Hydrogen Fuel Cell Vehicle & Infrastructure Demonstration Program Review

Ford Motor Company

Research & Advanced Engineering

Greg Frenette

June 10, 2008

This presentation does not contain any proprietary, confidential or otherwise restricted information

Overview

Timeline

- Project start:
  - Nov. 17, 2004
- Project end:
  - Jun. 2010*
- 50 % complete

*Revised end date

Barriers Addressed

- Vehicles
- Storage
- Hydrogen Refueling Infrastructure
- Maintenance Training & Facilities
- Codes & Standards

Budget

- $88 mil project
  - DOE $44 mil
  - Ford $44 mil
- FY07: $8.0 mil
- FY08: $5.8 mil

Partners

- BP America
- Ballard/AFCC
- States of California & Florida
- City of Taylor, MI
- SMUD, Progress Energy & NextEnergy

Program Extension

- In November of 2007, discussed the possibility of extending fleet operations beyond the program's 36 month plan
- DOE agreed to extend operations:
  - Increased quantity of operational data
  - Better understanding of factors affecting fuel cell life
  - Better understanding of end-of-life criteria
  - Opportunity for operational data from alternative geographic areas
  - Improved understanding of Next Generation Fuel Cell Propulsion Systems
- Finalizing Plans with fleets, suppliers and all participants to operate vehicles thru December, 2009

Vehicle Project Objectives

To gain FCV operational data in differing climate conditions to direct and augment future design efforts

<u>Since Last Review</u>

- **Continue Phase I Vehicle Operation**
- **Report operational data**
- **Maintain fleet**
- **Survey customers**
- **Investigate updated concept vehicles and demonstration**

Infrastructure Project Objectives

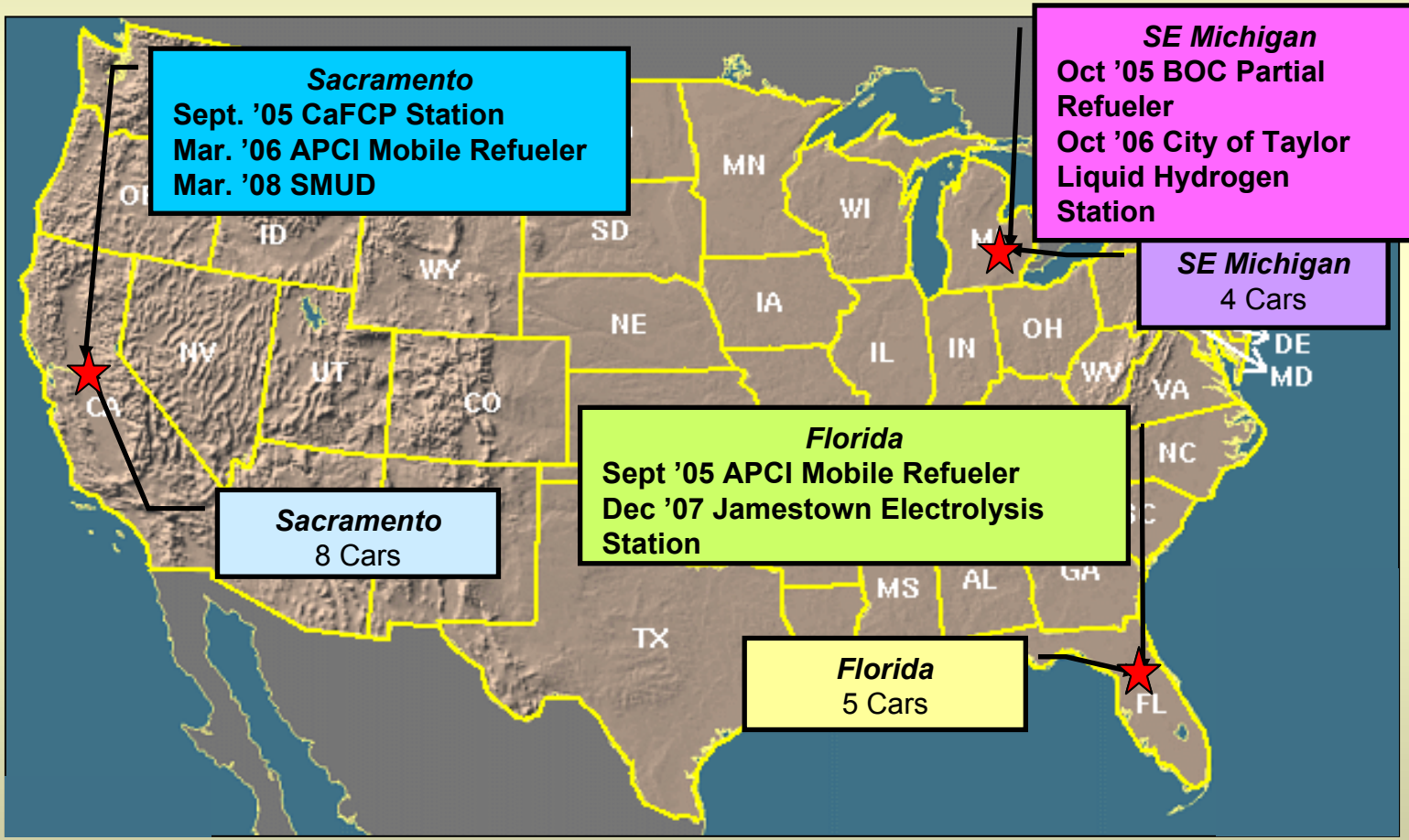
- **Provide safe, reliable user friendly hydrogen infrastructure**
- **Install technology to meet cost targets**
- **Test a variety of hydrogen delivery options**

