NASEO: Truck Platooning

Mike Lammert

National Renewable Energy Lab

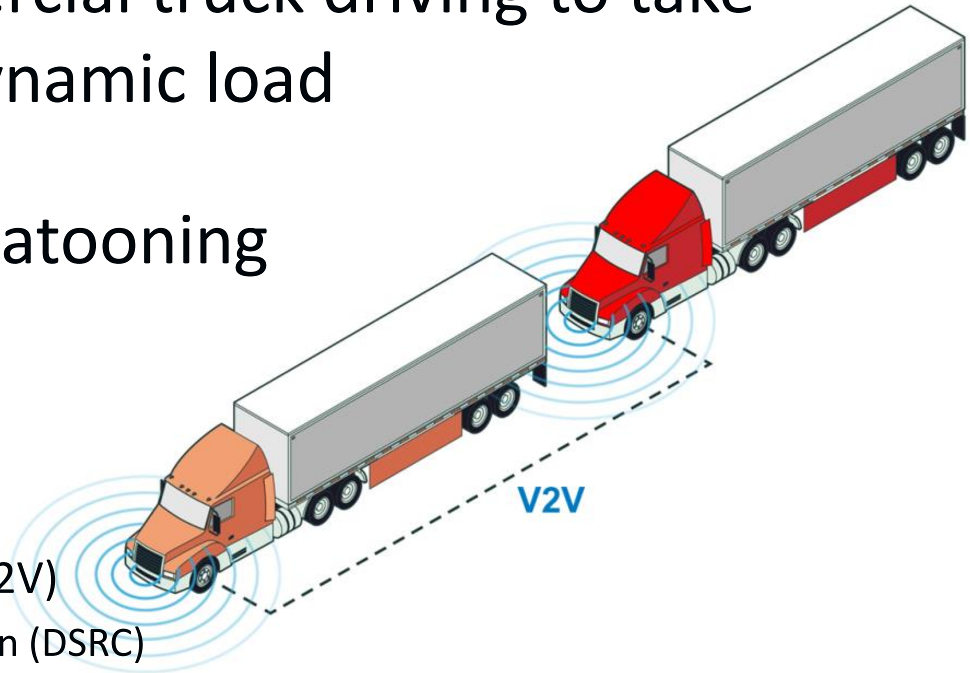
Only National Laboratory Dedicated Solely to Energy Efficiency and Renewable Energy

- Leading clean-energy innovation for over 35 years
- 1800 employees with world-class facilities
- Campus is a living model of sustainable energy
- Owned by the Department of Energy
- Operated by the Alliance for Sustainable Energy
- Energy Systems Integration Facility – newest national "users facility on NREL campus"

What is Platooning?

- Electronically linked commercial truck driving to take advantage of shared aerodynamic load

- Enabling technologies for platooning
  - Forward object detection
    - Radar
    - Lidar
    - Stereo cameras
  - Vehicle-to-vehicle communications (V2V)
    - Dedication short-range communication (DSRC)
    - 5G
  - Vehicle-to-infrastructure communications (V2I)
    - Cloud
    - Direct road way communication
  - Vehicle braking and torque control interface
  - Driver displays & communication interface



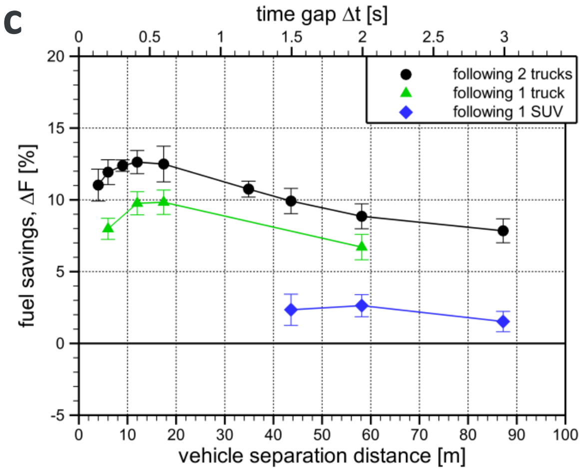
NREL Platooning Research

2014-2018

- Lead or been involved in 3 truck platooning track testing campaigns
- 2 National Impact of platooning Big Data studies
- Correlation of LLNL wind tunnel platooning studies to track studies
- Reanalyzed Volpe "naturalistic" truck driving behavior as relevant to background platooning
- https://www.nrel.gov/transportation/fleettest-platooning.html
- ARPA-E NEXTCAR advanced platooning team
- DOE Fuel Efficient Platooning FOA teams

