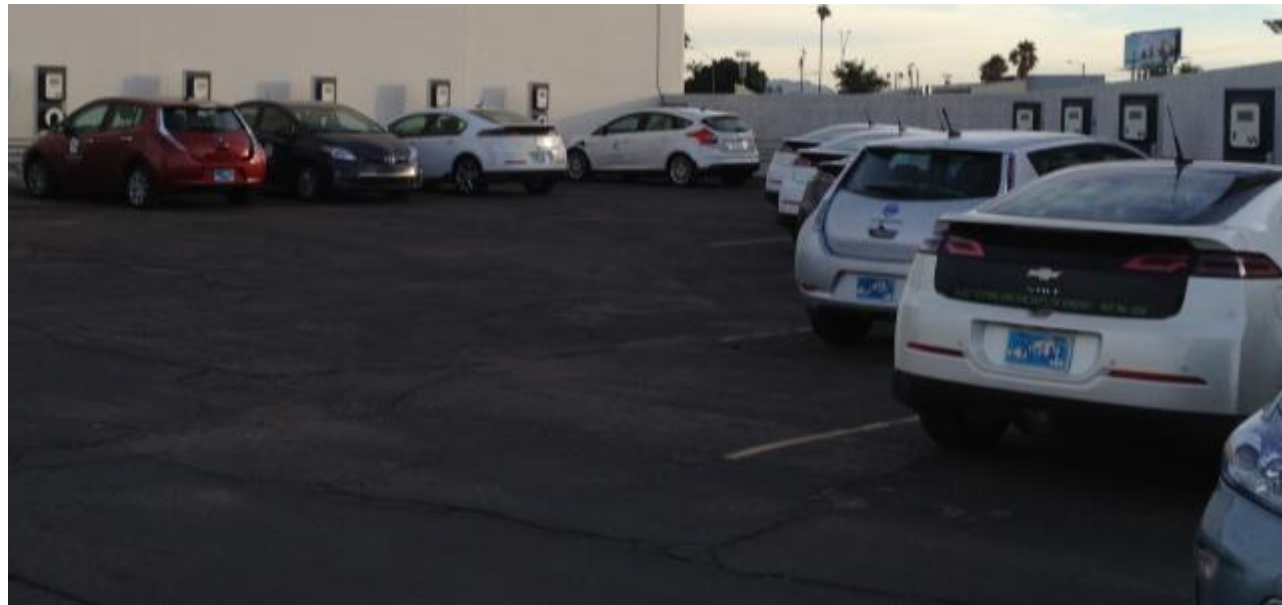


AVTA/AVTE On-Road Vehicle Evaluation Updates



www.inl.gov



Shawn Salisbury

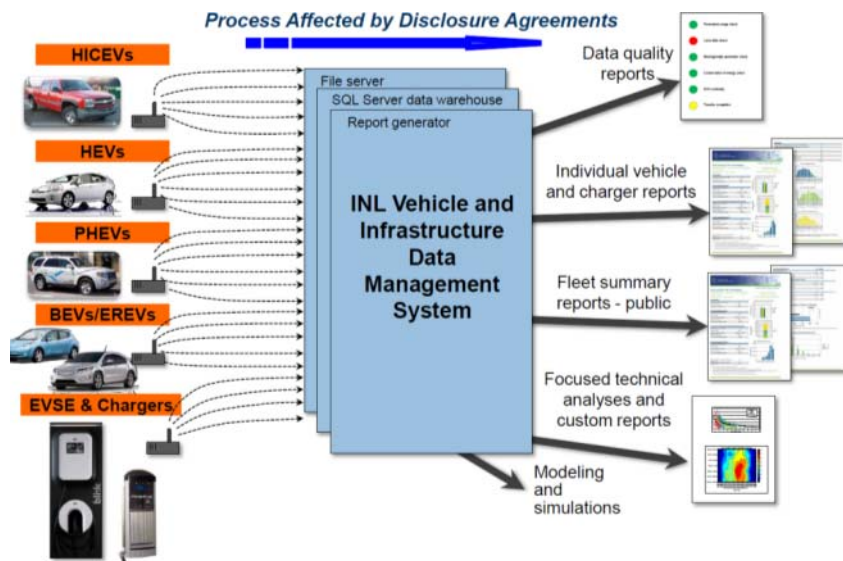
VSATT Meeting

October 14, 2015

INL/MIS-15-36909

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



Purchase Vehicle (4 of each model typical)

Baseline Traction Battery Testing



Install On-Board Data Logger (all cars)

4,000 Miles for Break-In

Track Performance and Coast Down Testing (one each model)

Dynamometer Testing (one each model)



Data Collection During Fleet Operation (all cars)

