



Peloton

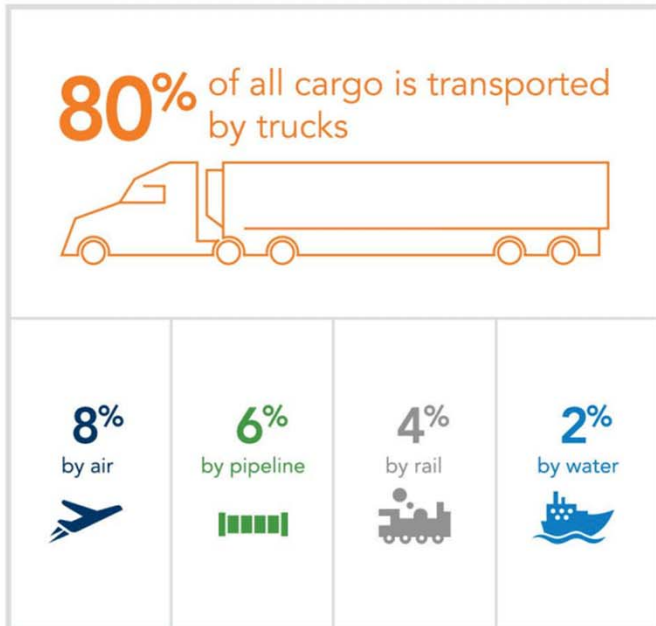
Peloton Technology

Overview on Driver-Assistive Truck Platooning

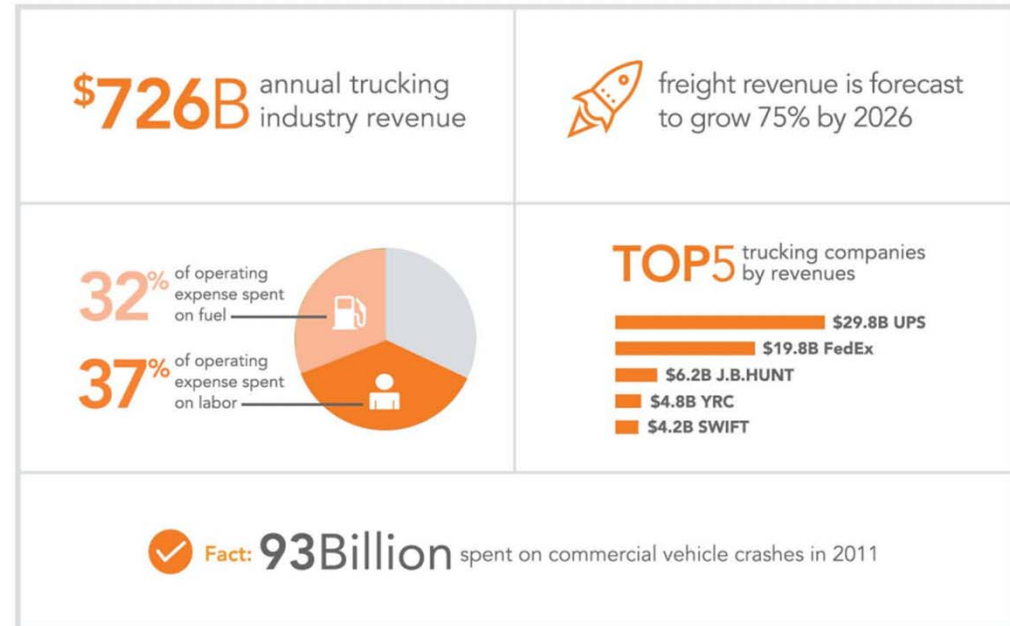
Illinois Transportation &
Highway Engineering Conference 2019
February 26, 2019

