Vehicle Mass Impact on Vehicle Losses and Fuel Economy

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Overview

Timeline

- FY11 – Project planning, Vehicle procurement, test plan preparation
- FY12 – Vehicle coastdown testing and data analysis; Vehicle dynamometer fuel economy and energy consumption testing and data analysis

Barriers

- A change in vehicle mass changes the energy consumption; Is this change the same for all vehicle technologies?
- Difficult to isolate mass impact from other factors (aerodynamic change from ride height change, vehicle fuel economy repeatability, etc)
- Maintaining environmental conditions repeatability during coastdown testing

Budget

- FY11 – $ 125,000
- FY12 – $ 225,000

Partners

- Idaho National Lab - lead
- ECOtality North America – coastdown testing
- Argonne National Lab – dynamometer testing

Objective / Relevance

- Determine for BEV, HEV and ICE the Impact of Vehicle Mass on:
  - Vehicle drag forces
  - Vehicle fuel economy or energy consumption (MPG and Wh/mi)
- Technology dependence of Mass Impact (HEV to ICE to BEV)
  - i.e. is mass reduction more beneficial for certain technologies?
- Share results of study with DOE, Tech Teams, OEMs, etc.

Approach

- Three vehicle tested (BEV, HEV, and ICE)
  - Nissan Leaf
  - Ford Fusion Hybrid
  - Ford Fusion V6
- Multiple test weights tested for each vehicle
  - Increase and decrease from stock weight (EPA certification weight)
- On test track, coastdown testing is conducted to determine the impact of mass change on vehicle drag forces
- Road load coefficients determined from coastdown testing are used to configure the chassis dynamometer
- Chassis dynamometer testing is conducted over standardized drive cycles to determine the impact of mass change on vehicle fuel economy and energy consumption (MPG and Wh/mi)

Approach - Coastdown Testing (ECOtality)

- For each vehicle, at each test weight
  - 14 coastdowns conducted to reduce sensitivity to external variables
    - 7 in each direction to nullify any track grade variability
    - Wind, ambient temp, and humidity limits strictly adhered to
- To reduce testing variability
  - Vehicle warmed up for 30 min. prior to testing
  - Ride height is held to a small tolerance at the various vehicle test weights
  - Temperatures monitored and recorded to ensure vehicle is functioning at steady state operating conditions
    - Transmission fluid temperature
    - Tire side wall temperature (non-contact temperature sensor)
  - Consistency between coastdown and dynamometer testing
    - Same vehicle operating mode utilized
    - Same three vehicles are used for all testing

	Fusion ICE (V6)	Fusion HEV	Leaf BEV
+500 lbs	4250	4500	4250
+250 lbs	4000	4250	4000
EPA cert. weight	3750	4000	3750
-100 lbs	3650	3900	3650
-250 lbs	3500	3750	3500

Approach - Chassis Dynamometer Testing (Argonne)

- For each vehicle, at each test weight
  - Standardized drive cycles used for dynamometer testing
    - UDDS
    - HWFET
    - US06

	Fusion ICE (V6)	Fusion HEV	Leaf BEV
+500 lbs	4250	4500	4250
EPA cert. weight	3750	4000	3750
-250 lbs	3500	3750	3500
-500 lbs	3250	3500	3250

- To reduce testing variability
  - Vehicle warmed up per dynamometer test procedures prior to testing
  - Same dynamometer driver for all tests
  - Temperatures monitored and recorded to ensure vehicle is functioning at same steady state operating conditions as on test track
    - Transmission fluid temperature
    - Tire side wall temperature (non-contact temperature sensor)
  - Consistency between coastdown and dynamometer testing
    - Same vehicle operating mode utilized
    - Same three vehicles are used for all testing

