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ABSTRACT

The U.S. Department of Energy's Field Operations Program evaluates advanced technology vehicles in real-world applications and environments, and the results are targeted to fleet managers and others considering the deployment of advanced technology vehicles. As part of these activities, the Field Operations Program performed initial testing of the Honda Insight hybrid electric vehicle (HEV), a technology increasingly being considered for use in fleet applications. This report describes the Pomona Loop testing of the Insight, providing not only initial operational and performance information, but also a better understanding of HEV testing issues. The Pomona Loop testing includes both Urban and Freeway drive cycles, each conducted at four operating scenarios that mix minimum and maximum payloads with different auxiliary (e.g., lights, air conditioning) load levels.

The two passenger Insight is powered by a 67-hp, 1.0-liter, 3-cylinder gasoline engine and a 13-hp (10-kW) electric motor. The Insight has a 144-volt nickel metal-hydride battery comprising 120 1.2-volt cells, with a rated capacity of 6.5 amp-hours. The Insight tested has a 5-speed manual transmission.

The Insight exhibited test results of 40.9 to 63.3 miles per gallon (mpg) during the four types of Urban Loop testing; the EPA estimate for city driving is 61 mpg. During the four types of Freeway Loop testing, the Insight got 47.9 to 62.5 mpg; the EPA estimate for highway driving is 70 mpg. The fuel economy for the Urban Loop testing was highest when the Insight was tested with the maximum payload and no auxiliary loads. Variables such as driver behavior (the "lead" foot), the use of air conditioning and other auxiliary loads, or the type of driving cycle used can result in significant variations in fuel economy.

The testing not only provided an initial performance benchmark for the Insight but also highlighted HEV-specific testing issues. The lessons learned from this testing will be used to prepare for expanded HEV testing, ensuring accurate fuel-use measurements are used and that the testing methods are meaningful and applicable to fleet managers.

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ACRONYMS

ATV	advanced technology vehicle
DOE	U.S. Department of Energy
EV	electric vehicle
EVTC	Electric Vehicle Technical Center
HEV	hybrid electric vehicle
INEEL	Idaho National Engineering and Environmental Laboratory
kWh	kilowatt-hour
mpg	miles per gallon
NiMH	Nickel metal hydride (battery)
QVTs	qualified vehicle testers
SCE	Southern California Edison Company
SOC	state-of-charge

Field Operations Program
Honda Insight Hybrid Electric Vehicle
Performance Characterization Report

1. INTRODUCTION

The U.S. Department of Energy's (DOE's) Field Operations Program provides fleet managers and other potential advanced technology vehicle (ATV) users with accurate and unbiased information on vehicle performance. This allows the purchaser to make informed decisions about acquiring and operating ATVs. Vehicle information is obtained by testing ATVs in conjunction with industry partners and disseminating the testing results. The ATVs are tested using three methods - Baseline Performance Testing (controlled testing), Accelerated Reliability Testing (accumulating high miles on test vehicles), and Fleet Testing (testing vehicles in normal fleet operations). The testing results are disseminated via the Program's Website in the form of vehicle fact sheets and summary reports (http://ev.inel.gov/fop). Additional information on the Website includes testing specifications and procedures as well as general information about ATVs, such as how they work and their histories.

The Field Operations Program signed a 5-year testing agreement in 2000 with the following group of Qualified Vehicle Testers (QVTs):

- Electric Transportation Applications (lead partner)
- American Red Cross
- Arizona Public Service
- Bank One of Arizona
- Potomac Electric Power Company
- Salt River Project
- Southern California Edison
- Southwest Airlines
- Virginia Power.

As part of the Field Operations Program testing activities and as a compliment to the more controlled EVAmerica Baseline Performance testing, Southern California Edison (SCE) performed Pomona Loop testing on a Honda Insight hybrid electric vehicle (HEV).

The Insight was tested not only to gather its operational and performance information, but also to better understand HEV testing issues. For instance, what testing variables are unique to HEVs and can these variables significantly affect the accuracy of the test results? Another question is how should HEVs be tested so the results are meaningful to fleet managers and other potential HEV users? Informal conversations with other HEV testers indicate that some test methods do not always accurately reflect the performance of HEVs when they are used in fleet applications.

Program personnel and the testing partners recognized that new test procedures and controls would be required for HEV testing. In an effort to determine whether past electric vehicle (EV) testing experience was applicable to HEV testing and to better understand HEV testing issues, the DOE and the QVTs decided to apply a lessons-learned approach to the first HEV tests.

For example, when EVs are range tested, the distance traveled per charge was rarely greater than 100 miles and the energy used was usually 20 to 30 kilowatt-hours (kWh). Electric energy use is easy to measure with kWh meters, and the mathematics of distance traveled versus energy units used make range calculations very accurate. However, when testing gasoline use in HEVs, more miles must be accumulated to accurately measure distance traveled per energy unit. In addition, measuring the amount of gasoline used in a non-laboratory environment is more difficult than measuring the amount of electricity used. This is explained in Section 3.3.

