ATDynamics

Driving the Efficiency Revolution

Advanced Devices for Rear Drag Reduction on Tractor-Trailers

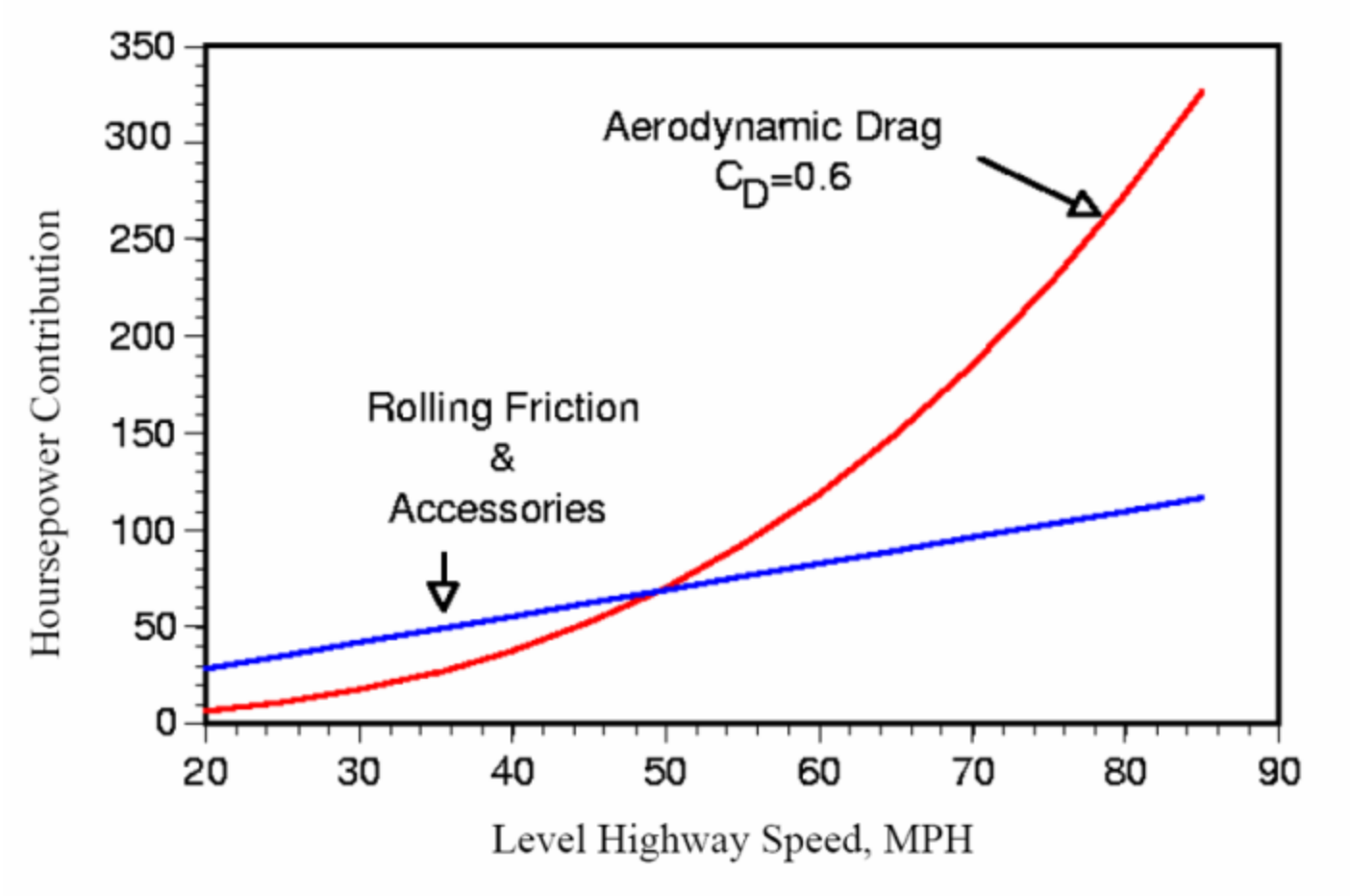
Andrew Smith - CEO

Chuck Horrell – Vice President of Engineering

August 11th 2010

Contact: *Chuck Horrell, VP of Engineering, Email: chorrell@atdynamics.com Tel: 650-871-5156*

Importance of Tractor-Trailer Aerodynamics: ~65% of Fuel Used to Overcome Drag at Highway Speeds



Source: McCallen, Rose et al. *DOE's Effort to Reduce Truck Aerodynamic Drag through Joint Experiments and Computations*, April 2006.

ATDynamics

Benefits to Fleets for Each 5% Fuel-Efficiency Gain

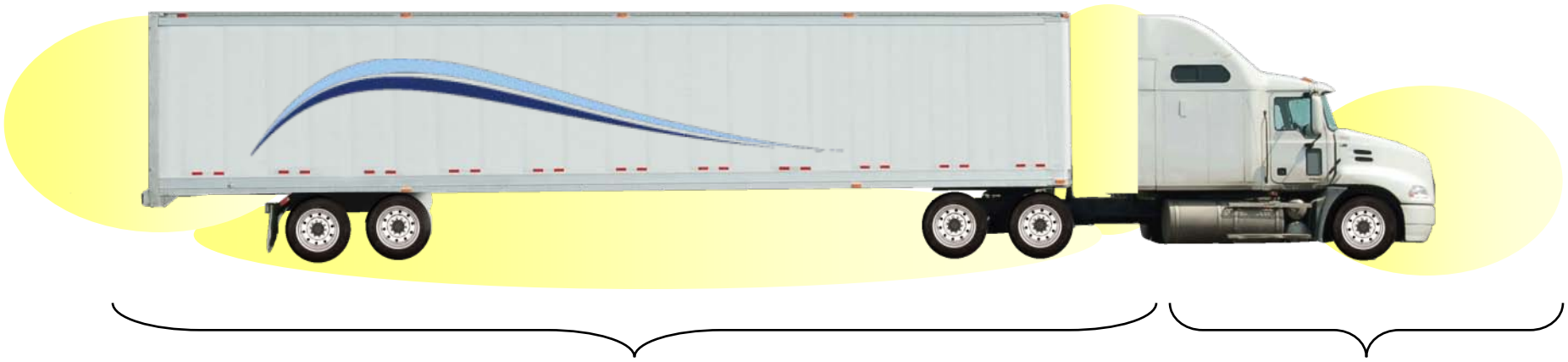
Annual Highway Mileage Per Trailer

Fuel Price (per Gallon)	50,000	75,000	100,000	150,000
$ 1.50	$ 625	$ 938	$ 1,250	$ 1,875
$ 2.50	$ 1,042	$ 1,563	$ 2,083	$ 3,125
$ 3.50	$ 1,458	$ 2,188	$ 2,917	$ 4,375
$ 4.50	$ 1,875	$ 2,813	$ 3,750	$ 5,625
$ 5.50	$ 2,292	$ 3,438	$ 4,583	$ 6,875

- 5% fuel-efficiency gain equates to a ~7.7% drag reduction
- 5% fuel-efficiency gain is the threshold at which dry vans comply with ARB requirements for trailer aerodynamics

ATDynamics

Tractor-Trailer Aerodynamics



75% Trailer Drag

25% Tractor Drag

This project will address the low pressure vacuum created behind tractor-trailers moving at highway speeds.

