Preventing Crashes
Saving Fuel
Connecting Trucks

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Safety must be our highest priority

- 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

FCAM Systems can avoid or mitigate many crashes

- Commercially available radar-based **Forward Collision Avoidance and Mitigation (FCAM)** Systems can reduce the frequency and severity of these commercial vehicle rear-end crash types.

- Conway study:
  - 30 months w/ 12,600 tractors
  - **71% reduction in rear-end collisions; 63% reduction in unsafe following behavior**

- Volvo/USDOT study:
  - 3 years w/ 100 trucks
  - **80% of drivers preferred to drive w/ collision avoidance systems**
  - 37% reduction in "conflicts" (i.e. hard braking, situations that could result in collision)

Bendix WINGMAN Fusion

MERITOR WABCO OnGuard™ Collision Mitigation System

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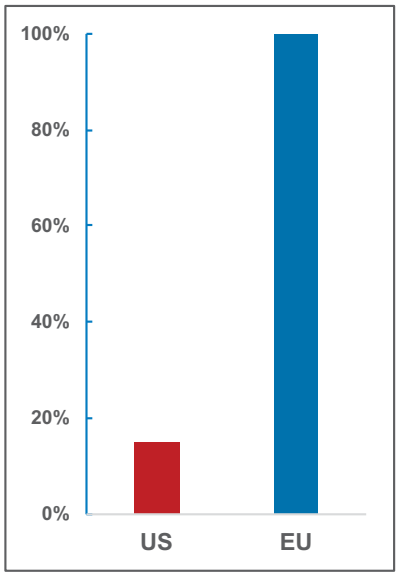
But FCAM uptake in the industry is slow

New Class-8 Trucks Sold w/ FCAM System



- EU regulations mandated FCAM systems on all heavy trucks since 2015, estimated to save 5,000 lives per year

- In US, Passenger car OEMs voluntarily pledge 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

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Similarly, Air Disc Brakes can improve safety but are rare

ADB provide improved braking performance and reduced fade…

…BUT, are on only about 13% of Class 8 Trucks because of increased cost

Summary of Air Disc Brake Benefits

Superior Performance	Shorter Stops	Stops 42 feet shorter than today's drum brakes** from 60 MPH
		Stops 100 feet shorter than today's drum brakes** from 70 MPH
	Better Braking Feel	Passenger car like feel
		Improved side to side brake consistency
	Safety	Greater braking power can result in fewer accidents
Lower Maintenance	Longer Lining Life	Typically twice the lining life of drum brake applications
	Sealed Design	Sealded design, no periodic lube required
		Sealed reliable, integrated automatic brake adjustment
	Quick Pad Changes	Quick change pads – 15 minutes per brake (with wheels off)
Light Weight	Design Optimization	Weight comparable to high performance larger (16.5") front drum brakes
		Patented splined rotor design with Aluminum Hubs for optimized weight
		Lightwest dual piston air disc brake available