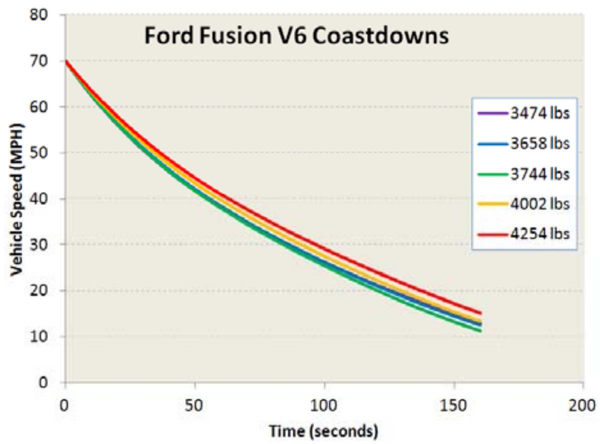
Milestones

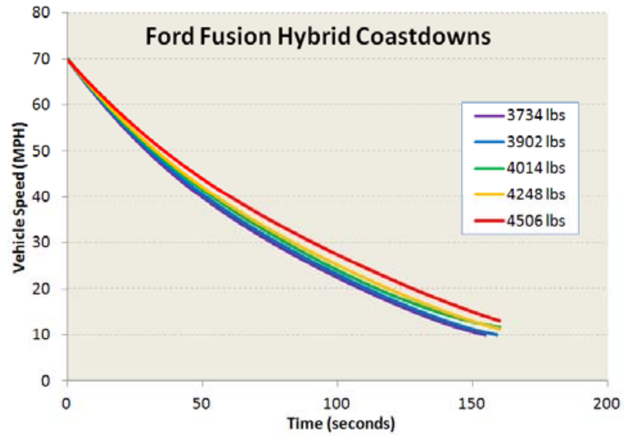
- Aug 2011 – Project planning and test plan complete
- Nov 2011 – Vehicles acquired and break-in miles accumulated
- Jan 2012 – Coastdown testing complete
- Feb 2012 – Analysis of coastdown data complete

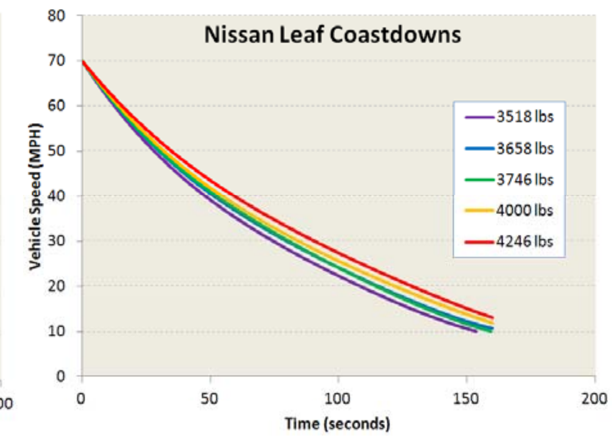
- April / May 2012 – Dynamometer testing in progress

