

U.S. Department of Energy FreedomCAR & Vehicle Technologies Program

Hybrid Electric and Pure Electric Vehicle Testing (Advanced Vehicle Testing Activity)

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Discovery Center of Idaho - September 2005

HEV & EV Testing Presentation Outline

- **Testing partners**
- **Hybrid electric vehicles**
 - **Performance**
 - **Fuel economy**
 - **Maintenance & repairs**
 - **Life-cycle costs**
 - **MPG in fleets, controlled testing & EPA results**
- **Neighborhood electric vehicles**
- **Urban electric vehicles**
- **Airport Ground Support Equipment testing**
- **WWW location**

Current AVTA Testing Partners

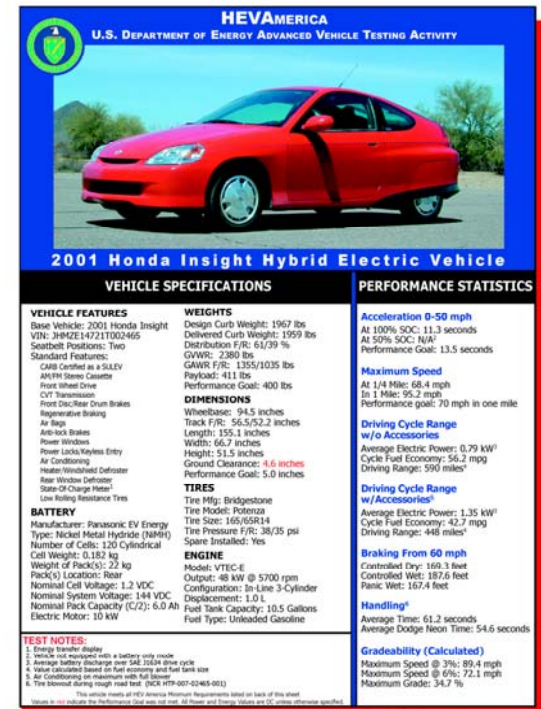
- **U.S. Department of Energy's Idaho National Laboratory**
- **Qualified Vehicle Testers (50/50 cost share)**
 - **Electric Transportation Applications (lead)**
 - **Arizona Public Service, Bank One of Arizona & Red Cross**
 - **Ford Motor Company**
 - **Luke AFB & Camp Pendleton**
 - **New York Power Authority, Southern California Edison & Salt River Project**
 - **Cities of Palm Springs, Palm Valley, Phoenix, Vacaville & San Diego, & UC Irvine**

HEV Testing Methods

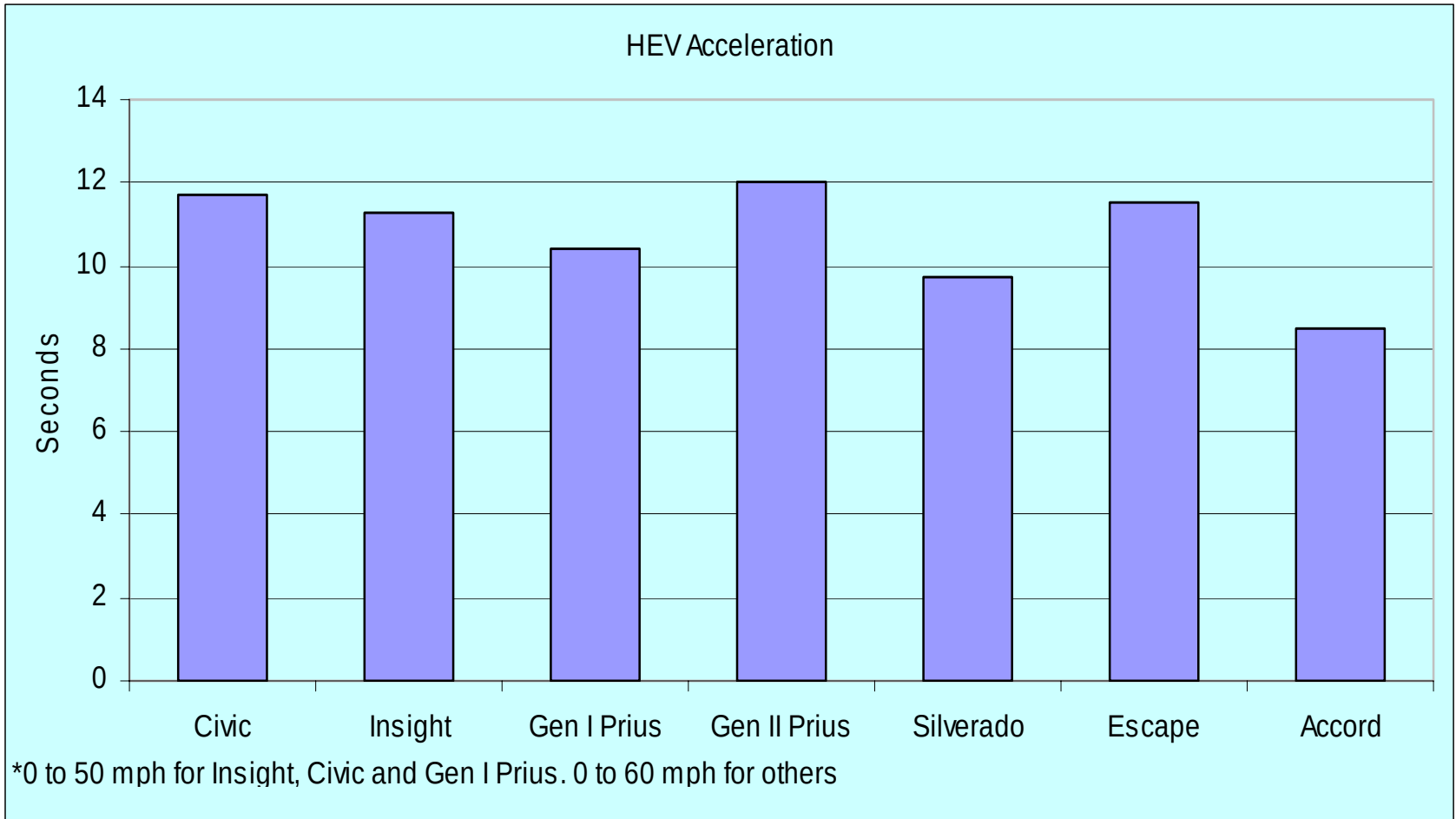
- **Baseline performance testing (dynamometer & closed track testing)**
 - Acceleration, max speed, braking, handling, & two fuel economy tests (SAE J1634 drive cycle - air conditioning on & off)
- **Fleet & accelerated reliability (AR) testing**
 - Fuel use, maintenance & operations (M&O), miles, mission, & life-cycle costs
 - Two of each HEV model accumulate 160,000 miles
- **End of life (160,000 miles) testing**
 - Rerun two SAE J1634 tests, & conduct battery capacity (Hybrid Pulse Power Characterization) & power testing (Static Capacity)



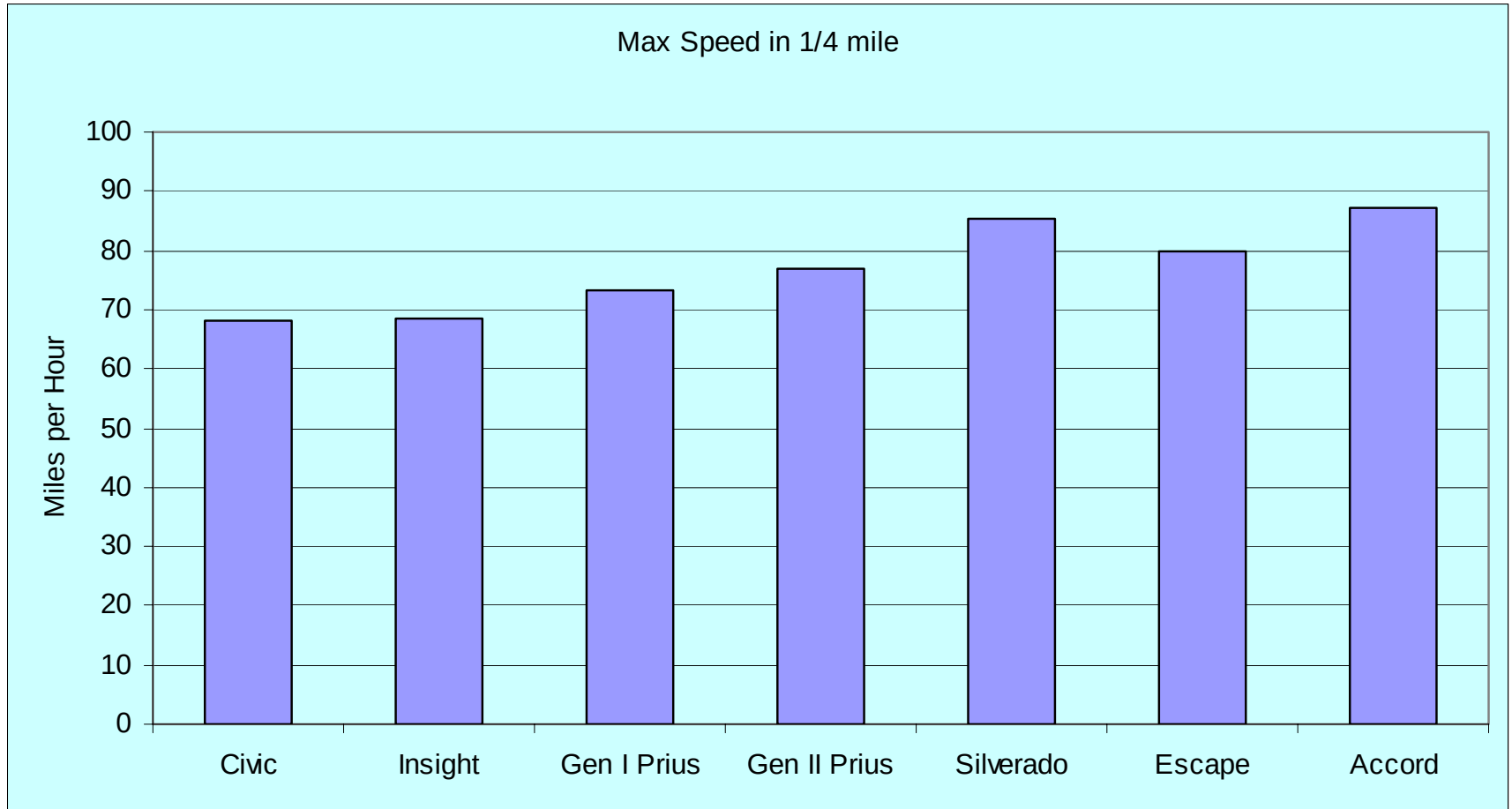
- 2002 test vehicles
 - Insight
 - Civic
 - Gen I Prius
- 2005 test vehicles
 - Accord
 - Gen II Prius
 - Silverado (2WD)
 - Escape (2WD)
 - Lexus RX400h (to be tested)
 - Toyota Highlander (to be tested)



