Our story is the story of the American Dream. All five of our founders came to America from around the world—Turkey, India, Australia and Canada—both to be educated and to educate at the top robotics university in the world, Carnegie Mellon.

With decades of experience in dozens of types of autonomous systems, we approached things a little differently. We decided to focus on trucking and developed solutions for its biggest pain points, in particular the urgent demand for more capacity in the supply chain, the high turnover of truck drivers, and the fundamental need to lower carbon emissions. We knew from experience in the world of robotics and autonomous vehicles that a fully driverless 80,000-pound tractor-trailer combination would require significantly more development time, safety validation, and regulatory support than was being touted by others at the time. At Locomation, we saw that the fastest and most viable path to full autonomy was to start with existing automated vehicle technology to augment, rather than replace, human drivers.

Only in America can five immigrants come together to create a business in the most dynamic free market in the world. We are proud to have started a company in Pittsburgh, raised $60 million, employed over 130 people (and counting!), and to have redefined the market for autonomous automotive technologies with a purpose-based approach that will lead to better outcomes for all users.

With safety as our North Star, we will be the first to deploy autonomous trucking technology safely, legally, and routinely in commercial operations at scale across the United States. We are building our technology the right way, evaluating and addressing the impacts our success will mean for professional truck drivers, for trucking companies and industry partners, for the communities where the technology will be deployed, for our supply chain, for the environment, and for the people of this great nation. When we succeed, everyone will benefit. And I mean that. I look forward to showing you how.

Catin Meriçli
At its core, Locomation’s strategy is to incrementally deliver on the promise of autonomous trucking through a practical approach that combines our advanced technology with the superior human ability to identify and respond to the variety of complex driving situations and interactions. We call this approach Human-Guided Autonomy™.

Locomation is on track to be the first company to deploy autonomous trucks safely, legally, and routinely in commercial operations at scale across the United States. We now have three executed customer contracts to put our technology on more than 2,600 trucks. These will not be pilot programs or geographically-limited operations, and there will not be any need for the vehicles to be followed by safety vehicles. These will be real, commercial deployments in wide circulation.

We are attracting customers because our solution alleviates the freight system’s chronic pain points: growing supply-chain capacity constraints, rising costs, historic driver shortages, and high greenhouse gas (GHG) emissions.

The Locomation solution works in two ways:

First, our Autonomous Relay Network™ augments a customer’s traditional operation with a 500-mile relay model that splits out long-haul operations from local activity along economically viable highway segments. Our Digital Transportation System is a service we provide to analyze and optimize a carrier’s operating model for freight management with autonomous vehicles, convoys and traditional equipment. We use this freight planning and scheduling service to optimize daily implementation. Long-haul drivers run from middle-mile hubs, avoiding high density traffic and pickup wait times. Carriers run their existing trucks substantially longer per day, with sizable gains in efficiency.
Our solution produces maximum efficiency from a driver’s time. This means better compensation, fewer wasted hours, and frequent returns to their home base, reducing driver frustration and boosting quality of life. This human-in-the-loop approach will enable our autonomy system to navigate complex and challenging scenarios such as interactions with law enforcement, adverse weather, construction zones, crash scenes, and inspections. Because Locomation convoys are controlled by a human driver, we require no new federal regulations to operate commercially.

And, because Locomation’s highly-optimized solution drastically cuts idling time and empty miles in addition to drastically cutting idling time and empty miles, carriers can achieve an unparalleled improvement in efficiency. In this timeframe, the two drivers have delivered twice the number of loads as a pair of team drivers and four times the number of loads as a solo driver.

We will generate millions of real-world, on-road miles in commercial operations years before any other technology provider has the ability to deploy driver-out solutions in long-haul trucking in any sort of commercially viable way. By the time federal rules allow driver-out operations, in particular the Federal Motor Carrier Safety Administration (FMCSA) rule on the “Safe Integration of Automated Driving Systems-Equipped Commercial Motor Vehicles,” we will have already conducted millions of on-road miles to prepare our systems to safely progress to driverless autonomy on controlled freeways with a hub-to-hub capability. And in the final phase, we will move to a dock-to-dock solution that spans both arterial roads and last-mile driving.

In the meantime, our customer carrier fleets and their shippers are implementing the relay model and freight optimizations today to ensure they are prepared to launch with our autonomous trucking technology. At Locomation, we see ourselves as the vanguard of Automated Vehicle Trucking 2.0. Our approach is mature, safe, and practical, using Human-Guided Autonomy to augment human drivers rather than replace them, and allowing Locomation to reshape the market. We will be the first to commercially deploy a real, on-road autonomous truck product, enabling our customers to make major improvements in capacity, costs, GHG emissions, and driver quality of life. We will be changing the market for the better, for good.

Our initial go-to-market approach is an after-market model. Motor carriers will be purchasing base vehicles directly from the Original Equipment Manufacturer with the specifications we provide to ensure compatibility with our ARC system. Our autonomy hardware kit is composed of sensors, computing units, and a human-machine interface unit and will be manufactured, installed and maintained following Locomation’s Quality Management System (QMS).

Second, we introduce our Autonomous Relay ConvoySM (ARC) technology onto this optimized relay system, featuring human-led, two-truck convoys with one human driver in each vehicle. The trucks are electronically tethered and equipped with Locomation’s autonomous driving technology. The lead driver drives a full shift while the second driver rests, off the clock in the second truck, which is following autonomously. At the destination hub they drop their trailers and pick up new ones, and the fresh lead driver takes the double load back while the follower driver rests. When you combine these two technologies, the benefits are substantial. In less than 24 hours, Locomation-equipped trucks will have delivered four loads and will be back at their home hub, ready to go again. In this timeframe, the two drivers have delivered twice the number of loads as a pair of team drivers and four times the number of loads as a solo driver.

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The Digital Transportation System is a Software as a Service (SaaS) platform and consists of tools that analyze, optimize, schedule, and monitor freight on customers’ traditional trucks and trucks equipped with our ARC system traveling on the Autonomous Relay Network. These systems provide the necessary support to operate the ARC system. After deployment, Locomation will be receiving operational data to assess the performance of the autonomy system and the driver. When driver inattention incidents occur (e.g., distracted or drowsy), real-time coaching alerts will be provided to the driver and notifications to the carrier managing the fleet operations.

