Controlled Hydrogen Fleet and Infrastructure Demonstration and Validation Project –

Progress Update

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Outline

- Project Overview and Industry Partners
- Data Collection and Processing
- Analysis Methodology
- First Public Results Now Available: Composite Data Products

Project Objectives and Targets

- Objectives
  - Validate H_2 FC Vehicles and Infrastructure in Parallel
  - Identify Current Status of Technology and its Evolution
  - Re-Focus H2 Research and Development
  - Support Industry Commercialization Decision by 2015

Hydrogen and gasoline station, WA DC

Key Targets

Performance Measure	2009*	2015**
Fuel Cell Stack Durability	2000 hours	5000 hours
Vehicle Range	250+ miles	300+ miles
Hydrogen Cost at Station	$3/gge	$2-3/gge

* To verify progress toward 2015 targets
** Subsequent projects to validate 2015 targets

Teams are Fielding Four Main* Types of Vehicles

*Validation also includes FCV Sprinter vans

*Validation also includes Kia Sportage FCVs

Sample Hydrogen Refueling Infrastructure

Refueling Stations from All Four Teams Creating Regional Networks

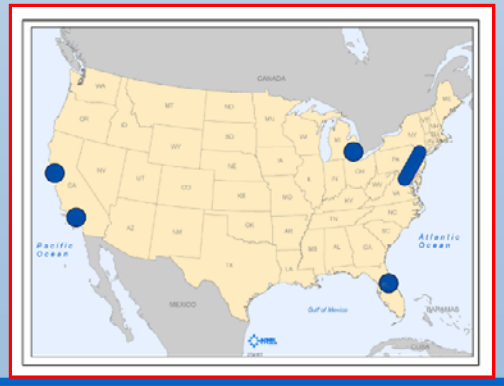
Additional Planned Stations
Ford & BP (3)
DaimlerChrysler & BP (TBD)
General Motors & Shell (1)

Additional Planned Stations
DaimlerChrysler & BP (2)
Ford (1)
Chevron & Hyundai/Kia (1)

Additional Planned Stations
General Motors & Shell (2)

Legend
- Chevron & Hyundai/Kia
- DaimlerChrysler & BP
- Ford & BP
- General Motors & Shell
- Other Companies

Additional Planned Stations
DaimlerChrysler & BP (2)
General Motors & Shell (2)
Chevron & Hyundai/Kia (2)

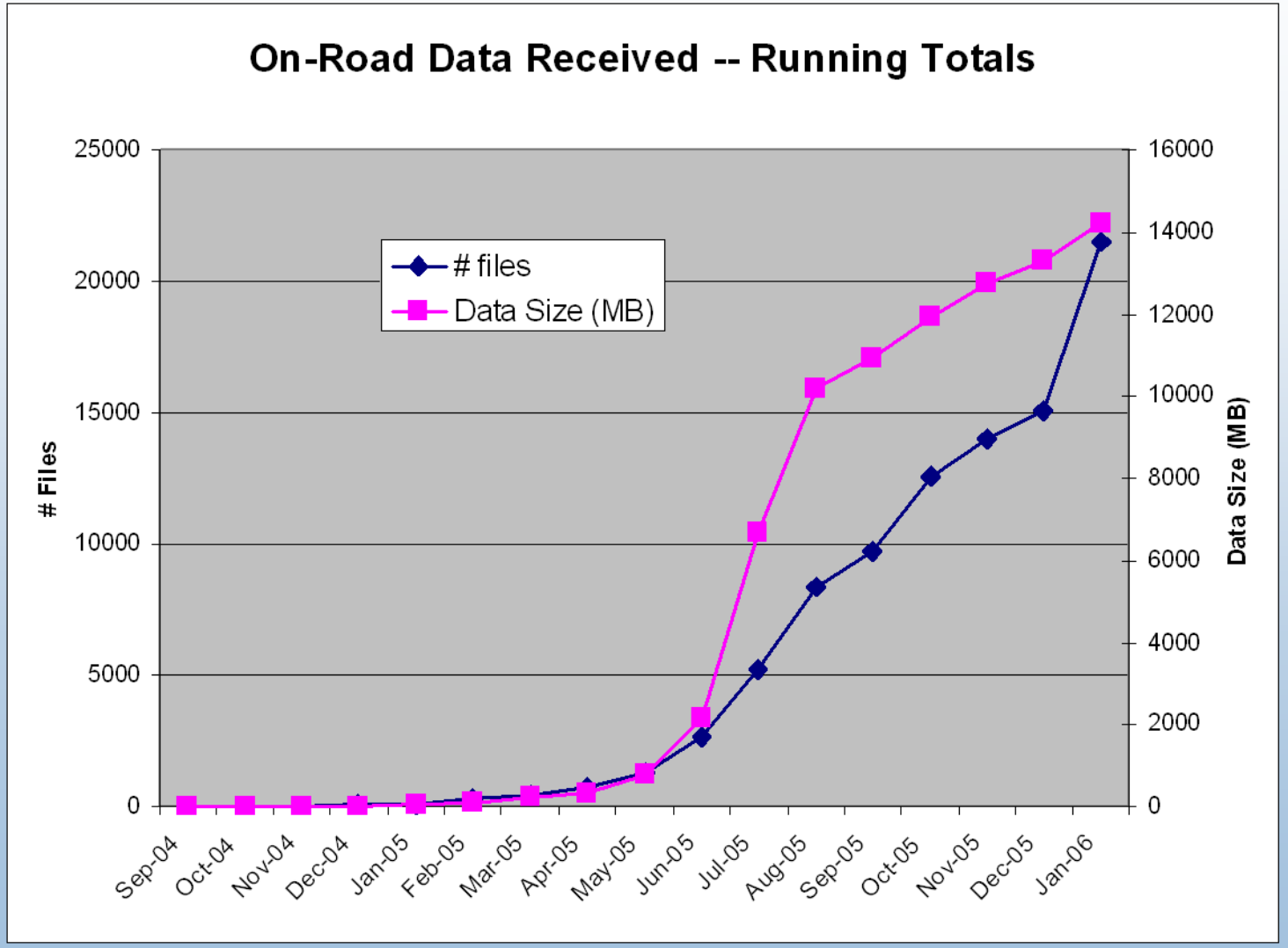


Data Collection: Overview

Key Vehicle Data	Key Infrastructure Data
Stack Durability	Conversion Method
Fuel Economy (Dyno & On-Road) and Vehicle Range	Production Emissions
Fuel Cell System Efficiency	Maintenance, Safety Events
Maintenance, Safety Events	Hydrogen Purity/Impurities
Top Speed, Accel., Grade	Refueling Events, Rates
Max Pwr & Time at 40C	H_2 Production Cost
Freeze Start Ability (Time, Energy)	Conversion, Compression, Storage and Dispensing Efficiency
Continuous Voltage and Current (or Power) from Fuel Cell Stack, Motor/Generator, Battery & Key Auxiliaries: (Dyno & On-Road)	

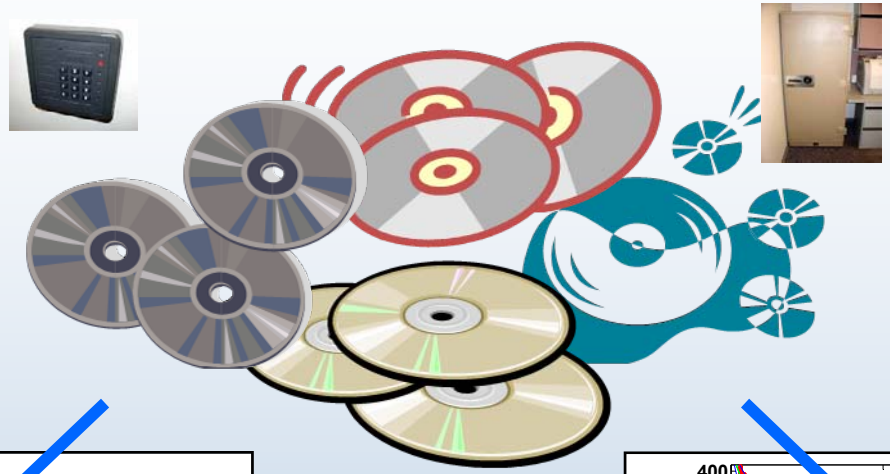
Project Now Well Underway

Current Status of Data Reporting to the Hydrogen Secure Data Center at NREL

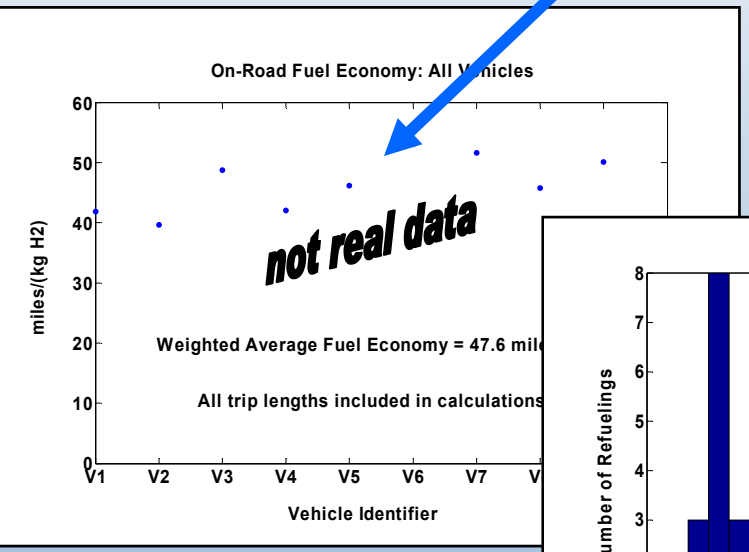


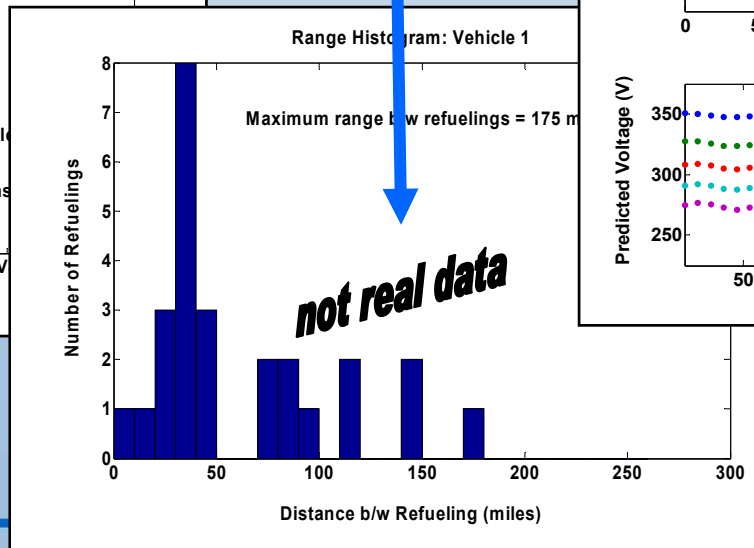
Vehicle Data Analysis: Automated Process from CD/DVD Delivery to Results