Source: Richard Wood

ATDynamics

Rear Drag Reduction – Passive Devices

Aerodynamic Principles

- Reduces aerodynamic drag by keeping laminar flow along trailer edges attached deeper into the wake
- Reduces the size and turbulence of low-pressure region behind trailer

History of passive rear devices

- Patents issued as early as 1950's
- First market-ready product offerings have been developed in the last 5 years
- Aerodynamic and mechanical optimization has been pursued as part of this project

Outlook for passive rear devices

- Potential for fuel-efficiency improvement is proven
- Industry awareness has increased dramatically since 2007
- Market penetration is improving

Rear Drag Reduction - Active Flow Control (AFC)

Aerodynamic Principles

- Reduces aerodynamic drag by pressurizing the low-pressure region behind a trailer
- Utilizes either suction, blowing, or both actions, done either continuously or pulsed

History of AFC

- Used for decades in aeronautical engineering
- Preliminary research into adapting technology for tractor trailers
  - Various academic institutions
  - Government research centers

Outlook for AFC

- Potential for fuel-efficiency improvement is proven
- Economics and market adoption outlook is positive
- Challenges are in aerodynamic optimization and mechanical engineering

Work Completed

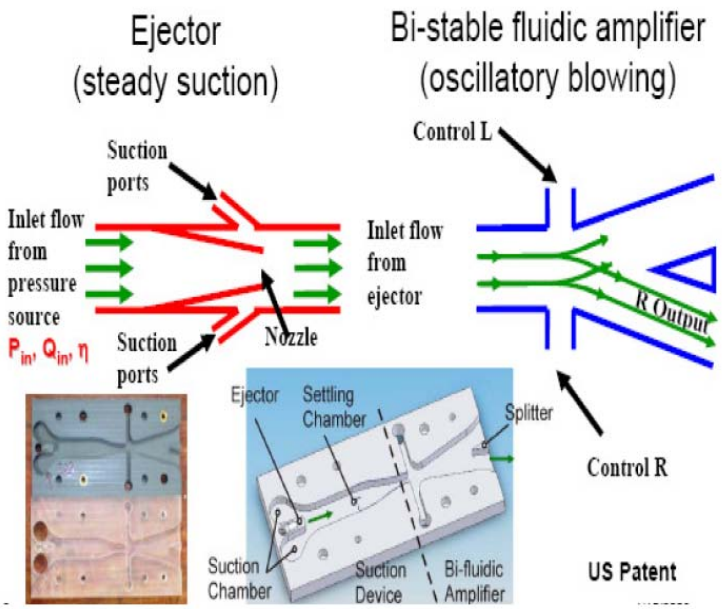
Contractual agreements

Tel Aviv University

- Commercialization partnership
- Exclusive license to ATDynamics to develop for the US market

Georgia Tech Research Institute

- Development partnership
- Commercialization strategy to be developed after more is learned about the commercial viability of the technology



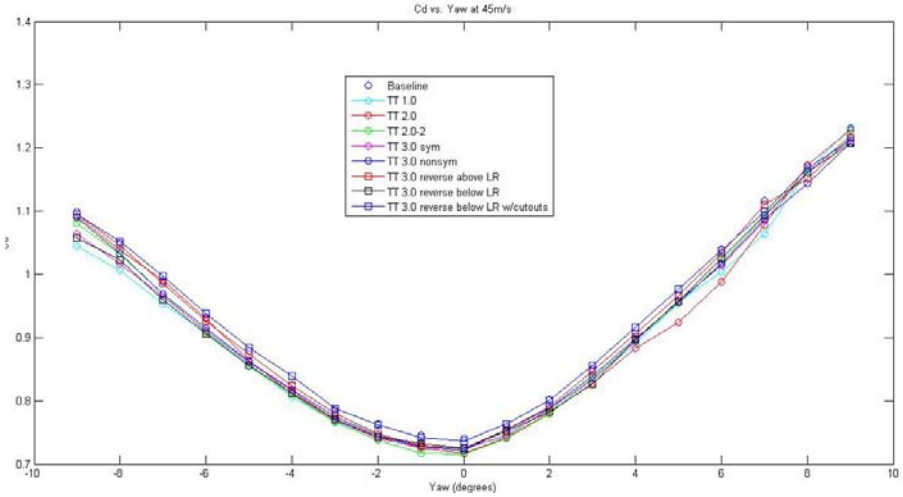
ATDynamics

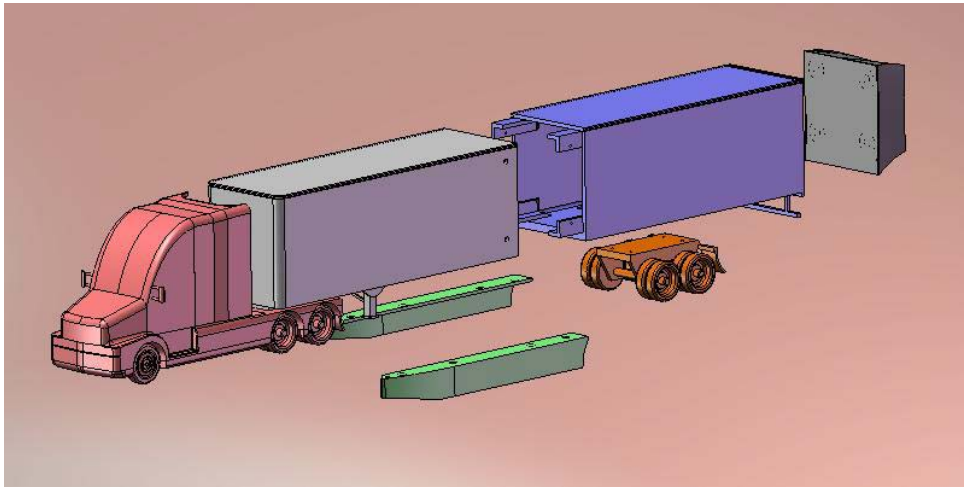
Work Completed

Aerodynamic Optimization

Clarkson University

- Wind tunnel optimization
- New high-precision instrumentation
- Detailed model design and fabrication using SLS construction
- Preliminary wind tunnel results





