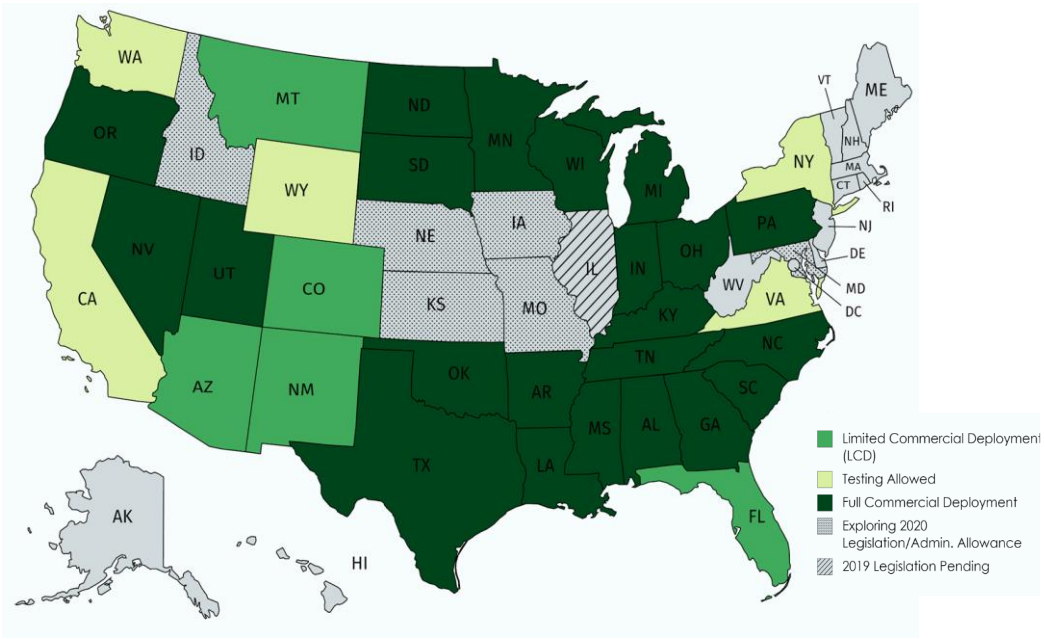
Peloton

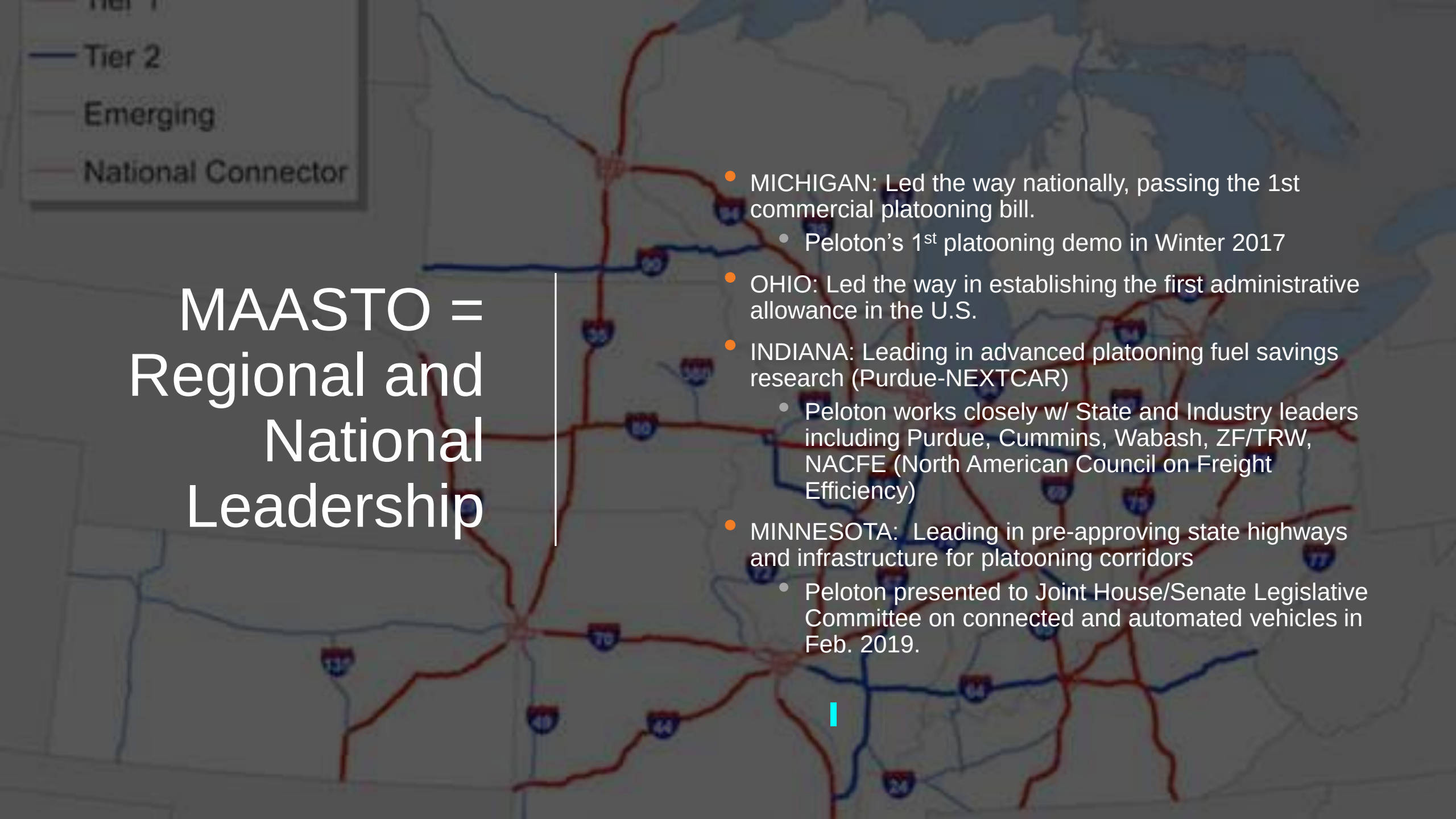
Peloton Technology
Teamwork for Freight Safety & Efficiency

Overview on Driver-Assistive Truck Platooning
MAASTO CAV Summit, Madison, October 18, 2019

MAASTO Platooning Snapshot

- **Great leadership by MAASTO to advance innovation in freight safety & mobility.**
- **Encouraging the development, testing, and deployment of CAVs.**
- **Regional Picture on Truck Platooning:**
  - Of 10 MAASTO states, 6 allow commercial deployment of truck platooning: Indiana, Kentucky, Michigan, Minnesota, Ohio, and Wisconsin.
  - Great work has also been done in 4 others, setting stage for 2020: Illinois, Iowa, Kansas, and Missouri.
  - MAASTO - excellent forum for sharing best practices.





MAASTO = Regional and National Leadership

- MICHIGAN: Led the way nationally, passing the 1st commercial platooning bill.
  - Peloton's 1st platooning demo in Winter 2017
- OHIO: Led the way in establishing the first administrative allowance in the U.S.
- INDIANA: Leading in advanced platooning fuel savings research (Purdue-NEXTCAR)
  - Peloton works closely w/ State and Industry leaders including Purdue, Cummins, Wabash, ZF/TRW, NACFE (North American Council on Freight Efficiency)
- MINNESOTA: Leading in pre-approving state highways and infrastructure for platooning corridors
  - Peloton presented to Joint House/Senate Legislative Committee on connected and automated vehicles in Feb. 2019.