Pomona Loop testing is a relatively fast and inexpensive method to identify these and other issues such as the significant variations in fuel consumption that can occur in HEVs when conditions vary. These conditions can include the aggressiveness in how the test driver drives the HEV, what on-board vehicle accessories are turned on during the drive, and how much payload is on-board. For instance, it appears that air conditioning can have a significant energy use impact, especially with the smaller gasoline engines used in HEVs.

To more fully understand the above and other issues, as well as to prepare for more complex (and expensive) testing, the Field Operations Program partnered with SCE to Pomona Loop test the Insight.

SCE also has their own organizational interests that compelled them to want to test the Insight. These are briefly discussed below.

The Insight testing results discussed in this report are based on the SCE Insight testing report (TC-01-138-TR02. Performance Characterization - Honda Insight Hybrid Electric Vehicle. SCE). This report summarizes the testing results.

1.1 Southern California Edison's Testing Interests

Over the years, new technologies have evolved that appear likely to have a significant impact on the transportation industry. One such technology is the hybrid power train. It is important that these early market entrants be evaluated and understood in terms of performance, energy efficiency, and emissions. Once different models have been tested, an evaluation of the benefits of the different hybrid configurations, including plug-in hybrids, will be possible. To this end, SCE partnered with the Field Operations Program to conduct a performance characterization of a Honda Insight.

The purpose of SCE's evaluation of EVs, HEVs, EV chargers, batteries, and related items is to support their safe and efficient use and to minimize potential utility system impacts. The following facts support this purpose:

- As a fleet operator and an electric utility, SCE uses EVs to conduct business.
- SCE must evaluate EVs, HEVs, batteries, and charging equipment in order to make informed purchase decisions.
- SCE must determine if there are any safety issues with EV and HEV equipment and their usage.

- SCE has a responsibility to educate and advise its customers about the efficient and safe operation of EVs and HEVs.

Tests performed were: weight certification, range, fuel efficiency, performance (acceleration, maximum speed, and braking), and sound measurements. They were conducted at SCE's Electric Vehicle Technical Center (EVTC), on the Urban and the Freeway Pomona Loops, and at an area race track. Testing was conducted in accordance with the SCE HEV test procedure.

2. MANUFACTURER'S SPECIFICATIONS

Table 1. Manufacturer specifications for the 2001 model, two passenger Honda Insight, with a 5-speed manual transmission. Source – http://www.honda2001.com/models/insight/features.html

Item	Specification
Gasoline Engine	
Type:	Aluminum-Alloy In-Line 3-Cylinder
Displacement (cc)	995
Horsepower @ rpm	67 @ 5700 / 73 @ 5700 (SAE net/with Integrated Motor Assist™)
Torque @ rpm	66 @ 4800 / 91 @ 2000 (lb.-ft. @ rpm/with Integrated Motor Assist ™)
Compression Ratio	10.8:1
Valvetrain:	12-Valve SOHC VTEC™-E Lean-Burn
Fuel System:	Multi-Point Fuel Injection
Ignition System:	Electronic w/Immobilizer
Emission Rating:	Ultra Low Emission Vehicle*(ULEV)
Idle-Stop Feature	
105,000-Mile Tune-Up Interval	
*California Air Resources Board ULEV-certified in California and parts of the Northeast; LEV-rated in rest of country.	
Electric Motor/Generator	
Motor Type	Permanent Magnet
Power Output	10 kW @ 3000 rpm
Motor Width (mm)	60
Electric Power Storage	
Battery Type	Nickel-Metal Hydride (NiMH)
Output	144v (120 cells @ 1.2v)
Rated Capacity	6.5 AH
Drivetrain	
Type:	Front-Wheel Drive
Transmission:	Manual, 5-Speed
Final Drive Ratio	3.21
Body/Suspension/Chassis	
Body Type:	Aluminum monocoque
Front Suspension:	MacPherson Strut
Rear Suspension:	Twist Beam

Table 1. (Continued)

Item	Specification
Front Stabilizer Bar (mm)	17.3
Electric Power Steering (EPS)	Variable-Assist Rack-and-Pinion
Turning Diameter, Curb-to-Curb (ft.)	31.4
Brakes:	4-Wheel Anti-Lock Braking System (ABS), Power-Assisted Ventilated Front Disc/Rear Drum
Wheels:	14 in. Alloy
Tires:	P165/65 R14 78S Low Rolling-Resistance
Interior Dimensions	
Head room (in.)	38.8
Leg room (in.)	42.9
Shoulder Room (in.)	50.5
Hip room (in.)	48.7
Cargo Volume (cu. ft.)	16.3
Passenger Volume (cu. ft.)	47.4
Rear Hidden Storage Well (cu. ft.)	2.0
Exterior Dimensions	
Wheelbase (in.)	94.5
Length (in.)	155.1
Height (in.)	53.5
Width (in.)	66.7
Track (in., front/rear)	56.5/52.2
Curb Weight (lbs.)	1856/1887- With available automatic air conditioning.
EPA Mileage Estimates††/Fuel Capacity	
(City/Highway)	61/70 mpg
Fuel (gal.)	10.6
Fuel Required	Regular unleaded