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COMPANY TIMELINE

OCTOBER 2020
Locomation partners with Nvidia to leverage its autonomous vehicle computing platform

JUNE 2021
PGT Trucking signs up as our second customer for 1,000 units

AUGUST 2021
Locomation forms partnership with ZF for joint development of safe and autonomy-ready redundant steering units

OCTOBER 2021
Locomation partners with Cummins to improve fuel efficiencies

SEPTEMBER 2020
Smart Belt deployment in Pennsylvania, Ohio and Michigan

FEBRUARY 2021
Locomation partners with Rush Enterprises for installation and maintenance services

JULY 2021
Locomation makes first commercial deliveries, transporting a shipment of goods during the early days of the COVID-19 pandemic

SEPTEMBER 2021
Locomation announces collaboration with Aon to develop risk management plan

FEBRUARY 2022
Christenson Transportation signs up as our third customer for 500 units

MARCH 2022
Locomation and Edge Case Research team up to deliver safer autonomous trucking

MARCH 2019
First autonomous truck upfit complete

NOVEMBER 2018
Purchased our first generation of trucks, and leased our first dedicated garage and workshop

MAY 2020
Locomation and Wilson Logistics Partner on ARC Pilot

AUGUST 2020
Locomation successfully completes first public road test

SEPTEMBER 2020
Locomation and Wilson Logistics announce world’s first large-scale autonomous truck commercial contract for 1,120 units

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From the beginning, our approach to safety has been grounded in decades of experience in autonomy. Our human-guided solution combines the superior cognitive ability of a human driver to navigate the convoy through complex roadway situations with the superhuman reaction times and the controlled precision of autonomous technology to maintain tight synchronization between the two trucks. Even with our human-guided approach, there needs to be significant rigor in how we engineer, manufacture, operate, and improve the ARC system.

Locomation has established a five-pillar safety framework to guide our design, development, validation, and operations.

Safety Culture: Everyone in the organization is responsible for safety. Anybody can report safety concerns without fear of retribution, including by initiating a fleet and crew grounding.

Engineer It Right: The ARC system shall be engineered to be functionally safe at all times—both during manual and autonomous operations. In the presence of significant faults or failures, it shall transition to a safe state. It shall behave predictably to other road users. The system shall be evaluated through verification and validation testing.

Manufacture It Right: The ARC system shall be free of manufacturing and/or assembly quality deficiencies and/or defects that pose an unreasonable safety risk.

Operate It Right: The ARC system shall be operated only by authorized human drivers. The drivers shall be appropriately trained and situationally aware. The driving performance of the human drivers and the ARC system shall be monitored. The vehicles, including the ARC technology, shall be properly maintained, and pre- and post-trip inspections shall be performed and documented.

Improve It Right: The safety of the ARC system shall be continuously improved through actively monitoring performance indicators, tracking outcomes, and analyzing trends. Anomalies and issues shall be properly tracked, reported, and resolved, including implementation of appropriate preventative measures.

Locomation uses this five-pillar safety framework to structure the way we work—our policies, processes, methods, and tools. The framework drives a holistic and comprehensive approach to safety. Rigor is reinforced through the use of industry standards and best practices. Locomation has adopted the widely used “safety case” approach. The safety case, outlined in the System Safety section, guides the system’s safe development and provides a mechanism to build the evidence to substantiate that we have achieved an acceptable level of safety.
Among these problems, safety is of greatest concern. Trucking is the 4th most dangerous occupation in the United States. In recent years, there have been about 550,000 police-reported crashes involving large trucks (gross vehicle weight rating Class 3–8) annually. Over 100,000 of these crashes resulted in at least one injury, and nearly 4,500 resulted in at least one fatality. For 2019, in 33% of the fatal crashes involving a large truck, driver factors such as speeding, impairment (fatigue, alcohol, illness, etc.) and inattentiveness were reported for the truck driver. With Locomation, routes are organized to ensure drivers don’t have incentives to speed, speed limiters and driver monitoring systems are present on the trucks, and drivers are able to get the appropriate rest in the sleeper berth.

Locomation’s concern for driver safety goes beyond the truck itself. Suicide rates for long-haul truckers are among the worst in the country. Surveyed truckers found that 56% of drivers said they did not have enough savings to cover 60 days of expenses. That study also found that high levels of stress were associated with a 50% higher chance of a driver experiencing a preventable crash. Suicide rates for long-haul truckers are among the worst in the country. One of the key things that drives the truck drivers’ frustration—and despair—is the wasted time, miles, and opportunities that come from disorganized routes and decentralized loads.

Women in Trucking: Industry efforts to increase the number of women in trucking haven’t been successful yet, but by organizing routes to get drivers home every 24 hours, these safety concerns can be mitigated. Locomation’s concern for driver safety goes beyond the truck itself. Suicide rates for long-haul truckers are among the worst in the country. Surveyed truckers found that 56% of drivers said they did not have enough savings to cover 60 days of expenses. That study also found that high levels of stress were associated with a 50% higher chance of a driver experiencing a preventable crash. Suicide rates for long-haul truckers are among the worst in the country. One of the key things that drives the truck drivers’ frustration—and despair—is the wasted time, miles, and opportunities that come from disorganized routes and decentralized loads.

Today, drivers are typically paid by the miles they move their loads. According to the American Trucking Associations’ 2021 Operational Cost of Trucking Report, drivers waste over 20% of their miles moving to pick up the next load, also known as dead-head routes. By focusing on key routes identified as part of our Autonomous Relay Network, building a relay-hub model, and organizing loads with our Digital Transportation System, we separate local and long-haul driving and achieve huge efficiencies in both. This process brings carriers immediate benefits and economic benefits and emission reductions. Transportation makes up 28% of total GHG emissions in the U.S. More than two-thirds of that amount comes from freight transportation, especially from medium and heavy trucks, which accounted for 24% of U.S. transportation sector GHG emissions despite making up only 9% of total vehicle travel. According to a comprehensive, independent third-party environmental impact evaluation, Locomation’s ARC system will dramatically reduce the GHG footprint, fuel consumption, and operating costs of transporting goods by truck. Based on this, the evaluation found that compared to traditional Class 8 trucks, trucks equipped with Locomation’s technology would:

- Reduce the GHG footprint of freight transportation up to 22%;
- Cut operating costs up to 19%;
- Reduce fuel consumption up to 21%;
- Lower photochemical ozone formation up to 22%; and
- Cut operating costs up to 21%.