ATDynamics

Work Completed

Passive device development

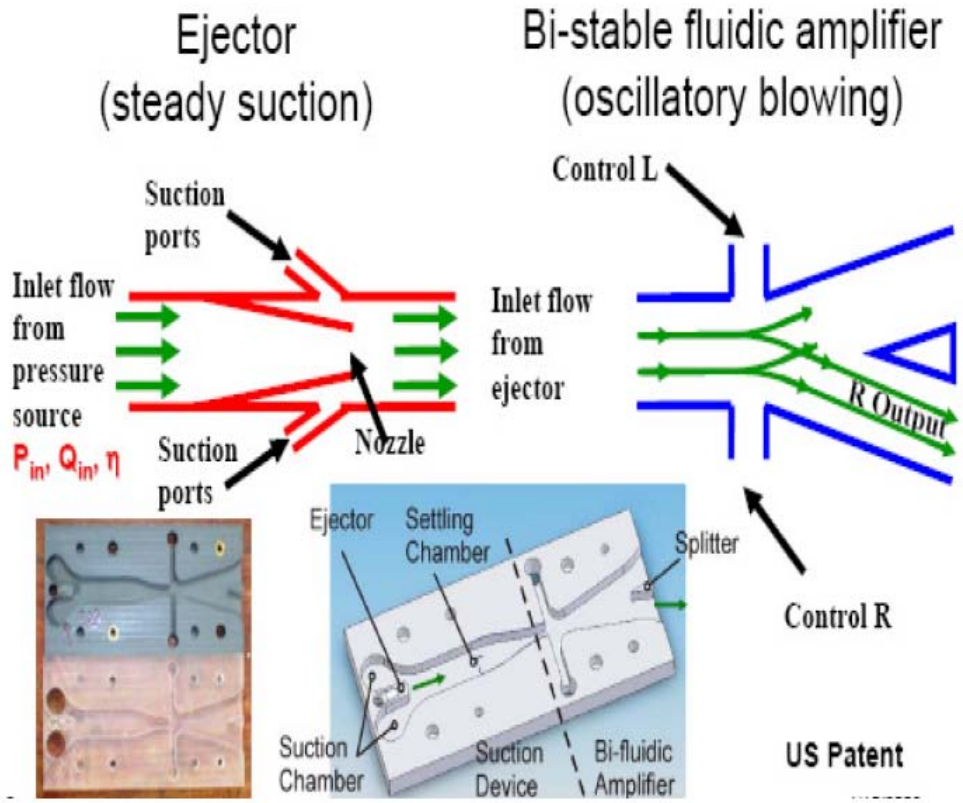
ATDynamics

Work Completed

Aerodynamic Optimization

Tel Aviv University

- Valve body geometry optimization
- Frequency of oscillation
- Synchronization channel length
- Inlet pressure
- Desired flow rate
- Angular placement of outlet nozzles
- Span-wise placement of outlet nozzles
- Angular placement of suction holes
- Span-wise placement of suction holes
- Inlet nozzle geometry

