OVERVIEW – CURRENT AGREEMENT

**TIMELINE**
- Project Start: 10/1/05
- Project End: 12/31/12
- Percent Complete: 90%

**BUDGET**
- Total Project: $10,659,094
- DOE Share: $8,659,094
- Thru 12/31/11: $7,217,111
- Remaining: $1,444,983

**BARRIERS**
- Contract End Date
- Vehicle Availability

**PARTNERS**
- EZ Messenger
- Idaho National Laboratory
- Argonne National Laboratory
OVERVIEW – NEW AGREEMENT

**TIMELINE**
- Project Start: 10/01/11
- BP1 End: 01/31/13
- Percent Complete: 2%

**BUDGET**
- Total Project: $33,088,218
- DOE Share: $26,400,000
- Cost Share: $6,688,218
- BP1 Authorization: $3,000,000

**BARRIERS**
- Vehicle Availability
- Vehicle Reliability
- Infrastructure Requirements

**PARTNERS**
- EZ Messenger
- Idaho National Laboratory
- Argonne National Laboratory
- Oak Ridge National Laboratory
OBJECTIVES

» Provide benchmark data for advanced technology vehicles

» Develop lifecycle cost data for production vehicles utilizing advanced power trains

» Provide fleet operations data to the Idaho National Laboratory

» Disseminate vehicle and infrastructure testing results to industry and other DOE programs
<table>
<thead>
<tr>
<th>Year</th>
<th>Milestone</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011</td>
<td>Vehicles initiated in testing</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>Baseline tests completed</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>Ongoing fleet testing</td>
<td>42</td>
</tr>
<tr>
<td></td>
<td>Non-vehicle tasks completed</td>
<td>7</td>
</tr>
<tr>
<td>2012</td>
<td>Vehicle model scheduled for test</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td>Vehicles entering testing</td>
<td>44</td>
</tr>
</tbody>
</table>
Approach

PROCEDURE DEVELOPMENT

- Administrative Procedures For Control Of Test Conduct
- Vehicle Specification Defining Key Performance And Safety Parameters
- Vehicle Test Procedures Defining Tests Verifying Vehicle Specification Requirements
- Battery Test Procedures Defining Implementation Of Standard Test Requirements
Approach

BASELINE TESTING

- Benchmark Performance
  - Acceleration
  - Maximum speed
  - Driving cycle range
    - With accessory loads
    - Without accessory loads
  - Braking
  - Gradeability
ACCELERATED TESTING

Fixed Route Mileage Accumulation

<table>
<thead>
<tr>
<th>Cycle (mi)</th>
<th>Urban (10 mi)</th>
<th>Highway (10 mi)</th>
<th>Charge (hr)</th>
<th>Reps (N)</th>
<th>Total (mi)</th>
<th>Reps (%)</th>
<th>Miles (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>1</td>
<td>0</td>
<td>4</td>
<td>60</td>
<td>600</td>
<td>37%</td>
<td>11%</td>
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<tr>
<td>20</td>
<td>1</td>
<td>1</td>
<td>8</td>
<td>30</td>
<td>600</td>
<td>19%</td>
<td>11%</td>
</tr>
<tr>
<td>40</td>
<td>4</td>
<td>0</td>
<td>12</td>
<td>15</td>
<td>600</td>
<td>9%</td>
<td>11%</td>
</tr>
<tr>
<td>40</td>
<td>2</td>
<td>2</td>
<td>12</td>
<td>15</td>
<td>600</td>
<td>9%</td>
<td>11%</td>
</tr>
<tr>
<td>40</td>
<td>0</td>
<td>4</td>
<td>12</td>
<td>15</td>
<td>600</td>
<td>9%</td>
<td>11%</td>
</tr>
<tr>
<td>60</td>
<td>2</td>
<td>4</td>
<td>12</td>
<td>10</td>
<td>600</td>
<td>6%</td>
<td>11%</td>
</tr>
<tr>
<td>80</td>
<td>2</td>
<td>6</td>
<td>12</td>
<td>8</td>
<td>640</td>
<td>5%</td>
<td>12%</td>
</tr>
<tr>
<td>100</td>
<td>2</td>
<td>8</td>
<td>12</td>
<td>6</td>
<td>600</td>
<td>4%</td>
<td>11%</td>
</tr>
<tr>
<td>200</td>
<td>2</td>
<td>18</td>
<td>12</td>
<td>3</td>
<td>600</td>
<td>2%</td>
<td>11%</td>
</tr>
<tr>
<td>Total</td>
<td>2,340</td>
<td>3,100</td>
<td>1,344</td>
<td>162</td>
<td>5,440</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average</td>
<td>43%</td>
<td>57%</td>
<td>8.3</td>
<td>18</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
FLEET TESTING

