

# DaimlerChrysler

## HYDROGEN TO THE HIGHWAYS

### Controlled Hydrogen Fleet and Infrastructure Demonstration and Validation Project



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DaimlerChrysler  
May 17, 2007

**Project #: TV1**

# Program Overview

## US Dept. of Energy Fuel Cell Vehicle and Infrastructure Cooperative Program

|   |  |
|---|--|
| <p><b><u>Timeline</u></b></p> <ul style="list-style-type: none"> <li>- Project Start Date: 01/07/04</li> <li>- Project End Date: 09/30/09</li> <li>- Percent Complete: 65%</li> </ul>   | <p><b><u>Partners</u></b></p> <ul style="list-style-type: none"> <li>- DCX</li> <li>- MBUSA</li> <li>- BP America</li> <li>- DTE Energy</li> <li>- NextEnergy</li> </ul>   |
| <p><b><u>Budget</u></b></p> <ul style="list-style-type: none"> <li>- \$88.8M Total Project Funding             <ul style="list-style-type: none"> <li>- \$44.4M Federal Share</li> <li>- \$44.4M Industry Share</li> </ul> </li> <li>- \$5.1M FY05 Funding</li> <li>- \$7.1M FY06 Funding</li> <li>- \$6.0M FY07 Funding (to date)</li> </ul> | <p><b><u>Barriers</u></b></p> <ul style="list-style-type: none"> <li>A. Vehicles</li> <li>B. Storage</li> <li>C. Hydrogen Refueling Infrastructure</li> <li>D. Maintenance and Training Facilities</li> <li>E. Codes and Standard</li> </ul> |

# Objectives

**The main focus** of the ongoing DOE Fleet Validation and Demonstration Project is to collect data and evaluate the technology status of

- Fuel cell powered vehicles (OEMs)
- Hydrogen infrastructure (energy companies and suppliers)

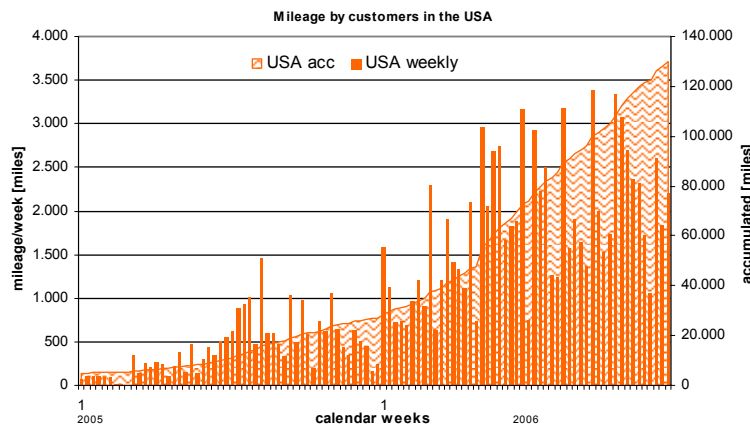
| Performance Measure                                     | Units                                  | 2009 Performance Target | 2015 Performance Target |
|---|--|-------------------------|-------------------------|
| Fuel Cell Stack Durability                              | Hours                                  | 2000                    | 5000                    |
| Range   | Miles                                  | 250                     | 300                     |
| Hydrogen Cost at station;<br>On- or Off-site Production | \$/GGE<br>(Gasoline Gallon Equivalent) | \$3.00                  | \$2.00-\$3.00           |

