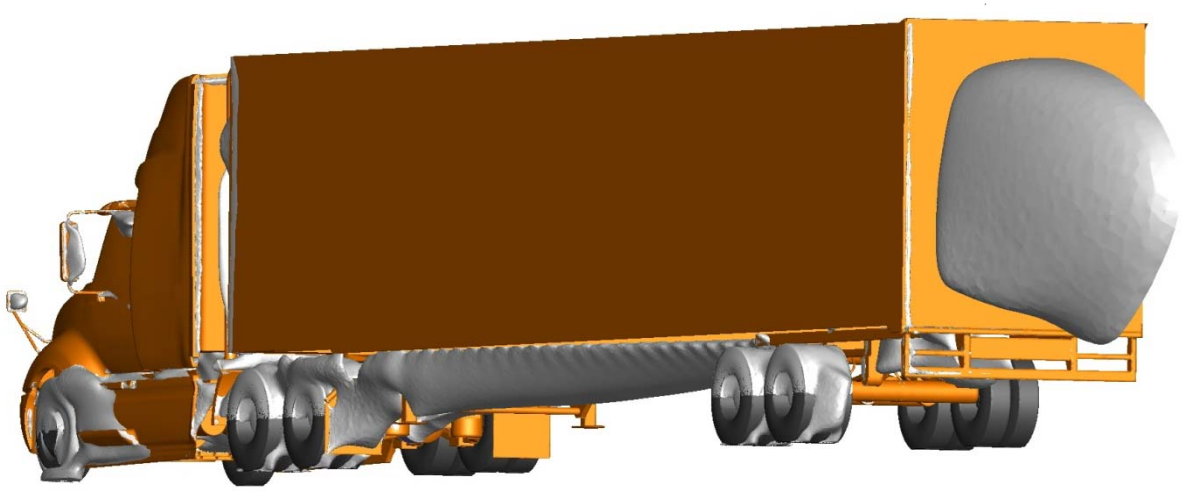
The Impact of the Jaguar Super Computer on Large Truck Aerodynamic Design

SciDAC Conference
Chattanooga, Tennessee
July 12, 2010

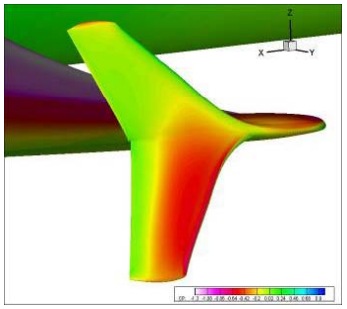


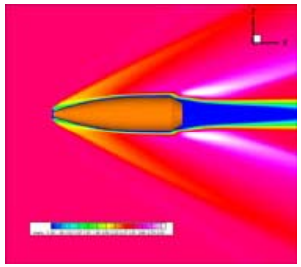
Mike Henderson

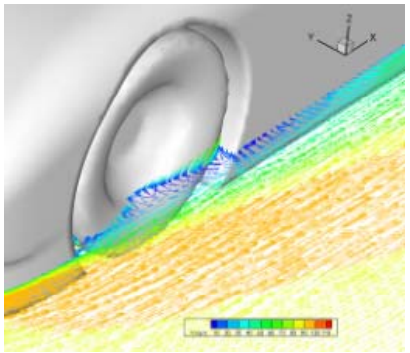
SmartTruck Overview

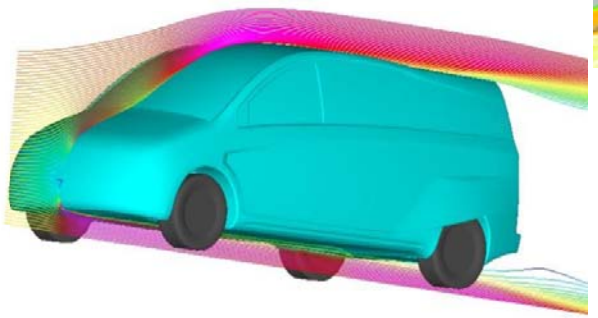
Aerodynamic Expertise

- 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 Overview

Executive Team

Mike Henderson – Chief Executive Officer

Mike has 40 years in aerodynamics. He spent 32 years at Boeing in senior engineering and management positions. He headed Boeings Subsonic heavy lift program as well as it's Supersonic Aircraft Program. Mike was a principal member of the team which developed the first CFD program (Navier Stokes) and has conducted more than 200 wind tunnel tests. For the past five years Mike has been COO of Aerion Corp. which is about to launch the first commercially successful Supersonic business jet. Mike has successfully been able to translate aerodynamics as it is used in aerospace into practical aerodynamics for ground vehicles through work in NASCAR, Champ Car, and through work on a Ford high mileage vehicle program.

Mitch Greenberg – President

Mitch has 20 years of experience in heavy truck emissions performance programs. Prior to joining Smart Truck, Mitch developed and managed EPA's SmartWay Transport Programs, focusing on all aspects of reducing fuel consumption and GHG emissions from trucks and goods movement. During his career, Mitch has managed all elements of transportation programs, including emissions standards development, heavy vehicle testing, and innovative partnership program development. Mitch received his BS in aerospace engineering from the University of Maryland at College Park in 1990.

Steven Wulff – Senior VP and General Manager

Steve brings over 25 years experience as a business owner and senior manager. Most recently as the Operations Director for a successful Champ Car racing team. Steve's experience includes overseeing all aspects of the successful creation and operation of the RuSPORT Champ Car team As Operations Director Steve employed skills in project management and was responsible for scheduling, budgeting, logistics, vehicle production, vendor relations, vehicle engineering, assembly, testing and competition.

Doug Nichols – Chief Financial Officer

Doug brings nearly 30 years of experience from a range of senior financial positions at Boeing. Among his roles there, Doug served as CFO for Boeing's Commercial Airplane Group 747/767 unit and also for Boeing Business Jets. Over the course of his Boeing career he gained extensive experience in all aspects of the operational and financial management of manufacturing programs, as well as in new aircraft market evaluation and product development, aircraft preliminary and detailed design processes, advanced final assembly processes, supply base management, support logistics, and marketing and sales.

Bob Balachowski – Chief Marketing Officer

Bob brings over 25 years of experience in economics, financial analysis, and marketing. Bob was senior Vice President at Merrill Lynch before beginning his career in Motorsports. Bob has over 10 years in Motorsports marketing, sponsorship, and activation.

Smart Truck Program

Mission Statement:

Apply advanced aerospace technology to substantially improve the fuel mileage of Class 8 Long Haul Trucks through a coordinated program of engineering, fabrication, and testing that will be used to **develop mechanical, aerodynamic and engine improvements.**

SmartTruck Overview

Our Partners

LARC
Kennedy Space Center

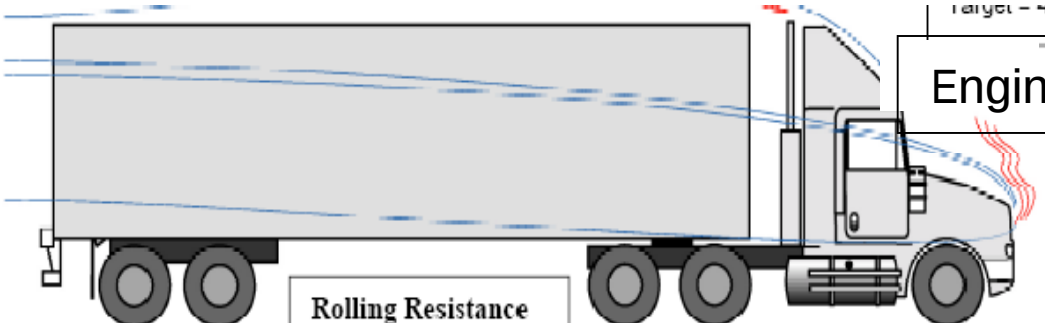
The Smart Truck Program Opportunity

Aerodynamic
53%

Rolling Resistance
32%

Driveline Losses
6%

Auxiliary Loads
9%



Engine Power

Travel @ 65 mph

Energy Losses in Class 8 Trucks

Aerodynamic Assessment and Opportunities

- Of all vehicles operating on the road, class 8 long haul trucks would benefit most from low drag designs
  - Class 8 long haul drive cycle: 80% highway vs. 20% non-highway
  - Class 8 long haul trucks average 125,000 miles per year (100,000 highway miles)

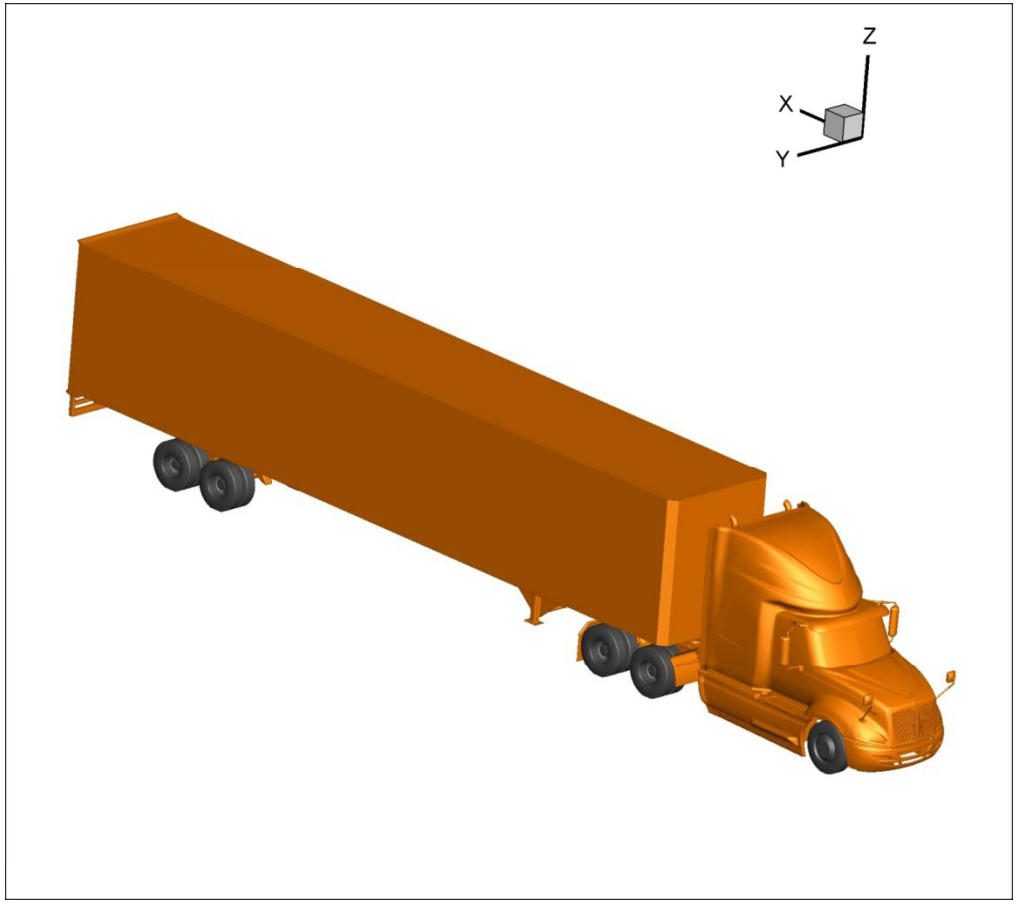
- However, among common vehicles on the road, class 8 long haul trucks have the highest drag

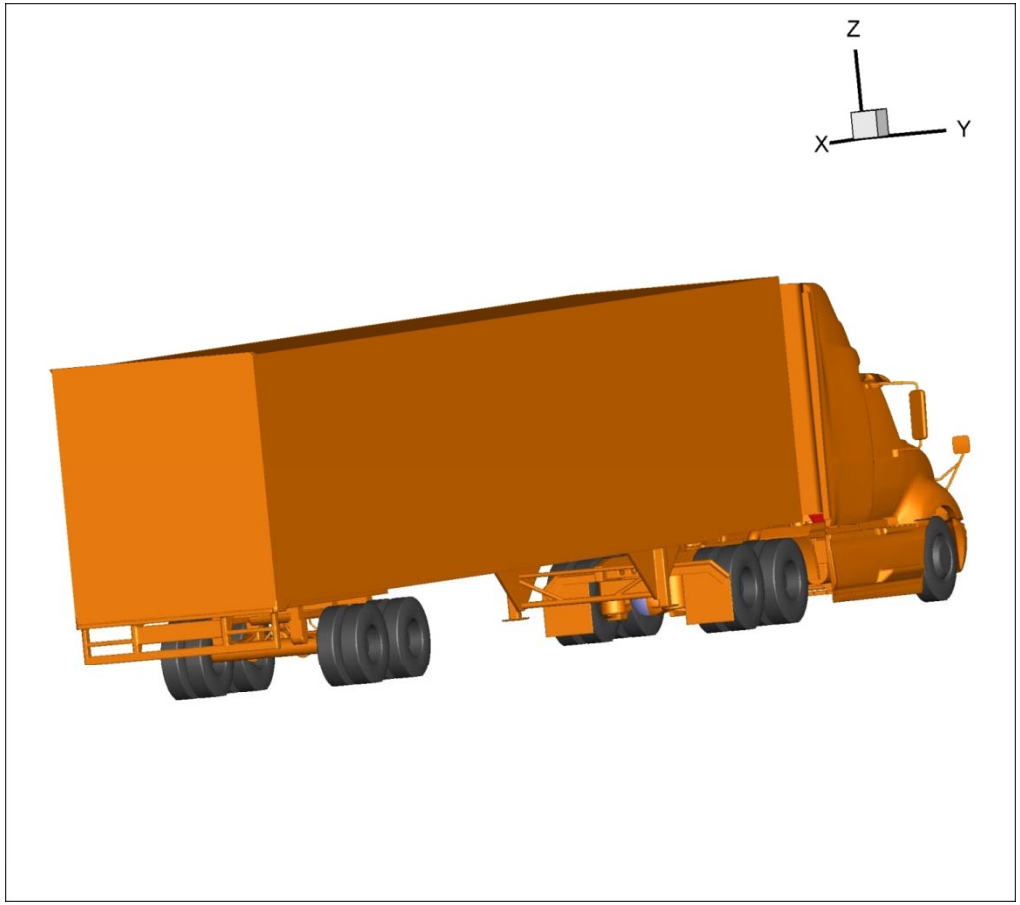
Type of Vehicle	Drag Coefficient (C_d)
Low Drag Production Car	.25 - .28
Typical Sedan	.3 - .35
Sport Utility Vehicle	.4 - .5
Pick-up Truck	.4 - .5
Today's Best Class 8 LH Truck	**.59 - .62**

