PlatoonPro Truck Platooning
Connected - Grounded in Safety - Properly Tested
# Table of Contents

- Josh Switkes on Peloton ...................................................................................................................... 2
- Truck Safety Today .................................................................................................................................. 3
- The Peloton Safety Principles ................................................................................................................ 4
- Introducing PlatoonPro ............................................................................................................................ 5
  - Benefits: Safety and Fuel Savings ........................................................................................................... 5
- Start with Industry-Leading Technology ................................................................................................. 6
  - Built on Collision Mitigation Systems .................................................................................................. 6
  - Require Advanced Vehicle Specification ............................................................................................ 6
  - Inspection Requirements ....................................................................................................................... 6
- Supervise Platooning ................................................................................................................................. 7
- Guided by an Appropriate Benchmark ................................................................................................... 8
- Implement the Right Functionality ......................................................................................................... 9
  - Connected Braking ................................................................................................................................. 9
  - Platoon ProXimity Dissolve .................................................................................................................... 9
  - Platoon Dissolve .................................................................................................................................. 10
  - Cut-in Detection and Reaction ............................................................................................................. 10
  - Driver Awareness Video and Info Display ............................................................................................. 10
  - Driver Teamwork Through Voice Communications ........................................................................... 10
  - Cybersecurity: V2C and V2V and intraCloud ....................................................................................... 10
    - DEVICE LEVEL SECURITY .................................................................................................................. 10
    - V2V AND V2I COMMUNICATIONS SECURITY ................................................................................ 10
    - CLOUD INFRASTRUCTURE SECURITY ............................................................................................. 11
    - CORPORATE LEVEL SECURITY ....................................................................................................... 11
- Implementing the Functionality Right ..................................................................................................... 12
  - ISO26262 ............................................................................................................................................ 12
  - HW Implementation ............................................................................................................................... 12
  - SW Implementation ............................................................................................................................... 12
<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manage Variation in Vehicle Spec and Condition</td>
<td>13</td>
</tr>
<tr>
<td>Stopping Distance Variation</td>
<td>13</td>
</tr>
<tr>
<td>Vehicle and Equipment Variation Assessment</td>
<td>13</td>
</tr>
<tr>
<td>Special Cases: Lead Vehicle Collision and Lead Vehicle Hard Braking</td>
<td>13</td>
</tr>
<tr>
<td>Overall Improvement Through Connected Driving</td>
<td>14</td>
</tr>
<tr>
<td>MANUAL DRIVING</td>
<td>14</td>
</tr>
<tr>
<td>FOLLOWING WITH ACC AND CMS</td>
<td>14</td>
</tr>
<tr>
<td>PLATOONING</td>
<td>14</td>
</tr>
<tr>
<td>Keep the Driver at the Center</td>
<td>16</td>
</tr>
<tr>
<td>Human-Machine Interface Features</td>
<td>16</td>
</tr>
<tr>
<td>Driver Training</td>
<td>16</td>
</tr>
<tr>
<td>Driver Study</td>
<td>16</td>
</tr>
<tr>
<td>Collaborate with Industry and Government</td>
<td>17</td>
</tr>
<tr>
<td>Working with OEMs and Tier-1 Suppliers</td>
<td>17</td>
</tr>
<tr>
<td>Society of Automotive Engineers Standard: P7 Torque Method</td>
<td>17</td>
</tr>
<tr>
<td>Federal Engagement</td>
<td>17</td>
</tr>
<tr>
<td>Regional Engagement</td>
<td>18</td>
</tr>
<tr>
<td>Test Properly</td>
<td>19</td>
</tr>
<tr>
<td>ISO26262 and Testing</td>
<td>19</td>
</tr>
<tr>
<td>HIL Capability</td>
<td>19</td>
</tr>
<tr>
<td>Road Testing</td>
<td>19</td>
</tr>
<tr>
<td>Testing Safely</td>
<td>20</td>
</tr>
<tr>
<td>About Peloton Technology</td>
<td>20</td>
</tr>
</tbody>
</table>
Document Purpose

To provide transparency to the community about PlatoonPro and Peloton’s safety approach.

This community includes truck drivers, fleets, government, law enforcement, and the general public.

“Safety is a promise we make together. Something special happens when we make a promise to each other.”

Former U.S. Secretary of Transportation
Rodney Slater
Josh Switkes on Peloton

Since earning my Ph.D. in mechanical engineering at Stanford more than a dozen years ago, I have been working in the automotive industry, first at Volkswagen, and then at a startup making engines more efficient. When I founded Peloton in 2011, I was new to the trucking industry.