**Standard drum brakes compared to all wheel disc brakes on a 6x4 Tractor, 59,470 pounds GVW, un-braked trailer

Table Courtesy Bendix

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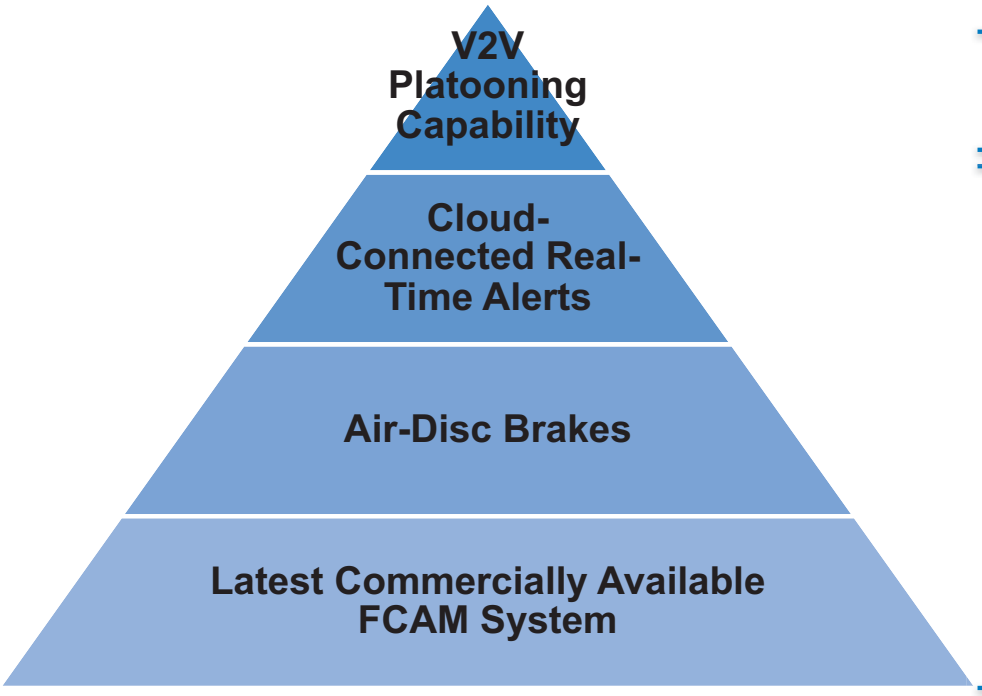
Peloton's Driver-Assistive Truck Platooning (DATP) System Requires and Incentivizes FCAM & ADB Adoption

- Trucks must have the latest FCAM systems and air disc brakes, along with Peloton's proprietary DATP hardware, in order to platoon.

- In return for spec'ing trucks 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-Equipped Trucks are Safer Trucks



Save Fuel: Application of Foundational Equipment to Improve Fuel Efficiency

Save Lives: Foundational Equipment and Technology to Improve Truck Safety

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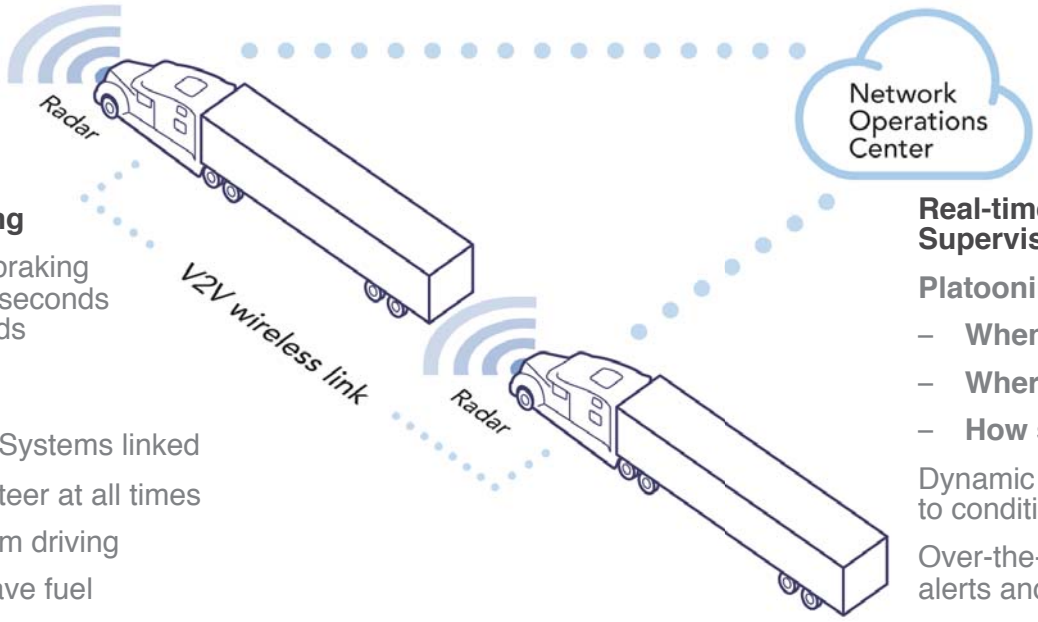
Connecting Pairs of Trucks: Better Safety and Efficiency