- If all 1.3 million long haul trucks operated with C_d = .26, the US would annually:
  - Save 6.8 billion gallons of diesel
  - Reduce 75 million tons CO_2
  - Save $19 billion in fuel costs

Typical Truck Today – Details Are Important

Understanding Where Drag is Coming From

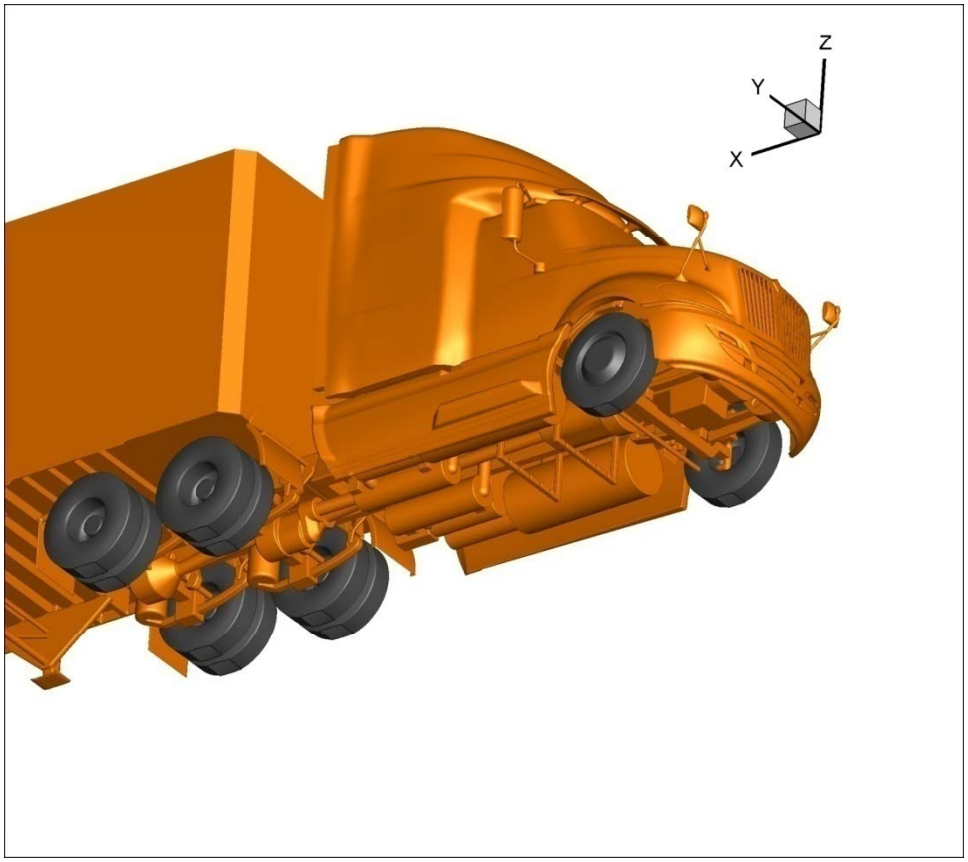


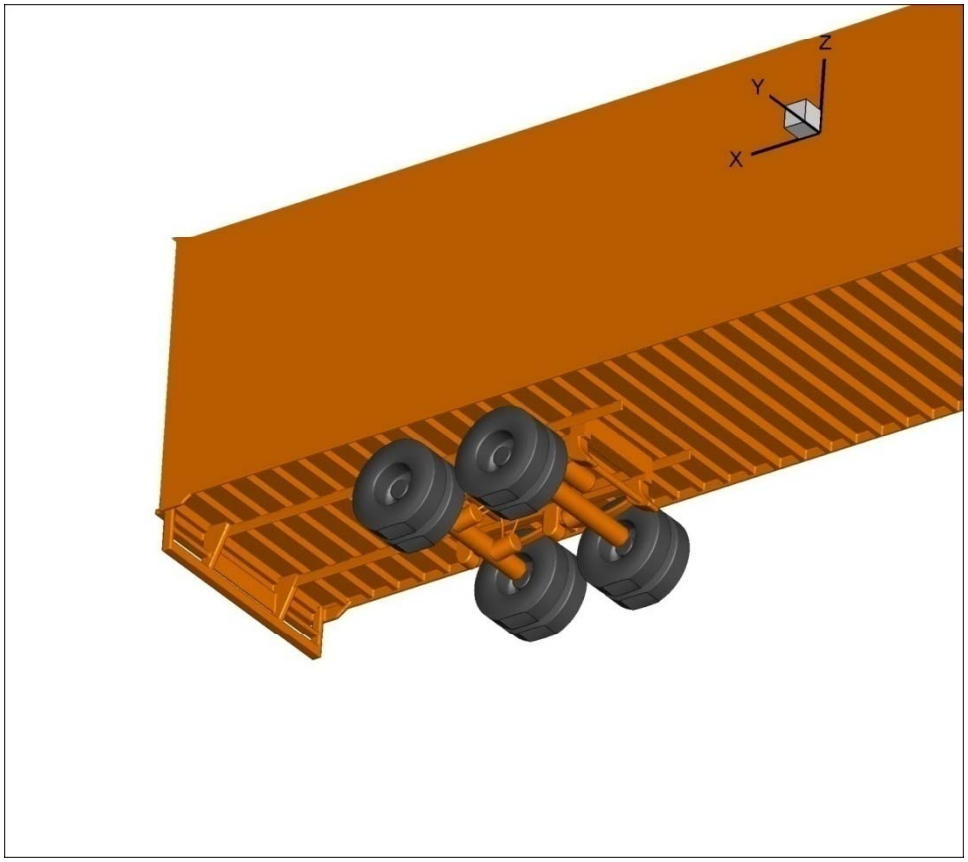


Laser Scanned and Measured Geometry

Typical Truck Today – Details Are Important

Understanding Where Drag is Coming From

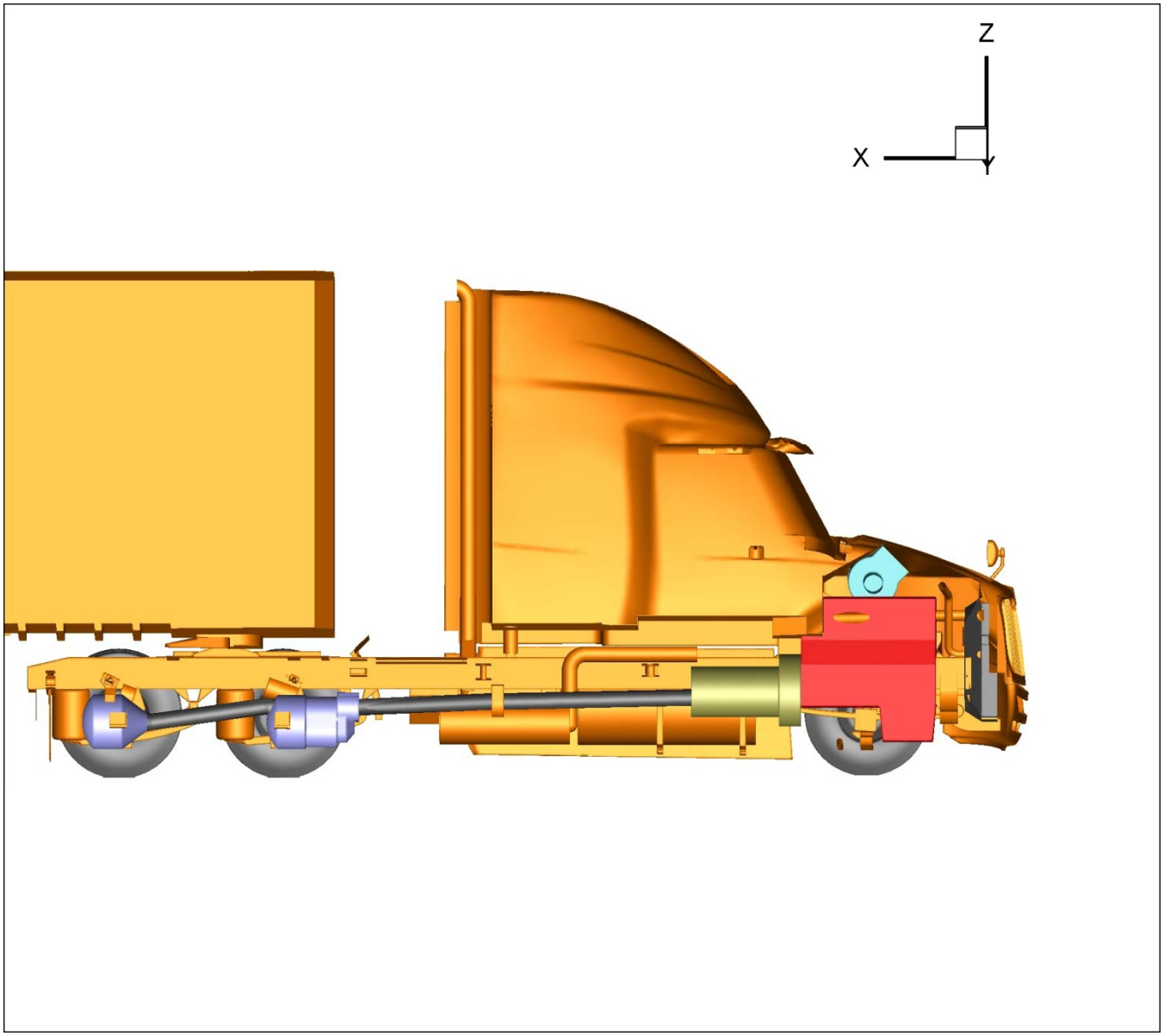




Laser Scanned and Measured Geometry Capture

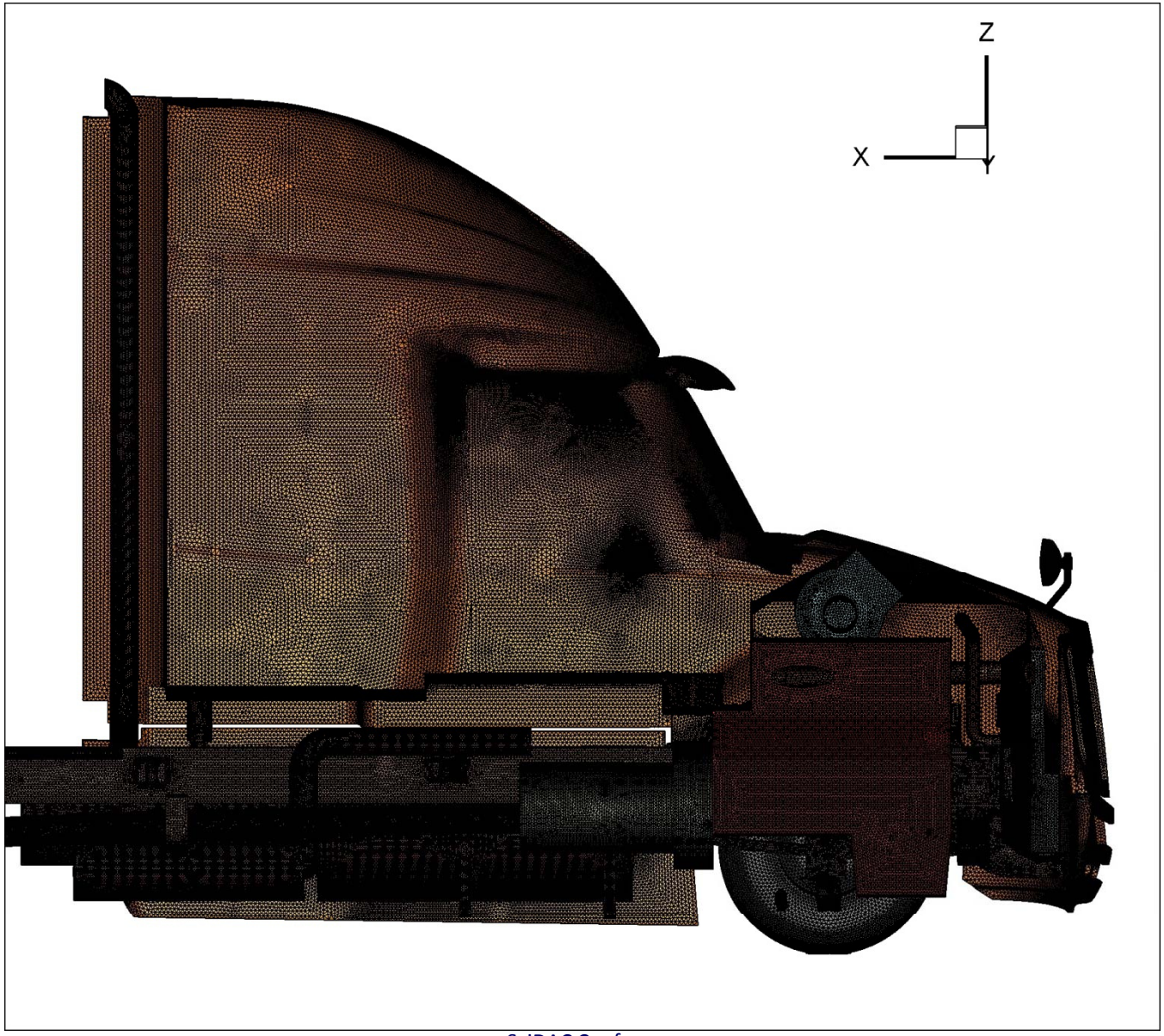
Typical Truck Today – Details Are Important