2017 Truck Platooning Track Test Campaign with LBNL & NRC

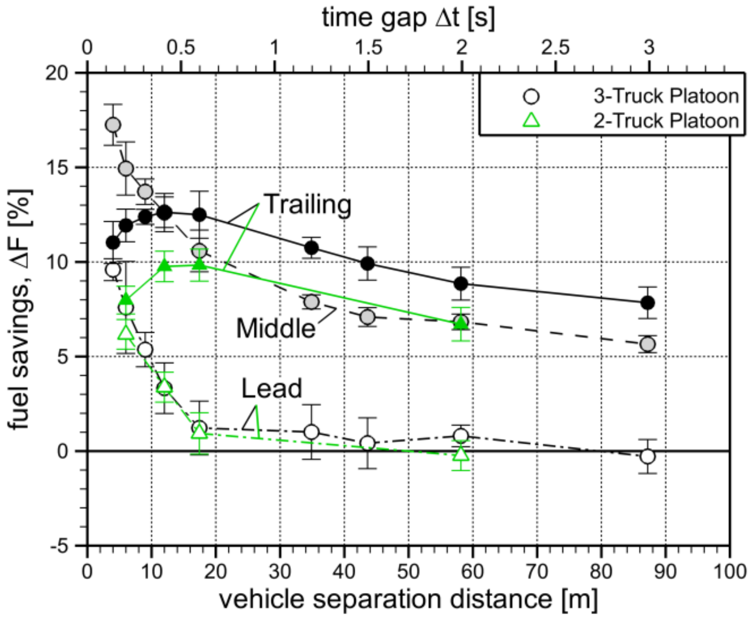
- 2017 Truck Platooning Track Test Campaign with LBNL & NRC
  - 26 two & three truck platooning scenarios investigated
    - Aerodynamic sleeper cabs, side skirts and trailer tails were tested
    - SAE J1321 gravimetric fuel measurement procedures
    - J1939 data collection
    - Additional wind/temperature/torque sensing on all trucks
    - Paper presented at SAE World Congress Experience April 2018 with LBNL & NRC
  - Findings match remarkably well to previous NREL & Auburn U. track testing and LLNL wind tunnel findings
  - **Confirms question on true "baseline" of trucks in traffic today**
    - 2% individual truck savings following compact SUV
    - 5-9% trailing truck savings at over 140' behind tractor trailer

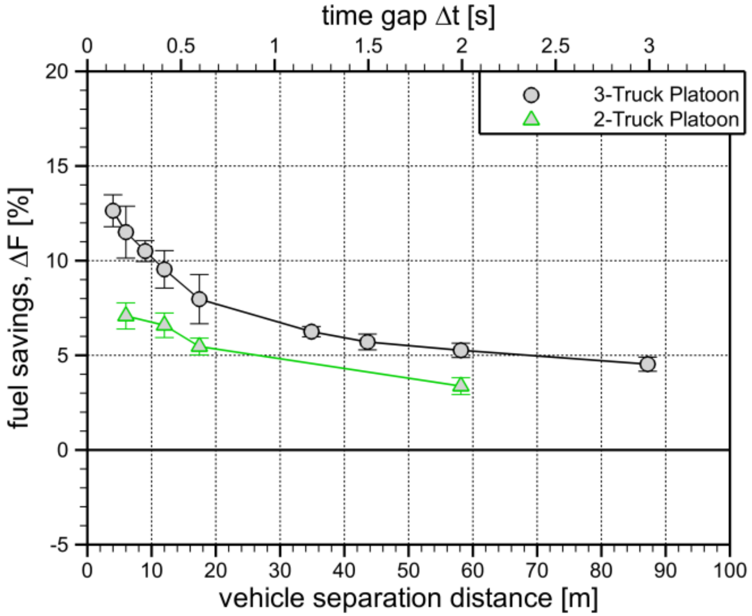


2018 Paper Gravimetric Data Results

Two and three Vehicle Platooning results.