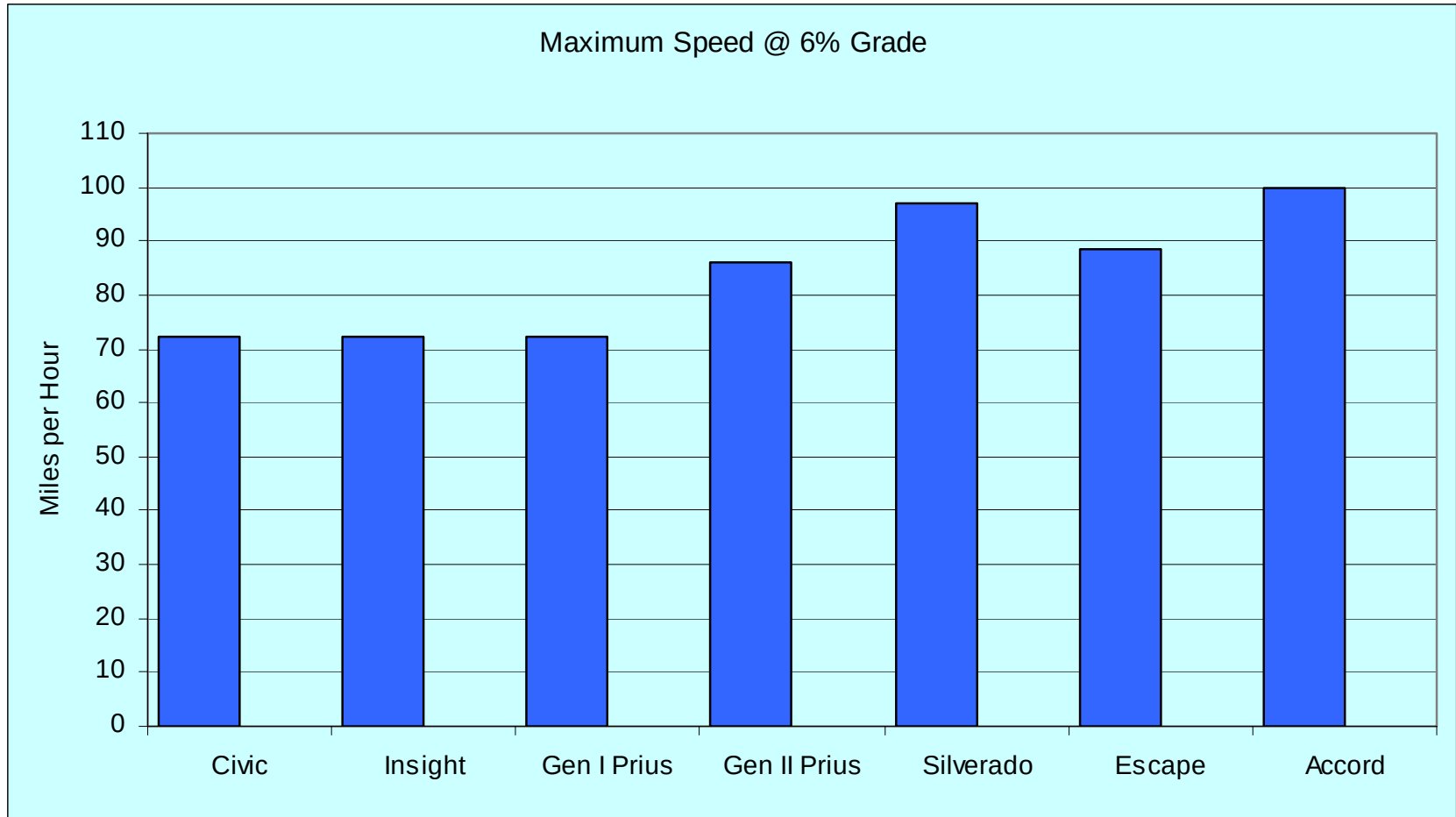
HEV Acceleration (0 to 50 & 0 to 60 MPH)