Vehicle Approach has not changed

- Two demonstration components
  - Phase 1: developed technology installed in contemporary vehicles for real world use
  - Phase 2: controlled in-house demonstration of extended range, durability, hydrogen pressure and operating temperature
- Fleet vehicles in differing geographic/climatic regions
  - ➔ Added fourth geographic region
- Automated data collection methodologies for effective data analysis

2008 Phase I Deployments:

Reassignments within and outside of geographic regions



Icelandic New Energy April 24, 2008

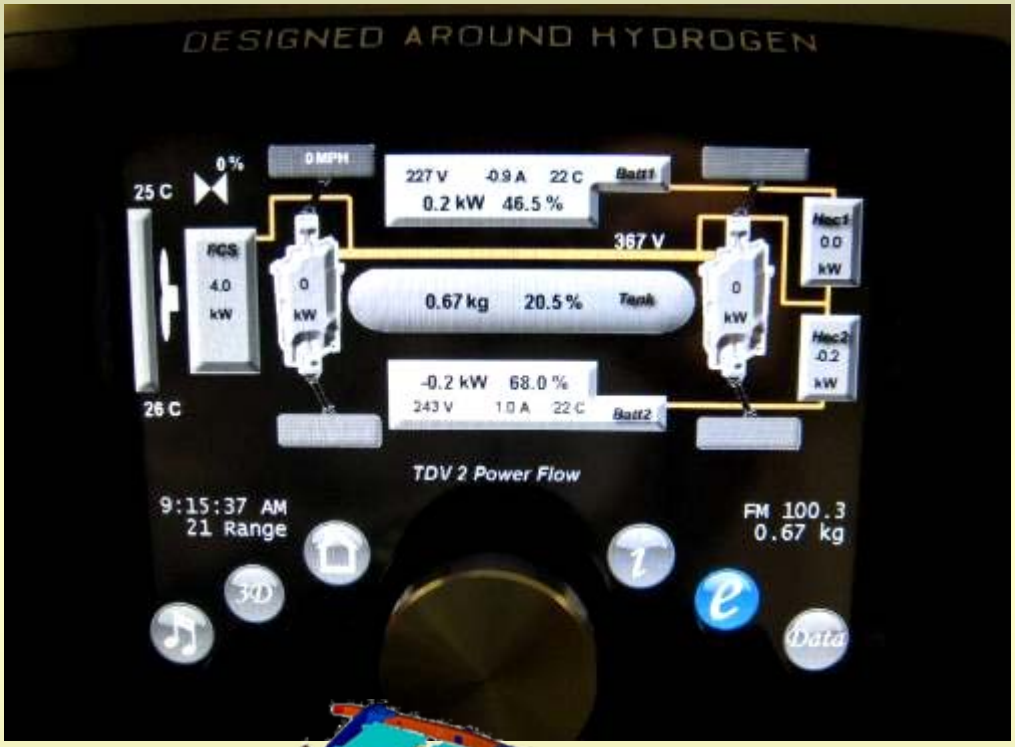
Technical Accomplishments/ Progress/Results