# Approach

- Operate 30 Gen I vehicles under real world conditions to monitor performance targets of:
  - Durability of fuel cell stack and system
  - Range of operation with compressed H<sub>2</sub>
  - Cost of H<sub>2</sub> from various production methods
  - Performance degradation over life via dynamometer and on-road testing
- Conduct market research on driver's perception, attitudes and usage of fuel cell vehicles with partner organizations in California and Michigan. Develop proposals to assist the design of next generation vehicles and communication activities
- Install a customer friendly data acquisition system that telematically collects vehicle data for submission to NREL which monitors the progress of fuel cell vehicles against the DOE technology validation milestones
- Develop demonstration projects to validate hydrogen fueling technology and provide hydrogen to DaimlerChrysler fuel cell vehicles
- Provide data from Gen II vehicles under same operating conditions as Gen I vehicles to compare technology maturity over program duration
- Align DaimlerChrysler communication/marketing activities with the education goals of the Department of Energy to raise public awareness of hydrogen technology and demonstration projects
- Develop Codes and Standards as well as implement rigorous safety processes such as Failure Mode and Effects analysis (FMEA), Management of Change (MOC), and Incident Management Plans.

# Accomplishments and Progress Overview

- Increased customer base with first hydrogen fuel cell powered emergency response vehicles:
  - Wayne State University Police Department
  - Sacramento Metropolitan Fire District
- Finalized FDA infrastructure to 17 Local File Servers
- Completed internal Incident Management Plan

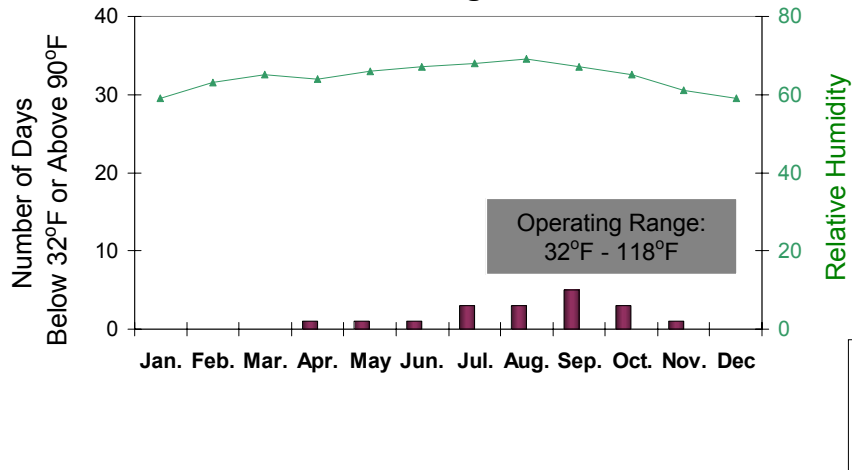


- Encountered no major safety issues.
- Doubled average weekly mileage from 2005 to 2006 as customers gained driving and fueling experience
- Accumulated over 130,000 miles although vehicles were operated by external customers who drive less often than internal test operators