Active Braking

Reduces the braking time from 1.5 seconds to 0.03 seconds

Platooning

Active Safety Systems linked

Both drivers steer at all times

Enhances team driving

Both trucks save fuel

Real-time Cloud Supervision

Platooning only…

- **When safe**
- **Where safe**
- **How safe**

Dynamic adjustment to conditions

Over-the-Horizon alerts and navigation

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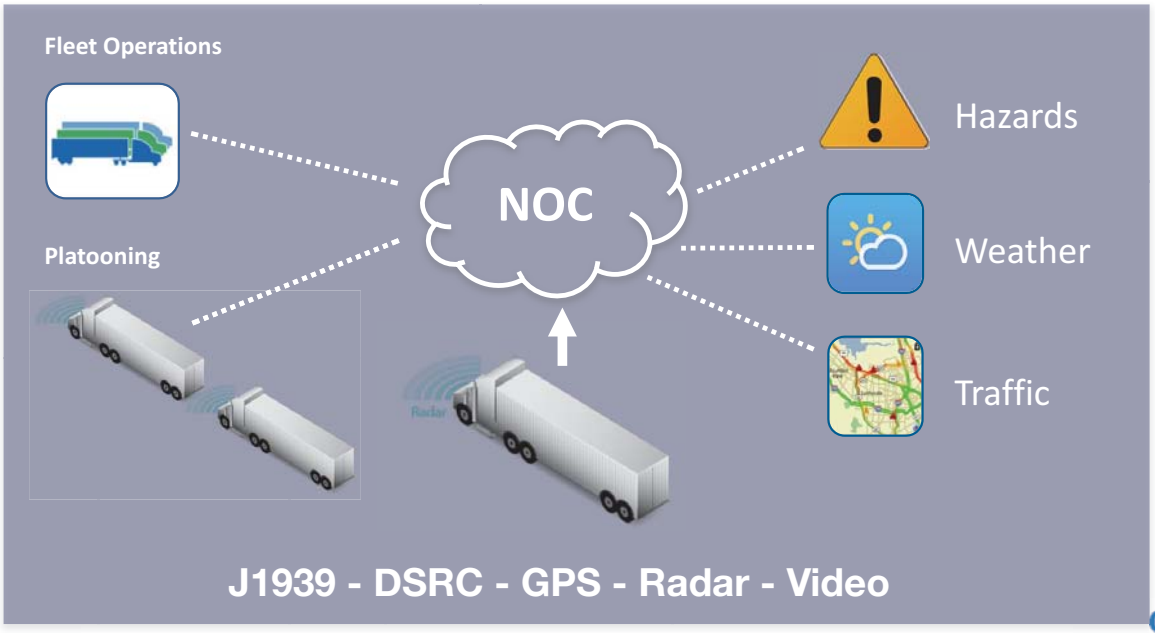
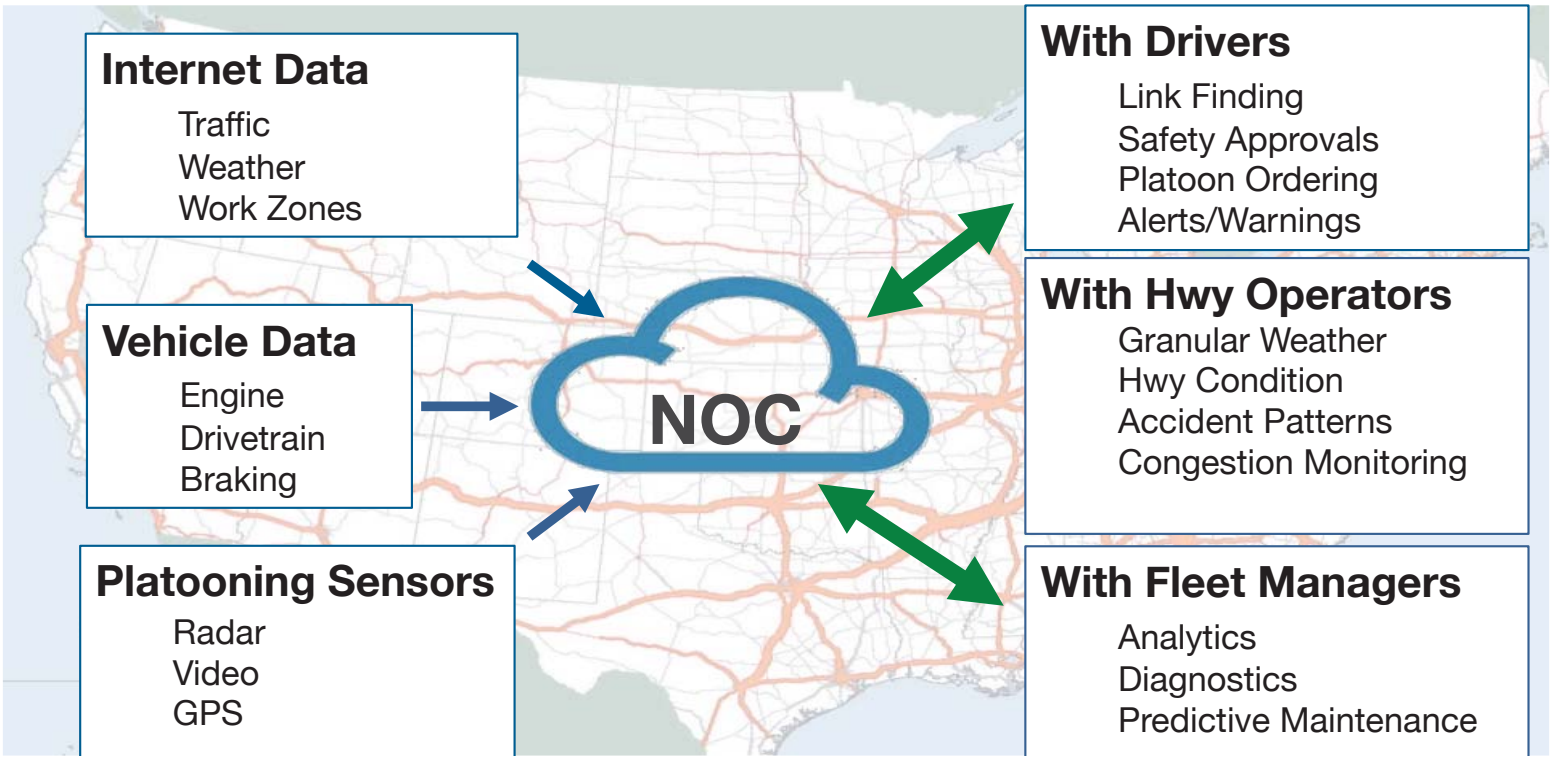
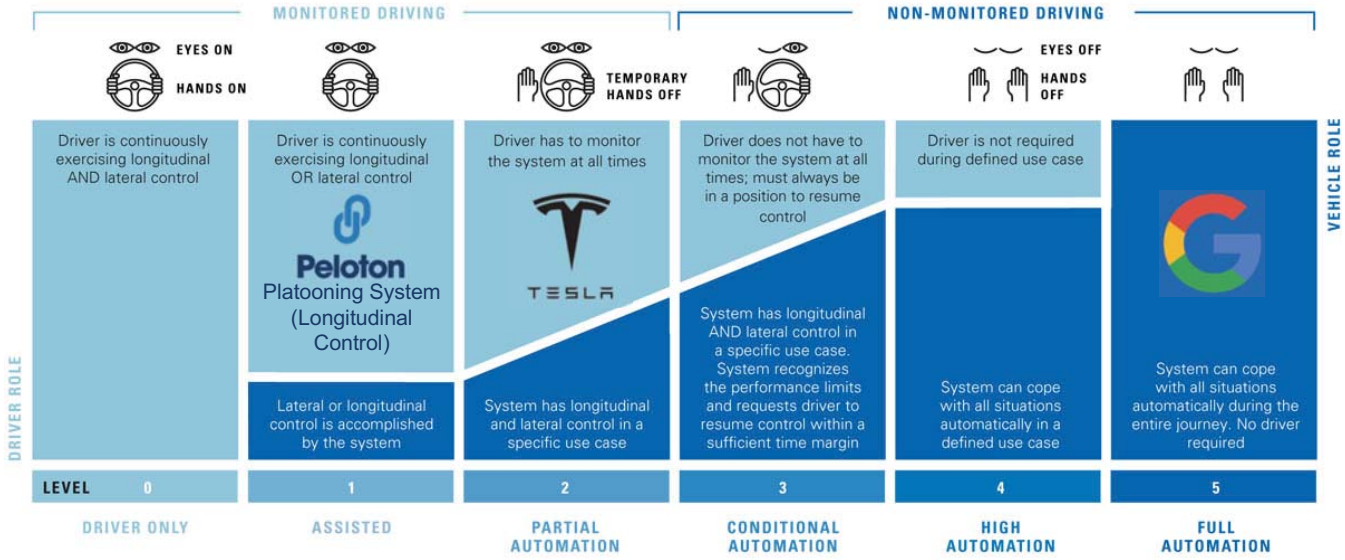
Peloton DATP: Safety and the Network Operations Center



