



# SmartTruck Systems

## *A Look at Tractor Trailer Aerodynamics and Fuel Efficiency*



ACEEE / ICCT

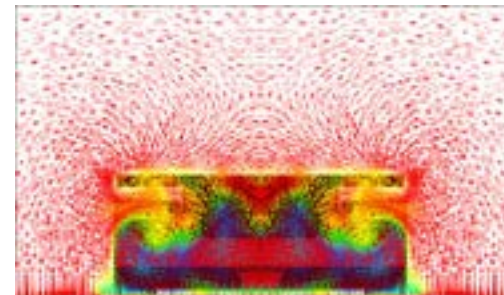
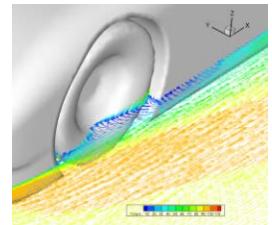
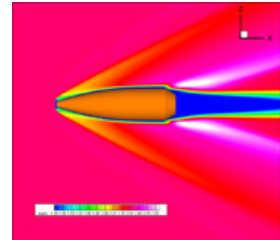
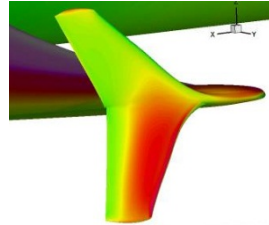
Workshop on Emerging Technologies for Heavy-Duty Vehicle Fuel Efficiency

Washington DC July 22<sup>nd</sup>, 2014



# SmartTruck Introduction

- Boeing and NASA Technology
- Aerion Super Sonic Business Jet
- Boeing MD 80 Winglet for aging aircraft
- Racing and Motorsports
  - Daytona Prototype development
  - Indy Car
  - NASCAR
- Ballistics
- Ford Hybrid Concept Car
- Bright Automotive Plug-In Hybrid Van





# SmartTruck Introduction

SmartTruck's current focus is on advanced aerodynamics for trailers





# Fuel Performance Perspective

Type of Vehicle
Class 8 Long Haul Truck
Compact Gas Hybrid
All Electric Compact

Which is the most fuel efficient vehicle on the road today?



# Fuel Performance Perspective

Type of Vehicle	FE Rating (miles/gallon)	
Class 8 Long Haul Truck	6.5	
Compact Gas Hybrid	50	
All Electric Compact	124 <sub>e</sub>	

Which is the most fuel efficient vehicle on the road today?

The language of passenger cars and light trucks: **miles/gallon**



# Fuel Performance Perspective

Type of Vehicle	FE Rating (miles/gallon)	Loaded Weight (lbs)	Vehicle Efficiency (ton-miles/gallon)
Class 8 Long Haul Truck	6.5	70,000	228
Compact Gas Hybrid	50	3,300	83
All Electric Compact	124 <sub>e</sub>	3,100	192 <sub>e</sub>

The language of heavy-duty vehicles: **ton-miles/gallon**



# Fuel Performance Perspective

Type of Vehicle	FE Rating (miles/gallon)	Loaded Weight (lbs)	Vehicle Efficiency (ton-miles/gallon)
Class 8 Long Haul Truck	6.5	70,000	228
Compact Gas Hybrid	50	3,300	83
All Electric Compact	124 <sub>e</sub>	3,100	192 <sub>e</sub>
????	<b>138</b>	3,300	228

The language of heavy-duty vehicles: **ton-miles/gallon**





# Fuel Performance Perspective

## with Aerodynamic Perspective

### Class 8 Long Haul Vehicle

Vehicle Efficiency: 228 ton-miles/gal

MPG: 6.5 mpg

**Cd: ~0.60**



### All Electric Compact

Total Vehicle Efficiency: 192 ton-miles/gal<sub>e</sub>

MPG: 124 mpg<sub>e</sub>

**Cd: 0.29**



### Compact Gas Hybrid

Total Vehicle Efficiency: 83 ton-miles/gal

MPG: 50 mpg

**Cd: 0.25**



### Gasoline Coupe

Total Vehicle Efficiency: 53 ton-miles/gal

MPG: 30 mpg

**Cd: 0.23**







# Class 8 Aerodynamic Potential

## Impact on Highway Fuel Efficiency

- Due to the amount of highway miles driven, the tractor trailer would benefit more than any other vehicle on the road from advanced aerodynamic improvements.