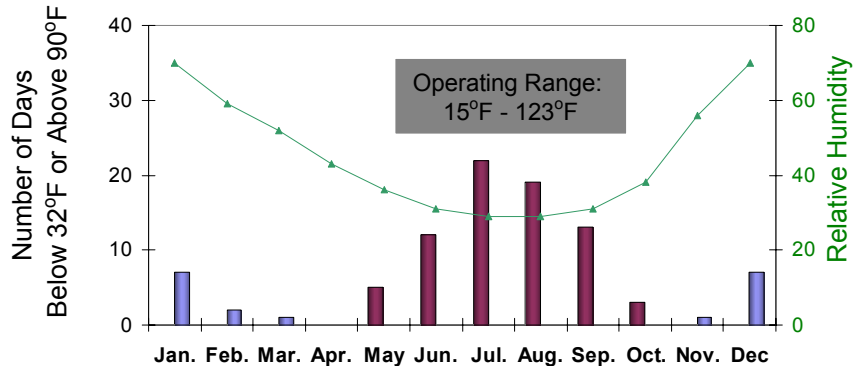
# Accomplishments and Progress

## Operations: Different Climate Conditions

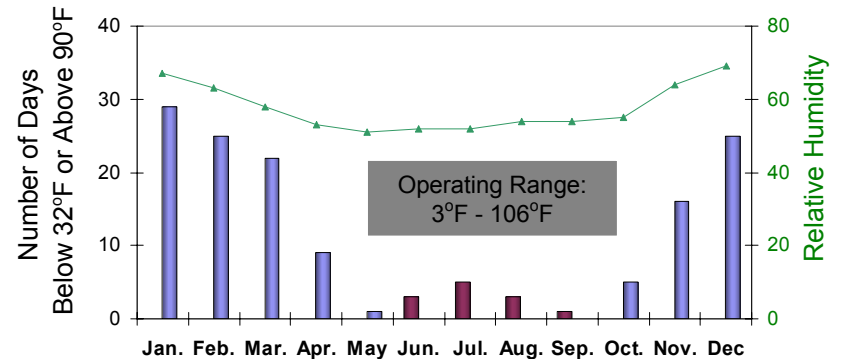
### Los Angeles



### Sacramento



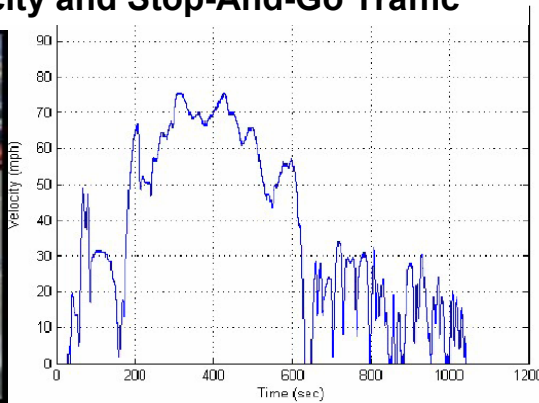
### Michigan



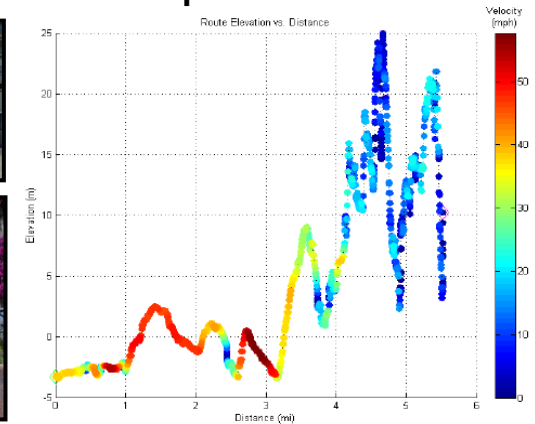
# Accomplishments and Progress

## Operations: Different Customer Usage

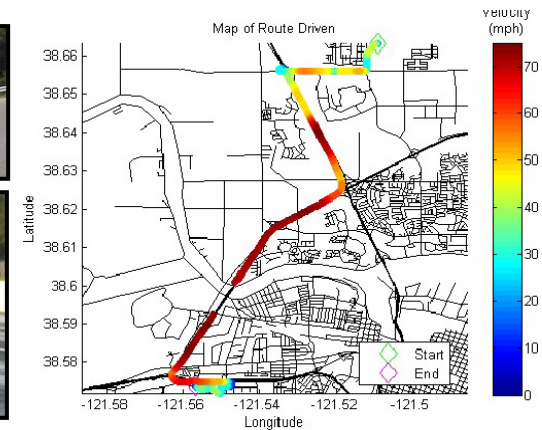
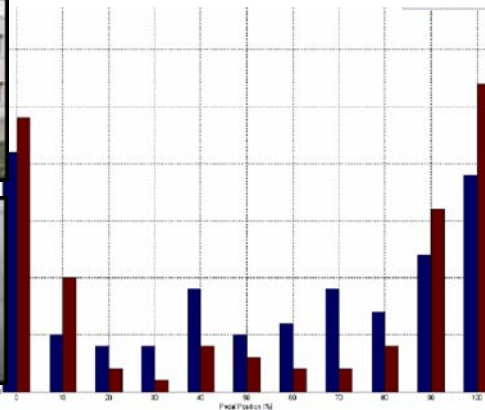
**Freeway Driving:  
High Velocity and Stop-And-Go Traffic**