Understanding Where Drag is Coming From



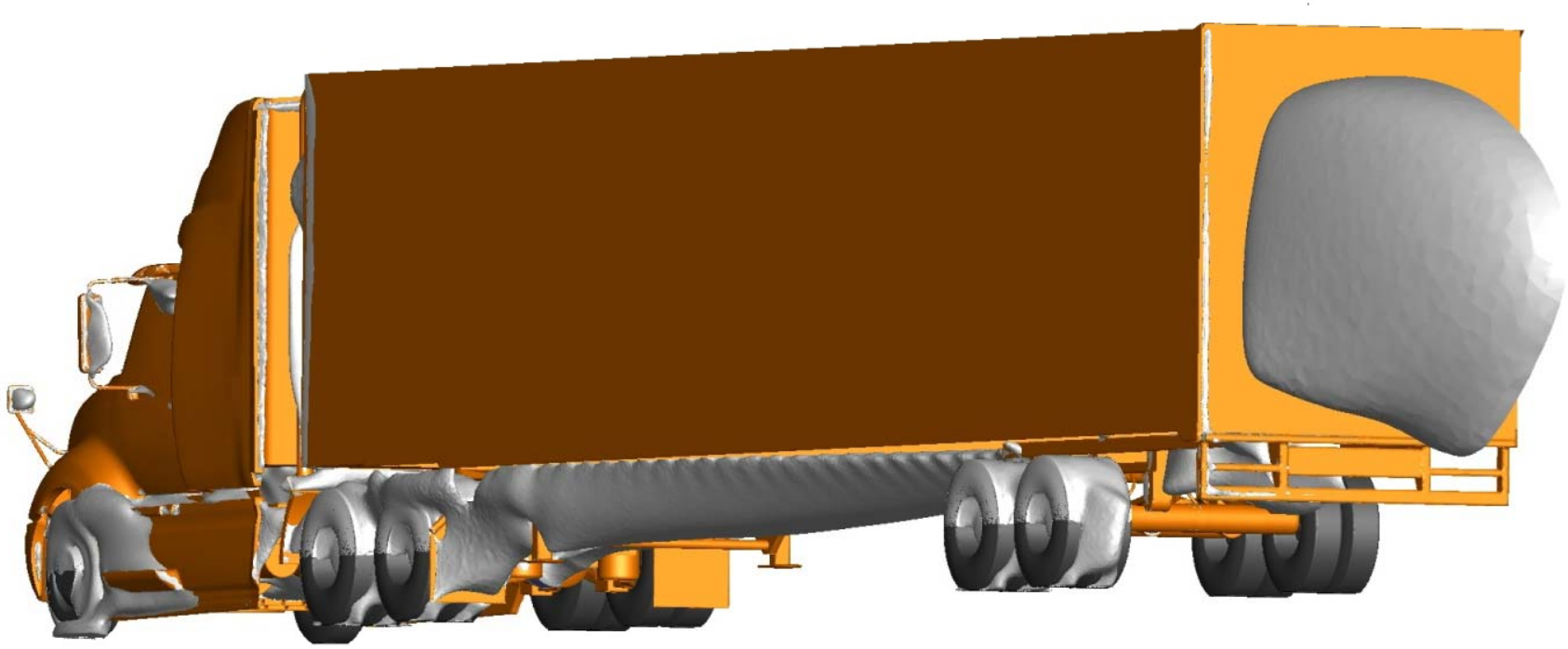
Typical Truck Today – A Very Fine Grid is Required

Drag Resolution - Key to Understanding Where Drag is Coming From



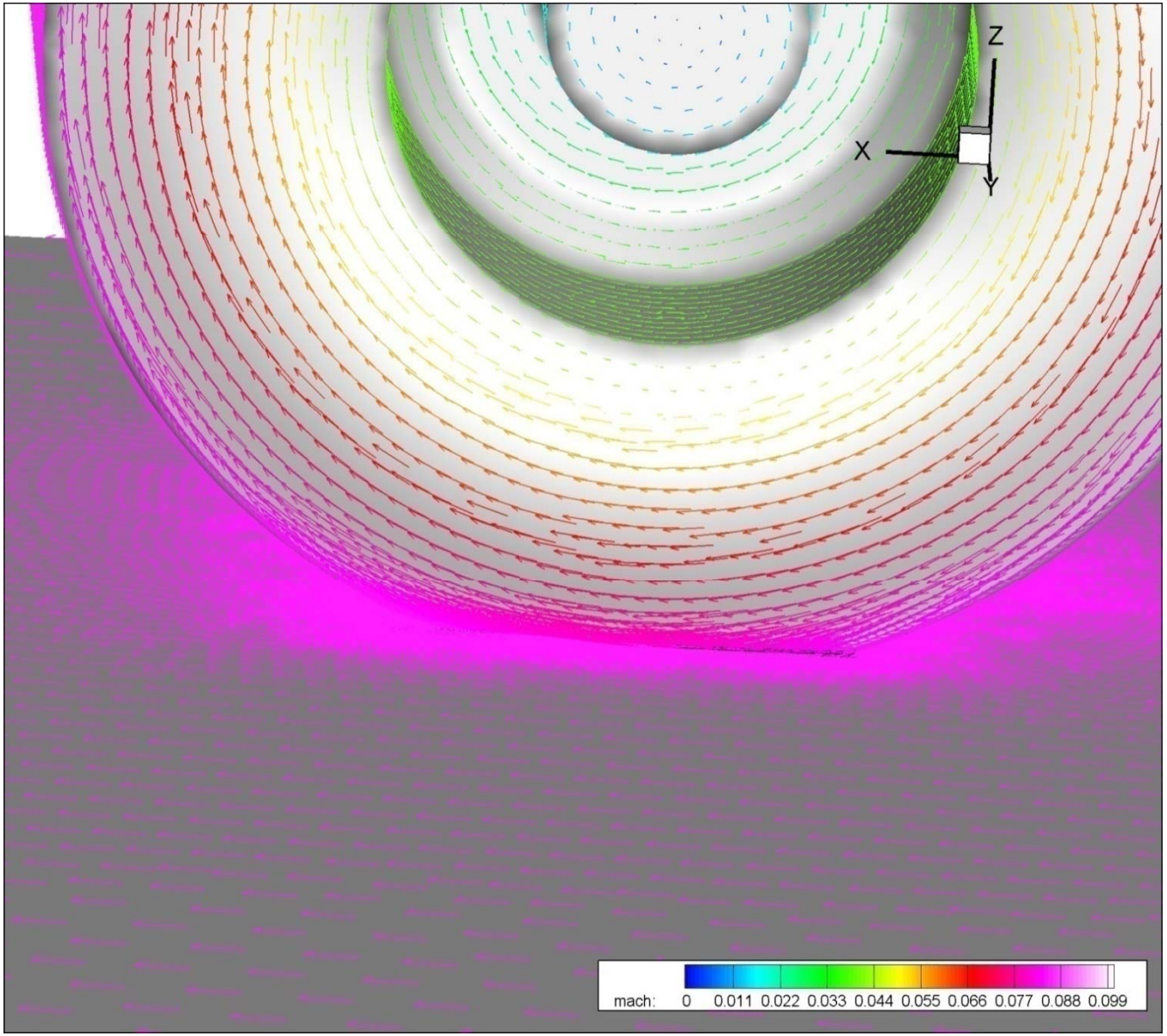
Typical Truck Today – A High Order Solution is Required

Many areas of Separated Flow – Wake Resolution and Interaction



Typical Truck Today – A High Order Solution is Required

Rotating Wheels and Moving Road Must be Properly Modeled



The Smart Truck Program Challenges

- **Advanced aerodynamic simulation using NASA's Fully Unstructured Navier Stokes system (FUN3D) has been a key element in our success to date.**

- **Solutions must be Navier Stokes – not short cuts need apply.**

- **Grids required for accuracy are in the order of 75 million grid points.**

- **Even with the highly efficient FUN3D system single solutions can take 15 + hours using a 100 node cluster.**

- **With these run times design and refinement are difficult and optimization techniques are not practical.**

The Smart Truck Program Impact of Jaguar Phase 1

- **Through the hard work of the NASA FUN3D team at the Langley Research Center and the engineers a ORNL, FUN3D is highly adaptable to massive parallel computing on Jaguar.**

- **Were able to reduce single run times to <2 hours.**

- **Large, fine grain solutions were shown to be very accurate.**

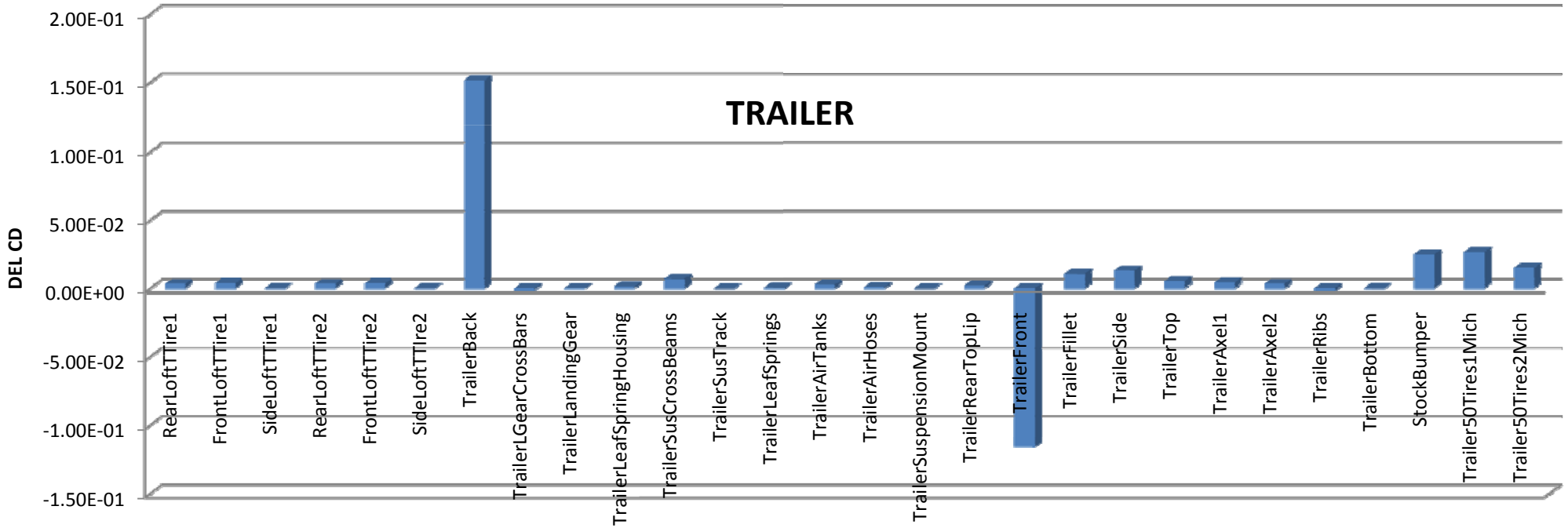
- **Aero development was terrifically accelerated.**

