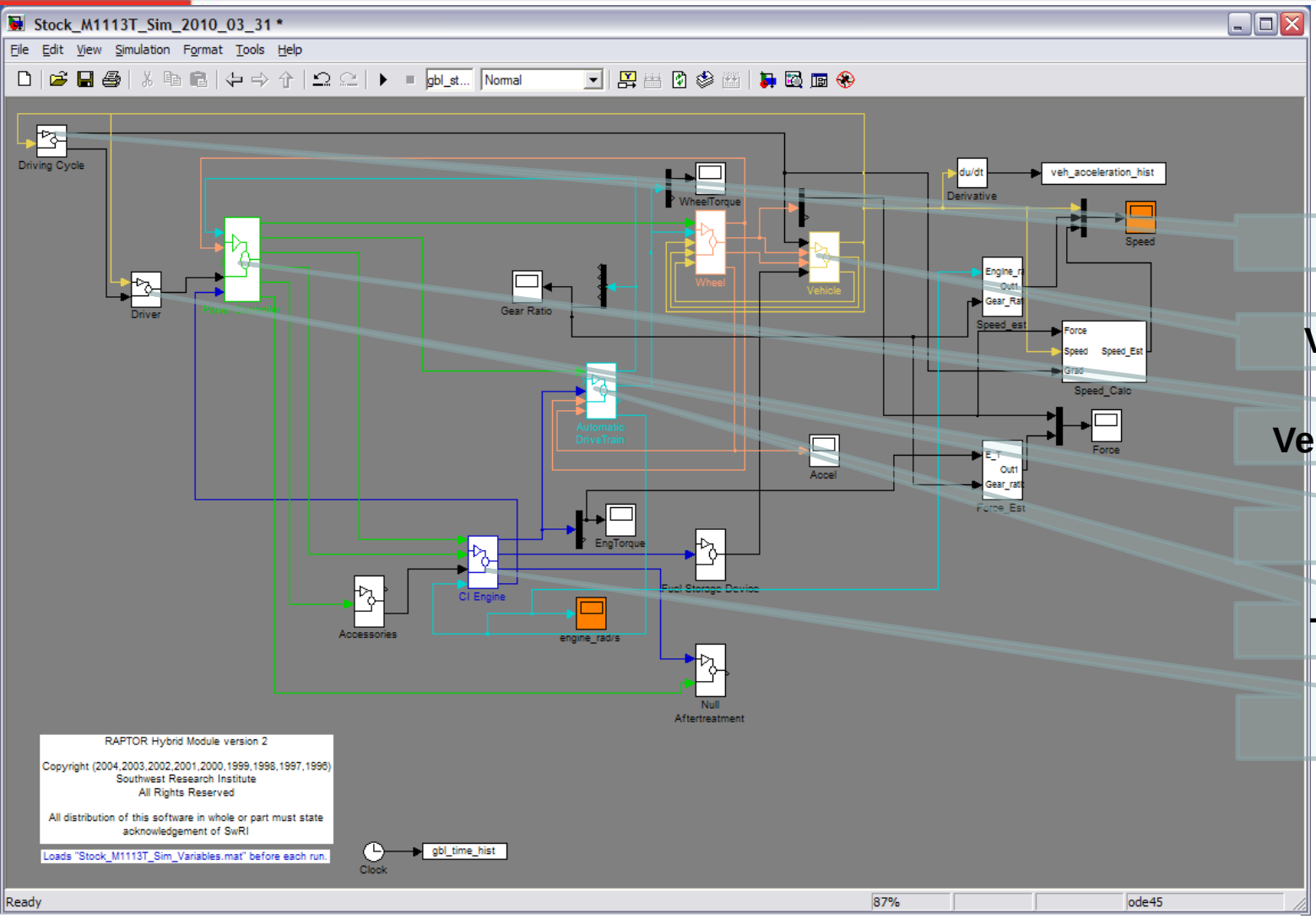
Controller will be identical to USMC HMMWV OBVP hardware developed on DRS IR&D funds. GFE Li Ion battery pack for experimental testing in GFY 11 and 12

Conclusions From GFY10 Trade Study

- Stationary fuel economy (based on vehicle data) can improve in excess of 50% with the inclusion of energy storage
- Software changes, added sensors, a new accelerator pedal, and a new speed controller are needed to perform mobile mild hybrid applications (mobile fuel economy enhancement, torque assist, starting capabilities).
- Trade study shows potential for fuel economy (reference 2010 trade study); more exploration and simulations are needed to determine details of potential improvement.
- If power is required from the vehicle on the move, the mild hybrid capabilities will be reduced. Supplying power is the priority of OBVP.