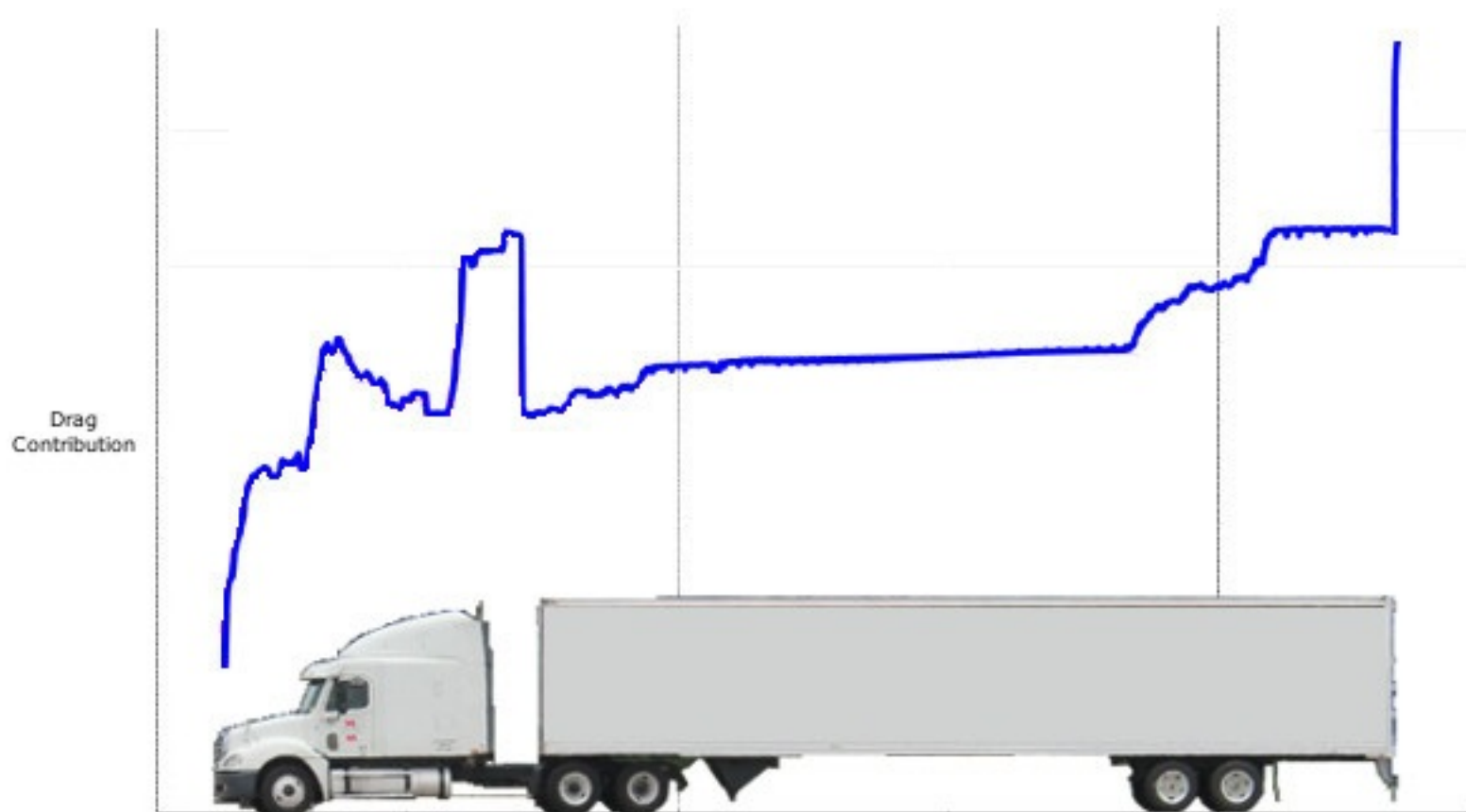
<b>Class 8 Long Haul Vehicle w/ Cd Similar to:</b>	<b>Drag Coefficient (Cd)</b>	<b>Highway MPG @ 65 mph (miles/gallon)</b>	<b>Highway Vehicle Efficiency (ton-miles/gallon)</b>
Today's Class 8 tractor-trailer Design	.60	6.8	238
Passenger SUV	.45	~8	280
Aerodynamically advanced car	.29	~9.7	340
Best production passenger car	.23	~10.6	371