†† Mileage shown for comparison only. Actual mileage may vary

3. RANGE AND FUEL ECONOMY TEST RESULTS

The Pomona Loop Testing consists of two types of on-road drive cycles:

1. The Urban Loop is 19.3 miles long with approximately 50 stop signs and traffic lights, and the elevation ranges from about 900 to 1,500 ft above sea level (see map in Appendix A). The Urban Loop is located in the greater Pomona, California area and it consists of city and residential area streets.
2. The Freeway Loop is 37.2 miles long with elevation ranges from about 700 to 1,150 ft above sea level (see map in Appendix A). The Freeway Loop is also located in the greater Pomona, California area and it consists of Southern California freeways.

Four vehicle-operating scenarios are used for each of the Pomona Loops, including operating the test vehicles with minimum or maximum payloads and either no auxiliary loads or auxiliary loads applied (Table 2). The Insight was tested twice at each of the four operating scenarios for both the Urban and Freeway Loops, so that a total of 16 drive cycles were performed. The testing was designed to not necessarily complete a set number of Loops per drive cycle, rather, it was designed to accumulate approximately 100 miles during each of the 16 drive cycles. A total of 1653 miles were driven during the fuel economy testing.

Table 2. Pomona Loop operating scenarios for test vehicles.

Pomona Urban Loop Vehicle Operating Scenarios	
UR-1	Urban Range Test, Min Payload, No Auxiliary Loads
UR-2	Urban Range Test, Min Payload, A/C on High, Headlights on Low, Radio On
UR-3	Urban Range Test, Max Payload, No Auxiliary Loads
UR-4	Urban Range Test, Max Payload, A/C on High, Headlights on Low, Radio On
Pomona Freeway Loop Vehicle Operating Scenarios	
FW-1	Freeway Range Test, Min Payload, No Auxiliary Loads
FW-2	Freeway Range Test, Min Payload, A/C on High, Headlights on Low, Radio On
FW-3	Freeway Range Test, Max Payload, No Auxiliary Loads
FW-4	Freeway Range Test, Max Payload, A/C on High, Headlights on Low, Radio On

For a full discussion of the Urban and Freeway Pomona Loop testing, the Southern California Edison Pomona Loop Test Procedures Report can be accessed at the following address http://ev.inel.gov/fop/pdf/pomoloop_tp.PDF

3.1 Urban Loop Test Results

The Insight was tested twice for each of the four operating scenarios on the Urban Pomona Loop (Table 3). For urban driving with a minimum payload and no auxiliaries used (UR-1), the average fuel economy was 52.4 mpg. With a minimum payload and the auxiliary loads turned on (UR-2), the fuel economy dropped to an average of 41.5 mpg. With the maximum payload and no auxiliaries on (UR-3), the fuel economy was 61.9 mpg. With the maximum payload and the auxiliary loads turned on (UR-4), the fuel economy was 47.7 mpg. It should be noted that while the driver was not supposed to play the radio during the no-auxiliary load tests, the radio was played during all of the mileage tests, including the no-auxiliary load tests (Loops UR-1 and UR-3).

The relationship between testing scenarios (minimum/maximum payload, and no loads/full auxiliary loads) and mpg results warrants the following discussion as the testing results were not as expected. The fuel efficiencies were comparatively better when the Insight was tested with full payloads and similar auxiliary loads (UR-3 compared to UR-1, and UR-4 compared to UR-2).

- UR-1 and UR-2 – The only difference between the two drive cycles is the auxiliary loads added during the UR-2 testing. The UR-2 result is a decrease of 11 mpg; these results are as expected.

- UR-1 and UR-3 – The only difference is the maximum payload added during the UR-3 test. One would anticipate that the UR-3 result would be lower, but it was actually 9.5 mpg higher. Normally, the heavier payload (UR-3) would suggest that fuel economy would be lower, especially during the many acceleration phases encountered during urban driving. Not having access to the operating and control algorithm for the

Insight's motors and controller, one can only guess that the electrical motor may be utilized more with the heavier payload. Therefore, the higher efficiency of electric motors may have contributed to the results. The Honda literature does state that the electric motor assists the gasoline motor when accelerating "hard". (http://www.hondacars.com/models/insight/engineering.html?show=ima)

- UR-4 and UR-2 – During the UR-4 operating scenario, with a full payload and auxiliary loads on, one would anticipate the lowest fuel economy. However, this is not true when compared to the UR-2 results. If the assumption is true that the electric motor operates more when a heavy payload is present (UR-3 and UR-4 drive cycles), then the UR-4 results make sense. For instance:
  - UR-4 has a 4.7-mpg lower result than UR-1 probably because of the auxiliary loads present during the UR-4 test. However, the UR-1 and UR-4 comparison does not exhibit the same reduction seen in fuel efficiency (11 mpg) when comparing the UR-1 and UR-2 results. The difference may be that the heavier payload present during the UR-4 tests results in greater use of the electric motor than during the UR-1 and UR-2 testing.
  - When comparing UR-4 and UR-2, the UR-4 results are 6 mpg higher. Under both scenarios, the auxiliary loads are on. However, the higher payload in the UR-4 tests may result in greater use of the electric assist motor, resulting in higher fuel economy.
  - The 14-mpg lower results between UR-3 and UR-4 may be the result of adding the auxiliary loads in the UR-4 tests. Both UR-3 and UR-4 tests are conducted with the maximum payload.