Market Overview: Freight Trucking Scale & 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 – 5% or less**

- Preventing Accidents
- Saving Fuel
- Improving Mobility
- Improving Decisions

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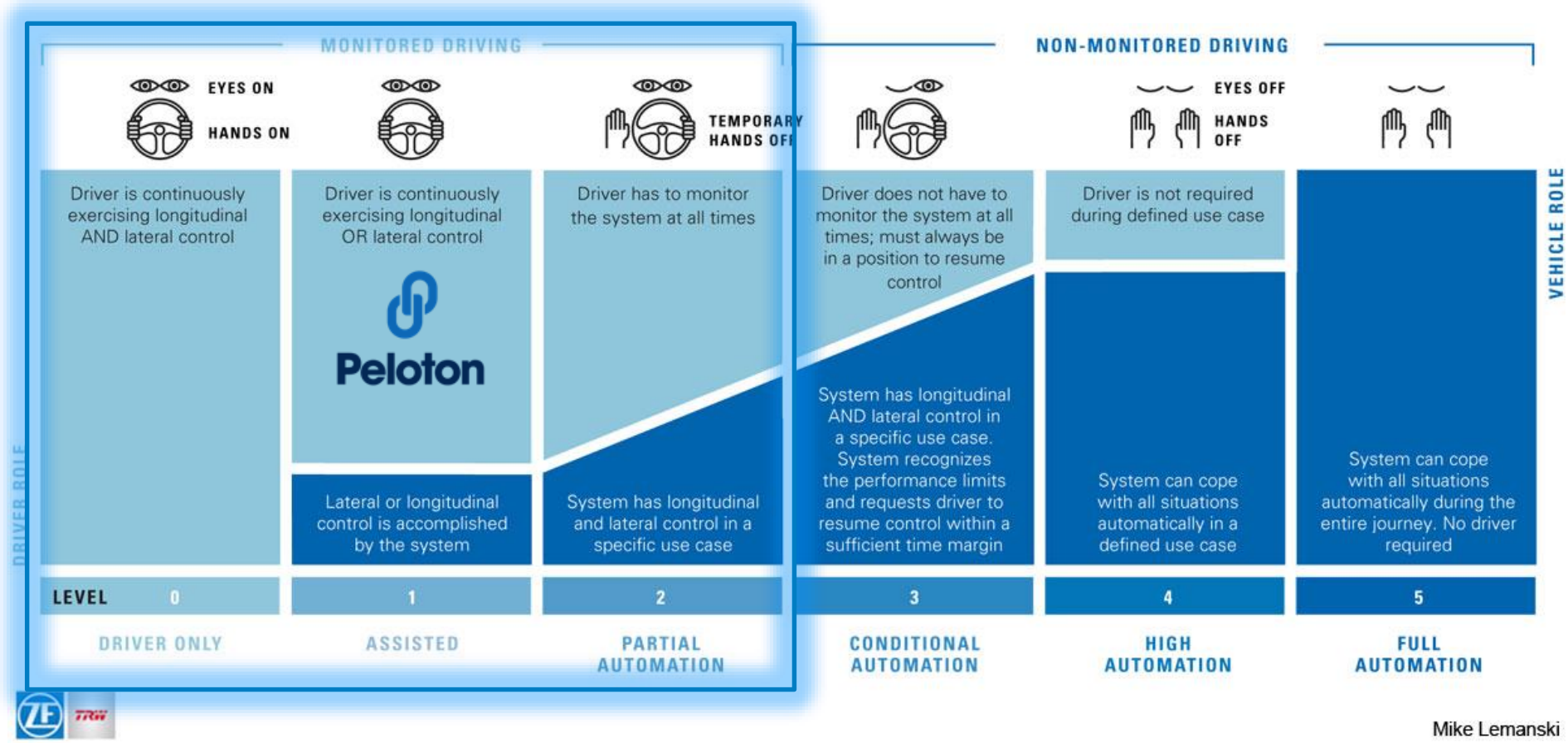
Enhanced
Fleet Economics
& Safety

PlatoonPro: Driver-Assistance, Not Self-Driving Trucks



Mike Lemanski

We Must Address the Growing Safety Crisis on our Highways

- **Challenge to address growing national safety crisis:** 37K+ fatalities, Millions of injuries.
- **Vehicles very safe; ADAS, V2X now key opportunities.**
- In 2012, over 1.7 million rear-end crashes (NTSB)
  - Almost half of all 2-vehicle truck crashes; 1,705 fatalities and over half a million injuries
- Highway end-of-queue crashes involving commercial vehicles are particularly deadly, ex:
- I-16 in GA (2015), I-70 in CO (2019), I-465 in IN (2019), too many others.

The Wild West: Tailgating Trucks on America's Roads Today

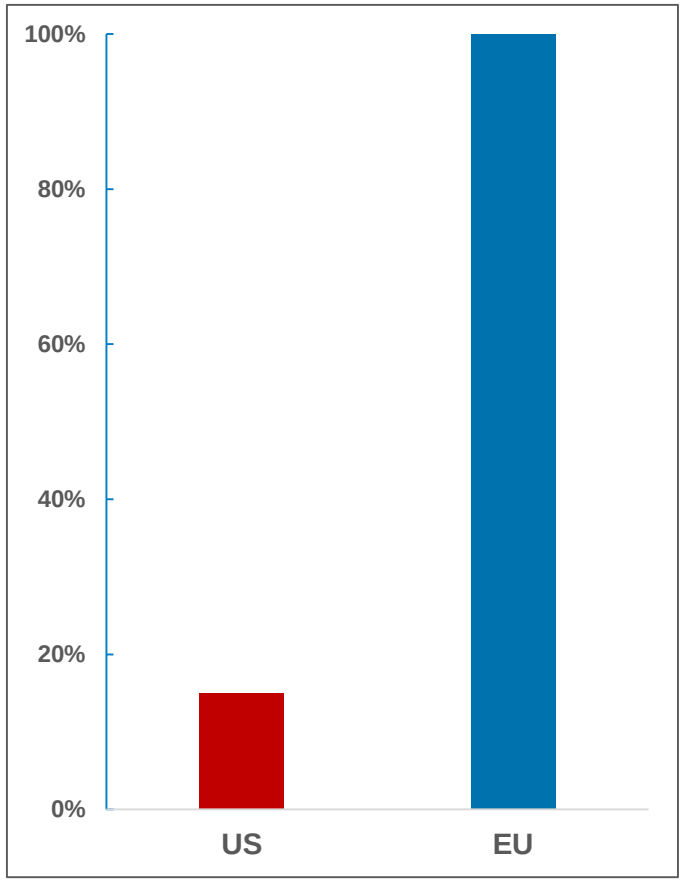
- **NO** advanced best-in-class safety systems
- **NO** linked safety monitoring the roadway ahead
- **NO** driver communications regarding road conditions or maneuvers
- **NO** look-ahead view of road ahead for rear driver

