PLUG-IN HYBRID ELECTRIC MEDIUM DUTY COMMERCIAL FLEET DEMONSTRATION AND EVALUATION

Principle Investigator: Matt Miyasato, Ph.D.

Presenter: Jeff Cox

South Coast Air Quality Management District

May 12, 2011

ARRAVT068

Overview

Timeline

- Start – November 2009
- Finish – August 2013
- 30% Complete

Budget

Total project funding

- DOE - $45,443,325
- Contractor - $45,612,649

Barriers

- Component reliability
- Sub-system interfaces
- Engine integration
- Emissions system impacts
- System/vehicle validation
- Wide distribution of demonstration fleet vehicles
- Quick deployment timeline
- Lack of developed supply chain

Partners

- SCAQMD
- EPRI
- Eaton
- Altec
- SCE
- A123
- Azure Dynamics

Objectives

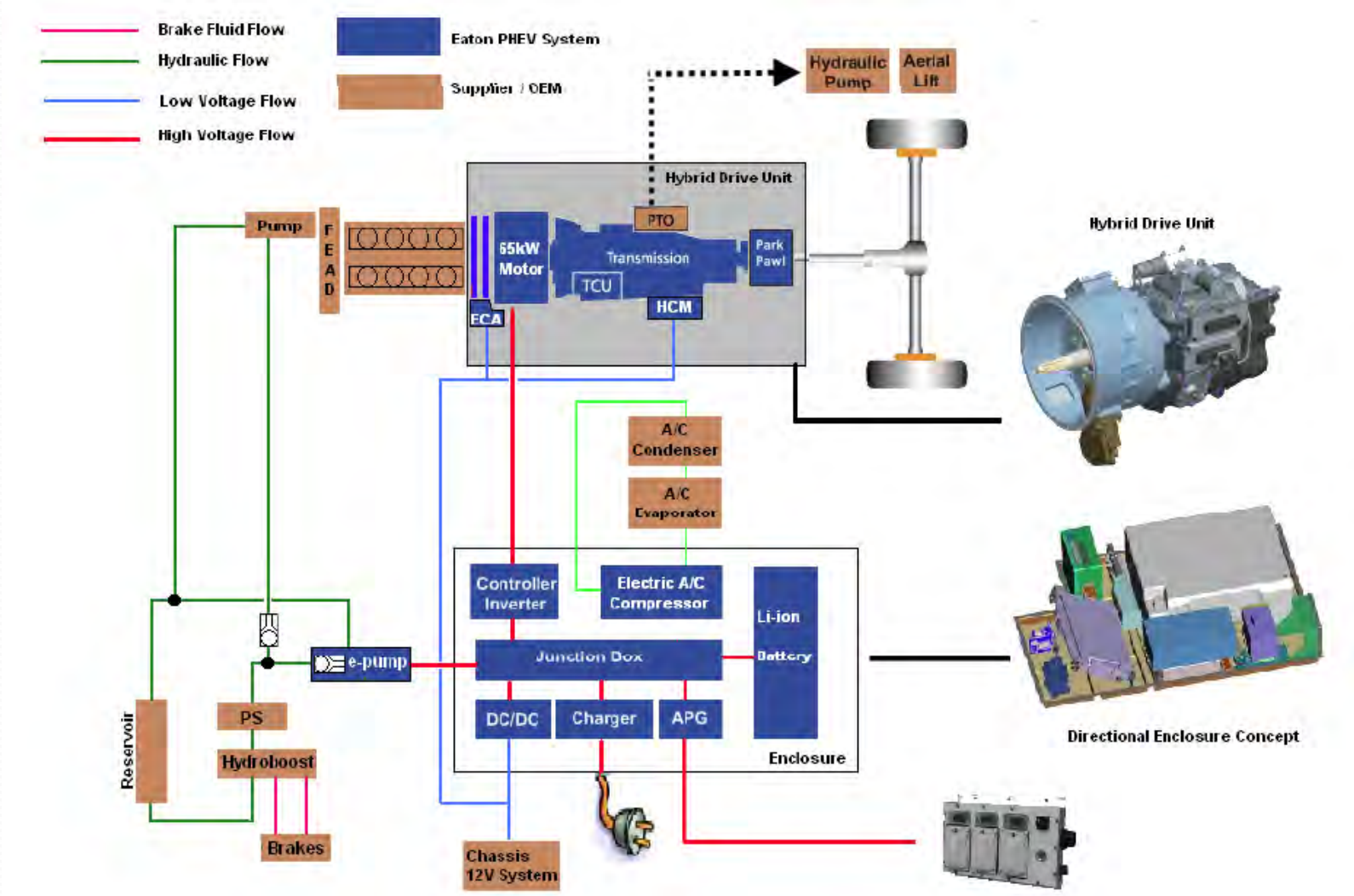
- Nationwide demonstration and evaluation of 280 medium-duty PHEVs
- Develop a near-production PHEV system for class 4 – 5 vehicles
- Develop production ready “smart charging” capability for the vehicle
- Build customer familiarity
- Quantify performance attributes and environmental impact
- Use project results for system development to optimize performance and reduce costs