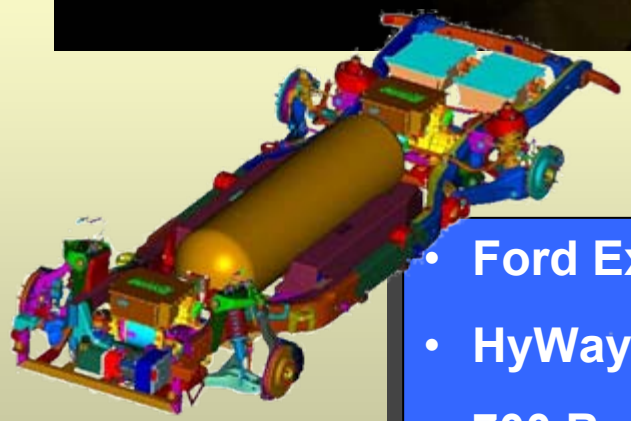
Phase I Fleet

- **Fleet operations continue with vehicle up-times above targets**
- **Below targets for mileage accumulation, but improving**
- **No safety incidents**

Technical Accomplishments

Phase II Ford Controlled Engineering Prototype Vehicles





- Ford Explorer Based
- HyWay 2/3 Proto Engine
- 700 Bar fuel storage

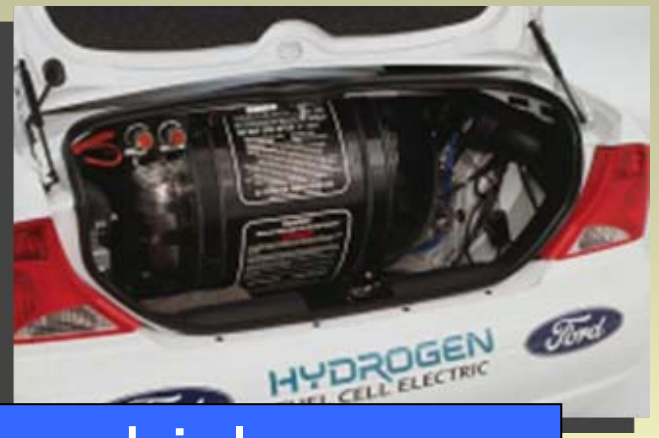
- Work continues on validation of HyWay 2/3 generation fuel cell technology
- Validating 700 bar storage systems

HyWay 2/3 Fuel Cell Technology

As Part of the ongoing Phase II Technology Demonstrator program:

- Successfully demonstrated Ford internal lifetime requirement for stack module during stack level testing.
- Performed a successful stack level lifetime test with out any incidents
- Successfully demonstrated Fuel Cell System Start-up capability from sub-freezing conditions
- Successfully demonstrated Fuel Cell beginning of life continuous power requirements
- Successfully demonstrated Fuel Cell Peak Power Boost capability

700 bar Hydrogen Storage Upgrade



700 bar Fuel System in Phase 1 vehicle.

- completed dynamometer performance comparison tests
- conducted abbreviated rough road durability cycles
- accumulated over significant real world customer miles at 700 bar capacity
- accomplished numerous 700 bar fueling events at a customer simulated station
- successfully operated without faults related to hydrogen leakage or on-road performance

