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NATIONAL RENEWABLE ENERGY LABORATORY

Summary of NREL's Recent Class 8 Tractor Trailer Platooning Testing




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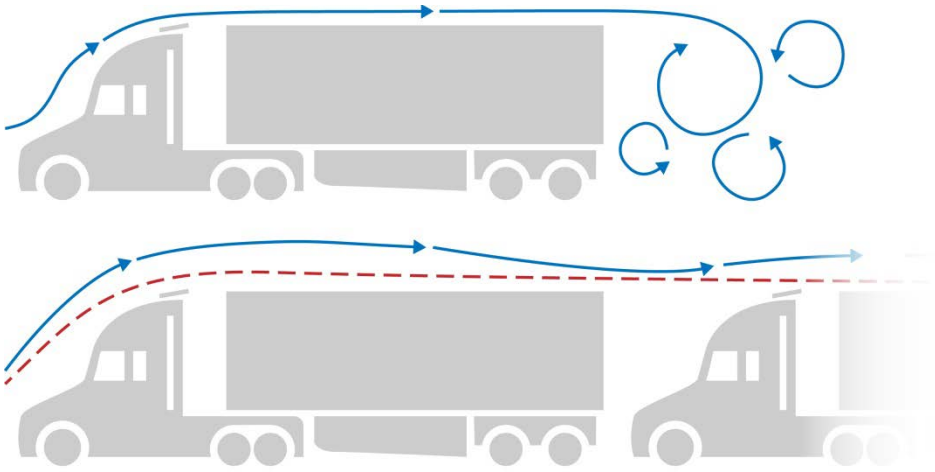
Project Objective

- Repeatable track testing to assess fuel savings potential from semi-automated truck platooning
  - Supported by DOE's Vehicle Technologies Office
  - SAE J1321 Type II Fuel Consumption Test Procedure
- Test American-style line haul sleeper cabs with modern aerodynamics
  - EPA SmartWay tractors; trailers with side skirts
- Test range of following distances, vehicle loadings and speeds common in the U.S. (up to 70 mph)

8.5-mile oval at Continental Tire Uvalde Proving Grounds *(© 2014 Google)*

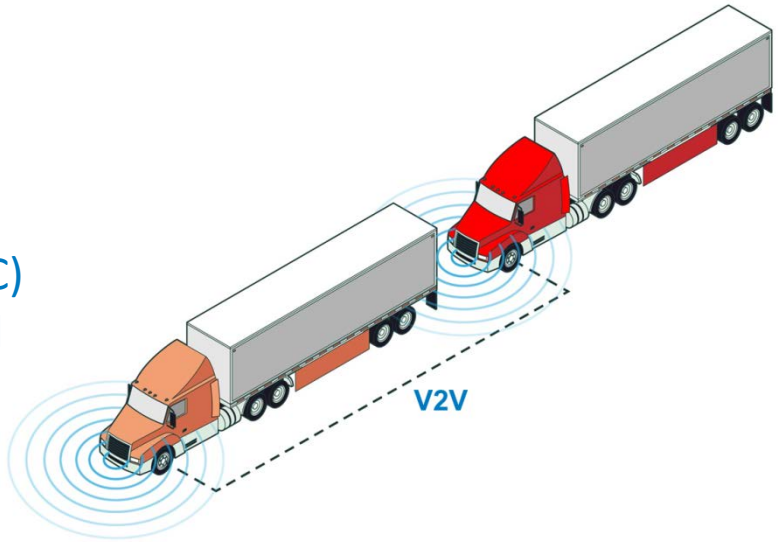


For Illustration Only

2011 Peterbilt tractors with 53-ft van body trailers
(Photo courtesy of Peloton, NREL 31236)

Platooning System Testing

- Demonstration system provided by Peloton Technology, Inc.
- Enabling technologies for platooning
  - Forward object detection (radar, laser, stereo cameras, etc.)
  - Dedication short-range communication (DSRC)
  - Vehicle-to-vehicle communications (V2V) and driver displays
  - Vehicle braking and torque control interface
- Testing details
  - Ten constant speed tests and one variable speed test
  - 20–75 ft vehicle gaps
    - 65 mph = 95 ft/s; 6-sec rule of thumb would give 570 ft following distance
  - Gravimetric fuel measurements with weigh tanks
  - J1939 data collection, including coolant temperature and fan state