Brownsburg, IN

Shellsville, PA

Active 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

Platooning Systems Put Best-In-Class Safety on Each Truck

Focus: Make Each Truck Safer At All Times

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

Vehicle-to-Cloud Connectivity

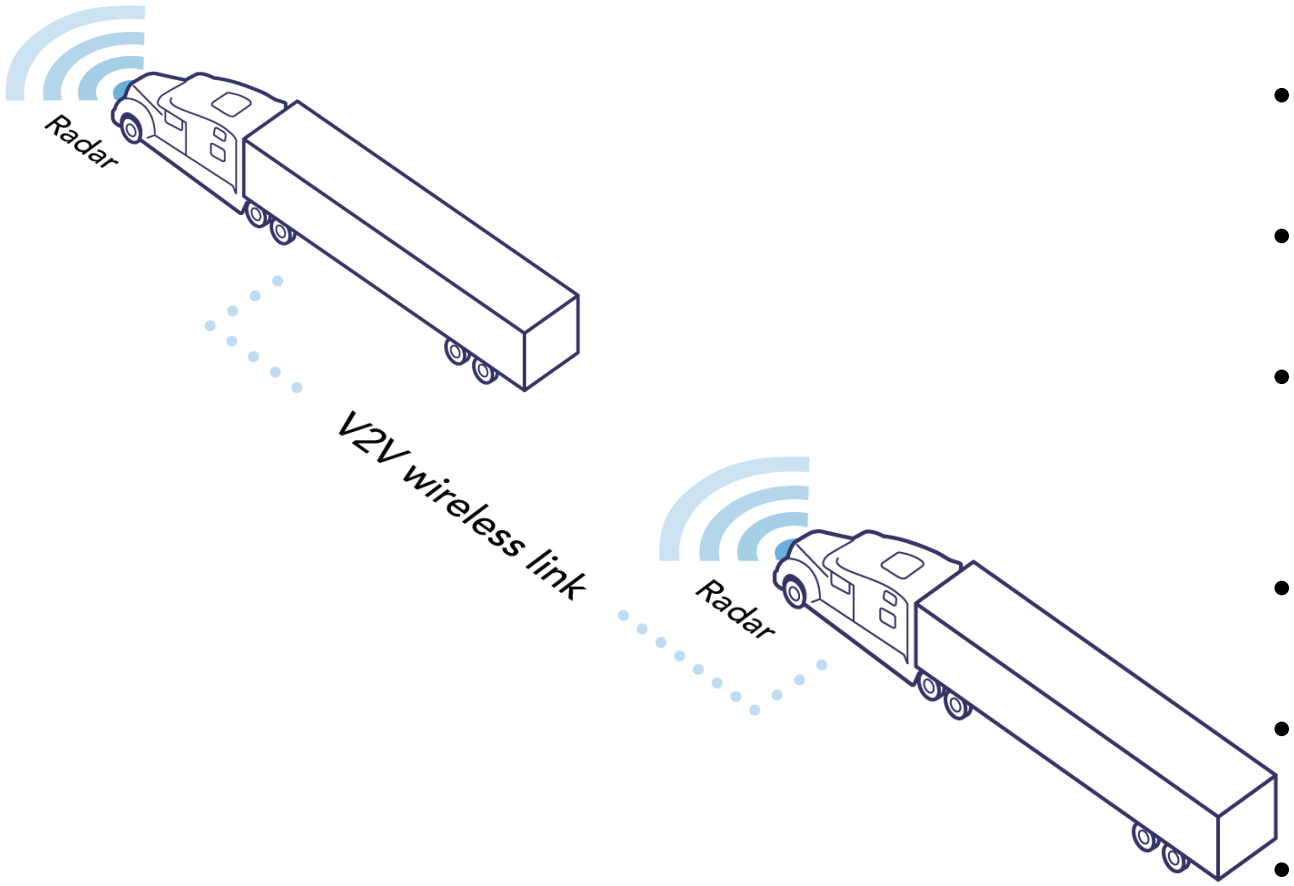
Vehicle-to-Vehicle Communications

Collision avoidance and LDW systems always on

Air Disc Brakes, Electronic Stability Control

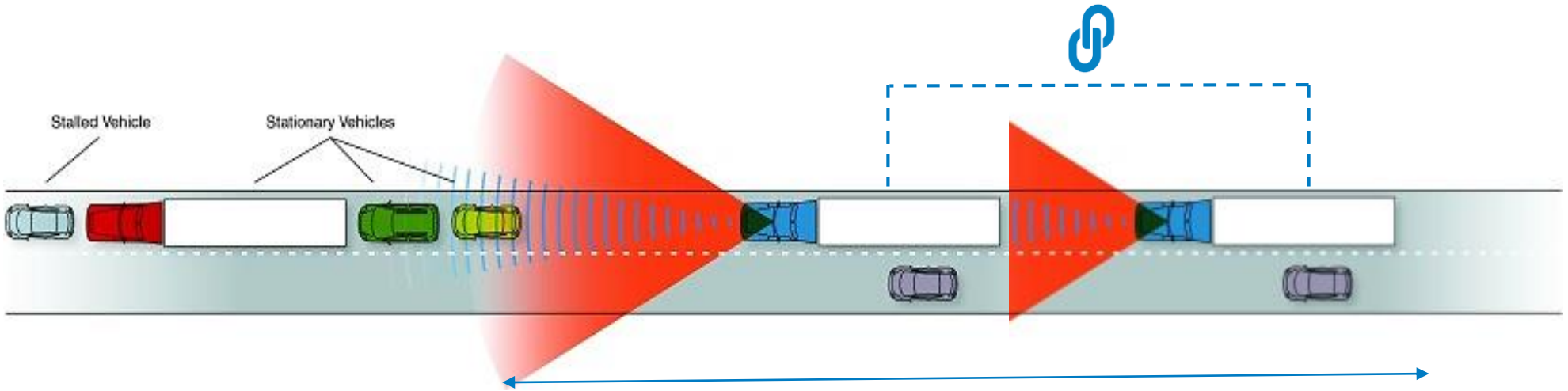
Continuous Safety Monitoring

PlatoonPro: Linked Active Safety using **V2V Communication**



- Link pairs of trucks on suitable highways
- V2V using 5.9 GHz DSRC
- Near instantaneous V2V connection
- ACC/Collision Avoidance looks ahead 100s of meters
- Linked Safety Systems benefit both Drivers
- Intelligent ordering by weight/braking ability
- Enhanced Driver Teamwork

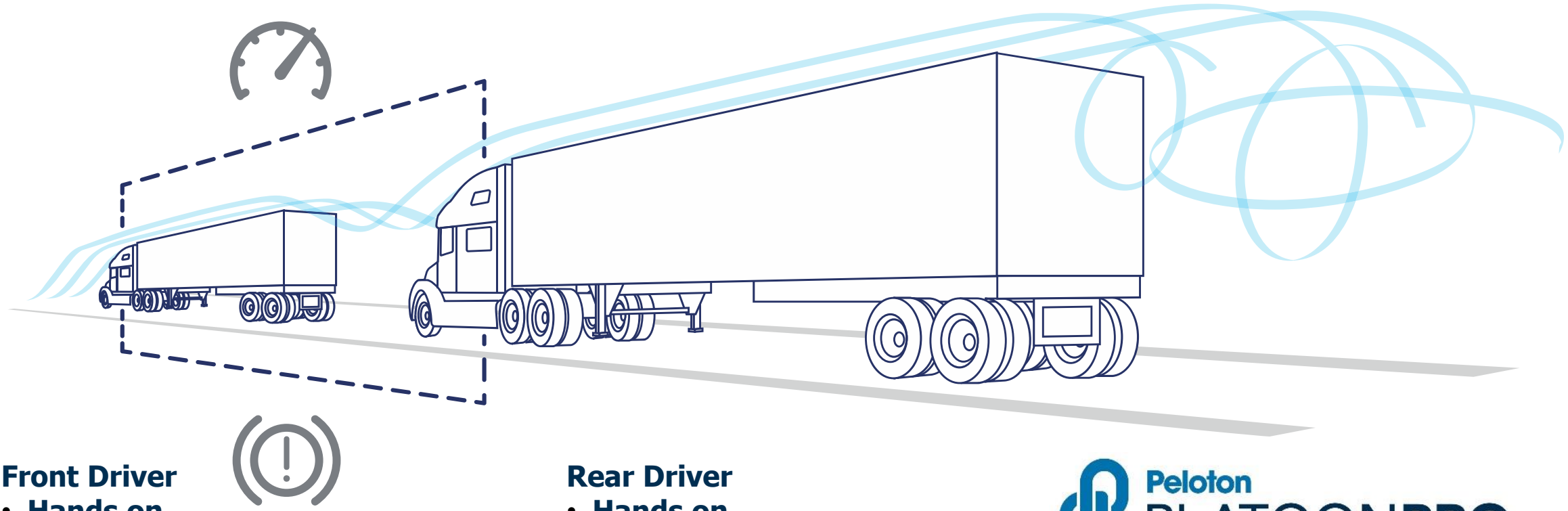
Platooning Trucks Benefit from Linked Active Safety Systems



Linked Active Safety Systems

- Follow truck is benefiting from the FCAM systems (w/ AEB) and ACC of the Lead Truck
- System instantaneously sends proportionate braking signals to Follow truck to proactively grow the gap between the trucks (or dissolve the platoon) in the event of a potential hazard in the roadway ahead of the front truck.
- Follow truck can break before the lead truck or harder to prevent collision.