Trucking Industry in the United States

TRANSPORTATION INDUSTRY



TRUCKING INDUSTRY

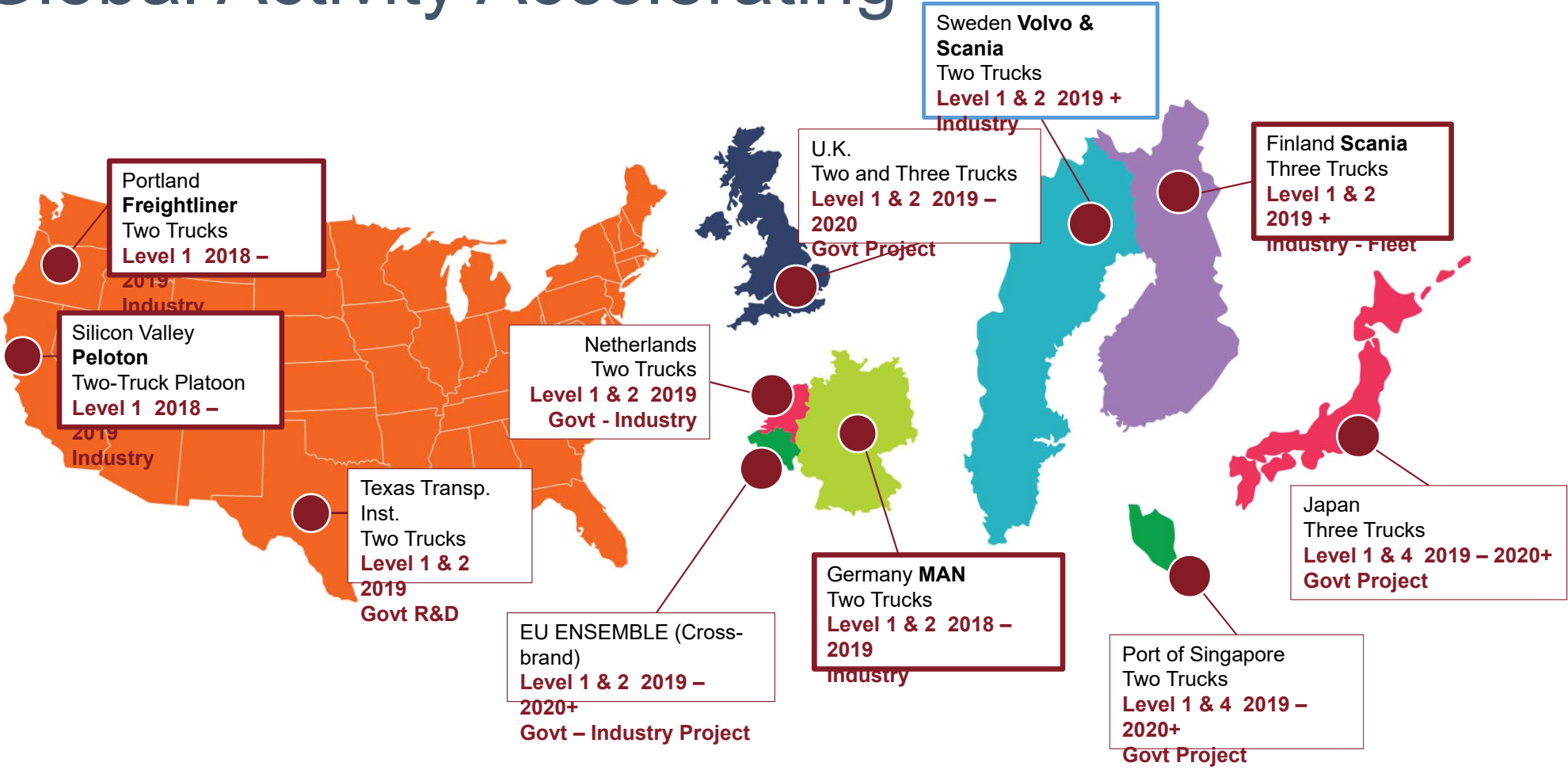


Market Overview: Freight Trucking Scale and Major Pain Points

- US Freight Trucking: **\$726 Billion in Revenues**
 - Fuel Cost: **\$100+ Billion (nearly 30 billion gallons of fuel)**
 - **34%+** Operating Costs
 - Crash Cost: **\$93+ Billion**
 - Crash Congestion: **113 million gallons of fuel**
 - Typical Fleet Net Profit: **3% or less**

-
- Preventing Accidents
 - Saving Fuel
 - Improving Mobility
 - Improving Decisions
- =
- Enhanced
Fleet Economics
& Safety

Global Activity Accelerating



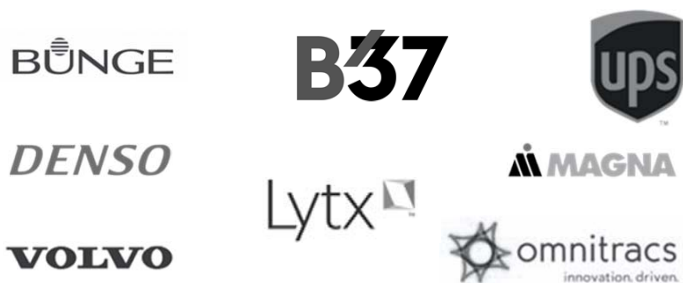
Driver-Assistive Truck Platooning Market Overview

Many Companies in US, Europe and Asia Testing or Bringing Truck Platooning to Market



Peloton Investor Base Supports and Reflects Pragmatic Approach

TRUCKING & TRANSPORTATION



ENERGY & INDUSTRIAL



TECHNOLOGY



FINANCIAL INVESTORS

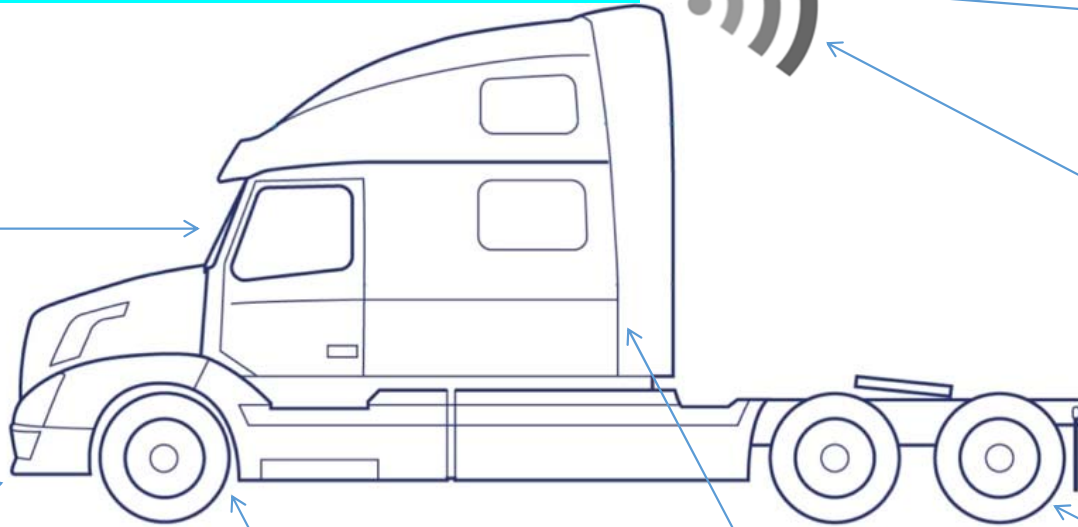


AND VALUED PRIVATE INVESTORS

We Start by Requiring Best-In-Class Safety on Each Truck

Our Focus: Make Each Truck Safer At All Times

Improved driver awareness & teamwork: shared video, dedicated radio, over-the-horizon alerts



Vehicle-to-Cloud Connectivity

Vehicle-to-Vehicle Communications

Collision avoidance and LDW systems always on

Air Disc Brakes, Electronic Stability Control

Continuous Safety Monitoring

Predictive Maintenance

Importance of Improving Truck Safety



- From NTSB: In 2012, over 1.7 million rear-end crashes
 - almost half of all 2-vehicle crashes
 - 1,705 fatalities and over half a million injuries
- Highway end-of-queue crashes involving commercial vehicles (often with fatigued or distracted drivers) are particularly deadly, such as the 2015 I-16 tragedy in Georgia.