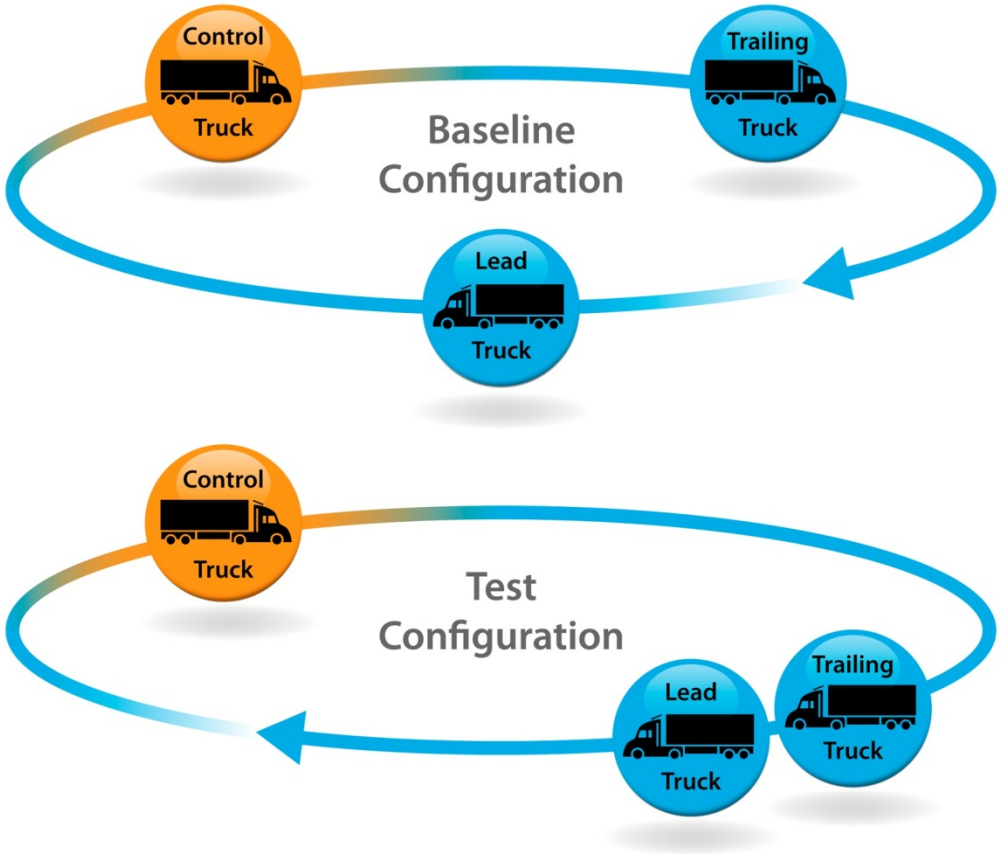
	Test Matrix				
Trailing Distance	55 mph, 65,000 lb	65 mph, 65,000 lb	70 mph, 65,000 lb	Variable Speed, 65,000 lb	65 mph, 80,000 lb
20 ft		X			
30 ft	X	X	X		
40 ft		X			
50 ft	X	X	X	X	X
75 ft		X			

Summary of SAE J1321 Type II Test Procedure

- Warm-up runs ensure all trucks at stable operating temperatures
- Control truck accounts for changes in atmospheric conditions between baseline and test runs

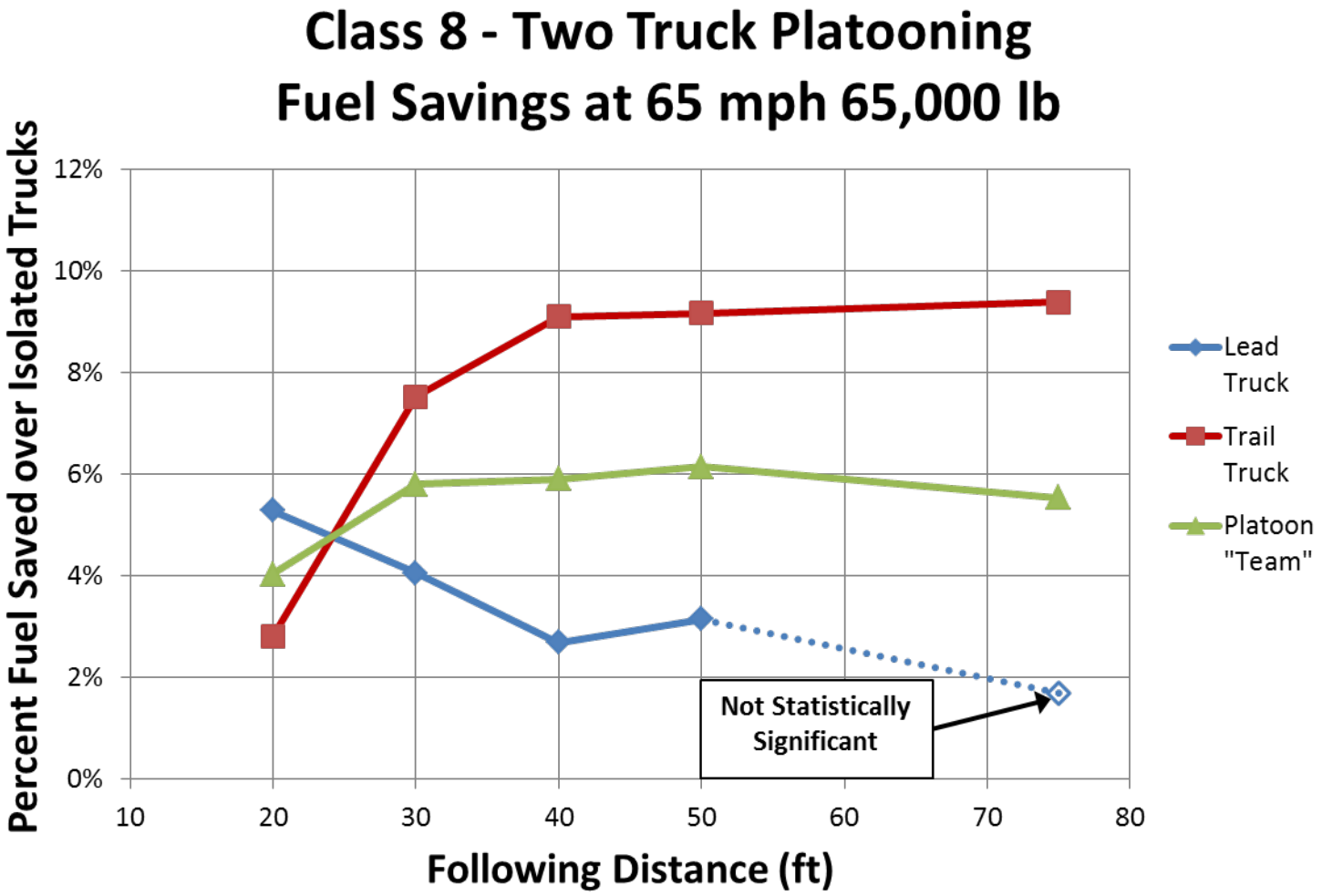
$$T/C\ ratio = \frac{Test\ vehicle\ fuel\ use}{Control\ vehicle\ fuel\ use}$$