Approach – F550 Utility Truck

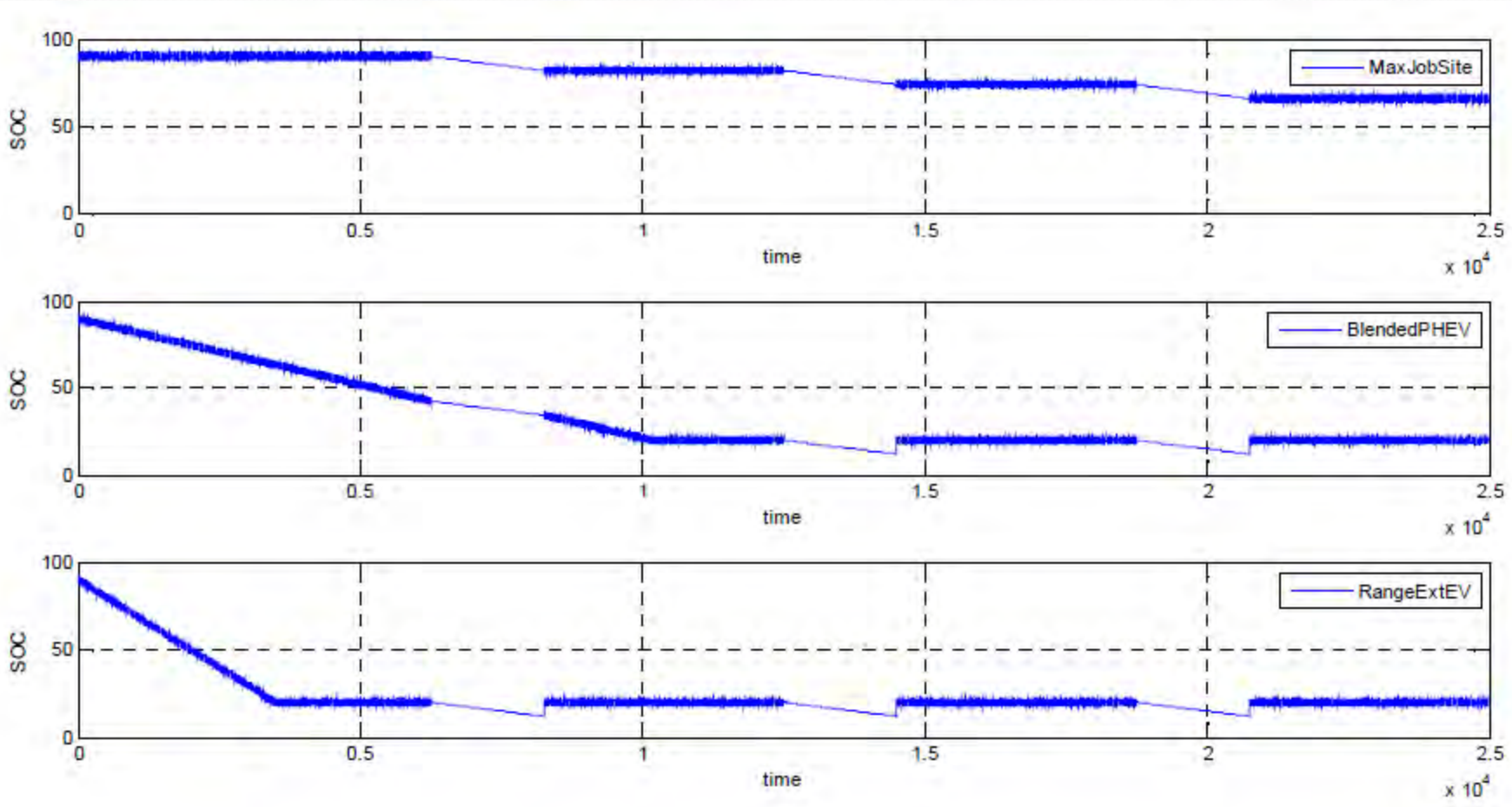
- Vehicle Design
  - Eaton Plug-in Hybrid Drive System
  - Ford 6.7L Diesel Engine
  - A123 Lithium-Ion Battery (23kWh)
  - Blended Regenerative Braking
  - Engine Off at Zero Speed
  - On-board Charger (7kW)
  - Charging-Level 1 (120 Vac) and Level 2 (240 Vac)
  - Electrified Accessories (Steering, Brakes, and HVAC)
  - Export Power (5 kW, 120 Vac, 60 Hz)

