DoE SuperTruck Program

Technology and System Level Demonstration of Highly Efficient and Clean, Diesel Powered Class 8 Trucks

Principal Investigator: David Koeberlein (Cummins)

Presenter: Ken Damon

Peterbilt Motors Company

Project ID: ARRAVT081

16 May 2013

Relevance - Program Objectives
(DoE Vehicle Technologies Goals)

Objective 1: Engine system demonstration of 50% or greater BTE in a test cell at an operating condition indicative of a vehicle traveling on a level road at 65 mph.

Objective 2

a: Tractor-trailer vehicle demonstration of 50% or greater freight efficiency improvement (freight-ton-miles per gallon) over a defined drive cycle utilizing the engine developed in Objective 1.

b: Tractor-trailer vehicle demonstration of 68% freight efficiency improvement (freight-ton-miles per gallon) over a defined 24 hour duty cycle (above drive cycle + extended idle) representative of real world, line haul applications.

Objective 3: Technology scoping and demonstration of a 55% BTE engine system. Engine tests, component technologies, and model/analysis will be developed to a sufficient level to validate 55% BTE.

Baseline Vehicle and Engine: 2009 Peterbilt 386 Tractor and Cummins 15L ISX Engine

Relevance - American Recovery and Reinvestment Act (ARRA) Goals

- Create and/or Retain Jobs

				Projections
Year	**2010**	**2011**	**2012**	**2013**
Full Time Equivalent	75.5	85	60	46

States: Indiana, Texas, Michigan, Wisconsin, Tennessee, Illinois, New York, Ohio, Mass, California

- Spur Economic Activity
  - Greater Than $62M Total Spend To Date
- Goals Align With VT Multi-year Program Plan 2011-2015
  - Advanced Combustion Engine R&D (ACE R&D):
    - 50% HD Engine Thermal Efficiency By 2015 (Ref: VT MYPP 2.3.1)
  - Vehicle And Systems Simulation And Testing (VSST):
    - Freight Efficiency Improvement of 50% by 2015 (Ref: VT MYPP 1.1)
- Invest In Long Term Economic Growth
  - Commercial Viability Assessment
  - Adopt Technologies into Product Plans to Meet GHG and CO_2 Regs

Peterbilt Participants

- Contract Lead - Cummins
- Suppliers
  - Modine – Cooling Module
  - Eaton – Transmissions
  - Bendix – Brakes and Suspension
  - Dana – Drivetrain
  - Bridgestone & Goodyear – Fuel Efficient Tires
  - Alcoa - Wheels
  - Delphi – Solid Oxide Fuel Cell APU
  - Bergstrom – eSHVAC
  - Exa – CFD Analysis
- OEM
  - Utility Trailer Manufacturing
- End User
  - US Xpress