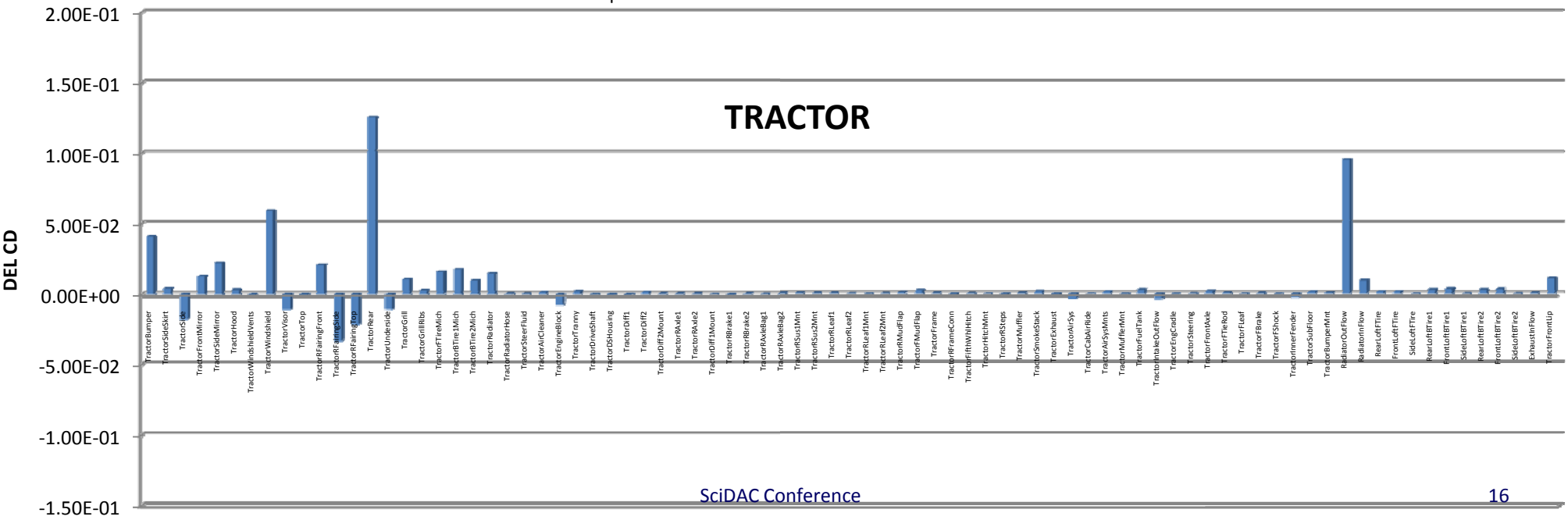
- **Resulted in tested, market ready, retrofitable products being developed in first nine months.**

- **Demonstrated fuel mileage improvements of 7% to 12% available next year.**

Typical Truck Today – Details Are Important

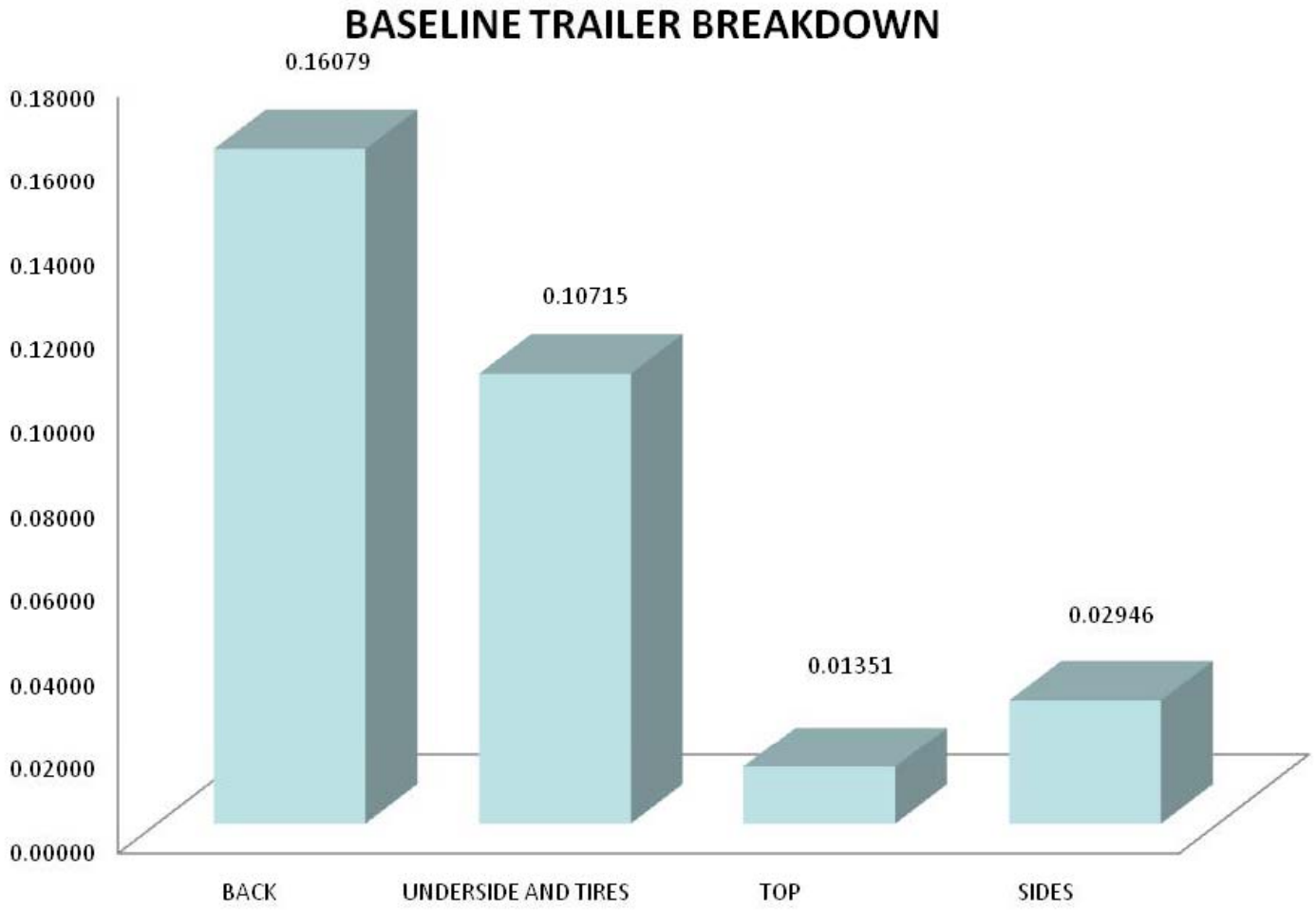
Understanding Where Drag is Coming From





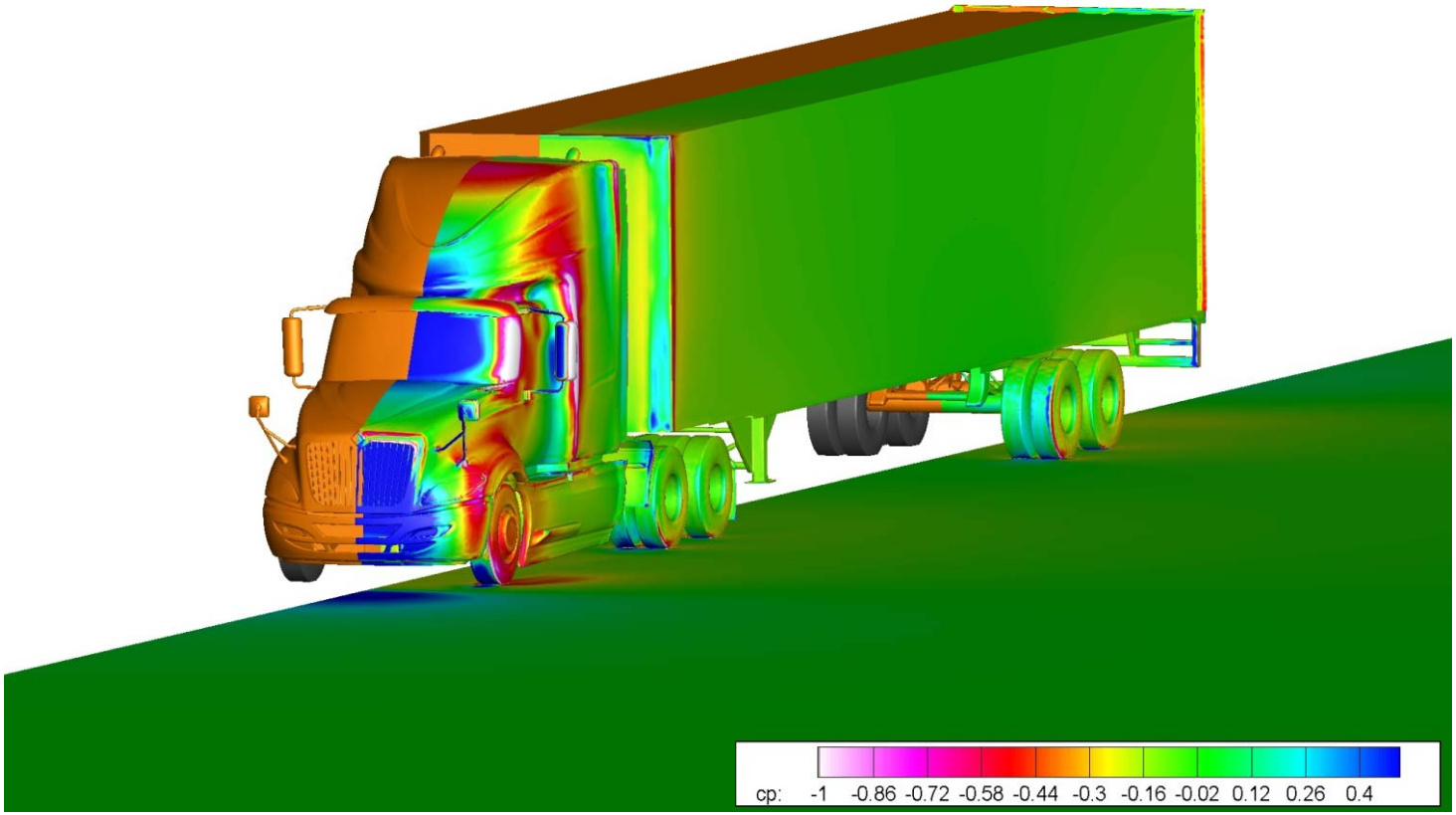
Class 8 Truck Drag Assessment

High Level Drag Assessment of Today's 53' Dry Van Trailer



Typical Truck Today – Details Are Important

Understanding The Flow



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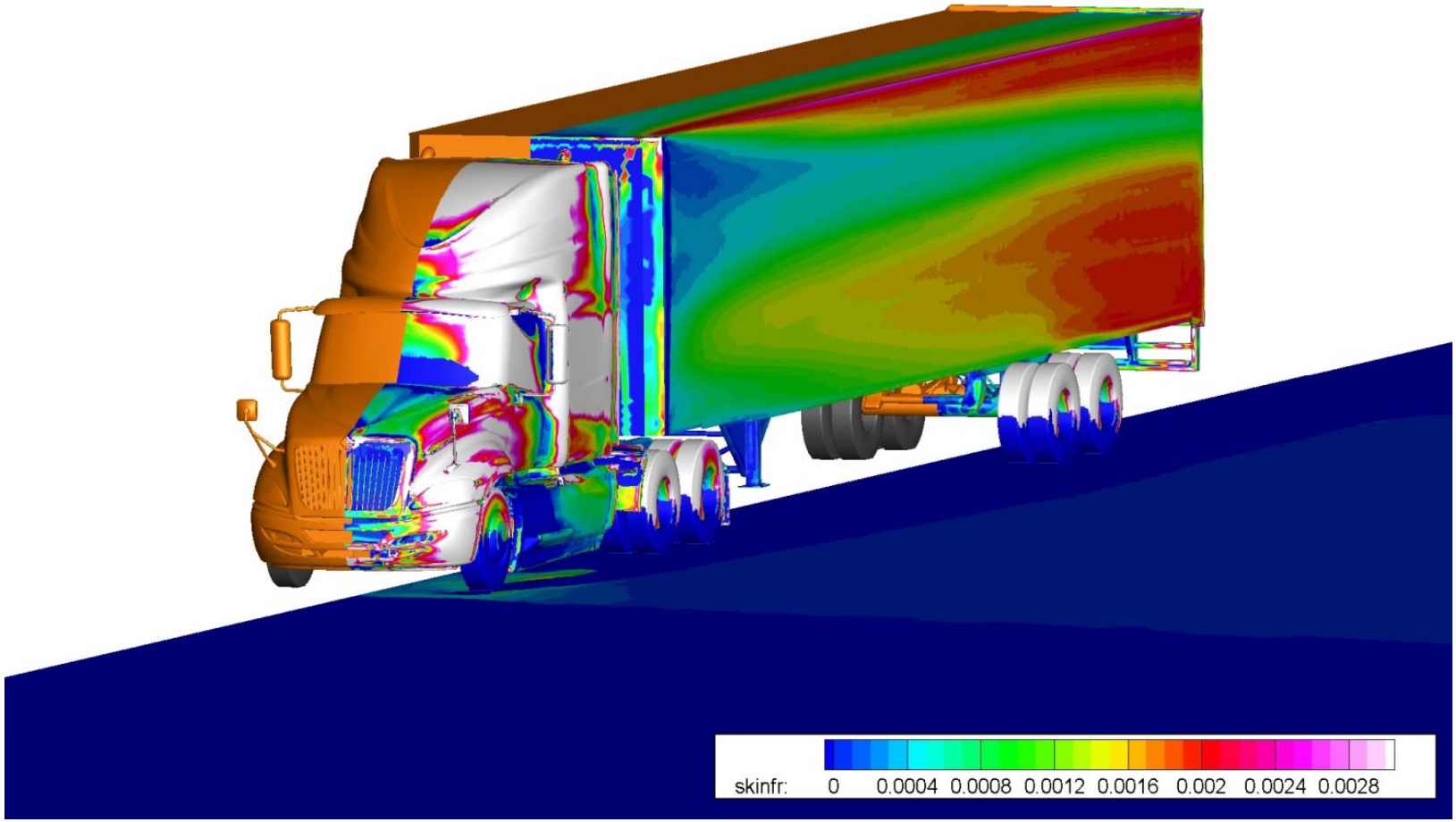