- Production Vehicles
- 160,000 Mile Current Duration
- 300,000 Mile Future Duration
- On Board Data Logger
- Fuel And Maintenance Logs
Approach

BATTERY TESTING

- Hybrid Vehicles
  - C₁ capacity
  - Hybrid pulse power characterization
  - Vehicle new & end-of-test
- Start-Stop – C₁ capacity
- Battery Electric Vehicles
  - C₁ capacity
  - Peak power characterization
Accomplishments

2011 PROCEDURES

- US Postal Service Delivery Vehicle Acceptance Test
- US Postal Service Delivery Vehicle Baseline Test
- US Postal Service Delivery Vehicle Accelerated Reliability Test
- Battery Electric Vehicle Fast Charge Test
- Battery Energy Storage Performance Test For DC Fast Charge Demand Reduction
Accomplishments

2011 BASELINE TESTS

- 5 US Postal Service Delivery Vehicles
- 2010 Honda Civic Ultra Battery HEV
- 2011 Hyundai Sonata HEV
- 2011 Ford Escape PHEV
- 2010 Smart For Two
- 2010 VW Golf Diesel
- 2011 Mazda 3
- Honda CRZ HEV
## Accomplishments

### 2011 ACCELERATED TESTS

#### 2010 Ford Escape PHEV

<table>
<thead>
<tr>
<th>Test Date</th>
<th>Cycle (mi)</th>
<th>Urban (10 mi)</th>
<th>Highway (10 mi)</th>
<th>Charge (Hr)</th>
<th>Repetitions (N)</th>
<th>Total (mi)</th>
<th>Repetitions (%)</th>
<th>Miles (%)</th>
<th>Cumulative (mi)</th>
<th>Electricity (kwh)</th>
<th>Fuel (E-85)</th>
<th>MPG</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>4/5-5/20/11</td>
<td>10</td>
<td>1</td>
<td>0</td>
<td>4</td>
<td>60</td>
<td>610</td>
<td>37%</td>
<td>11%</td>
<td>610</td>
<td>1231.6</td>
<td>238.26</td>
<td>2.00</td>
<td></td>
</tr>
<tr>
<td>2/15/11-4/4/11</td>
<td>20</td>
<td>1</td>
<td>1</td>
<td>8</td>
<td>30</td>
<td>621.6</td>
<td>19%</td>
<td>11%</td>
<td>1231.6</td>
<td>224.57</td>
<td>6.900</td>
<td>90.1</td>
<td>car did not fully charge on 3 days</td>
</tr>
<tr>
<td>1/24/-2/14/11</td>
<td>40</td>
<td>4</td>
<td>0</td>
<td>12</td>
<td>15</td>
<td>612.8</td>
<td>9%</td>
<td>11%</td>
<td>1844.4</td>
<td>186.12</td>
<td>3.200</td>
<td>191.5</td>
<td></td>
</tr>
<tr>
<td>8/24-9/15/10</td>
<td>40</td>
<td>2</td>
<td>2</td>
<td>12</td>
<td>15</td>
<td>620</td>
<td>9%</td>
<td>11%</td>
<td>2464.4</td>
<td>171.74</td>
<td>7.300</td>
<td>84.9</td>
<td></td>
</tr>
<tr>
<td>12/3/10-1/7/11</td>
<td>40</td>
<td>0</td>
<td>4</td>
<td>12</td>
<td>15</td>
<td>632.6</td>
<td>9%</td>
<td>11%</td>
<td>3097</td>
<td>200.02</td>
<td>9.700</td>
<td>65.2</td>
<td></td>
</tr>
<tr>
<td>11/17-12/2/10</td>
<td>60</td>
<td>2</td>
<td>4</td>
<td>12</td>
<td>10</td>
<td>624.2</td>
<td>6%</td>
<td>11%</td>
<td>3721.2</td>
<td>124.16</td>
<td>11.800</td>
<td>52.9</td>
<td></td>
</tr>
<tr>
<td>9/16-9/27/10</td>
<td>80</td>
<td>2</td>
<td>6</td>
<td>12</td>
<td>8</td>
<td>664.1</td>
<td>5%</td>
<td>12%</td>
<td>4385.3</td>
<td>89.60</td>
<td>13.600</td>
<td>48.8</td>
<td>*last day did not fully charge</td>
</tr>
<tr>
<td>8/16-8/23/10</td>
<td>100</td>
<td>2</td>
<td>8</td>
<td>12</td>
<td>6</td>
<td>603</td>
<td>4%</td>
<td>11%</td>
<td>4988.3</td>
<td>64.01</td>
<td>13.700</td>
<td>44.0</td>
<td>**shortened route low fuel</td>
</tr>
<tr>
<td>8/1-8/3/10</td>
<td>200</td>
<td>2</td>
<td>18</td>
<td>12</td>
<td>3</td>
<td>557.2</td>
<td>2%</td>
<td>10%</td>
<td>5545.5</td>
<td>31.53</td>
<td>15.280</td>
<td>36.5</td>
<td>**shortened route due to low fuel</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>16</td>
<td>43</td>
<td>96</td>
<td>162</td>
<td></td>
<td><strong>5546</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>
2011 FLEET TESTS