Overview - Schedule and Budget

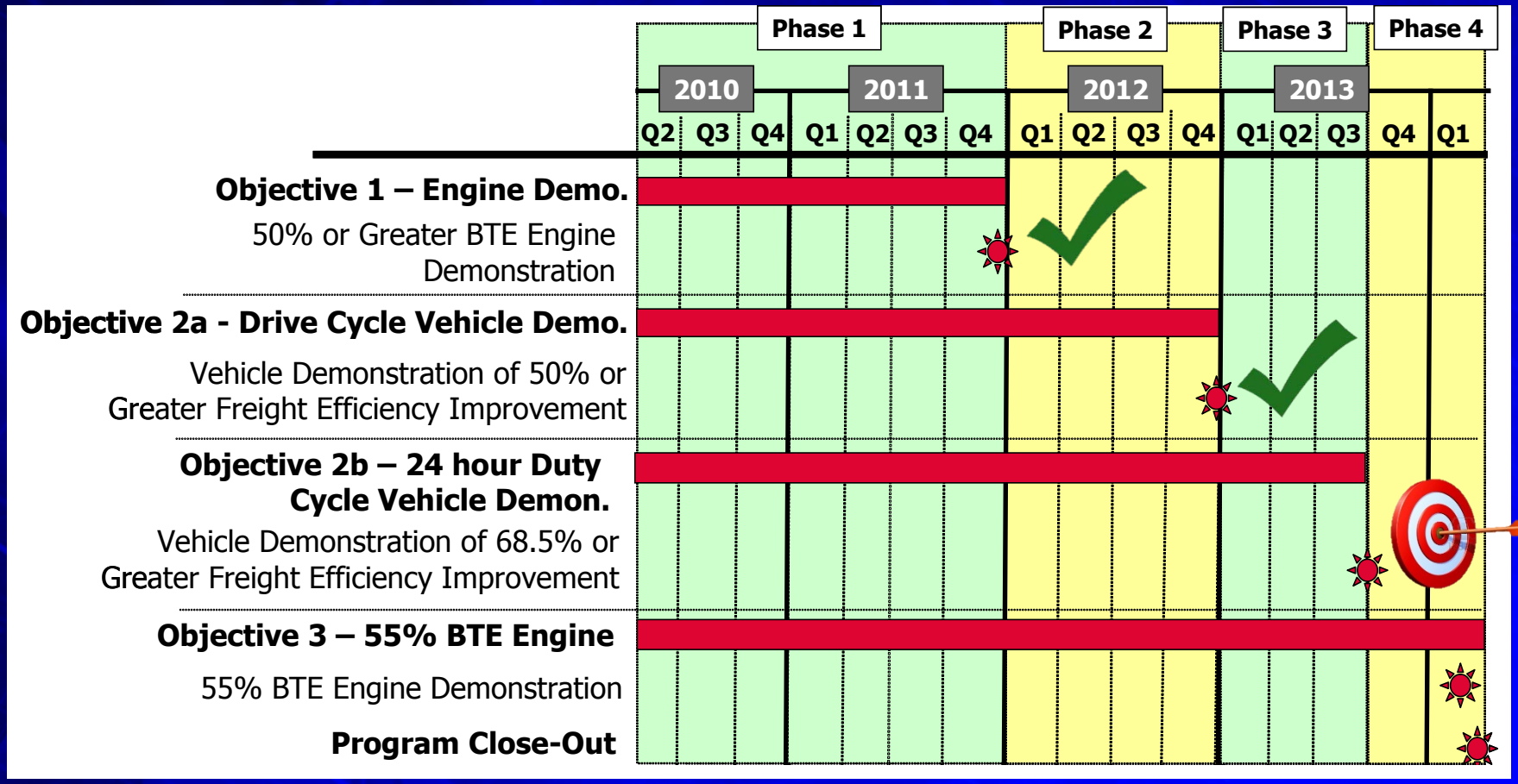
Budget

DoE Share: $38.8M (49%)

DOE Spend To-Date: $31M

Contractor Share: $40.3M (51%)