But right away, I was struck by how much the trucking industry spends in two areas: crashes and fuel.

At the same time, I realized vehicles were getting more electronic and more sophisticated, and processors and sensors were becoming cheaper, and cloud connectivity was getting ubiquitous. The time was ripe, I believed, to make a tremendous difference in the trucking industry by developing a driver-assistance platooning technology that could both help prevent trucking collisions and help trucking operators save fuel. It was something that could be done near-term and make a huge positive impact.

In the automation world, driver assistance is called “Level 1” automation. Our driver-assist solution for truckers, called PlatoonPro, is SAE Level 1 platooning automation, and our goal is to provide profound improvements in fuel economy and safety.

All of us at Peloton are guided every day by the words of former U.S. Department of Transportation Secretary Rodney Slater: “Safety is Our North Star.” As the Secretary has said, “Safety is a promise we make together. Something special happens when we make a promise to each other.”

Now, along with the entire Peloton team and in a spirit of transparency, I present to truck drivers, fleet operators, government officials, law enforcement, and the general public our approach to making Level 1 platooning safe for the trucking industry.
Due to the training and skills of professional drivers, along with advances in vehicle safety, trucks are remarkably safe today. However, although trucks are involved in far fewer collisions than passenger vehicles on a per-mile basis, truck collisions tend to be more severe and more noticeable.

Recent improvements to truck technologies, like mandatory anti-lock braking and the Collision Mitigation Systems (CMS) now offered by all truck makers (OEMs), have been shown to dramatically reduce collision rates.

A Department of Transportation/Volvo Trucks study has found that tractor-trailers equipped with only a collision warning system, or a collision warning system in combination with adaptive cruise control and electronic stability control, were involved in 37 percent fewer situations that had the potential to result in a rear-end collision. A Con-way study found a 71 percent reduction in rear-end collisions for tractor-trailers equipped with collision-avoidance systems, including automatic emergency braking, electronic stability control, and lane-departure warning1.

In 2016, for example, there were 475,000 police-reported crashes involving large trucks, which amounts to 1.65 crashes per million large-truck miles traveled. Approximately 0.8 percent of these crashes were fatal2.

When a truck is involved in a fatal collision, it's the people in the nearby vehicles, rather than the truck driver, who are most often harmed. So, in a very real sense, truck safety matters to everyone on the road.

The Peloton Safety Principles

Peloton has approached safety diligently from day one, and we continue to make a conscious effort to be transparent with our customers, partners, and the public about how we approach safety.

Our safety approach includes the following nine components:

- **Start with Industry-Leading Technology**: We build truck platooning on top of the leading active safety technologies available for trucks.

- **Supervise Platooning**: We actively constrain Operational Design Domain (ODD) to road and driving conditions for which we have developed and validated. We do not rely solely on the driver to know under what conditions to use the system.

- **Compare to an Appropriate Benchmark**: We analyze and compare safety statistics with the following in mind: How does the risk change when the driver presses the platooning button?

- **Implement the Right Functionality**: We implement the right set of functionalities to achieve our safety goals in today’s mixed traffic and conditions on real vehicles with today’s highway infrastructure.

- **Implement the Functionality Right**: We follow ISO 26262, the standard for functional safety of electrical and electronic systems in production automobiles, as defined by the International Organization for Standardization (ISO) in 2011. It is our structure for developing and validating a safe system.

- **Manage Variation in Vehicle Spec and Condition**: Real-world vehicles and road conditions vary considerably, and we design with this in mind, at the core of our engineering analysis.

- **Keep the Driver at the Center**: The driver is a key part of the safety of PlatoonPro, and we design and test with the driver’s safety and comfort front and center.

- **Collaborate with Industry and Government**: PlatoonPro is the result of joint development with truck OEMs and Tier-1 suppliers. Peloton and its partners deploy collaboratively with both state and federal government.

- **Test Properly**: We make a tremendous effort to ensure that the testing itself is safe, and that the safety testing is thorough and appropriate for our systems and products.
Introducing PlatoonPro

Trucking is a huge, growing industry that underpins the entire economy. It is attracting significant attention from technology companies – and for good reason.

*With over $700 billion in annual revenue and 80% of all transported cargo, trucking is ripe for innovation.*

As a mature industry, it has slim margins, and a few very significant costs. Fuel comprises 23 percent of total costs for an average trucking company, and collisions add up in both human and financial terms. Commercial vehicle crashes resulted in $87 billion spent in 2011. Every life lost, and every dollar spent, matters.