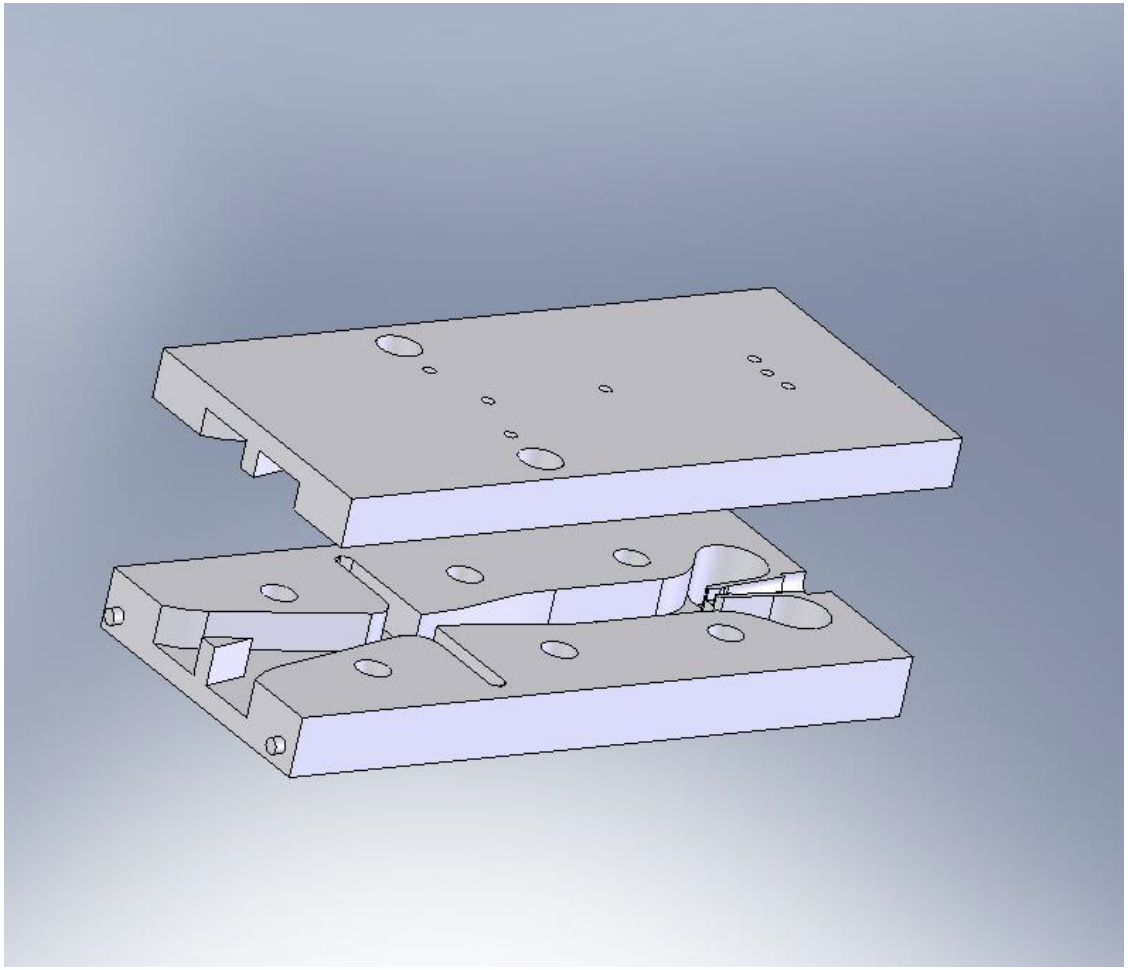


ATDynamics

Work Completed

Aerodynamic Optimization

Tel Aviv University
SaOB Actuator



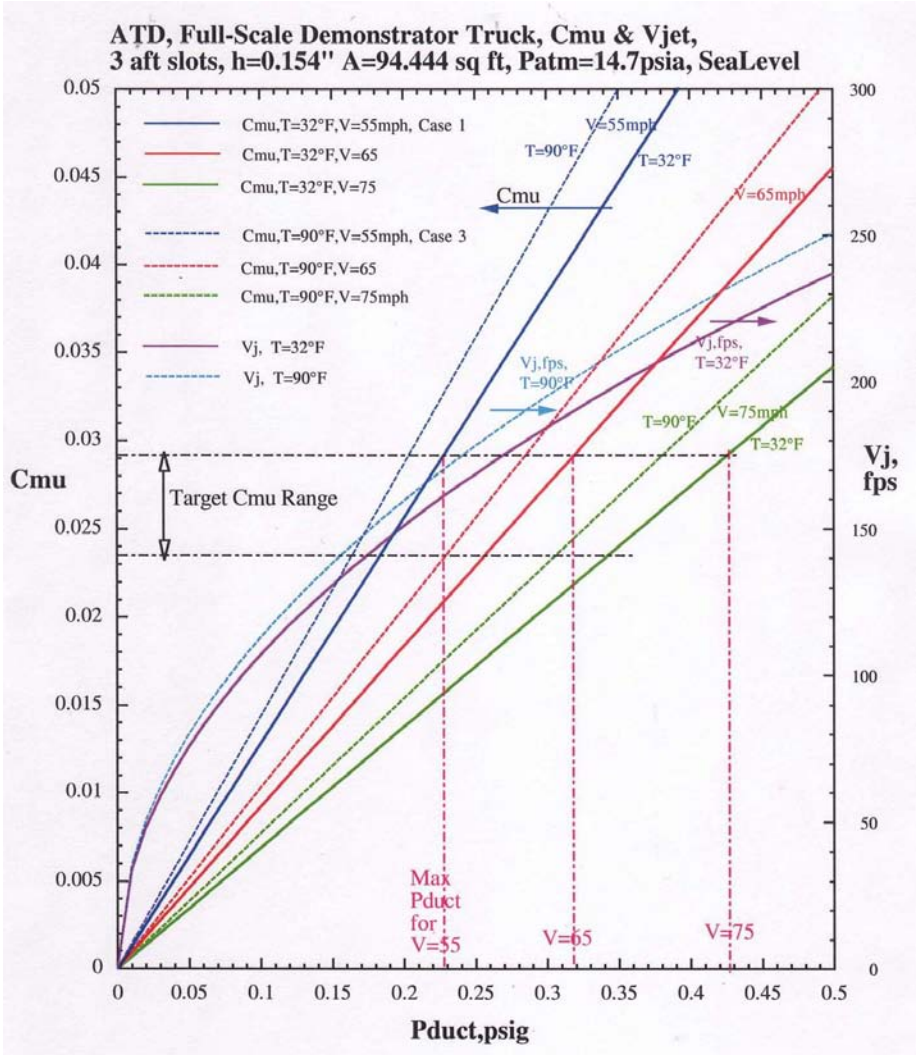
ATDynamics

Work Completed

Aerodynamic Optimization

Georgia Tech Research Institute

- ATDynamics completed mechanical design
- GTRI head researcher provided design parameters:
  - Slot height
  - Inlet pressure
  - Volumetric flow rate
  - Outlet velocity
- All parameters provided for multiple test scenarios
  - Temperature
  - Elevation
  - Test speed