$$\%\ Improvement = \frac{[T/C]_{Test}}{[T/C]_{Baseline}}$$



Results: Fuel Savings

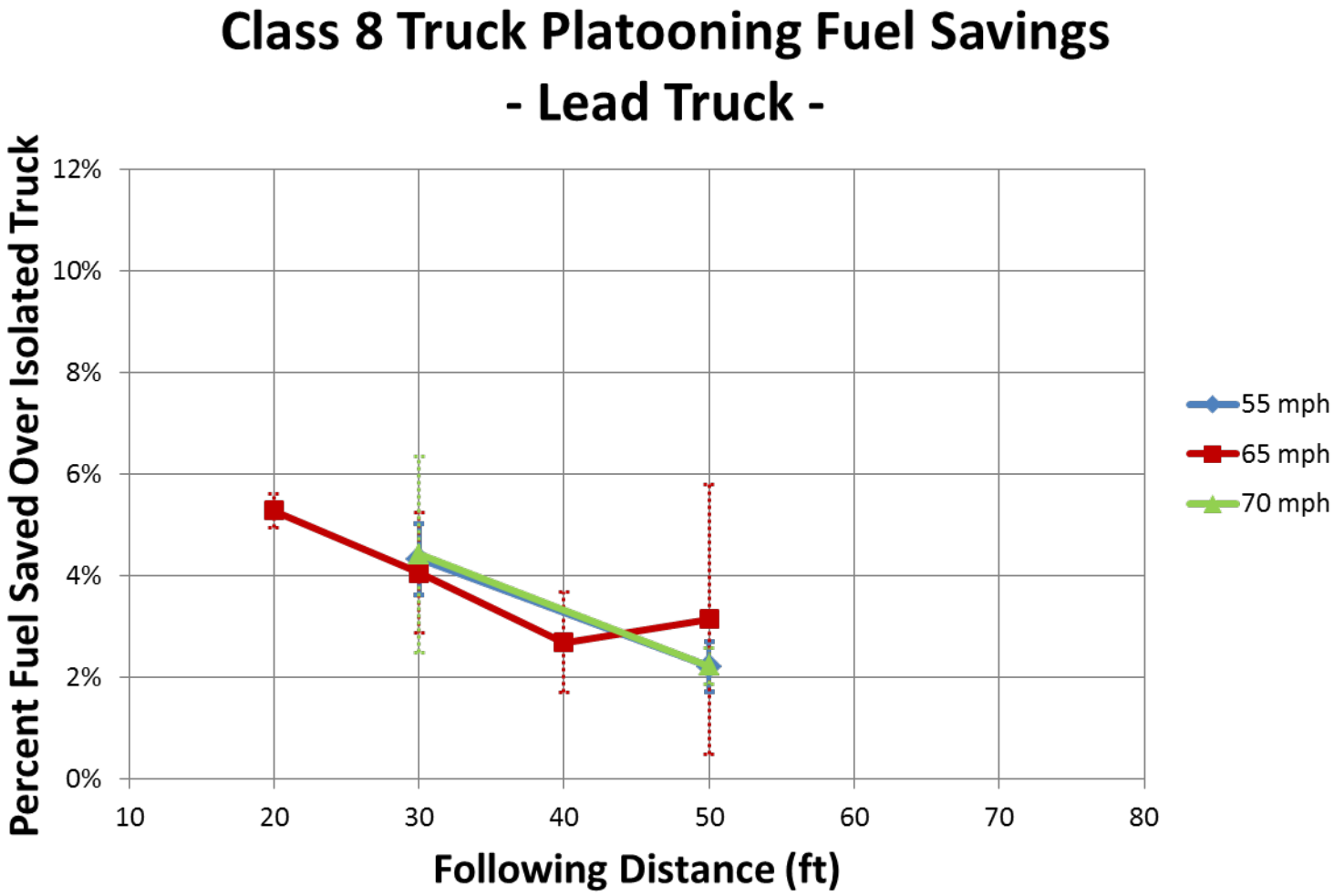
- Team fuel savings ranged from 3.7% to 6.4%
- Closer following distances caused the engine fan on the trailing truck to engage, negatively impacting fuel savings