4 Year Program: April 2010 to April 2014



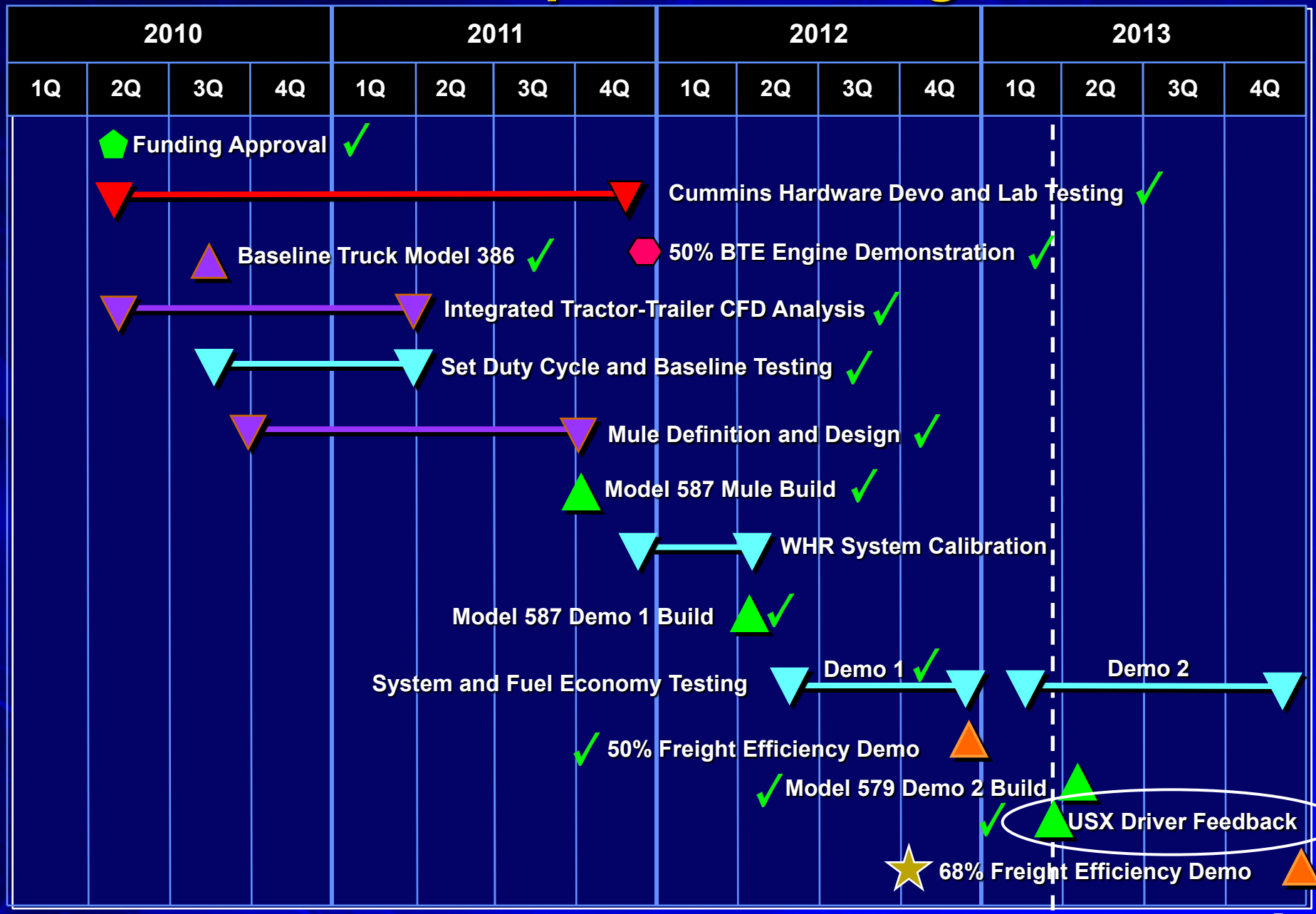
Overview - Program Barriers

- ✓ Underhood Cooling with Waste Heat Recovery
- ✓ Vehicle and Engine System Weight Reduction
- ✓ Engine Downspeed (Reduced Engine Speed)
  - Powertrain Components
  - Vibration/Customer Acceptance
- ✓ Vehicle and Powertrain Communication Speed
- ✓ Trailer Aero Devices That Meet Operational Requirements
- ★ Driver Acceptance of Drivability & System Displays