- Lead vehicles experience the same savings pattern
- Trailing vehicles experience the same savings pattern, including reduced savings at close following, but 3 vehicle system has larger savings for trailing vehicle
- Middle vehicle matches trailing vehicle of 2 vehicle platoon beyond 18m, but closer than 18m it has the pattern of the lead vehicle, but at higher savings
- Maximum Team Savings
  - 7% savings for 2 truck platoon team
  - 13% savings for 3 truck platoon team





2017 & 2018 Platooning "Big Picture" Papers

"Potentials for Platooning in U.S. Highway Freight Transport"

- Presented at SAE World Congress Experience April 2017
  - SAE Journal Publication
  - Over 3 million miles of high resolution data
  - Over 200 class 8 tractors
  - Vehicle Speed and time duration analysis
- **65.6%** of vehicle miles in this dataset can be considered to be platoonable.
- **76.6%** of vehicle miles from "early adopter" subset considered platoonable.

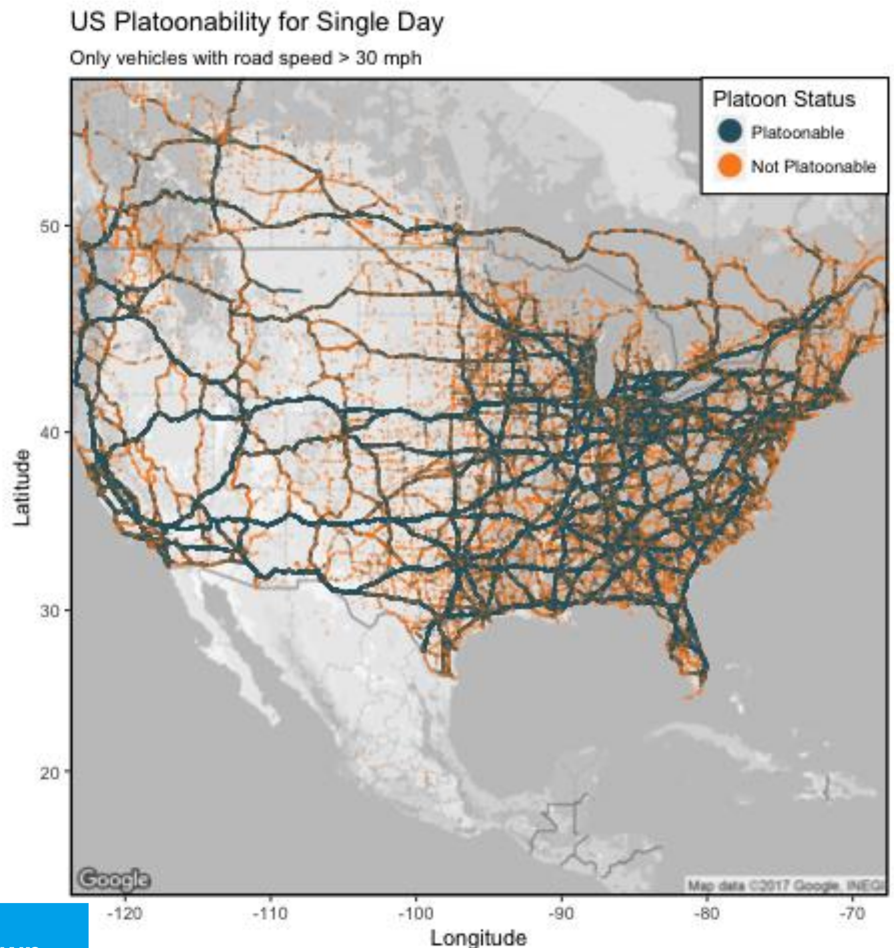
"Opportunities for Truck Platooning based on Telematics Data"

- Presented to SAE World Congress Experience April 2018 with Volvo Truck
  - Over 210 million miles telematics data provided by Volvo Truck
  - Over 57,000 class 8 Volvo tractors included
- Average Driving Speed Analysis Results
  - **63%** platoonable miles at 50 mph; matches well with previous analysis
  - Top 32% of trucks would account for 54% of the total platoonable miles
- Geospatial Partner Single Day Analysis Results
  - **55.7%** of all classifiable miles driven being platoonable (38% unknown)
  - Usually several partners are available if one is

2018 Paper Geospatial / Partner Method Results

Spatial distribution of platoonable observations with partner considerations

- highest regions of platoonability occur across major shipping corridors and interstate highways
- significant opportunity on Canadian shipping corridors
- 55.7% of all classifiable miles driven being platoonable