This will have significant impacts. In the long-haul trucking industry in North America, fuel consumption typically accounts for 25-40% of total costs. Improvements in long-haul fuel economy that can be realized with automation have the potential to directly lead to both economic benefits and emission reductions.

As the transportation industry moves towards autonomy, the benefits of Locomation’s technology to specifically address the real pain points of the freight transportation system. The trucking industry is plagued with major issues that it has been working to overcome for years: safety, driver shortages caused by high turnover and inequity, wasted time, and unnecessary fuel usage and emissions output. These issues that it has been working to overcome for years: safety, driver shortages caused by high turnover and inequity, wasted time, and unnecessary fuel usage and emissions output. NOVA • SPRING 2022
ARC technology is the best opportunity for long-haul trucking to reduce its carbon footprint in America until such a time as electrification is available and economically viable on 1000+ mile routes, which may not be achievable until close to 2030. Even a conservative adoption of the ARC system would yield savings equivalent to the amount of CO2 emitted from two million passenger vehicles annually.

Imagine a future for trucking where drivers had no incentive to speed, where their routes were designed to get them home every night, where they generated double the revenue by going twice the distance, hauling twice the cargo. Where wasted time, miles and emissions were significantly reduced, improving efficiency overall. We see this future coming soon, and we aren’t waiting to work with the leading industry partners to start this transition.

And, it matters that we get the transition right. It matters that we create solutions that work for real, human drivers. It matters that we make them part of the evolution of autonomy so that we can make these solutions work for them, not instead of them. Solve for the biggest issues facing the human drivers, and you can start to solve for the biggest problems facing the industry today. Solve for the biggest issues today and you can prepare to solve for the biggest issues in the future.

We want that future, and we are deeply committed to making it happen.

WHAT WE ARE DOING

The scope of this initial VSSA focuses on Locomation’s on-road testing of our ARC prototype systems while utilizing human drivers in both vehicles. In this VSSA we walk through key safety elements, the importance of these elements in our safety processes, and what we are doing to ensure the safety of our development testing. These elements, informed by the safety framework and the evidence generated to prove the safety case, will provide us assurance that the deployed vehicles will operate safely.

Our on-road testing will consist of human-led, two-truck convoys. The convoy size will never be greater than two-trucks, for testing or for the commercial product. Our on-road tests are conducted at SAE Level 2. Today, the trucks are linked by wireless communication devices that help inform the coordinated motion of—including the distance between—the trucks.

As a rule, Locomation will not claim any aspirational standard conformity, accomplishment, or safety claim until we have fully proven or complied with the claim. This initial VSSA serves as a marker of our progress, a commitment to our approach to transparency, and an outline of where we are headed.

We plan to submit updated VSSAs as we progress to removing the human driver from the following vehicle, upon the completion of our Safety Case prior to delivery of Locomation-equipped trucks to our customers for commercial deployment, and in the future before removing human drivers from the operations of the trucks entirely.
OUR APPROACH TO SYSTEM SAFETY

Safety is incorporated in everything we do: from design, development, verification, validation, manufacturing, and operation. Industry best practices, tools, and standards are used to help minimize potential safety risks in every step of the process. Locomation’s ARC system must—and will—be transparent and verifiably safe. To achieve this, Locomation is creating a Safety Case to prove that the ARC system is acceptably safe: defined as free from unreasonable risk of harm to humans and/or property. The Safety Case provides Locomation with a clear, actionable, and responsible path to product delivery.

THE ARC SAFETY CASE

A safety case is a structured argument based on evidence to justify that a system is safe for specific uses and operating conditions. Safety-critical industries such as nuclear, aerospace, and rail have demonstrated the benefit of similar approaches. Locomation’s ARC system is leveraging the UL 4600, Standard for Safety for the Evaluation of Autonomous Products to guide the creation of our Safety Case.

Locomation’s Safety Case is centered around our single, top-level objective: the ARC system shall be acceptably safe (i.e., free of unreasonable risk of harm to humans and/or property) to operate on public roads.
Locomation is using a variety of metrics to measure and analyze the safety performance of our system. These measures include predictive metrics (e.g., maintaining a safe distance around our convoy) and more traditional metrics capturing safety outcomes (e.g., crashes and compliance traffic laws). The safety performance data will provide the initial evidence that we engineered and manufactured the system right and will continue to serve as a way to monitor the manufacturing and operation of our system to ensure we improve it right. We leverage a variety of applicable standards and tools in our system safety and engineering processes to produce the work products that substantiate our Safety Case argument. Especially important to our safety and engineering processes to produce the work products that substantiate our Safety Case argument is Functional Safety (FuSa) and Safety of the Intended Functionality (SOTIF), which introduce analyses including Fault Tree Analysis (FTA). Applying these tools and standards helps us identify and mitigate or prevent malfunctions, functional insufficiencies, systematic failures, as well as designing for Fault Management Safety to keep the system performing safely. One of the most critical aspects of the Safety Case is proving that we’ve established the right safety culture, which is all about the way safety is perceived, valued, and prioritized in our company. One of the ways we achieve this is by establishing an effective Safety Management System (SMS) program. A SMS program is used for aviation to create a systematic approach to organizational safety and have begun to be used for autonomous automotive technologies. Locomation has a pilot SMS program in place and a Safety Review Board to support our development testing. The SMS program will continue to be refined and expanded as we progress towards production. Our Quality Management System (QMS) is built under the guidance of ISO 9001 and IATF 16949 and aligned with Locomation’s purpose and strategic direction. As we have implemented policies and resources, this enables our organization to adopt standard practices and ensure consistent quality. Our QMS complements the SMS program and provides oversight to our lifecycle processes and requirements.