Collision Avoidance Systems can prevent many crashes

- Commercially available radar-based **Forward Collision Avoidance and Mitigation (FCAM)** Systems can dramatically reduce the frequency and severity of these commercial vehicle rear-end crash types.
- Studies have shown great results even for earlier version systems – and these did not brake trucks to a full stop like the new systems used in platooning.
- UMTRI - Con-way study:
 - 30 months w/ 12,600 tractors
 - **71% reduction in rear-end collisions**
- Volvo/USDOT study:
 - 3 years w/ 100 trucks
 - **80% of drivers preferred to drive w/ collision avoidance systems**
 - 37% reduction in conflicts/hardbraking situations that could lead to collisions

Bendix

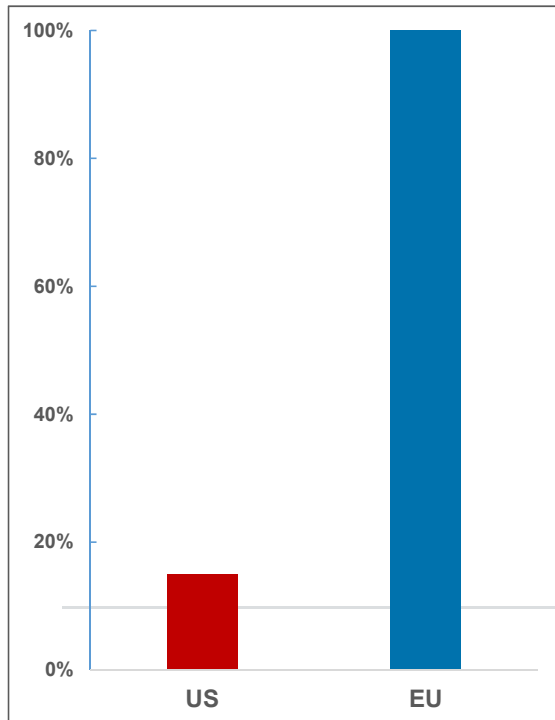

WINGMAN
Fusion™

MERITOR WABCO

OnGuard™
Collision Mitigation System

But Safety System uptake in US trucking has been slow

New Class-8 Trucks Sold w/ FCAM System



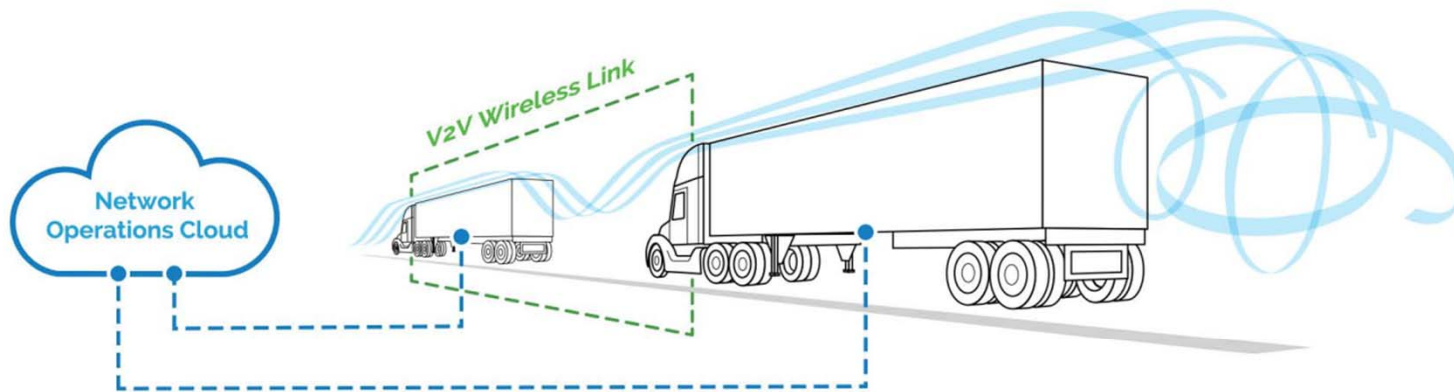
- EU regulations mandated FCAM systems on all heavy trucks starting in 2015, estimated to save 5,000+ lives per year.
- In US, Passenger car OEMs voluntarily pledged to make FCAM standard on all vehicles by 2022.
- No similar agreement on commercial vehicles in US, and years away from possible mandate.
- Systems can cost \$2-3k upfront and have hard-to-measure payback for fleets

Peloton's Platooning System Requires & Incentivizes Adoption of Best Safety Specs & Systems

- Trucks must have the latest FCAM systems, LDW and air disc brakes on tractors, along with Peloton's Platooning System, in order to platoon.
- In return for spec'ing tractors with FCAM, ADB, and the Peloton System, fleets are able to platoon and save fuel, creating a tangible economic benefit for adopting the latest safety equipment.