Fuel Consumption Results: Individual Fuel Savings

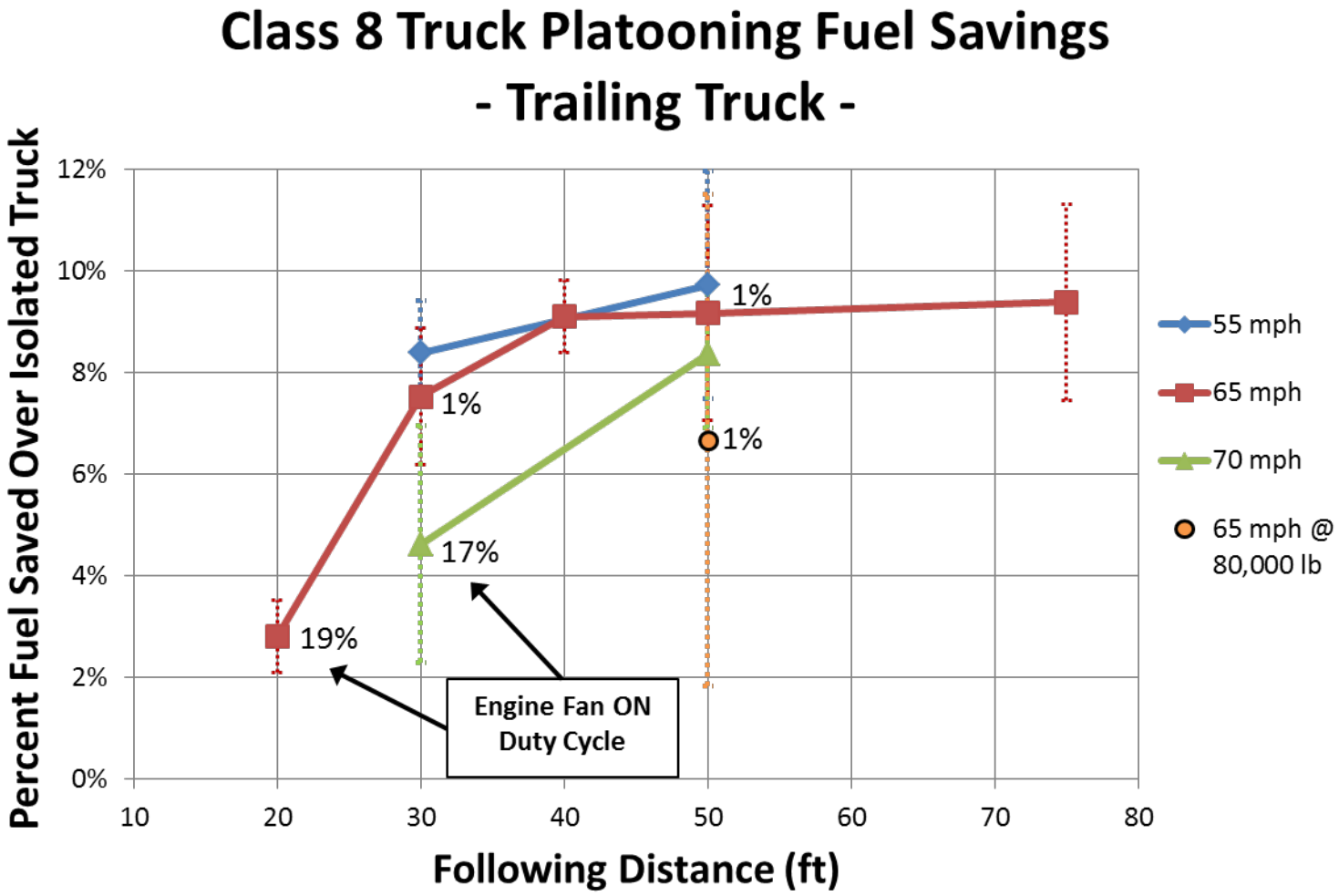
- 2.2% to 5.3% savings @ 65,000 lb GVW
- Shorter following distances consistently produced greater fuel savings

(95% CI bars are calculated with SAE J1321 software)



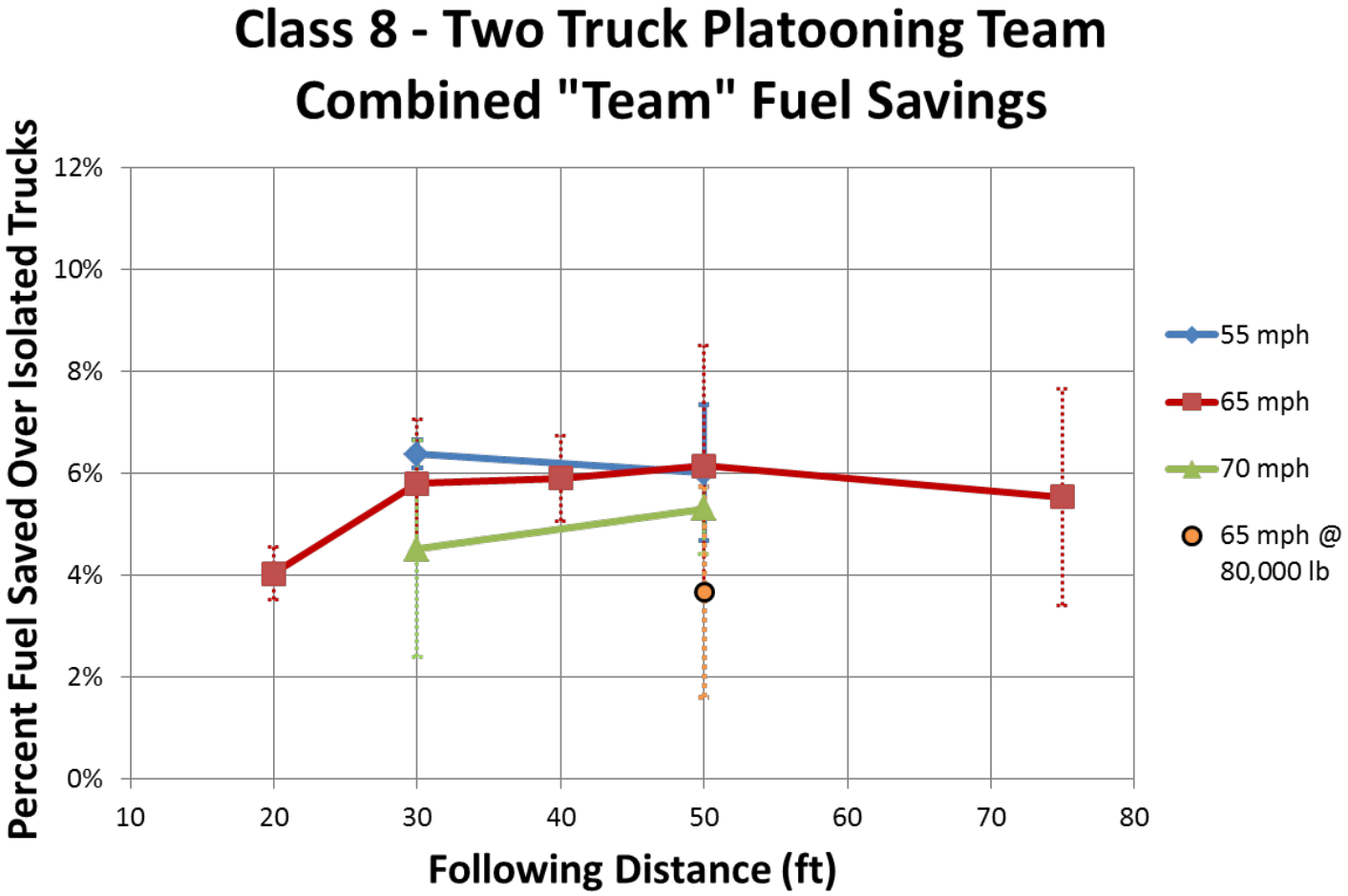
Fuel Consumption Results: Individual Fuel Savings