To help reduce fuel expenses and create a safer – and therefore less costly – driving experience, Peloton Technology has developed PlatoonPro truck platooning, a driver-assist technology. By utilizing vehicle-to-vehicle (V2V) communications and radar-based active braking systems, combined with vehicle control algorithms, Peloton links pairs of heavy trucks for connected driving that improves aerodynamics, fuel economy, and safety.

PlatoonPro is already showcasing its benefits to the industry by operating with select customers and on select routes.

**Benefits: Safety and Fuel Savings**

PlatoonPro forms a wireless connection to enable one truck to draft safely behind another while providing fuel savings for both vehicles. Today, we typically platoon at 55ft, with shorter distances enabled over time with additional testing.

Peloton’s V2V communications connect two platooning trucks together electronically, allowing them to accelerate and brake together as a single system. For example, when the driver of the lead truck brakes, the following truck brakes nearly instantaneously – well before the driver would have had time to react to the brake lights. With Peloton’s V2V communications, two platooning trucks no longer behave as discrete vehicles. Because of their direct electronic connection, the platooning trucks brake and accelerate as a single unit – predictably and safely. The V2V functionality is enabled by Dedicated Short Range Communication (DSRC). DSRC is a proven communications protocol. It occupies a Federal Communications Commission-allocated radio spectrum (in the 5.9 Gigahertz band) for private short-range wireless communication, specifically designed for moving vehicles.

At 65 miles per hour, fuel savings across a two-truck platoon are approximately 7.25 percent (10 percent for the follow truck and 4.5 percent for the lead truck) based on testing by the North American Council for Freight Efficiency, the U.S. Department of Energy, and the U.S. Department of Transportation. The fuel savings will enhance the competitiveness of fleets and drivers using PlatoonPro.
PlatoonPro Truck Platooning

Start with Industry-Leading Technology

Built on Collision Mitigation Systems

To reach new heights of safety, we build upon existing safety technology that has been shown to be very effective at reducing collision rate and severity.

For example, Peloton PlatoonPro builds upon – and works seamlessly with – CMS, including collision mitigation braking, forward distance alerts, as well as anti-lock braking systems (ABS).

Require Advanced Vehicle Specification

So that we can be confident in a vehicle’s performance, we always require sufficient safety equipment to be present on vehicles that use Peloton PlatoonPro. For example, today we require air disc brakes on all tractor axles and ABS on all trailer axles. With further testing, we may be able to support drum brakes on tractors.

Inspection Requirements

Similar to our requirements on the vehicle specification, we require certain inspection practices by the fleet operator to make sure the vehicle performs within the scope of our analysis and testing.
Supervise Platooning

PlatoonPro is designed for a specific set of circumstances, known in the industry as the Operational Design Domain (ODD). We have designed a safety approach around this ODD, in that

PlatoonPro dynamically limits its operation only to controlled-access, divided, multi-lane highways.

The ODD does not include operation in inclement weather conditions and certain construction zones. To limit platooning to the ODD, we leverage a combination of the cloud and vehicle checks. Each truck has a cellular connection to a cloud network, and through that connection we send authorizations to the vehicle. These connections are protected by encryption and other industry-standard security protocols.

We also perform vehicle checks as an additional layer of safety to ensure vehicle speeds are above a certain threshold, and below – or at – the speed limit while platooning. In this way, the system does not operate in non-highway settings. Wiper usage and stability control activations can be monitored as additional indicators of unfavorable weather conditions. The platoon automatically dissolves if unfavorable weather signals the possibility of unsafe platooning.

Authorizations are valid for a given location and time and specify a platooning partner vehicle. If the connection is lost, the trucks smoothly separate – thus the loss of cellular does not create a safety risk, just a loss of platooning availability. This authorization process will be rolled out initially for intra-fleet pairing (two trucks from within the same fleet). In the future, authorizations will expand to cross-fleet pairing.
Guided by an Appropriate Benchmark

We strive to increase the safety of trucks on the road and our goal is for drivers to be safer after they push the platooning button.

To do this, we compare platooning vehicles not just to average vehicles, but to the vehicles that lead the industry in safety: trucks equipped with active safety systems. Our goal is for drivers to be safer after they push the platooning button compared to before they’ve pushed the platooning button.

To quantify this, we first examine the active safety system collision rate, which is the estimated rate specific to Class 8 trucks on the highway equipped with active safety systems. (This rate is based on FMCSA data modeled as if every truck on the road were equipped with active safety systems.)