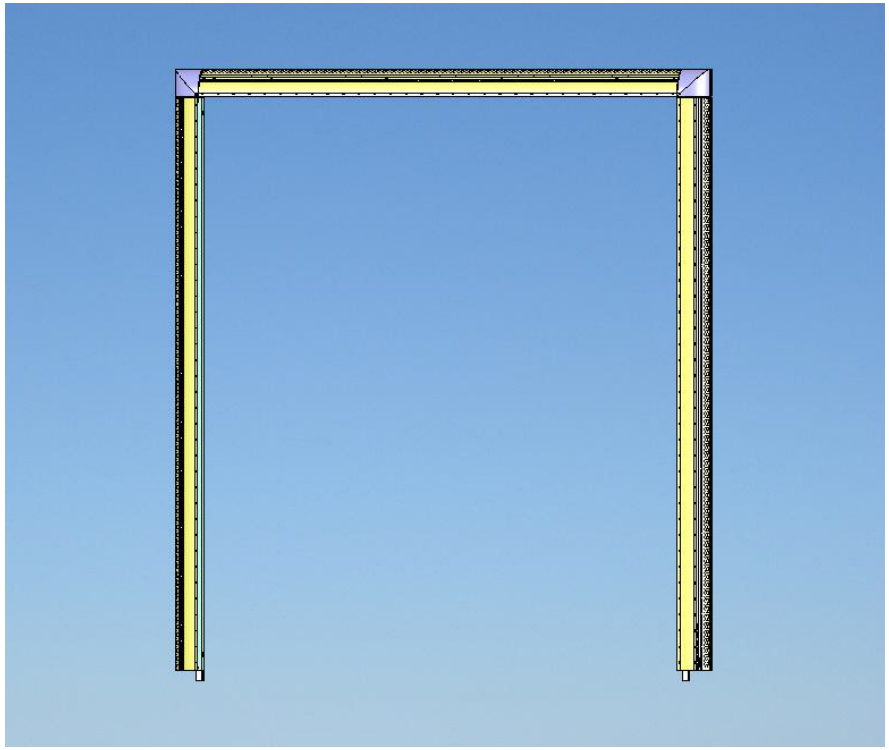


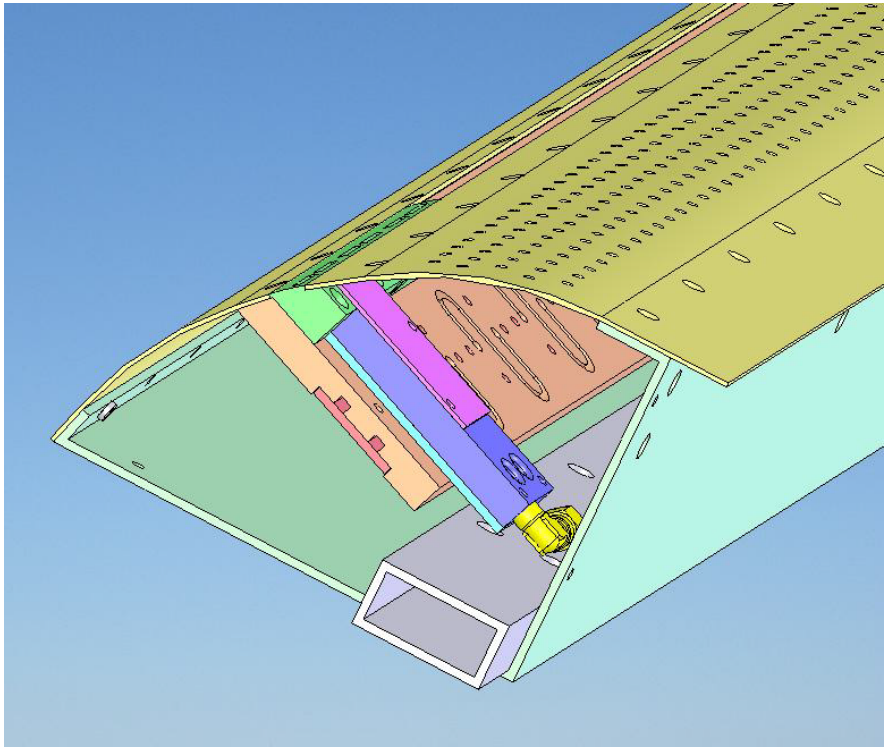
ATDynamics

Work Completed

Mechanical Design

Tel Aviv University Device



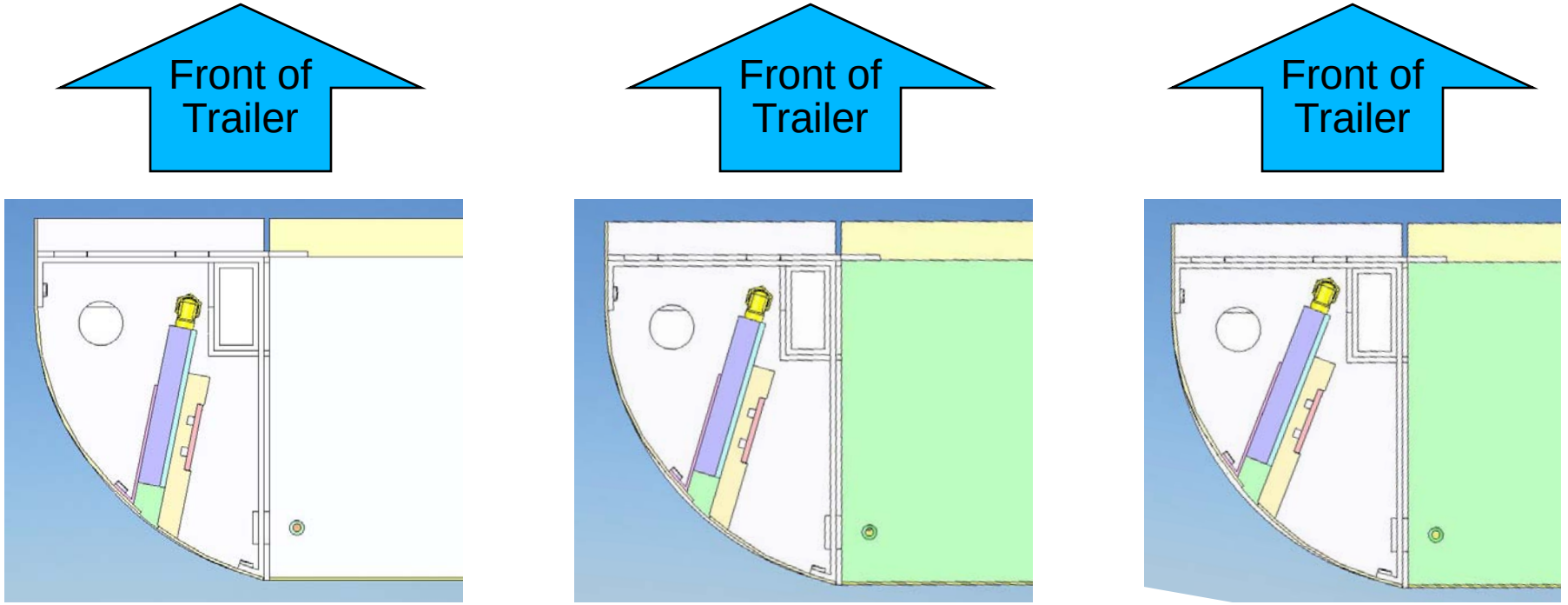


ATDynamics

Work Completed

Mechanical Design

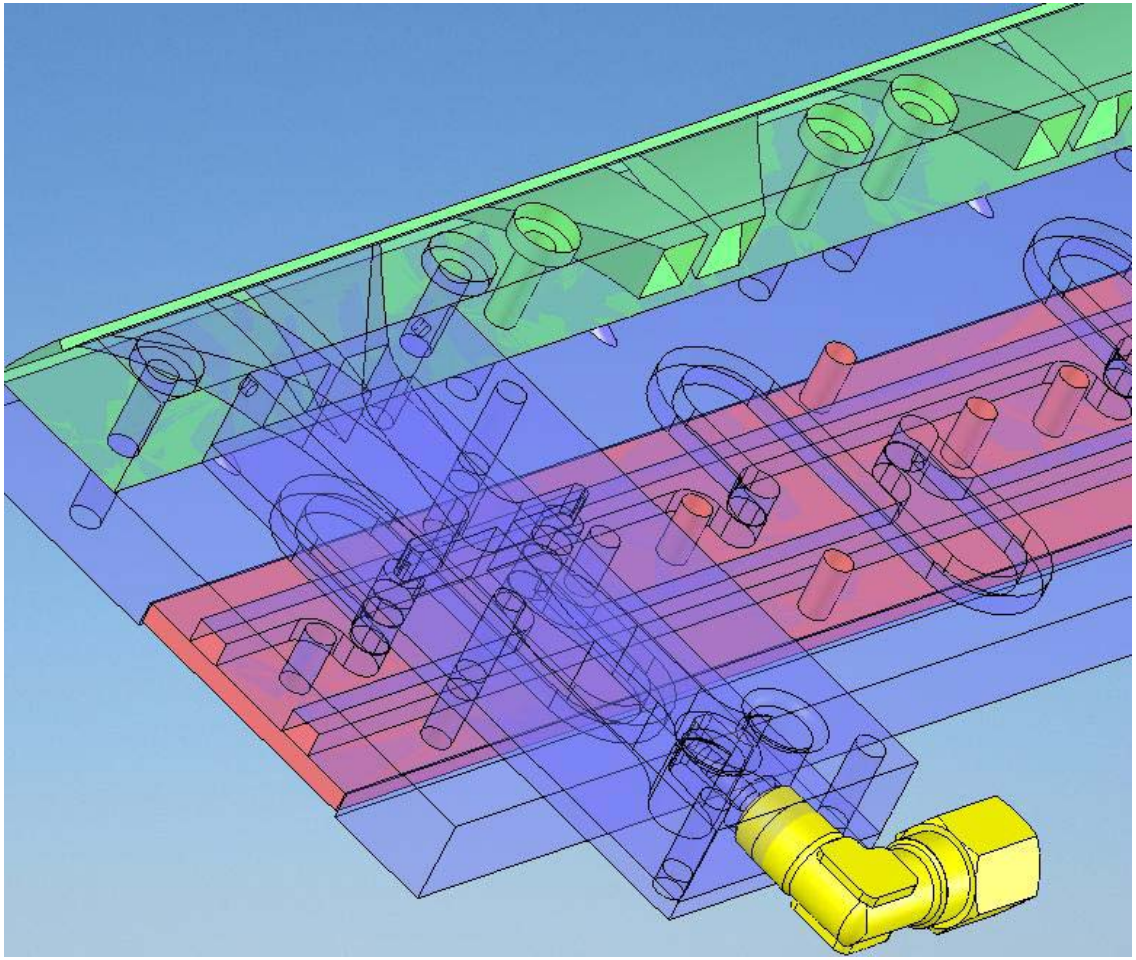
Tel Aviv University Device