- Trailing truck demonstrated savings from 2.8% to 9.7%
  - Tests with no "fan on" time had savings of 8.4% to 9.7%
  - Fan duty cycle as high as 19%



Fuel Consumption Results: Team Fuel Savings

- Team fuel savings ranged from 3.7% to 6.4%
  - Best combined result was for 55 mph, 30-ft gap, 65,000 lb GVW
- Higher GVW negatively impacted fuel-saved percent
- Percent savings at 70 mph were lower than at 55 mph and 65 mph

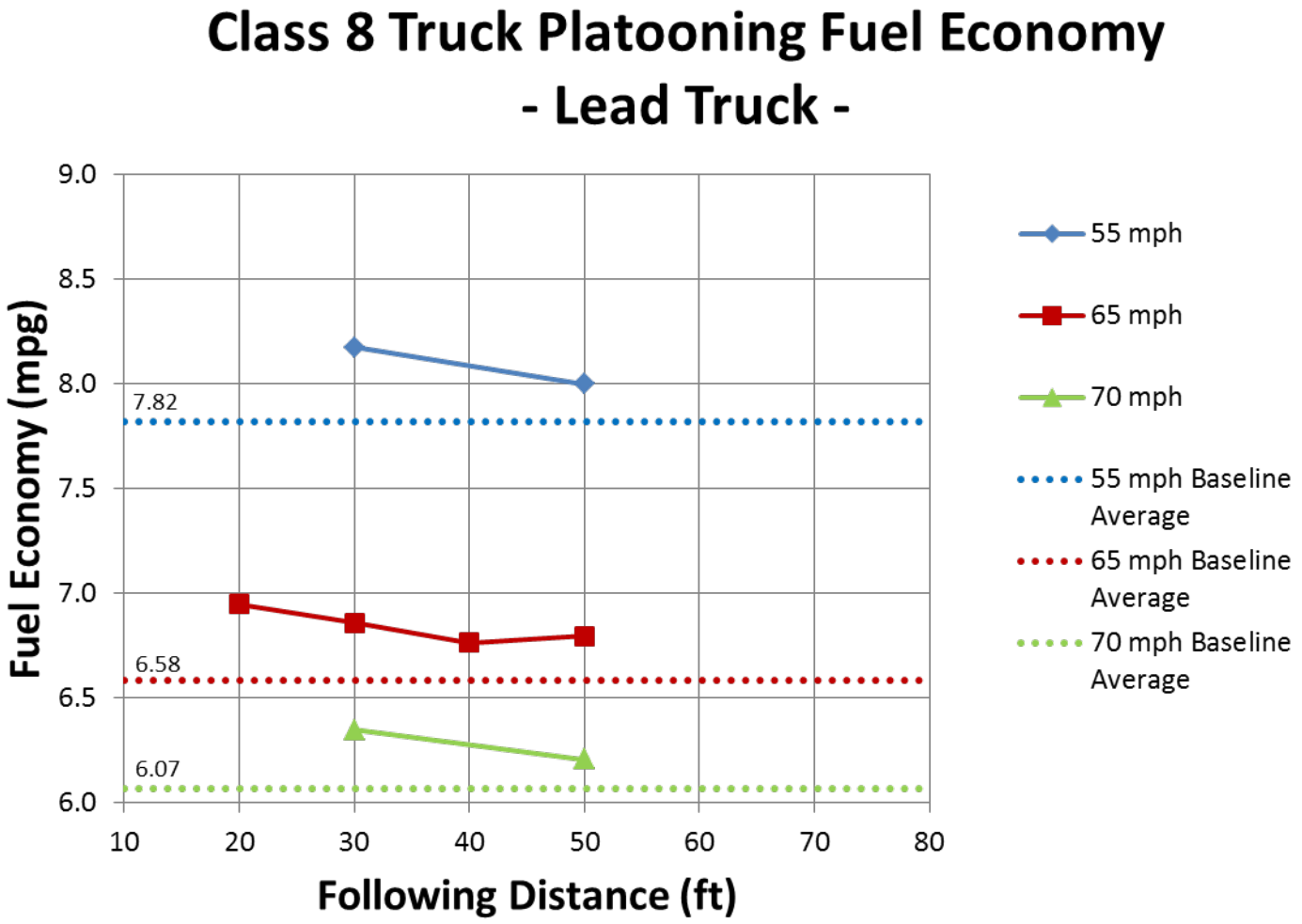


Fuel Economy Results

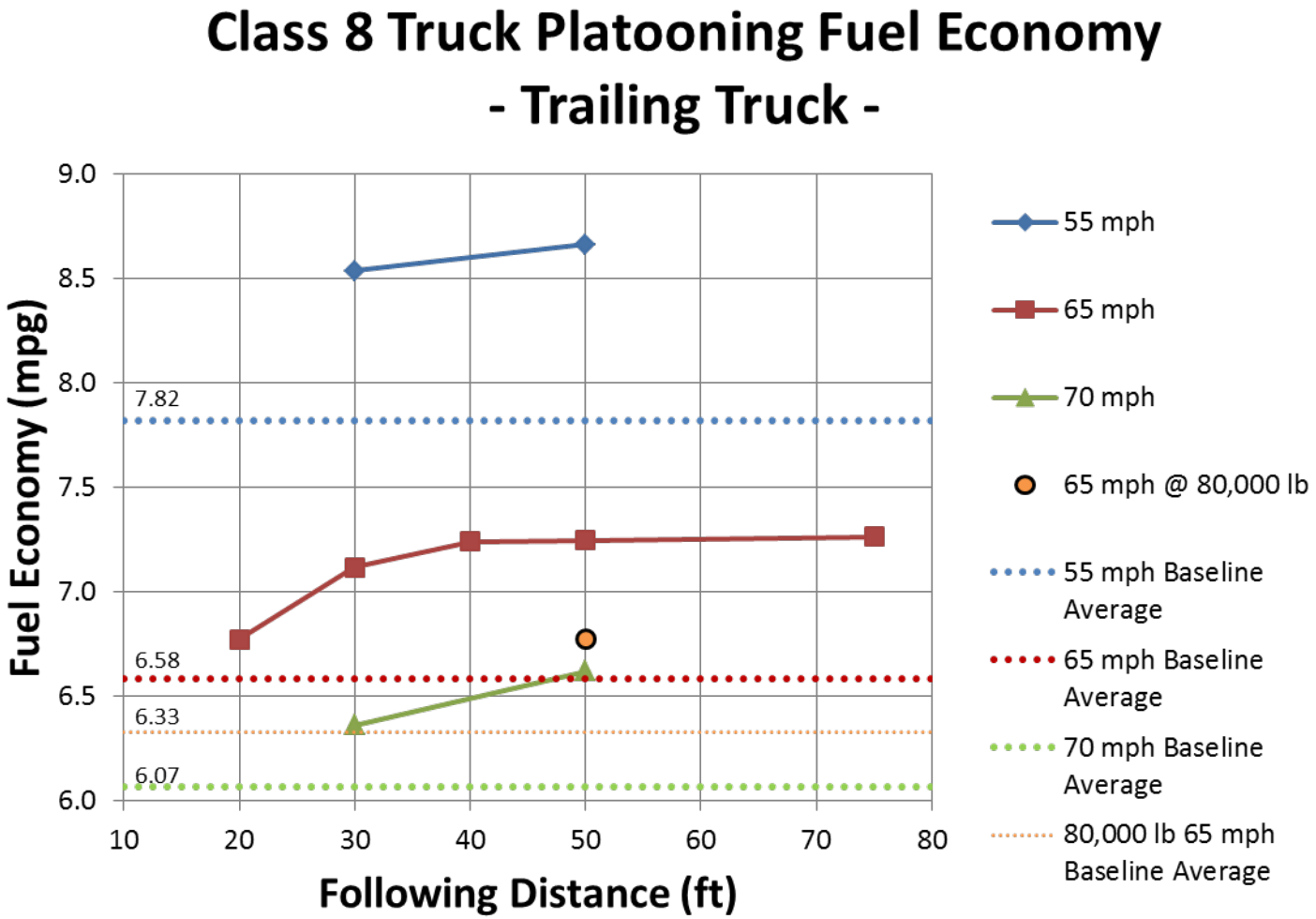
- ❖ Baseline mpg is the test distance of 59.4 miles divided by an average of all baseline run fuel-consumption results from both test trucks for each speed and load condition
- ❖ Platooning mpg is calculated by applying the SAE procedure calculated-percent fuel savings to the baseline fuel consumption average

- Platooning improved fuel economy at all speeds and conditions
  - Best mpg overall was platooning at 55 mph
- Baseline condition tests show effect of speed on mpg
  - 7.82 mpg @ 55 mph
  - 6.58 mpg @ 65 mph
  - 6.07 mpg @ 70 mph
- Baseline condition tests show effect of mass on mpg
  - 6.58 mpg @ 65 mph & 65,000 lb
  - 6.33 mpg @ 65 mph & 80,000 lb.