Next, we calculate a rate of collision for these active-safety-equipped trucks in the use case targeted for platooning. We do this by estimating a PlatoonPro benchmark rate that is a certain percentage of the estimated Active Safety System Collision Rate.

These calculations are used to establish a goal and guide us in our iterative system-design process to improve upon the current safety state of the art.
Implement the Right Functionality

Connected Braking

Peloton’s direct V2V communication, based on the industry-standard DSRC, allows two platooning trucks to accelerate and brake together as a single system. Specifically, the DSRC connection enables the follow truck in a platoon to react nearly instantaneously to acceleration and braking by the lead truck.

In communicating lead-truck braking force to the follow-truck system, following distance is reduced, perception delay is eliminated, and reaction delay – from the typical braking sequence of perception/reaction/braking – is vastly shortened. This is a key differentiator between PlatoonPro-equipped trucks and manual or radar-based braking.

In summary, the platooning system reacts extremely quickly, accurately, and reliably. Its reaction time is quicker than that of the human driver. It applies the brakes precisely to match or exceed the braking by the lead truck. And, unlike a human driver who may sneeze, sip coffee, or even text, it doesn’t become distracted.

Platoon ProXimity Dissolve

Platoon proXimity Dissolve, or PXD, is a feature and capability of the PlatoonPro system designed to enhance the overall safety and performance of the system. Through integration with the CMS, we utilize radar and camera sensor data to monitor traffic in front of the lead truck. V2V is used to relay this sensor information to the rear vehicle. The system in the rear vehicle uses the sensor data to evaluate traffic, or “targets” in front of the lead truck. If events occur in close proximity to the lead truck (e.g., a car cutting closely in front of the lead truck), then the system will preemptively dissolve the platoon. In this way, the system separates the trucks to a safe distance and slows the follow truck relative to the lead vehicle before situations occur that may require hard braking.
Platoon Dissolve

While we do not rely on the drivers to assess system readiness and faults (the system handles that), we do train drivers to dissolve the platoon themselves when upcoming conditions may be inappropriate.

When a driver decides to end platooning, the follow-truck system will increase the gap between the trucks until a safe manual follow distance is reached. At that point, the follow driver takes control using the brake or accelerator pedal. During dissolve, the system will respond to the lead truck’s braking or to avoid a vehicle that cuts in between the two trucks.

Cut-in Detection and Reaction

While the close proximity of the two platooning trucks makes it easier for other vehicles to navigate ahead or behind the platooning trucks, another vehicle may cut between them. Platooning drivers likely will recognize a cut-in threat before the system does, and therefore drivers are trained to dissolve the platoon to make room for the cut-in. But if they don’t, the system will initiate dissolve immediately upon detection and will also simultaneously alert the drivers.

We have also kept the initial release of PlatoonPro to just two trucks – a lead truck and a follow truck. Many people are commonly concerned about the ability for other road users to navigate near the trucks, including the need to cut between the trucks. Our experience is that it is actually easier to drive around platooning trucks than it is to drive around conventional trucks, due to the automatic cut-in reaction and the greater ease of passing the pair of trucks compared to passing two manually following trucks. But we want to give the public a chance to get familiar with this before we would roll out a three truck platooning system.

Driver Awareness Video and Info Display

In platooning, the follow driver is as aware and engaged as the lead driver in the driving task. While follow drivers have a generally clear view of the road, PlatoonPro provides a video feed from a forward-facing camera in the lead truck. This enables them to see vehicles, objects, and road features like entry ramps ahead of the lead truck. Follow drivers look at the video view as part of their mirror-scan cycle.

Driver Teamwork Through Voice Communications

PlatoonPro has shown a tremendous potential to facilitate teaming between drivers. Drivers use a hands-free driver-to-driver radio communications feature to meet on the road, share information about road conditions, and coordinate maneuvers such as lane changes.

Cybersecurity: V2C and V2V and intraCloud

We have worked with security experts to review our systems, infrastructure, and facilities from top to bottom. Using this detailed information, we have focused on the following key areas:

DEVICE LEVEL SECURITY

System updates, stored data, and intrusion detection are managed to ensure only Peloton-
created and validated content is used on Peloton vehicle systems. Communication in and out of the Peloton vehicle platooning controller is secured by public/private key technologies to enable secure authentication. Should anomalies be detected in the code images before or during execution, our hardware/software system directs and monitors a safe dissolve and return of control to the driver.