Work Completed

Mechanical Design

Tel Aviv University Device

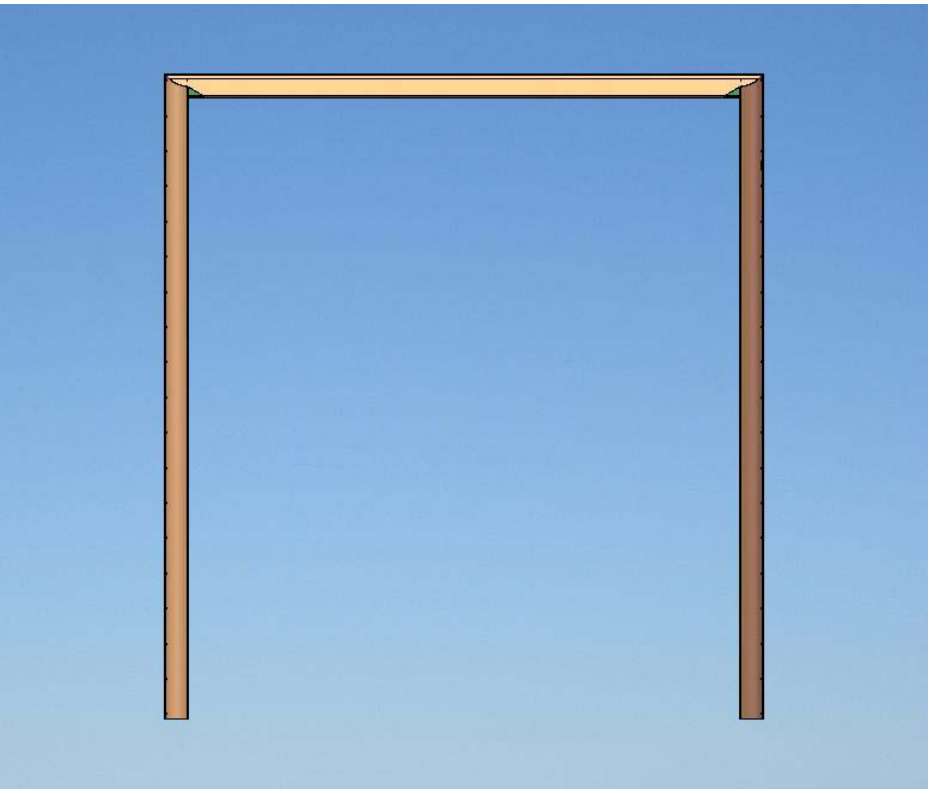


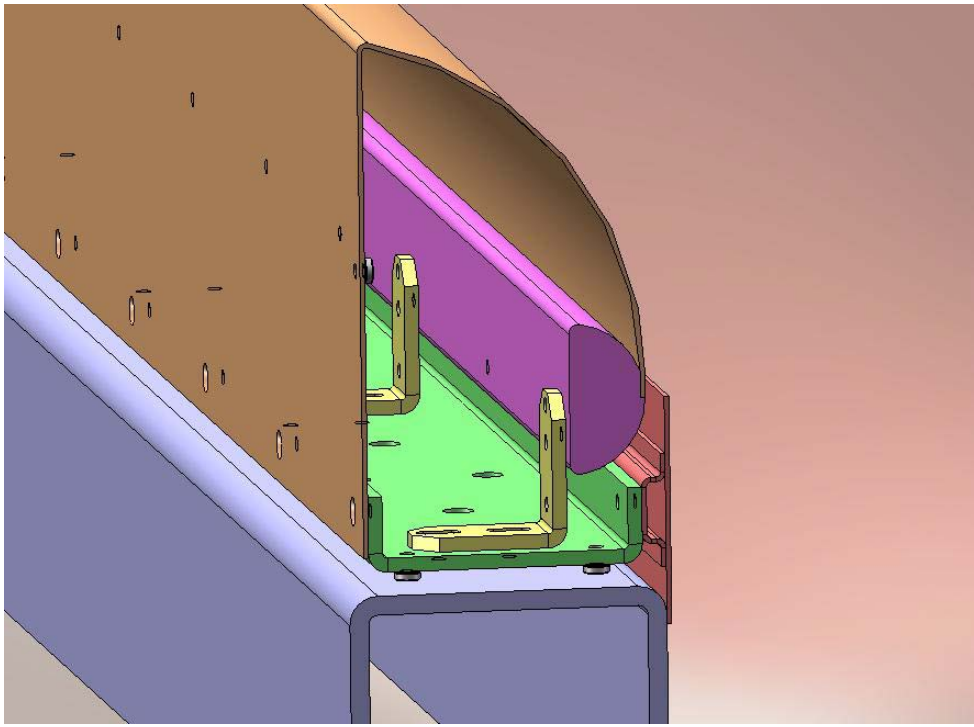
ATDynamics

Work Completed

Mechanical Design

GTRI Design



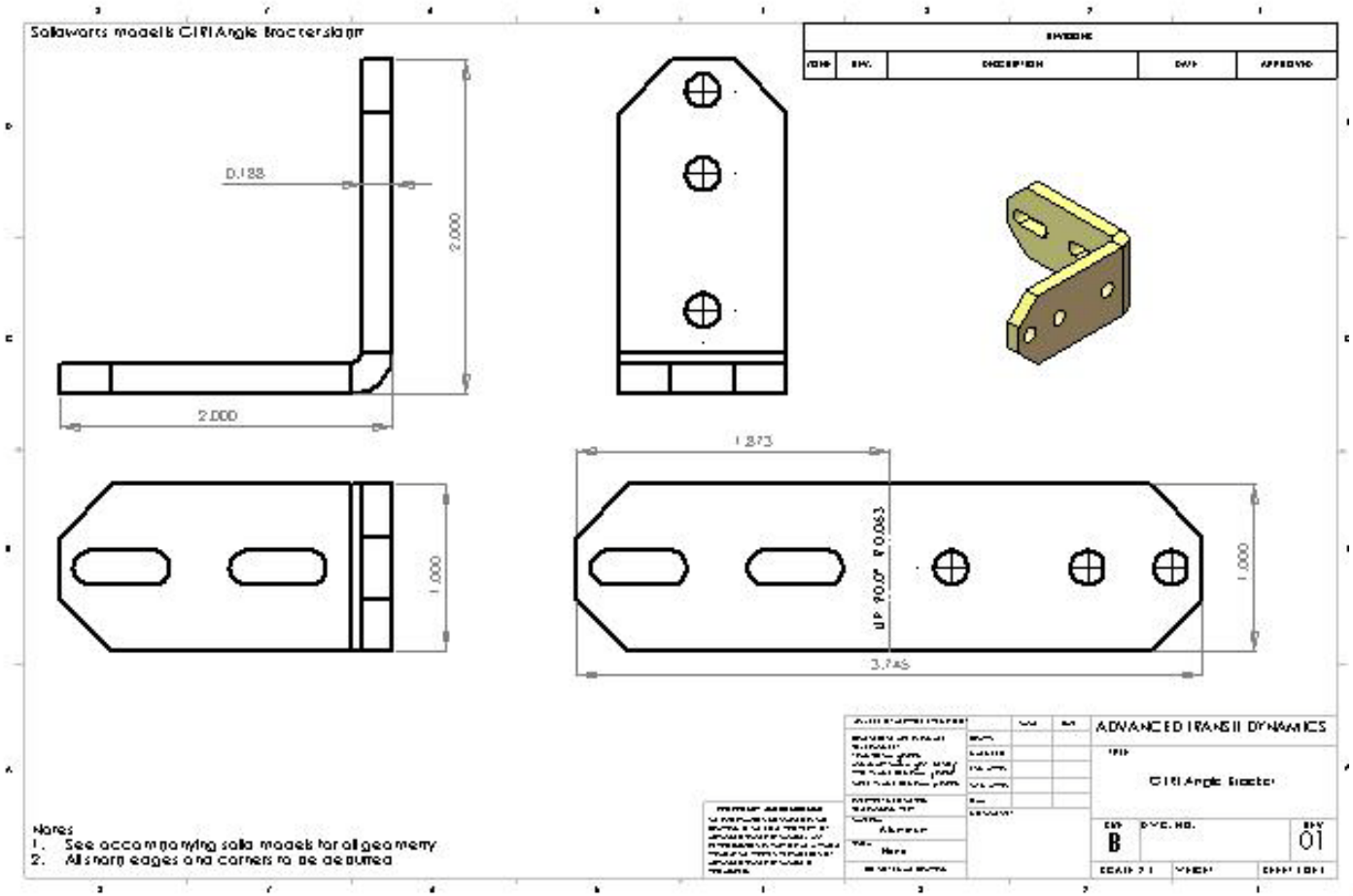


ATDynamics

Work Completed

Fabrication

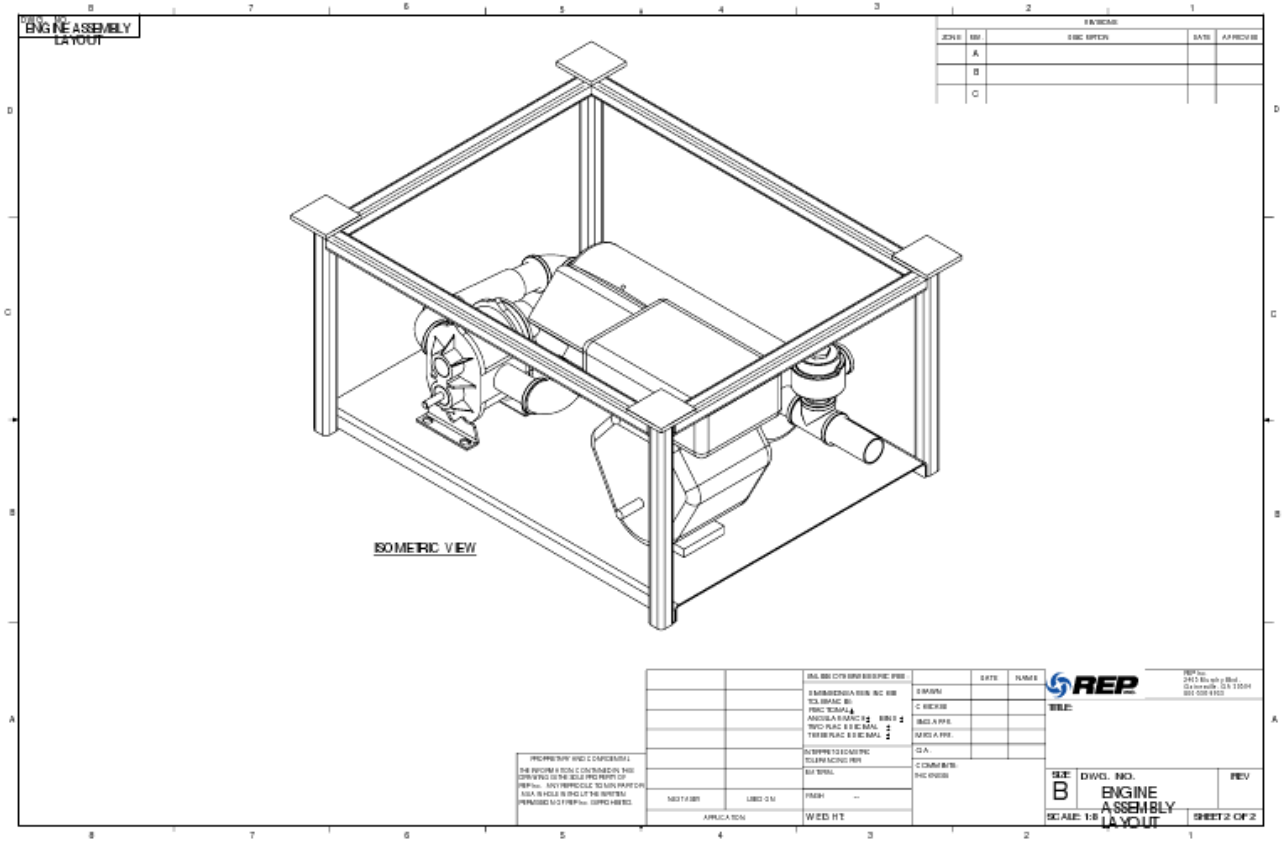
Prototype shop selection



Work Completed

Fabrication

Blower selection – TAU device



ATDynamics

Work Completed

Fabrication

Blower selection – GTRI device

ATDynamics

Track Testing

Schedule

- Test design completed after fabrication of devices was completed
- Testing itself took place the week of April 5th-9th