Flexible Series Hybrid

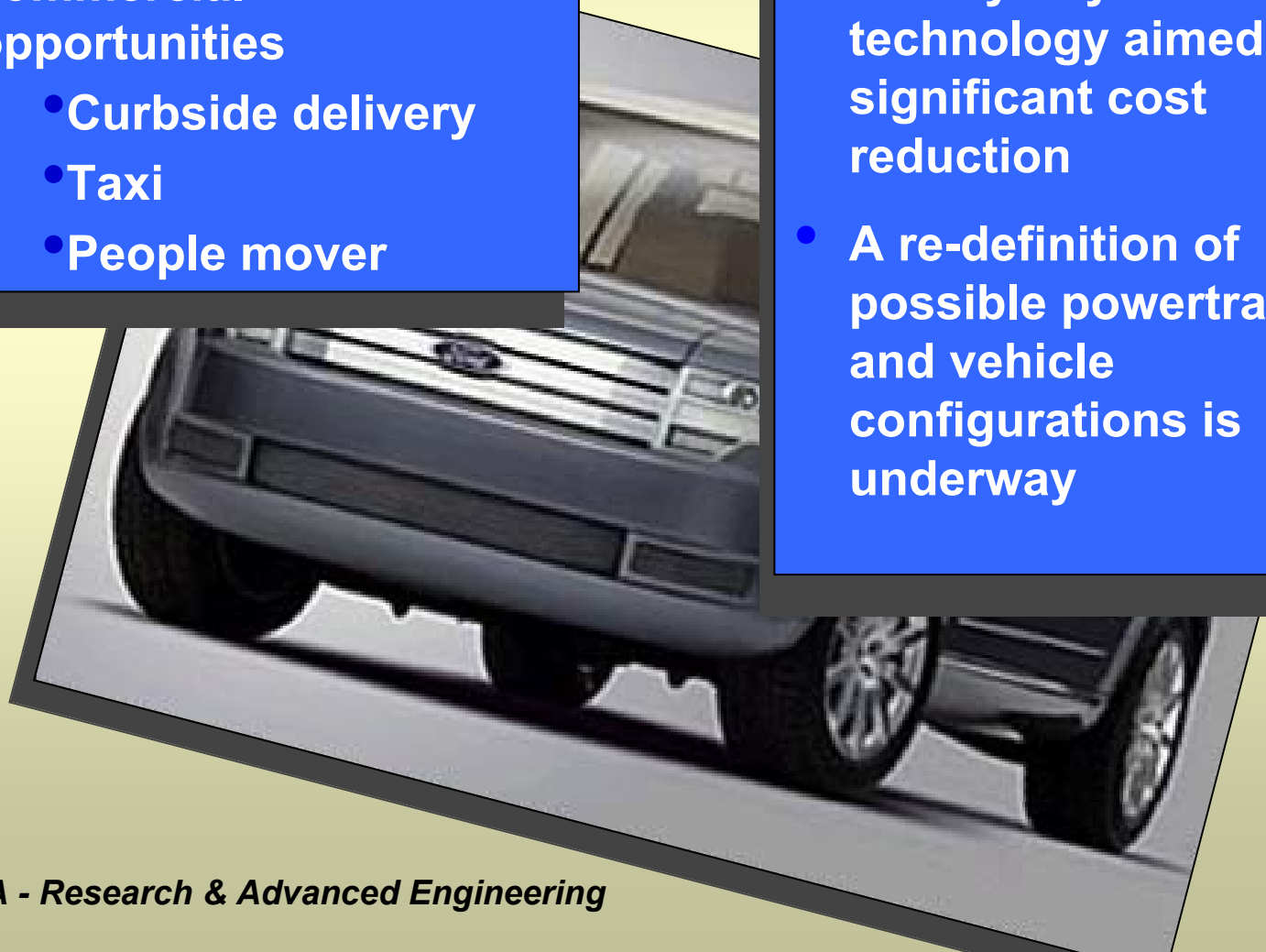
The HySeries powertrain with a fuel cell APU continues to operate

- **gained additional experience and insight with fuel cell auxiliary power unit application**

Redefining Next Vehicles & Powertains

Working towards a near-term vehicle application that provides commercial opportunities

- Curbside delivery
- Taxi
- People mover



- HyWay 2/3 technology for improved functionality/durability and HyWay 4 technology aimed at significant cost reduction
- A re-definition of possible powertrain and vehicle configurations is underway

Vehicle Lessons Learned

- Hydrogen Fuel storage packaging continues to be a significant challenge
- In a hybrid drivetrain configuration, stack life exceeds expectations
- Over time, operator satisfaction with the vehicle operation and driveability has remained high
  - Current fleets want to continue using their vehicles
- Economic viability remains uncertain