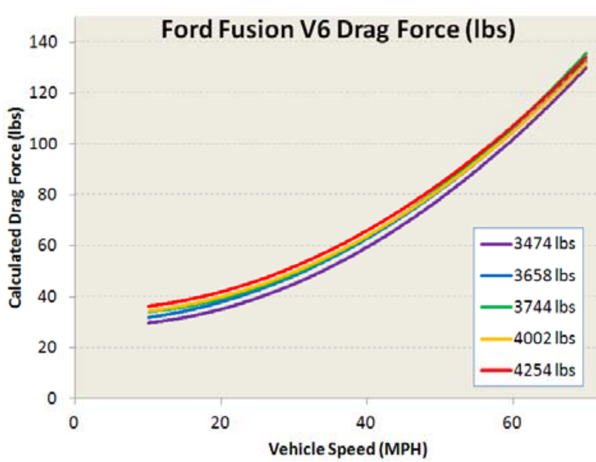
Technical Accomplishments

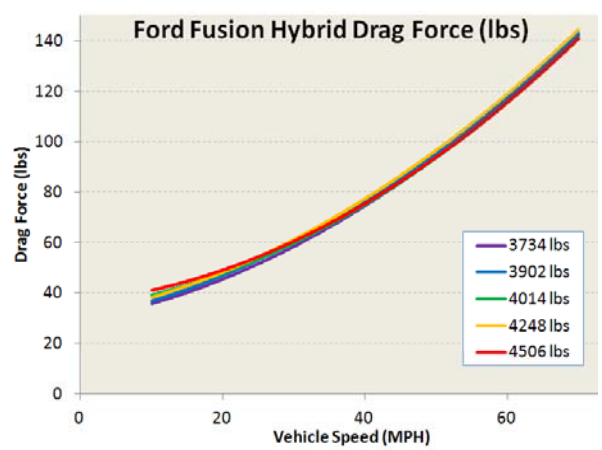
- A change in vehicle mass has shown a change in low speed rolling drag but less significant change in high speed drag forces

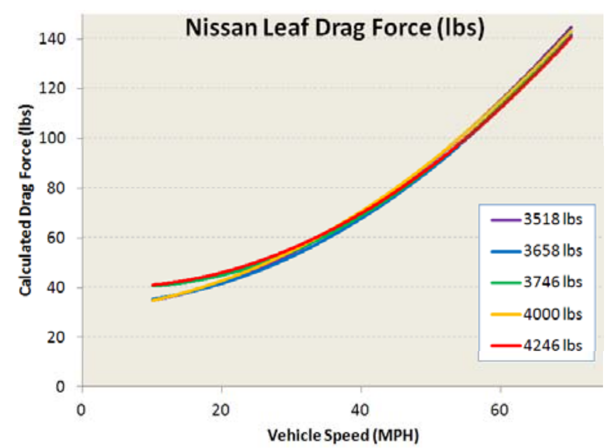








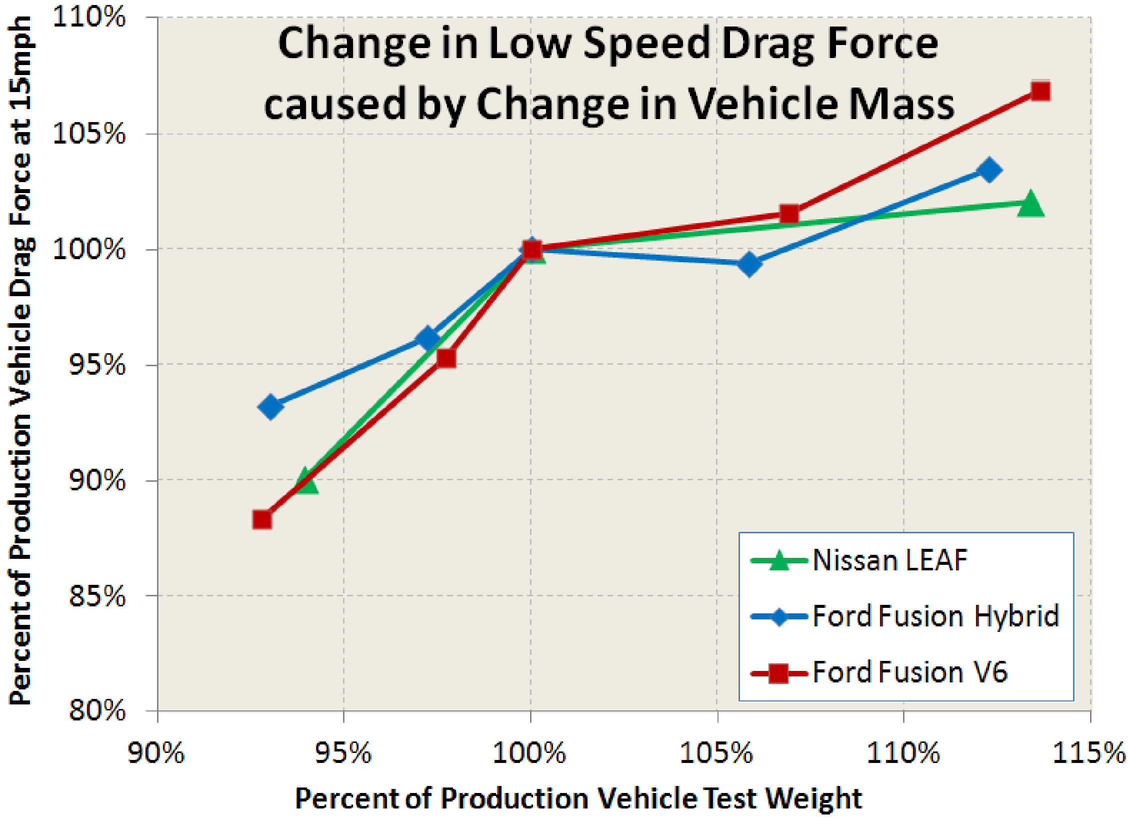




Technical Accomplishments (continued)