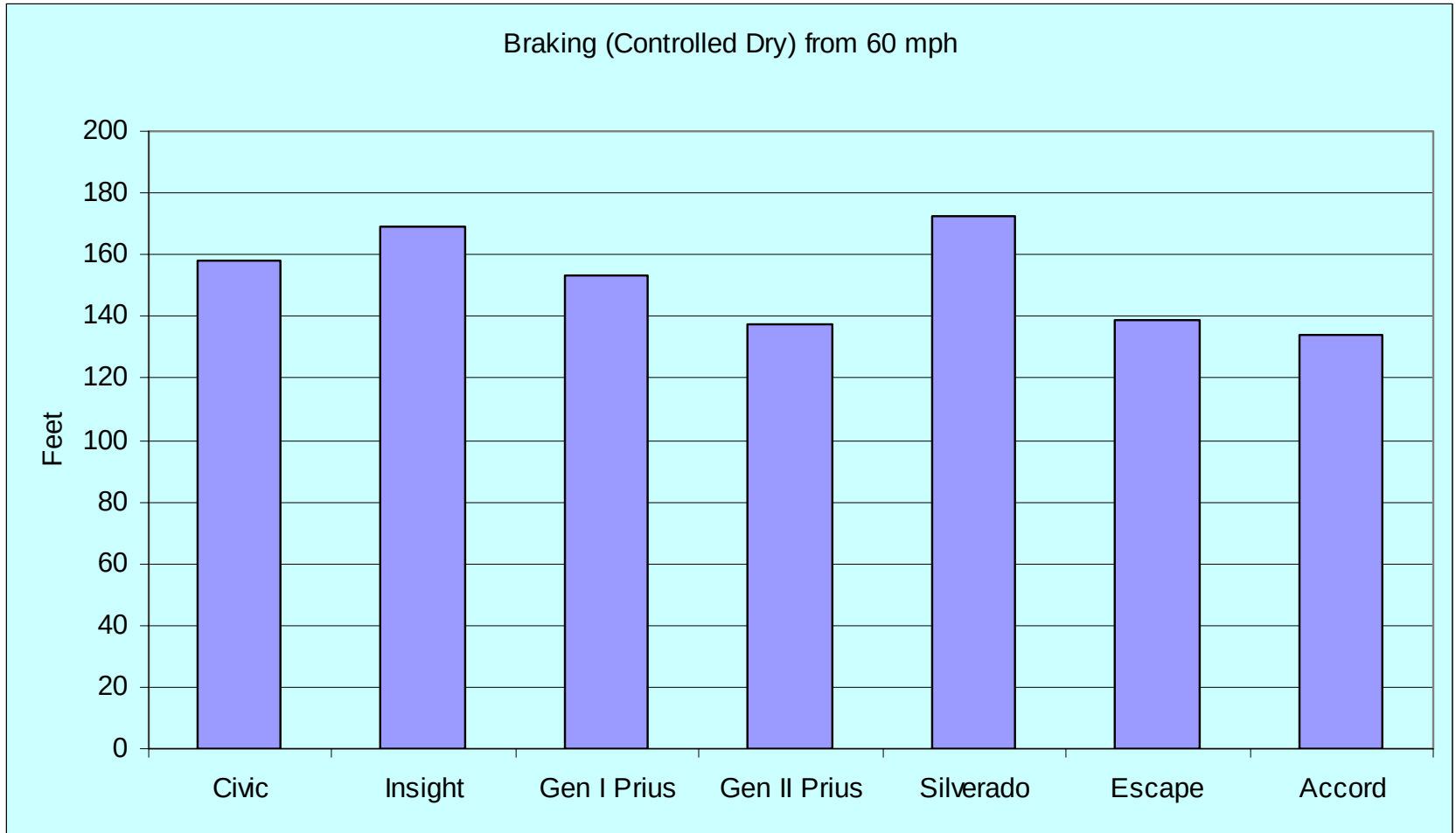
HEV Maximum Speed in ¼ Mile



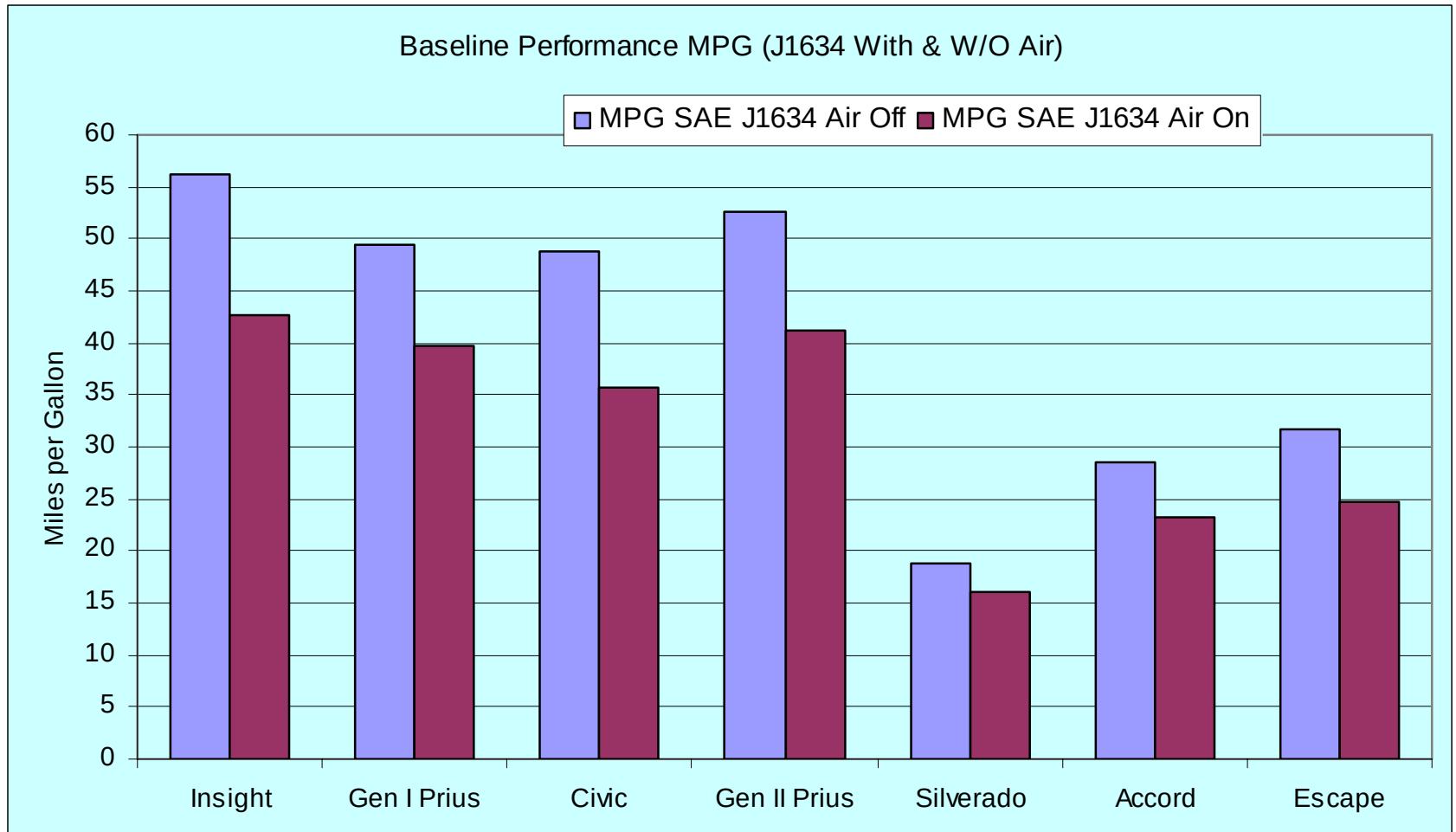
HEV Maximum Speed @ 6% Grade



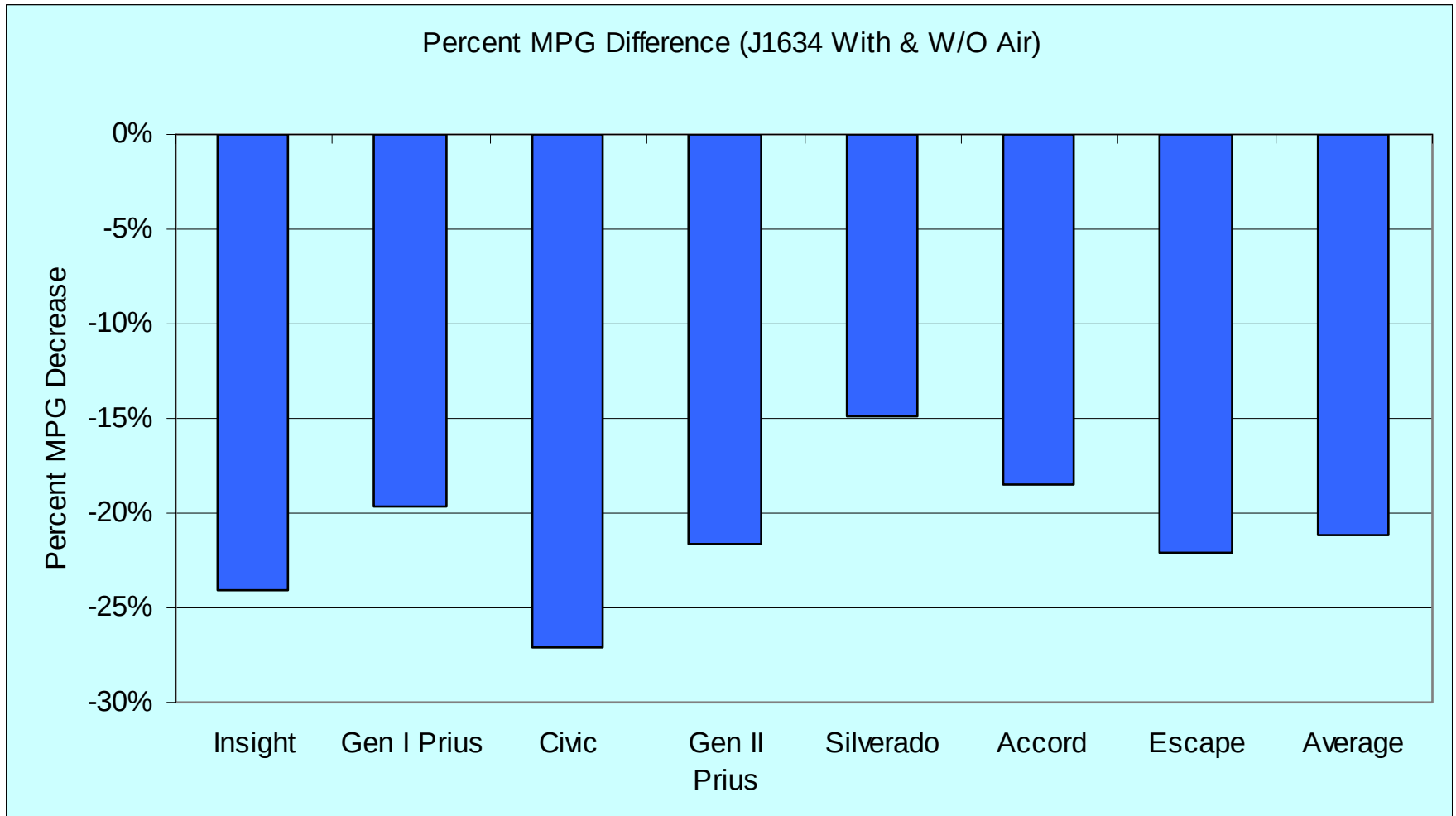
HEV Braking



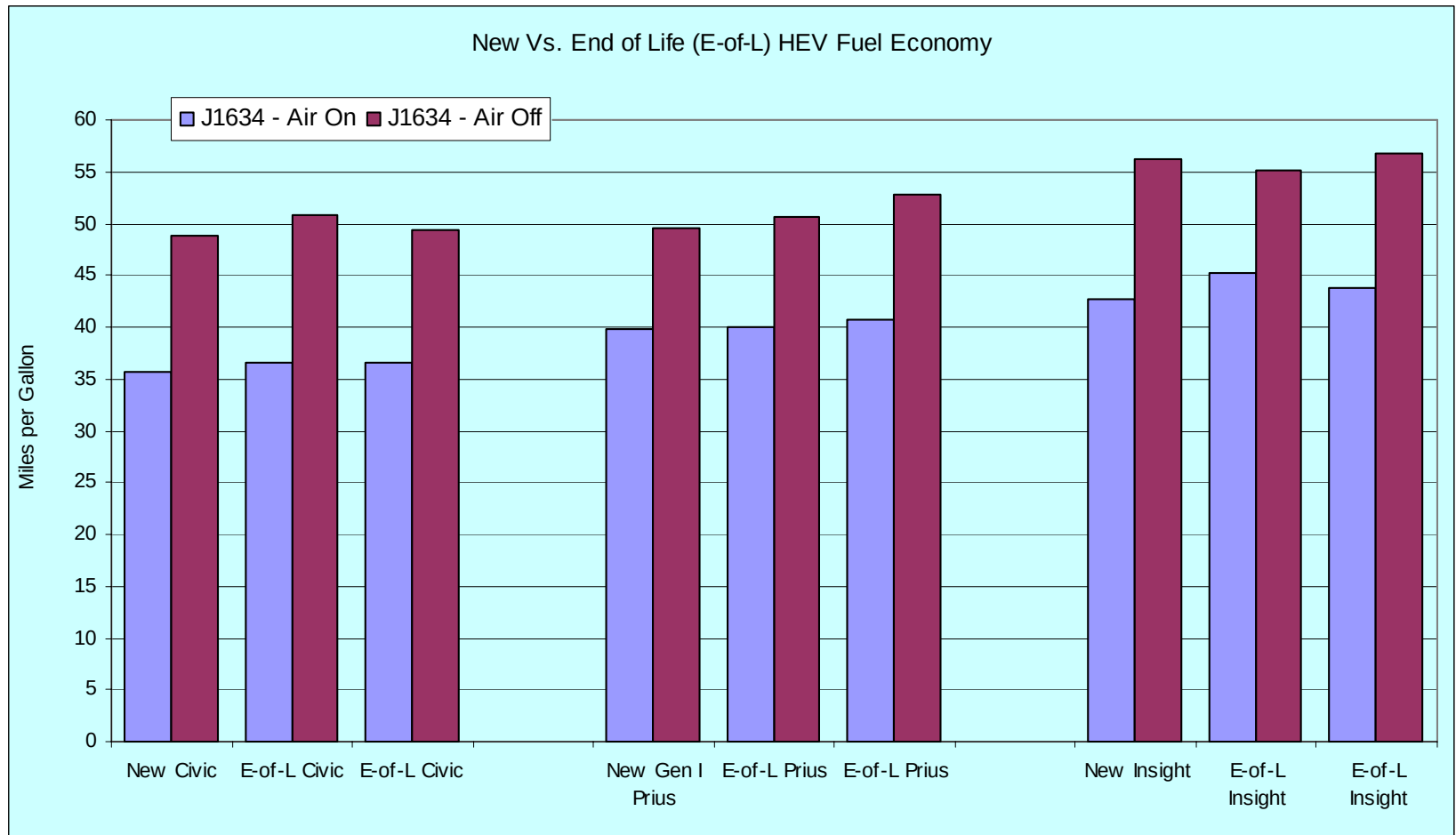
HEV Fuel Economy (SAE J1634)