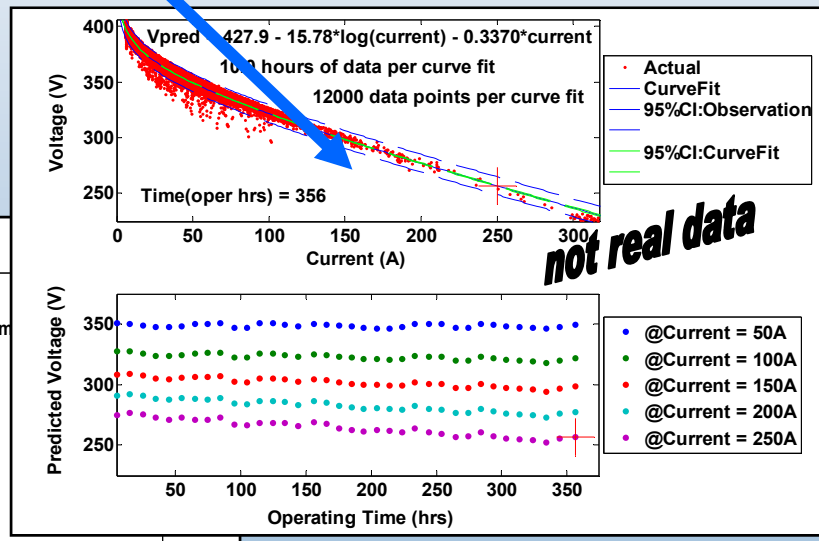
Data is delivered to NREL's Hydrogen Secure Data Center (HSDC) on CD/DVDs



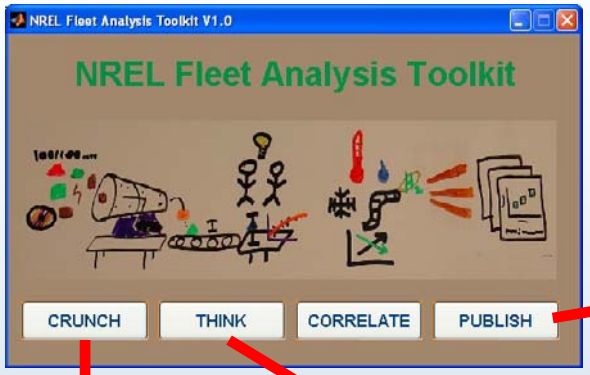
Data protected in HSDC for 5 years after data developed under EPACT 2005, Sec. 810

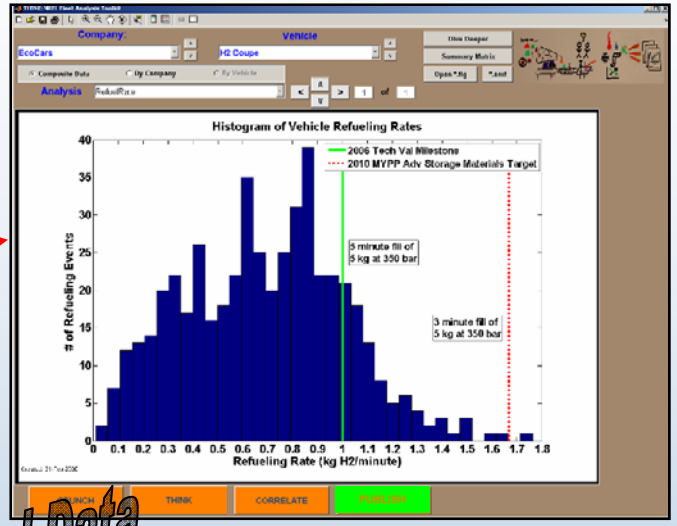


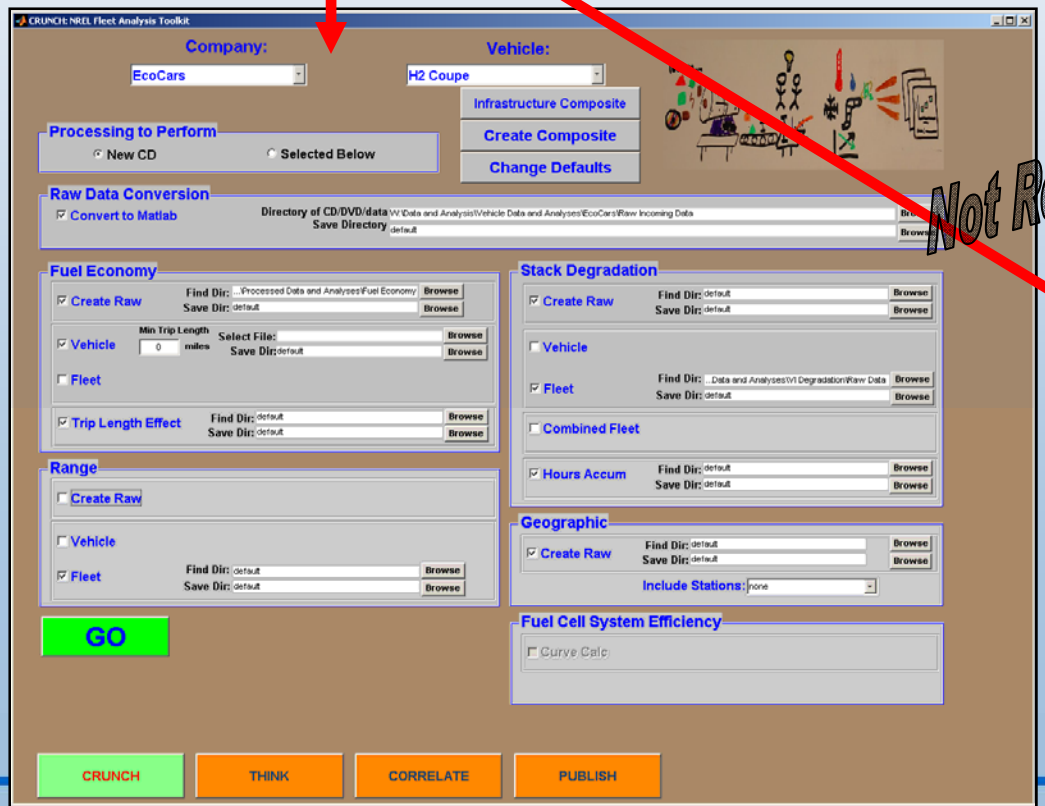




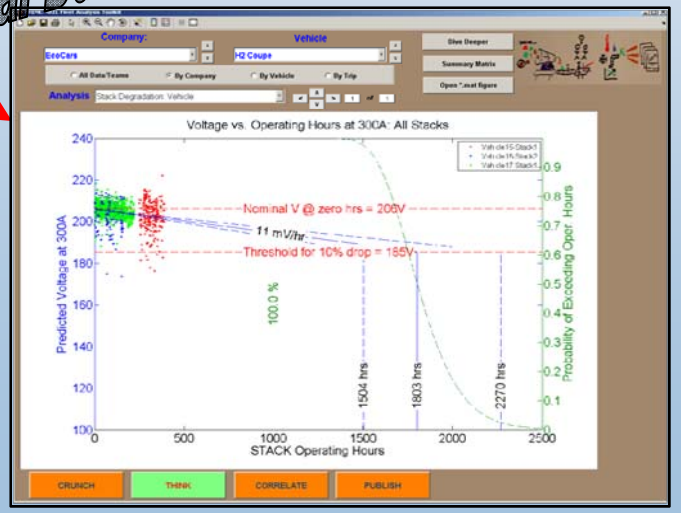
Analysis Controlled by New NREL-Developed GUI: Fleet Analysis Toolkit (FAT)