Peloton PlatoonPro: Driver Teamwork, Safety, Efficiency



Active Braking

Reduces the braking time from 1.5 seconds to approx 0.03 seconds

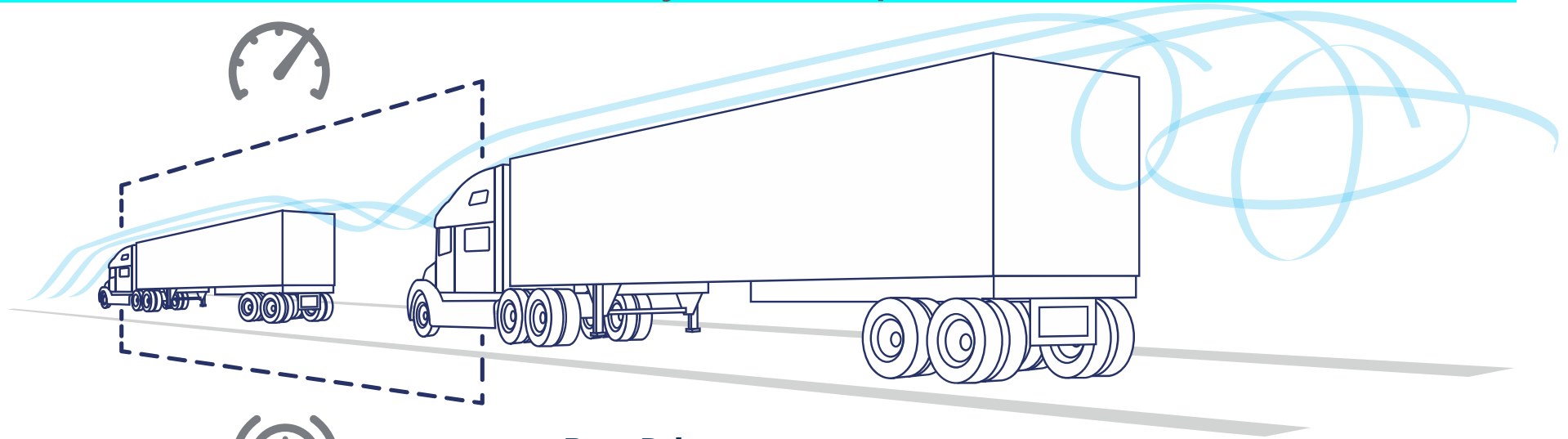
Platooning

- Active Braking Systems linked
- Both drivers steer
- Both trucks save fuel

Real-Time Cloud Supervision

Platooning only... • When safe • Where safe • How safe
Dynamic adjustment to conditions

Pairs of Trucks with Both Drivers Steering At All Times Enhanced Teamwork & Safety via Cooperative Collision Avoidance