- 2 Gen III Prius HEV
- 2 Honda Insight HEV
- 1 Ford Fusion
- 2 Mercedes S400
- 2 Honda CRZ HEV
- 2 Hyundai Sonata HEV
- 21 SCAQMD Escape PHEV
- 2 Smart For Two Start-Stop
- 2 VW Golf Diesel Start-Stop
- 2 Mazda 3 Start-Stop
- 1 Ford Escape PHEV
- 1 Chevrolet Volt EREV
- 1 Nissan Leaf BEV
Accomplishments

2011 BATTERY TESTS

◆ Hyundai Sonata HEV
◆ Honda Civic Ultra Battery HEV

Hyundai Sonata HEV

Honda Civic Ultra Battery HEV

2011 BATTERY TESTS

Hyundai Sonata HEV

Honda Civic Ultra Battery HEV

2011 Honda Civic with UltraBattery Conversion - 5577

Hybrid BOT Battery Test Results

Hybrid System Specifications

Battery Specifications

- Manufacturer: East Penn Manufacturing
- Type: Lead-Carbon
- Number of Cells: 84
- Number of Modules: 14
- Nominal Cell Voltage: 2.1 V
- Nominal System Voltage: 176.4 V
- Nominal Pack Capacity: 7.5 Ah

Vehicle Specifications

- Manufacturer: Honda
- Model: Civic
- Year: 2011
- Number of Motors: 1
- Motor Power Rating: 124.9 kW
- VIN #: JHMFA3F92BP0800577

Battery Lab Test Results

HPPC Test

- Peak Pulse Discharge Power @ 10s: 9.1 kW
- Peak Pulse Charge Power @ 10s: 10.8 kW
- Peak Pulse Charge Power @ 1s: 9.2 kW
- Peak Pulse Charge Power @ 1s: 19.2 kW
- Maximum Charge Voltage: 2.45 V
- Minimum Discharge Voltage: 1.8 V

Battery Lab Test Results

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- Peak Pulse Charge Power @ 1s: 9.2 kW
- Peak Pulse Charge Power @ 1s: 19.2 kW
- Maximum Charge Voltage: 2.45 V
- Minimum Discharge Voltage: 1.8 V

Analysis Notes:

1. Motor refers to any motor capable of supplying traction power.
2. Motor power rating refers to the maximum peak power rating to the individual(s) supplying traction power.
3. Calculated using based on nominal battery voltage while at a certain SOC.
4. Actual vehicle mileage may vary due to factors such as driving style and test conditions.
Accomplishments

2011 SPECIAL TESTS

◆ USPS Long-Life Vehicle Prototypes
◆ Start-Stop Fuel Economy Study
  ◆ Dynamometer Testing
  ◆ Fuel Economy Test Cycles
  ◆ USA, Europe, Japan
◆ Fleet Testing Validation
  ◆ With & Without Start-Stop Enabled
◆ Real World Validation
Collaborations

NATIONAL LABORATORIES

- Idaho National Laboratory
  - Procedure development
  - Data collection & analysis

- Argonne National Laboratory
  - Procedure development
  - Dynamometer testing

- Oak Ridge National Laboratory
  - USPS dynamometer testing
Collaborations

INDUSTRY PARTNERS

- EZ Messenger
  - Mileage accumulation
  - Route design
- Discount Cab
  - Mileage accumulation
Future Work

CONTRACT CHANGE

- Current Contract Closeout
  - Complete fleet testing of 41 vehicles
  - Complete 6 non-vehicle tasks