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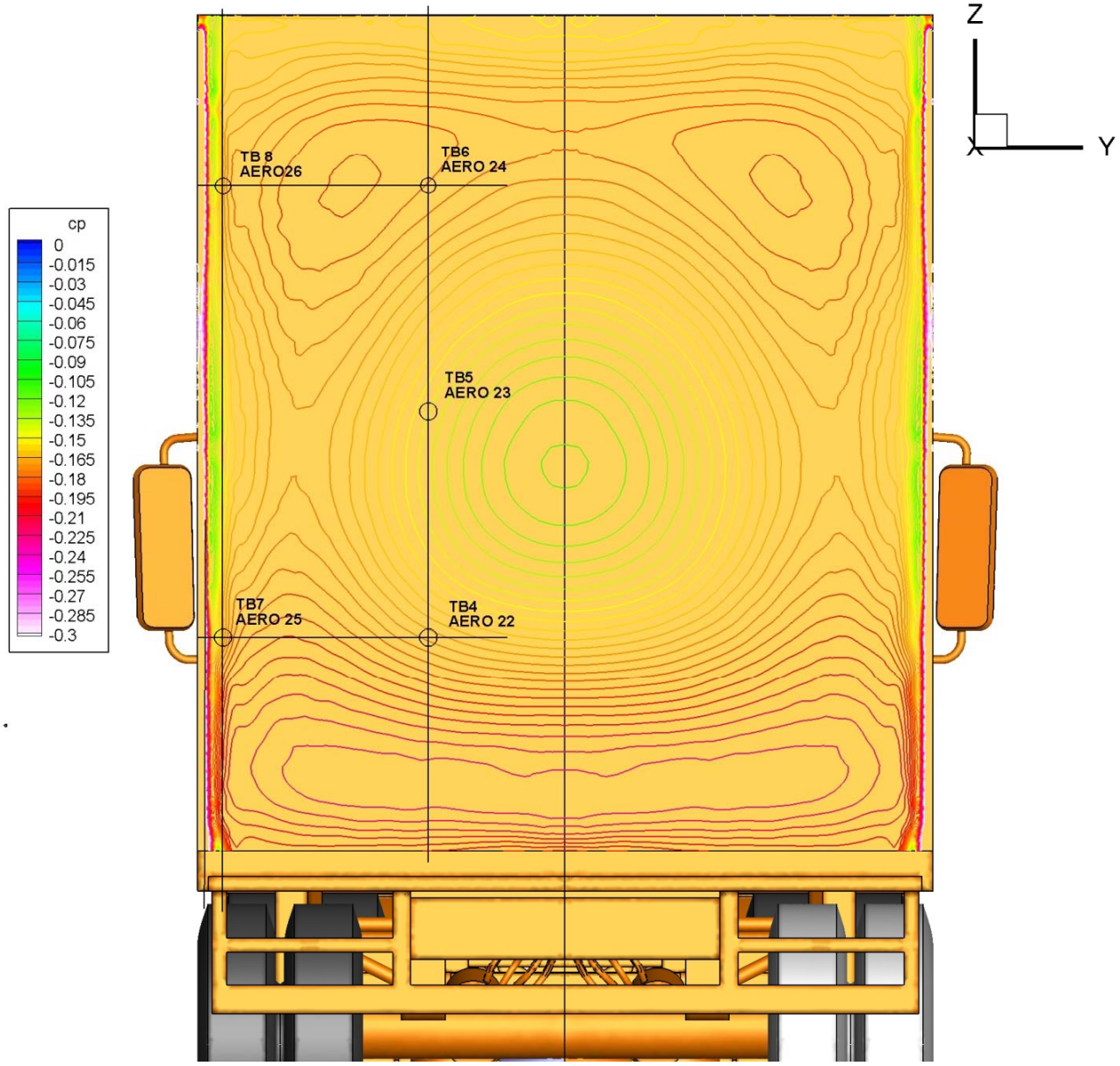

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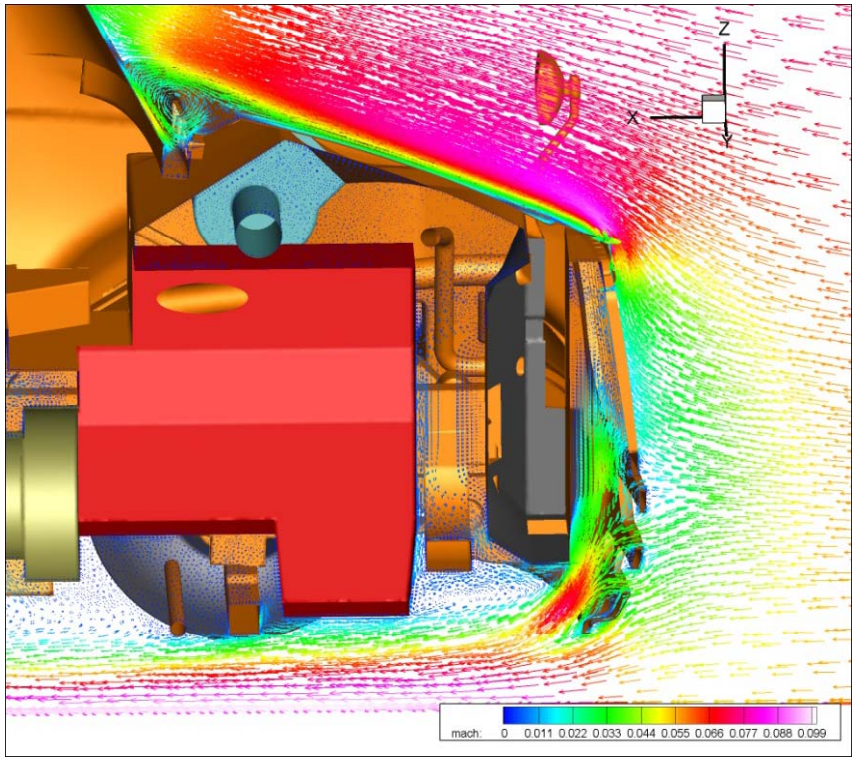

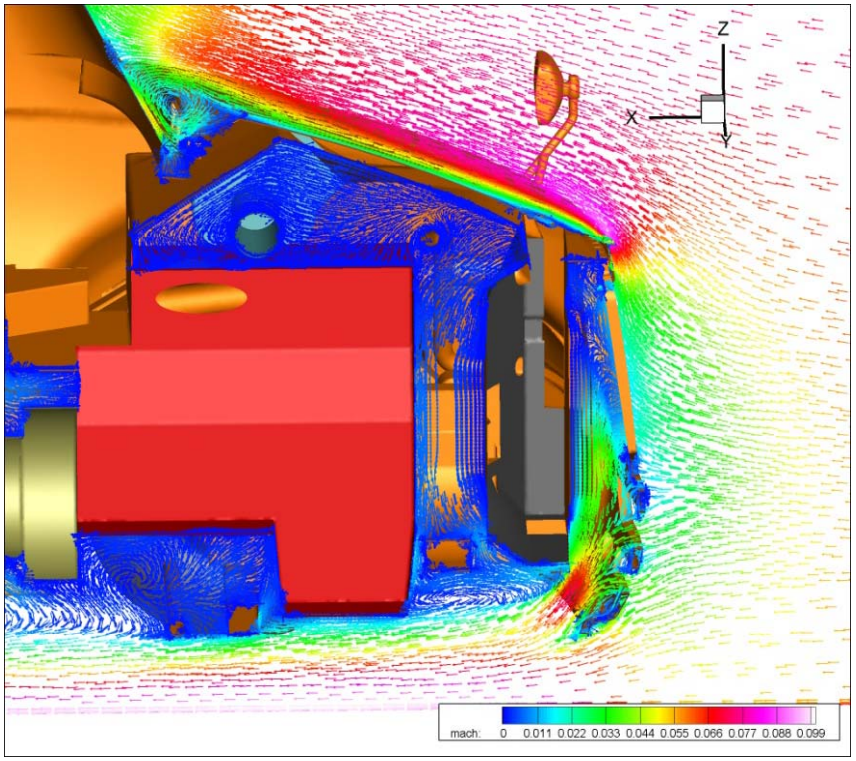

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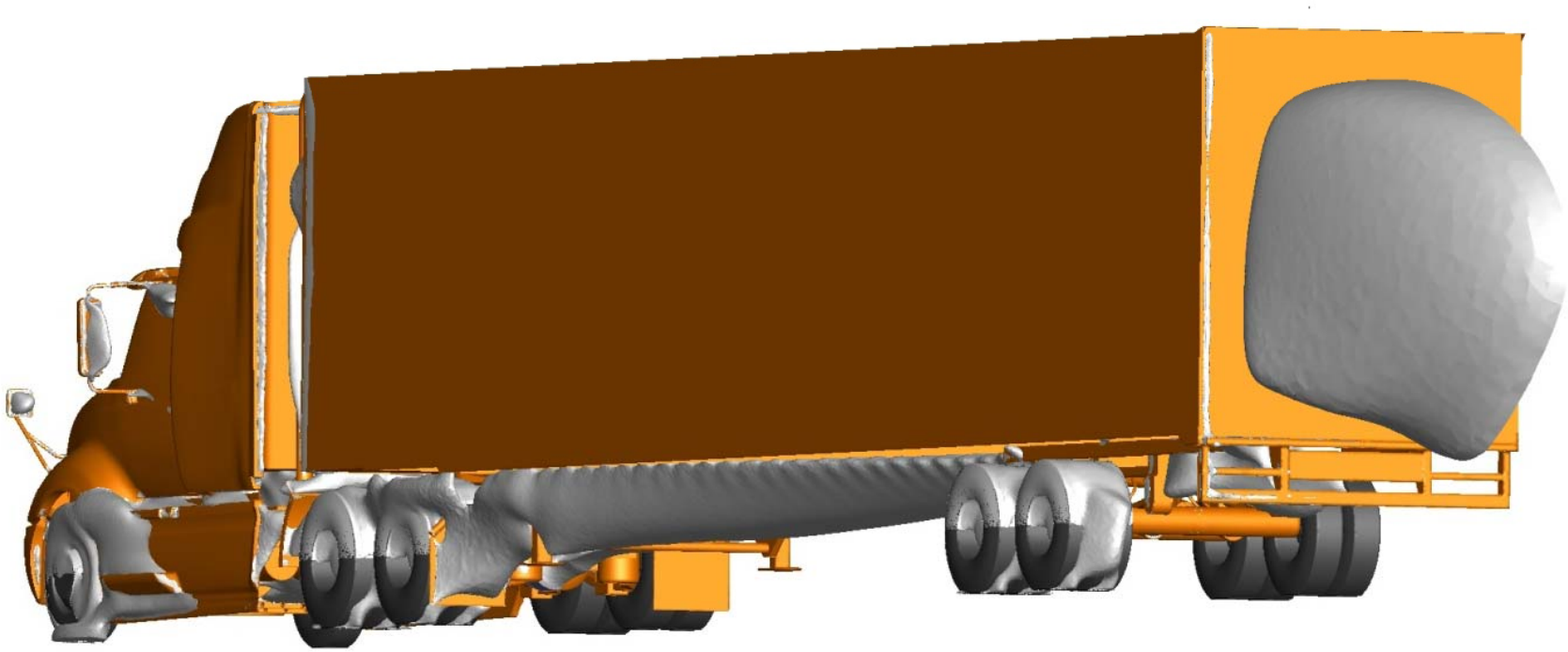
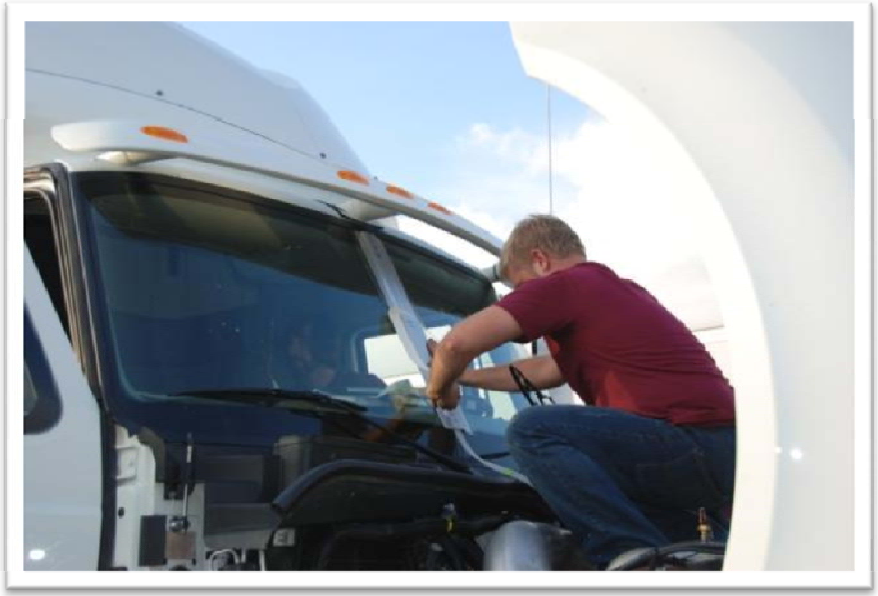
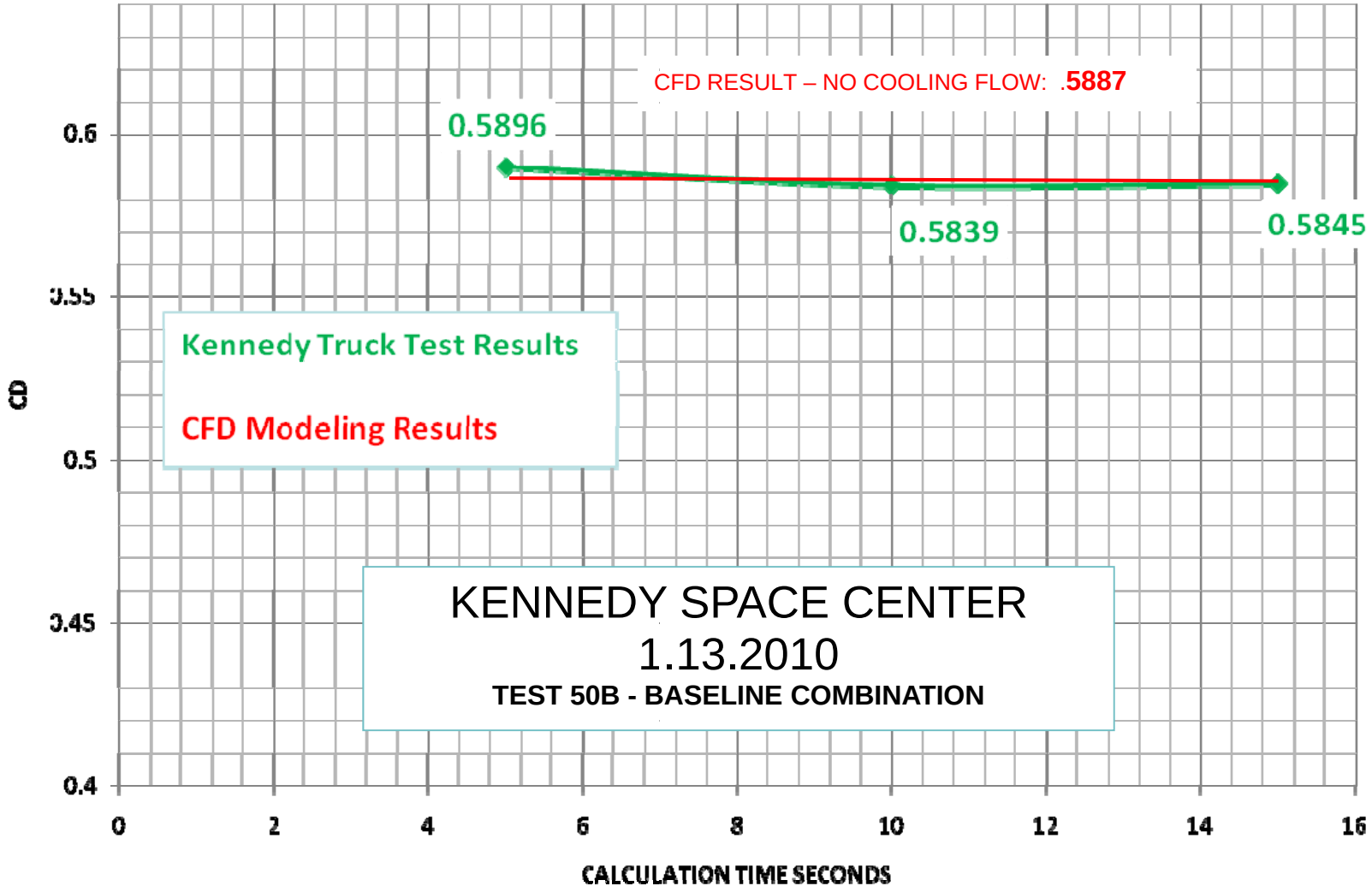