**Steep Road Grades**



**Pedal Engagements**





# Accomplishments and Progress

## Customer Perception and Acceptance Study: Research Methodology

- Longitudinal study consisting of 49 participants for three rounds in 2006
  - **Round I:** May
  - **Round II:** September
  - **Round III:** November
  
- Sample taken from F-Cell partner organizations in California and Michigan consisting of governmental organizations, for-profit, and non-profit entity

|                          |   |  |   |  |   |   |
|--------------------------|---|--|---|--|---|---|
| Government Agencies      |  |   |   |   |  |  |
| Non-Profit Organizations |  |   |   |   |  |  |
| For-Profit Organizations |  |  |  |  |   |   |

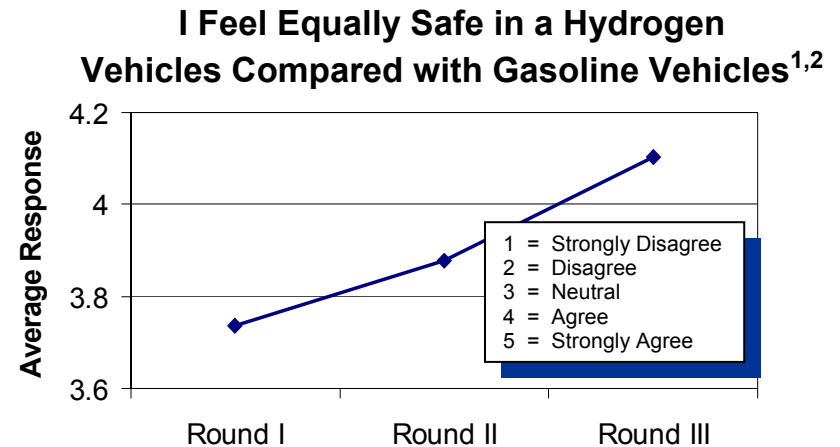
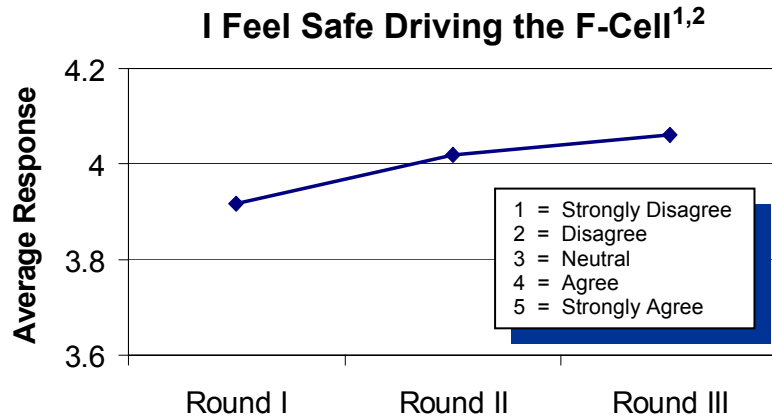
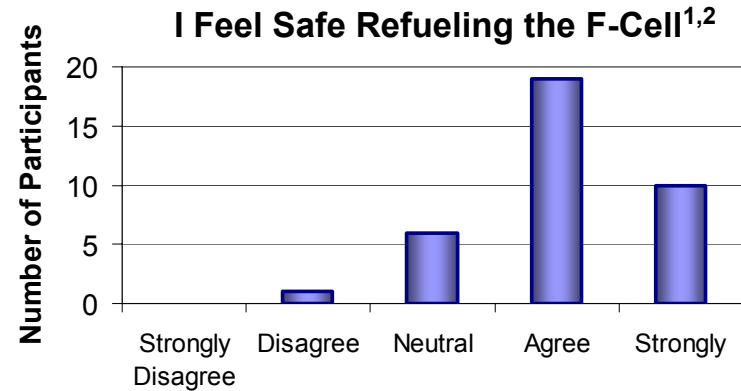
- Survey and study methodology developed jointly with University of California, Berkeley researchers