Front Driver

- **Hands on**
- Feet on+ Collision Avoidance
- Eyes/Mind on

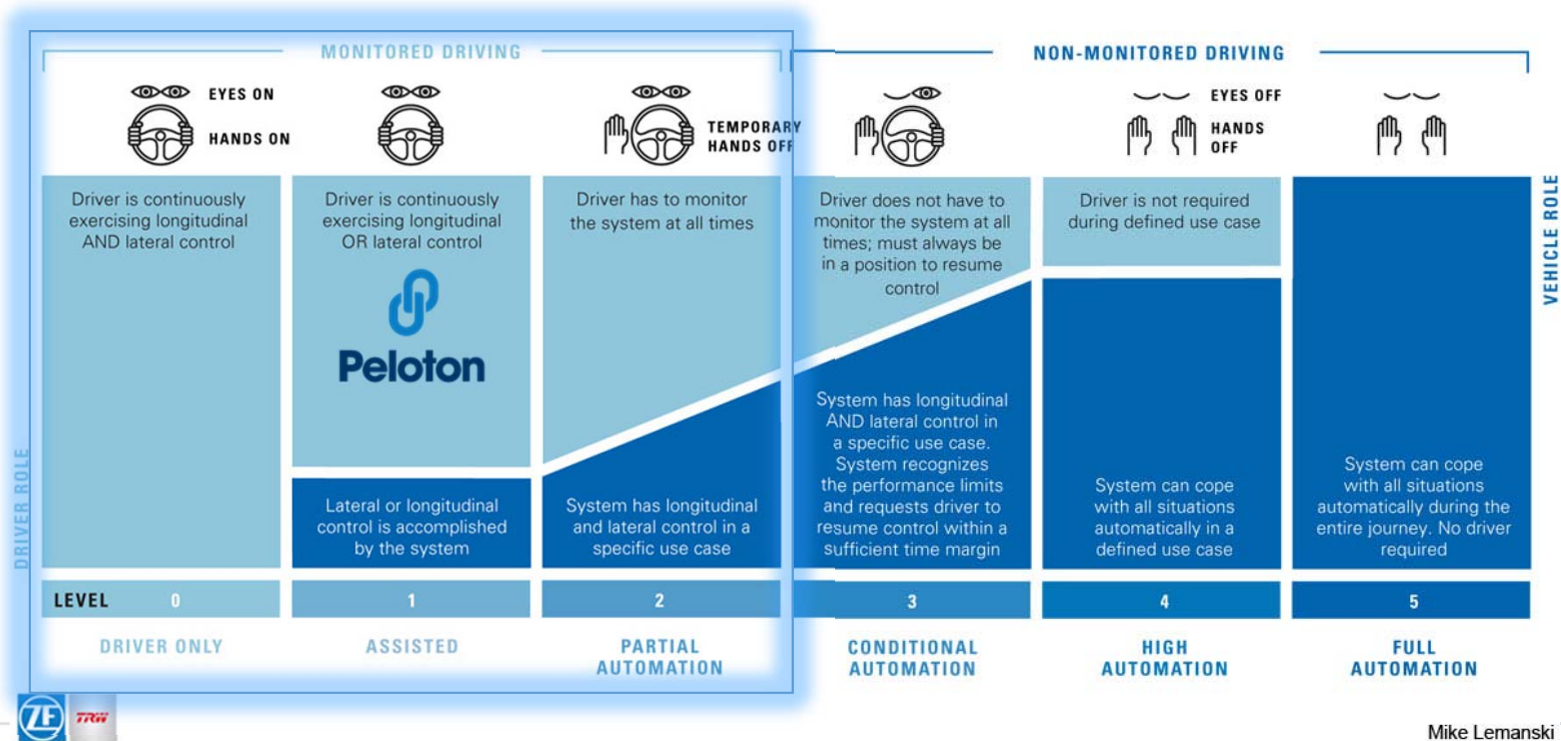


Rear Driver

- **Hands on**
- **Feet off + Collision Avoidance**
- Eyes/Mind on



PlatoonPro: Driver-Assistance -- Not High Automation



Mike Lemanski



Peloton System: Driver Teamwork Not “Self-Driving” Trucks

- All Drivers steering & in command at all times: L1 not Self-Driving
- Only Pairs of Trucks – not longer chains
- Integrated with OEMs
- Trucks require Best-In-Class Safety Systems
 - CMS, ESC, Air Disc Brakes on tractors
- Improved Driver Teamwork:
 - Dedicated driver radio link
 - Shared real-time video and linked safety
- Limited to Suitable Conditions:
 - Multi-lane, divided, limited access highways, in suitable weather and traffic.



Enhanced Driver Teamwork & Awareness

Real-time video forward driver's view

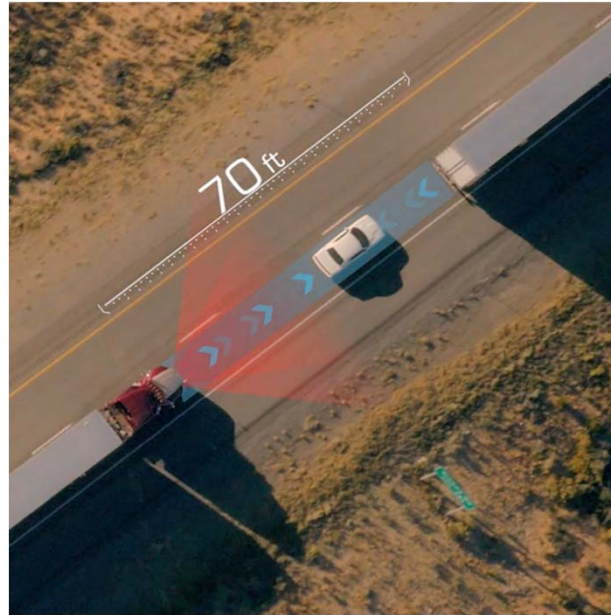
- Look-ahead view of road ahead for rear driver
- Dedicated push-to-talk radio for drivers to share information.
- Each driver looking out for the other.



Safety: Handling Vehicle Cut-ins



Driver sees car cutting in and backs off
OR



If driver does not respond, system radar detects cut-in vehicle and automatically begins to back off follow truck



Follow truck will continue to back off to safe manual following distance (100+ ft) and then give full manual control back to follow driver

Safety: Geofenced to Suitable Roads & Conditions

Network Operations Cloud (NOC) & Fleet Procedures limit platooning to:

- Multi-lane, divided, limited access highways
- Moderate or low traffic conditions (and platoons dissolve automatically below 40 MPH)
- Suitable traction conditions and weather
- Appropriate topography (not major grades)
- Geofencing can exclude construction zones, lower capacity bridges, and other specialized areas



Best Practice Cybersecurity Approach

Collaboration with Industry on Best Practices

Our Philosophy and Approach:

1. We use the **strongest available, independently audited systems.**
2. We **encrypt all communication** between trucks and with the Network Operations Cloud.
3. All communications are **mutually authenticated.**
4. We actively monitor for and **defend against malicious attacks.**
5. Systems are continually improved through **automatic updates.**