**V2V AND V2I COMMUNICATIONS SECURITY**

V2V communication between platooning tractors is provided over DSRC with authenticated and encrypted data transfers. The V2V systems are monitored and linked closely into the Peloton safety systems. Problems identified in the V2V communications link result in a safe dissolve and provide alerts to the fleet as well as Peloton’s Network Operations Cloud (NOC). The communication between the vehicle and the cloud is securely implemented over LTE 4G technology. All communication over the 4G network is through a standard, secure HTTPS tunnel keeping all location, performance, and driver information confidential. The communications are monitored and if anomalies – such as jamming, denial-of-service attacks, loss of signal or other unexpected occurrence – are seen, our Safety Manager directs and monitors a safe dissolve and return of control to the driver. The Safety Manager can perform this dissolve in the absence of vehicle to vehicle communication.

**CLOUD INFRASTRUCTURE SECURITY**

The NOC is implemented in a commercial cloud environment, using their best practices for secure operations. Standard secure processes include use of Identity and Access Management role-based access, multi-factor authentication, Security Groups, Encryption at rest and in transit, Intrusion Detection Services, and CloudTrails to record all console activity. Furthermore, Peloton engages third-party auditing to ensure ongoing security.

**CORPORATE LEVEL SECURITY**

Peloton security practices keep our customer data, development, and connected assets secure. As we do with our cloud security, we engage third parties to assess and direct efforts on corporate-level security, including physical access, employee processes, and IT infrastructure.

*Customer information is safely located within our secure cloud infrastructure and access is limited to specific personnel.*

Internal access is also monitored by intrusion detection services and logged to aid in our carefully considered incident response plans in case of a systems breach.
Implementing the Functionality Right

Even the best planned functionality is only as good as its implementation,

so Peloton leverages leading development practices from both the automotive and high-tech industries in our joint development programs with OEMs and Tier-1 suppliers. The result is a high-reliability system that can also rapidly add new capabilities without requiring a multi-year validation cycle.

ISO 26262

Together with our development partners, Peloton has been guided by ISO 26262, the leading standard for functional safety. Following this standard is invaluable to several critical aspects of our development process:

- Traceability: The International Organization for Standards (ISO) process allows us to trace back to high level safety goals every vehicle test, every Hardware in the Loop (HIL) test, and every Software in the Loop (SIL) test.

- Full coverage: The ISO process gives confidence that our analysis and testing cover key safety areas.

- Rapid re-validation: ISO gives us the ability to rapidly re-validate through our test processes on HIL, SIL, and track testing.

Furthermore, the ISO process has guided us towards several areas of development work that are critical to ensuring that safety goals are met:

- Automotive Safety and Integrity levels (ASIL) and safety requirements for subsystems

- Verification and validation

- Tool-chain evaluation and qualification

Hardware Implementation

The Peloton Electronic Control Unit (ECU) is architected to meet our safety goals. Guided by ISO 26262, the ECU and its key components have undergone ASIL assessment and validation.

Software Implementation

On the architected hardware, Peloton has implemented a multi-tiered software structure. We have taken leading Operating Systems (chosen for each processor) and implemented a safety critical middleware. We have found this combination of software has the iteration capability of the best prototype-level middleware, combined with full traceability and other safety requirements from production operating systems. This allows rapid development while meeting our safety goals.
Manage Variation in Vehicle Spec and Condition

Peloton is working towards a significant reduction in the collision rate compared to trucks on the road with advanced safety systems. To do this, we actively manage the variations in truck specifications and equipment conditions, and we have extensively tested the braking capabilities of tractors and trailers under a wide variety of vehicle and road conditions. We use all this information to set the platooning gap – the distance between the trucks while platooning.

Stopping Distance Variation

Today's trucks vary considerably in on-board equipment, such as brake types, or vehicle attributes like wheelbase. And the condition of their on-board equipment varies from truck to truck. In addition, trucks carry different types of cargo, which affects their total mass, and, consequently, their stopping distance. Taking two random trucks from the highway today, one truck might be able to stop 100 feet or more sooner than the other.

This is one of the primary reasons why truck drivers are instructed to follow at quite large following distances such as six or seven seconds of time headway. In the real world, however, drivers often follow at what are considered unsafe distances.

To make the road safer, PlatoonPro uses V2V communication to assess two trucks as a possible platoon, including evaluating their relative stopping distances.

The system goes beyond using sensor data on stopping-distance variation to select which trucks are allowed to platoon safely, and which trucks in a team should lead or follow.