Aerodynamic Performance Testing
Trailer Loading System and Pressure Measurement

Aerodynamic Performance Testing
Kennedy Space Center
Calibrate CFD and Evaluate Prototypes

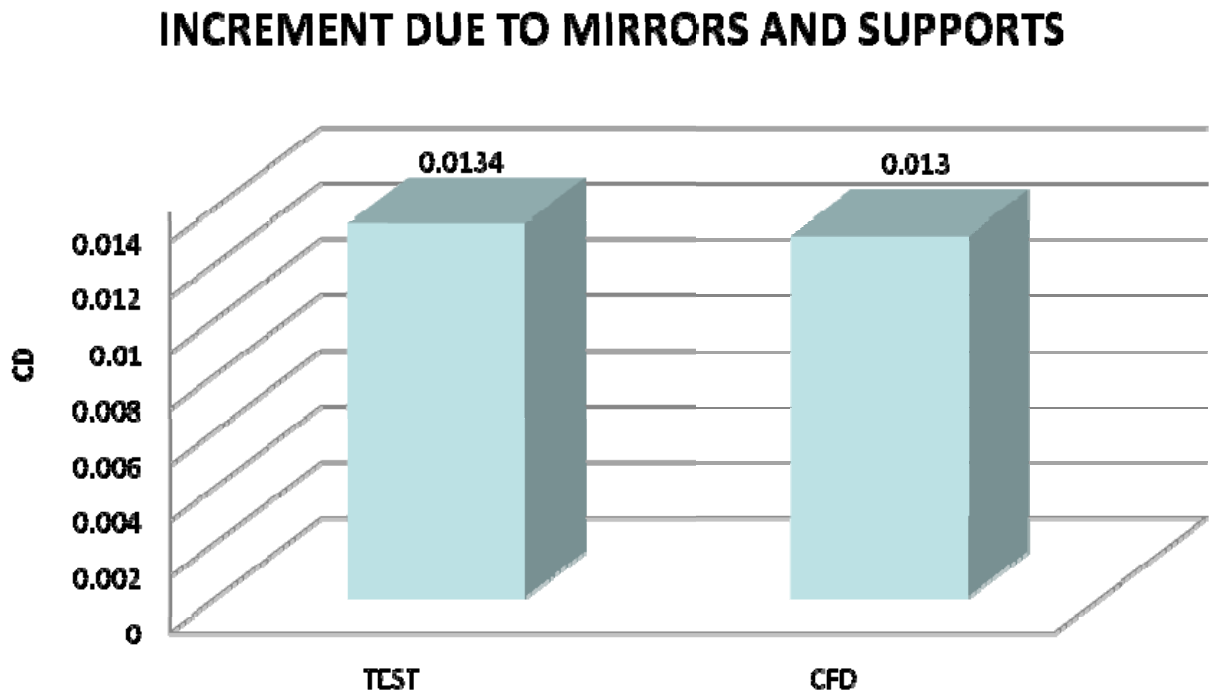


Aerodynamic Performance Testing
Baseline Truck Results



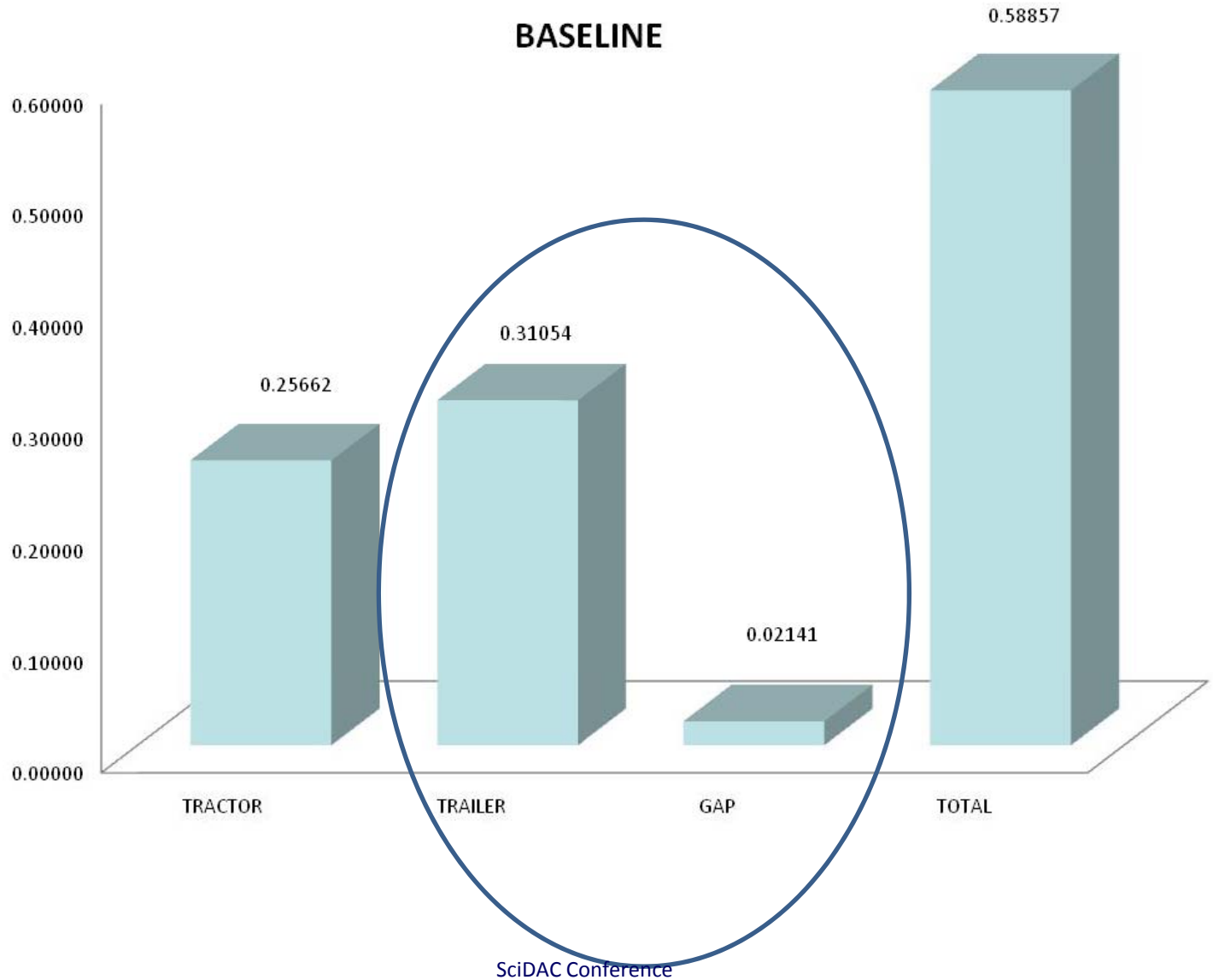
Aerodynamic Performance Testing
Baseline Truck Results