PlatoonPro: Pairs of Trucks, Both Drivers Steering At All Times Linked Safety, Enhanced Driver Teamwork and Efficiency



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

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

Peloton PLATOONPRO

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.

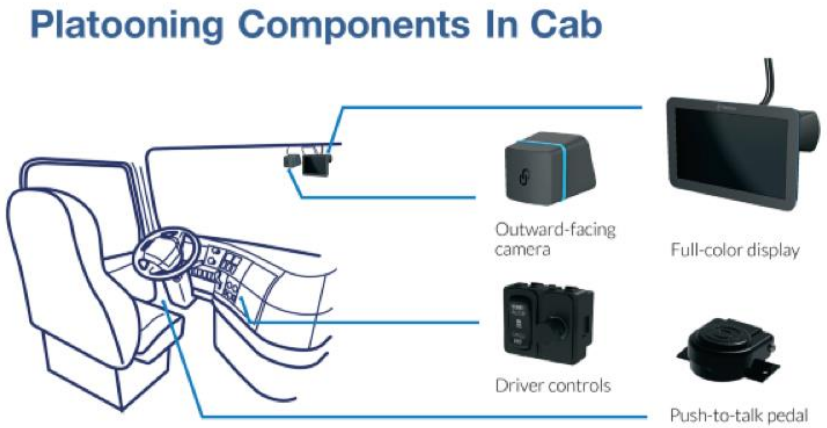
Drivers are Key

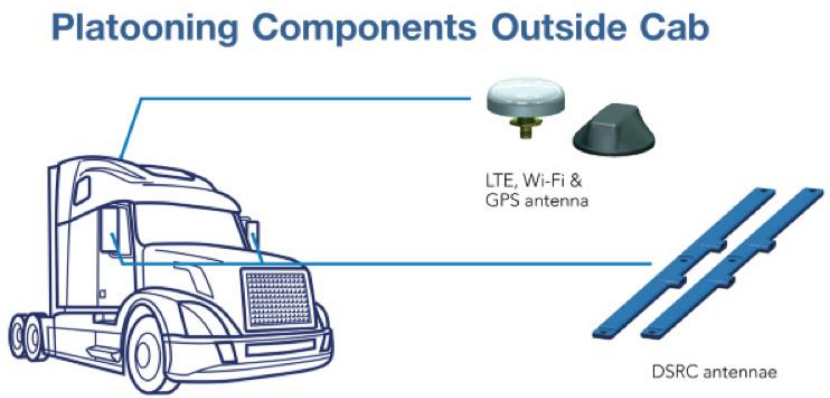
- PlatoonPro enhances Driver Teamwork.
- Veteran Driver-informed System Design & Training Program.
- Trained, CDL-certified drivers fully engaged in each truck.
- Peloton teams with Fleets to provide Training.

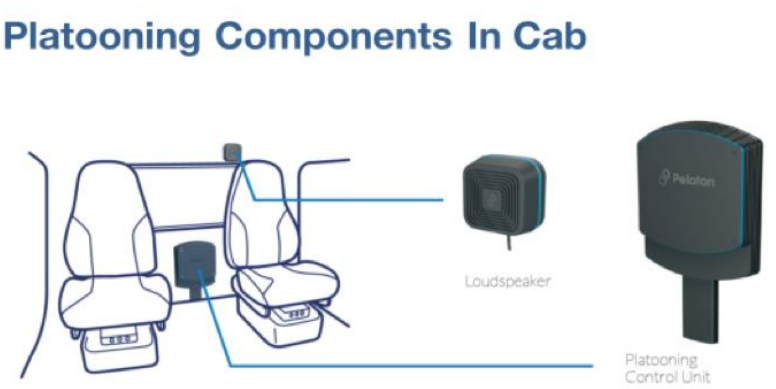
“A driver will feel safer behind the wheel because the truck can hit the brakes prior to a human in critical situations...”
Dave Mercer - Peloton Driver (~3 million MTD)

Peloton Hardware in the Smithsonian Design Museum

- Contributed the hardware components of our truck platooning system to Cooper Hewitt Smithsonian Design Museum (NYC)
- Part of "The Road Ahead" exhibition Dec. 2018 - March 2019.
- Museum placed the Peloton hardware in the appropriate sites on a full-size line drawing of a truck.
- Strong functional technology design, with visual appeal of the industrial design
- Platooning software design that has safety as its dominant design mandate.
- Design of the user interface so that professional truck drivers are empowered to make decisions and can operate the system easily.
- Design of the hardware look and feel to co-exist harmoniously with the driver so OEMS want to incorporate into their vehicles.