Peloton Network Operations Cloud

Internet/Other Data

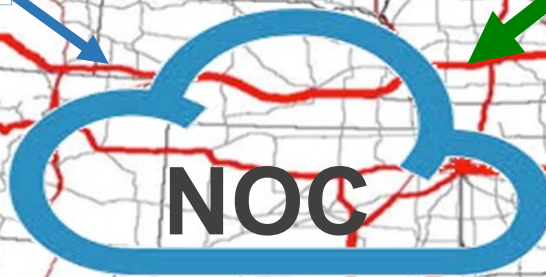
Traffic
Weather
Construction Zones

Vehicle Data

Engine
Drivetrain
Braking

Platooning Sensors

Radar
Video
GPS



With Drivers

Link Finding
Safety Approvals
Platoon Ordering
Alerts/Warnings

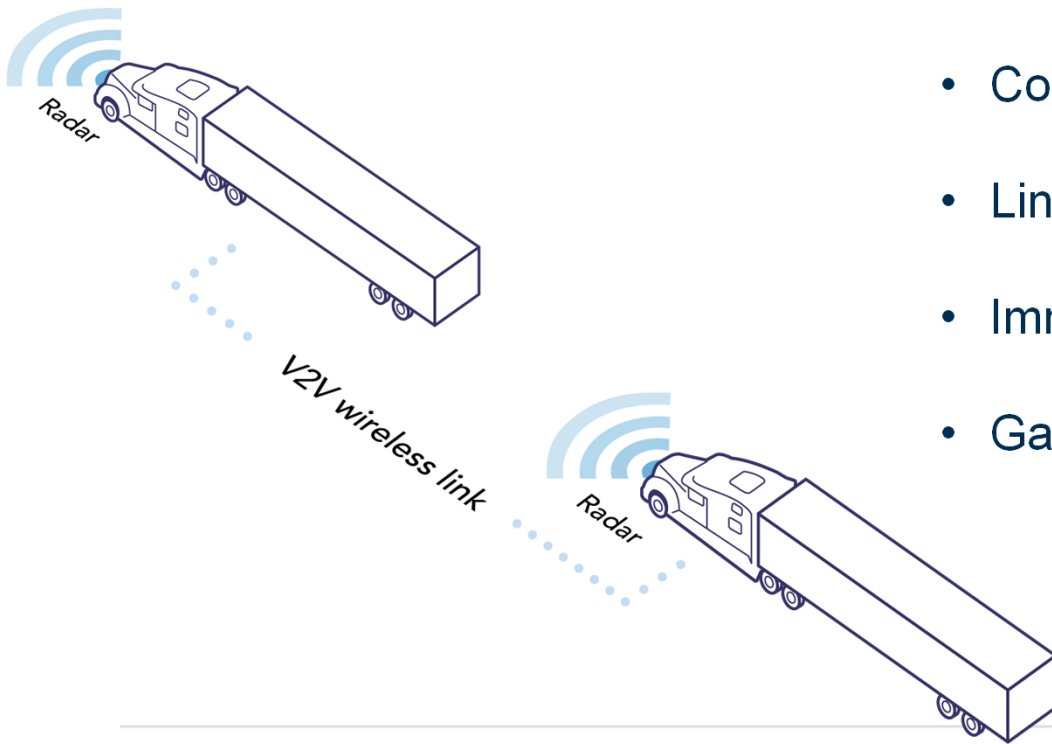
With Hwy Operators

Granular Weather
Hwy Condition
Accident Patterns
Congestion Monitoring

With Fleet Managers

Analytics
Diagnostics
Predictive Maintenance

Making Close Following Safe: V2V



- Constant comms between Trucks
- Linked Active Safety Systems benefit both Drivers
- Immediate knowledge of required braking level
- Gap set to support safety

Making Aerodynamic Following Safe: V2V linked Safety



Driver Perception & Reaction Time:

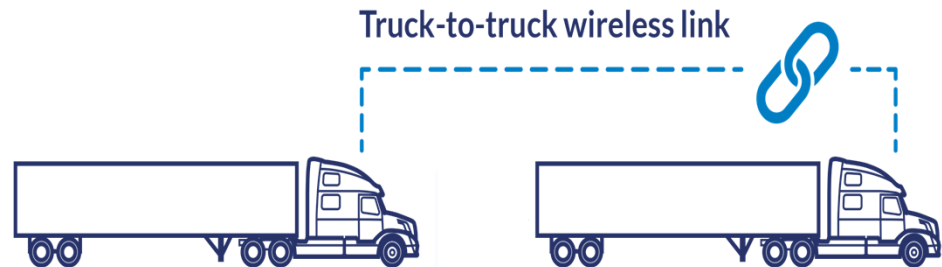
2 sec



< 10th of a sec



Truck-to-truck wireless link



Faster than a Driver or Radar/ACC on a single truck



Peloton

<https://vimeo.com/234760532>

Enhancing Teamwork



Team
d
Drivers

Team
d
Trucks

Team
d
System
s

Drivers are Key



- Driver-informed Design & Training
- Trained, CDL-certified driver in both trucks
- Both Drivers fully engaged at all times
- Peloton Driver Training Program for each Fleet

“A driver will feel safer behind the wheel because the truck can hit the brakes prior to a human in critical situations...”

Dave Mercer - Peloton Driver (~3 million MTD)



Integration & Safety Validation working with OEMs



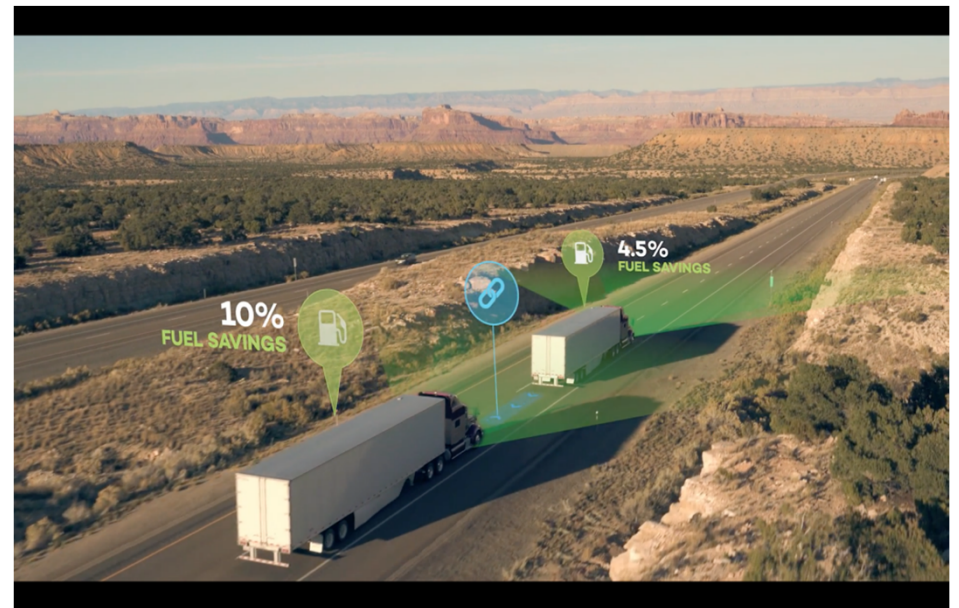
Benefits: Improved Fuel Savings, Safety, Fleet Management

Platooning Reduces Fuel Consumption

- 4.5% fuel savings for the lead truck
- 10% fuel savings for the follow truck
- Verified combined fuel savings of 7.25% savings at 40 foot gap at 65 mph (NACFE)
- Corresponding Reductions in GHG & Diesel Emissions

Peloton Provides Value to Fleets

- Economically viable with less than 1 year payback for typical regional or long-haul trucks.
- High-quality data and improved analytics for fleets
- \$726 billion U.S. trucking industry benefits by saving on fuel and enhancing individual truck safety