The above discussion is ripe with supposition; and as mentioned previously, the Insight powertrain control algorithm is unknown. However, if the operation of the electric assist motor is greatest because of the presence of the full payload, the fuel economy results make sense. It is not known why all of the fuel economy results obtained during the second test for each urban drive cycle are higher than the first test for each respective drive cycle. All of the second tests did occur after completing the first test for each drive cycle. Possibly, cognitive driver behavior or an unintended learned driver bias caused the second test changes.

Table 3. Honda Insight Urban Loop testing results.

Drive Cycle	Test Date	Average Ambient Temp (°F)	Total fuel usage (gal)	Miles driven	Calculated mpg	Average mpg	Manufacturer mpg[1]
UR-1	07/03/01	94.5	2.01	104.8	52.1	52.4	57.8
UR-1	07/20/01	81.0	1.95	102.5	52.6		58.1
UR-2	06/28/01	88.5	2.54	104.0	40.9	41.5	44.3
UR-2	07/24/01	80.0	2.44	102.5	42.0		44.2
UR-3	07/06/01	83.5	1.73	104.8	60.6	61.9	58.5
UR-3	07/13/01	83.5	1.63	103.2	63.3		59.3
UR-4	07/11/01	87.5	2.20	104.7	47.6	47.7	44.4
UR-4	07/17/01	81.5	2.19	104.8	47.9		44.3

[1] Fuel Economy Meter mpg is average of 21 readings.

It should be noted that when comparing the "Calculated mpg" test results to the "Manufacturers mpg" test results (Table 3), the "Calculated mpg" is lower for all four tests conducted with minimum payloads (UR-1 and UR-2). Inversely, the "Calculated mpg" is higher than the "Manufacturers mpg" (Table 3) for all four tests conducted with maximum payloads (UR-3 and UR-4). It should also be noted that the simple mean average for the eight "Calculated mpg" results is 50.9 mpg while the simple mean average for the eight "Manufacturer mpg" results is 51.4 mpg, less than a 1% difference. (The simple mean average is the sum of each of the eight values divided by 8).

The estimated range calculation is based on the nominal 10.6-gallon fuel tank and the above testing results. The average estimated ranges are listed by operating scenarios:

- UR-1, minimum payload and no auxiliaries – 555 miles
- UR-2, minimum payload and auxiliaries on – 440 miles
- UR-3, maximum payload and no auxiliaries – 656 miles
- UR-4, maximum payload and auxiliaries – 506 miles

The total mileage driven during the eight urban drive cycles (four types of urban tests, each driven twice) was 831.3 miles and the total fuel used was 16.69 gallons. Therefore, the overall fuel economy during the eight urban drive cycles was 49.8 mpg, and based on the 10.6-gallon fuel tank, the estimated maximum range under mixed urban driving conditions is 528 miles.

3.2 Freeway Loop Test Results

The Insight was also tested twice for each of the four operating scenarios on the Freeway Pomona Loop (Table 4). Unfortunately, the FW-3 test conducted on 07/09/01 was considered to have invalid fuel usage data, so it is not included in any of the averages or summary values.

Table 4. Honda Insight Freeway Loop testing results.

Drive Cycle	Test Date	Average Ambient Temp (F)	Total fuel usage (gal)	Miles driven	Calculated mpg	Average mpg	Manufacturer mpg[1]
FW-1	06/29/01	83.4	1.89	104.7	55.4	55.6	65.8
FW-1	07/23/01	79.0	1.84	102.6	55.8		66.2
FW-2	07/02/01	88.0	1.65	103.2	62.5	59.9	57.9
FW-2	07/25/01	81.5	1.79	102.8	57.4		57.8
FW-3	07/09/01	74.6	1.22	101.0	82.8[2]	59.9	69.2
FW-3	07/16/01	79.5	1.71	102.5	59.9		59.3
FW-4	07/10/01	81.5	2.15	103.0	47.9	49.5	57.6
FW-4	07/18/01	81.5	1.99	102.1	51.3		56.3

[1] Fuel Economy Meter mpg is average of 21 readings.

[2] Invalid Data. SCE reports that the results for this test were not accurately measured.