Integration & Safety Validation Working with OEMs

Peloton

PACCAR

Bendix

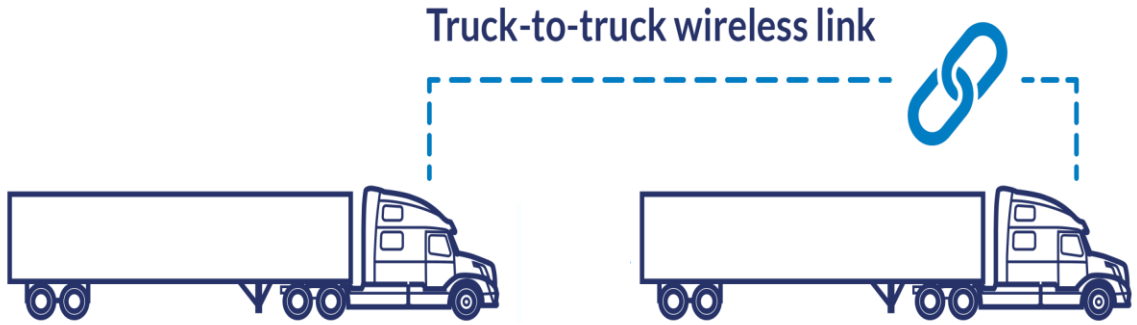
Cummins

Making Aerodynamic Following Safe: V2V linked Safety

Driver Perception & Reaction Time:
2 sec

< 10th of a sec

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

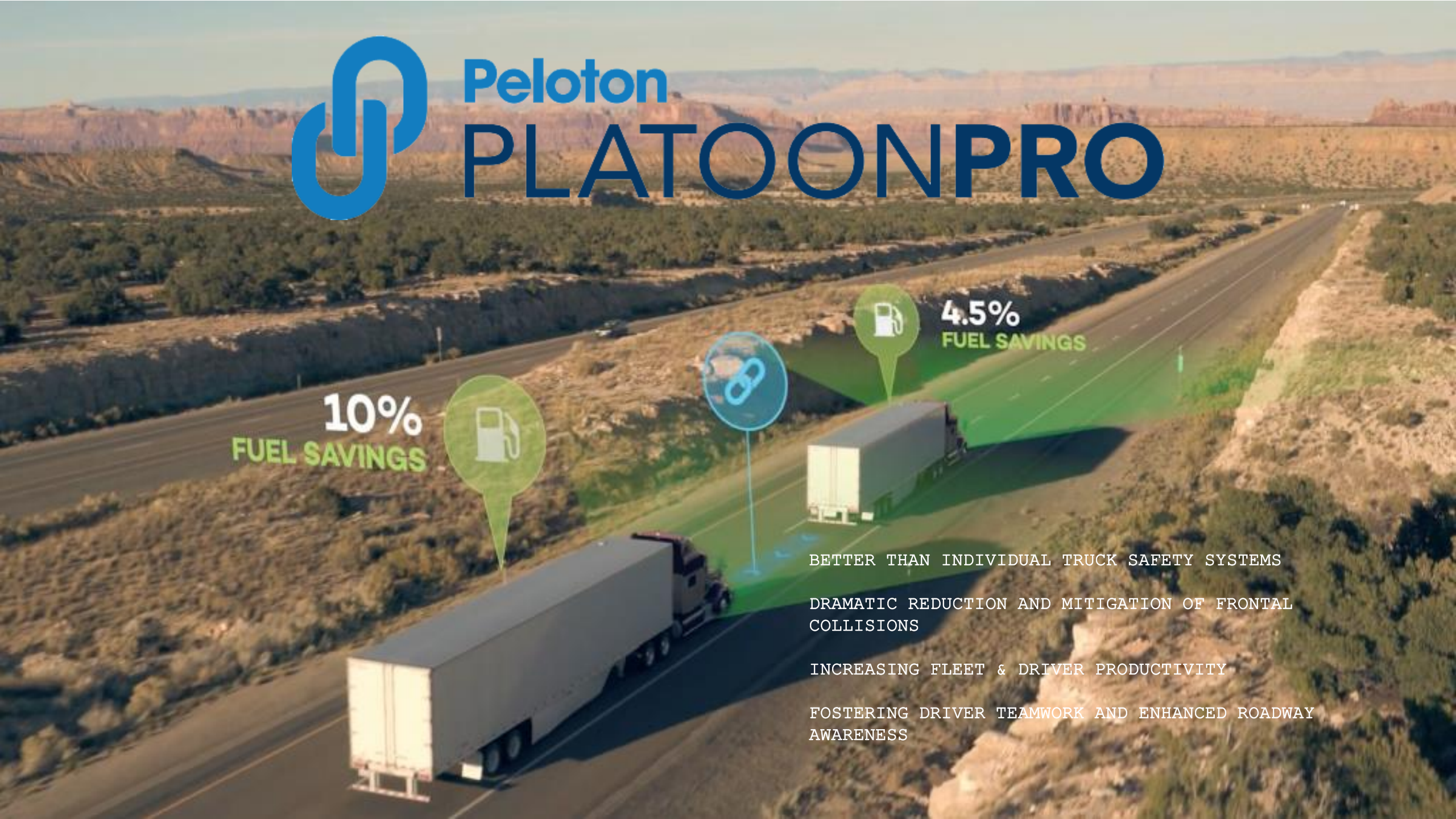


Supervision, Enhanced Safety: Geofencing to Suitable Roads & Conditions

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

- Multi-lane, divided, limited access highways
- Suitable traffic conditions (platoons dissolve automatically below 35 MPH)
- Suitable weather and road conditions
- Appropriate topography (no major up and down grades)
- Excluding construction zones, lower capacity bridges, and other specialized areas

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


Peloton
PLATOONPRO
10%
FUEL SAVINGS
4.5%
FUEL SAVINGS
BETTER THAN INDIVIDUAL TRUCK SAFETY SYSTEMS
DRAMATIC REDUCTION AND MITIGATION OF FRONTAL COLLISIONS
INCREASING FLEET & DRIVER PRODUCTIVITY
FOSTERING DRIVER TEAMWORK AND ENHANCED ROADWAY AWARENESS

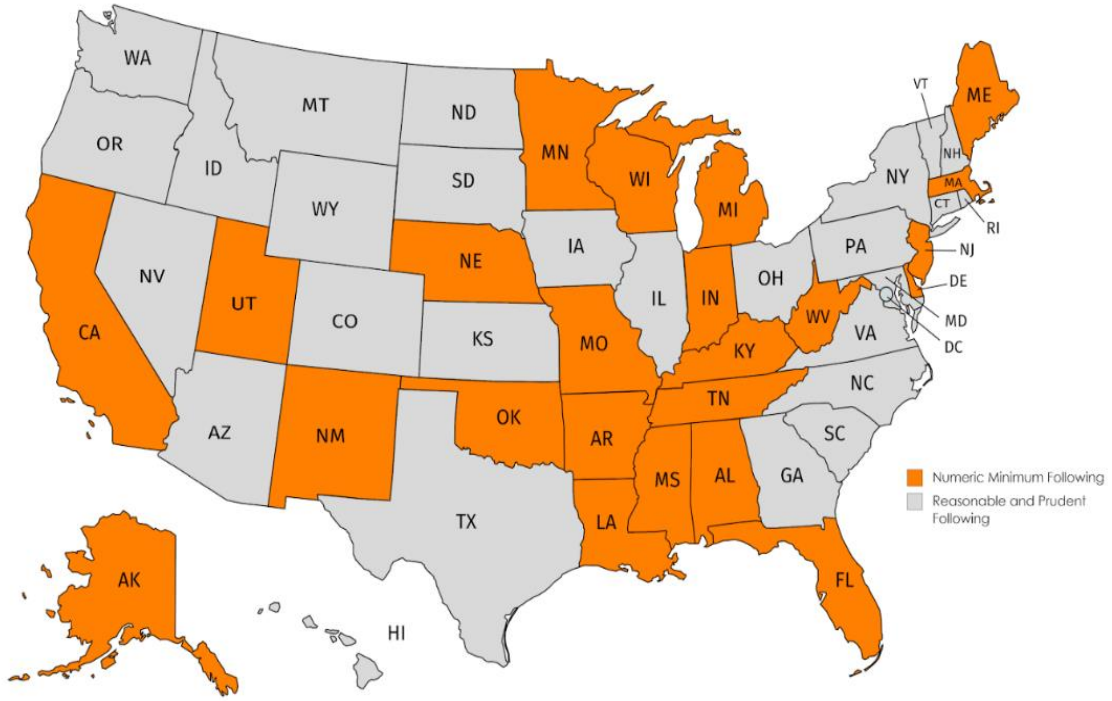
National Context: State Following Distance Laws

Numeric Minimum Following States

- A defined numeric minimum following distance in 23 states
- Platooning requires change in law.