HEV - MPG Difference (Air on/off SAE J1634)



HEV MPG New Vs. MPG @ End-of-Life (~160,000 miles) SAE J1634

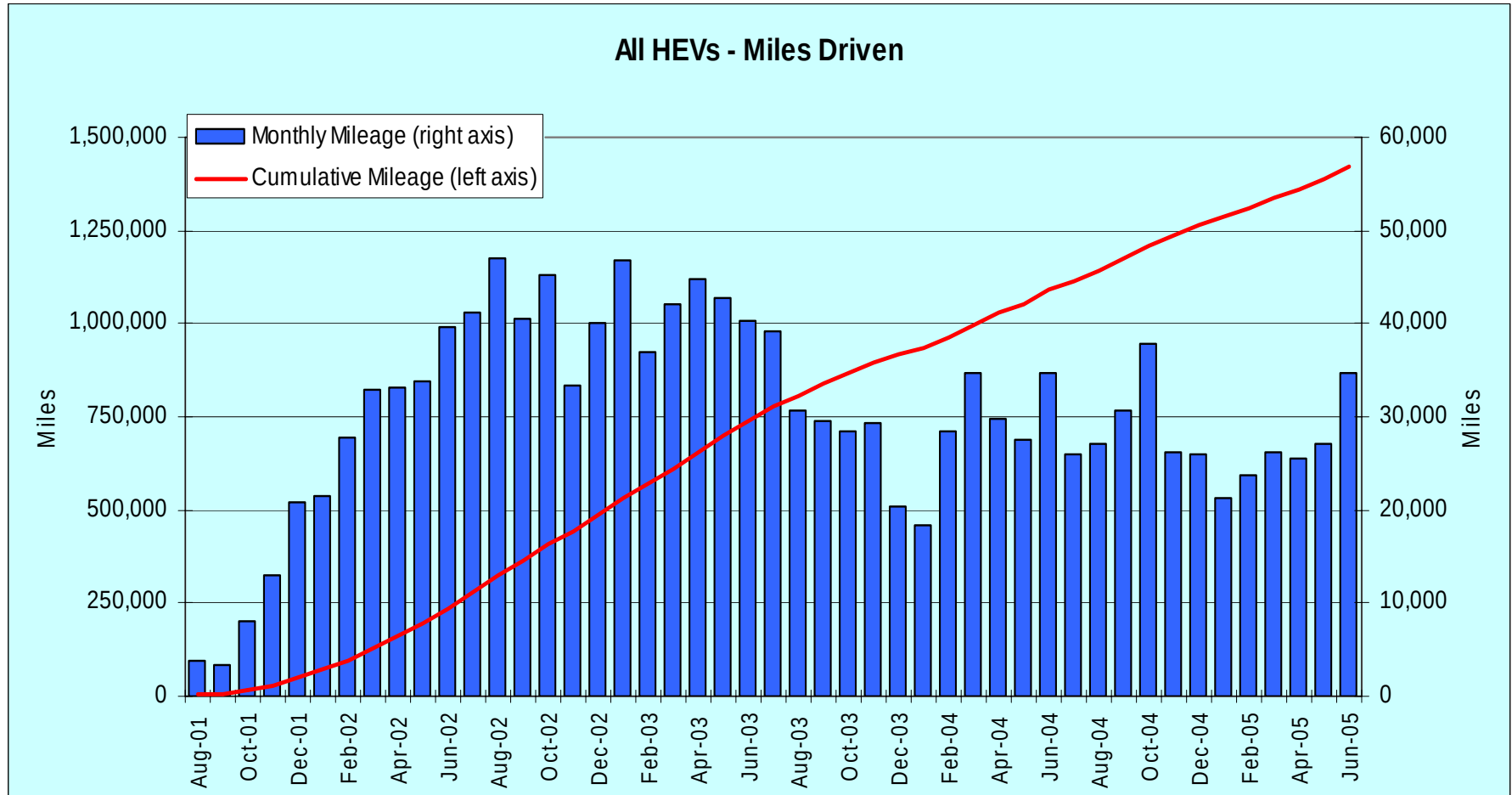


28 HEVs - Fleet Testing Status

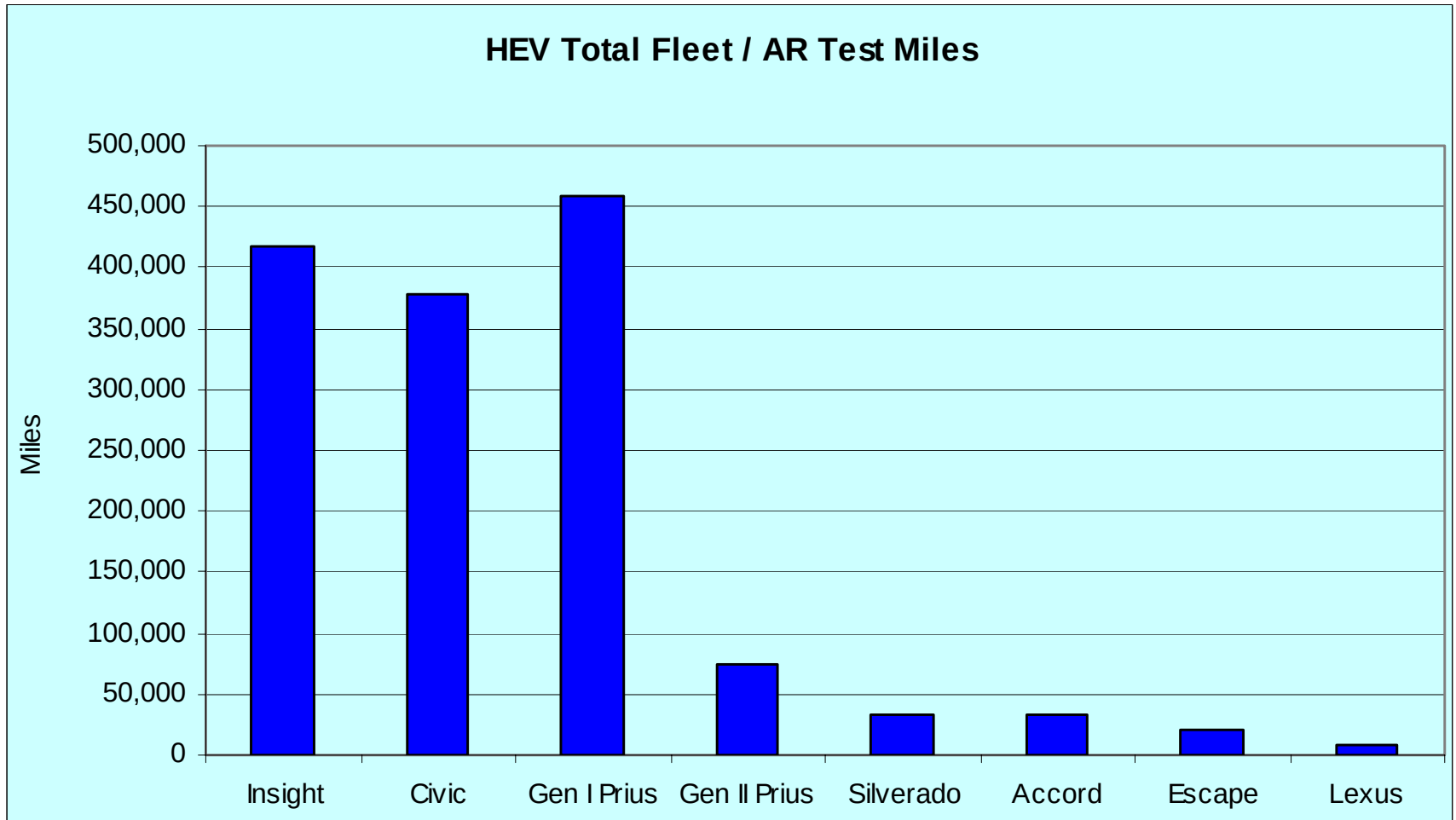
- 6 - 2001 Honda Insights: Aug/01 - March/05
- 6 - 2002 Gen I Toyota Prius: Nov/01 - April/05
- 4 - 2003 Honda Civics: May/02 - April/05
- 2 - 2004 Gen II Toyota Prius: Nov/03 - ongoing
- 2 - 2004 Chevrolet Silverado: Sept/04 - ongoing
- 2 - 2005 Honda Accord: Jan/05 - ongoing
- 2 - 2005 Ford Escape: April/05 – ongoing
- 2 - 2005 Lexus RX400h SUVs: May/05 – ongoing
- 2 - 2006 Toyota Highlander SUVs: Oct/05 start