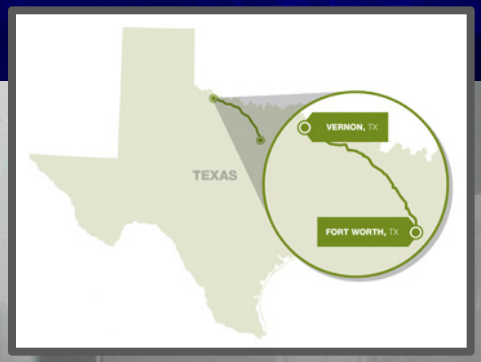
✓ = Validated on Demonstrator 1 Truck

★ = To Be Validated on Demonstrator 2 Truck

DoE SuperTruck Program

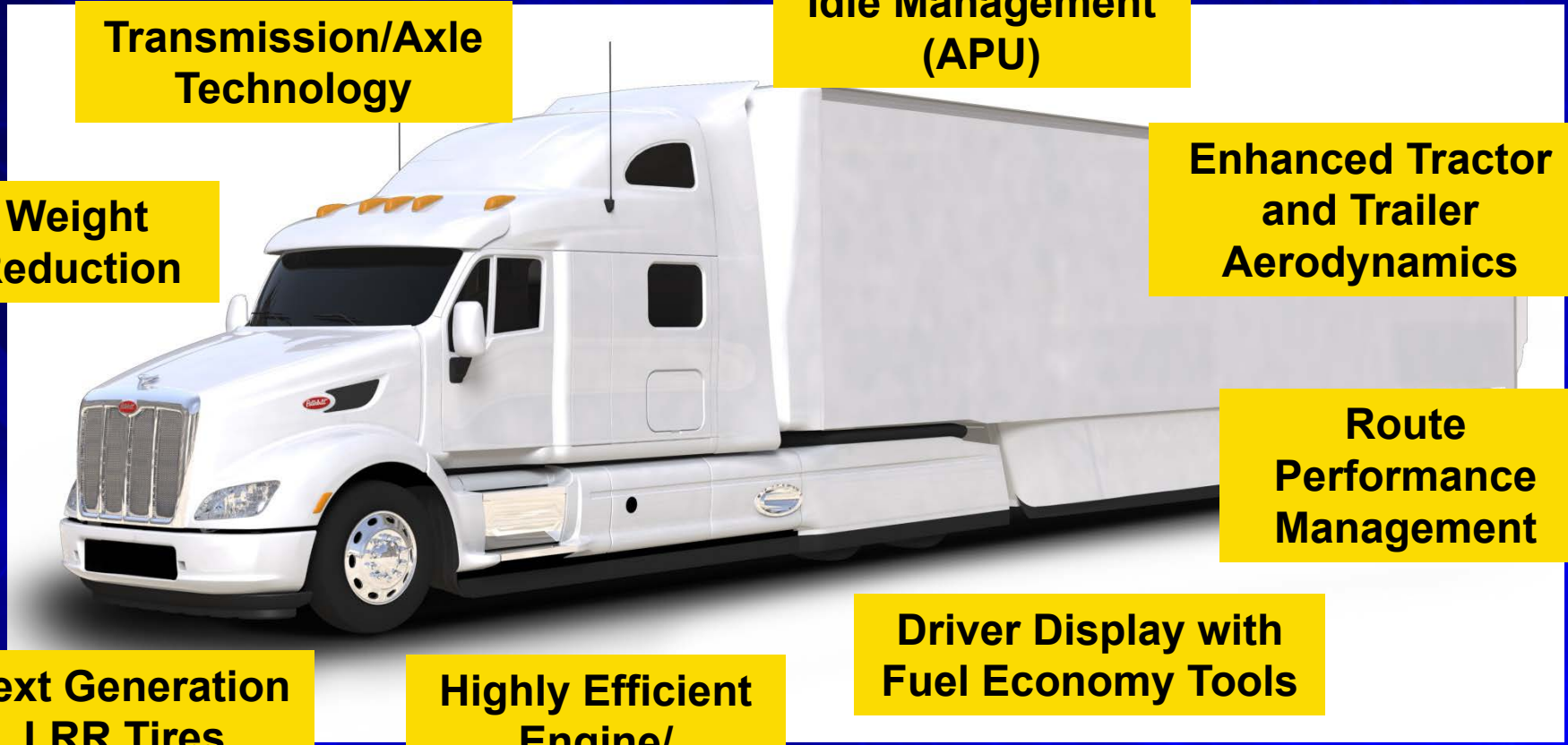