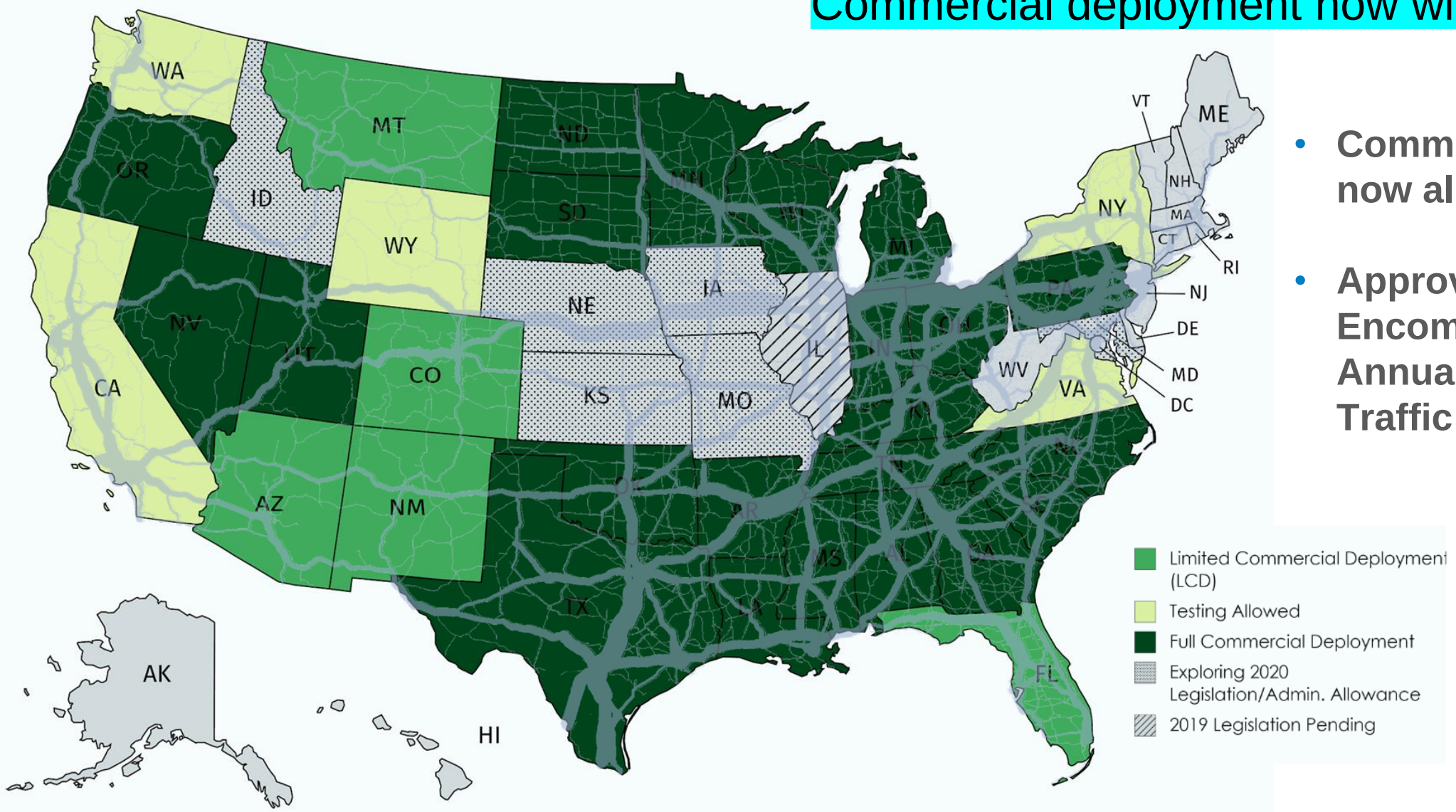
“Reasonable and Prudent” States

- A flexible, discretionary standard in 27 states
- Platooning can be legal under current law.



Oct. 2019- U.S. State Allowance for Truck Platooning

Commercial deployment now widely allowed



- **Commercial Deployment now allowed in 27 States**
- **Approved States now Encompass over 80% of Annual US Freight Truck Traffic**

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 (typical platooning systems operate at over 40 feet spacing).
  - 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**.

Initial Major Use Case: Same-Fleet, Hub-to-Hub Routes

Example Strong Customer Profile:

- Hub to Hub Regional Haul
- Fleet drivers
- Scheduled and ad hoc truck pairings
- Similar tractor configurations

Peloton Customer Trials

- July 2018: Peloton began running freight with PlatoonPro, giving fleets and shippers the opportunity to experience the benefits of platooning by paying us to haul their freight.
- Many customers in **Transport Topics Top 100 Fleets**.
- High utilization -- as high as **90% of platoonable miles platooned**.
- Platooned miles per day **> 700 miles per truck** in some cases
  - Projected gross fuel savings per truck of up to $7,000-10,000 per year.
- Trials to help customer fleets determine **favorable operations for platooning** and to introduce drivers to the the system.
- Robust driver **training curriculum enhanced**

Ahead:

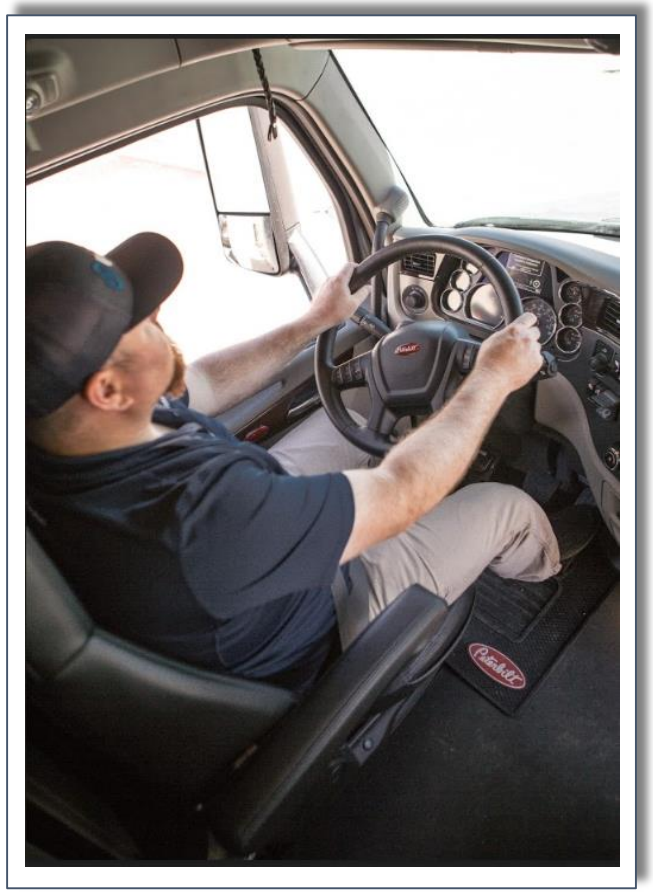
- Major multi-month, **customer acceptance trial is now underway** with using their trained fleet drivers and customer trucks.

Field Results from First 6 customers

Driver Feedback:	Consistently positive
Hard Braking:	None (0 above 0.4 g-force)
Cut-ins:	Only 1 every 620 mi; Smooth dissolves
Safety Incidents:	None
Fuel Savings:	Approx. 7% team savings
Cargo Moved:	+3,000,000 lbs of freight

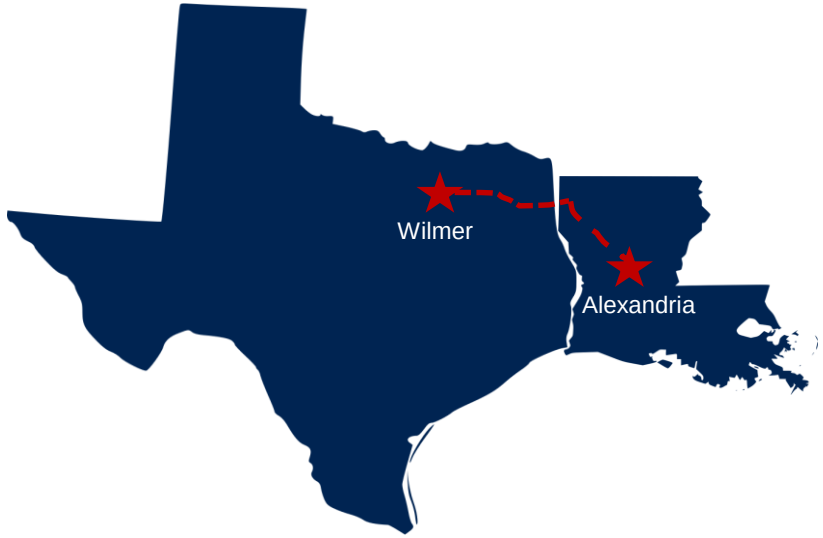
Positive Fleet Driver Feedback

- Seeing it in action clears up misnomers about platooning.
- Greatly impressed by the reliable cut-in dissolve feature.
- “I don’t fixate on the back of the front trailer because I scan for traffic.”
- Platooning is easy.
- I think other drivers could learn to use the system quickly.
- System encourages teamwork
- Platooning makes sense and “ who wouldn't want to go traveling with his buddy?”
- “It's a really well-designed system. I like the lay-out of it. I like the simplicity of it.”



Peloton Interstate Customer Trial: Aug. 2019

- First U.S. Interstate Customer Platooning Trial
- Two trucks, multi-week, hauling freight
- Peloton Network Operations Cloud enables interstate platooning on suitable multi-state highways without supervision interruption.
- Voluntary demonstration with department of public safety and highway patrol in Alexandria, LA prior to platooning for the first time in Louisiana.



Advancing Stakeholder Confidence in Our System Safety Approach

- Initiated development of a robust, voluntary safety system approach report to enhance regulator and stakeholder transparency and ensure adherence to overall best practices for AV systems.
    - **Purpose:** To provide transparency to the community about PlatoonPro and Peloton's safety approach for platooning.
    - **Intended Audience:** Truck drivers, fleets, government, law enforcement, and the general public.
- Designed report to complement NHTSA voluntary guidance for HAV companies to develop self-assessment reports of their systems (L3-L5) in order to demonstrate to stakeholders their varied approaches to achieving safety.