- If the tractor trailer had the aerodynamic performance of the top passenger cars it could achieve ~11 mpg at highway speed.
  - With no other technical advancements: same vehicle weight, engine efficiency, tire rolling resistance, etc.
  - 371 ton-miles/gallon is the equivalent of a compact passenger car achieving **225 MPG**



# Aerodynamics

## Where is the Drag on Tractor Trailers?

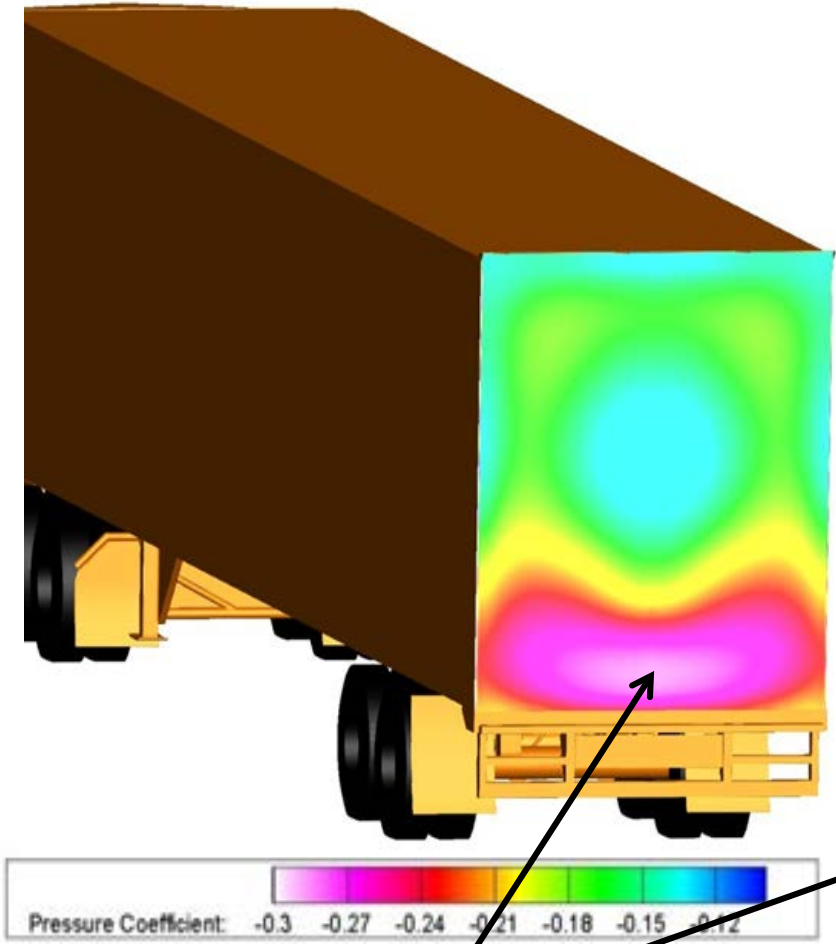




# Aerodynamics

The Low Pressure Wakes are Real

Standard 53' Trailer



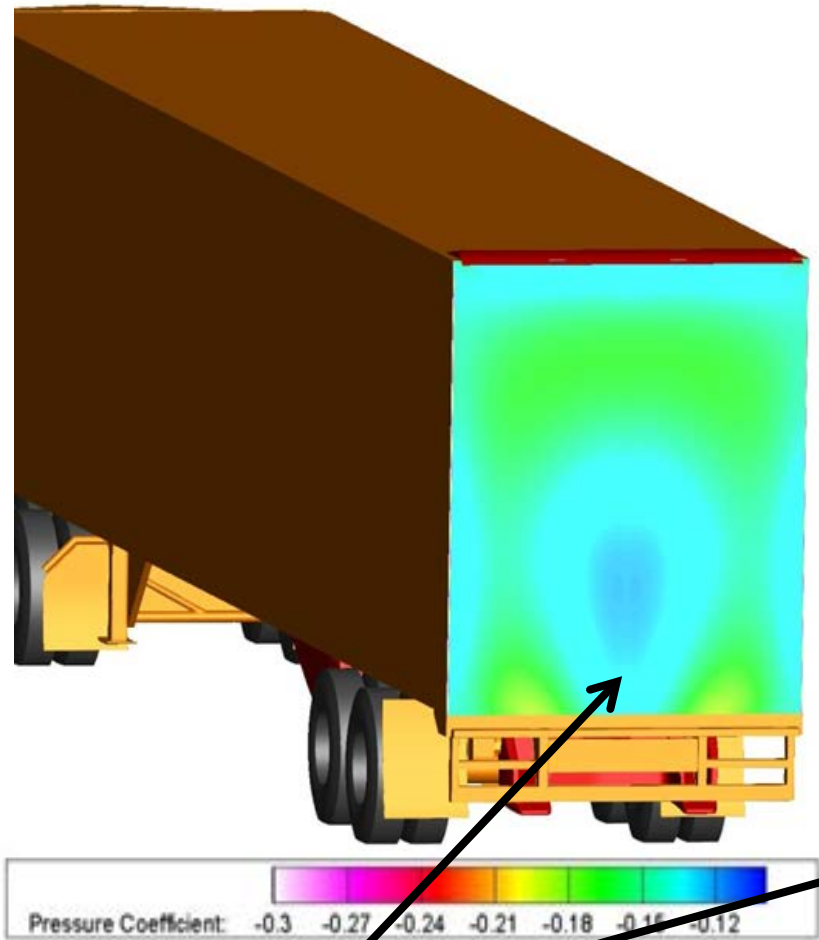
Low pressure hot spot causes high drag and low pressure creates snow and ice build up



# Aerodynamics

The Low Pressure Wakes are Real and can be Greatly Reduced

Trailer Equipped with UT System



UT System dramatically reduces low pressure hot spot and reduces drag. Significantly less snow and ice build up on the rear doors proves the point.