Driver Assistive Truck Platooning: Wider Benefits

- **Safety:** Crash reduction and crash congestion-related fuel savings
 - NTSB: Widely deployed Collision Avoidance Systems could reduce ~80% of rear-end crashes. NHTSA: Over \$3B annual savings and thousands of saved lives possible with full deployment of early generation active safety systems (2015 study)
- **Air Quality:** Corresponding reductions in GHG & Diesel emissions
- **Insight:** High quality data generation for fleets & governments
- **Mobility:** Increased freight efficiency
- **Economy:** <1 year payback period for typical regional/longhaul fleet trucks

Solid Demand From Top Fleets



Initial Market Deployment

Today: Within Same Fleet

Many Fleet trucks travelling in groups today

Future: Cross-Fleet

Peloton as intermediary
Fleets interested in linking with others

Installation to New Trucks with our Required Safety Spec



Limited Upfits to Very Recent Model Trucks -- Not Old Trucks

Collaboration

Truck OEMs + Suppliers + Fleets + Drivers

Top Use Case: Single-Fleet, Hub-to-Hub Routes

Example Strong Customer Profile:

- 50+ “return-to-hub” runs (regional haul)
- Fleet drivers
- Scheduled and manual NOC pairing
- Homogenous tractor configurations



Operational Domain: Multi-lane, Divided, Limited Access Highways



National Context:

Federal Encouragement rather than any barriers

- Driver-assistive truck platooning complies with federal law, and requires no changes for commercial deployment, as confirmed by federal regulators.
- USDOT, FHWA, NHTSA, FMCSA, and USDOE have participated in demonstrations and funded studies to promote and understand the benefits of the technology.
- USDOT's recent Policy Guidance 3.0 calls on states to remove barriers to truck platooning, stating:

“States should consider reviewing and potentially modifying traffic laws and regulations that may be barriers to automated vehicles. For example, several States have following distance laws that [may] prohibit [conventional] trucks from following too closely to each other, effectively prohibiting automated truck platooning applications.” – US DOT Automated Vehicles 3.0, Preparing for the Future of Transportation

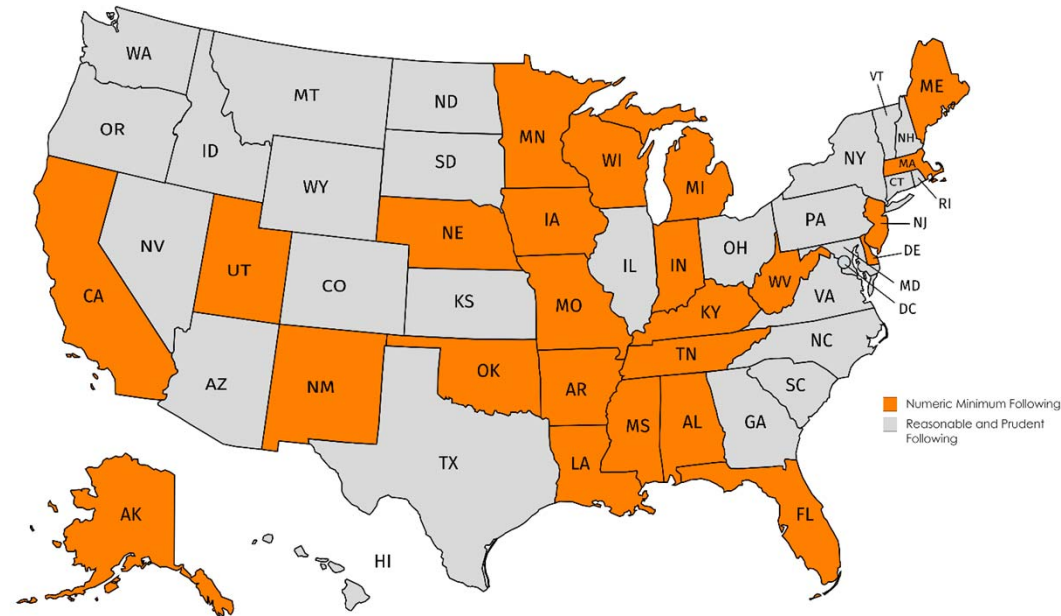
National Context: State Following Distance Laws

Numerical Minimum Following States

- A defined numeric minimum following distance in 24 states
- Platooning requires change in law