For freeway driving with a minimum payload and no auxiliaries used (FW-1), the average fuel economy was 55.6 mpg. With a minimum payload and the auxiliaries turned on (FW-2), the fuel economy raised to an average of 59.9 mpg. With maximum payload and no auxiliaries on (FW-3), the fuel economy was 59.9 mpg. With maximum payload and the auxiliary load on (FW-4), the fuel economy dropped to 49.5 mpg. It should be noted that while the driver was not supposed to play the radio during the no-auxiliary load tests, the radio was played during all of the mileage tests, including the no-auxiliary load tests (Loops FW-1 and FW-3). It should also be noted that the simple mean average for the seven “Calculated mpg” results is 55.7 mpg (Table 4) while the simple mean average for the seven “Manufacturer mpg” results is 60.1 mpg, an approximately 8% difference. (The simple mean average is the sum of each of the eight values divided by 8).

Understanding the various Freeway Loop drive cycle test results for the Insight is difficult, as a clear pattern does not seem obvious. However, while the Urban Loop results had a variance of as great as 50%, the average results for the seven tests comprising the Freeway drive cycles vary by a maximum of 21%. The energy efficiency results for the FW-4 tests were from 6 to 10 mpg lower than the average results for the other tests. Given that the FW-4 test scenario includes a full payload and auxiliary loads, it is reasonable to expect that the fuel economy results for this drive cycle would be lowest of all of the Freeway Loop tests. The power assist electric motor probably did not operate during most of the Freeway Loop testing, as periods of hard acceleration should have been mostly avoided. The Freeway Loop testing usually was conducted during mid morning hours, after the heavy morning commuter traffic was completed.

The estimated range calculation was based on the 10.6-gallon fuel tank and the above testing results. The average estimated freeway ranges are listed by operating scenarios:

- FW-1, minimum payload and no auxiliaries – 589 miles
- FW-2, minimum payload and auxiliaries on – 635 miles
- FW-3, maximum payload and no auxiliaries – 635 miles
- FW-4, maximum payload and auxiliaries – 525 miles.

The total mileage driven during the seven freeway drive cycles (four types of freeway tests, each driven twice, minus the FW-3 07/09/01 results) was 720.9 miles and the total fuel used was 13.02 gallons. Therefore, the overall fuel economy during the seven freeway drive cycles was 55.4 mpg, and based on the 10.6-gallon fuel tank, the estimated maximum range under mixed freeway driving was 587 miles.

The overall fuel economy for all 15 Urban and Freeway tests averaged 52.2 mpg (UR&FW Average in Figure 1). Figure 1 also shows the average fuel economy results for the two tests performed for each operating scenario as well as the average fuel economy results for all eight urban tests (UR-Average) and all seven freeway tests (FW-Average). (See Table 2 for an explanation of the operating scenarios).

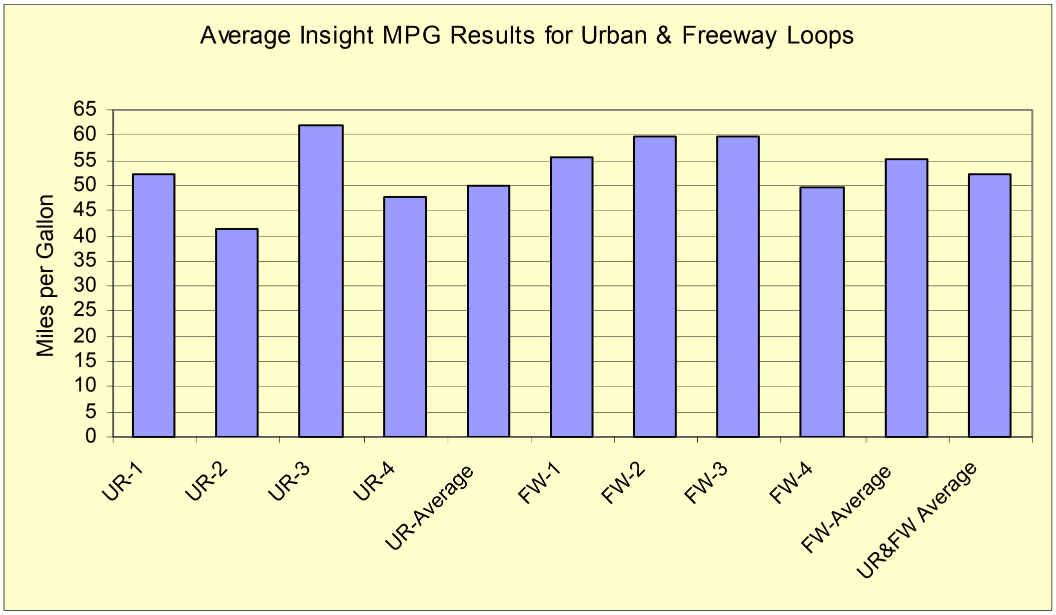

Figure 1. Average miles per gallon (mpg) testing results for the Urban and Freeway Pomona Loops.