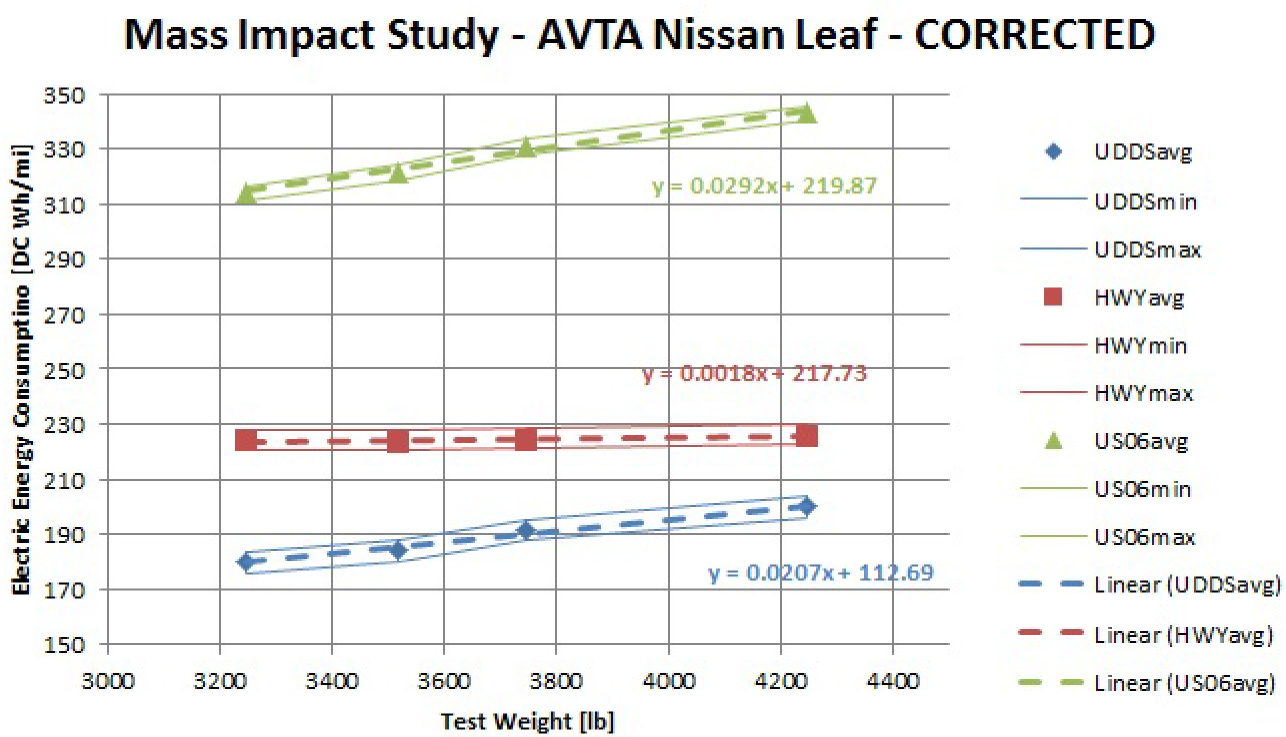
- The mass impact on vehicle drag appears to be independent of vehicle powertrain technology

- The change in vehicle drag shows a slightly non linear trend



Technical Accomplishments (continued)