# Accomplishments and Progress

## Customer Perception and Acceptance Study: Results

**Most respondents feel safe when driving or fueling the F-Cell.**

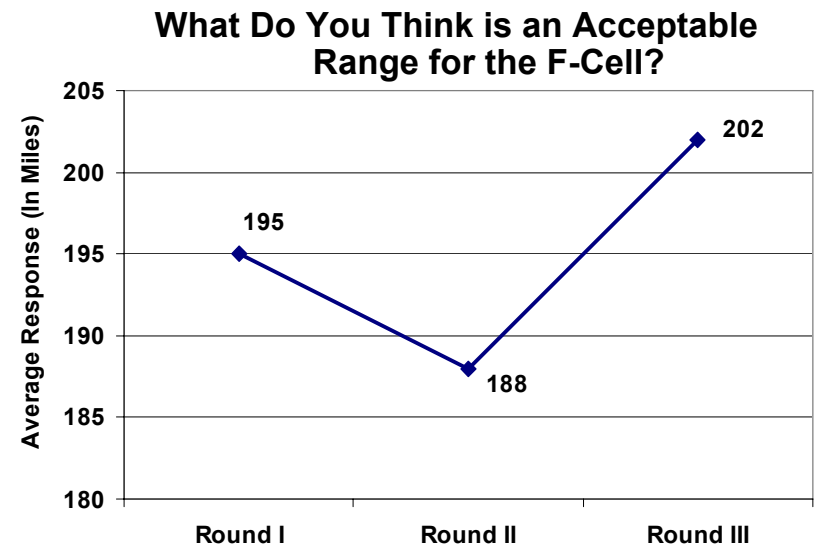
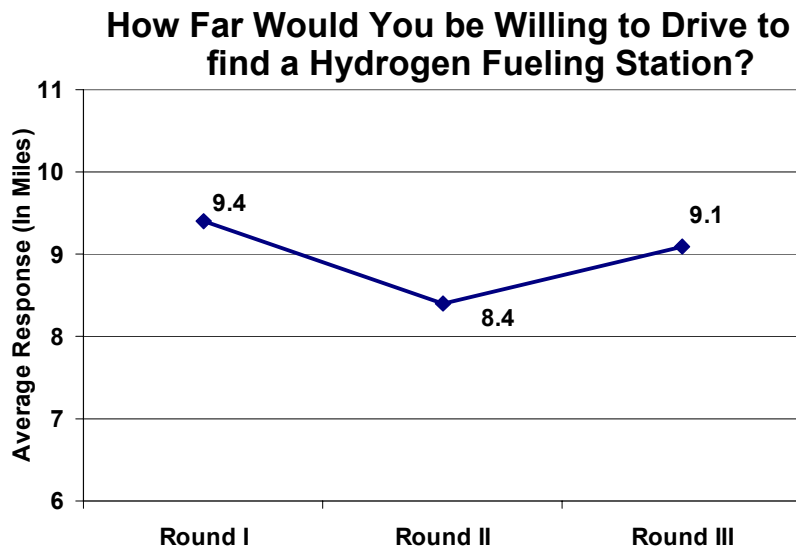


<sup>1</sup>Demographics of 49 respondents who participated in all three rounds of survey; <sup>2</sup>Participants not reflective of typical U.S. Customers

# Accomplishments and Progress

## Customer Perception and Acceptance Study: Results

- Participants are willing to drive approximately **9 miles** to find a hydrogen station
- Average desirable range for a fuel cell vehicle is approximately **200 miles**.