Traction Batteries or Components

3 Interim Tests

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

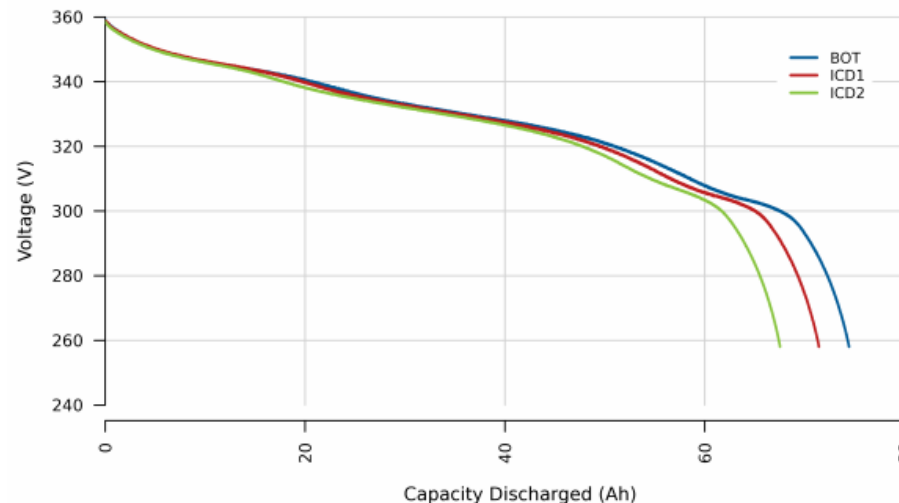
Data provided for every vehicle in fleet:

- 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



Voltage versus capacity discharged during static capacity test of 2013 Focus EV

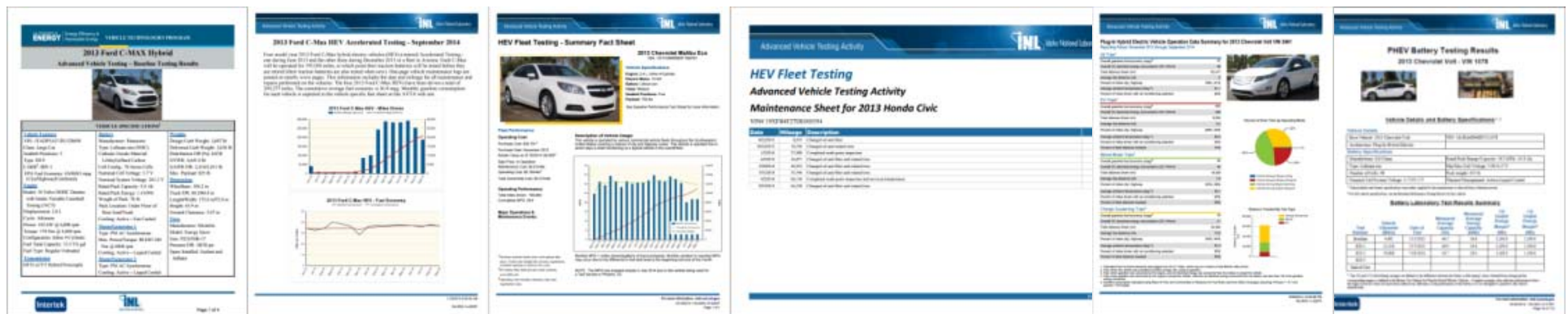
Reporting

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

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



Photos of new models introduced to project

Vehicle Testing Progress: Plug-in Hybrid

- 5 PHEV Models

Vehicle	Baseline track and dyno testing	Battery Test	Fleet mileage accumulation	Vehicle sample size	Miles target (per vehicle)
2011 Chevrolet Volt	Complete	4/5 Tests Complete	66% Complete	2	160,000
2013 Chevrolet Volt	Complete	3/5 Tests Complete	67% Complete	4	160,000
2013 Toyota Prius Plug-In	Complete	3/5 Tests Complete	75% Complete	4	160,000
2013 Ford C-Max Energi	Complete	3/5 Tests Complete	41% Complete	4	160,000
2013 Ford Fusion Energi	Complete	2/5 Tests Complete	46% Complete	4	160,000

Vehicle Testing Progress: Battery Electric

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

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



Photos of new models introduced to project

Vehicle Testing Progress: Advanced ICE

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

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



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

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

Upcoming Vehicles To Be Tested

2016 Chevrolet Volt

Vehicle Features

Class: Compact
 Type: Multi-Mode PHEV (EV, Series, and Power-split Configurations)
 CARB Credit: TZEV
 Transmission: e-CVT, Front Wheel Drive, 2.64:1 Final Drive Ratio
 Curb Weight: 3,543 lb (est.)
 MSRP: \$33,995

Performance

Top Speed: 98 mph
 0-60 Acceleration: 8.4 s
 EPA Fuel Economy: 106 MPGe (Charge-Depleting Mode); 42 mpg (Charge-Sustaining Mode)
 EPA Range: 53 miles (Charge-Depleting Mode); 374 miles (Charge-Sustaining Mode)