Our “human-in-the-loop” solution is a key part of our system and its safe operation including during the testing stages. The development is guided by our Safety Case plan and system safety engineering practices are used to safely conduct our test program. We also apply a careful progression to our development stages that includes a combination of simulation and test-track testing along with expert reviews prior to advancing to on-road testing. The ARC prototype is designed and tested to ensure that the safety driver can assume manual driving control of the vehicle at all times during the testing and that the automated driving system will not perform any unsafe actions that cannot be controlled by its safety driver. Autonomy requires a simple, multi-step process to arm and engage the system to help avoid unintended activation. When armed, the system performs a self-health check before allowing the safety driver to engage autonomy-controlled driving. Any engagement of the manual operated driving controls (e.g., steering wheel and brakes) automatically disengages autonomy. There is also an emergency-stop button within arms-reach of the safety driver and test engineer. Each ARC prototype is equipped with a driver monitoring system to make sure the safety drivers keep their primary focus on the driving task. Locomation’s policies (e.g., Driver Distraction Policy), testing protocols/procedures and training are aimed at making sure Locomation has the safest drivers and test engineers on the road. For example, our testing protocol for lateral autonomy requires the safety driver to have a light touch on the steering wheel at all times to allow for quick manual steering recovery.

Most importantly, every employee at Locomation is responsible for reporting issues and can initiate a fleet and crew grounding at any time. There is no retribution for initiating a grounding in good faith, and all reported issues are acted on promptly and tracked to make sure that all issues are properly resolved. System safety brings together all of the safety elements to provide a holistic safety approach to the development, verification, and validation of the ARC system. Central to this approach is ensuring that as prototype development evolves, the correct assignment of driving functions between human drivers and autonomy is made. Additionally, the context in which these driving functions are exercised is considered when determining when it is appropriate for a safety driver to take over. Together, we believe this approach gives Locomation the rigor we need to ensure we will be introducing no unreasonable risk to safety in the testing, development and ultimately the deployment of our technology.
The concept of Operational Design Domain (ODD) has become a standard element in automated driving systems development since its incorporation in SAE J3016 and inclusion in the National Highway Traffic Safety Administration’s (NHTSA) ADS 2.0: A Vision for Safety. The ODD describes the operating conditions under which a given driving automation system or feature thereof is specifically designed to function, including, but not limited to, environmental, geographical, and time-of-day restrictions, and/or the requisite presence or absence of certain traffic or roadway characteristics. In other words, the ODD describes the specific conditions the system is designed to operate within.

Monitoring is needed to ensure that operational constraints in the ODD are not violated. Locomation’s ARC prototype includes human operators: there will be an ATO or safety driver and a test engineer in each truck, who share the burden of monitoring and deciding if the constraints of the ODD are met. Furthermore, we are following best practices to assess each route, i.e., both development testing and future commercial routes, to understand the specific conditions and elements. This information is combined with the expected design capabilities of the ARC to determine the appropriate ODD limitations or constraints for testing and final product deployment.

We are using a careful approach to progressing through our development testing. An important part of this approach is starting with a limited ODD and cautiously expanding it over time. For example, our Spring 2022 on-road testing is initially planned to take place in Pennsylvania, Indiana and Ohio, particularly on highways near the Transportation Research Center (TRC) in East Liberty, Ohio where Locomation maintains a permanent test garage in order to be able to conduct around-the-clock truck testing. Specifically, the ARC system initially will only operate on freeways with four or more lanes (at least two lanes in each direction) or a divided highway with full control of access. In addition, the convoy routes are reviewed to confirm the availability and appropriateness of the right lane’s shoulder width. Initially, the convoy will mainly operate in the rightmost lane to allow passing room for other vehicles. The ARC prototype will only enter autonomy at pre-approved stop locations. These stops are evaluated for a range of criteria such as entry length and sightline obstructions on the entrance ramp to help ensure that the ARC prototypes can safely merge.

The ARC system shall operate following all local rules, regulations, and limits. For example, all of our test vehicles have speed limiting devices that limit their speed to 70 mph. The ARC ATO and test engineer will monitor the speed of the vehicles to ensure they are operating within the posted speed limit range. The safety drivers will also monitor traffic conditions. In the initial development testing, autonomy will only be operated when the traffic is free-flowing, meaning traffic is traveling at its desired speed in low-volume conditions.
Roadway zones and elements have also been reviewed along the route, and during initial development testing the ARC system will not be engaged within construction zones or tunnels, or at toll plazas or weigh stations.

In addition, the initial system development testing will only be conducted in suitable, on-road weather conditions; i.e., when the visibility range, temperature levels, and precipitation types and rates are within acceptable ranges. As Locomation advances its on-road testing, the ODD will continue to be updated in line with the development of Locomation’s Safety Case and ongoing ODD analysis and ARC system readiness.
OBJECT & EVENT DETECTION & RESPONSE

Object and Event Detection and Response (OEDR) refers to the parts of the driving tasks that include monitoring the driving environment (detecting, recognizing, and classifying objects and events and preparing to respond as needed) and executing an appropriate response to such objects and events. An important part of OEDR is the ability to properly detect and respond to emergency vehicles, temporary work zones, and other dynamic conditions and situations that may impact safe operations within the ODD. Locomation’s human-guided autonomy means the lead human driver will be able to perceive and interpret the driving environment and then guide the convoy through the scenario.

Locomation’s human-centric approach to autonomy combines superior human cognition and semantic understanding with superior machine precision in control and reaction times.

### RESPONSIBILITIES

**LONG-HORIZON PERCEPTION AND PLANNING**

**LANE CHANGE, EXIT AND MERGE**

- Performed by the lead human driver
- The maneuver is initiated by the lead human driver
- Lead human driver prepares dynamic and guidance from workers, flaggers and law enforcement officers
- Autonomy system has to perceive and plan for traffic on adjacent lanes and around merge ramps, and handle situations like lane shifts

**WORK ZONE NAVIGATION**

- Lead human driver interprets signage and guidance from workers, flaggers and law enforcement officers
- Follower robot driver follows the path of its leader
- Autonomy system needs to be able to identify the work zone boundaries, detect human worker presence, interpret flagger guidance, and navigate the zone

**INTERACTING WITH LAW ENFORCEMENT, INSPECTION, AND EMERGENCY UNITS**

- Lead human driver interacts with the human law enforcement, inspection and emergency personnel
- Follower robot driver follows the path of its leader
- Autonomy system has to detect special vehicles and personnel and understand their gestures and intents