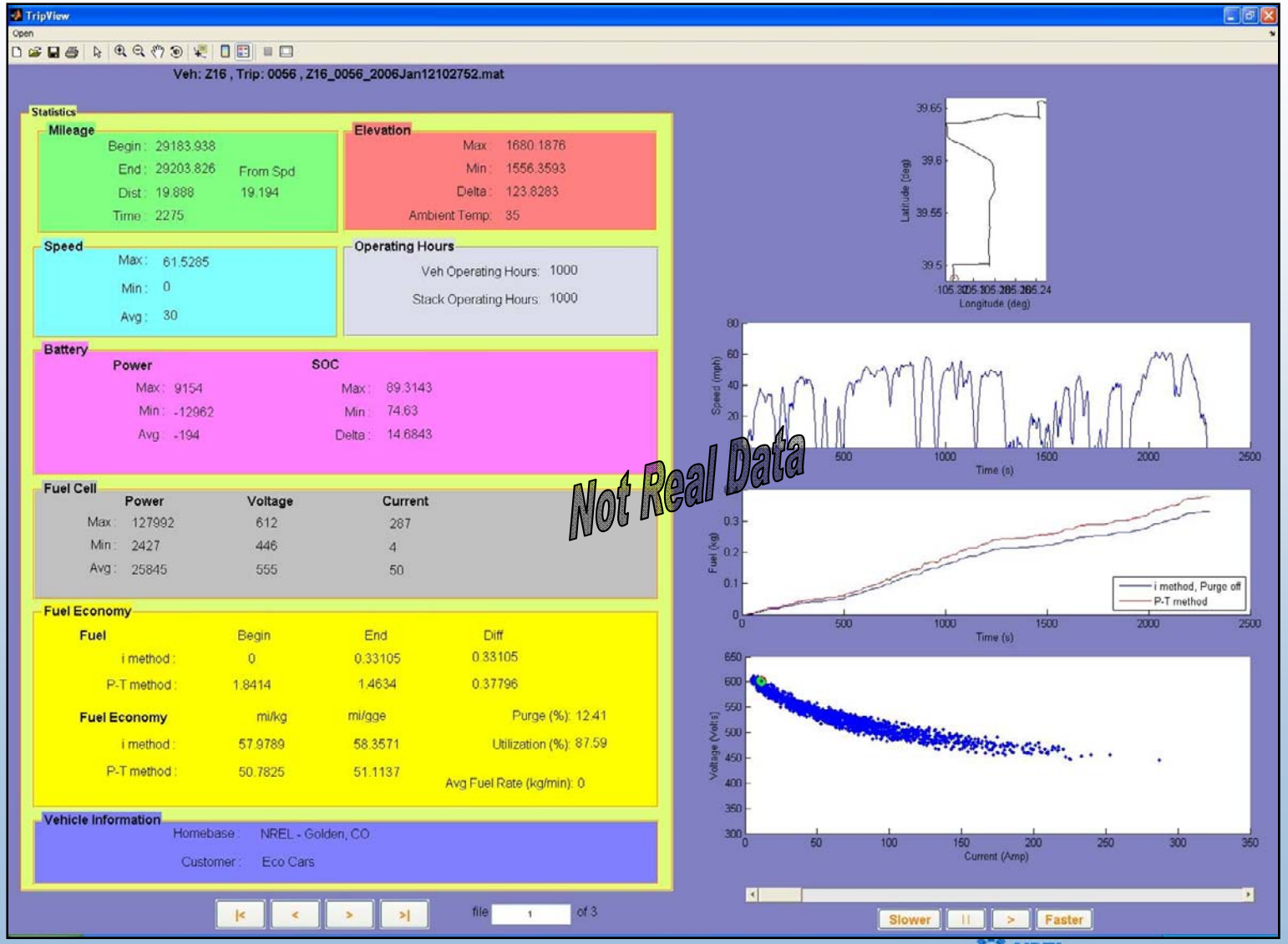




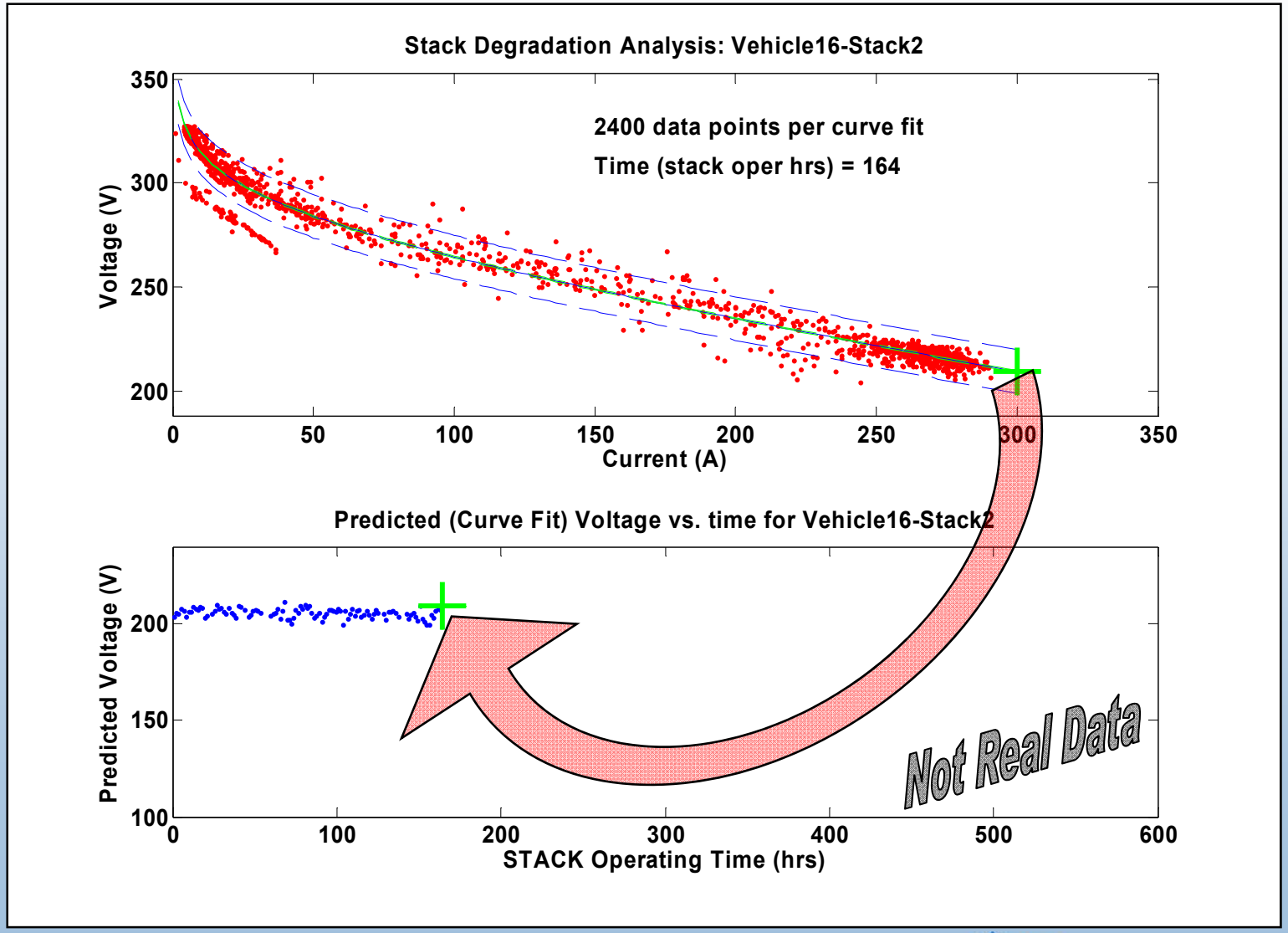
Not Real Data



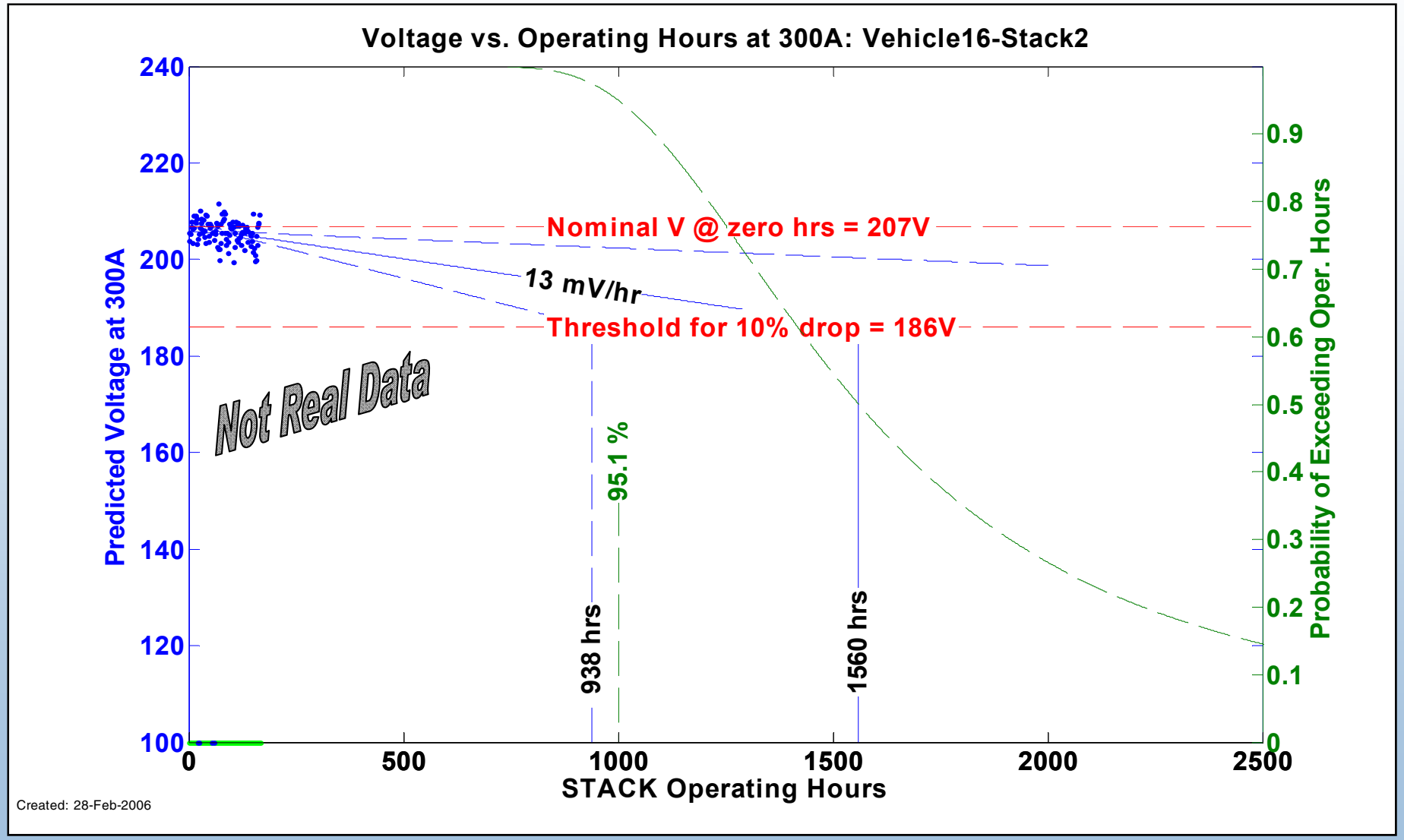
FAT GUI Includes TripView to Dive Deeper and Investigate Individual Trips and Refuelings



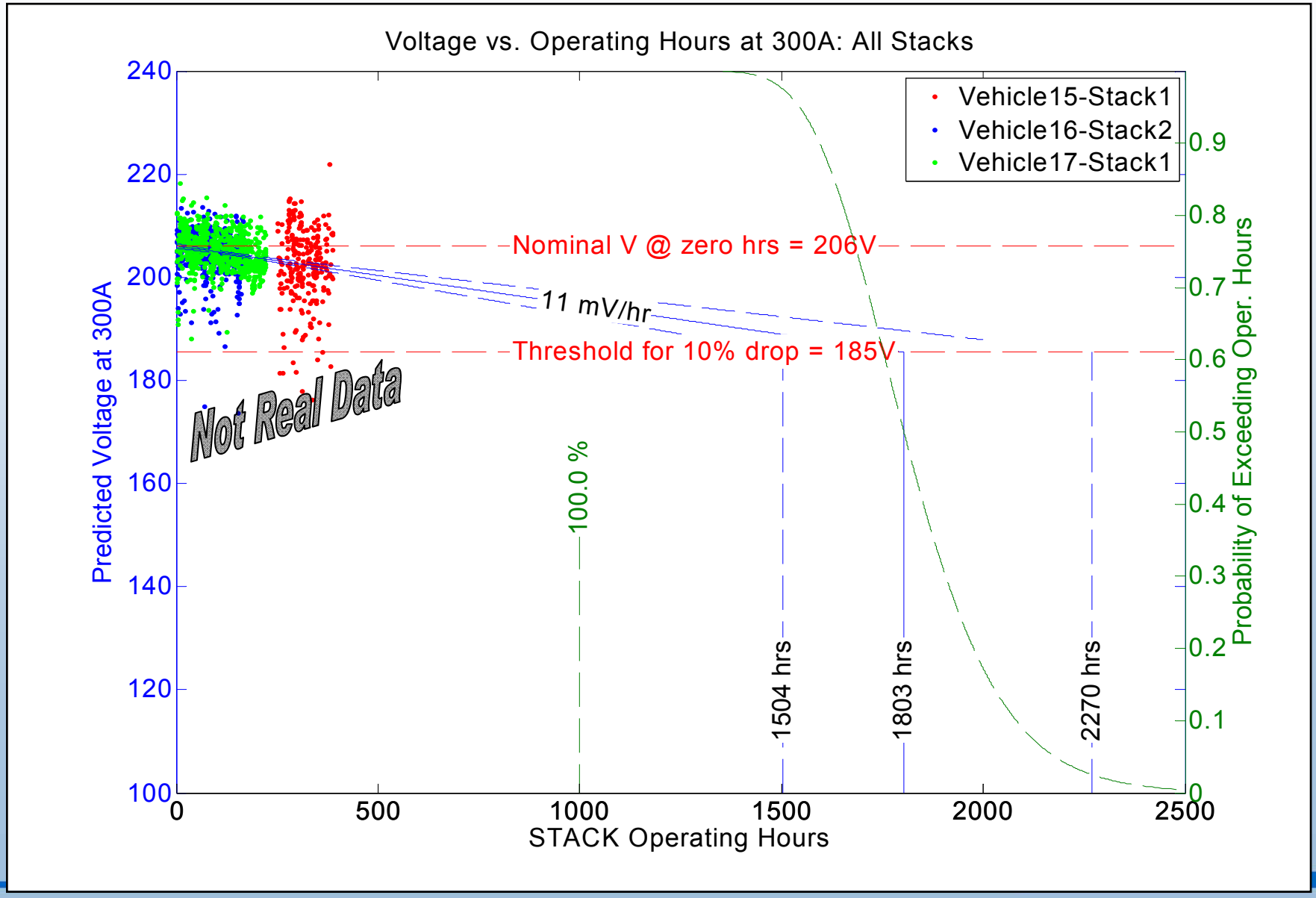
On-Road Voltage Degradation Analysis: Polarization Curve Fitting, Piecewise in Time