Freight Efficiency Testing
Technical Progress

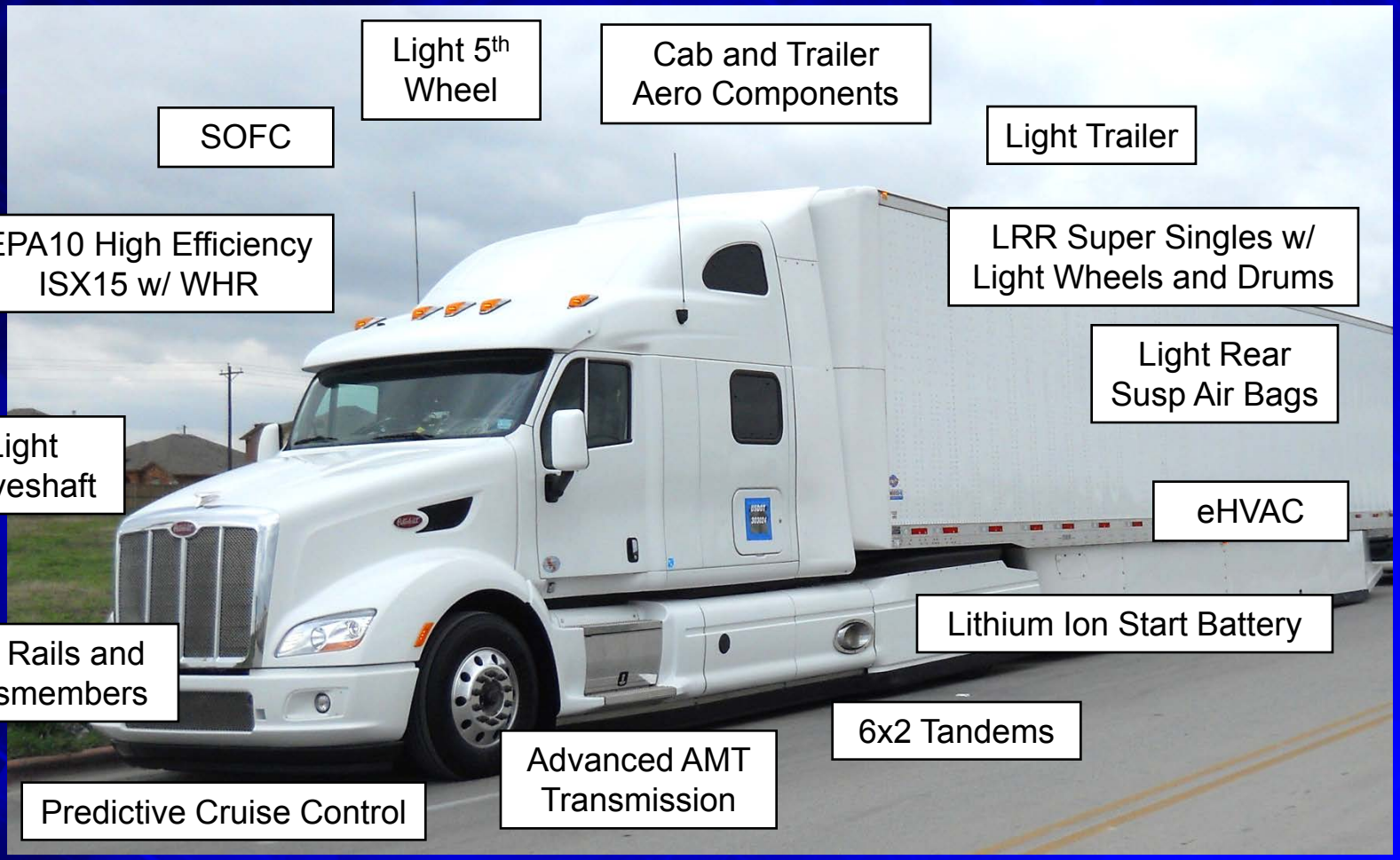


	GVW	Freight	MPG (Range)	(Ave) FTMPG Improvement	(Ave) MPG Improvement
587 Demo 1	65k	32,705	9.3-10.2	61%	54%
		+1434			