**EMERGENCY AND OFF-NOMINAL SITUATION HANDLING**

- Lead human driver guides the follower robot driver as much as possible per the fault management strategy
- Robot driver brings the vehicle to a minimal risk condition
- Autonomy system has to perceive all static and dynamic obstacles and predict intentions from a distance
- Autonomy system has to perceive and plan for traffic on adjacent lanes and around merge ramps, and handle situations like lane shifts
- Autonomy system needs to be able to identify the work zone boundaries, detect human worker presence, interpret flagger guidance, and navigate the zone
- Autonomy system has to detect special vehicles and personnel and understand their gestures and intents
- Autonomy system has to assess the situation, evaluate the suitability of the environment, determine the safest response and execute the minimal risk maneuver

### HUMAN-GUIDED AUTONOMY

- Performed by the lead human driver

### FULL AUTONOMY
Locomation’s current generation ARC prototype vehicles use a combination of cameras and lidars in a “hammerhead” configuration consolidated on our patented mirrorpods, as well as a radar on the front bumper of the truck. This provides excellent surround sensor coverage as well as redundancy.

Additionally, Locomation’s hardware suite includes wireless communications provided by Cellular Vehicle To Everything (C-V2X) On-Board Units (OBU) to allow the trucks in the convoy to exchange control and situational awareness critical information within tens of milliseconds to drive safely and in concert.

We are taking a careful approach to the distance between the convoy trucks and starting our development testing with a gap of 1.25 seconds. Eventually, we plan to close this gap to 0.5 seconds headway in optimal conditions after further testing is completed to demonstrate it is safe to do so.

Locomation has already completed extensive analysis, simulation, and track testing to establish a safe gap distance and supporting test plan. Research findings from Volpe’s Naturalistic Study of Truck Following Behavior; Nodine 2016, provide insight into driving behaviors associated with headway. Nodine (2016) assessed the safety impact of trucks following at different headways and concluded “in the fast reaction time condition (0.30s, which was used to model automatic braking) crash risk was extremely low, even at very short headways. There was no crash risk observed in any speed bin at headways over 0.5s.”

A critical part of determining the optimal gap is deterring other motorists from cutting in between the convoy. Nodine found that other road users will not generally cut-in between two trucks when the distance gap is less than 131 feet. If a motorist does cut-in between the two ARC trucks, the lead human driver will be immediately informed by the autonomous follower and can help safely resolve the situation. The lead human driver can have the convoy change lanes or gradually slow down the convoy to encourage the motorist to leave and mitigate the potential of a collision. As Locomation engages in on-road testing we will abide by all state and/or local regulations, including those governing minimum following distances.

As we build for the future, we will run our autonomy software on the lead truck in “shadow mode” as a proxy to a solo driverless vehicle to collect information regarding real-world interactions and compare the autonomy system’s plans to the actions of the human driver and gather data on how the autonomy system would have handled the situation if it were controlling the truck. To explain shadow mode further, SAE J3018 states “shadow mode testing of ADS-equipped prototype vehicles allows ADS developers to observe the behavior of the ADS to determine what it would have done during the drive, had it been controlling vehicle motion.”

Locomation will use this data to continuously refine our current ARC system and capture the right data to safely deploy full autonomy in the future.

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Fallback (Minimal Risk Condition)

Fallback is the ability of the system to transition to a safe state in the event of a system failure or when encountering conditions unacceptable for sustained automated driving. The ARC system is engineered for redundancy in safety-critical subsystems to eliminate single point failures and respond to safety-critical events. Consistent with our Safety System approach, we are applying best practices to address possible hazards caused by malfunctioning behavior of safety-related components and systems and develop the necessary protocols (i.e., fail-safe responses) to achieve a safe state.

During our development testing, when a failure that could affect the operation of the following vehicle occurs, the system alerts, and returns driving control to the safety driver in that vehicle. The ATO in the lead truck will also be notified so they can safely respond to the failure or situation. A communication system independent from the ARC system is used by the drivers and test engineers executing the testing to ensure they remain in constant communication and to make sure all testing is conducted safely.

Additional measures—beyond the engineering and design features identified above—are taken to make sure potential hazards are mitigated during on-road testing. Locomation’s ATOs are evaluated for manual driving proficiency and trained to drive safely in normal road conditions as experienced by conventional truck drivers today, and they are also trained on situations unique to Locomation’s two-truck linked convoys. See more on driver training. The complexity of on-road testing operations is carefully controlled so that its progress is commensurate with system maturity and the drivers ability to mitigate potential operational hazards. For example, during initial testing, if a vehicle cuts in between the two convoying trucks, the human safety driver in the follower truck takes manual control of the following truck and alerts the lead driver. These systems and protocols will be continuously matured as we progress towards driver-out testing for the following vehicle.

The human-centric model of our eventual commercial product will use a combination of automated system responses and the lead truck’s ATO to transition the convoy to a safe state and mitigate potential hazards. We are designing the product’s Fault Management System to detect and respond to faults and failures that could affect the safety of sustained system operation. The Fault Management System provides a hierarchy of automated system responses designed to achieve a safe state in as graceful a manner as possible using available system functionality.

The fault response hierarchy includes, in order of decreasing desirability and sophistication, the following summary actions: Fail-Operational; Fail-Degraded; Pull-to-Shoulder; Stop-in-Lane; Emergency Stop. The ARC product is being developed to maximize the operational availability of the system and minimize the potential frequency at which less-desirable fault responses may be needed.
This fault management strategy is intended to maintain uninterrupted commercial operations by designing the product to fail-operational (i.e., contain any hazards caused by the fault while still maintaining all or near full system functionality and performance) or fail-degraded (i.e., mitigate any hazards caused by the fault while still continuing operations at a reduced level of performance) whenever it is safe to do so. For example, if an issue is detected while convoying and does not present uncontained risk to safe sustained operations, the convoy will fail-operational and continue to its destination—where the product can be serviced and the issue resolved. If an issue is detected, but the convoy can continue operating safely within more restrictive constraints, the convoy will fail-degraded (such as by reducing maximum driving speeds) until it reaches an appropriate location for issue resolution.

If a fault is detected that may prevent the convoy from safely continuing with sustained operations, the lead driver would be notified of the issue and guide the convoy’s transition to a safe state. For example, in the rare event that the convoy lost wireless communication between both trucks due to simultaneous failure of redundant components, the lead driver would guide the follower truck through a pull-to-shoulder maneuver using the remaining system functionality. After the follower truck is guided to a safe state, the system would automatically immobilize itself and alert the off-duty driver of the follower vehicle’s situation.