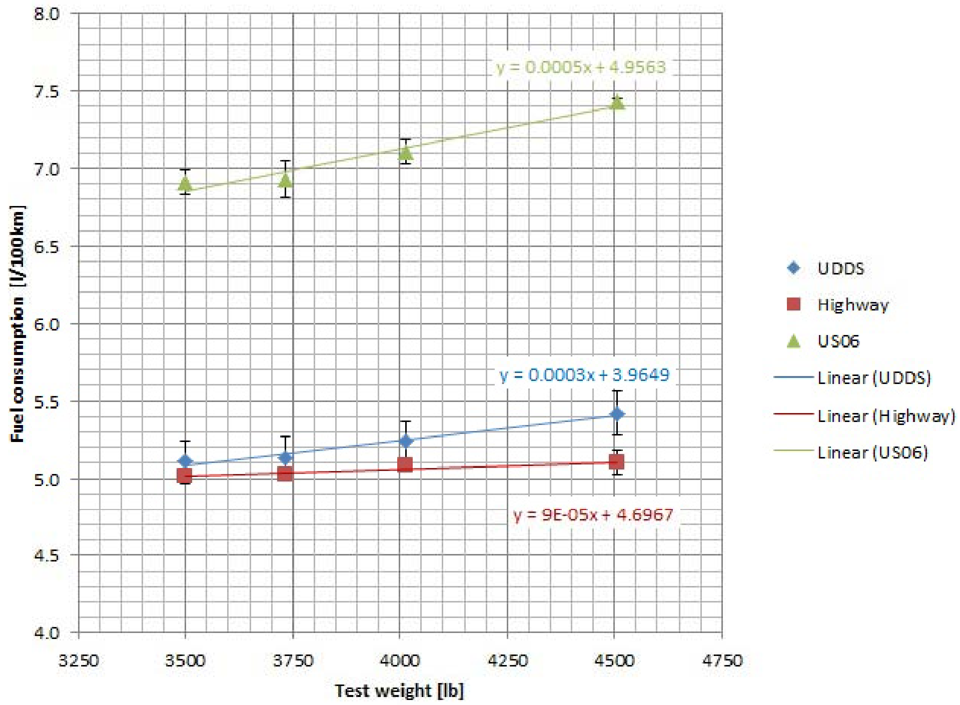
- The mass impact of the Nissan LEAF on Energy Consumption
  - Decreased Energy Consumption over UDDS and US06 cycle for decreased mass
    - 1000 lbs decrease → 15 to 20 DC Wh/mi decrease
  - Negligible change in Energy Consumption over HWFET cycle



Technical Accomplishments (continued)

- The mass impact of the Ford Fusion Hybrid fuel consumption
  - Decreased fuel consumption over UDDS and US06 cycle for decreased mass
    - 1000 lbs decrease → 0.3 to 0.5 L/100km decrease
  - Negligible change in Energy Consumption over HWFET cycle

Mass Impact Study – Ford Fusion Hybrid (Preliminary results)



Collaboration

- Results from testing will be shared with US DOE, Tech Teams, OEMs, and others in support of improving petroleum displacement technologies

Future Work

- Dynamometer testing at multiple vehicle test weights to determine Fuel Economy and Energy Consumption
  - Nissan Leaf (completed)
  - Ford Fusion Hybrid (completed)
  - Ford Fusion V6 (in process)
- Analysis of dynamometer testing results
- Report and present on results and findings
- Possibly investigate mass impact on other vehicle technologies
  - PHEV
  - Advanced diesel
  - Downsized gasoline engine with turbocharger
  - Advanced transmissions (CVT or Dual Clutch)

Summary

- Determination of vehicle mass impact on vehicle drag losses is complete
  - Coastdown testing is complete
  - Analysis of coastdown testing data is complete
- Determination of vehicle mass impact on vehicle fuel economy and energy consumption is in progress
  - Chassis dynamometer testing (Argonne National Lab)

- Provide results from Mass Impact on
  - Vehicle Drag Losses
    - A slightly non linear trend of decreasing vehicle mass results in decreased vehicle drag
    - Shows no dependency on powertrain technology

  - Vehicle Fuel Economy or Energy Consumption
    - Results will be provided after testing and analysis are completed