AVTA/AVTE On-Road Vehicle Evaluation Updates

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VSATT Meeting

October 14, 2015
**Intro to AVTA/AVTE**

- Conducted primarily by INL and Intertek Testing Services North America, with dynamometer testing by ANL
- Vehicles are purchased by Intertek and placed into one of several fleets to accumulate miles
  - EZ Messenger (Phoenix, Tucson, OKC/Dallas)
  - Total Transit (Phoenix)
- Vehicle data automatically uploaded, sent to INL for data management and analysis
Vehicle Testing Process

Data from 95 AVTE Vehicles Collected This Year

1. Purchase Vehicle (4 of each model typical)
2. Baseline Traction Battery Testing
3. Install On-Board Data Logger (all cars)
4. 4,000 Miles for Break-In
5. Track Performance and Coast Down Testing (one each model)
6. Dynamometer Testing (one each model)
7. Data Collection During Fleet Operation (all cars)
   - Traction Batteries or Components
   - 3 Interim Tests
8. End-of-test Component and Performance Evaluation
   - EV end-of-test: 36,000 Miles
   - PHEV end-of-test: 160,000 Miles
   - HEV, ICE end-of-test: 195,000 Miles
Data Collection

Data provided for every vehicle in fleet:

- Hand-written driver logs for fuel purchases, mileage
- Charging data from Blink Network with redundant AC energy meter
- Driving data from Isaac WRU Logger
  - Built-in Wi-Fi module for auto-uploading
**Battery/Component Testing**

- Battery testing for every vehicle with a HV battery (HEV, PHEV, BEV)
  - Tested according to USABC Battery Test Manual
  - Static Capacity and Pulse Power Characterization tests
- CNG Vehicles have maximum cylinder compression measured
- Mazda 3 i-ELOOP undergoes ultracapacitor testing
  - Tested according to FreedomCAR Ultracapacitor Test Manual
  - Reference Capacity and Constant-Current Discharge and Charge Tests

![Graph](Voltage versus capacity discharged during static capacity test of 2013 Focus EV)
Reporting

Reports and facts sheets published quarterly for each vehicle:

- Fuel consumption and mileage accumulation
- Vehicle operating costs
- Maintenance and repair costs
- On-road usage and performance

Battery/component testing reports at regular mileage intervals
Test results published once after track and dynamometer testing:
## Vehicle Testing Progress: Hybrid Electric

- 5 HEV Models

<table>
<thead>
<tr>
<th>Vehicle</th>
<th>Baseline track and dyno testing</th>
<th>Battery Test</th>
<th>Fleet mileage accumulation</th>
<th>Vehicle sample size</th>
<th>Miles target (per vehicle)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013 Chevrolet Malibu Eco (BAS mild HEV)</td>
<td>Complete</td>
<td>3/5 Tests Complete</td>
<td>70% Complete</td>
<td>4</td>
<td>195,000</td>
</tr>
<tr>
<td>2013 Honda Civic Hybrid</td>
<td>Complete</td>
<td>3/5 Tests Complete</td>
<td>67% Complete</td>
<td>4</td>
<td>195,000</td>
</tr>
<tr>
<td>2013 Ford C-Max Hybrid</td>
<td>Complete</td>
<td>2/5 Tests Complete</td>
<td>54% Complete</td>
<td>4</td>
<td>195,000</td>
</tr>
<tr>
<td>2014 Volkswagen Jetta Hybrid</td>
<td>Complete</td>
<td>2/5 Tests Complete</td>
<td>31% Complete</td>
<td>4</td>
<td>195,000</td>
</tr>
<tr>
<td>2015 Honda Accord Hybrid</td>
<td>Complete</td>
<td>1/5 Tests Complete</td>
<td>1% Complete</td>
<td>4</td>
<td>195,000</td>
</tr>
</tbody>
</table>

*Photos of new models introduced to project*
Vehicle Testing Progress: Plug-in Hybrid