Our fault management strategy aims to reduce the potential stop-in-lane and emergency stop responses to extremely rare occurrences. In the event of a fault that may present an immediate hazard and that prevents the lead truck from guiding the follower truck to safety, the follower truck will automatically and independently achieve a safe state. The follower truck will either independently perform a controlled stop-in-lane or emergency stop, depending on the criticality of the detected fault and remaining capabilities of the system, before immobilizing the vehicle. The system will also alert the lead vehicle’s driver and the follower vehicle’s off-duty driver to the situation for further action.

Though the Fault Management System and safe-state capabilities are designed for the product and commercial operations, they will be gradually introduced to our development vehicles in support of our testing progression.
VALIDATION METHODS

Our System Safety process is guiding the development of verification and validation requirements, and the safety criteria, to confirm the ARC system’s safety performance. The validation of the system will cover all of the safety elements outlined in this document: functional safety, safety of the intended function, autonomy behaviors, crash avoidance, human-machine interfaces, occupant protection and cybersecurity. Traceability—from the requirement to the evidence—for each of the elements and the specific components, subsystems and systems is an important part of the validation and testing processes. Locomation is already leveraging several test methods in the development of our ARC system that will be used to validate that the ARC system is acceptably safe.

We have employed a multifaceted testing architecture that includes analytical, simulation and closed-course test methods, which informed our decision to move to on-road testing. The virtual testing approach allows Locomation to simulate a large variety of scenarios in a controlled, repeatable, and predictable manner and to evaluate how our system will perform in the most safety-critical situations. Closed course testing is essential to validating our simulation outputs while also putting our ARC system through conditions similar to those found on the roadway but that are controlled and repeatable. Finally, on-road testing will confirm performance in the real-world where there is limited control and repeatability of the conditions the system will encounter.

Together, these will provide Locomation with the necessary evidence to validate that we have achieved an acceptable level of safety.
Locomation’s simulation testing is conducted through a tiered system of virtual simulation technologies; each method provides a unique testing value and helps Locomation to effectively test across different system levels (e.g., components, subsystems, vehicle, and convoy).

The first step is model-in-the-loop (MIL) testing, which allows our autonomy and hardware teams to conduct early stages of development testing before proceeding to more advanced levels of testing. Once MIL testing is completed, software-in-the-loop (SIL) testing is used to evaluate changes made to the autonomy software before proceeding to the next stage of testing. Hardware-in-the-loop (HIL) testing helps Locomation understand how the hardware is accepting the autonomy input commands. Scenario-based simulation methods are used during each stage to test the many different situations and the variety of conditions we expect to encounter in our ODD. An important step in the validation process is to demonstrate that the tools we are using are actually proving what they are intended to prove. Physical testing of components, subsystems and variations of the vehicles (tractors and trailers) is used to refine and validate our virtual models. As we continue our development testing, the simulation models and testing methods continue to be improved through iteration and evaluation.

Prior to testing on public roads, the ARC prototype is being tested on multiple closed courses. This allows testing in an environment where road conditions and interactions with external factors, such as other road users, are highly-controlled. Testing progresses from low to medium driving speed exercises conducted at a private testing space or at a Pittsburgh-area closed course driving facility. For operations at highway speeds, Locomation has a permanent space at the Transportation Research Center (TRC) in East Liberty, OH. This facility is the largest independent proving grounds in North America and includes lanes built to highway specifications to test Class 8 tractor trailers at full highway speeds. Locomation is able to use different facilities within TRC, including a skid pad and a high-speed test track, for different types of testing. Every new ARC system asset undergoes core functional testing of its safety features before it is released for on-road testing use. After new asset commissioning, each hardware and software change undergoes a release process, safety reviews, and a testing progression. Furthermore, there will always be an ATO/safety driver, a test engineer and support crew present during prototype development testing. There are safety-checks, system and vehicle inspections, and training to support safely conducting this testing. Moreover, feedback from the ATO and test engineers is an important part of our safety culture and safe testing.
Locomation has provided notifications to Pennsylvania, Ohio and Indiana officials about our intent to conduct on-road testing of our ARC prototypes on public roads in their states. As Locomation expands our testing, we will continue to notify additional state officials, even if the state has no formal requirement to do so.

Our development testing employs an iterative approach that provides information that allows us to continually improve and advance the ARC system. As we work towards ARC system production, we will update this document to share information on how our testing and validation methods are progressing.
The Human Machine Interface (HMI) allows interactions to take place between the ARC trucks and their occupants (Operator HMI) as well as people outside the trucks (External HMI). Our ARC HMI complements the original equipment manufacturer’s HMI and the information inputs that drivers are already familiar with and use today.

Our approach is simple when designing the ARC HMI: create intuitive interfaces that convey the necessary information and minimize distractions.

The Driver Alert Subsystem of the ARC HMI provides the safety driver with audible feedback to help the safety driver quickly elicit the appropriate response through the available control takeover mechanisms.

Generally, we refer to the driver of the lead vehicle as an Automated Truck Operator (ATO) and the driver of the following vehicle as a “safety driver.” In reality, both drivers have the same (preliminary) Class A Commercial Drivers License (CDL) and job title. When conducting a test, both drivers (the ATO and the safety driver) are paired with test engineers in the right seat of the convoy vehicles. As we move to the production phase, there will not be a safety driver behind the wheel in the follower vehicle while that vehicle is operating autonomously. The occupant in the sleeper berth will be an off-duty ATO.

Locomation’s development test fleet has an HMI subsystem designed to support both the ATO/safety driver and test engineer in each truck. The ARC user interface for testing provides information on the system diagnostics and performance, autonomy status or mode, and control-transfer requests from autonomy to the safety driver. The Driver Alert Subsystem of the ARC HMI provides the safety driver with audible feedback to help the safety driver quickly elicit the appropriate response through the available control takeover mechanisms.