# Aerodynamics

The Low Pressure Wakes are Real and can be Greatly Reduced



Standard Trailer



Trailer Equipped with UT System



# Current Trailer Aerodynamic Strategies



Nose Fairings



Side skirts



Under Trailer Systems



Boat tails



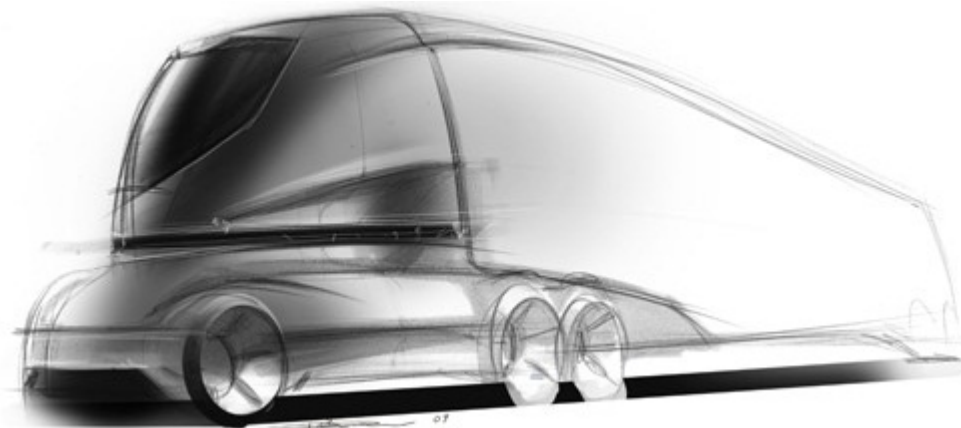
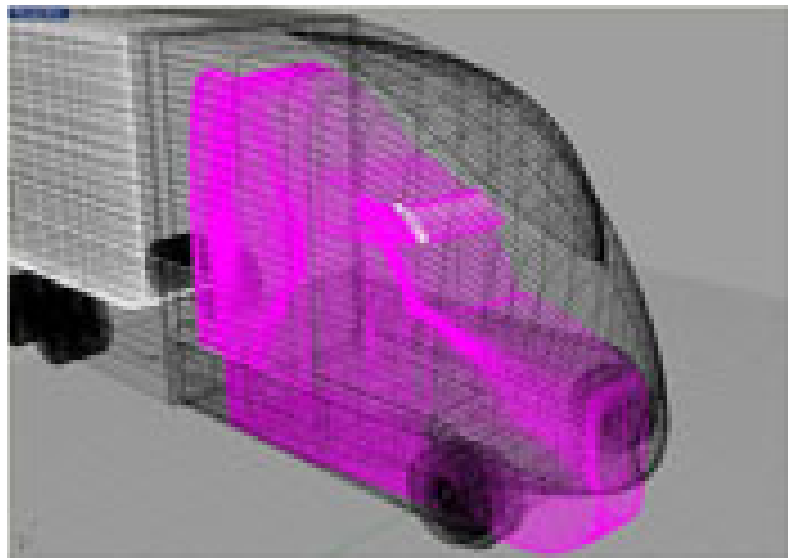
# Current and Emerging Aero Targets

- EPA SmartWay: 5% highway MPG improvement
  - Skirts, Boattails, Undertrailer systems
  - CARB requirements
- EPA SmartWay Elite: 9% MPG improvement
  - Combinations of skirts, boattails, undertrailer systems, nose
  - Undertrailer systems with inboard rear fairings
- DOE SuperTruck Program: ~10 mpg
- EPA Phase I and II regulations
- **More sophisticated aero designs beyond the first wave:**
  - Robust and durable (out of harms way, do more with less)
  - Sophisticated system cooling strategies (tractor and trailer)
    - Intake and exhaust of cooling air flows
  - Managed airflow over vehicle components
  - Integrated aero packages: tractor/trailer