Voltage Degradation Analysis: Individual-Stack Methodology



Voltage Degradation Analysis: Multiple-Stack-Average Methodology



Composite Data Products are Main Output to Public and Hydrogen Community

A. Critical Program Metrics:

1. Fuel Cell Durability, Actual vs. DOE Targets, All OEM's
2. Vehicle Ranges, Actual vs. DOE Targets, All OEM's
3. H2 Production Cost. Actuals/Projections vs. DOE Targets

B. Composite Performance Tracking:

Vehicles

4. Reliability (FC System & Powertrain, MTBF)
5. Start Times vs. DOE Target
6. Fuel Economy: Dyno, On-Road
7. Normalized Vehicle Fuel Economy
8. Fuel Cell System Efficiency
9. Safety Incidents - Vehicle Operation
10. Weight % Hydrogen
11. Energy Density of Hydrogen Storage
12. Vehicle Hydrogen Tank Cycle Life

Hydrogen Infrastructure

13. H2 Production Efficiency vs. Process
14. Combined Heat and Power (CHP) Efficiencies
15. H2 Production Cost vs. Process
16. H2 Purity vs. Production Process
17. Hydrogen Impurities - Range for Production Process A
18. Histogram: Refueling Rate
19. Average Maintenance Hours - Scheduled and Unscheduled
20. Safety Incidents - Infrastructure

Highlighted CDPs Have Been Completed and Will Be Presented

C. High Level Program Progress:

Vehicles

21. Range of Actual Ambient Temperatures During Vehicle Operation – All Vehicle Teams
22. Histogram: # Vehicles vs. Operating Hours to Date
23. Histogram: # Vehicles vs. Miles Traveled to Date
24. Cumulative Vehicle Miles Traveled - All Teams
25. Progression of Low to High Pressure On-board H2 Storage

Hydrogen Infrastructure

26. Cumulative Hydrogen Production – All Teams

Accomplishment: Baseline Vehicle Chassis Dynamometer Testing Completed by All 4 Teams

- One vehicle per team per geographic region
- 11 vehicles tested using SAE J2572
- Some teams may elect to use test results for EPA certification

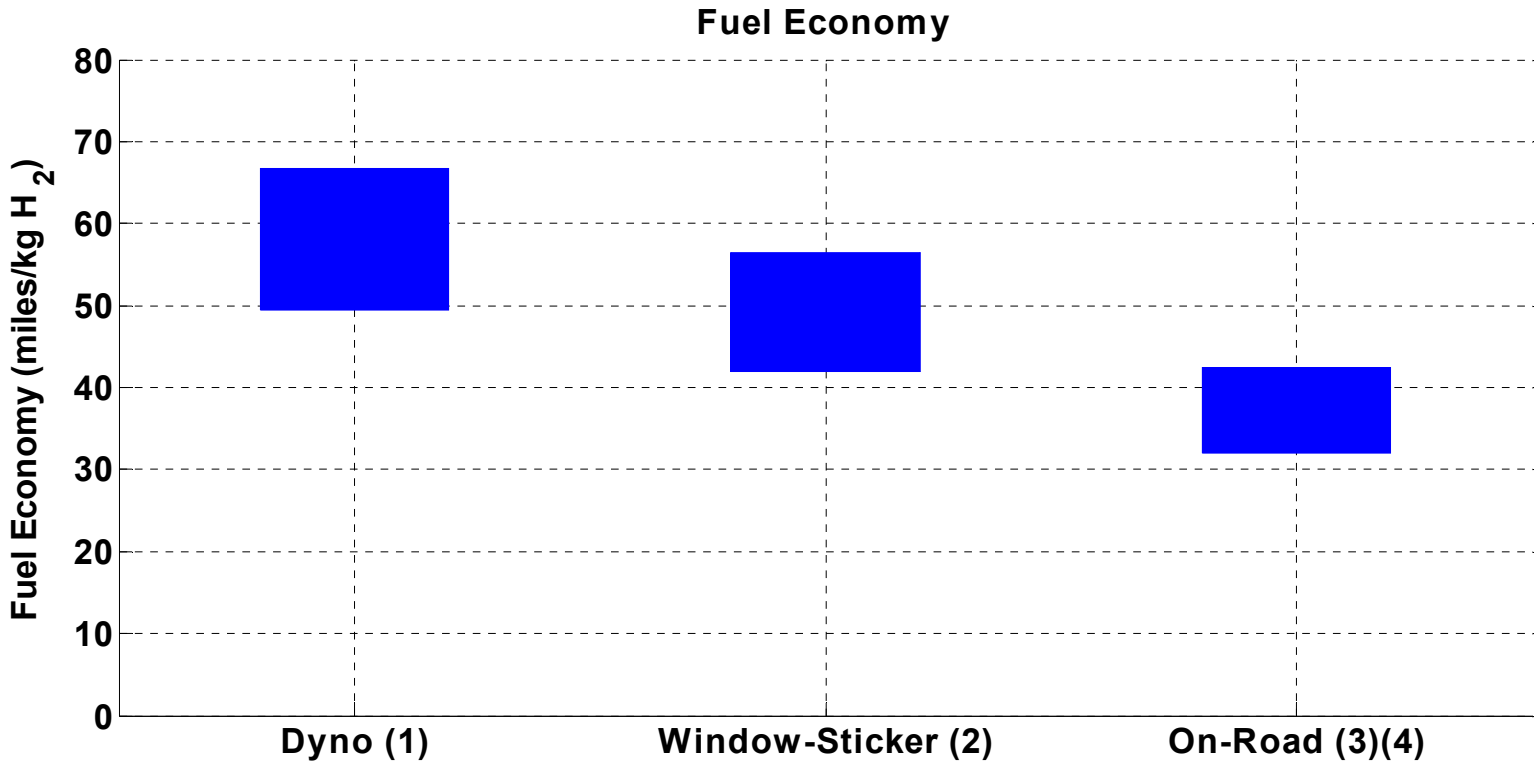
DaimlerChrysler/BP

Chevron/Hyundai-KIA

Ford/BP

GM/Shell

Dynamometer and On-Road Fuel Economy



(1) One data point for each make/model. Combined City/Hwy fuel economy per DRAFT SAEJ2572.

(2) Adjusted combined City/Hwy fuel economy (0.78 x Hwy, 0.9 x City).

(3) Excludes trips < 1 mile. One data point for on-road fleet average of each make/model.

(4) Calculated from on-road fuel cell stack current or mass flow readings.

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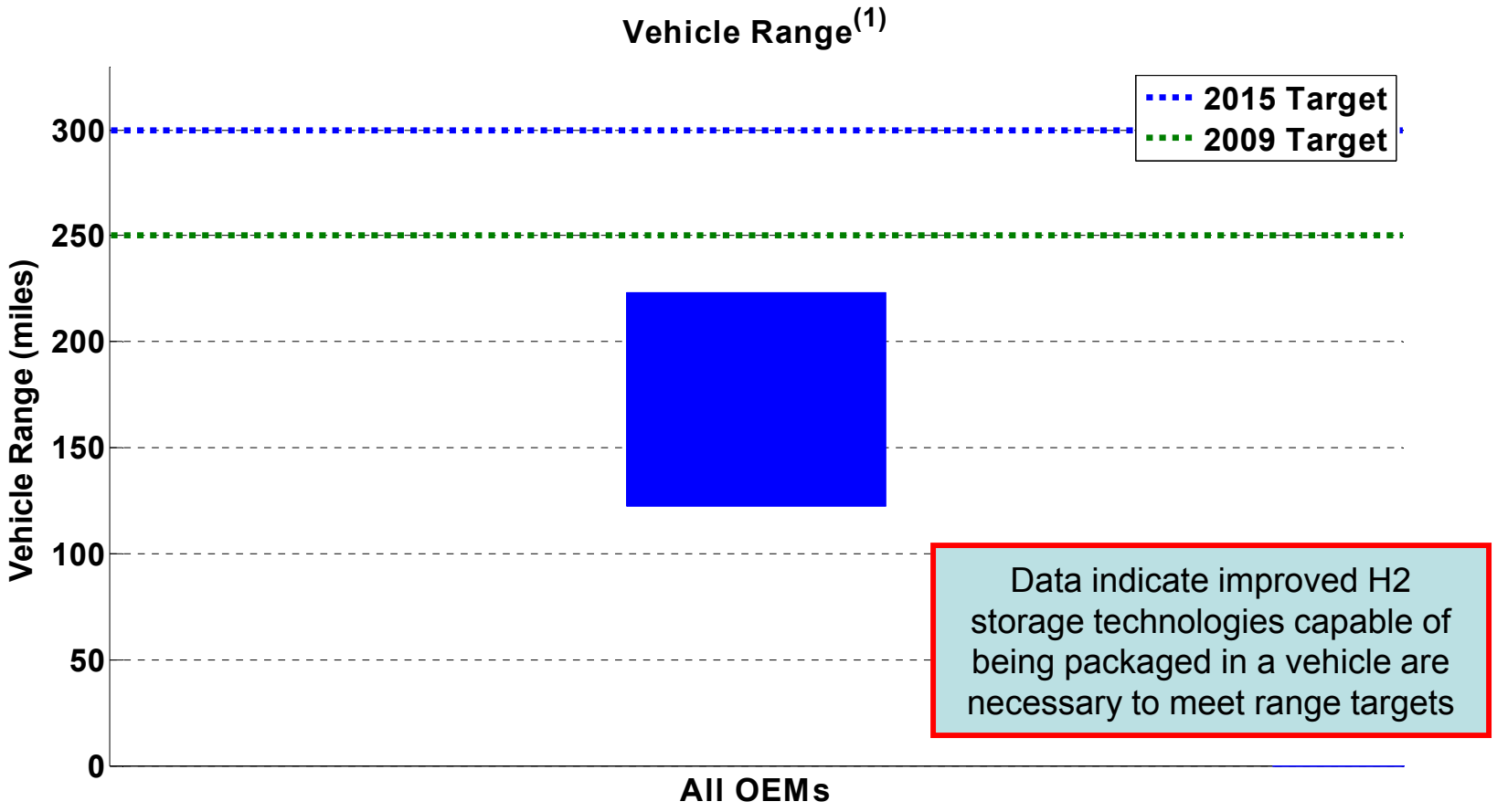
Vehicle Range Based on Dyno Results and Usable H2 Fuel Stored On-Board