Comprehensive Approach with Enabling Technology



Freight Efficiency Improvement – Technical Progress



Aerodynamic Improvements – Technical Progress

Demo 1 Progress Since Last Review

4.1 % Over Target

Baseline

Demo 1 - 14% Target

Demo 1 – 18.1%

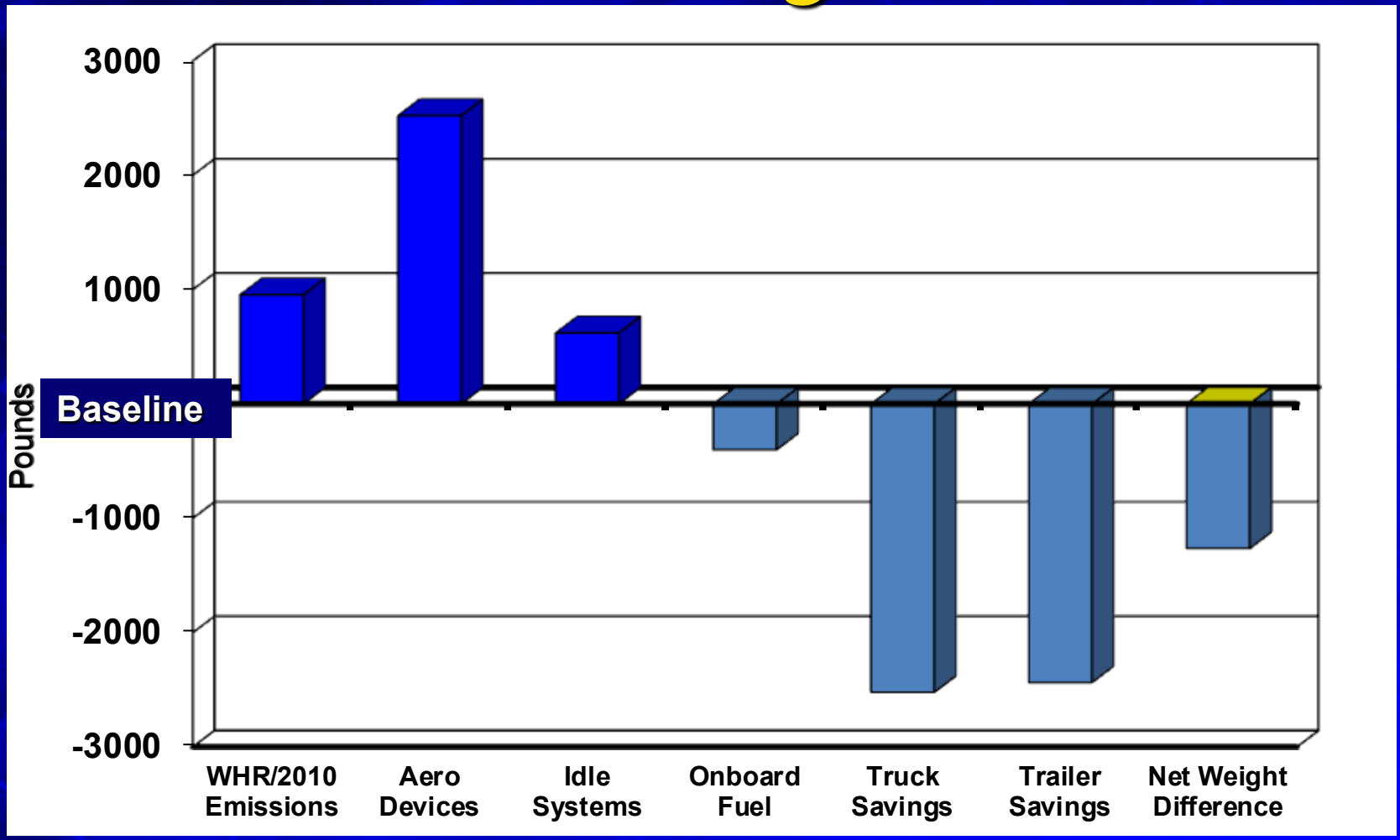
Demo 2 - 24% Target

Freight Efficiency Improvement

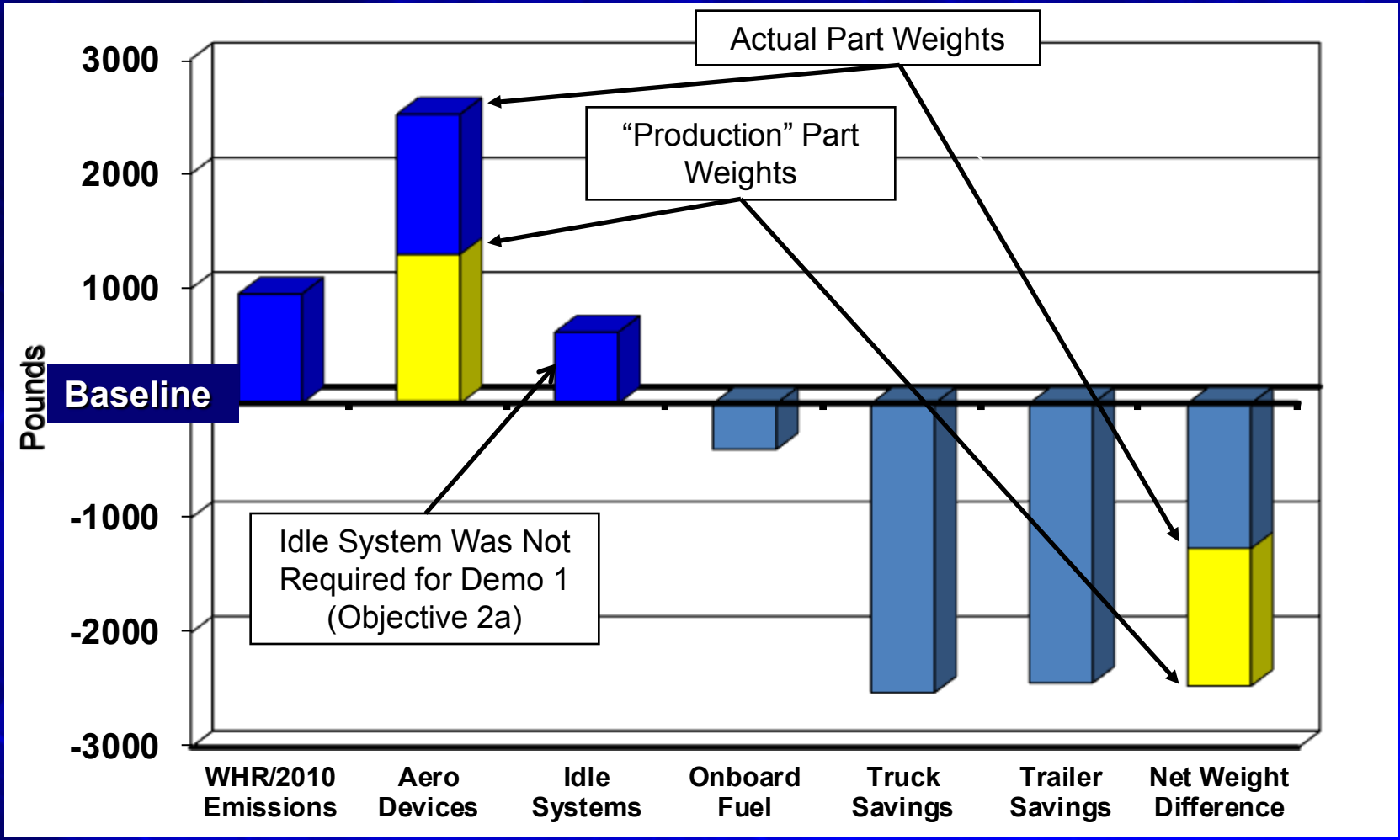
Configurations

11

Demo 1 Truck/Trailer Weight Technical Progress



Demo 1 Truck/Trailer Weight Technical Progress



Driver Acceptance
Technical Progress

- US Xpress Drive Event, Mar 21, 2013
  - Irving, TX to Laredo, TX
    (950 mile round trip)
  - Commercial Freight
  - US Xpress Drivers
- Feature/Functional Evaluation
  - Loading/Unloading Aero Trailer
  - Drivability
- Very Positive Event
- Critical and Valuable Feedback