Vehicle and Equipment Variation Assessment

We generally separate areas of variation into two categories: those we can measure or determine on the vehicle, and those we cannot. Examples of the ones we can measure or determine are the vehicle mass (we calculate that in real time), or the type of brakes on the tractor. Ones we cannot measure in real time today include tire-tread depth, or the height/center of mass of cargo inside the trailer. Therefore, our platooning gap is set to be large enough to absorb uncertainties in stopping distance due to these unknown factors. As we continue to improve our ability to measure more of these factors in real time, we may safely decrease the platooning gap and improve the overall efficiency of the system.

Special Cases: Lead Vehicle Collision and Hard Braking

While platooning may reduce collisions, we recognize that collisions involving platooning trucks will nonetheless occur. So, we have also analyzed specific scenarios such as the lead truck getting in a collision, and the lead truck employing full (hard) braking. In each of these scenarios our goal is to reduce the collision rate and severity compared to a non-platooning truck. We've leveraged crash data recorded in the field by production-event capture systems to feed our simulations with realistic, real-world data. These data include relevant events and associated vehicle and sensor data, represent hundreds of millions of miles, and are invaluable to understanding the real hazards encountered by trucks on the road.
Overall Improvement Through Connected Driving

When the functionality is combined with our design-and-test methodology, the end result is that we can operate the trucks much closer together than what, in the past, has been considered safe.

MANUAL DRIVING

Let’s look at manual driving – that is, typical, individual trucks on the road.

When a truck brakes, there is a lag before it starts to slow down. For drivers following that truck, it can take 1.0 to 1.5 seconds to perceive and react to the braking of the first truck. When following drivers apply their brakes, their own trucks experience a brake lag. But there could potentially be a big difference in braking distance – 100 feet or more – compared to the lead truck.

Combining these factors, the safe following distance for a manually driven truck is many hundreds of feet, but because drivers feel it is impractical in many cases to follow at such distances, collisions occur too frequently for heavy trucks, and many collisions occur at a high velocity.

FOLLOWING WITH ACC AND CMS

Because sensors do not get distracted the way human drivers do, a vehicle equipped with an Automatic Emergency Braking and/or a collision mitigation system, can eliminate the attention lag time for braking. They also can dramatically reduce the perception distance, and partially reduce the reaction distance.

Trucks equipped with such systems can reduce the appropriate following distance to about 300 feet, while lowering collision rates. They also reduce the impact velocity of many collisions, reducing the severity.

In the real world, however, such following distances are difficult to maintain. Other vehicles cut in between these following vehicles frequently, often reducing typical following distances to less than 200ft, creating higher risk.

These systems do not help at all with braking differences between vehicles, or with brake lag.
PLATOONING

When platooning, the V2V and Vehicle-to-Cloud (V2C) dramatically improve several of these factors.

The perception and reaction times are reduced dramatically, and because the follow truck can react to the lead truck brake application (before the lag), the lag is effectively eliminated (the two trucks experience the lag at nearly the same time). The PlatoonPro system also has partial information about the braking capability of the lead truck, which eliminates a large portion of the uncertainty in braking between the two vehicles.

The end result is a dramatically shorter following distance than that prescribed for manual driving. In addition, our analysis suggests that the residual collisions that do occur are mostly at very low impact velocities, and thus are far less severe than a typical collision. This means that the potential safety benefit is even greater than the reduction in collision rate.
Keep the Driver at the Center

In the PlatoonPro system, drivers are in primary control of their trucks. To ensure that the system works well for them, we are guided by these principles:

- Be sure the driver is aware of the actions and state of the system
- Provide the driver with enough information to know what actions to take or not take
- Keep the driver engaged in the driving task

Human-Machine Interface Features

The PlatoonPro Human-Machine Interface is designed to facilitate an appropriate level of driver engagement so that the driver can focus on the driving task at all times.

The PlatoonPro system has a display, control cluster, foot pedal, and speaker. The display provides each driver in a platoon with system status information and instructions. For the follow driver, there is also a forward-facing video from the lead truck. In addition to visual alerts on the display, audio alerts accompany various changes in state or events.

Platooning requires approval from both drivers. Before platooning begins, the lead driver must evaluate road conditions based on Peloton training. If it is safe to platoon, the lead driver will press the “All Clear” button. Only then can the follow driver press the “Start” button.

Either driver can end the platoon at any time. The follow driver can dissolve the platoon by pressing the “End” button or the brake pedal. The lead driver uses the “End” button to dissolve the platoon.

Driver Training

While most Advanced Driver-Assist Systems do not include driver training, we have designed a training program to teach drivers how to safely operate a platoon of trucks while sharing the road with other drivers. Training involves classroom and on-road instruction and includes safety, system operation, platoon maneuvers, and team situational awareness.