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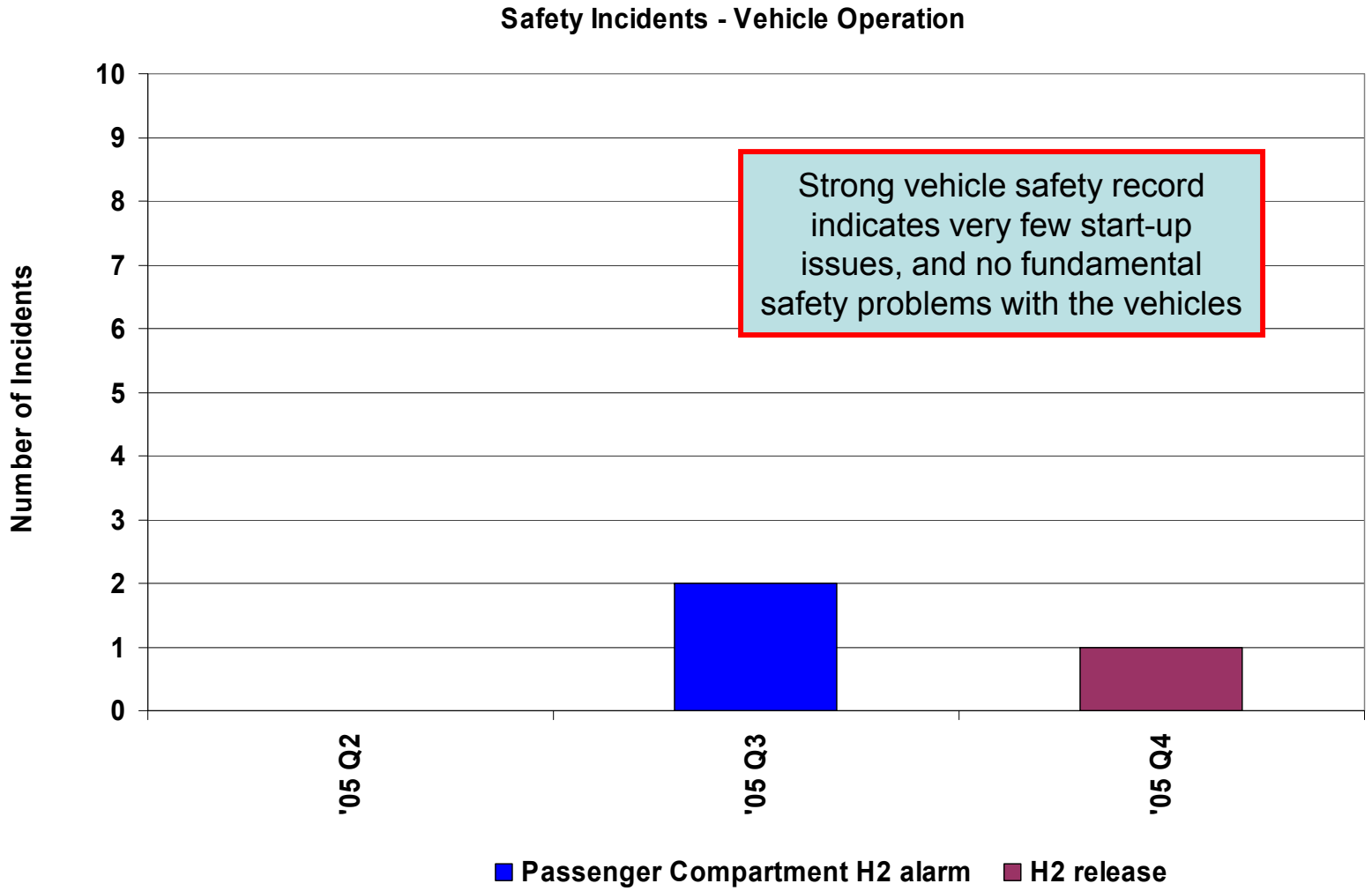
(1) Calculated from combined City/Hwy fuel economy (dyno test) per DRAFT SAE J2572 and usable fuel on board.

Safety Incidents – Vehicles



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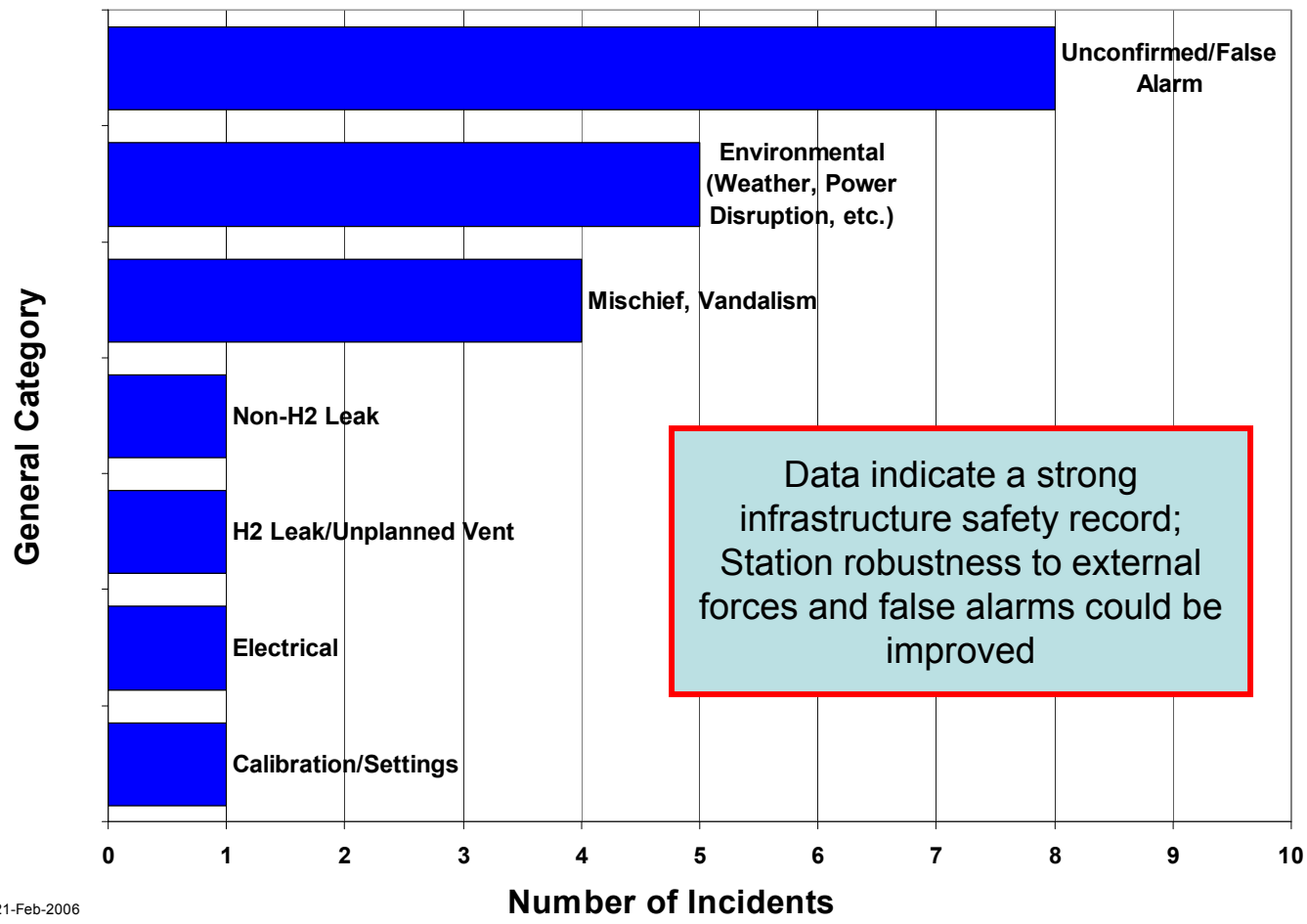
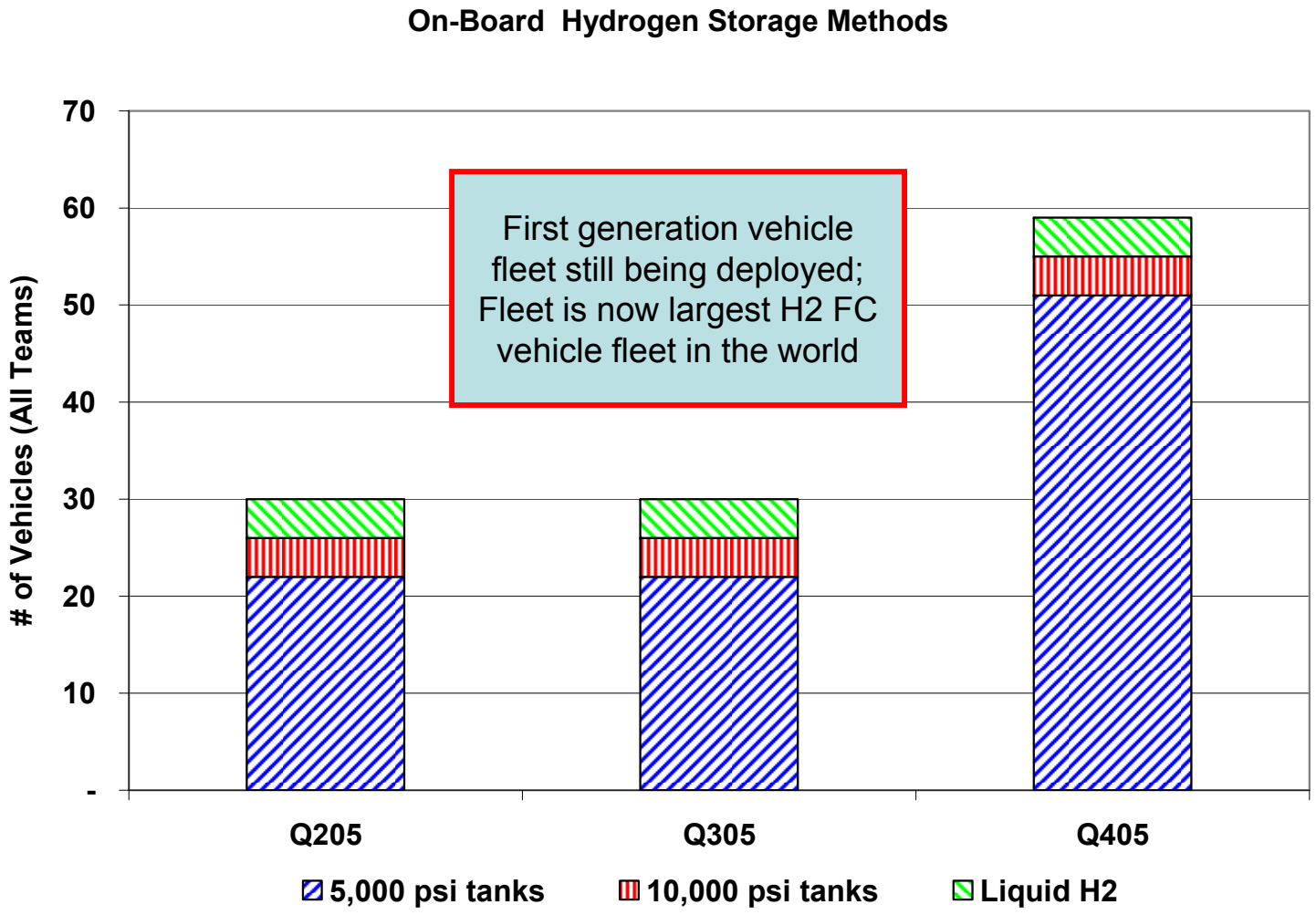
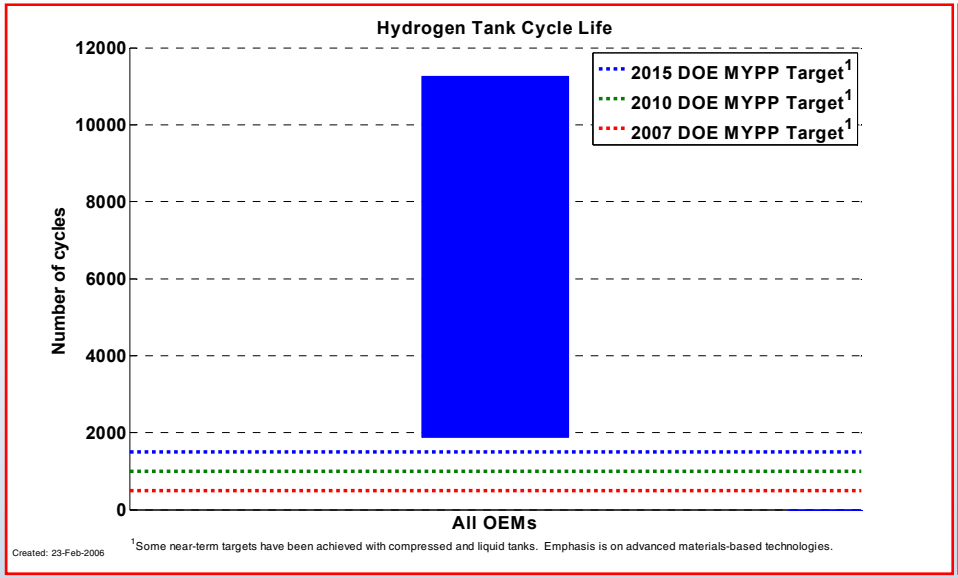
Safety Incidents – Infrastructure