Peloton Safety Principles

Safe Base Vehicle	Constrain ODD	Apples to Apples	Right Functionality	Right Implementation	Handle Variation	Work With Driver	Work with Ind. / Gov.	Test Properly

Thank You for Your Safety Spectrum Leadership

AASHTO 50 State DOT Letter- Aug. 2019

- "State DOTs understand that a CV environment holds the potential to support a fundamental advancement in ensuring the safety of our nation's surface transportation system. And in order for this promising future to become a reality, the 5.9 GHz spectrum must be preserved for transportation safety purposes."
- Cites the hundreds of millions of dollars of investment by private and public sectors to develop and deploy lifesaving CV technologies in the 5.9 GHz spectrum.

Coalition for Safety Sooner Letter- July 2018

- "[We] strongly support the protection, and accelerated utilization of the 5.9 Gigahertz (GHz) Dedicated Short Range Communications (DSRC) Spectrum for safety critical, life-saving transportation applications. DSRC communications technology is ready to deploy now."
- Represents several U.S. state DOTs

COALITION FOR SAFETY SOONER

January 23, 2018

The Honorable Elaine L. Chao
Secretary
United States Department of Transportation
1200 New Jersey Avenue, S.E.
Washington, D.C. 20590

The Honorable Mick Mulvaney
Director
Office of Management and Budget
725 17th Street, N.W.
Washington, D.C. 20503

The Honorable Ajit Pai
Chairman
Federal Communications Commission
445 12th Street, S.W.
Washington, D.C. 20554

Dear Secretary Chao, Director Mulvaney, and Chairman Pai:

The Transportation Infrastructure Owner and/or Operator (IOO) signatories of this letter strongly support the protection, and accelerated utilization of the 5.9 Gigahertz (GHz) Dedicated Short Range Communications (DSRC) Spectrum for safety critical, life-saving transportation applications. DSRC is uniquely configured to enable continuous, low latency, and secure data exchanges between vehicles and the roadway infrastructure to support safety-critical applications. Connected Vehicle technologies based on DSRC have the potential to provide benefits, including increasing mobility, reducing crashes, and most importantly saving lives. DSRC communications technology is ready to deploy now.

AASHTO

August 19, 2019

The Honorable Ajit Pai
Chairman
Federal Communications Commission
445 12th Street, Southwest
Washington, DC 20554

Dear Chairman Pai:

As Members of the American Association of State Highway and Transportation Officials (AASHTO) representing the state departments of transportation (state DOTs) of all 50 states, the District of Columbia, and Puerto Rico, we urge you to continue our nation's commitment to improving transportation safety by reserving the 5.9 GHz wireless spectrum for this critical purpose. The top priority for the state DOTs and AASHTO has been—and will always remain—the safety of all transportation system users. The loss of 36,750 lives last year on our nation's highways and streets demands that we act boldly. To this end, connected vehicles (CV) utilizing Vehicle-to-Everything (V2X) communication in the 5.9 GHz spectrum will save lives by creating a seamless, cooperative environment that significantly improves the safety of our transportation system.

As infrastructure owners and operators of the nation's surface transportation infrastructure, state and local transportation agencies are at the core of creating the optimal CV environment. While automakers and device manufacturers will dictate availability of vehicular equipment, transportation agencies will control the deployment and operation of roadside infrastructure and the incorporation of CV technologies into infrastructure applications. Together, the public and private sectors have already invested hundreds of millions of dollars to develop and deploy lifesaving CV technologies in the 5.9 GHz spectrum.

State DOTs fully recognize that there is no current agreement among the transportation industry on which particular technology will be used to broadly deploy V2X applications. That being said, the current debate among stakeholders in the transportation industry on how best to use the 5.9 GHz spectrum should not be an excuse to open the spectrum for non-transportation safety purposes; rather, by preserving the spectrum, it will facilitate the transportation industry to agree on the best technology solution to broadly deploy V2X applications.

In closing, state DOTs understand that a CV environment holds the potential to support a fundamental advancement in ensuring the safety of our nation's surface transportation system. And in order for this promising future to become a reality, the 5.9 GHz spectrum must be preserved for transportation safety purposes.

–1–

General Outlook

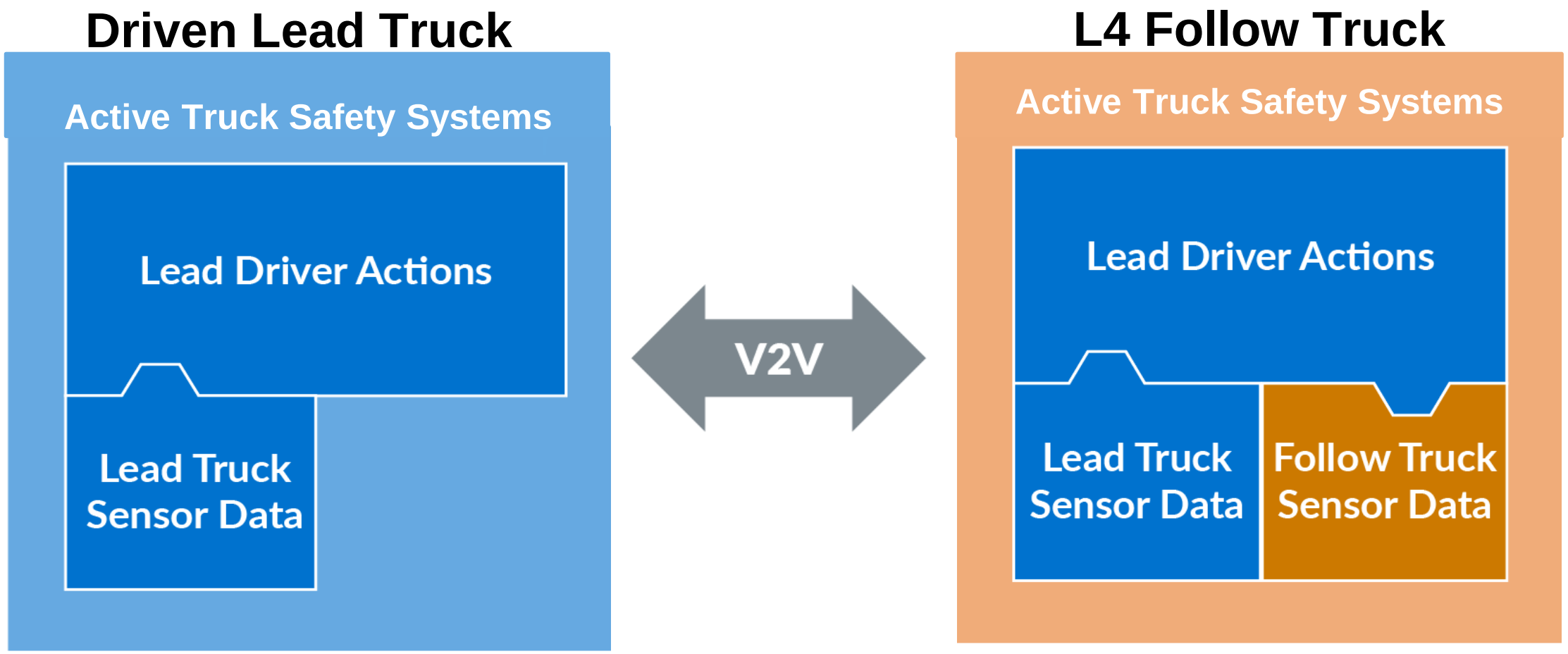
Growing Commercial activity using Driver Assistive Truck Platooning Solutions:

- **US:**
  - Peloton bringing driver-assistive truck platooning into operations with selected fleets, 2019-20.
  - Other OEMs continue to develop commercial systems including Kenworth, Peterbilt, Volvo.
  - FHWA and NHTSA projects underway exploring best-practices.
- **International:**
  - MAN Trucks, Scania commercial fleets trials -- Germany and Scandinavia, 2019-20.
  - EU Multi-brand platooning project: Platooning by the 6 European Truck OEMs, 2019-2020+.
  - Platooning commercial demonstration and fleet programs beginning -- UK, Australia, Asia.
- **Key Activity Ahead – Peloton Technology:**
  - Ongoing work with allies to arrange commercial allowance in additional states and int'l markets.
  - Continued collaboration with industry and state officials in the MAASTO region.
  - Ongoing work w/ industry: Purdue, Cummins, ZF/TRW, Wabash, NACFE, others.