KENNEDY SPACE CENTER
1.13.2010



Class 8 Truck Drag Assessment

High Level Drag Assessment of Today's Best Tractor/Trailer



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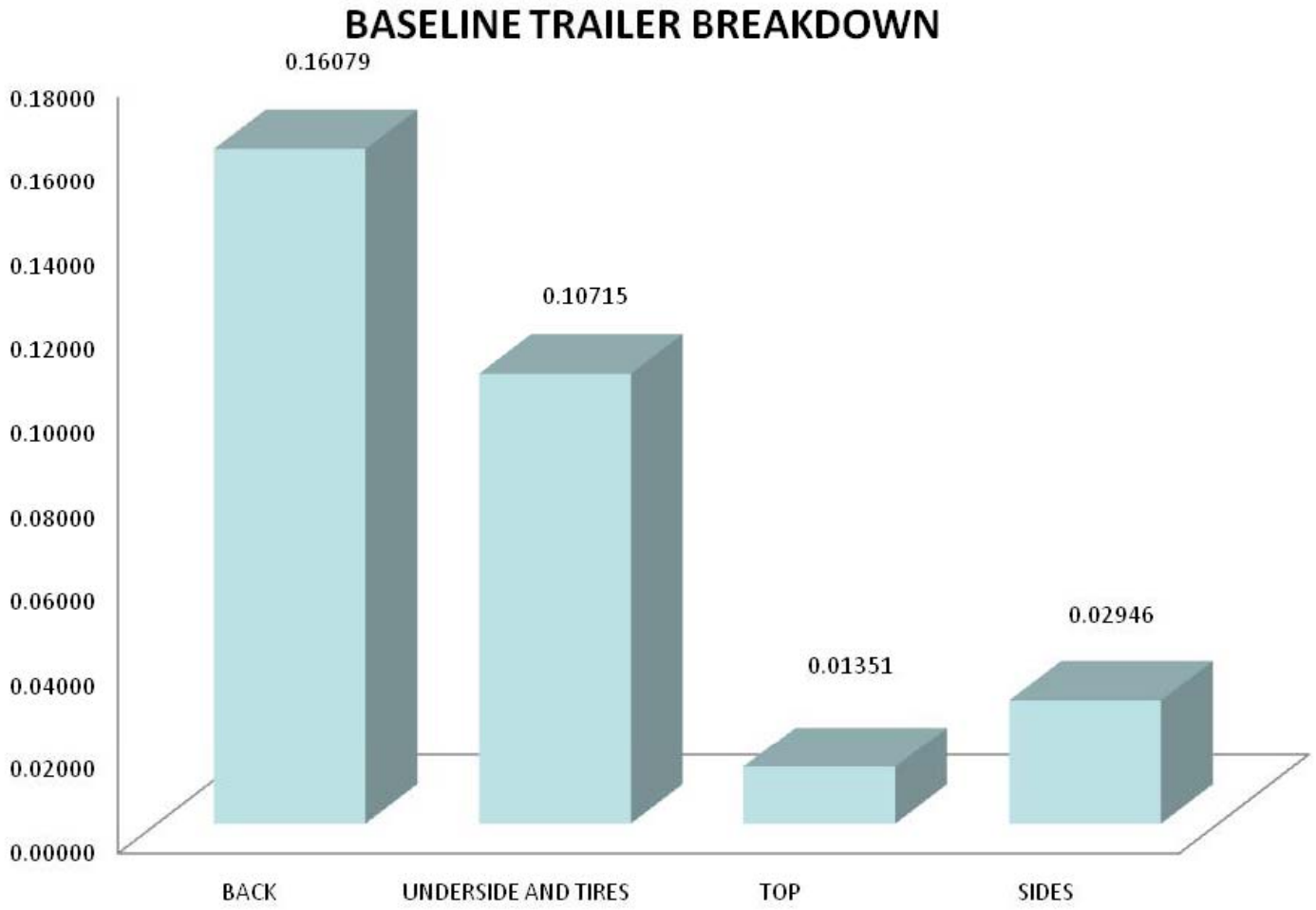
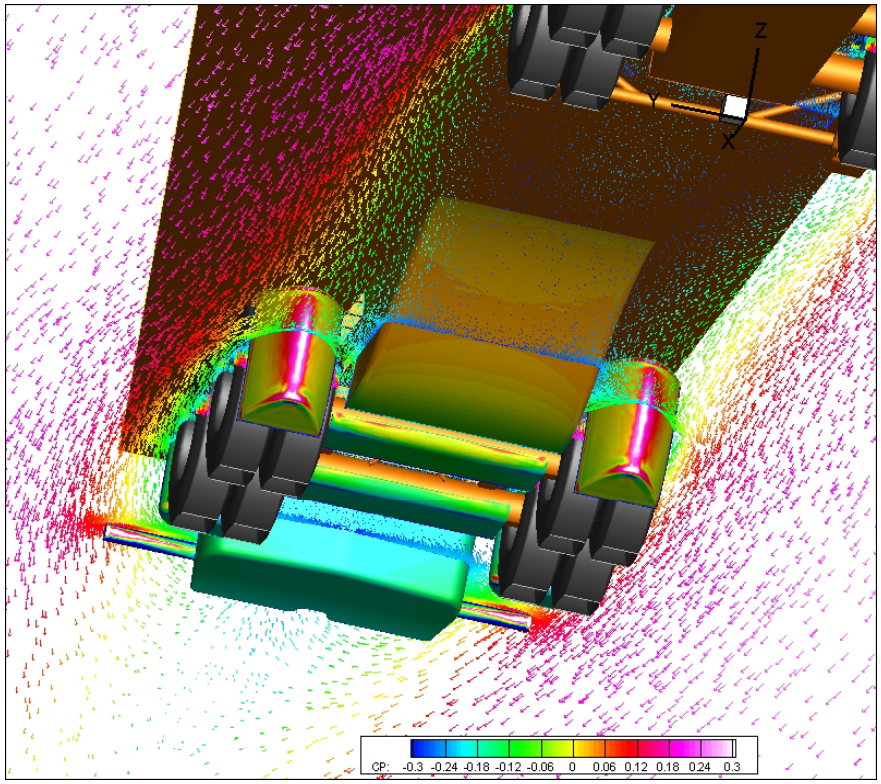
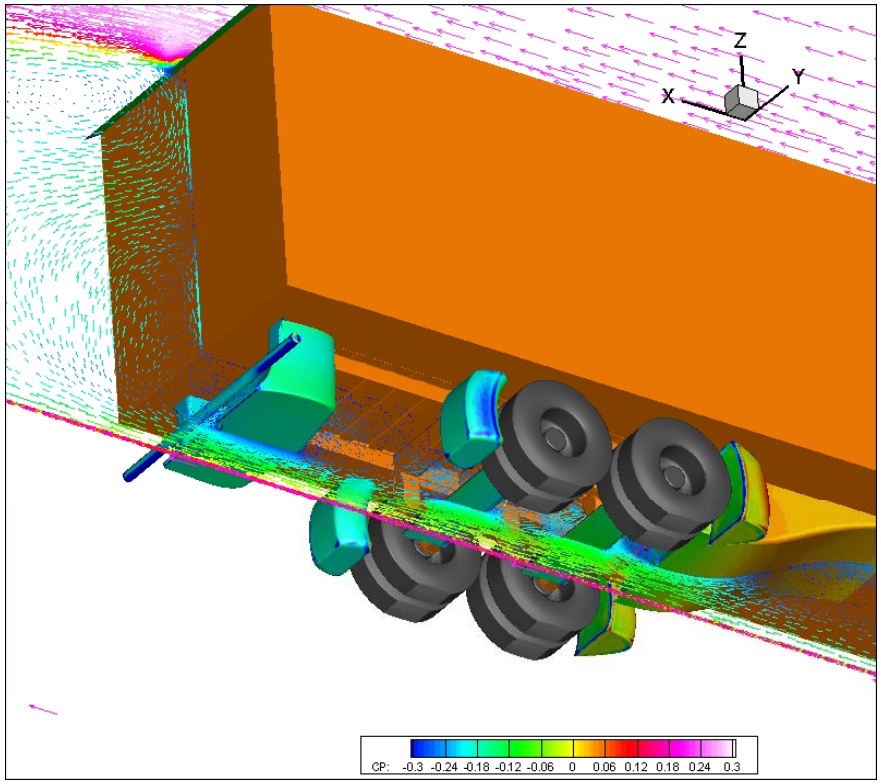


SmartTruck Trailer Designs:

UT-6 Trailer UnderTray System





UT-6 reduces Tractor/Trailer drag by 12%. It performs by:

- Minimizing drag associated with trailer underside components
- Compressing and accelerating incoming air flow and injecting high energy air into trailer wake
- Pulling high energy, attached air flow from the top of the trailer down into trailer wake

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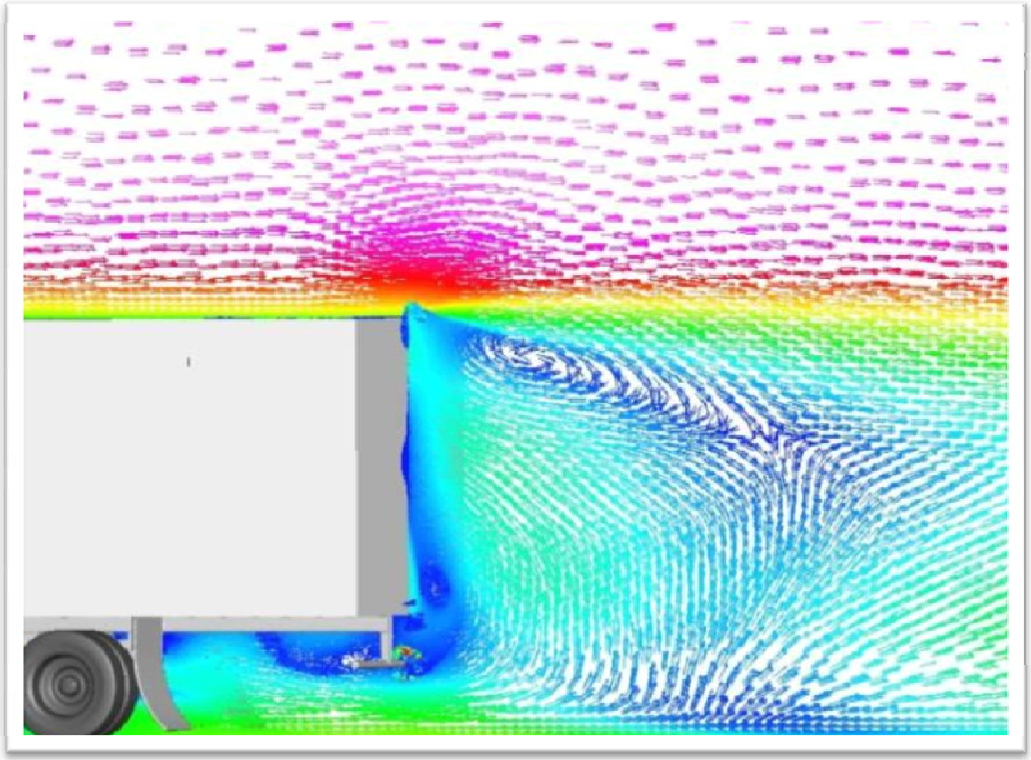

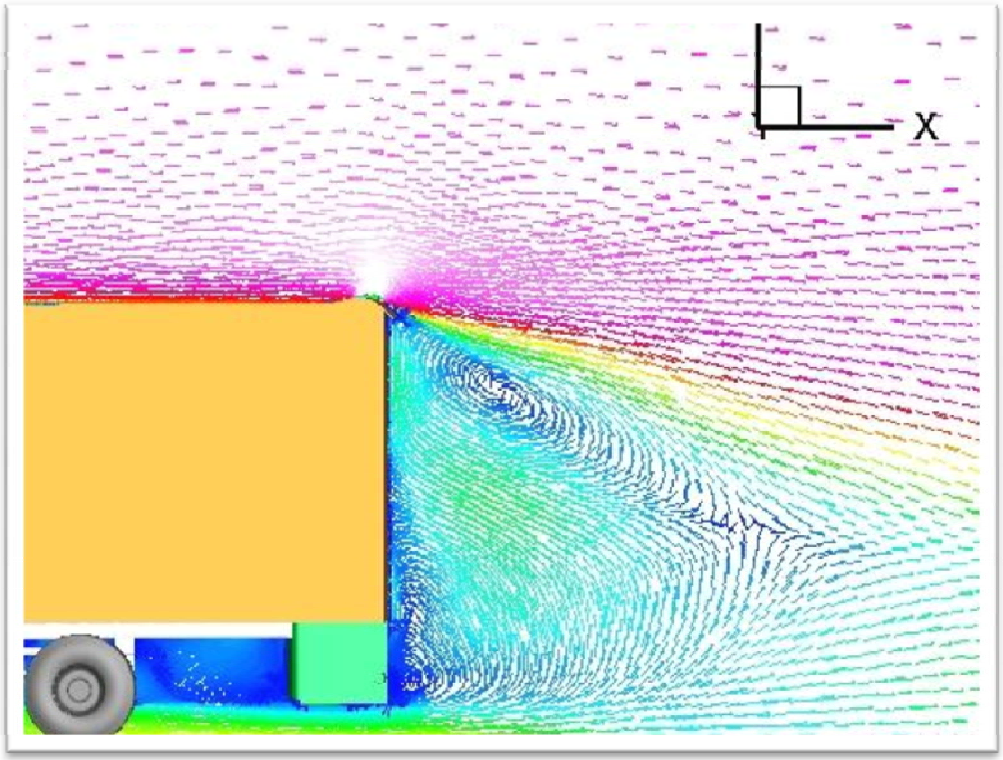

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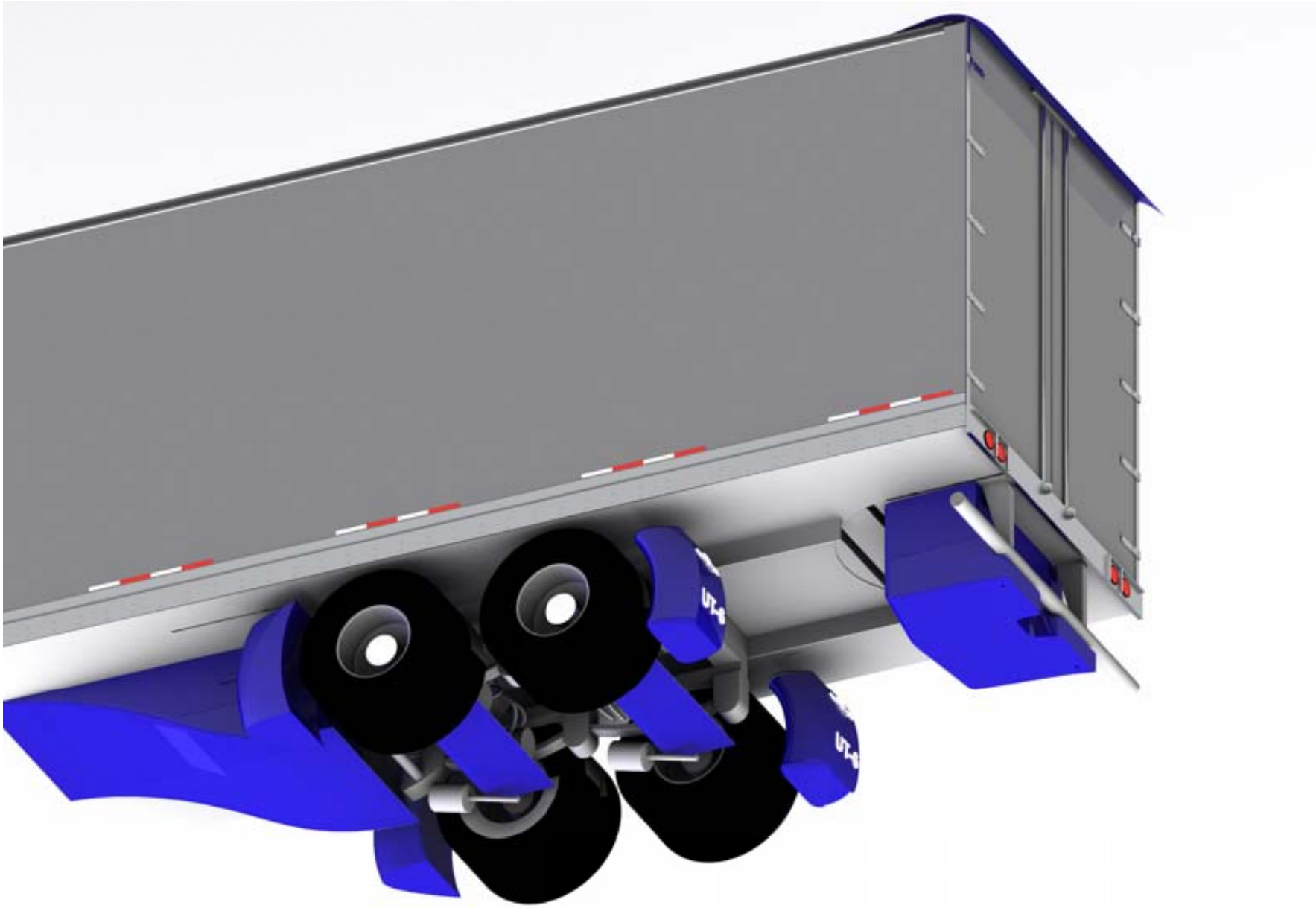