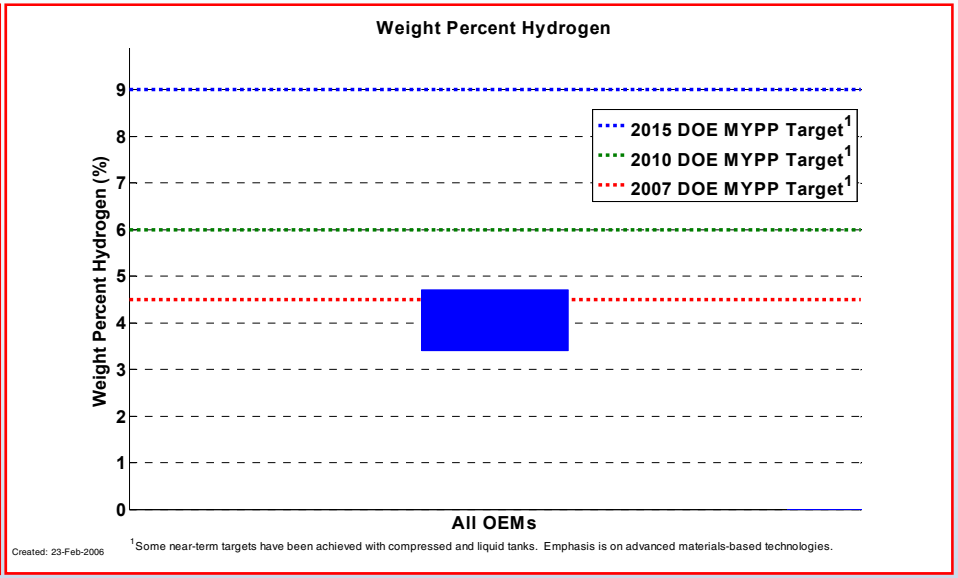


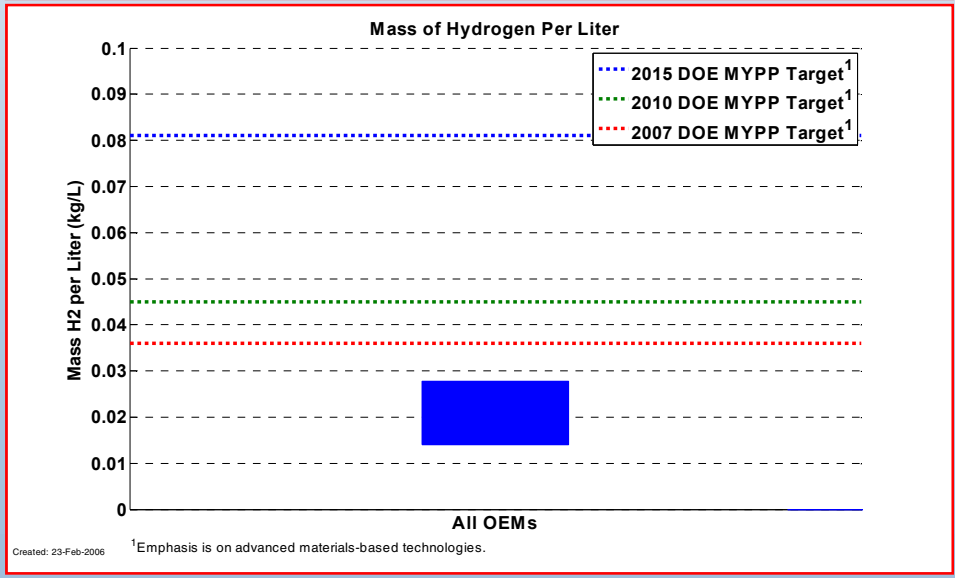
Vehicle H2 Storage Technologies Include 350 bar, 700 bar, and Liquid H2



Technical Status of On-Board H2 Storage Technologies Being Validated

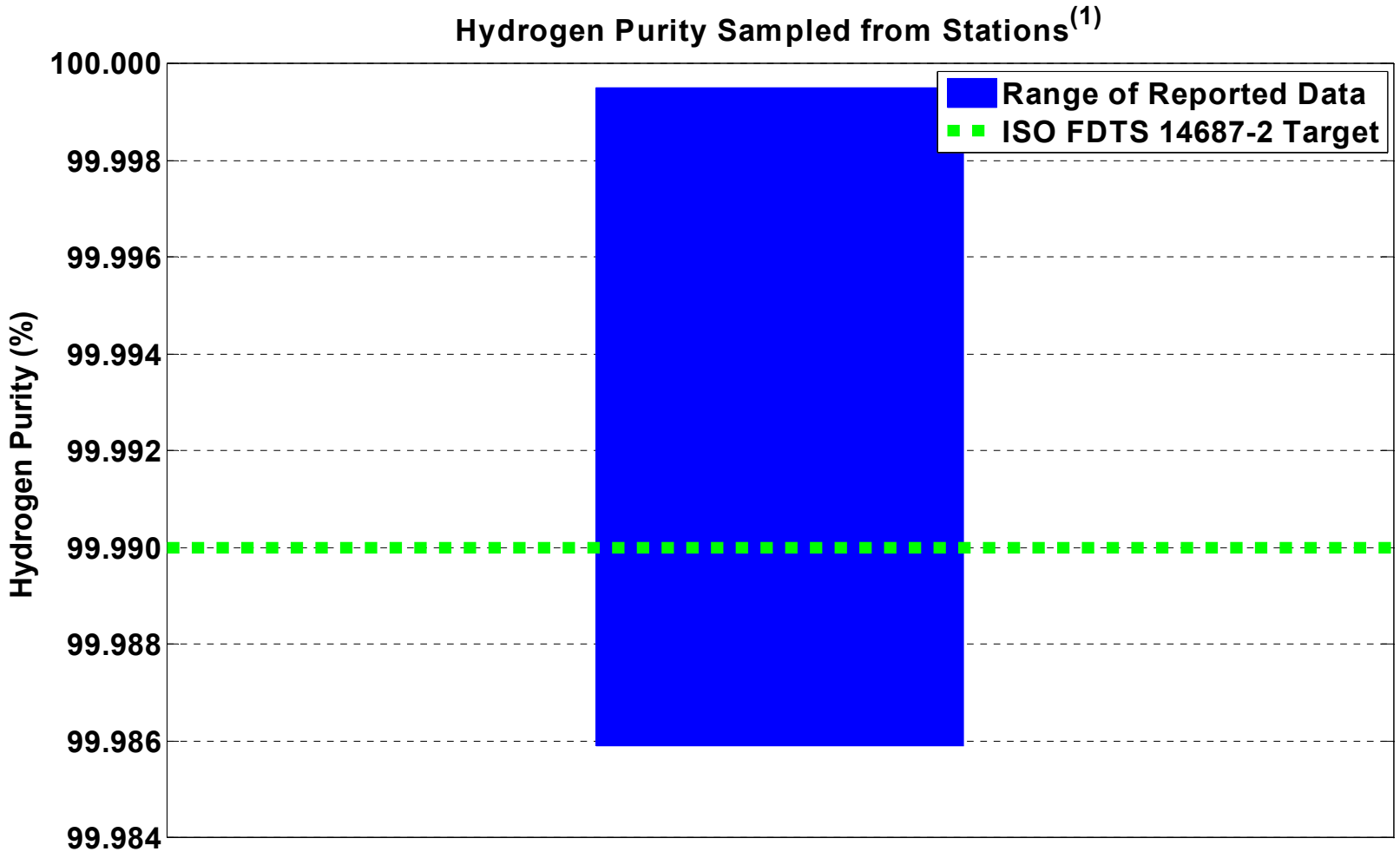






Compressed and liquid H2 tanks meet durability and short term weight %, but don't meet long-term weight % or volumetric capacity targets for vehicles