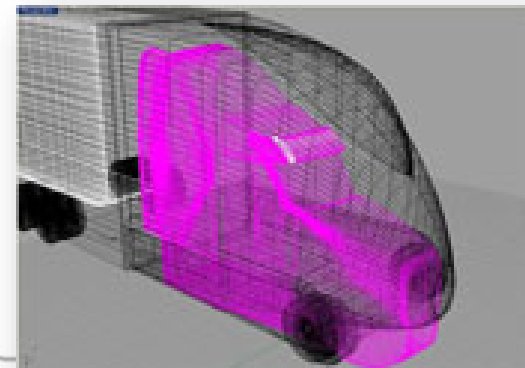


# Tractor Trailer Concepts

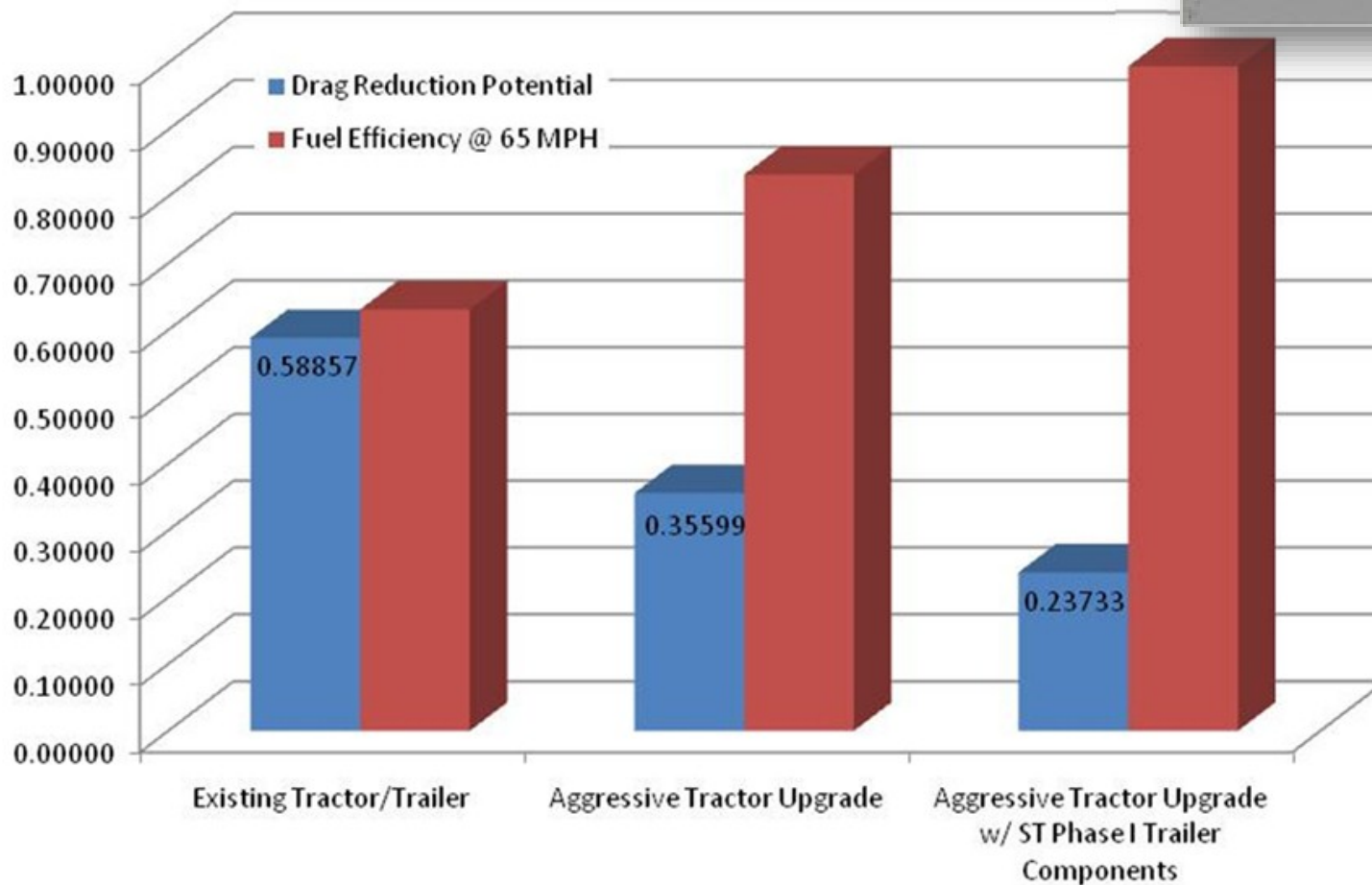




# Tractor Trailer Concepts



SmartTruck Aerodynamic Projections





# Fixed Trailers vs. Multi-position Trailers

## Single 53' Trailer

- Single Trailer, Single gap
- Generally, one optimized trailer strategy



## 28' Pup Trailers

- Double Trailer, Two gaps
- Trailer aero solution must be ubiquitous for interchangeable trailer positions #1 and #2



## Rocky Mountain Doubles

- Double Trailer, Two gaps
- Generally, trailers remain in fixed positions: Can optimize for trailer #1 and trailer #2





# Intelligent Transportation Creates Opportunities



- Platooning vehicles for safety and fuel performance
- Gap reduction at highway speeds
- Video rear vision systems
- GPS and vehicle awareness
- Vehicle learning to optimize aero (especially for trailer packages)



# Factors to Consider

- Testing and validating fuel performance
  - Wind tunnel, Road and Track Tests, Coastdown, CFD
- Ensuring individual system improvements work with other system improvements
- CapX vs. ROI vs. NPV (value of investment)
- Trailer to tractor ratio: national average is 2.75
- Driver training and capability
  - Drivers impacts can be 30%
- Vehicle size and longer combination vehicles





# Thank You

## SmartTruck Systems

[www.SmartTruckSystems.com](http://www.SmartTruckSystems.com)

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