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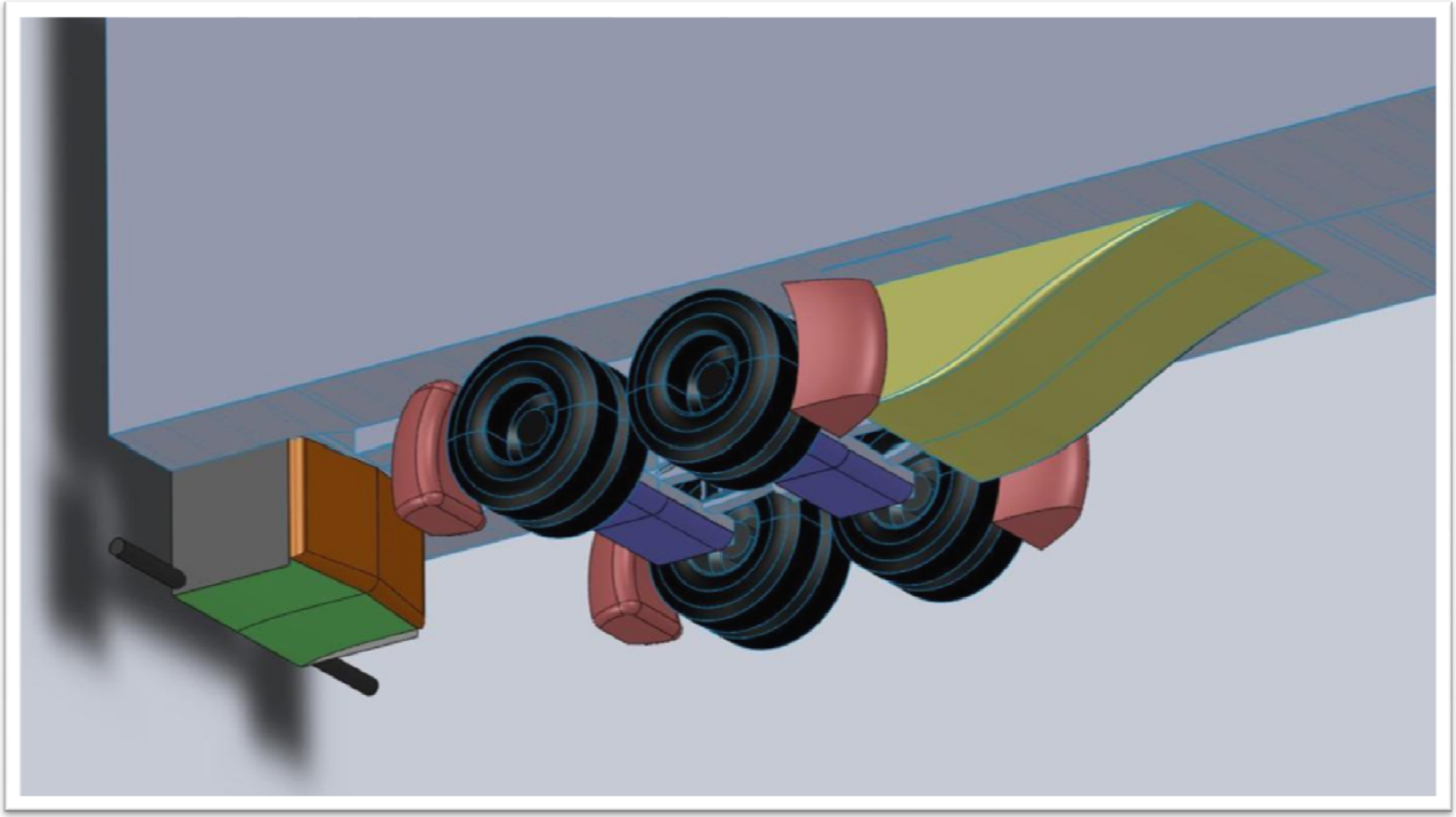
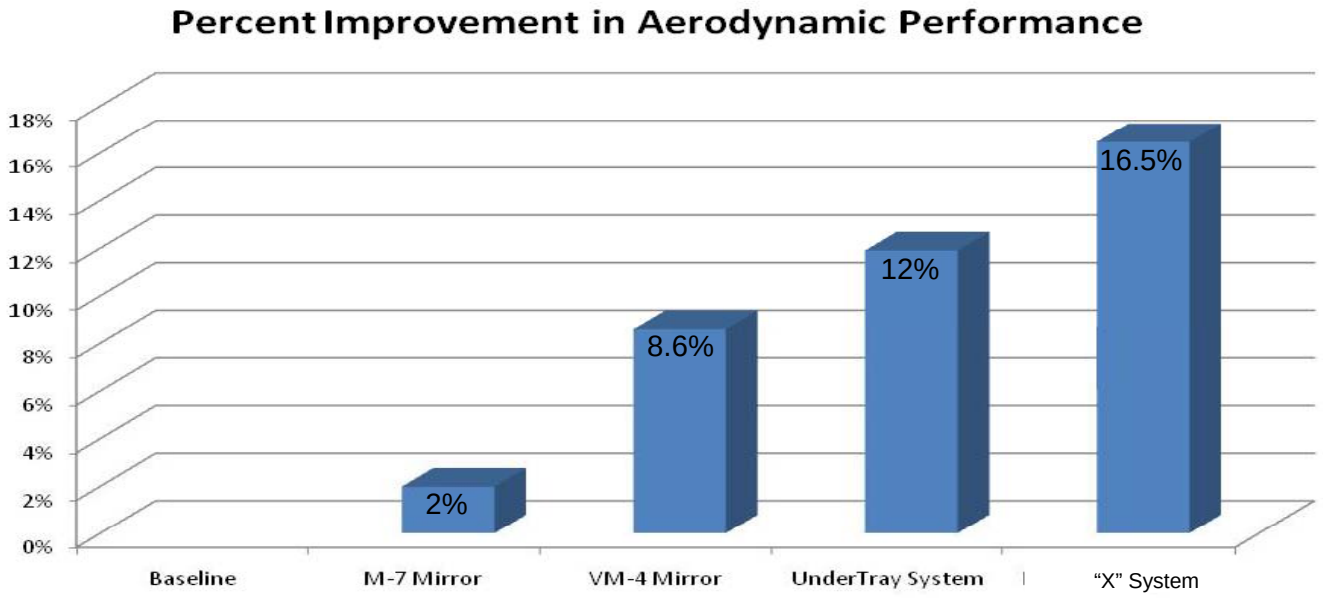
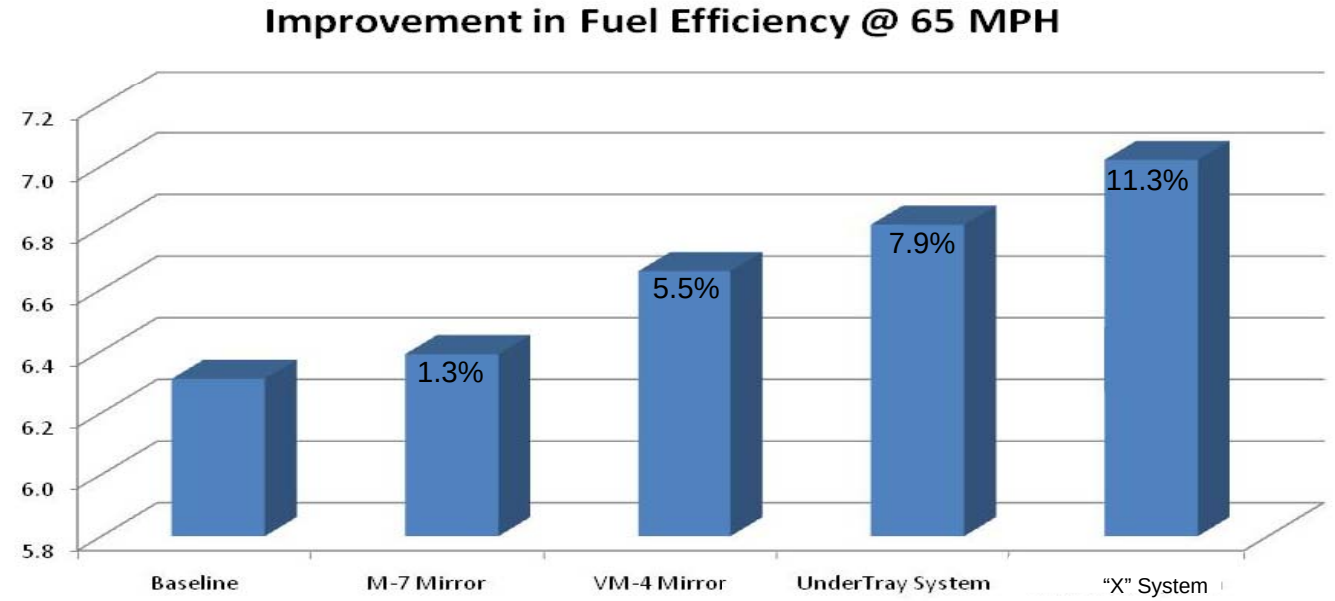


- Symmetrical fairings (unhanded – reduced inventory)
- Open sides and underside for cooling and easy inspections
- Aerodynamic mudflaps

SmartTruck Performance Summary

Phase I Products – Individual Performance



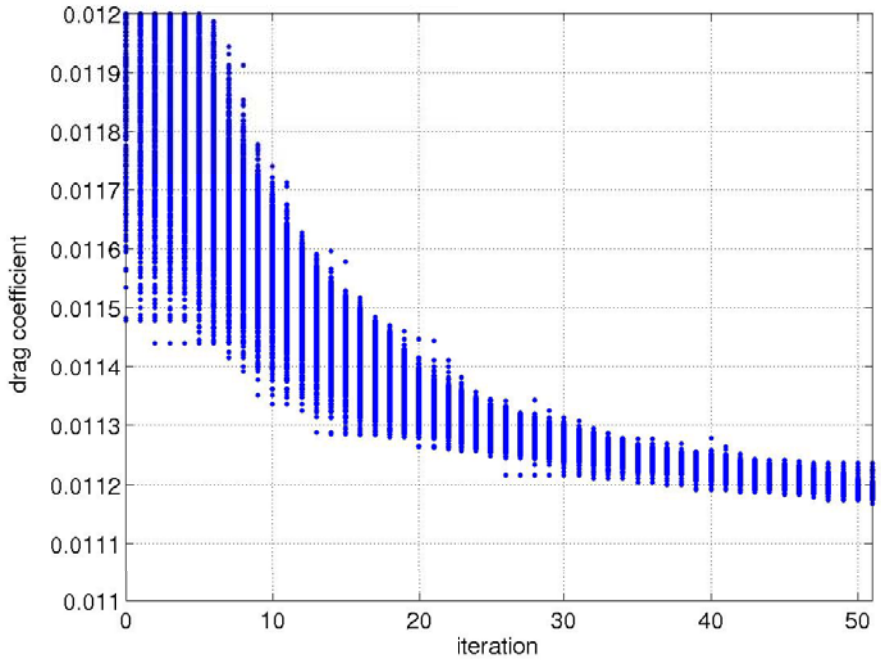


SmartTruck Design

The Next Level - Optimization

The Optimization Advantage

- Compare Optimum Designs
- Very Subtle Improvements
- Often Counter-Intuitive Solutions
- VERY Computer Intensive
- VERY Knowledge Intensive



The Smart Truck Program Impact of Jaguar

- **Allowed *unprecedented* detail and accuracy of a Class 8 Tractor-Trailer aerodynamic simulation.**

- **Enabled rapid development of practical improvements. Parts will be available this Fall.**

- **Early energy savings for the trucking companies and the country.**

- **Will allow, in the near future, full Navier Stokes based optimization of large trucks, something that has never before been achieved.**

Science Impact of Access to Leadership Computing

Examples could be:

- Advanced your R&D
- Discovered something new
- Scaling software
- Running current simulations faster than possible on in-house systems
- Producing more information by running more simulations
- Carrying out much larger/more detailed simulations than possible on in-house systems

Competitive Impact of Access to Leadership Computing

Examples could be:

- New insights accelerated new product development for faster time to market /increased market share
- Allowed you to respond to a competitive threat (market pressures)
- Enabled you to meet customer (internal or external) requirements
- Created new business opportunities
- Allowed you to better differentiate yourselves in the market
- Lowered costs
- Increased revenue