Trade study verifies that fuel savings can be achieved with a mild hybrid architecture

Stock HMMWV VPSET/Simulink Model



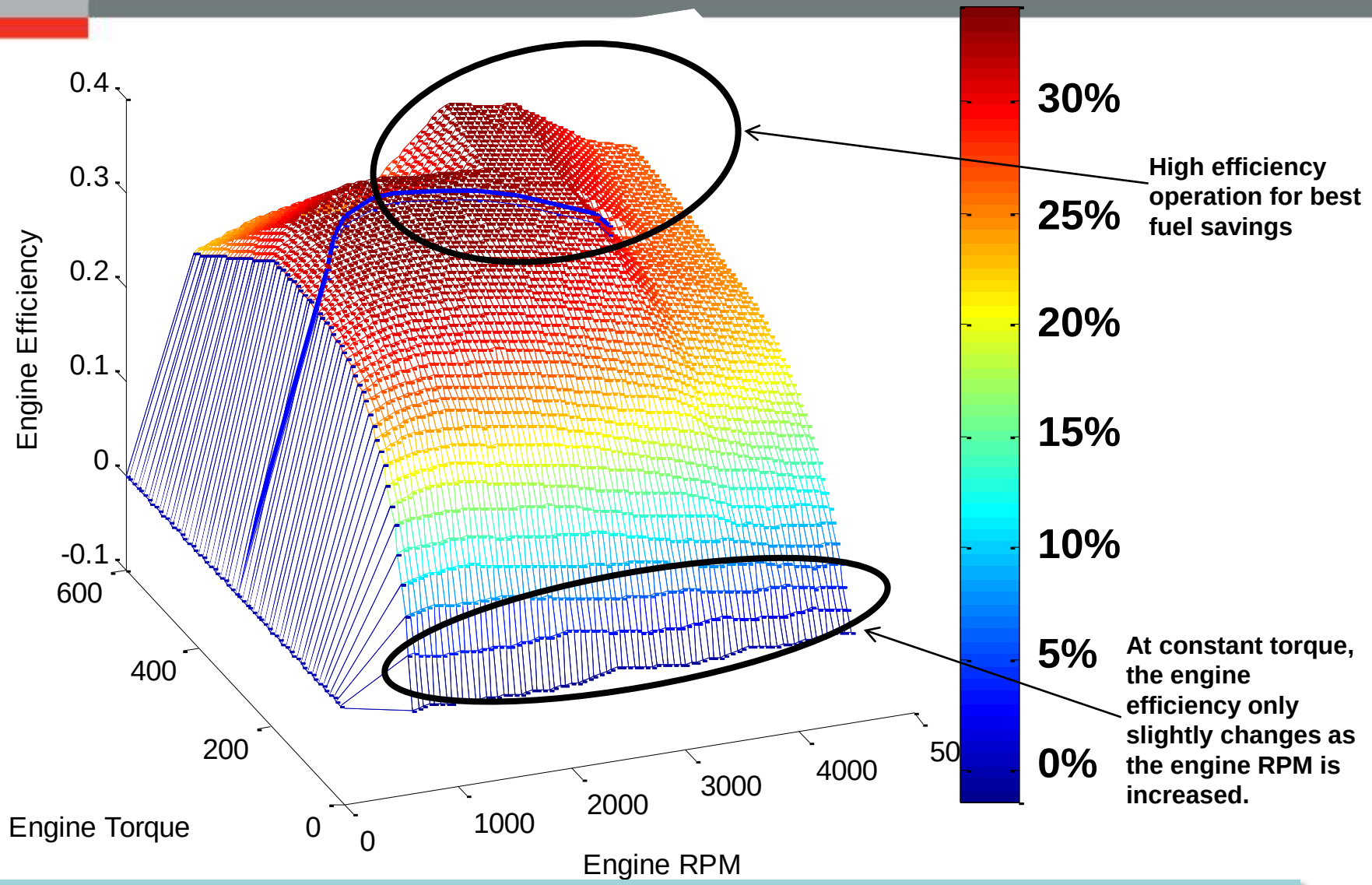
- Drive Cycle
- Vehicle Profile
- Vehicle Controller
- Driver
- Transmission
- Engine

Stationary Generation Fuel Efficiency

- Currently the vehicle must run at 2000 rpm for every load on the system.
- If energy storage is used, the engine can run at lower speeds based on the load.
- If a higher load is step-loaded, the batteries will take the immediate difference and allow the engine to reach the new speed based on the new load.
- The stationary generation software is the algorithm that will control the engine speed and transfer loads between the GSC and the batteries.