HEV 1.4 Million Fleet Testing Miles



1.4 Million Testing Miles By HEV Model

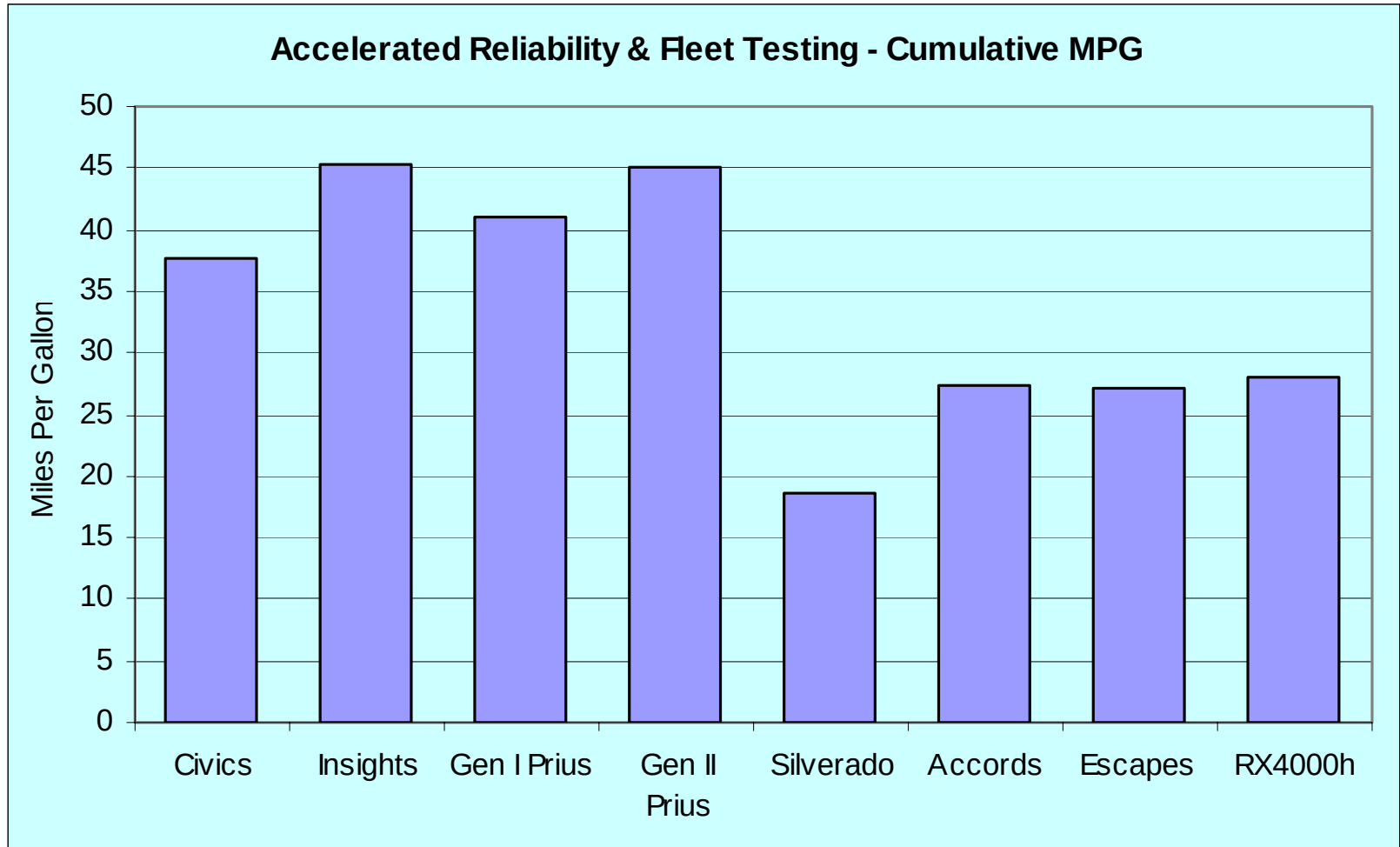


HEV Fleet Testing Fact Sheets

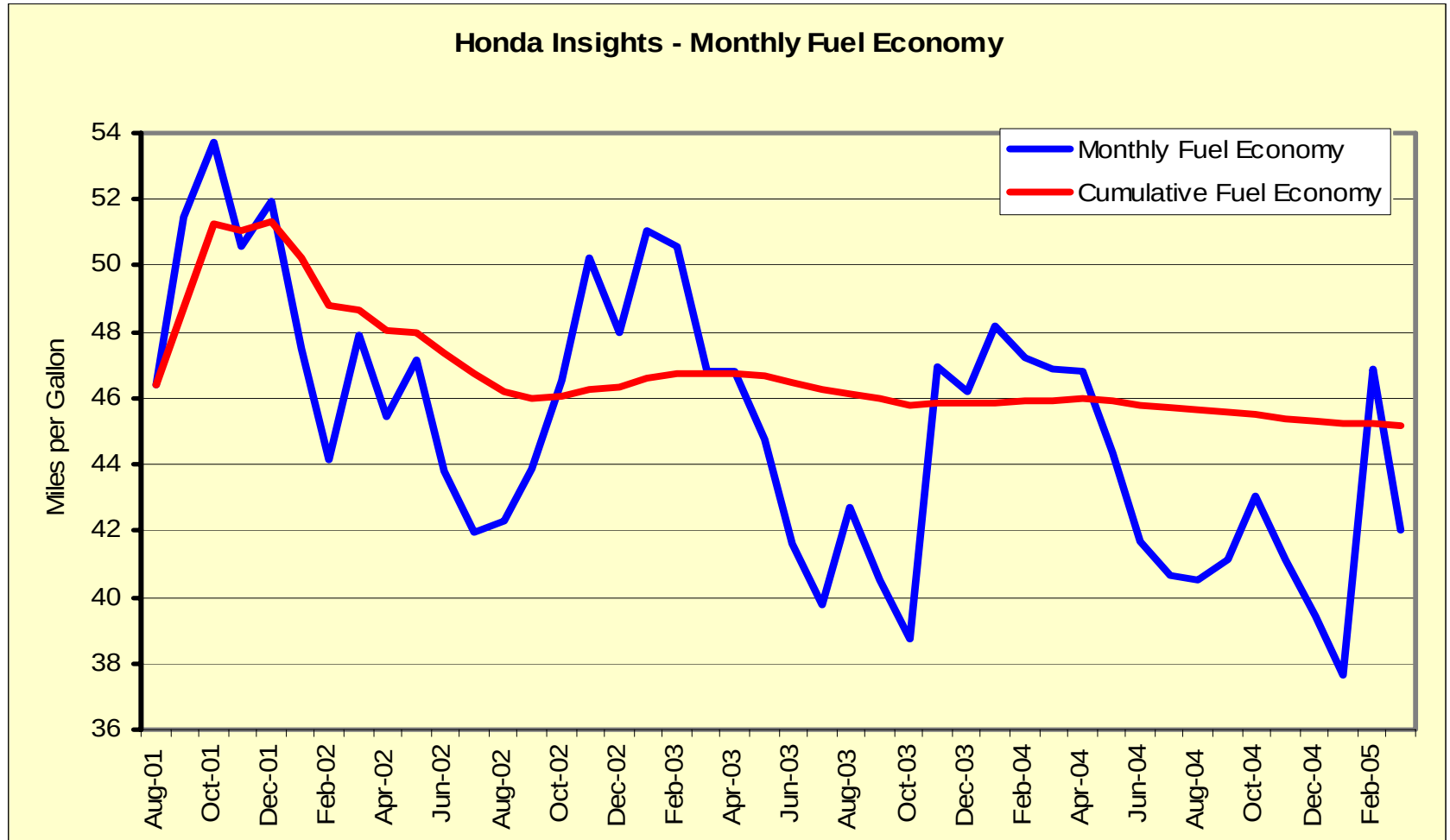
- Summarize:
 - Vehicle use
 - Major operations & maintenance events
 - Mileage profile
 - Cumulative fuel economy
 - Life cycle operating costs