Hydrogen Purity Sampled from Stations Meets Target Majority of the Time



(1) Includes sampling from both electrolysis and reforming

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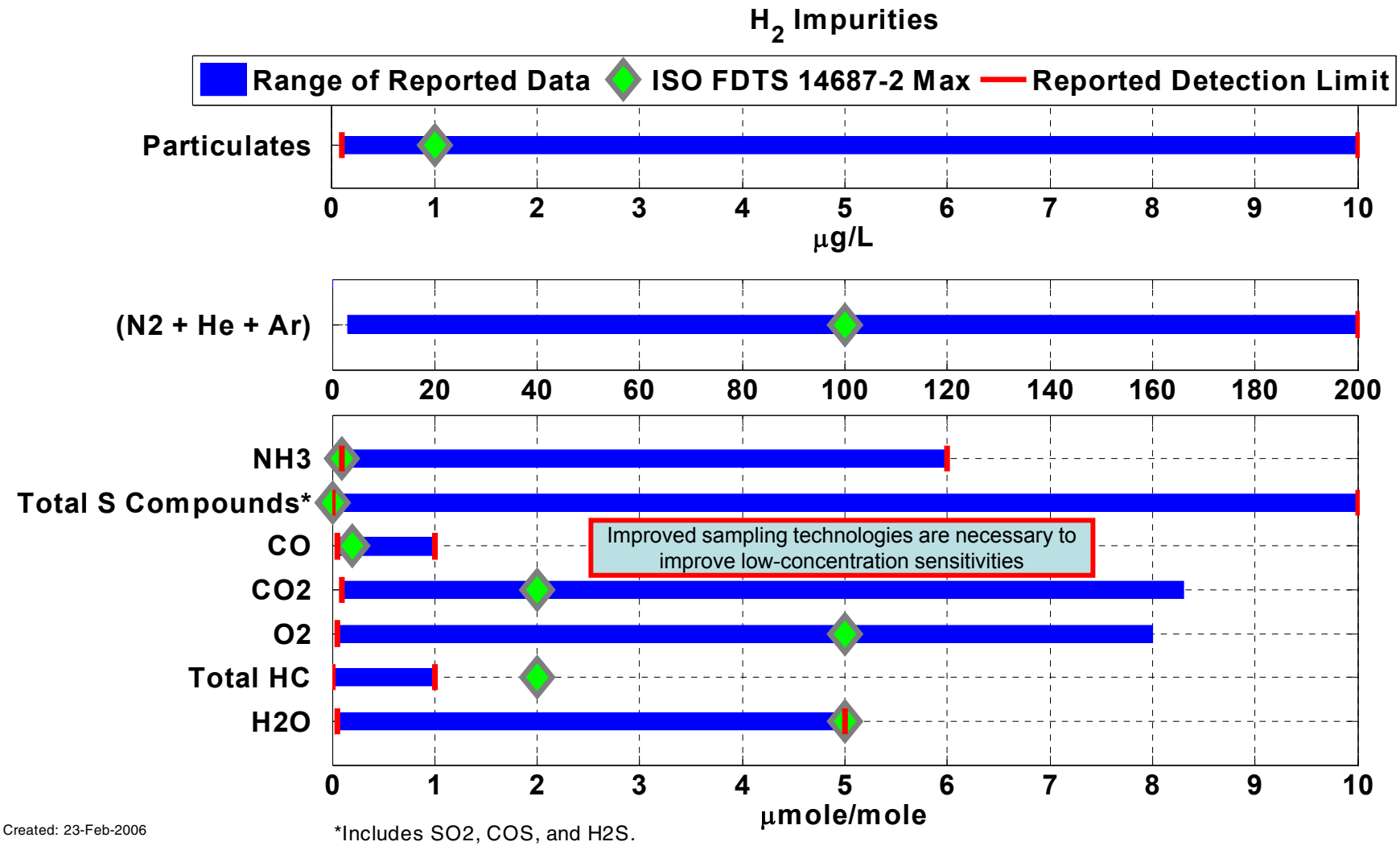
Hydrogen Impurities Sampled from All Stations – Includes On-Site Reformation, Electrolysis, and Delivered H2



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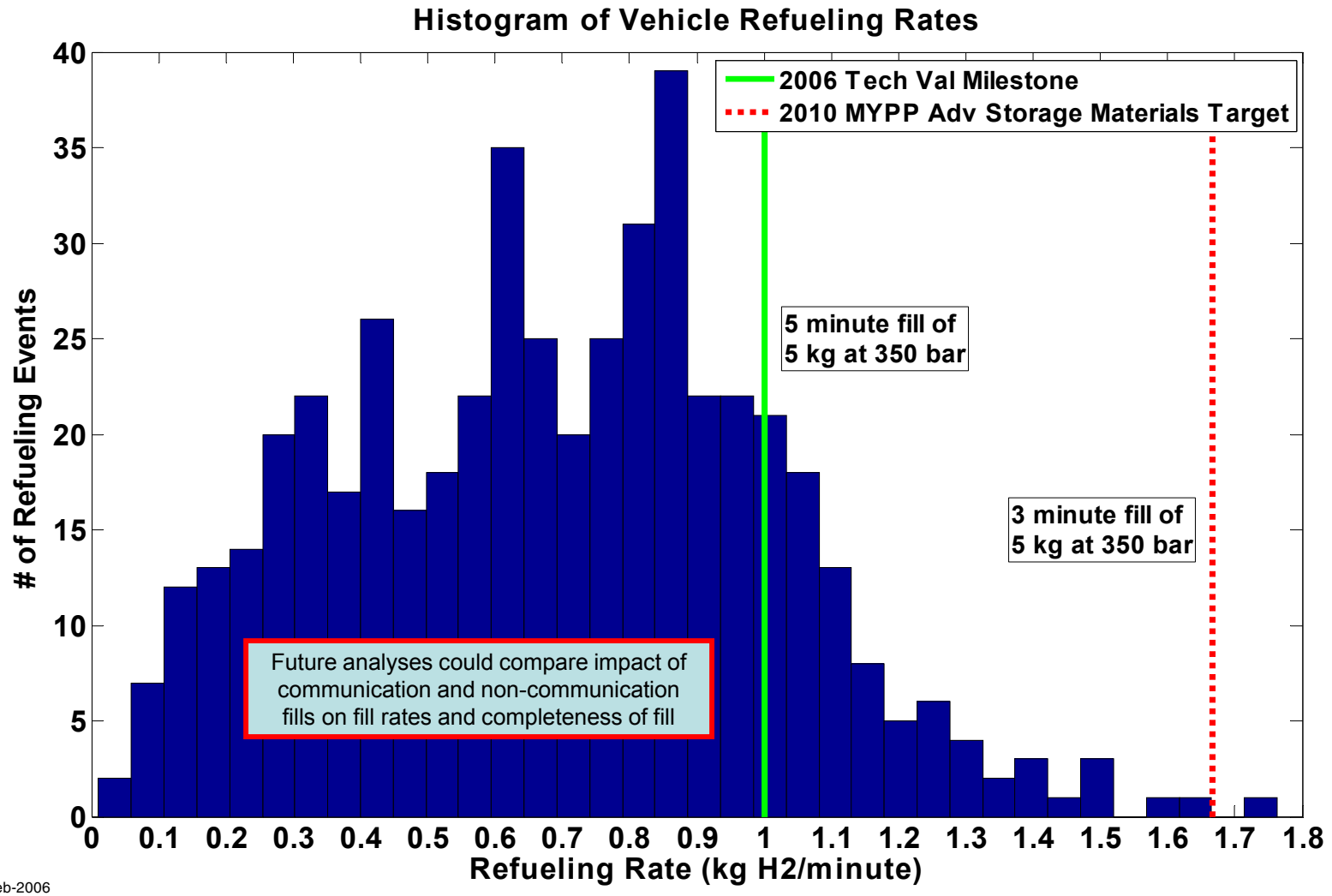
*Includes SO2, COS, and H2S.

Actual Vehicle Refueling Rates: Measured by Stations or by Vehicles



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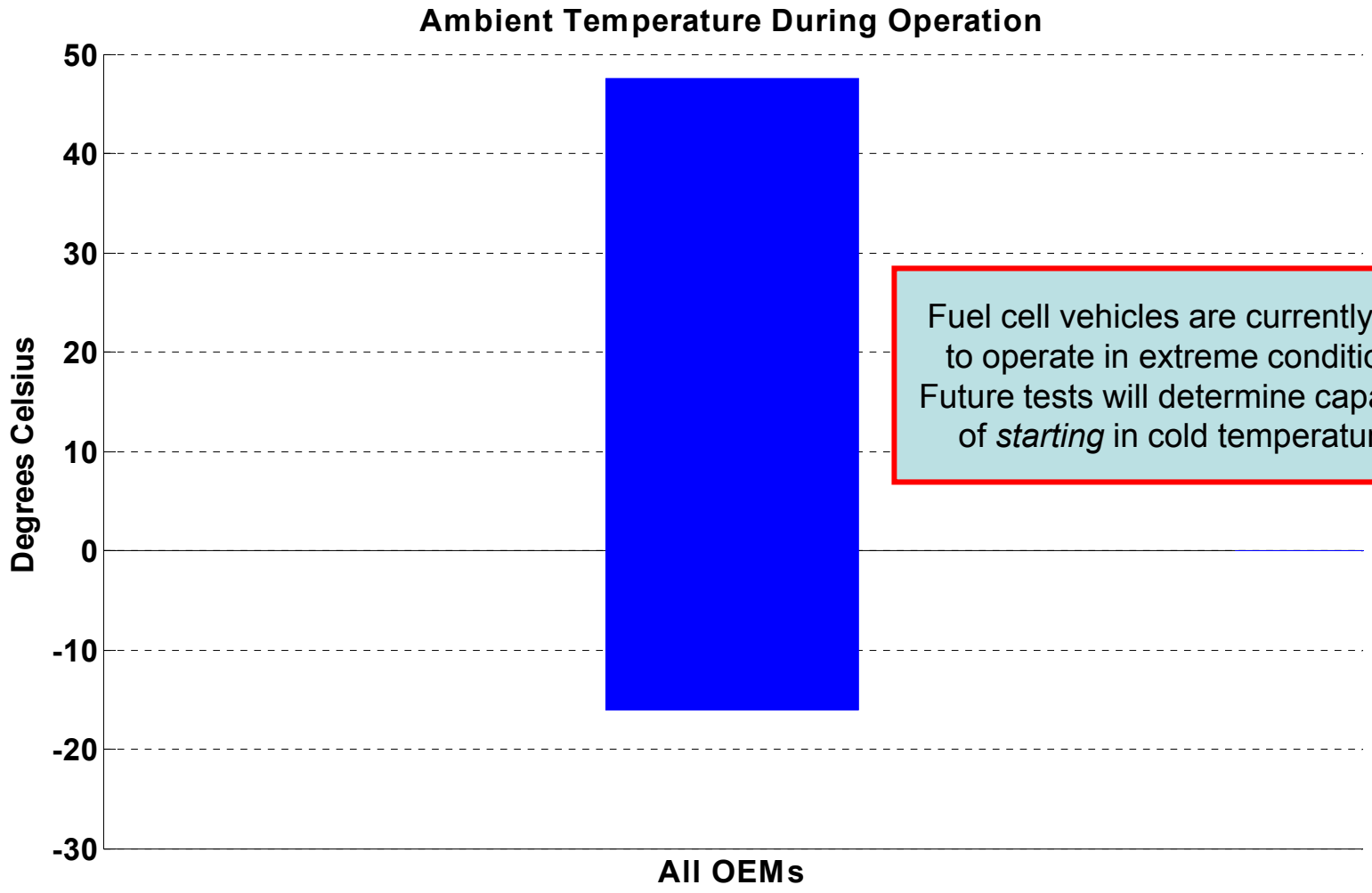
Range of Ambient Temperature During Vehicle Operation