Peloton DATP: Safety and the Network Operations Center



Peloton DATP: Minimal Automation



Graphic courtesy: ZF TRW

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Peloton DATP: Drivers Fully Engaged At All Times

<u>Lead Driver:</u>
-Hands on
-Feet on
-Eyes/Brain on

<u>Follow Driver:</u>
-Hands on
-Feet off
-Eyes/Brain on
-Similar to Adaptive Cruise control

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Peloton DATP: Drivers Fully Engaged At All Times

Live video from other driver's view

- Look Ahead view of road ahead of lead truck for follow driver
- Both drivers in communication to share critical information

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Peloton DATP: Fuel Efficiency

Fuel savings of 10% on rear truck and 4.5% on front truck

Verified savings at 40 foot gap at 64mph (NACFE)

Further independently testing by US DOE and US DOT

NREL & FHWA tests confirming savings at varying speeds, gaps of 75ft +

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Peloton DATP: Wider Benefits

- **Improves fleet economics for adopting FCAM systems and ADB**
- **Crash reduction and crash congestion-related fuel savings**
  - NTSB: Collision Avoidance Systems could reduce ~80% of rear-end crashes. NHTSA: $3.1B annual savings from full deployment of just current FCAM technology (and system capability is improving)
- **Corresponding reduction in GHG & Criteria Pollutant emissions**
- **High quality data generation for fleets & governments**
- **Increased infrastructure efficiency**
- **Economically viable with <1 year platoon system payback period for fleets**