- Performance Specifications:
  - ePTO operation (>5 Hours with Engine-Off)
  - Up to 10 miles pure electric range (30 mph average)
  - Charge time less than 3 hours with Level 2
  - FMVSS compliant

F550 System Design



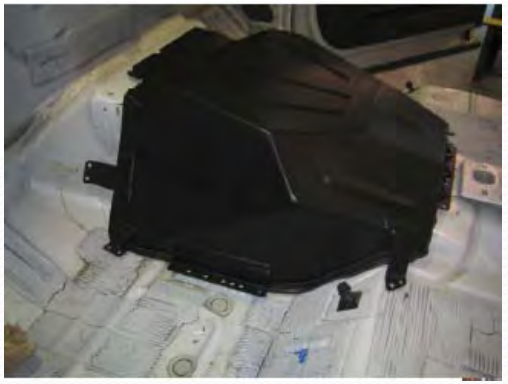
F550 Vehicle Calibration

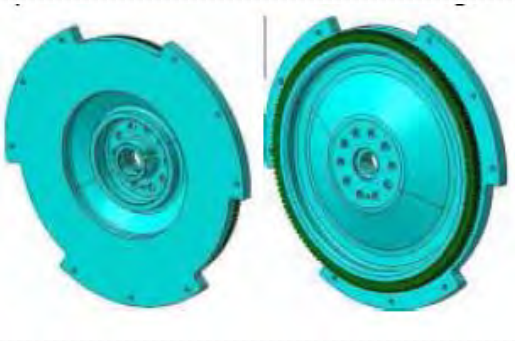


F550 -Technical Accomplishments

Vehicle Modifications

- Eaton Hybrid Transmission
  - Park Pawl & 65 kW Motor
- Floor Pan Modification and Transmission Cover
- Manual Transmission Flywheel
- Transmission Cross member





F550 - Technical Accomplishments

Component Development

- Design of Power Electronics Carrier (PEC) is complete. The PEC houses:
  - 23 kWh Li-ion Battery
  - Traction Motor Inverter
  - 5 kW APG
  - Electric power steering/ brake pump
  - Engine Gateway Module
  - Electric AC Compressor
  - 7 kW On-board Charger
- Component Supplier Selection Complete
- All PHEV components will be PPAP'd
- Material order has been placed for first 50 vehicles

F550 - Technical Accomplishments

F550 prototype vehicles have been built to:

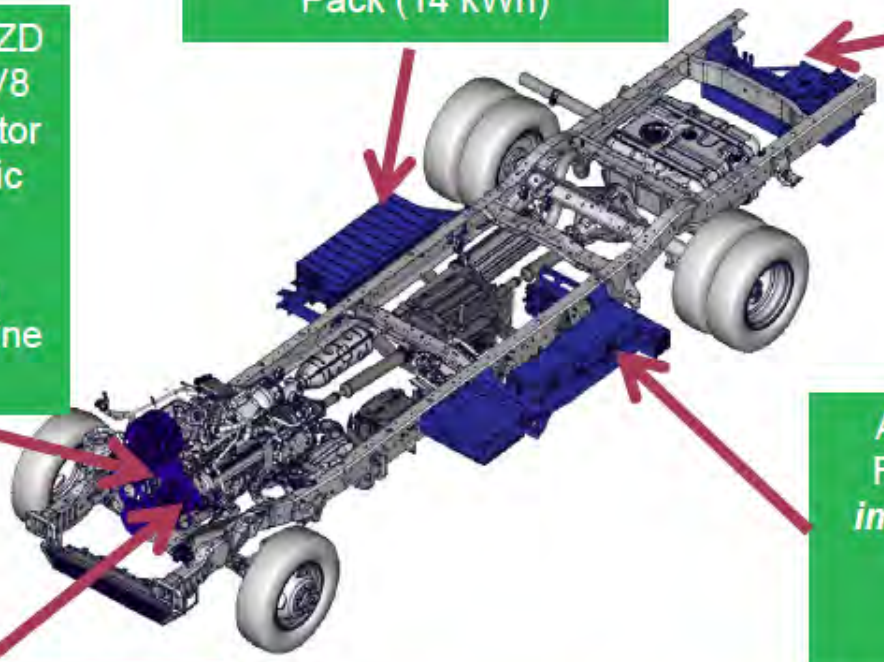
- Validate hardware architecture and system design
- Optimize vehicle calibration strategy to:
  - Reduce Fuel Consumption
  - Maximize Grid Energy Usage
  - Vehicle Performance
  - Engine-off Operation (stationary and driving)
  - Reliability
  - Safety

Approach – E450 Shuttle Bus

- Vehicle Design:
  - Azure Hybrid System
  - Ford 5.4L Gasoline Engine
  - Lithium-Ion Battery (14 kWh)
  - Blended Regenerative Braking
  - Engine Off at Zero Speed
  - On-board Charger (3.3 kW)
  - Charging-Level 1 (120 Vac) and Level 2 (240 Vac)
  - Electrified Accessories (Steering, Brakes, and HVAC)

- Performance Specifications:
  - Up to 20 miles charge depleting range
  - Charge time less than 6 hours with Level 2
  - FMVSS compliant

E450 System Design



JCS Li Ion PHEV Battery Pack (14 kWh)

65,000 BTU Electric A/C compressor – AZD Force Drive controlled

Advancements to AZD Industry Leading V8 Belt Starter Generator - integrated electric Clutch