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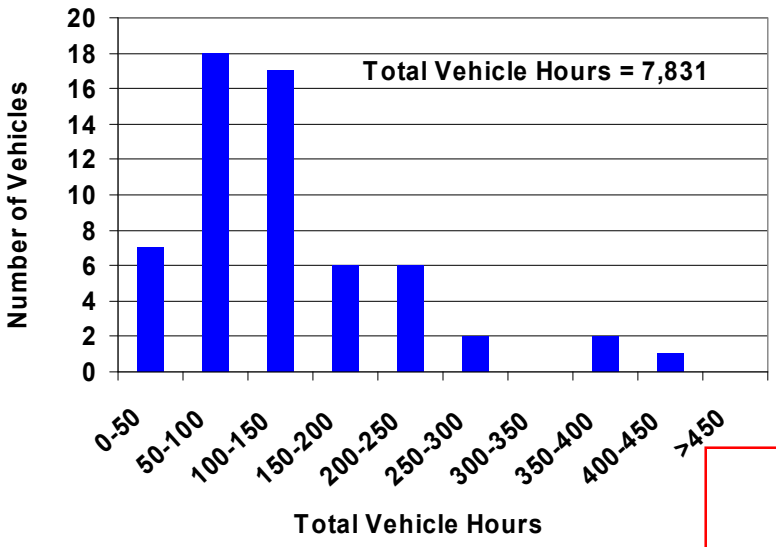
Vehicle Operating Hours and Miles Traveled Distribution



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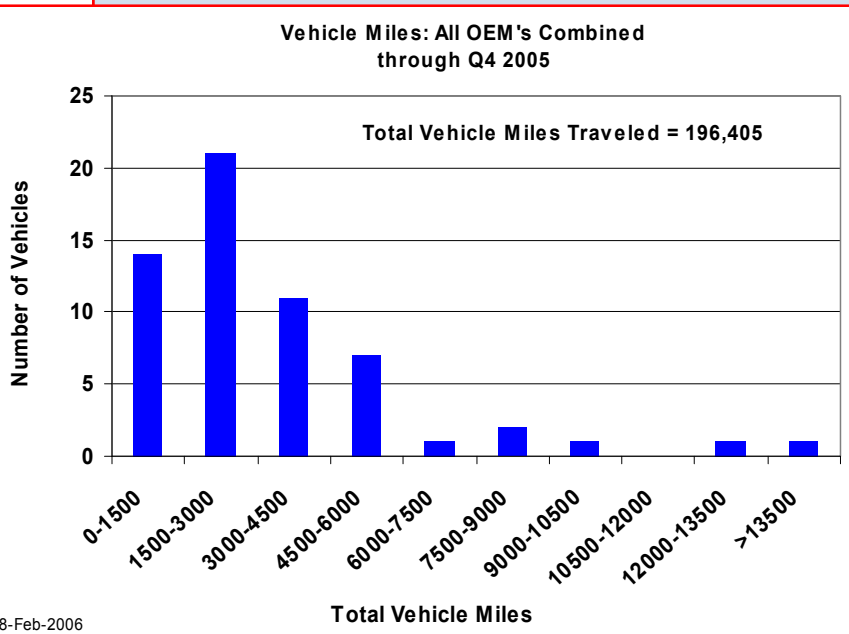
Data reflect youthful nature of current fleet



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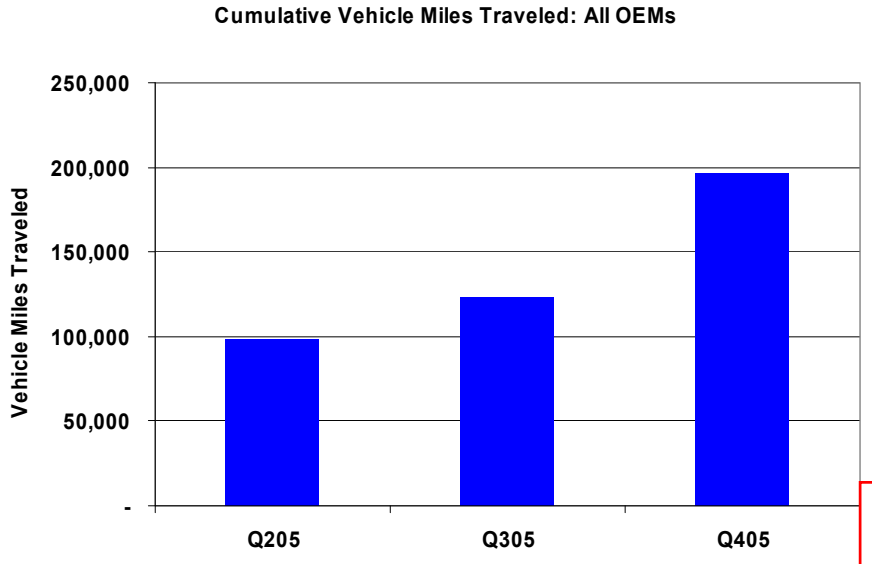
Cumulative Vehicle Miles Traveled and Mass of H2 Produced or Dispensed



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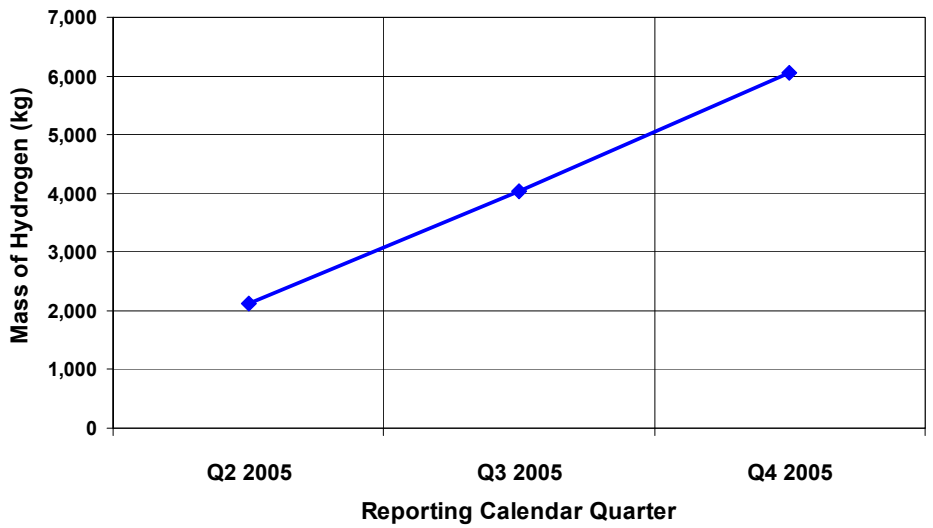
Rate of mileage accumulation increasing as initial fleets approach full deployment

Current deployment of new H2 refueling stations for this project is about 20% complete



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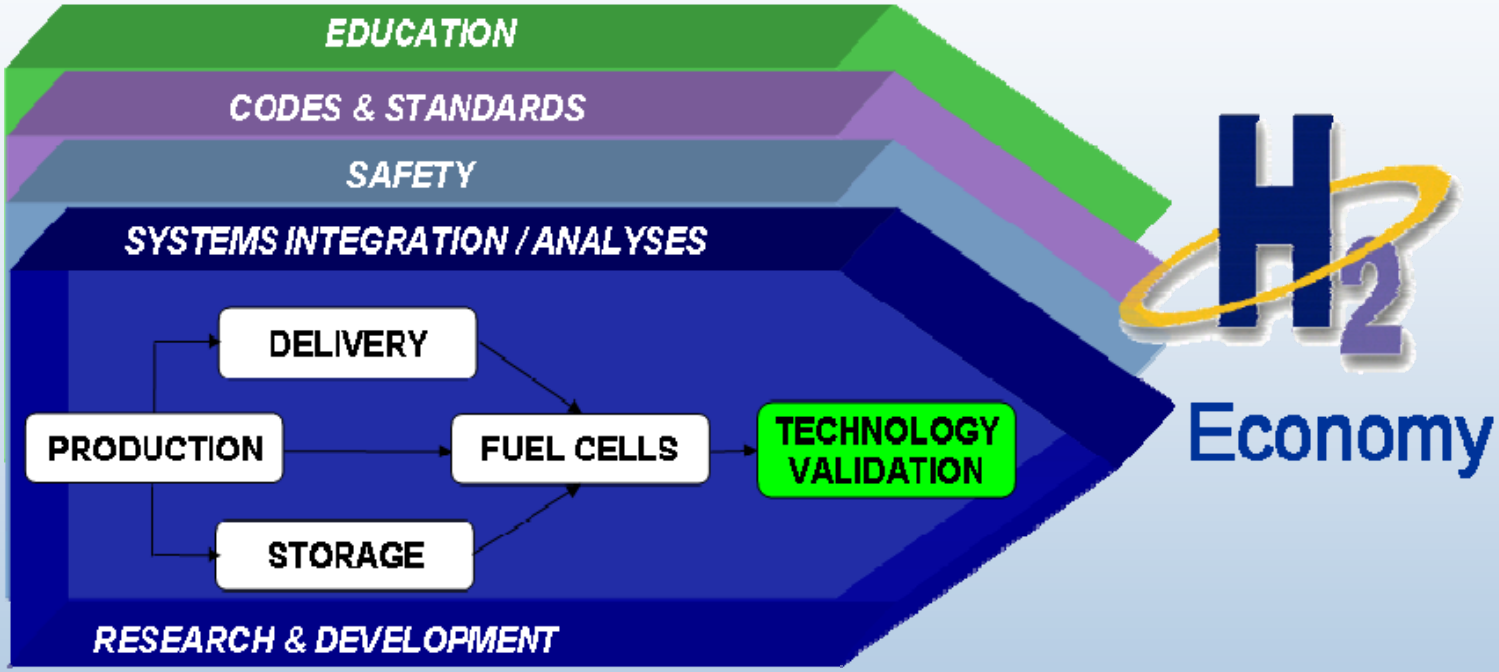
Summary

- First year of the 5-year project completed
  - 59 vehicles now in fleet operation
  - Several new refueling stations opened
  - No major safety problems encountered
- Project has identified current technical status relative to program targets
  - Will track improvements from 2nd generation stacks/vehicles introduced mid-way through project
- Future public results will include:
  - FC durability, reliability, efficiency, and start-up times
  - H2 production cost, efficiency, and maintenance

Questions and Discussion



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