Charging System

On-Board Charger: 3.9 kW
 DCFC: None
 Approximate Charge Time:
 AC Level 1: 13 h
 AC Level 2: 4.5 h



Propulsion

Engine: 1.5 L, Direct Injection I-4, 75 kW@5,600 rpm
 Compression ratio: 12.5:1
 Motor: PMSM, 111 kW/398 Nm
 Generator: N/A



Battery Pack

Type: Lithium-ion
 Number of cells: 192 Prismatic
 Nominal Pack Voltage: N/A
 Nominal Pack Capacity: 52 Ah
 Nominal Pack Energy: 18.4 kWh
 Peak Power: 120 kW
 Pack Weight: 474 lb
 Thermal Management: Active, Liquid
 Cell Manufacturer: LG Chem

Plan to get 4 in November from California dealer

2016 Audi A3 e-tron

Vehicle Features

Class: Hatchback
Type: Parallel PHEV
CARB Credit: TZEV
Transmission: Six speed, dual-clutch
Curb Weight: 3,471 lb
MSRP: \$37,900
HV Charge mode: Allows driver to choose to add load to the engine to charge the battery during Charge-Sustaining Mode
Available: Oct. 2015

Performance

Top Speed: 138 mph
Top Speed Electric: 81 mph
0-60 Acceleration: 7.6 s
Fuel Economy: 105 MPGe (Charge-Depleting Mode, est.), 36 mpg (Charge-Sustaining Mode, est.)
EPA Range: 20 miles (Charge-Depleting Mode, est.), 377 miles (Charge-Sustaining Mode, est.)



Charging system

On-board Charger: 3.3 kW
DCFC: None
Approximate Charge time:
 AC Level 1: 3:45 h
 AC Level 2: 2.5 h

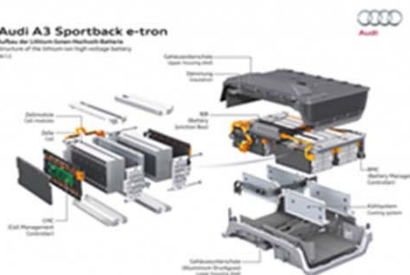
Propulsion

Engine: 1.4 L, I-4, Turbo, 112 kW/249 Nm
Electric Motor: 75 kW/350 Nm
Configuration: P2 pre-Trans.

Audi A3 Sportback e-tron
 drivetrain
 2015



Audi A3 Sportback e-tron
 battery pack
 2015



Battery Pack

Type: Lithium-Ion
Number of Cells: 96 prismatic cells (8 modules of 12 cells each)
Nominal Pack Voltage: 280-390
Nominal Pack Capacity: N/A
Nominal Pack Energy: 8.8 kWh
Pack Weight: 276 lb
Thermal Management: Active, Liquid Cooling

Plan to get 4 in Nov/Dec

2016 Hyundai Sonata PHEV

Vehicle Features

Class: Sedan

Type: PHEV

CARB Class: TZEV

Transmission: 6 Speed

Automatic

Curb 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 MPGe (Charge-Depleting Mode); 40 mpg (Charge-Sustaining Mode)

EPA Range: 22 miles (Charge-Depleting Mode); 565 miles (Charge-Sustaining Mode)



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



Charging System

On-Board Charger: 3.3 kW

DCFC: None

Approximate Charge Time:

AC Level 1: 9 hr

AC Level 2: 3 hr

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

2016 Toyota Mirai

Vehicle Features

Class: Compact Sedan
 Type: FCV
 CARB Credit: Type V ZEV
 Transmission: N/A
 Curb weight: 4,079 lb (est.)
 MSRP: \$57,500 or \$499/month lease, with 3 years of free hydrogen fuel)
 External Power
 Generation: CHAdeMO Socket

Performance

Top Speed: 111 mph
 0-62 mph Acceleration: 9.6 s
 EPA Fuel Economy: 67 MPGe (Combined, est.)
 EPA Range: 312 miles (est.)



Fuel Cell System

Type: PEM
 Max Output Power: 114 kW
 Fuel Tank: 5 kg in 2 tanks at 70 MPa
 Volume Power Density: 3 kW/l
 Mass Power Density: 2.0 kW/kg
 Number of Cells per Stack: 370 (single line stacking)
 Stack Weight: 124 lb
 Hydrogen Tank Weight: 193 lb
 FC Boost Converter output: 650 V
 Tank Storage Pressure: 70 MPa



Propulsion

Electric Motor: AC
 Synchronous, 113 kW, 335 Nm



Battery Pack

Type: Nickel-MetalHydride
 Number of Cells: N/A
 Nominal Pack Voltage: N/A
 Nominal Pack Capacity: N/A
 Nominal Pack Energy: N/A
 Max Power Output: N/A
 Thermal Management: N/A
 Manufacturer: N/A

- 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



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