3.3 Fuel Usage Measurement

As mentioned in the introduction, definitively measuring the amount of gasoline used for each test was more difficult than first envisioned. Because the Insight was leased (thus preventing alterations to the vehicle), fuel usage measurement options were limited to nonintrusive methods. Given these constraints, three low-cost, nonintrusive (or quasi–nonintrusive) fuel usage measurement methods were considered, the first two of which were discarded.

The first method would have relied on gas pump readings to determine the quantity of fuel used for a given test. When the vehicle tank was refilled, the "first click" of the pump nozzle would be accepted as indication of a "full" tank and the fuel quantity displayed by the pump would be read. However, the variability of this method is well known to anyone that has added gasoline after the first "click".

To improve the accuracy of the tests, a second method was considered and attempted. It relied on draining the vehicle tank with the fuel system pump (by temporarily disconnecting the fuel supply line and activating the pump with the "ignition key on") and subsequently filling it with a known quantity of fuel. Using up all of the known quantity of fuel would have yielded fuel usage. Unfortunately, it was not possible to get a consistent "empty tank" condition; successive reactivation of the fuel pump always drained an additional amount of fuel.

The third method relied on carefully refilling the vehicle tank in the EVTC lab, early in the morning (to minimize ambient temperature swings and gasoline expansion during driving), before each drive cycle with a lab-quality calibrated graduated cylinder (Figures 2 and 3). A notch in the tank filler tube gave the necessary liquid level reference. This method was used and it met the criteria of being nonintrusive and low cost, while elucidating HEV testing variables and issues.

Figure 2. Fuel usage measurement equipment.

Figure 3. Tank filling operation.

4. VEHICLE PERFORMANCE TESTS

Performance testing was conducted at the Los Angeles River test site on September 22, 2000.

4.1 Vehicle Acceleration Testing

Table 5 shows the results from the acceleration tests. The results for 0 to 30 mph and 0 to 60 mph were obtained with a performance computer. The average acceleration time for 0 to 30 mph was 4.2 seconds and for 0 to 60 mph it was 12.7 seconds. The 30 to 55 mph accelerations were hand timed; the average time was 7.2 seconds (the time was only captured during 3 of the tests). Speed and distance versus time for one of the 0 to 60 mph acceleration tests is shown Figure 4. Table 6 shows the results of quarter-mile acceleration results. The average time was 19.1 seconds, with an average speed of 72.2 mph.

Table 5. Insight acceleration test results in seconds.

Sequence	Direction	0 – 30 mph (s)	0 – 60 mph (s)	30 – 55 mph (s)
1	S	3.67	12.58	-
2	N	3.94	11.56	7.15
3	S	4.16	12.38	7.37
4	N	4.18	12.20	7.06
5	S	4.60	13.40	-
6	N	4.64	13.79	-
	Average (s)	4.20	12.65	7.19

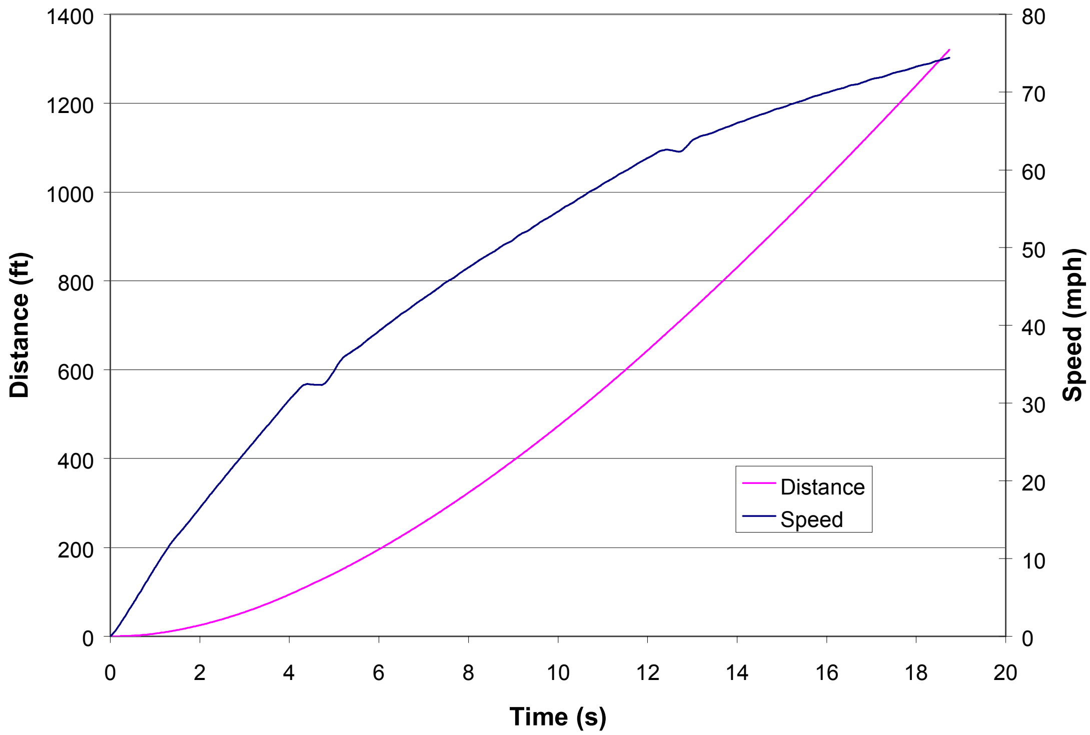

Figure 4. Zero to 60 mph acceleration test results.