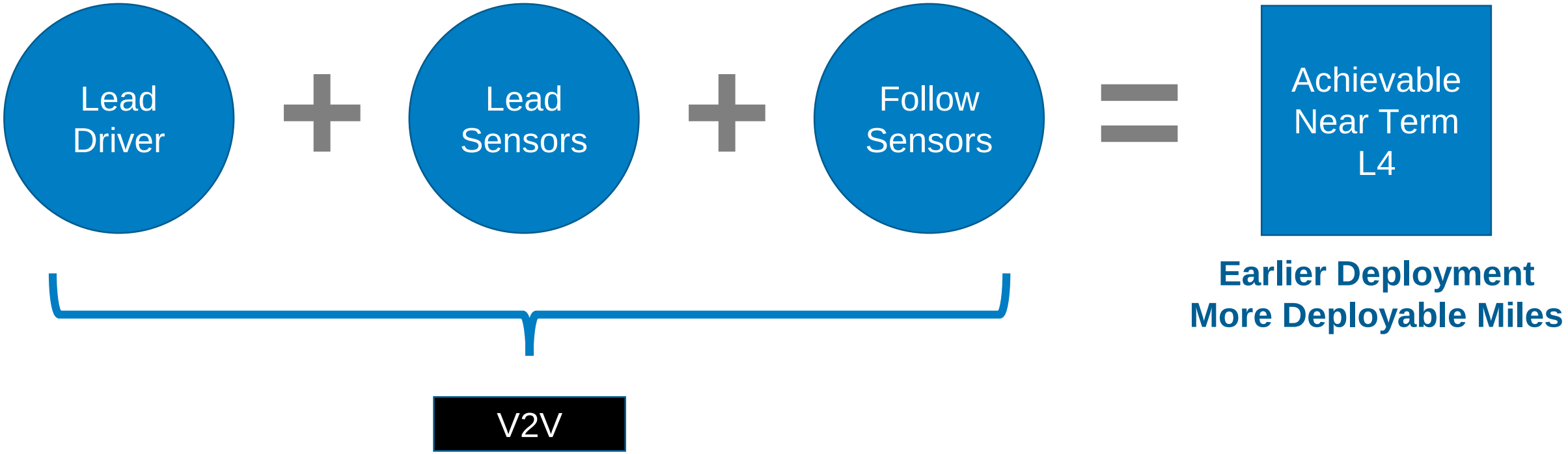
Michigan Leading in L1/L4 Platooning Testing

- Michigan is a U.S. leader in on-road testing of automated platooning.
- U.S. Army-TARDEC tested automated following technology on Continental and Magna international crossing in 2017.
- Crossed over the Blue Water Bridge in Port Huron, Michigan, to Sarnia, Ontario, and back again.
- Four vehicles, including two M915 line haul tractors carrying flatbed trailers loaded with cargo containers
- Semi-autonomous driving along a pre-programmed path to test of TARDEC's autonomous steering and leader-follower platooning technologies.
- Lead vehicle instructs follower vehicles on where and how to drive — including how closely to follow — and when to brake, accelerate and steer.

AutoFollow: Drivers Lead, Technology Follows



Harnessing the World's Best Sensor: Drivers



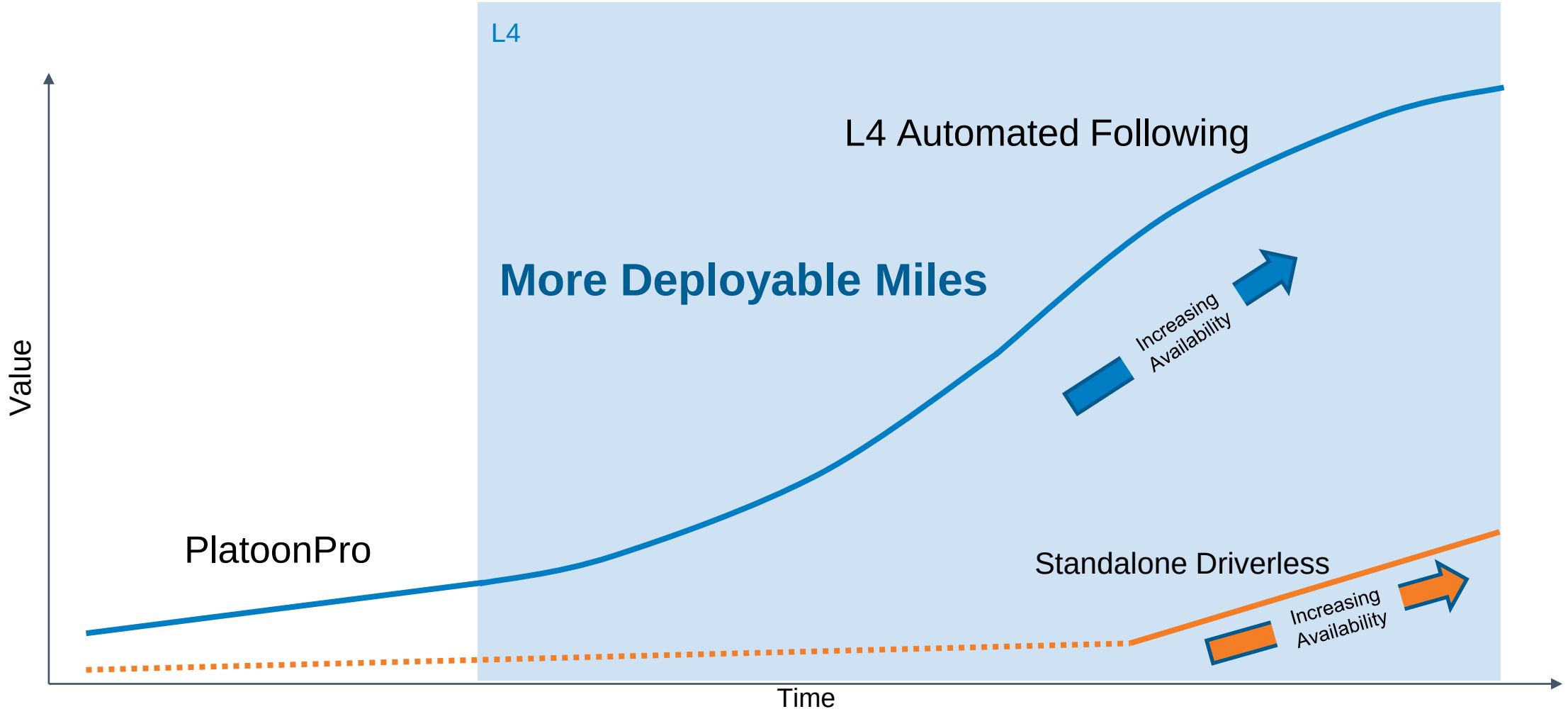

Construction


Traffic Control


Erratic Drivers


Weather Changes

L4 Automated Following



Peloton Benefits Trucking and Drivers

Drivers become twice as productive

- Accommodate growth in industry
- Alleviate growing driver shortage
- Increased skills: Integral to system operation
- Improved WORK: Better routes, trucks, compensation
- Improved LIFE: Shift to hub-to-hub, returning home every night

Stephen Boyd
Co-Founder
Peloton Technology, Inc.
steve@peloton-tech.com