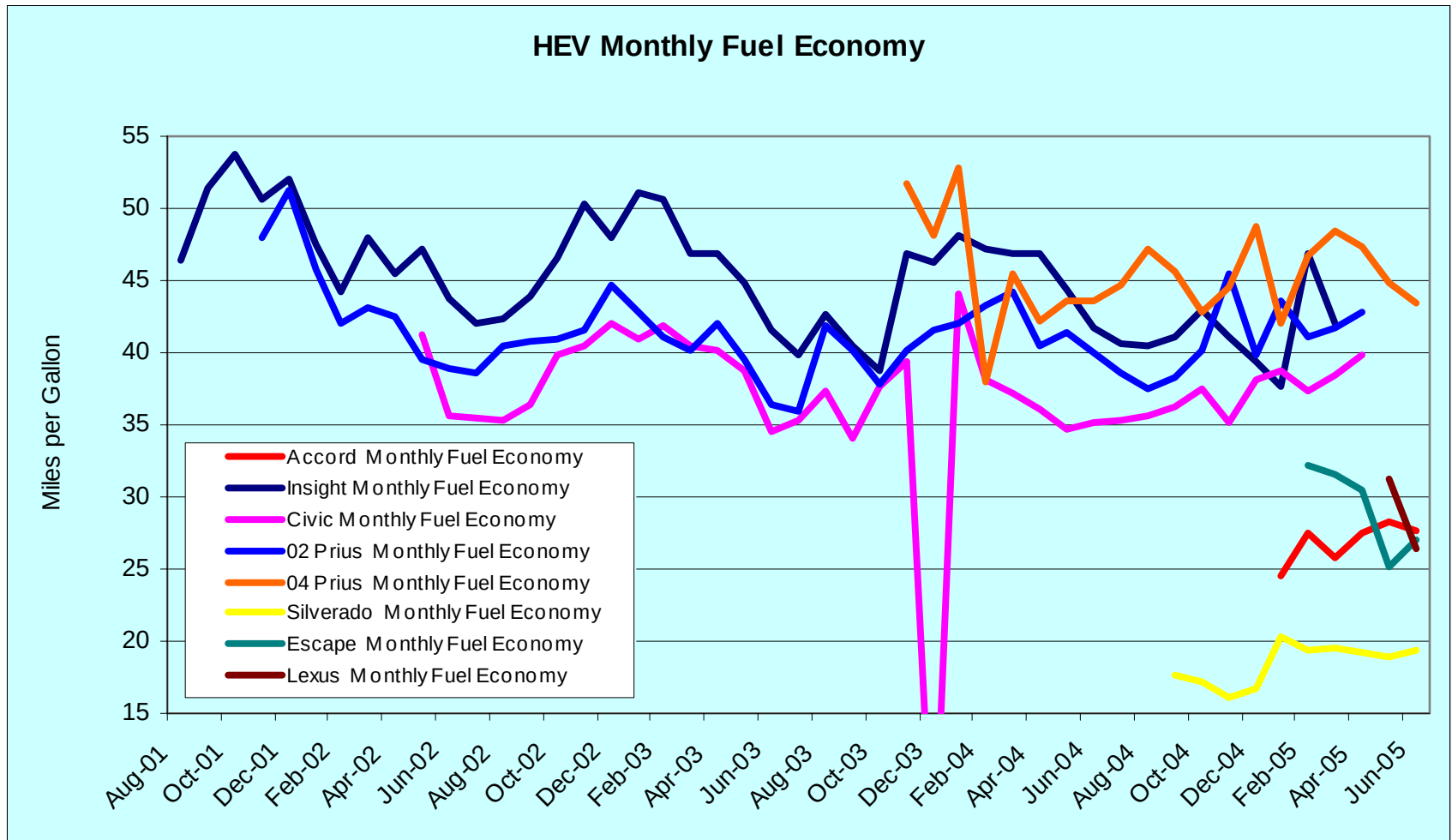
HEV Fleet Testing Average MPG



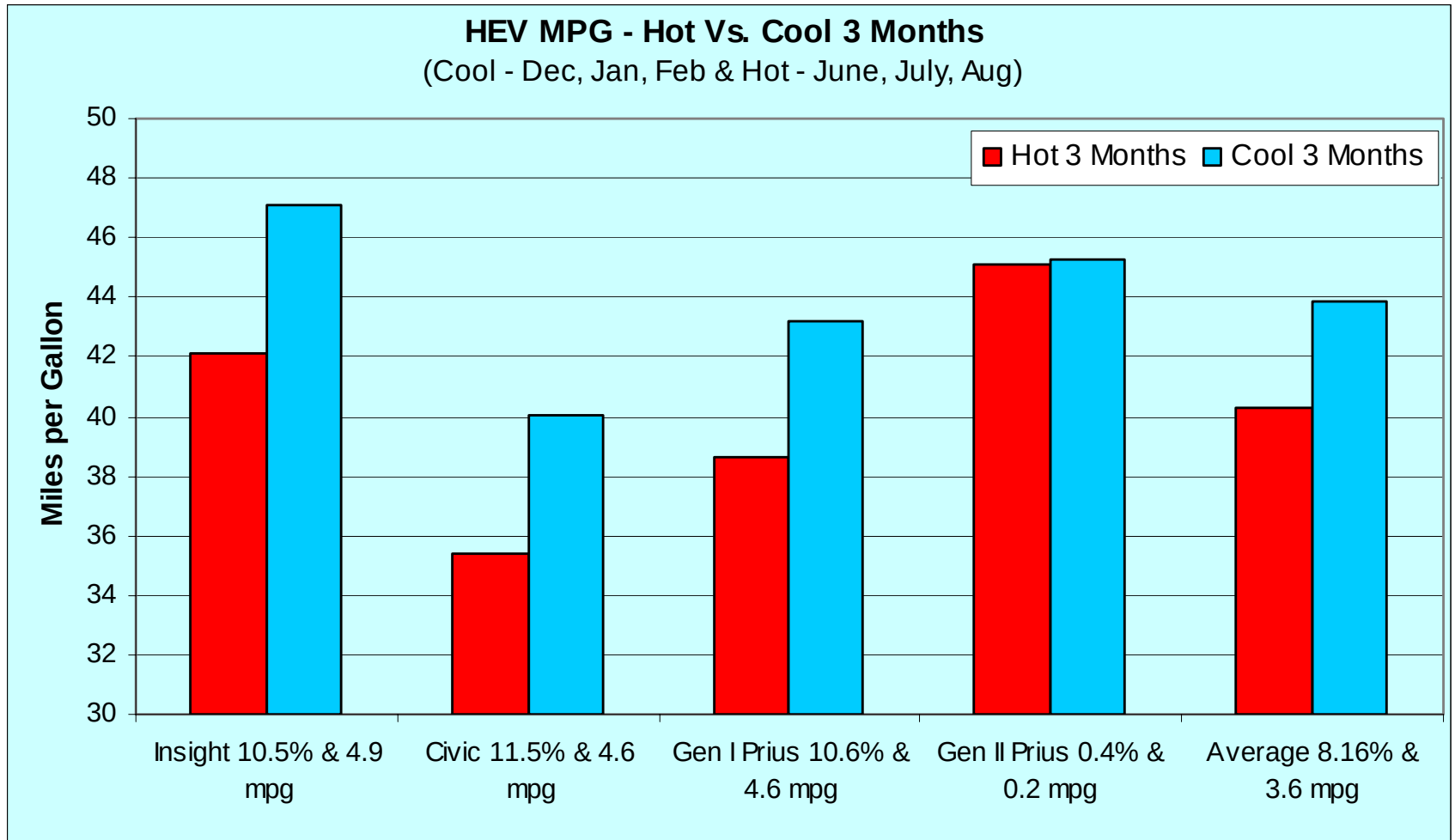
Insight Fleet Testing Monthly MPG



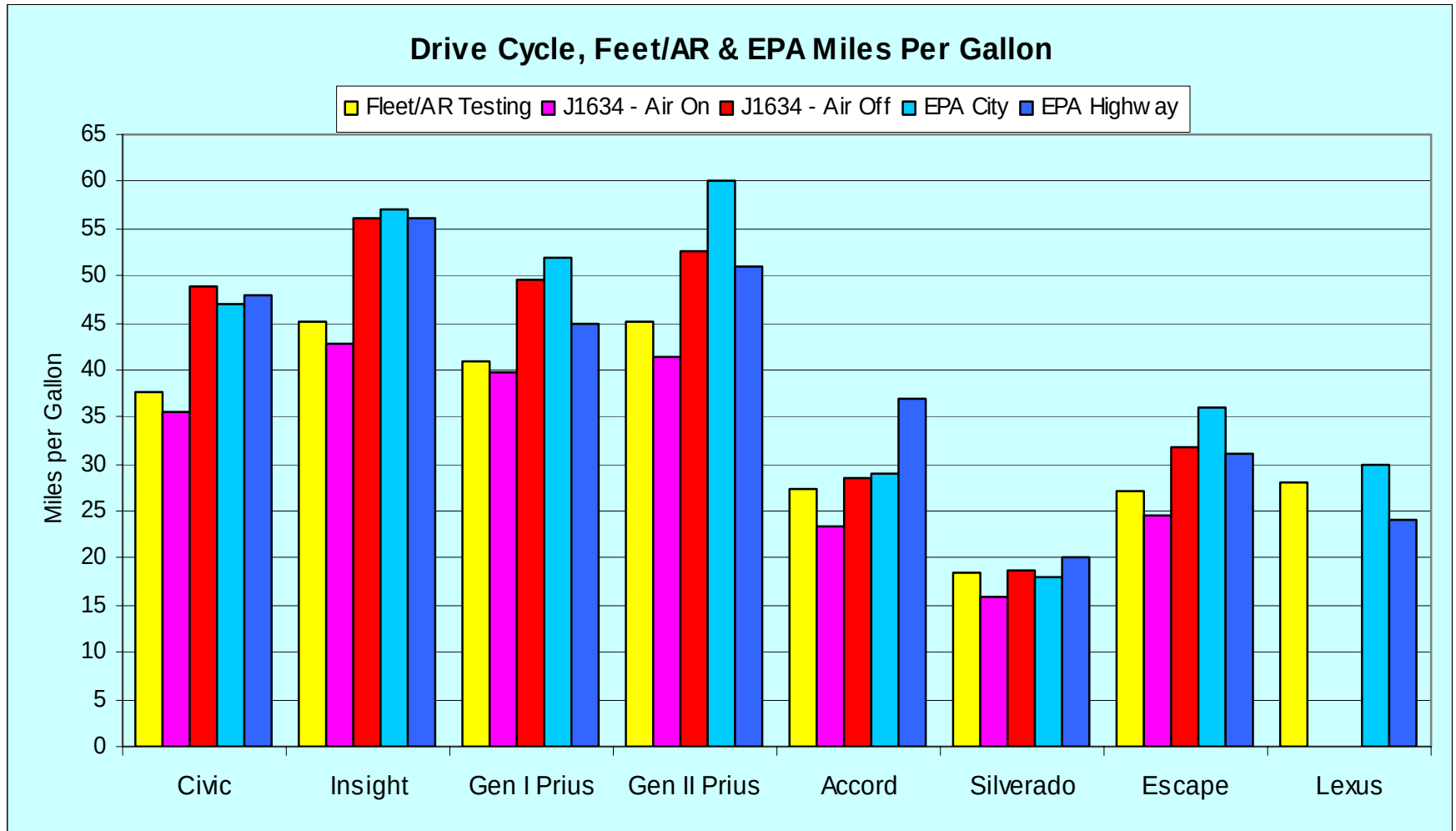
HEV Fleet Testing Monthly MPG



HEV Fleet Testing MPG Hot & Cool Months



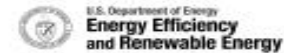
HEV MPG – Fleet SAE J1634, & EPA



HEV Maintenance & Repairs Fact Sheets

- All events - date, mileage, description & cost/warranty

HEV Fleet Testing - Maintenance Sheet 2003 – Honda Civic Hybrid



Advanced Vehicle Testing Activity

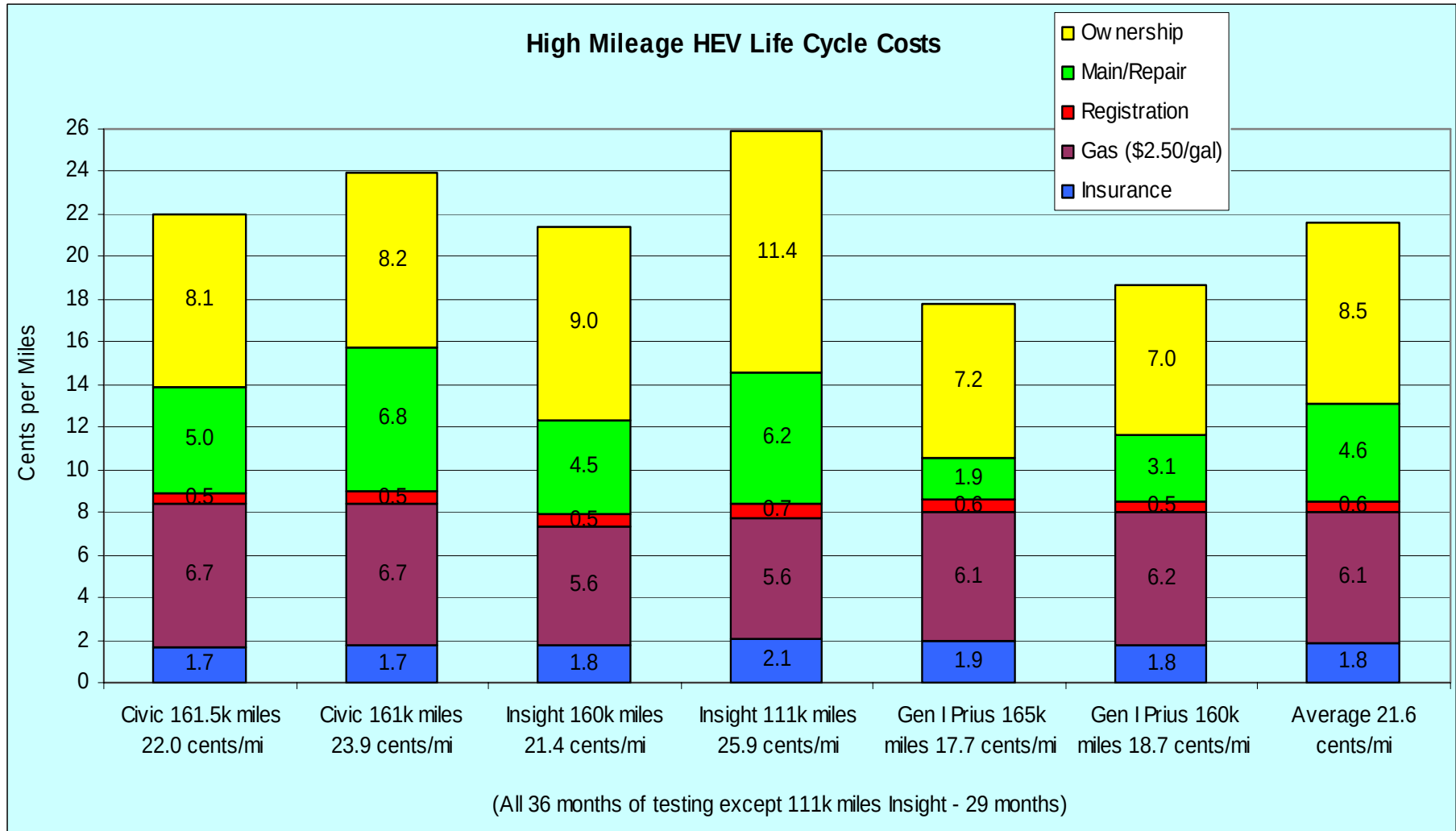
VIN #JHMES96663S003864

Date	Mileage	Description	Cost
7/10/2002	5,041	Change oil and rotate tires	\$ 27.00
8/6/2002	9,979	Change oil and rotate tires	\$ 28.62
9/6/2002	15,023	15,000 mile service	\$ 231.38
9/24/2002	18,706	Repair accident damage to left front (not included in maintenance costs)	\$ 1,222.34
10/6/2002	20,142	Change oil and rotate tires	\$ 28.99
10/29/2002	25,147	Change oil and rotate tires	\$ 30.87
12/20/2002	33,270	Change oil and rotate tires	\$ 31.07
2/10/2003	43,290	45,000 mile service	\$ 341.58
2/13/2003	43,500	Repair accident damage to rear bumper (not included in maintenance costs)	\$ 834.42
3/18/2003	53,381	Change oil and rotate tires	\$ 30.67
4/22/2003	62,573	Change oil and rotate tires	\$ 30.67
5/23/2003	69,932	Change oil and rotate tires	\$ 30.67
6/6/2003	74,353	30,000 mile service	\$ 324.18
6/24/2003	77,828	Replace four tires and align front wheels	\$ 185.33
6/19/2003	77,589	Check Engine trouble light illuminated. Dealer reset, no problem found.	warranty