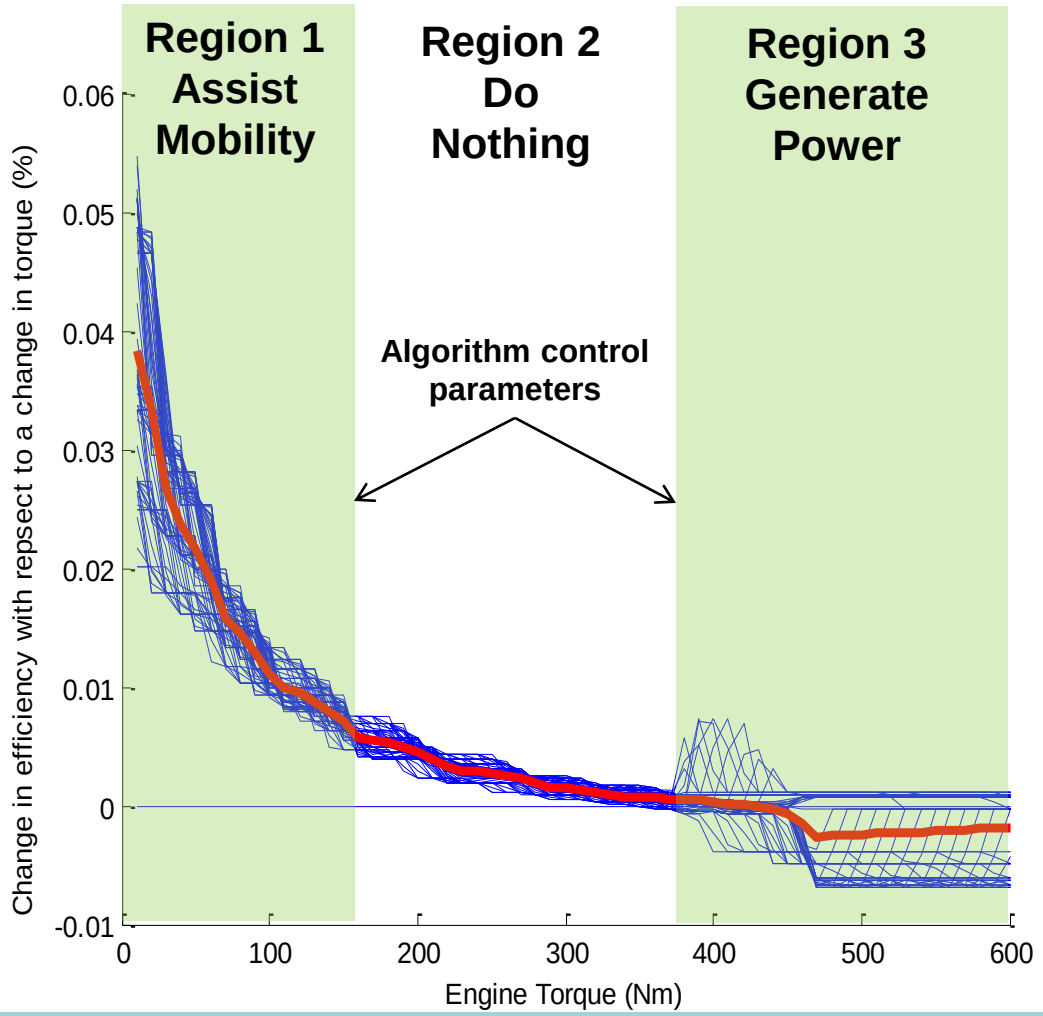
According to data taken from OBVP, the system uses 2.42 gal/hr at 10.2 kW in stationary mode (~2000 RPM) and 1.41 gal/hr at 10.21 kW in mobile mode (~930 RPM). This results in a 41% savings in fuel

Optimizing Engine Efficiency
(Derived from VPSET parameters)