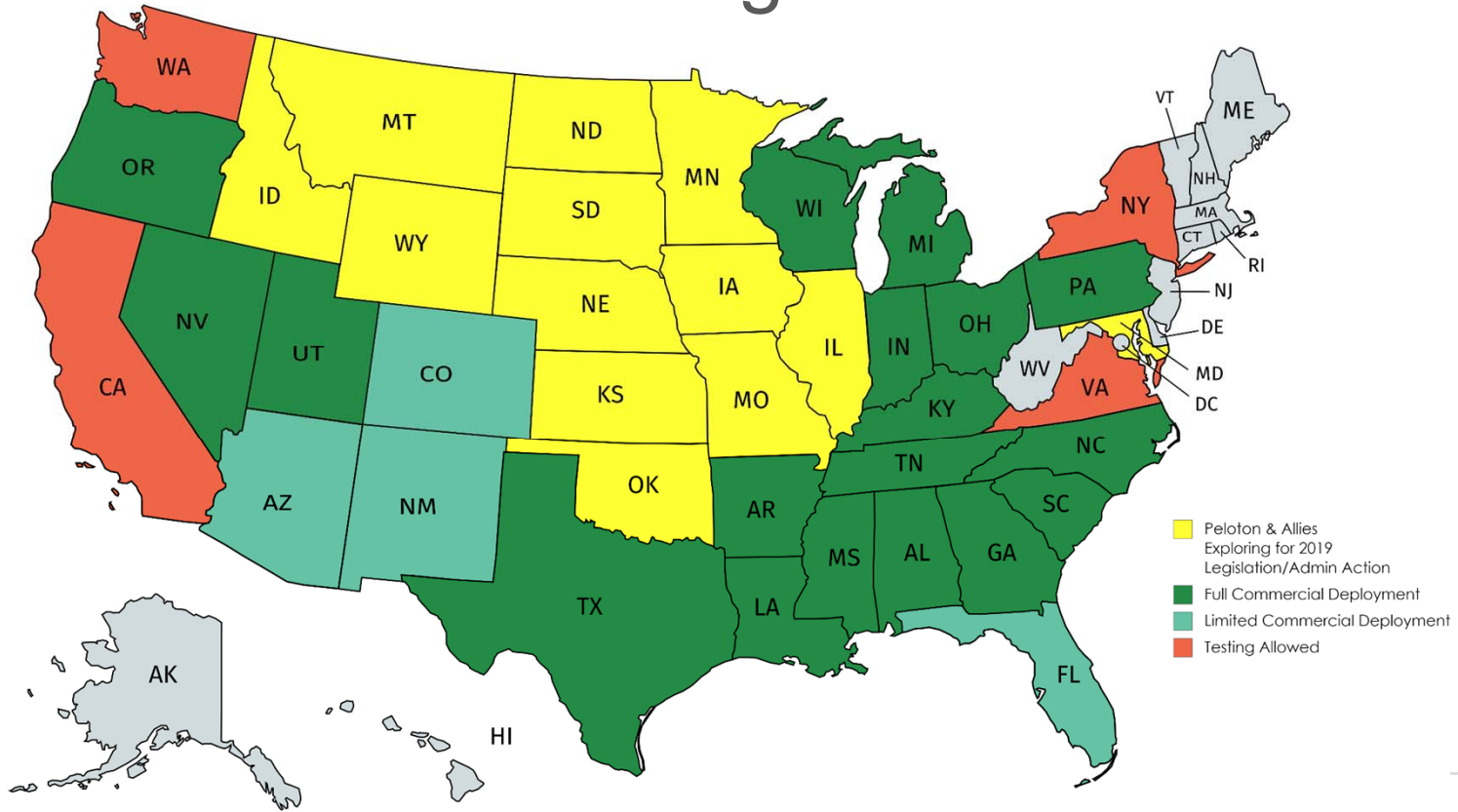
“Reasonable and Prudent” States

- A flexible, discretionary standard in 26 states
- Platooning can be legal under current law



Created with mapchat.net ©

National Context: Platooning Allowance Clarified



Videos of Notable Peloton Platooning Demos

Michigan 2017



Florida 2017



FL DOT Study: No New Highway or Comms Infrastructure Needed Platooning Works within Existing Infrastructure



FDOT-FHSMV-University of Florida Study (2018)

- **Highway Issues:**
 - Allow DATP operations on any limited access, multi-lane, divided highway.
 - Allow DATP operations on any lane currently allowable for trucks.
- **Infrastructure Effects**
 - FDOT analysis found that **well less than one percent of bridges on interstate and turnpike mainlines might be subject to stresses** exceeding bridge design specifications with trucks platooning at even a close 30 foot spacing.
 - However typical driver-assistive platooning systems operate with a gap of over 40 feet.
 - The State can notify system providers and fleets regarding any locations/areas where platooning should be restricted, due to specific infrastructure elements or other factors.
- **Traffic Interactions**
 - At high market penetration, simulation studies have shown that platooning would **improve flow** in heavier traffic, since platooning trucks take up less road space than trucks traveling alone.
 - Other modeling found possible negative effects in congested traffic at some types of interchanges – however these are situations in which platoons will dissolve; fuel economy benefits are minimal at lower speeds.
 - Traffic interactions during the recent Florida Platooning Pilot operational demonstration, which included interchanges, bridges, Service Plazas, etc. showed smooth dynamics and **did not raise concerns**.

Preventing Negative effects on Bridges & Pavement

Pavement

- “Rutting” and or pavement fatigue that might be caused by vehicles following an exact path is generally mitigated by the natural wander of drivers operating each truck in an SAE Level 1 platoon.
- Systems using L2 Lane Keeping Assist versus precise lane centering can also allow for sufficient natural wander.
- For higher automation systems that could follow a more precise path, random wander can be programmed to occur.

Bridges

- According to FDOT 2018 study: Spacing of over 30 feet for standard load and configuration trucks in platoon does not present a weight capacity challenge to the vast majority of bridges in Florida -- well less than 1% on the interstate and turnpike mainlines where platooning is to occur.
- Using State and Private sector data, any bridges or other infrastructure areas that could have weaknesses or are otherwise not suitable for platooning can be geofenced out by platooning technology providers.
- Construction zones and other work areas can also be geofenced so that truck platoons dissolve before entering the given area.

Outlook

Growing US and Global Activity using Driver Assistive Truck Platooning Solutions:

- **US:**
 - Peloton bringing driver-assistive truck platooning into commercial ops with selected fleets, 2018-2019.
 - Other OEMs continue to develop commercial platooning systems including PACCAR, Volvo and Navistar.
- **International:**
 - MAN Trucks and Scania running commercial test programs with fleets in Germany and Scandinavia, 2018-2019.
 - EU Multi-brand platooning project: Platooning by the 6 European Truck OEMs, 2019-2020+.
 - Platooning commercial demonstration and/or deployment programs planned in UK, Australia, Asia.

Key Activity Ahead – Peloton Technology:

- Robust activity continues in California as Peloton continues joint integration and validation work with OEMs.
- Commercial freight platooning activity over the coming months in Texas with major fleets.
- Activity expanding into other states over next quarters in coordination with major fleets.
- Ongoing work with allies to explore platooning allowance in additional states and international markets.

 Peloton