Table 6. Quarter-mile acceleration test results

Sequence	Direction	Time (seconds)	Speed (mph)
1	S	19.389	70.995
2	N	18.739	74.416
3	S	19.261	71.268
	Average	19.130	72.226

4.2 Vehicle Braking Testing

Table 7 shows the results of the 25-mph braking tests. The results were obtained with a performance computer. The average stopping distance adjusted for 25 mph was 28.8 ft.

Table 7. Insight braking test results from 25 mph.

Sequence	Direction	Speed (mph)	Time (seconds)	Distance (ft)	25 mph Adjusted Distance (ft)
1	S	23.48	1.68	27.92	31.78
2	N	22.12	1.32	20.55	26.49
3	S	22.53	1.55	24.47	30.39
4	N	22.03	1.33	20.49	26.67
				Average (ft)	28.83

4.3 Sound Measurements

These measurements were made with a Sound Level Meter placed at head level in the front passenger seat area. The sound tests were conducted for approximately 50 minutes during the Urban Loop (Figure 5) and 37 minutes during the Freeway Loop (Figure 6). The sound averaged approximately 65 decibels during the Urban loop and 74 decibels during the Freeway Loop.

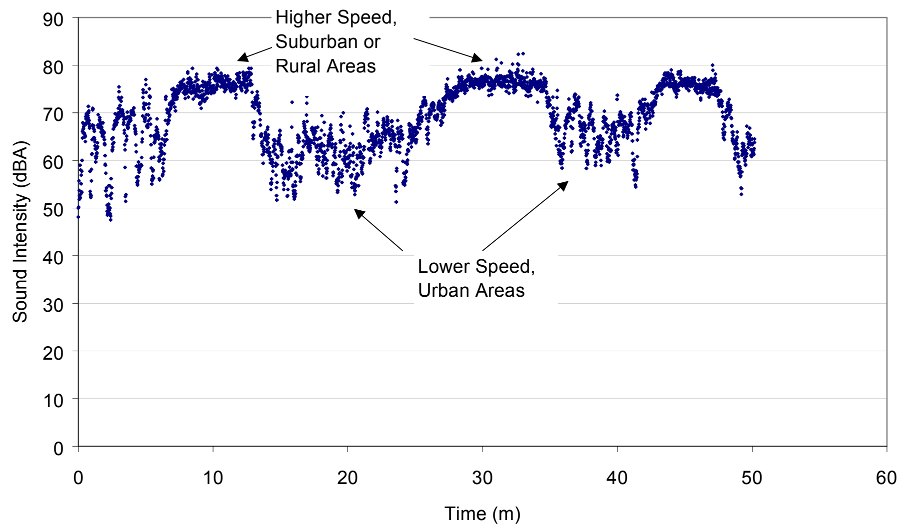

Figure 5. Urban Loop sound measurement results.

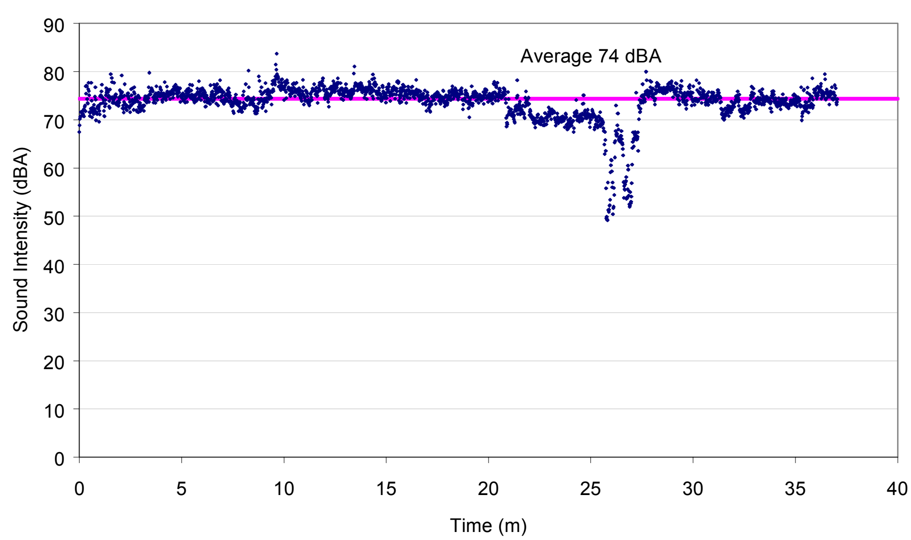

Figure 6. Freeway Loop sound measurement results.