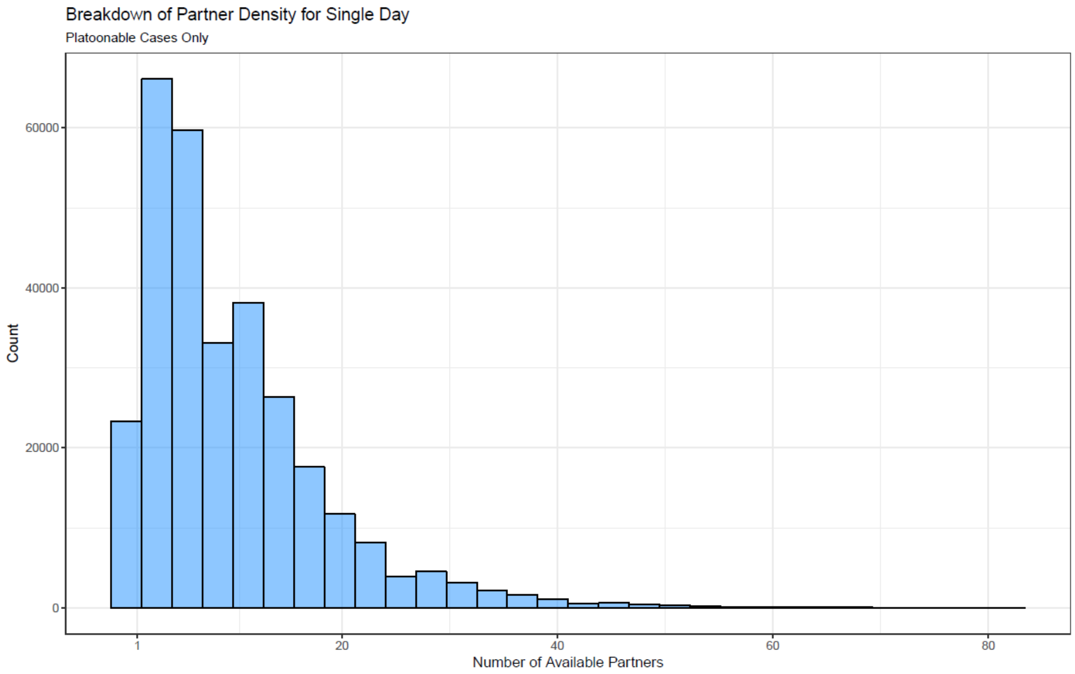


	Platoonable	Non Platoonable	Unknown
All Data	34.0%	27.4%	38.6%
Known Data Only	55.7%	44.3%	NA

2018 Paper Geospatial / Partner Method Results

Volvo platooning partners:

- Usually more than 1
- Peak around 3 partners
- mean of 10 partners
- Opportunity for 3 and 4 truck platoons needs to be investigated
- Even some level of fleet/technology incompatibility minimal impact on partner availability



So where are we now?

- European Truck Platooning Challenge
- Demonstrations in Michigan I-96, Washington DC, Colorado…
- Most truck OEMs have CAV truck demos
- Semi autonomous "driver assist" platooning is close to market ready
- Level 4/5 driverless systems are a long way off

So where are we now?

- 2018
  - Lots of platooning papers at SAE & TRB conferences
  - DOE Platooning FOA awards 3d: Fuel Efficient Platooning - - $2.5 million
    - Cummins
      - Advancing platooning with advanced driver assisted systems control integration and assessment
    - American Center for Mobility
      - Fuel-efficient platooning in mixed traffic highway environments
  - DOT FHWA
    - BAA- Truck Platooning Early Deployment Evaluation, Phase 1 - - $500K
    - Proposals currently being evaluated

Obstacles / Needs

- Technical
  - Sensor & controls refinement stage
  - System interoperability standards
  - Fleet/user cooperation savings sharing
- Regulatory
  - Where can I platoon & when?
  - Who decides?
  - What happens at state lines?
  - Law enforcement knowledge?