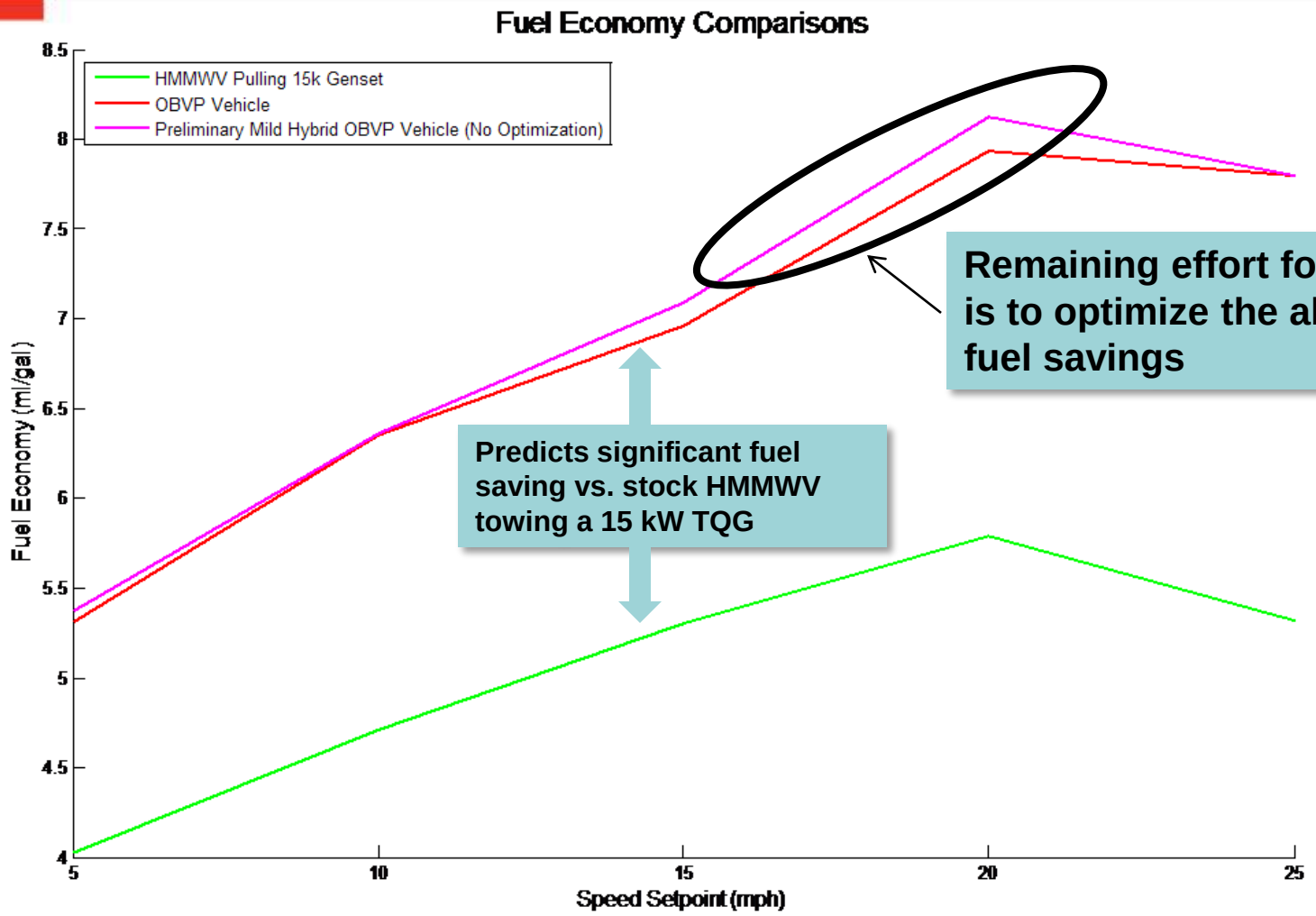
Mild hybrid algorithm must optimize control of torque for best performance

Engine Optimization Strategy



Speed does not significantly affect efficiency, the hybrid algorithm needs to monitor torque. The "rule based algorithm" will use the optimization graph to identify the 3 regions of operation as shown

First Non-Optimized VPSET Results



GFY 2011 and 2012 Future Plans

GFY 11 Plans

- Complete baseline vehicle testing
- Add idle engine speed control based on power demand capability (Stationary mode)
- Code simulation algorithms in control DSP inside of GSC
- Utilize SIL to evaluate baseline algorithms
- Evaluate simulated vs. “real world” performance of simulated algorithms in SIL and truck
- Update models based on testing/actual data

GFY 12 Plans

- Acquire hardware/integrate to truck (GSC, batteries, throttle control, etc.)