7/7/2003	80,425	Change oil and rotate tires	\$ 31.09
7/8/2003	80,434	Check Engine light illuminated. Dealer repaired an intermittent problem with a valve sticking.	warranty
8/27/2003	89,304	90,000 mile service	\$ 324.13
8/4/2003	86,353	Change oil and rotate tires	\$ 31.09
9/12/2003	90,507	Check Engine trouble light illuminated. Updated PCM software installed by dealer.	\$ 50.00
10/14/2003	93,616	Ignition switch replaced	\$ 50.00
10/24/2003	93,912	Change oil and replace brake pads	\$ 146.22
11/20/2003	96,556	Check Engine light illuminated. Dealer replaced the Purge System pressure sensor	\$ 50.00
1/15/2004	96,802	Transmission shifting erratically. Transmission replaced	\$ 3,503.82
1/26/2004	97,750	Check Engine trouble light illuminated. Catalytic converter replaced.	\$ 1,124.38
2/24/2004	103,901	15,000 mile service	\$ 260.83
4/6/2004	113,685	30,000 mile service and accessory 12 volt battery replacement	\$ 464.09
4/15/2004	115,649	Replace front tires	\$ 112.38
5/3/2004	119,570	Change oil and rotate tires	\$ 31.92

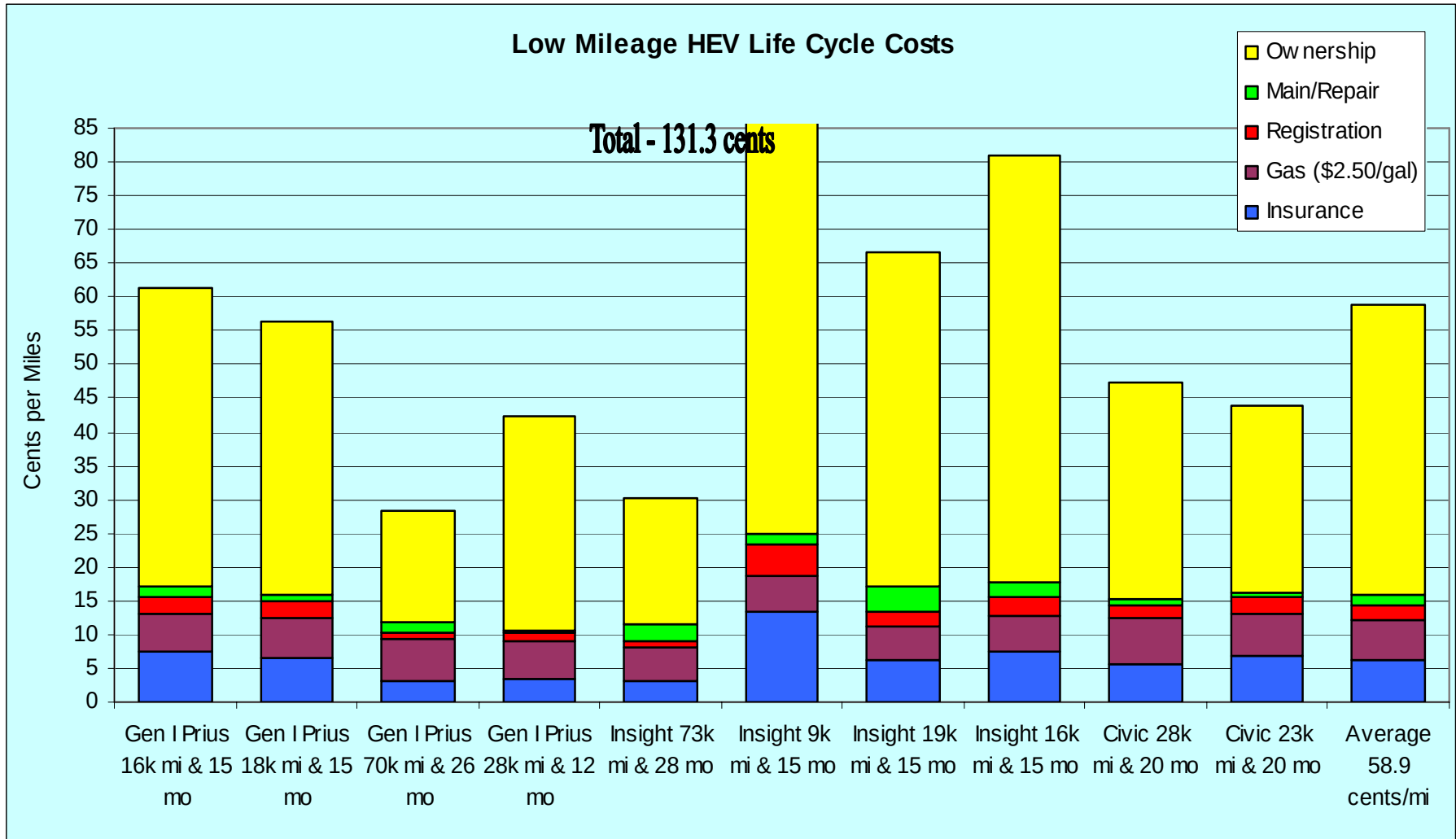
HEV Maintenance & Repairs Summary

- **Civic & Insight - 6 continuously variable transmission (CVT) failures in 4 vehicles @ 97k, 99k, 89k & 77k miles. Again @ 157k & 146k miles**
- **Insight battery control module & traction battery replaced @ 72k**
- **Insight & Civic - 7 software upgrades & 2 catalytic converters replaced**
- **Gen I Prius - rack & pinion replacements 1st Prius @ 106k, & 2nd Prius @ 25k & 32k miles**
- **Gen II Prius – oil changes, tires, normal service @ 42k & 27k miles**
- **Other HEVs – normal maintenance @ low mileages**