- 5 PHEV Models

<table>
<thead>
<tr>
<th>Vehicle</th>
<th>Baseline track and dyno testing</th>
<th>Battery Test</th>
<th>Fleet mileage accumulation</th>
<th>Vehicle sample size</th>
<th>Miles target (per vehicle)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011 Chevrolet Volt</td>
<td>Complete</td>
<td>4/5 Tests Complete</td>
<td>66% Complete</td>
<td>2</td>
<td>160,000</td>
</tr>
<tr>
<td>2013 Chevrolet Volt</td>
<td>Complete</td>
<td>3/5 Tests Complete</td>
<td>67% Complete</td>
<td>4</td>
<td>160,000</td>
</tr>
<tr>
<td>2013 Toyota Prius Plug-In</td>
<td>Complete</td>
<td>3/5 Tests Complete</td>
<td>75% Complete</td>
<td>4</td>
<td>160,000</td>
</tr>
<tr>
<td>2013 Ford C-Max Energi</td>
<td>Complete</td>
<td>3/5 Tests Complete</td>
<td>41% Complete</td>
<td>4</td>
<td>160,000</td>
</tr>
<tr>
<td>2013 Ford Fusion Energi</td>
<td>Complete</td>
<td>2/5 Tests Complete</td>
<td>46% Complete</td>
<td>4</td>
<td>160,000</td>
</tr>
</tbody>
</table>
**Vehicle Testing Progress: Battery Electric**

- 11 BEV Models: 1 model completed, 1 model just began testing

<table>
<thead>
<tr>
<th>Vehicle</th>
<th>Baseline track and dyno testing</th>
<th>Battery Test</th>
<th>Fleet mileage accumulation</th>
<th>Vehicle sample size</th>
<th>Miles target (per vehicle)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011 Nissan Leaf</td>
<td>Complete</td>
<td>5/5 Tests Complete</td>
<td>100% Complete</td>
<td>2</td>
<td>36,000</td>
</tr>
<tr>
<td>2012 Mitsubishi iMiev</td>
<td>Complete</td>
<td>2/5 Tests Complete</td>
<td>43% Complete</td>
<td>2</td>
<td>36,000</td>
</tr>
<tr>
<td>2013 Nissan Leaf</td>
<td>Complete</td>
<td>3/5 Tests Complete</td>
<td>44% Complete</td>
<td>4</td>
<td>36,000</td>
</tr>
<tr>
<td>2013 Ford Focus EV</td>
<td>Complete</td>
<td>3/5 Tests Complete</td>
<td>36% Complete</td>
<td>4</td>
<td>36,000</td>
</tr>
<tr>
<td>2014 Smart ED</td>
<td>Complete</td>
<td>2/5 Tests Complete</td>
<td>22% Complete</td>
<td>4</td>
<td>36,000</td>
</tr>
<tr>
<td>2014 BMW i3</td>
<td>Complete</td>
<td>2/5 Tests Complete</td>
<td>17% Complete</td>
<td>4</td>
<td>36,000</td>
</tr>
<tr>
<td>2014 BMW i3 Range Extender</td>
<td>Complete</td>
<td>2/5 Tests Complete</td>
<td>23% Complete</td>
<td>4</td>
<td>36,000</td>
</tr>
<tr>
<td>2015 Kia Soul EV</td>
<td>Complete</td>
<td>1/5 Tests Complete</td>
<td>15% Complete</td>
<td>4</td>
<td>36,000</td>
</tr>
<tr>
<td>2015 Chevrolet Spark EV</td>
<td>Complete</td>
<td>1/5 Tests Complete</td>
<td>9% Complete</td>
<td>4</td>
<td>36,000</td>
</tr>
<tr>
<td>2015 Volkswagen eGolf</td>
<td>Scheduled</td>
<td>1/5 Tests Complete</td>
<td>3% Complete</td>
<td>4</td>
<td>36,000</td>
</tr>
<tr>
<td>2015 Mecedes B-Class</td>
<td>Scheduled</td>
<td>1/5 Tests Complete</td>
<td>1% Complete</td>
<td>4</td>
<td>36,000</td>
</tr>
</tbody>
</table>

*Photos of new models introduced to project*
Vehicle Testing Progress: Advanced ICE