4.4 Weight Certification

When weighed at a certified scale, the Insight was found to have a total available payload of 520 pounds (Table 8).

Table 8. Measured vehicle weight.

	Front Axle	Rear Axle	Total Weight
Sticker GVWR (lb)	1320	990	2310
Measured Weight (lb)	1090	700	1790
Available Payload (lb)	230	290	520

5. CONCLUSIONS

- The Pomona Urban Loop test most similar to the EPA test that estimates “City” mileage is the UR-1 scenario (minimum payload and no air conditioning). The UR-1 results averaged 52.4 mpg, or 8.6 mpg lower than the 61 mpg EPA result. Overall, the individual Urban Loop fuel economy results ranged from 40.9 to 63.2 mpg for the two-passenger Insight. The overall average fuel economy for the eight Urban Loop tests was 49.8 mpg.
- The EPA “Highway” fuel economy estimate for the Insight is 70 mpg. The FW-1 loop results, which are closest to the EPA test conditions, were considerably lower at 55.6 mpg. The individual Freeway test results ranged from 47.9 to 62.5 mpg, averaging 55.4 mpg. The results for the Freeway testing, while lower than the EPA estimates, is within the bounds reported by a group of Insight enthusiasts (Figure 7). It should be noted that some enthusiasts report drafting behind tractor-trailers and using non-recommended engine oils to obtain their results.
- The testing did highlight that future range and fuel economy on-road testing should include test distances that are much longer than traditionally used for the Pomona Loop testing (and other testing) due to the stingy fuel use rates and fuel use must be measured more accurately. Accelerated reliability testing, under which 100,000 miles are placed on individual vehicles, will provide representative fuel use rates.
- The EVAmerica type of Baseline Performance testing will provide accurate fuel use rates as it allows for the use of more intrusive fuel measurement methods. The EVAmerica testing will also provide very accurate vehicle performance data given the controlled testing possible when using a dynamometer and a closed track.
- Two Insights are currently undergoing Accelerated Reliability testing, under which 100,000 miles are accumulated per Insight in 2 years. The results of this testing will document any long-term operational issues, including the performance and life of the hybrid battery back.

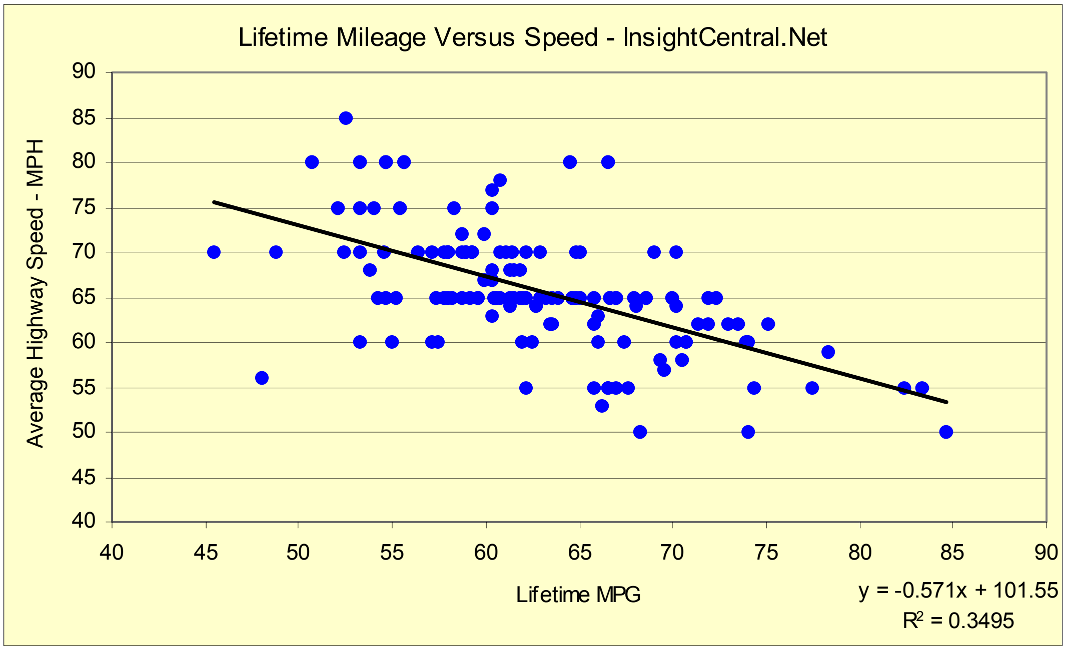

Figure 7. Honda Insight miles per gallon versus average highway speed. Linear trend line plotted. Data provided by 139 Honda Insight owners, posted on the InsightCentral.net webpage. http://www.InsightCentral.net/registry.mv?action=ListLifetime

Appendix A: Urban and Freeway Pomona Loop Maps