Driver Study

A frequent concern or question about platooning centers around driver attention. Peloton takes this issue seriously and is rigorously studying it. We are partnering with industry-leading experts whose preliminary results have not shown any decrease in performance while platooning for long durations.

Many people picture the follow vehicle driver staring at a wall ahead of them (i.e. the rear of the preceding tractor-trailer combination); in reality, at typical platooning gaps of 30-60ft, the follow driver can see the road just fine, especially with the additional video feed from the lead truck.

Additionally, driving while platooning is very similar to driving with adaptive cruise control or even normal cruise control in low traffic areas: the main task is to steer.

That being said, it is important to be sure that drivers do stay engaged and at a similar level of performance over long-duration driving, as they do when not platooning.
Cooperation with industry and government can promote safety as systems like PlatoonPro are brought to market.

Working with OEMs and Tier-1 Suppliers

Peloton has worked directly with most of the leading truck makers, brake suppliers, and other Tier-1 suppliers. This work has included safety analysis and evaluation, track and road testing and evaluation, implementation of interfaces, and much more.

This approach allows the system to build upon the benefits of existing systems and enhance those benefits through the unique capabilities of platooning. More importantly, it has allowed Peloton to develop the platooning system integration with the experts in each of the control functions. Our system is not just an ‘add on’ but has been provided a dedicated interface to the truck control systems. This has been enabled through our close ties to the OEMs and Tier-1 suppliers who have modified their systems to support the integration of the Peloton platooning system. These close ties and integration at the embedded system level have enabled a fully integrated approach to our safety concept.

Society of Automotive Engineers Standard: P7 Torque Method

As one example of our collaboration, with platooning as a prime use case, a new torque control method has been added to the SAE (formerly Society for Automotive Engineers) J1939 standard for communication and diagnostics among vehicle components: the P7 torque method. The SAE standards for J1939 were established to provide OEMs and suppliers a common way to communicate and share information. With respect to engine control there are six standard methods (or control purposes) to request engine torque control. Our partners have worked with the standards committee to establish a new control purpose (P7) providing a standard engine torque interface for platooning and other autonomous systems. This approach will allow standardization among OEMs and suppliers to use a standard torque interface for PlatoonPro, while interacting properly with the existing safety systems on board the vehicle.

Federal Engagement

Driver-assist truck platooning requires no federal action with respect to regulations or otherwise, yet Peloton has adopted a proactive approach to engaging officials at the federal level. PlatoonPro requires driver engagement at all times, including the driver steering, and requires no fundamental changes to the design of the vehicle. Consequently, the deployment of driver-assist truck platooning requires no policy changes at the federal level. However, Peloton appreciates the need for...
policymakers to understand platooning – both its fuel economy benefits and safety. Regulators from the U.S. Department of Transportation, including FMCSA, Federal Highway Administration, and National Highway Traffic Safety Administration, have participated in demonstrations of the technology. Peloton has also contributed to federal projects related to platooning, including fuel economy research by the National Renewable Energy Laboratory\(^3\). In addition, Peloton is a participant in the Next-Generation Energy Technologies for Connected and Automated On-Road Vehicles (NEXTCAR) program, sponsored by the U.S. Department of Energy’s Advanced Research Projects Agency-Energy (ARPA-E). The project applies next-generation truck platooning technology and concepts for cloud-connected powertrains, seeking 20 percent fuel savings for tractor-trailers. Peloton has partnered with Purdue University and Cummins in this project\(^4\).

**Regional Engagement**

Regional governments across the country are assessing the economic and safety benefits of platooning. As platooning transitions from research and development to commercialization, state legislatures and law enforcement officials have considered the impact of platooning on freight efficiency, and the need to maintain the safety of roadways and adherence to traffic laws. As of this writing, 26 U.S. states have changed their traffic laws, or their interpretation of existing laws, to allow platooning – 18 of those fully authorizing platooning and 8 additional allowing testing or limited deployments. These 18 states represent more than 50% of freight movement in the US, with the collective 26 states representing more than 75% of freight movement.

Along with other truck OEMs and research institutions, Peloton has engaged policymakers to explain our technology, and how it can integrate into traffic conditions. After Michigan passed the nation’s first state law confirming allowance of driver-assist truck platooning, Peloton briefed Michigan state regulators and law-enforcement officials on the technology and held demonstrations for more than 20 officials and stakeholders along Interstate 96. In connection with Florida’s platooning pilot project, Peloton operated more than 1,000 miles along the Florida Turnpike, showcasing the maturity and driver-centric nature of the PlatoonPro system.