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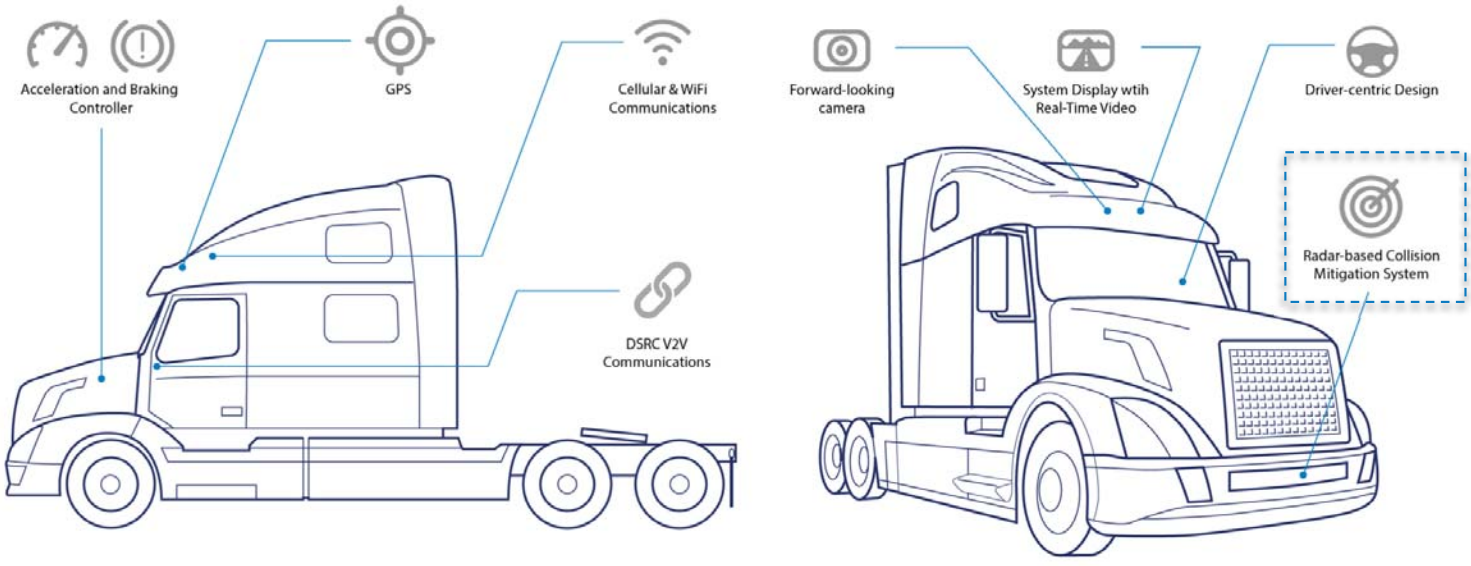
Peloton Platooning System: Tractor Components



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Cybersecurity

Our philosophy and practices:

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

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Platooning is real and widely supported

Companies Developing Near Commercial Systems **and/or** Research/Future Systems:

Peloton, Continental, DELPHI, DAF A PACCAR COMPANY, VOLVO, NAVISTAR, DAIMLER, SCANIA, NXP, MAN, IVECO, DENSO, HINO, Bendix, WABCO, Peterbilt A PACCAR COMPANY, KENWORTH A PACCAR COMPANY, Cummins

Market Development: Global Activity in Platooning

EU - Platooning Challenge 2016

Japan - ENERGY ITS 2009-12

EU (Sweden) - SARTRE 2009-Present

Canada - PIT 2009

Germany – KONVOI 2005-09

US – PATH, NREL, etc. '90s and ongoing

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Peloton Technology: Wide-Ranging Investor Base

Trucking Industry

VOLVO

DENSO

ups

MAGNA

Lytx

Technology and Energy

intel

NOKIA

LOCKHEED MARTIN

bp

Financial Investors

SAND HILL ANGELS

birchmere VENTURES

band OF ANGELS

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Market Development:
Government Engagement & Partnerships

Demonstrating platooning with fleets, establishing best practices & creating deployment pathway

Federal	States

• Two USDOT (FHWA) platooning projects
  • CalTrans/PATH/Volvo
  • Auburn/Peterbilt
• DOE Volvo Supertruck 2
• USDOT Smart City: Smart Columbus
• USDOE ARPA-E (Purdue-Cummins+)
• State projects include: TX Transportation Institute-TxDOT; CEC Port of San Diego
	• Deployment Approval Laws in **7** states [edited 6/14]: AR, GA, NC, SC, TN, TX, NV
	• Demo activity held in **7** states (MI, UT, NV, FL, CA, TX, OH, more ahead)
	• Trials/testing approved in other states incl. AL, AZ, CA, FL, VA, UT
	• **28** states with "reasonable and prudent" following distance standard conceptually permissive of platooning (for example, OH officials have taken this position)

Funded Projects with: U.S. Department of Transportation Federal Highway Administration; FMCSA; NHTSA www.nhtsa.gov; NREL National Renewable Energy Laboratory; Peloton

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Legal Slides –
North/West Passage Coalition

“Following too closely” laws – typical legal elements

- Two common elements to prevent rear-end collisions involving combination vehicles
  - Variable distance standard
    - typically phrased as a “reasonable and prudent” requirement
    - discretionary – accounts for speed, traffic, etc.
    - 28 states – including ID, MT, ND, SD, WA, WY
  - Fixed distance standard
    - varies by state between 100 and 500 ft
    - 22 states – including MN
- All states have additional element(s) such as requiring “sufficient space” for another vehicle to “enter and occupy”

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Typical variable, “reasonable and prudent”-type law

North Dakota Century Code. 39-10-18. Following too closely.