- New Contract Launch
  - Update all test procedures
  - Write 2 battery test procedures
  - Place 35 vehicles in testing
  - Initiate 4 infrastructure tests
2011 SUMMARY

- 13 Major Tasks Completed
- One Million Fleet Test Miles Accumulated
- 41 Vehicles Tested
- Testing Conducted Using Four Different Fuels
- Testing Conducted For BEV, PHEV, EREV, HEV & Start-Stop Vehicle Configurations
- All Test Results Posted To AVTA Website
HEV Fleet Testing - Summary Fact Sheet

Advanced Vehicle Testing Activity

2010 Toyota Prius
VIN JTDBM3DU2A5010452

Vehicle Specifications

- Engine: 1.8 L, 4-cylinder
- Electric Motor: 60 kW
- Battery: NiMH
- Seatbelt Positions: Five
- Payload: 905 lbs
- Features:
  - Regenerative braking
  - Traction control

Description:
This vehicle is operated throughout the valley of Phoenix, Arizona by EZ Messenger, a legal document courier business. It is operated five days a week, transferring documents between courts, law offices, and medical facilities on city streets and urban freeways.

Fleet Performance

- Operating Cost:
  - Purchase Cost: $29,174 ($109)*
  - Kelley Blue Book: $8,944 (11/12)
  - Sale Price: In Operation
  - Maintenance Cost: $0.13/mile
  - Operating Cost: $0.12/mile**
  - Total Ownership Cost: $0.32/mile

- Operating Performance:
  - Total miles driven: 136,151
  - Cumulative MPG: 45.5

- Major Operations & Maintenance Events:
  - None

*Purchase includes dealer price with options plus taxes. It does not include title, license, registration, extended warranty or delivery fees.

**Operating costs includes insurance, fuel, and registration costs.

Monthly MPG = (miles driven)/(gallons of fuel purchased). Monthly variation in reported MPG may occur due to the difference in fuel tank level at the beginning and end of the month.
HEV Fleet Testing

2010 Toyota Prius
VIN: 462
Fleet Testing Results To Date

Operating Statistics
Distance Driven: 133,232
Average Trip Distance: 13.8 mi/Stop Time with Engine Idling: 5%
Trip Type City/Highway: 82% / 18%

Operating Performance
Cumulative MPG: 47.5

Test Notes
2. Calculated from electronic data logged over a subset of total miles traveled equal to 126,791 miles.
3. Fuel economy calculated for this figure using mass air flow over dynamic vehicle operation.
4. Calculated from battery current data logged over a subset of total miles traveled, equal to 102,538 miles.

Distribution of Trip Fuel Economy

Percent of Drive Time by Operating Mode:

Vehicle Topped Engine Running: 19%
Vehicle Driving Engine Running: 88%
Vehicle Topped Engine Stopped: 1%
Total charge into battery pack (Ah)*: 15,150
Total charge out of battery pack (Ah)*: 13,950
Battery round trip efficiency*: 92%
# HEV Fleet Testing