Driver Acceptance
Technical Progress

U.S. XPRESS ENTERPRISES, INC.
Strategically Positioned To Deliver A Difference

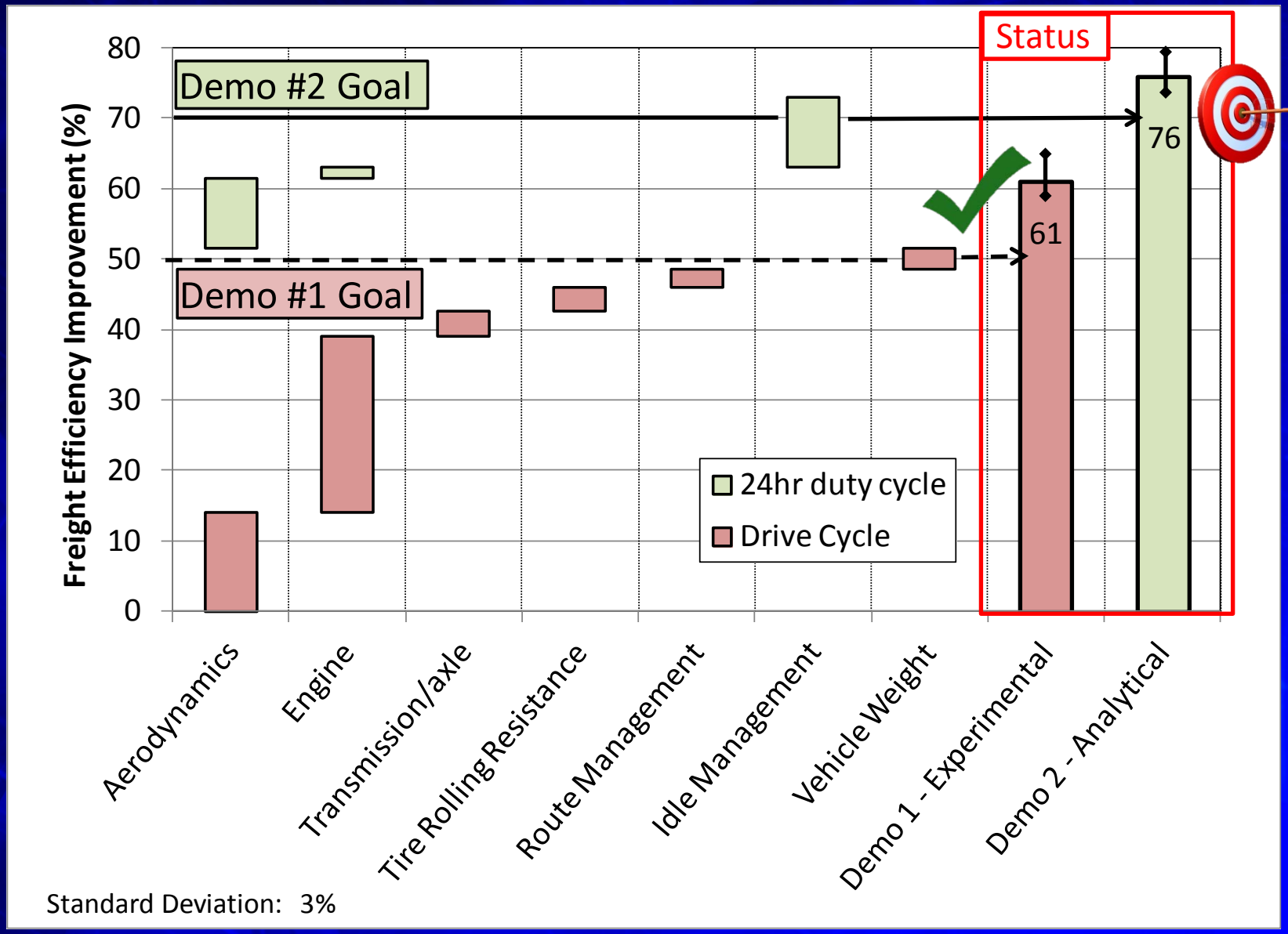

Austin, TX


Texas Hill Country


USX Hub, Laredo, TX

Laredo, TX

Approach – Freight Efficiency Path to Target



Standard Deviation: 3%

Aerodynamic Improvements – Technical Progress

Demo 2 Progress Since Last Review

1.9% Increase

Demo 2 - 24.9%

Baseline

Demo 1 - 14% Target

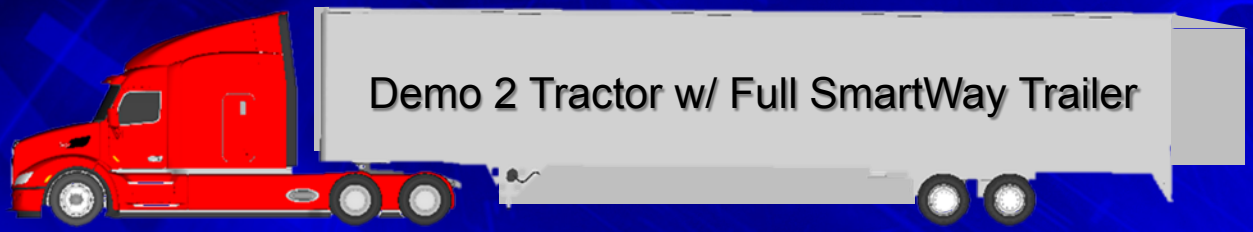
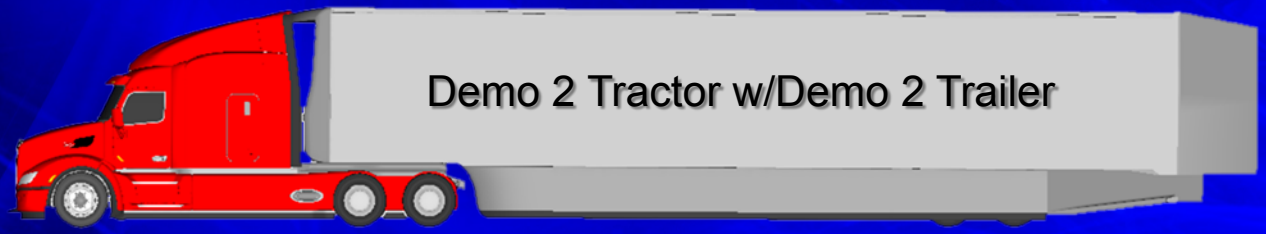
Demo 2 - 24% Target

Freight Efficiency Improvement

Configurations

17

Aerodynamic Improvements – Technical Progress

	Freight Efficiency Improvement
	0%
	14%
	25%

Milestones and Technical Accomplishments

- March 2012 to March 2013 – **Technical Accomplishments**
  - √ Demonstrated 61% Freight Efficiency Improvement (Obj 2a)
  - √ Tested Advanced Transmission
  - √ Developed Hotel Profile w/ End User Concurrence
  - √ Performance Tested SOFC APU
  - √ Demo 2 Design Freeze (Objective 2b)
  - √ End User Testing of Tractor/Trailer Aerodynamic Solution
- March 2013 to March 2014 – **Future Work**
  - Demo 2 Build, Engine "Vehicle" Calibration/Optimization
  - APU Technology Study – Investigate Alternatives to SOFC
  - Test Vehicle Demonstration #2 (Objective 2b)
    - Vehicle Freight Efficiency on 24hr Cycle

Summary

- Program Remains on Schedule
  - Meeting the ARRA and DoE VT MYPP goals
- Demonstrated a 50+% BTE Engine System
- Demonstrated a 60+% Vehicle Freight Efficiency Improvement
- Analytical Roadmaps Updated with Experimental Component Data
- Vehicle Packaging and Integration Proceeding without Major Issues
- Built and Tested Sub-systems
  - Cummins Waste Heat Recovery Vehicle Testing (Objective 2a)
  - Advanced Transmission Dynamometer and Vehicle Test (Objective 2a)
  - Tractor-Trailer Aerodynamic Aids (Objective 2a)
  - Predictive Cruise
  - Solid Oxide Fuel Cell lab and Vehicle Tests (Objective 2b)
- Developed Framework and Analysis for 55% Thermal Efficiency
- Developed Working Relationship with Excellent Vehicle and Engine System Delivery Partners

FTE Deliverables On Track
Technical Progress

4Q2013!