The ARC prototype HMI system is designed to prevent unintended engagement of autonomy-controlled driving. The system requires a simple, multi-step process to arm and then engage the automated driving system using a custom interface. The safety driver changes the autonomy status from a disarm state to an armed state using the arm/disarm switch. When the system is armed, the safety driver presses on the autonomy switch to change the mode from “ready for autonomy” to “autonomy engaged.” The safety driver can easily cancel autonomy by interacting with the manual driving controls (e.g., steering wheel and/or brakes) or the autonomy disengage switch. Additionally, in emergency situations, the E-Stop button is within arms-reach of the safety driver and can be used independently...
to disable the automated driving system and prevent reengagement of autonomy-controlled driving.

The prototype user interfaces are designed to make it simple for the ATOs, safety drivers and the test engineers to understand the purpose of each HMI subsystem element and the state of the system in order to reduce the potential for testing mistakes due to mode confusion. For example, the rocker switch for autonomy has red, amber, and green lights to communicate the autonomy status as “manual drive,” “ready for autonomy,” and “autonomy engaged” respectively.

As part of the HMI subsystem, Locomation trucks are also equipped with a driver monitoring system. The driver monitoring system in-cabin alerts are designed to make sure the safety drivers are primarily focused on the driving task and paying attention to the roadway and the environment. The driver monitoring system is also used to monitor the performance of our safety drivers.

To support drivers’ situational awareness in our ARC prototype vehicles, ATOs, safety drivers, and the test engineers exchange information about the autonomy system’s performance and the driving environment. Currently, this is done using an open line communication setup. If this communication fails, the safety driver will disengage autonomy and transition to driving the vehicle manually. As a next step, the prototype HMI subsystem will progress to support the test progression and include a visual driver information display to support the ATO/safety driver. The driver information display aims to (1) provide only necessary information about the convoy to the ATO and safety driver to support their decision making based on the surrounding traffic condition and the autonomy status, and (2) increase the situational awareness of the lead truck’s ATO guiding the convoy.

Our human factors engineering, design and operations teams are constantly collaborating to refine the HMI subsystem based on the ATOs’, safety drivers’, and test engineers’ feedback. In short, we are making sure our human drivers are providing input and feedback based on their real-world experiences with the trucks. As discussed in the System Safety section, we are making sure we engineer the system right and use best practices for designing, testing, and validating the HMI subsystem.

In addition to all the ways vehicles communicate with each other and with the ATO/safety driver and test engineers today, we have added external HMI to indicate to other road users when the convoy is operating in autonomous mode to help make sure all roadway users will use the road safely together. Our trucks are equipped with indicator lights on each mirror pod that turn on in autonomous mode.

For other road users, we are also placing signage outside of the ARC prototype test vehicles that either say “Test Truck” or, more recently, “Autonomous Linked Convoy. Do Not Cut In Between.” We chose this language based on the January 2021 FHWA Brief on Effective Indicators of Partially Automated Truck Platooning. The findings from this study indicated that signs to identify automated truck platoons are likely to be an effective method for supporting driver comprehension, safety, and acceptance of heavy truck automation. Our human factors engineering team continuously works on evaluating the external sign usage and the language, and monitoring the transportation human factors study briefs to refine external HMI design.
VEHICLE CYBERSECURITY

Vehicle cybersecurity is a key safety priority, and Locomation’s cybersecurity specialists are leading the design, testing, and monitoring of the ARC system and its security lifecycle. Locomation is designing layers of security protections and plans to conduct rigorous testing to protect and mitigate against unauthorized access and malicious attacks on our ARC system. Cybersecurity is part of Locomation’s safety culture, and we are establishing the organizational policies and processes to address potential real-world cybersecurity threats. Locomation is following the Autonomous Vehicle Cybersecurity Development Lifecycle (AVCDL), which is aligned with ISO 21434. We are also following best practices and methods for developing our autonomy code and deploying it on our vehicles in a secure way.

Our ARC system uses C-V2X wireless communications On-Board Units (OBU) to provide the foundational connection between the trucks in the convoy. C-V2X is a short-range broadcast communications system intended to provide low-latency data exchange between road users. Even though C-V2X is not capable of providing internet access, it still requires security measures to protect against vulnerabilities that could impact safety. Cryptographic credentials such as digital certificates provide methods to mediate data delivery to our ARC system’s computers. Locomation uses IEEE 1609.2 to support the security functions necessary for our wireless communication system.

This standard offers mechanisms to ensure integrity, authenticity, and privacy through the use of digital certificates.

Security measures are designed into the base architecture of the trucks by the Original Equipment Manufacturer. Our development fleet modifications and ARC system development and testing are done with security in mind, and steps are taken to reduce the attack surface. One of the ways we control potential vulnerabilities is by limiting internet connections; that is, our components and test systems are not connected to the internet (e.g., LTE and Wi-Fi) in any operating mode. Updates, including new software releases, require physical access to the ARC prototype vehicles. We are also piloting protection methods planned for production such as using a trusted vendor for prototype digital certificates to secure our C-V2X OBU wireless communications. Our development fleet is only operated and accessible by approved team members. Finally, we actively participate in cybersecurity community forums for awareness and collaboration with industry partners.
For on-road ARC prototype testing, Locomation is using 2019 Kenworth T680s and 2022 Peterbilt 579s. These vehicles are compliant with Federal Motor Vehicle Safety Standards (FMVSS), which include crashworthiness standards. We know that seat belts save lives and several of the FMVSS specify requirements for seating systems and seat belts. All of our safety drivers and test engineers must be belted during all testing, and pre-test protocol and training is in-place to help ensure occupants are buckled.

Crashworthiness comes down to physics. Speed has a direct impact on the outcomes of crashes; even small increases in speed have significant impacts to the force of a crash. Speed limiters have been added to all of the Locomation trucks as a safety precaution. Furthermore, the Kenworth and Peterbilt vehicles are equipped with collision mitigation systems. These systems use radar to detect objects and will apply braking when they detect a possible collision.

As we make modifications to the Kenworth and Peterbilt vehicles, such as adding redundant control systems, care is taken to exceed or maintain the same level of safety performance as the original equipment manufacturer. We understand the importance of ensuring that we do not “make inoperative” any equipment or otherwise take any steps that would take these vehicles out of compliance.
Locomation has protocols in place to address potential post-crash situations and extensive ATO training focused on handling emergency situations. Quick emergency response to a crash has been proven to save lives. On-scene procedures for our ATOs are aimed at rapid response both onsite and offsite and provide coordination and assistance to emergency service personnel. This starts with informing the appropriate authorities of our testing plans before conducting on-road testing.