<sup>1</sup>Demographics of 49 respondents who participated in all three rounds of survey; <sup>2</sup>Participants not reflective of typical U.S. Customers

# Customer Acceptance and Perception Studies: Key Findings



- Respondents believe the F-Cell was easy to use and did not require much time to learn how to operate.
- Both F-Cell and refueling perceptions were positive. Those who were initially uneducated and cautious with the F-Cell grew to be more comfortable over time.
- The limited network of hydrogen which existed during this study placed constraints on participants. Respondents indicated they would be willing to drive approximately 9 miles to find a hydrogen fueling station.
- Range is a crucial point for the acceptance of the technology. This is of particular importance with regard to the switch from 35MPa to 70MPa.

# Accomplishments and Progress

## Outreach and Media Events



**Shows & Conferences: 7**  
**Public Outreach Events: 18**



**Customer Outreach:**  
**Events w/ Customer: 10**  
**Events by Customer: 80**

**Media Outreach Events: 26**

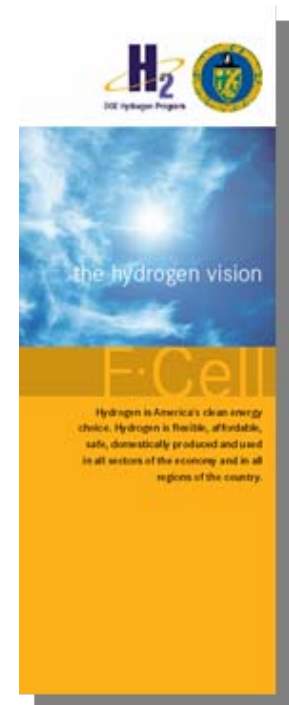
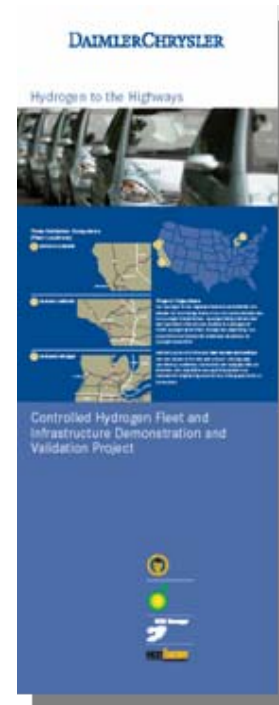




# Accomplishments and Progress Outreach

## DOE plays a more prominent role in DaimlerChrysler outreach efforts:

- DOE flyers distributed at outreach events
- Display banners produced describing the DOE project and DC customers
- Joint flyer created describing the DOE project and DC's role in it
- Educational giveaways produced



# Accomplishments and Progress

## Infrastructure



### ➤ Northern California – PG&E Mobile

- Status: in operation
- Technical Data: hydrogen produced by SMR; storage capacity of 150kg; 10-15 kg hydrogen dispensed
- Accomplishments: in operations since beginning of 2006. No safety incidents, no significant downtime. Serving a number of DaimlerChrysler vehicles on a regular basis (BAAQMD, PG&E), and other OEM's vehicles. More than 600kg's of hydrogen dispensed to date to more than 500 vehicles refills.

### ➤ Southern California – LAX (non-DOE)

- Status: in operation
- Technical Data: hydrogen produced by electrolysis
- Accomplishments: in operations for most of 2006. No safety incidents, no significant downtime. Serving a number of DaimlerChrysler vehicles on a regular basis, and other OEM's (Ford, Toyota, etc.) vehicles. More than 300 vehicles refilled in 2006, with a capacity of about 25kg/day.



### ➤ Southern California – Los Angeles

- Status: Location selected for possible 700Bar station
- Technical Data: hydrogen produced by SMR
- Accomplishments: Numerous sites evaluated. Commercial agreements in progress. Technical assessment for 700Bar refueling technology in progress.



# Accomplishments and Progress

## Infrastructure



### ➤ Michigan – DTE

- Status: in operation
- Technical Data: hydrogen produced by electrolysis, storage capacity of 140kg; 15 kg hydrogen dispensed per day
- Accomplishments: agreement with DTE to extend operations for 3 years, rigorous safety analysis paid by BP



### ➤ Michigan – NextEnergy

- Status: in operation
- Technical Data: hydrogen produced by SMR, storage capacity of 50kg; 10-16 kg hydrogen dispensed per day
- Accomplishments: site identification, legal agreements (APCI/NEC), safety processes coordination with NEC, successful community outreach, finalized design, construction, commissioning and customer training.