– motor can spin auxiliaries with Engine off

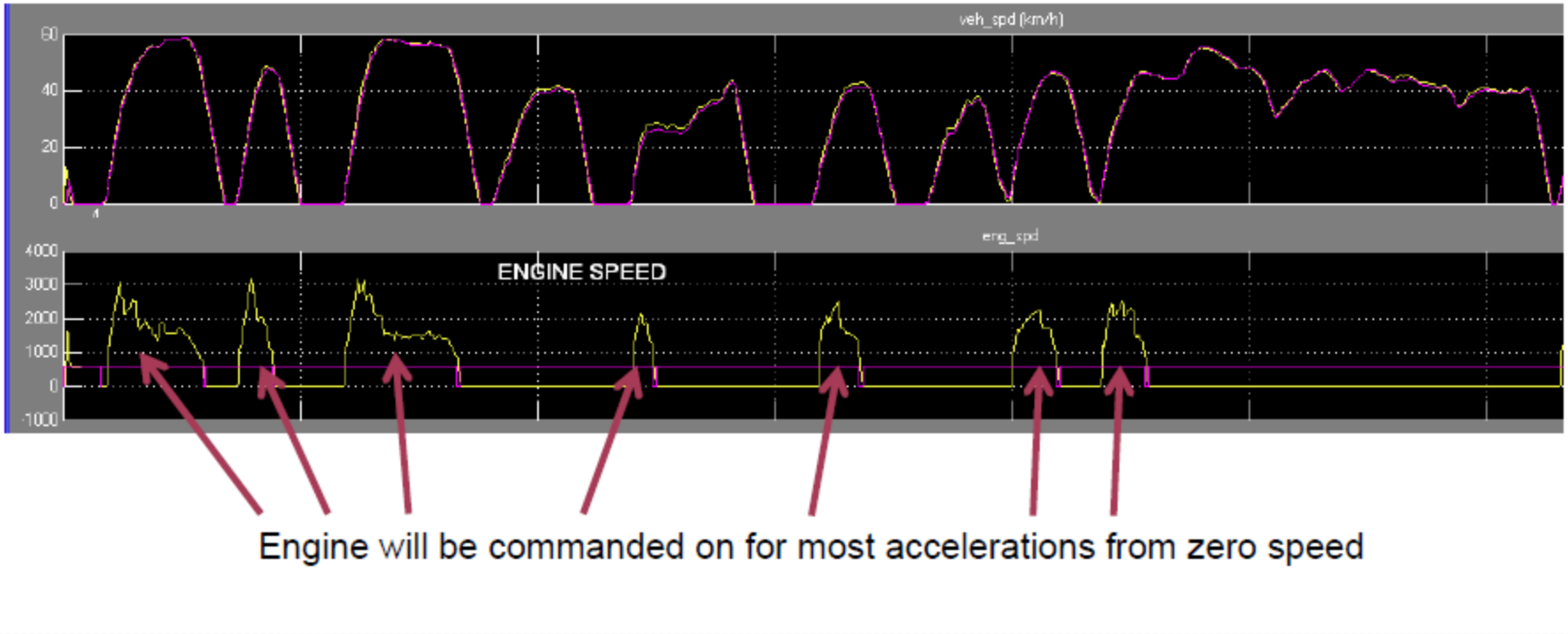
Advancements to AZD Force Drive inverters – ***improved performance, manufacturability improvements***

Ford 5.4 L Gasoline Engine

Charger 3.3 kW capable of Level 1 or Level 2 Charging

E450 Blended EV Strategy

Top graph is vehicle speed (km/h) on UDDS cycle in lab; bottom graph is engine speed (whenever non-zero, engine is running).



E450 - Technical Accomplishments

- Completed design of the PHEV battery pack
  - Liquid Cooled
  - 346 V nominal
  - 14 kWh
- Integrated larger battery pack within Azure's E450 Balance Hybrid System

Johnson Controls | SAFT

Collaborations/Partnerships

- SCAQMD – Prime Recipient
- California Energy Commission – Funding Partner
- EPRI – Program Management and Fleet Coordinator
- Eaton – Hybrid System Developer
- Azure Dynamics – Hybrid System Developer
- Altec – Body Builder & PHEV Integrator
- So Cal Edison – Battery and Vehicle Testing
- A123 Systems – Battery Supplier
- Ford – Chassis Supplier & Integration Support

Future Work

- Fiscal Year 2011
  - Complete system and calibration validation testing
  - Deploy fleet of 280 medium-duty PHEV's
  - Install cellular based data acquisition systems and set-up download servers to acquire in-use performance data
  - Install 240V vehicle charging infrastructure

- After 2011
  - Evaluate and analyze the vehicle operation in the field
  - Conduct laboratory emissions and fuel economy tests
  - Conduct battery cycle life testing
  - Conduct user surveys
  - System performance optimization
  - System cost reduction through design optimization

Project Summary

- The project will:
  - Quantify the attributes of a medium-duty PHEV for shuttle bus and utility truck vocations in terms of:
    - Criteria pollutant emissions
    - Greenhoouse gas reductions
    - Fossil fuel displacement
  - Further optimize the efficiency of the system based on data that is collected in the field
  - Pathway to commercialization for a medium-duty PHEV system
- The design specifications are complete to enable an EV capable medium-duty PHEV that can operate electrically at a job site and/or drive electrically.
- Fleet participants have been engaged to enable a nationwide demonstration program of 280 vehicles
- Manufacturing has been kicked-off to initiate the build the 280 vehicle fleet