## Advanced Vehicle Testing Activity

### Maintenance Sheet for 2010 Toyota Prius

VIN# JTDKN3DU2A5010462

<table>
<thead>
<tr>
<th>Date</th>
<th>Mileage</th>
<th>Description</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>11/23/2009</td>
<td>5,935</td>
<td>Changed oil and filter, rotated tires, and inspected brakes</td>
<td>$31.75</td>
</tr>
<tr>
<td>12/18/2009</td>
<td>13,330</td>
<td>Changed oil and filter and inspected brakes</td>
<td>$36.94</td>
</tr>
<tr>
<td>1/22/2010</td>
<td>19,549</td>
<td>Changed oil and filter, inspected brakes, and replaced air filter</td>
<td>$57.88</td>
</tr>
<tr>
<td>3/16/2010</td>
<td>26,896</td>
<td>Changed oil and filter</td>
<td>$48.74</td>
</tr>
<tr>
<td>3/29/2010</td>
<td>28,250</td>
<td>Replaced and balanced one tire</td>
<td>$100.94</td>
</tr>
<tr>
<td>4/6/2010</td>
<td>28,288</td>
<td>Recall on ABS actuator ECU</td>
<td>n/c</td>
</tr>
<tr>
<td>5/20/2010</td>
<td>32,160</td>
<td>Changed oil and filter</td>
<td>$57.85</td>
</tr>
<tr>
<td>6/17/2010</td>
<td>38,302</td>
<td>Changed oil and filter</td>
<td>$57.85</td>
</tr>
<tr>
<td>7/23/2010</td>
<td>43,789</td>
<td>Changed oil and filter and rotated tires</td>
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<tr>
<td>9/13/2010</td>
<td>48,766</td>
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<tr>
<td>10/21/2010</td>
<td>59,049</td>
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<td>12/1/2010</td>
<td>59,307</td>
<td>Changed oil and filter</td>
<td>$62.31</td>
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<tr>
<td>12/9/2010</td>
<td>60,481</td>
<td>Replaced four tires</td>
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</tr>
<tr>
<td>1/6/2011</td>
<td>64,378</td>
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<tr>
<td>2/2/2011</td>
<td>69,797</td>
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</tr>
<tr>
<td>3/3/2011</td>
<td>75,211</td>
<td>Changed oil and filter and rotated tires</td>
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<td>80,269</td>
<td>Changed oil and filter</td>
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<tr>
<td>4/28/2011</td>
<td>85,894</td>
<td>Changed oil and filter and rotated tires</td>
<td>$74.51</td>
</tr>
<tr>
<td>5/23/2011</td>
<td>91,795</td>
<td>Changed oil and filter, replaced cabin filter and 90K service</td>
<td>$209.34</td>
</tr>
<tr>
<td>5/24/2011</td>
<td>91,801</td>
<td>Replaced one tire</td>
<td>$31.49</td>
</tr>
<tr>
<td>6/24/2011</td>
<td>96,843</td>
<td>Changed oil and filter</td>
<td>$60.27</td>
</tr>
<tr>
<td>Date</td>
<td>Mileage</td>
<td>Description</td>
<td>Cost</td>
</tr>
<tr>
<td>----------</td>
<td>---------</td>
<td>-----------------------------------------------------</td>
<td>-------</td>
</tr>
<tr>
<td>7/29/2011</td>
<td>104,247</td>
<td>Changed oil and filter and rotated tires</td>
<td>$75.27</td>
</tr>
<tr>
<td>8/18/2011</td>
<td>109,150</td>
<td>Changed oil and filter</td>
<td>$60.27</td>
</tr>
<tr>
<td>8/29/2011</td>
<td>112,047</td>
<td>Replaced left front low beam bulb</td>
<td>$9.21</td>
</tr>
<tr>
<td>9/26/2011</td>
<td>118,626</td>
<td>Changed oil and filter and rotated tires</td>
<td>$77.57</td>
</tr>
<tr>
<td>10/19/2011</td>
<td>123,278</td>
<td>Replaced tire under warranty and purchased a new warranty</td>
<td>$28.76</td>
</tr>
<tr>
<td>10/21/2011</td>
<td>123,376</td>
<td>Changed oil and filter</td>
<td>$64.98</td>
</tr>
<tr>
<td>11/9/2011</td>
<td>126,973</td>
<td>120 K mile service</td>
<td>$498.59</td>
</tr>
<tr>
<td>11/10/2011</td>
<td>126,973</td>
<td>Installed new front brake pads and resurfaced rotors</td>
<td>$194.78</td>
</tr>
<tr>
<td>11/21/2011</td>
<td>129,050</td>
<td>Replaced rear tire</td>
<td>$133.69</td>
</tr>
<tr>
<td>11/21/2011</td>
<td>129,056</td>
<td>Changed oil and filter and rotated tires</td>
<td>$77.66</td>
</tr>
<tr>
<td>11/15/2011</td>
<td>127,769</td>
<td>Replaced left and right front low beam bulbs</td>
<td>$33.86</td>
</tr>
<tr>
<td>12/20/2011</td>
<td>134,262</td>
<td>Changed oil and filter</td>
<td>$62.64</td>
</tr>
</tbody>
</table>
Two model year 2010 Toyota Generation III Prius hybrid electric vehicles (HEVs) entered Accelerated testing during July 2009 in a fleet in Arizona. Each Gen III Prius will be operated for 160,000 miles, at which point their traction batteries will be tested before they are retired (one battery is also tested when new). One-page vehicle maintenance logs are posted on nearby www pages. This information includes the date and mileage for all maintenance and repairs performed on the vehicles. The two Gen III Prius HEVs have been driven a total of 229,000 miles and the cumulative average fuel economy is 44.3 mpg. Note that initial mileage accumulation was slow due to baseline performance and battery testing. Note that during late April and May 2010, fueling event timing and fleet management realignment resulted in exaggerated swings in monthly mpg.