1. The driver of a motor vehicle **may not follow another vehicle more closely than is reasonable and prudent**, having due regard for the speed of such vehicles and the traffic upon and the condition of the highway.

2. The driver of **any truck or motor vehicle drawing another vehicle** when traveling upon a roadway outside of a business or residence district and which is following another truck or motor vehicle drawing another vehicle shall, whenever conditions permit, **leave sufficient space so that an overtaking vehicle may enter and occupy such space without danger**….

3. Motor vehicles being driven upon any roadway outside of a business or residence district in **a caravan or motorcade** whether or not towing other vehicles must be so operated as to **allow sufficient space between each such vehicle or combination of vehicles so as to enable any other vehicle to enter and occupy such space without danger**….

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How the Peloton System enables compliance with a "reasonable and prudent" following distance element

1. The driver of a motor vehicle **may not follow another vehicle more closely than is reasonable and prudent**, having due regard for the speed of such vehicles and the traffic upon and the condition of the highway.

*Peloton's Platooning System is engineered and safety-validated with Tier 1 HD collision avoidance system manufacturers to ensure that the Follow Truck will **automatically** and **safely** stop without colliding into the lead truck, even during a full-brake event. The System orders the two trucks in a platoon so that **the truck with shorter stopping distance capability is always the Follow Truck**. The System applies commercial radar-based collision avoidance systems (e.g. Bendix, WABCO) and DSRC vehicle-to-vehicle (V2V) communications to **bypass delays in human perception and response time**, reducing braking latency between the Trucks to less than 0.1s.*

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Connected Braking for following distance compliance

An operator can safely stop without colliding with the preceding vehicle under manual driving conditions only by allowing **enough distance for human perception and reaction**.

Radar can reduce the assured clear distance needed to safely stop without colliding by automatically reacting to the preceding vehicle slowing.

Via a low-latency truck-to-truck wireless link, the follow truck reacts automatically to the brake activation of the lead truck's brakes within 0.03-0.1s, **before the lead truck actually begins to slow**. The truck with the longer stopping distance – based on integrated active braking system data – is ordered as the lead truck in the platoon.

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How the Peloton System enables compliance with "sufficient space" to "enter and occupy" elements

2. … **leave sufficient space so that an overtaking vehicle may enter and occupy such space without danger** …

3. … **allow sufficient space between each such vehicle or combination of vehicles so as to enable any other vehicle to enter and occupy such space without danger** ...

*All drivers of trucks equipped with the Peloton System are **trained to monitor the driving environment** for vehicles that may move between the trucks in a platoon, and to **increase the gap between trucks** to a distance typical of safe manual following in order to allow other vehicles to safety enter and occupy the space.*

*In addition, Peloton's platooning system **detects vehicle cut-ins via commercial radar-based CAS**, resulting in automatic platoon dissolution which involves deceleration by the follow truck in order to increase the gap between trucks.*

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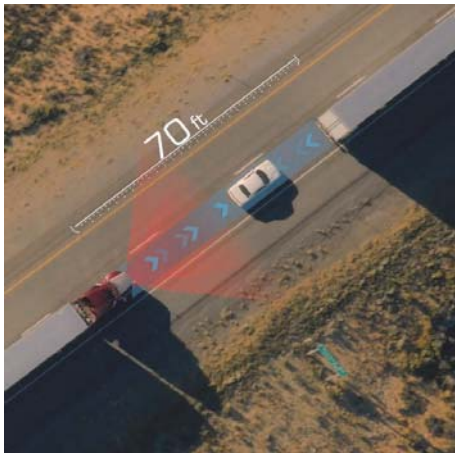
Responsive Gap Increase for following distance compliance

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 and then give full manual control back to follow driver

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