Location

- Goodyear Proving Grounds in San Angelo, TX
- Wal-Mart provided tractors and roll-door trailer
- CRST provided a swing-door trailer

ATDynamics

Track Testing

Day 1

1. Run GTRI test article with blower turned off on roll-door trailer (3 runs)
2. Baseline swing-door trailer (3 runs)

Day 2

1. Run GTRI test article configurations on roll-door trailer (4 runs)
2. Run baseline skirts on swing-door trailer (5 runs)

Day 3

1. Run full aero trailer configuration (TrailerTail and baseline skirts) on swing-door trailer (8 runs, 7 with winds outside of SmartWay envelope)
2. Run through various configurations of TAU test article on roll-door trailer (7 runs, 6 with winds outside of SmartWay envelope)

Day 4

1. Run full aero trailer configuration (TrailerTail and baseline skirts) on swing-door trailer (2 runs)
2. Run TrailerTail on swing-door trailer (7 runs)
3. Continue running TAU configurations with roll-door trailer (10 runs)

Day 5

1. Run advanced skirts on swing-door trailer (4 runs)
2. Baseline roll-door trailer (4 runs)

Testing

ATDynamics

Testing

ATDynamics

Testing

ATDynamics

Testing Results

	Test Configuration	% Fuel Saved	Comments
Active	GTRI test article, blower off	**1.48**	Test run to quantify effects of geometry of GTRI device
	GTRI test article, blower on	**0.19**	Does not account for fuel burned to power blower
	GTRI test article, blower on, with input fuel counted	**-8.78**	
	TAU test article, blower off	**1.81**	Test run to quantify effects of geometry of TAU device
	TAU test article, blower on, best configuration	**5.00**	This was with the blower at maximum pressure, outlet ports in position 2, rows 4 and 5 of suction holes uncovered
	TAU test article, blower on, best configuration, with input fuel counted	**-3.76**	With improvements to blower setup to increase pressure and efficiency, Dr. Seifert estimates we can get this to ~5%
Passive	TrailerTail only	**6.58**	

ATDynamics

Next Steps

Active Flow Control

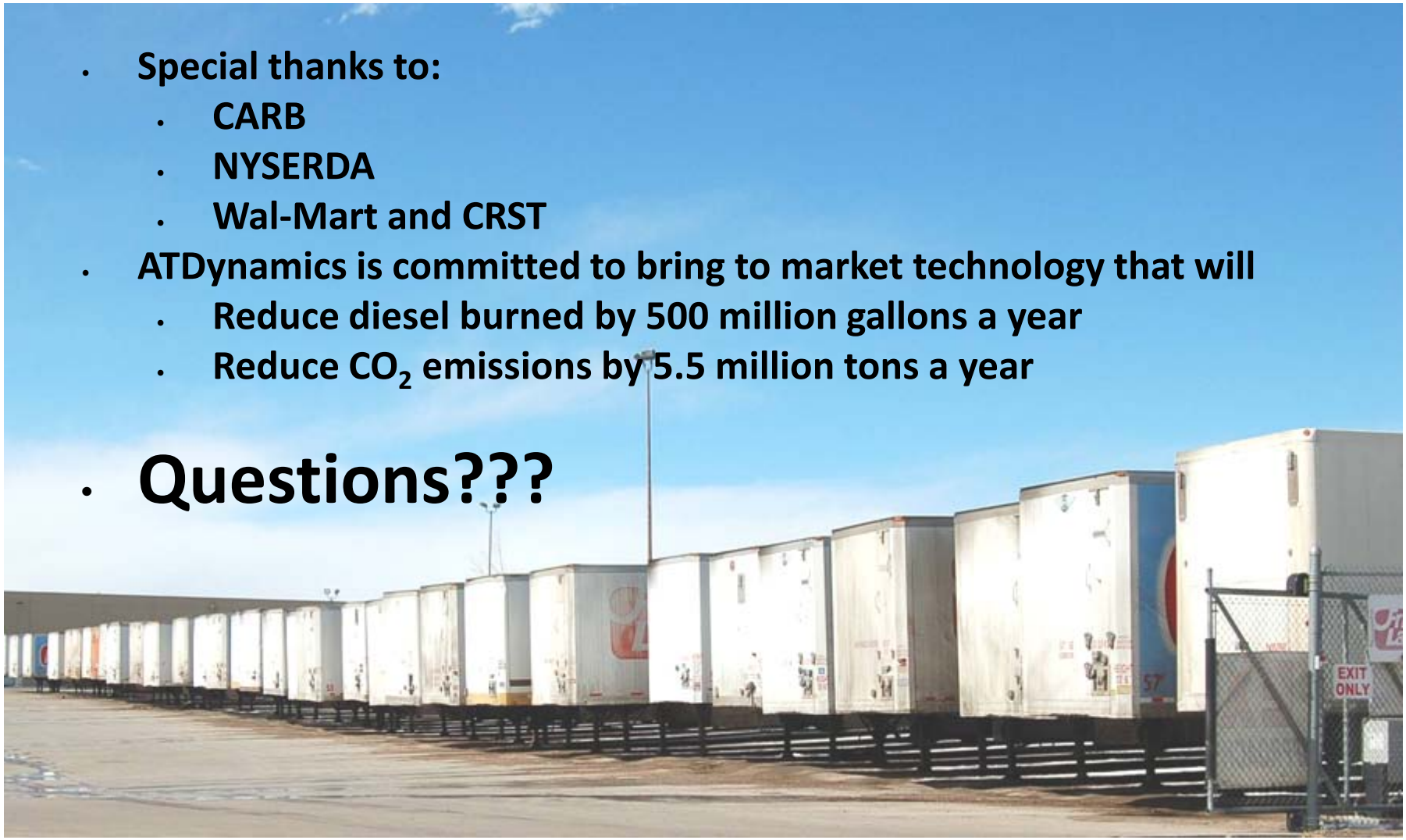
- Feedback given to GTRI and TAU
- Potential areas for improvement of TAU device identified
- Partnership formed with team from Europe and Israel to take next development steps with TAU technology

Advanced Passive Devices

- ATDynamics has upgraded design of 2011 TrailerTail – both durability and efficiency performance
- Commercial rollout of the TrailerTail is underway with forward-looking fleets
- New green jobs created in South San Francisco to meet current demand

ATDynamics

Conclusion



- Special thanks to:
  - CARB
  - NYSERDA
  - Wal-Mart and CRST
- ATDynamics is committed to bring to market technology that will
  - Reduce diesel burned by 500 million gallons a year
  - Reduce CO_2 emissions by 5.5 million tons a year
- **Questions???**

ATDynamics