- 5 ICE Models: 1 model put into fleet this week

<table>
<thead>
<tr>
<th>Vehicle</th>
<th>Baseline track and dyno testing</th>
<th>Component Test</th>
<th>Fleet mileage accumulation</th>
<th>Vehicle sample size</th>
<th>Miles target (per vehicle)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012 Honda Civic CNG</td>
<td>Complete</td>
<td>3/5 Tests Complete</td>
<td>45% Complete</td>
<td>4</td>
<td>195,000</td>
</tr>
<tr>
<td>2013 Volkswagen Jetta TDI</td>
<td>Complete</td>
<td>NA</td>
<td>53% Complete</td>
<td>4</td>
<td>195,000</td>
</tr>
<tr>
<td>2014 Chevrolet Cruze Turbo Diesel</td>
<td>Complete</td>
<td>NA</td>
<td>15% Complete</td>
<td>4</td>
<td>195,000</td>
</tr>
<tr>
<td>2014 Mazda 3 (ultracapacitor)</td>
<td>Complete</td>
<td>1/5 Tests Complete</td>
<td>18% Complete</td>
<td>4</td>
<td>195,000</td>
</tr>
<tr>
<td>2015 Chevy Impala Bi-Fuel</td>
<td>Future</td>
<td>0/5 Tests Complete</td>
<td>0% Complete</td>
<td>4</td>
<td>195,000</td>
</tr>
</tbody>
</table>

Photos of new models introduced to project
**Tesla Model S 85 Testing**

- Rented a 2014 Model S 85 in early September
  - Performed track testing like that of other fleet vehicles
- Data collection:
  - CAN messages using production CrossChasm logger
  - Dewetron logger and optical 5th wheel sensor for speed and distance
- Data still being analyzed
- Slimmed down version of baseline testing report will be published
  - No dyno results

<table>
<thead>
<tr>
<th>Signal</th>
<th>Available Today</th>
<th>Available as of Dec 4, 2014 (or sooner if possible)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vehicle Speed</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Ambient Air Temperature</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HV Battery Current</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>HV Battery Voltage</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Vehicle Speed for EV (If not available via OBDII messages)</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>A/C Selected (true when A/C selected, i.e. defrost if automatic, a/c button on, etc)</td>
<td></td>
<td>Yes</td>
</tr>
<tr>
<td>Accelerator pedal position (%)</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Brake pedal (On/Off)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HV Battery SOC</td>
<td>Yes</td>
<td></td>
</tr>
</tbody>
</table>
Upcoming Vehicles To Be Tested

2016 Chevrolet Volt

Plan to get 4 in November from California dealer
Plan to get 4 in Nov/Dec
2016 Hyundai Sonata PHEV

Vehicle Features
Class: Sedan  
Type: PHEV  
CARB Class: T2EV  
Transmission: 6 Speed Automatic  
Carb Weight: 3,800 lb (est.)  
MSRP: $40,000  
Availability: Selected Markets

Performance
Top Speed: 75 mph (All-Electric Propulsion), 125 mph (Hybrid Propulsion)  
0-60 Acceleration: 8.3 s  
EPA Fuel Economy: 93 Mpg (Charge Depleting Mode), 44 mpg (Charge-Sustaining Mode)  
EPA Range: 22 miles (Charge Depleting Mode), 555 miles (Charge-Sustaining Mode)

Charging System
On-Board Charger: 3.3 kW  
DC FC: None  
Approximate Charge Time:  
AC Level 1: 9 hr  
AC Level 2: 3 hr

Propulsion
Engine: 2.0 L 4 Cylinder, GDI, 115 kW / 190 Nm  
Electric Motor: PMSM, 51 kW  
System: 151 kW @6,000 rpm  
Configuration: P2 Pre-Transmission, P1 BAS

Battery Pack
Type: Lithium-Ion in a polymer case  
Number of cells: N/A  
Nominal Pack Voltage: 360 V  
Nominal Pack Capacity: 27.2 Ah  
Nominal Pack Energy: 9.8 kWh  
Pack Weight: N/A  
Thermal Management: N/A

Plan to get 4 in Dec/Jan
- Accelerated Reliability out of Irvine Intertek office with one vehicle
- Have a reservation from a CA dealer, planned for Mar 2016 OR Utilize DOE Fuel Cell Partnership vehicle via DOE FCTO
Other Potential Vehicles for Testing

- 2016 VIA VTRUX Pickup (Loan through EV Everywhere)
- 2016 Toyota RAV4 PHEV
- 2016 Toyota Prius?
- 2016 Chrysler Town & Country PHEV
- 2016 Chevrolet Malibu HEV
- 2016 Volvo XC90 PHEV
- 2016 BMW x5 xDrive e40
- 2016 Mitsubishi Outlander PHEV (if it becomes available in the U.S.)
- 2017 Chevrolet Bolt BEV
- 2017 Cadillac CT6 PHEV