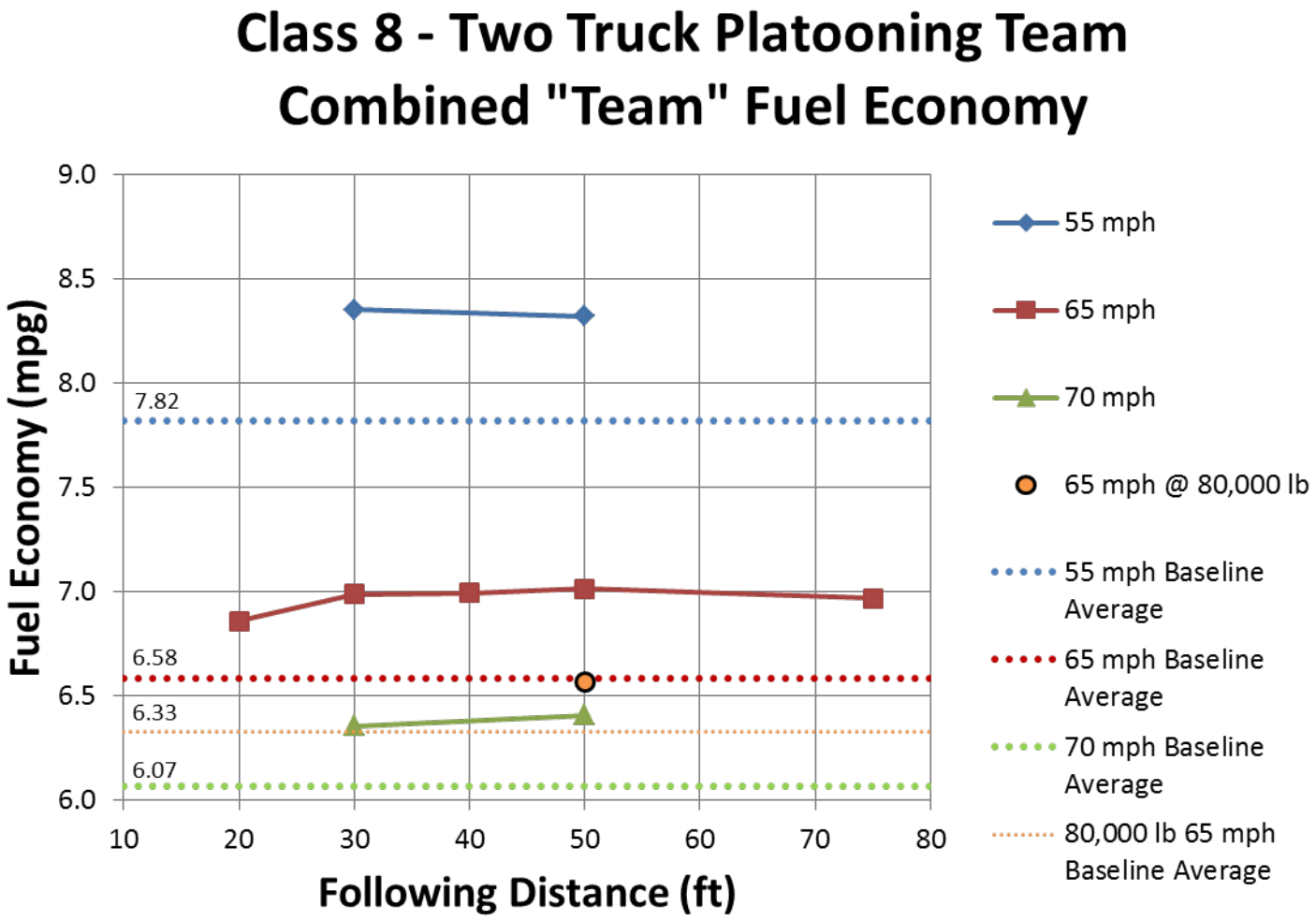
Fuel Economy Results: Lead Truck MPG



Fuel Economy Results: Trailing Truck MPG

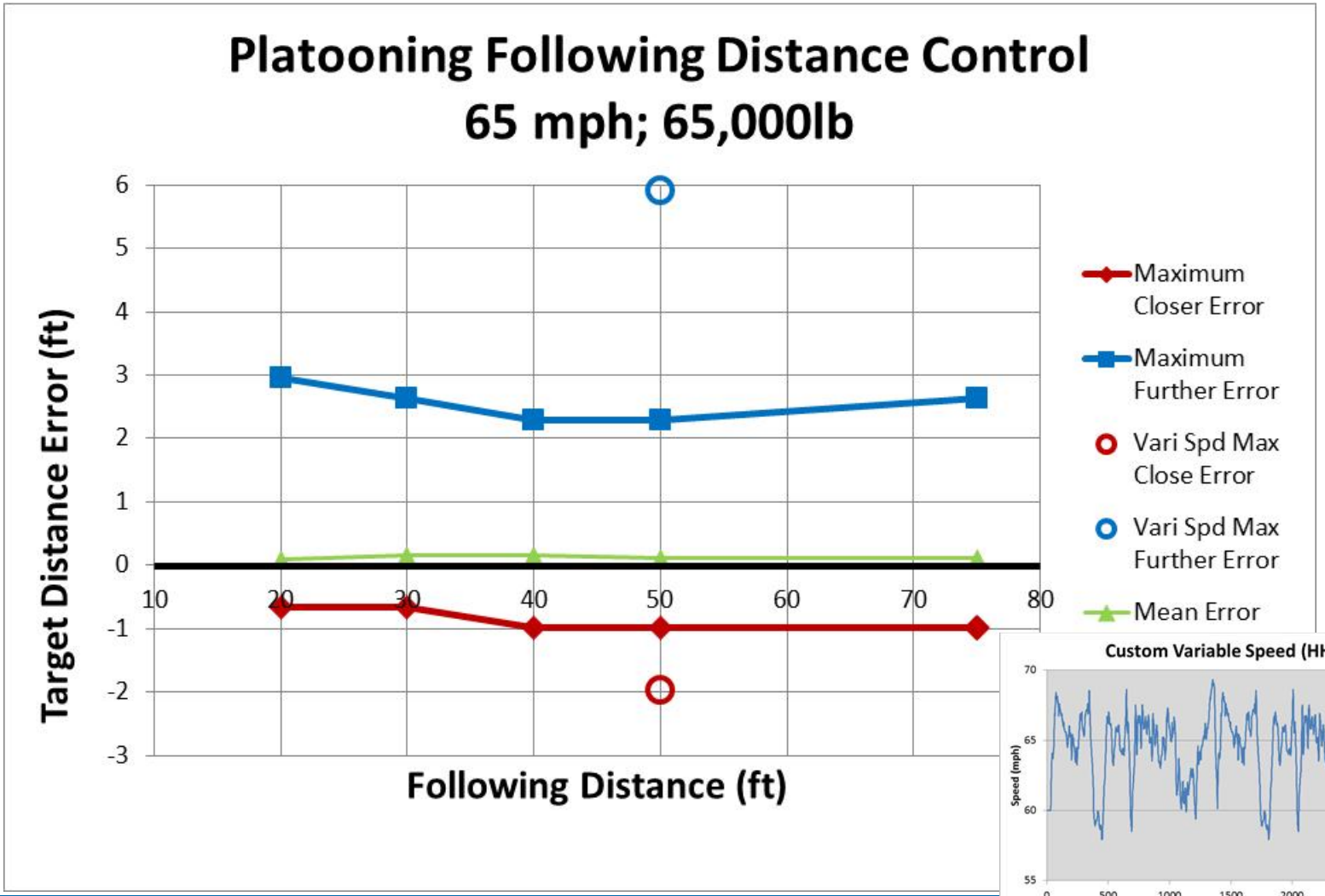


Fuel Economy Results: Team MPG



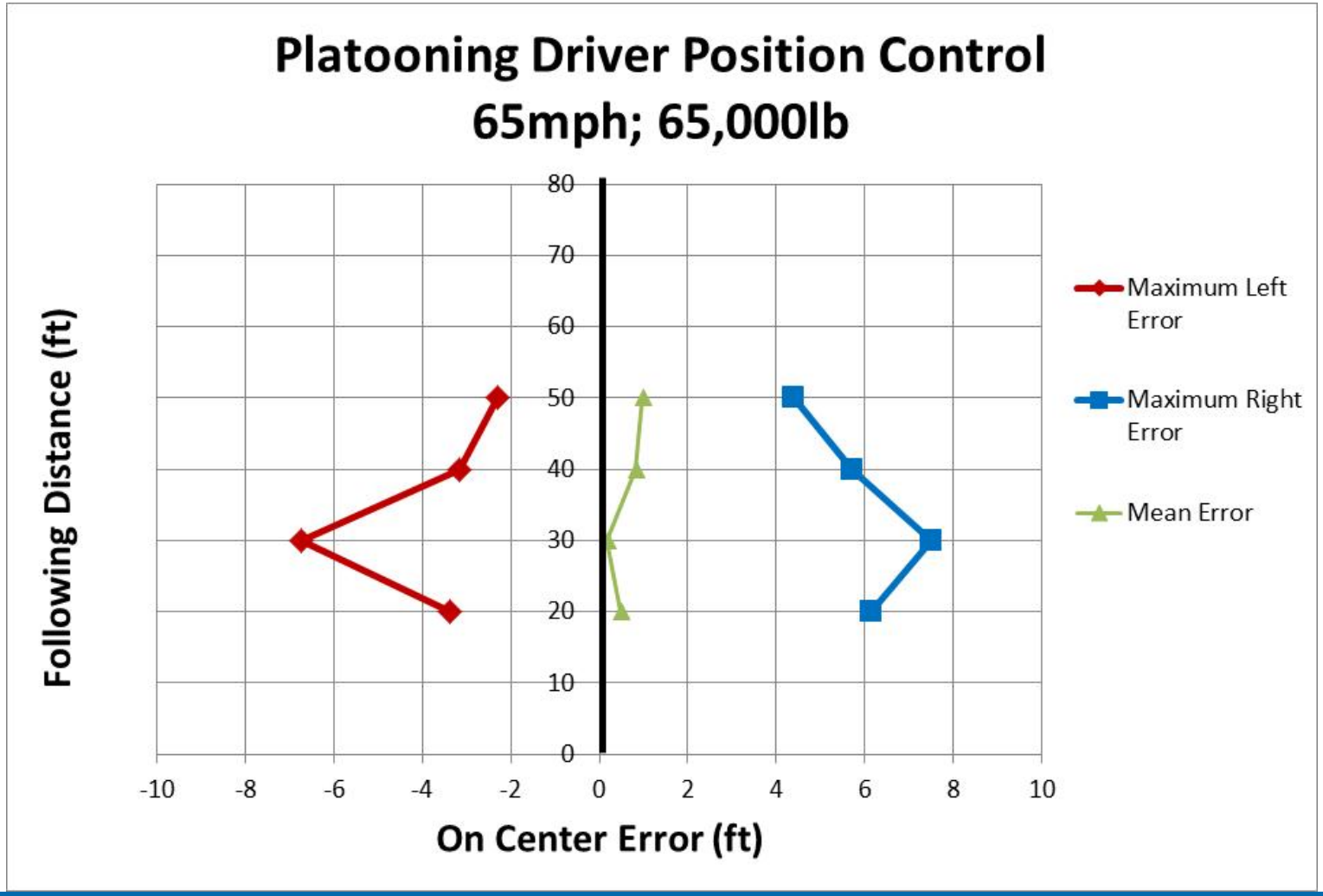
Platooning Following Distance Error

- Error biased to greater following distance
- Even aggressive variable speed test had minimal encroachment of following distance



Platooning Driver Position Error

- Driver error bias in consistent direction throughout testing
- Increased maximum error at 30’ could have reduced savings and was a test series run from 8-12PM after a long test day so fatigue / darkness could be contributing



Summary of Key Findings

- Significant line-haul fuel savings possible through platooning
  - Tests showed fuel savings for the lead (up to 5.3%) and trailing (up to 9.7%) trucks
  - The demonstrated "team" savings of 6.4% could be an attractive return on investment for a fleet
- Engine coolant temperature needs to be monitored/addressed for the trailing vehicle
  - Optimum following distance may depend on ambient temperature and vehicle load (absent some aerodynamic aid for radiator air flow)
- Heavy payloads affect the percent improvement from platooning, but still result in substantial fuel savings

Full details from present study will be published:

- At SAE COMVEC in October 2014 (paper number 2014-01-2438)
- In an NREL technical report in late 2014

Potential Future Work

- More data points/test sets to confirm the trends seen here
  - Including greater following distances to clarify the optimum configuration
- Incorporate direct aerodynamic study into track testing (truck-mounted anemometer, smoke trails, etc.)
- Complementary computational fluid dynamics modeling
- Test platoons of more than two tractor trailer combinations
- Further analysis including assessments of current line-haul travel
  - What percent of national line-haul miles would be conducive to platooning?
  - How often trucks typically travel together and at what following distance?
- Design aerodynamic aids specific to platooning to address the loss of cooling airflow over the radiator for the trailing tractor
- Assess any impact of platooning on criteria emissions (e.g., NO_x)

Acknowledgements

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Thanks! Questions?

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