As more legislators and regulators consider the emergence of platooning technology, Peloton will continue to collaborate with stakeholders at the regional level.

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Test Properly

With the right functionality and the right intended implementation, it is then critical to conduct appropriate testing to be sure the implementation meets the requirements.

As is common in the industry, the testing of the system is a multifaceted activity using a number of tools and test methods. Fundamental to testing properly is the design of the test methods and test plans. These are derived and made traceable to the system requirements and the system safety goals, as guided by ISO 26262. Testing to the requirements is commonly known as verification and validation (V&V) testing. In this testing, one validates that the design meets the requirements and verifies that the system performs as designed.

Peloton has embraced industry standard test methods and developed the tools and test methods to fully validate the system. This includes a Software in the Loop tester and Hardware in the Loop tester, vehicle on-track test methods and procedures, and an extensive test process to verify that the system is ready for on highway use.

ISO 26262 and Testing

ISO 26262 provides an excellent framework for the testing, allowing each requirement to be tested in one or more tests. The ISO process starts with a Hazard and Risk Analysis (HARA) which is used to determine the safety goals of the system. These in turn are used to derive functional and technical safety requirements which then provide the framework for testing the safety of the system.

The tests derived from the analysis can be vehicle level track tests, Hardware in the Loop, or Software in the Loop. Using this test process, all of the tests are traceable back to the safety goals so that we can gain confidence that the function has been tested and the safety goal has been met.

HIL Capability

The PlatoonPro system is heavily tested in a Hardware in the Loop (HIL) test environment. This consists of PlatoonPro hardware being exercised in a variety of ways to mimic real-world use of the system. This includes a broad set of tests following the ISO 26262 process. In addition, we can take data collected from real world driving conditions, feed the data into the HIL tester, and repeatedly test a variety of operational conditions.

These HIL testers are very importantly made from actual PlatoonPro hardware, to make sure the testing is covering any potential issues resulting from the hardware such as timing of signals or other issues that might not be found in a software-only tester.

Road Testing

The ISO 26262-driven tests complement the on-road testing that is a critical component of ensuring safety of PlatoonPro. The road testing, which is done only after substantial track testing, is not primarily to verify that the functionality meets the requirements. Rather, it is performed to ensure the system performs properly over the longer term, and to confirm that the original requirements are aligned with the real operating environment and hazards.
Testing Safely

Safe testing really includes two aspects: safety of testing and testing for safety. The previous sections have described how we test for safety, but also how we take the safety of our testing very seriously.

Before Peloton software ever goes on the road, it goes through an extensive process of peer code review, unit tests, SIL and HIL testing, and then a gamut of track tests that test a safety-critical subset of the full set of functional tests derived from ISO 26262.

Even then, trucks are only driven by highly trained test drivers. These drivers are not only highly trained truck drivers, they have also been trained in various evasive maneuvers and other practices to enhance safety during pre-production testing. Only after production validation (including HIL, SIL, and mileage accumulation) has been completed can a non-test driver drive the system.

Peloton also doesn’t disable the existing active safety systems on test vehicles. In fact, these systems are a core part of the PlatoonPro system and remain fully active with the system onboard.

Conclusion

Since its inception, Peloton has had the singular aspiration of creating and developing products that improve the safety for the trucking and transportation industry while providing real world improvements in operational efficiency. Following the mantra that “Safety is our North Star”, we have created a culture of transparency to make sure our employees, customers, partners, government, and the general public understand the safety approach laid out in this paper.

This report summarizes the nine components of our safety approach that have guided the development of the Peloton Driver-Assistive Truck Platooning product, which we feel is the foundation for commercial vehicle automation. As this technology is commercially deployed, we, along with our customers and partners, are excited to see the benefits in safety and efficiency this technology will deliver.

About Peloton Technology

Peloton is a connected and automated vehicle technology company dedicated to improving the safety and efficiency of U.S. and global freight transportation. Backed by ten Fortune Global 500 companies, Silicon Valley-based Peloton partners with customers to deliver innovative tools that save fuel, provide safety, and improve operational insight through connectivity, automation, and advanced data analytics. Peloton’s flagship driver-assist platooning system links the active safety systems of pairs of trucks, enhances driver teamwork, and connects trucks to a Network Operations Cloud which limits platooning to appropriate roads and conditions. Peloton solutions also provide for the safety of individual trucks by requiring best-in-class collision-avoidance systems and other safety features that are active both in and out of platoon.

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