### ➤ Northern California – San Francisco

- Status: postponed to 2008
- Technical Data: hydrogen produced by SMR
- Accomplishments: > 10 sites evaluated, optimal location/partner at SFO, other option under evaluation.



# Accomplishments and Progress

## NextEnergy Hydrogen Fueling Station – Lessons Learned

- Time to design, manufacture, construct and commission are significantly lengthened with multiple parties involved, primarily due to the many layers of approval that must be managed.
- As Built documentation and associated equipment manuals (at least for life safety systems) need to be available when the Authorities Having Jurisdiction (AHJs) are asked to "clear" their permits and issue a Certificate of Occupancy.
- Having a "packaged solution" from an equipment supplier limits the creativity of the design in terms of taking advantage of host site features and doesn't lessen the time to deliver or commission the equipment.
- The Gas & Flame Detection System, an addition to the original design due to a change in the governing code; NFPA 52, has experienced some false alarms being generated.
- The mandatory gas and flame detection system (per NFPA 52) for the vehicle fueling station should be designed by the party who is responsible for the overall facility gas and flame / fire monitoring and alarm system.
- There are at least two, and sometimes more, layers of responsibility within the same AHJ and each layer likely has a different set of concerns and needs to be addressed uniquely. The needs of all must be clearly understood and satisfied.
- The persons who conduct system safety reviews should be familiar with hydrogen and hydrogen vehicle fueling station design in general and the vehicle fueling station under review in particular.
- Early and frequent discussions about the station were entered into with all the stakeholders including the general public represented by NEC's neighbors. This resulted in no dissention and often times support of the project.
- Engage local contractors who are familiar with City approval processes and ideally with hydrogen projects. The approval process is the most uncertain aspect of the project to schedule.

# Future Work Plans for 2007/2008

- Fuel Cell Vehicles
  - Maintain smooth operation of the fuel cell vehicles with ongoing service, maintenance and customer support.
  - Accumulate more miles in the three ecosystems to validate status of DOE Performance Targets.
  - Finalize technical and operational development of the 70MPa fuel tank upgrade and GEN II activities.
- Hydrogen Infrastructure
  - Continue operations of the NextEnergy, LAX and CaFCP stations as well as the PG&E mobile unit. Assure safety processes through possibly another safety audit.
  - Continue site development of the Los Angeles station. Start site identification and equipment supplier selection for the station.
- Safety and Data Reporting
  - Maintain project safety through continued inter-team communication, vehicle and infrastructure training, employee and customer education, “tabletop” crisis management drills and emergency responders training.
  - Maintain the high quality of technical vehicle and infrastructure data reporting structure to NREL/DOE.
- Outreach/Media Events
  - Pursue novel approaches toward outreach and media events in order to raise public knowledge of hydrogen technology and demonstration projects.

# Conclusion

- Increased customer base to 18 governmental, for-profit and non-profit organizations to accumulate over 130,000 miles in different climate conditions as well as various terrain and customer usage
- Expanded the FDA (Fleet Data Acquisition) from 13 to 17 local file servers
- Completed “Customer Perception and Acceptance Study” concluding that participants:
  - Believe the F-Cell to be easy to use
  - Require a vehicle range of 200 miles
  - Will drive approximately 9 miles to find a hydrogen station
- Finalized the development, construction and training of the NextEnergy fueling infrastructure whereby Michigan external vehicle customers are currently operating the hydrogen station.
- Conducted more than 640 vehicle refills with the PG&E Mobile refueler and DTE Energy. (other stations e.g. LAX are not included)
- Completed over 140 media/outreach events to raise public knowledge of hydrogen technology and demonstration project.