Infrastructure Approach

THEN -2006


NOW-2008

- **Phase One**
  - **Install Mobile Refuelers**
  - **Install H2 Delivered Stations**
- **Phase Two**
  - **Install On-site H2 Production**
  - **Install 700 bar**
- **Station Locations**
  - Orlando, Florida
  - Sacramento, CA
  - Taylor, MI
  - Dearborn, MI

Station Timeline

California	Open	Planned	Decom-mission
Sacramento Mobile Refueler	Oct 2005		Jun 2008
SMUD	Mar 2008		Dec 2009
Florida			
Jamestown Mobile Refueler	Sep 2005		Jan 2008
Jamestown Stationary Site w/electrolyzer	Apr 2007		Dec 2009
Michigan			
City of Taylor Temporary Station	Oct 2005		Jan 2007
City of Taylor Stationary Site (Liquid delivery)	Oct 2006		Dec 2009
Dearborn (700 bar) (liquid delivery)		June 2008	Dec 2009

Technical Accomplishments

	Taylor, MI	Jamestown, FL	SMUD, CA
Opened	**Oct 2006**	**Apr 2007**	**Mar 2008**
Technology	Liquid Delivered	Electrolysis	Electrolysis
Service Pressure	6600 psig	6600 psig	6600 psig
Total Capacity	2149 kgs/	24 kgs/day	24 kgs/day
Fill Types	Wireless RF Wired Comm Non-Comm	Wireless RF Wired Comm Non-Comm	Wireless RF Wired Comm Non-Comm
Safety Training	40 emergency responders/ 25 fleet operators	90 emergency responders/ 60 fleet operators	200 emergency responders/ fleet operators
Data Collection	Obtaining fueling data from vehicles	On-site electronic data collection	On-site electronic data collection

SMUD Station Opened March 2008

Powered by Renewable Energy

Infrastructure Safety Implementation

Approach has not changed

Hydrogen for Transport remains committed to no accidents, no harm to people, no damage to the environment

Project Management

- Managerial Gate Approvals
- Management of Change
- Pre-Construction Safety Induction for Contractors and Suppliers (Injury and Incident Free training)
- Advanced Safety Audits
- Integrity Management Standard

Adherence to relevant safety codes

Collaborative system safety assessments, reviews and plans

- HAZID / QRA
- HAZOP
- pHSSEr approach
- BP-Global Alliance safety training for contractor and supplier
- Emergency Response Plan

H2 Safety Training

- Contractors
- Fleet operators
- Station operators
- Emergency Responders

No Serious Safety Related Incidents in Program

Infrastructure Lessons Learned

Experience in the last year has reinforced the lessons learned in the opening of previous fueling stations

Station Loading

- Difficult to justify multi-million dollar stations in program. Load is too small.
- DOE and industry should work together to guarantee substantial station loading

Limited Supply Base

- Results in high cost of equipment
- Small suppliers can add complexity and significant cost

Permitting

- distributed production stations may be too large for most urban area retail sites
- Permitting hydrogen at retail stations is very challenging

Developing Codes & Standards

- Emerging safety codes add cost and time
- New ASTM test methods must be developed

Infrastructure Critical Issues

Critical Issues in the Infrastructure remain the same

- Cost of equipment
- Station loading
- Suppliers
- Assessment of 700 bar dispensing safety

Future Work: 2008 Work Plan

Upcoming Events:

- Continue Phase I vehicle operation
  - Complete all requirements to keep the fleet operating through the end of 2009
- Evaluate 700 Bar Vehicle Performance
- Complete 2nd Phase II Designed Around Hydrogen Concept Vehicle
  - Redefine Phase II vehicle configurations
- Operate Orlando, City of Taylor and SMUD Stations
- Complete Dearborn 700 bar station- June 2008

Summary

- **Vehicles:**
  - Program remains on track, Phase I vehicles performing well. Operation to be extended through 2009
  - Phase II: existing vehicles performing very well and proving viability of concept.
  - Remaining Phase II vehicles require redefinition.
- **Infrastructure**
  - 2006 began evaluation of liquid hydrogen station
  - 2007 began operations of distributed electrolysis production station.
  - 2008 installed and operating renewable hydrogen station.
  - 2008 will complete 700 bar station.

Research and Advanced Engineering

bp