Obstacles / Needs

- Liability/Insurance
  - What happens if there is an accident?
- Driver acceptance
  - Sure it saves fuel – but do I know/trust the guy in the lead?
- Public acceptance
  - My mom would panic if she saw 3 trucks driving 20’ apart
  - Other drivers would cut right in between

Opportunity

- Maximum Team Fuel Savings
  - 7% savings for 2 truck platoon team ** about 5.5% to begin with
  - 13% savings for 3 truck platoon team

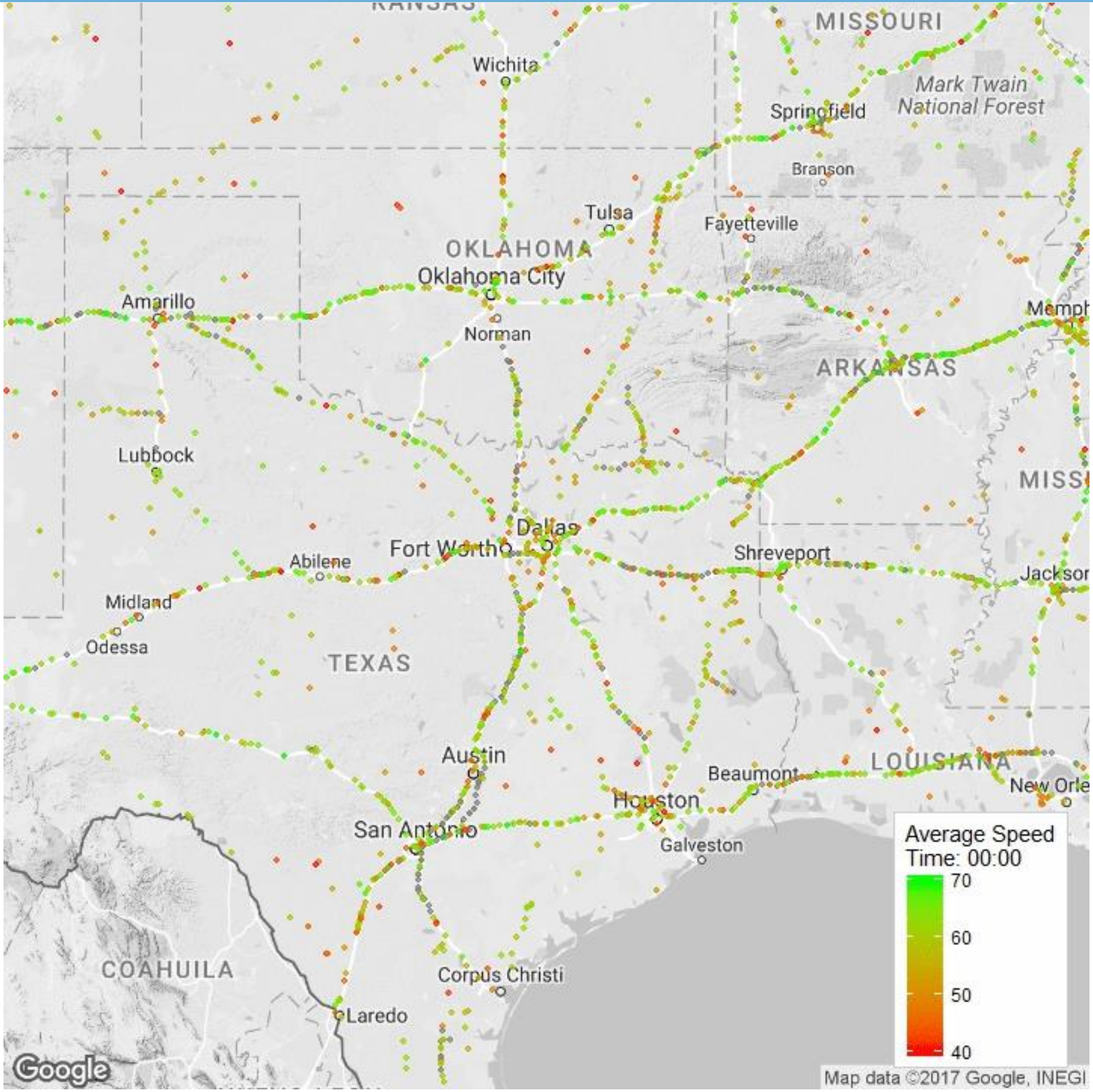
- Big Data Truck Average Driving Speed Analysis Results
  - **63%** platoonable miles above 50 mph; matches well with previous analysis
  - Top 32% of trucks would account for 54% of the total platoonable miles
- Geospatial Partner Single Day Analysis Results
  - **55.7%** of all classifiable miles driven being platoonable (38% unknown)
  - Usually several partners are available if one is
  - ****Data set limitations; some fleets could be much higher****

- Safety increase from connectivity & synchronized braking

Opportunity

Truck speed distribution over time

2018 Telematics Big Data Paper Average Driven Speed Results



Opportunity

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