HEV Life-Cycle Costs (high mileage HEVs)



HEV Life-Cycle Costs (low mileage HEVs)



Additional Near-term HEV Testing

- **HEV Hydrogen Prius (Quantum)**
- **Plug-in HEV Dodge Sprinter (lithium)**
- **Plug-in HEV Escape conversion (lithium)**
- **Other OEM HEVs?**

Neighborhood Electric Vehicle (NEV) Testing

- **Street legal ~40 states on ~35 mph speed limit streets**
- **14 NEVs with lead acid batteries completed baseline performance testing (max speed, acceleration, range, braking, charging)**

– 8 GEM (DaimlerChrysler) - Deka gel & Trojan flooded

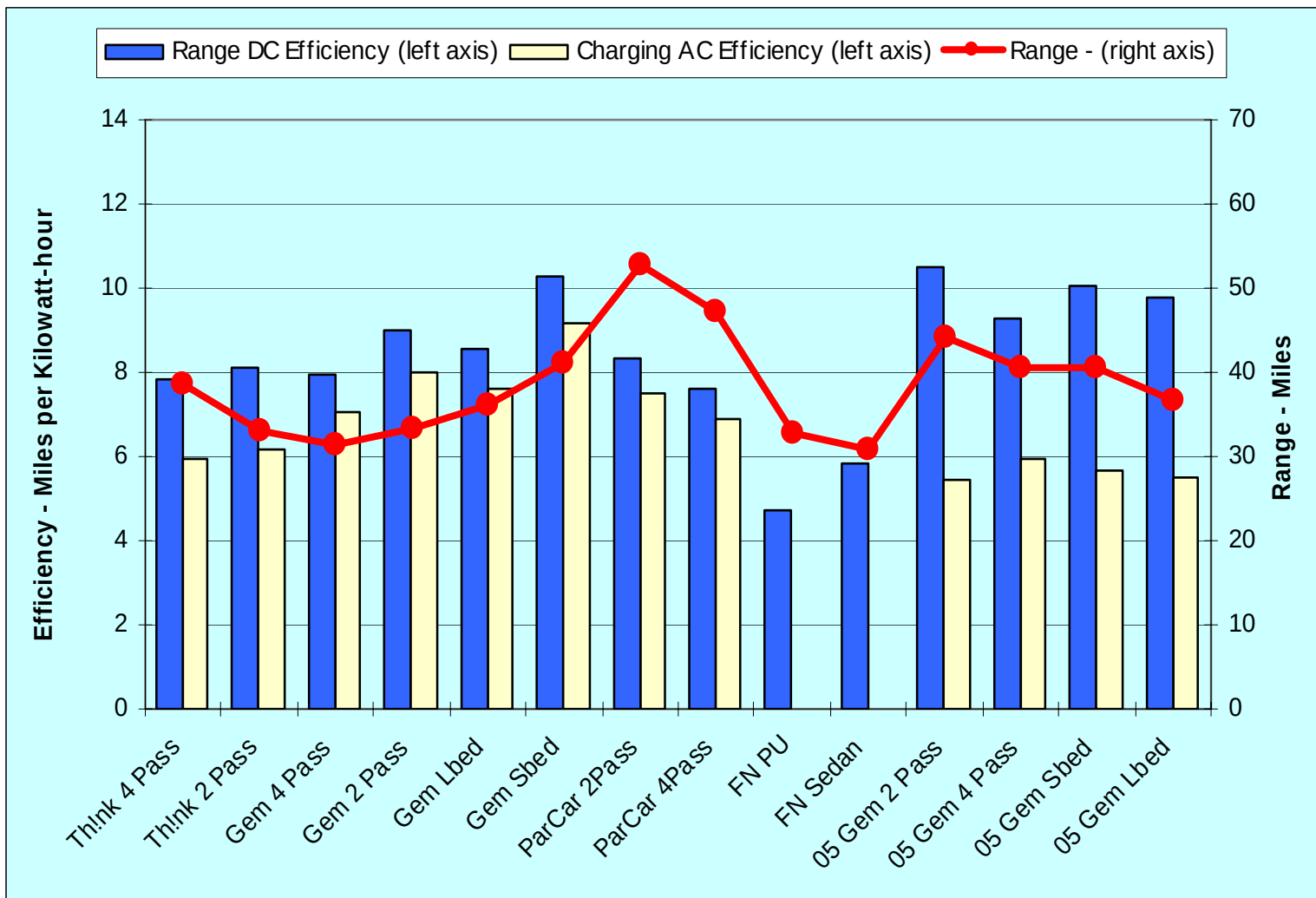
– 2 ParCar - Trojan flooded

– 2 TH!NK (Ford) - East Penn Gel

– 2 Frazier Nash - Electrosource Glass Mat

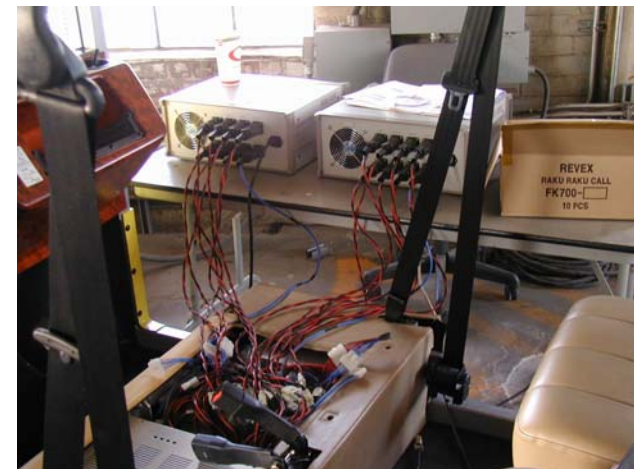


NEV Range & Energy Efficiency Testing



Katech *Invita* Lithium Polymer Testing

- Onboard charger failed on arrival & several cells failed
- Constant speed range test (94 miles Kokam test)
 - Start at 80% SOC (offboard charger)
 - 47.9 miles, 91.3 A·H, 6.19 kWh, 4.25 to 3.0 V
 - 2 cells at 3.0 V (3.6 norm end-of-test)
- Two Kokum characterization tests (discharge to 2.7 V)
 - one cell failed each time @ 0.5 & 0.2 V
 - 102.21, 94.34, & 96.05 A·H
 - 98.34 & 98.11 A·H



NEVs Fleet Testing

- 90 NEVs in fleet testing (including fast charging)
 - San Diego Police Department
 - Luke Air Force Base
 - Palm Valley
 - Palm Springs
- Future NEV testing candidates
 - Ford Courier class NEV pickup from Roush
 - NEV(s) from Marsh Automotive



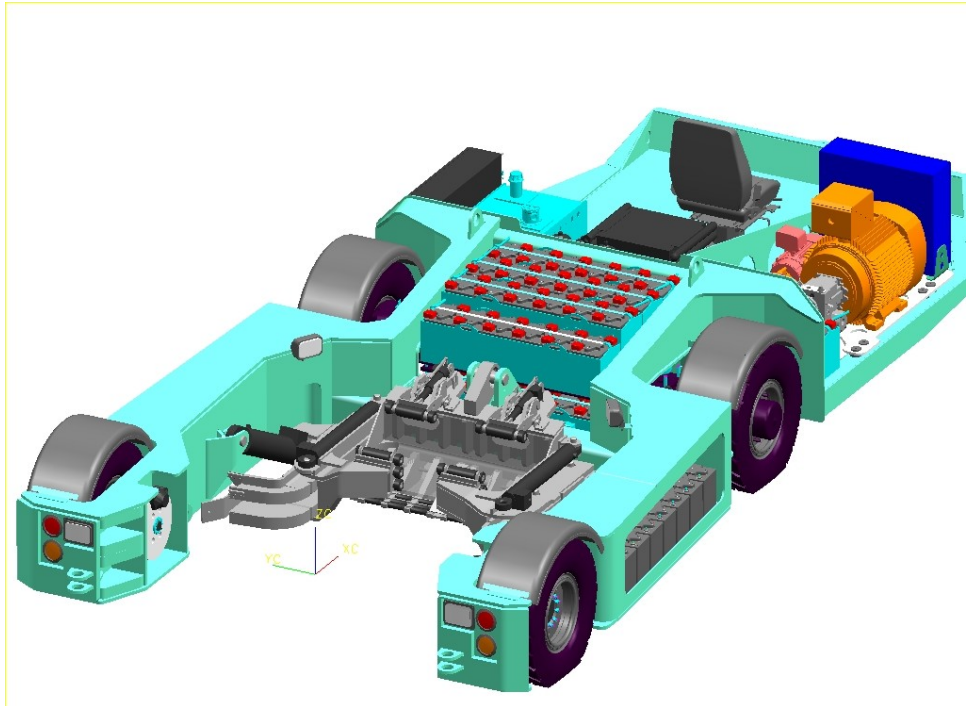
Urban Electric Vehicle (UEV) Testing

- Internet-based data collection of 100 Th!nk *city* UEVs in New York. Total & vehicle miles & missions, trip profiles, emissions, & gasoline avoidance collected. Partnered with New York Power Authority.
- In partnership with Ford Motor Company, tracked 276 additional Th!nk cities in CA, MI, GA, Canada, & Bermuda, including shared-car programs.



Airport Ground Support Equipment Testing

- Developed electric GSE (eGSE) specifications for pushback tractors, bag tractors & bag loaders
- Developing eGSE test procedures for same 3 vehicle classes
- Test (including fast charging) an FMC battery electric pushback tractor for 757-sized aircraft (fall 2005)





<http://avt.inl.gov>

AVTA Questions?



INL/CON-05-00693