Should a Locomation vehicle be involved in any crash or incident, the onsite ATO, safety driver, and test engineers’ protocols include:

- Engage E-Stop button, stop the vehicle, and shut off the truck’s engine
- Turn on the vehicular hazard warning signal as an immediate warning signal to other roadway users
- Immediately contact 911, if there are any potential injuries or emergency response needed
- If able, safely move vehicle out of harm’s way to side of road
- Set out emergency warning devices
- Contact supervisor to begin Locomation’s incident response plan, which may include actions to inform external regulators such as NHTSA
- If 911 was not required, contact the appropriate emergency service personnel (e.g., law enforcement, fire)
- Assist first responders with any information needed about the operation of the truck
- Complete a standard Locomation accident report form
- SMS program will analyze the accident, identify any potential root causes, and track corrective actions

As a principle, Locomation will seek to cooperate with and/or participate in other external investigations, including those held by entities such as the NHTSA and National Transportation Safety Board (NTSB).
Data collection and analytical tools help Locomation to continually improve our ARC prototype. Our data pipeline and tools are an important part of our development process and eventually the validation and operation of our ARC prototype. In addition to the rich data streams provided by our autonomy system, we also use electronic logging devices and Controller Area Network (CAN bus) loggers to make sure we have a robust system for collecting detailed data from situations we may experience.

As discussed in the post-crash section, protocols and procedures are also in place for our ATOs to properly respond to a crash event. Currently, the associated laws and regulations focus on capturing data for a period of time (often five seconds but in some cases up to 30 seconds) before a crash or collision. Locomation has several tools that meet the regulatory requirements and support our continual learning and root-cause analysis of any safety-related events:

**Autonomy system data recorders:** This configurable storage for sensor inputs and command outputs from the autonomy system, as well as all the internal variables used in the development of the system. The data captured will vary by the test purpose and can be extremely large. Following our QMS and data stewardship best practices, the data collection is targeted at the intended purpose and therefore not all types of data are recorded during every operation.

**Commercial vehicle CAN bus data recorders:** These record all of the data on the primary vehicle CAN bus that the autonomy system accesses, as well as all data on the private CAN buses that have been added to the ARC prototype vehicle.

**Electronic Logging Devices (ELD):** Digital log-recording devices in our vehicles automatically capture the driver status, among other information. ELDs also enable the capability to electronically transfer logs during an inspection to comply with federal requirements.

**Driver Vehicle Inspection Reporting (DVIR):** A driver must prepare a DVIR at the completion of each day’s work and submit those reports for record keeping. Along with the DVIR, data from the testing is recorded to help make sure testing is conducted safely (e.g., a threshold for harsh accelerating/braking triggers camera data recording). The DVIR and recorded data from the testing are stored and tracked following our QMS.

Data recording to actively monitor performance and track incidents and outcomes are an important part of how we **Improve it Right**. Locomation has processes in place to help ensure that we will comply with data recording regulations and standing orders.
People often don’t trust what they haven’t seen or experienced. A survey by Partnership for Automated Vehicles Education (PAVE) found that consumer mistrust and skepticism of automated driving technology comes from a lack of knowledge and exposure rather than specific incidents. Most people haven’t had the chance to interact with an automated vehicle, but those that have (e.g., Pittsburgh, for example) have a higher opinion of them. People need to interact with automated vehicles, see demonstrations, or even ride in them to feel more comfortable.

In general, people today feel more comfortable with automated vehicles moving goods, rather than moving people. They also want to understand what the automated vehicle is doing, or its intent—and clear markings can go a long way. For example, in a recent US Department of Transportation study, 60% of people understood what a “linked convoy” was and expected the second vehicle to follow the first when they changed lanes.

According to a recent study by AAA and the Harvard Kennedy School’s Belfer Center, 53% of people say they would feel less safe sharing the road with self-driving semi-trucks, while only 11% would feel safer (47% say they’d feel less safe sharing the road with light-duty automated vehicles). However, AAA found that 66% of people are worried about sharing the roads with conventionally-driven trucks today.

Interestingly, a November 2021 poll by the Consumer Technology Association found that nearly 1.5 times as many people, a majority of Americans, favor automated truck convoys compared to “self-driving trucks.” Only 25% favor “self-driving trucks” that do not have a human driver present. Locomation’s unique model is a great way for Americans to begin to see and understand how autonomous trucking may work.

According to a survey conducted by Morning Consult on behalf of the Progress Chamber, a majority of adults support automated vehicle testing in their state (53%), with support especially high among union members (75%). Those polled also indicated that two-thirds of union members (68%) support proposals in Congress to increase automated vehicle development and deployment. Unions are often assumed to oppose the development of automated vehicles due to job concerns.

While these results are heartening, this provides ample evidence that Locomation should continue to find opportunities to safely demonstrate our technologies on public roads for the general public and other stakeholders to gain experience.
the HMI section, the ARC prototype uses external HMI to indicate to other road users when the convoy is operating in autonomous mode aimed at safely sharing the roadway.

One great example is the October 2020 Smart Belt Deployment where Locomation demonstrated our ARC technology for food bank deliveries. Traveling more than 280 miles, Locomation made a delivery of groceries from the Greater Pittsburgh Community Foodbank to the Toledo Northwestern Ohio Foodbank and the Forgotten Harvest Food Bank in Detroit to help provide needed supplies for those put out of work by the COVID-19 pandemic and its economic fallout. As part of this, we worked with three partner States on roadways operated by the five Smart Belt Coalition agencies (Ohio Department of Transportation, the Ohio Turnpike Commission, Michigan Department of Transportation, Pennsylvania Department of Transportation, and the Pennsylvania Turnpike Commission). This effort resulted in lessons learned for the partners on the steps needed to facilitate advanced truck technology operations across jurisdictional boundaries.

Lastly, Locomation actively works with PAVE, which focuses on providing public education regarding automated vehicles in an effort to improve the safety and sustainability of our transportation system. We intend to continue to use strategic opportunities to demonstrate our technologies and to share information with the general public, government agencies, and other interested parties.

Locomation’s drivers—also referred to as ATOs—only operate the ARC prototypes when they are adequately prepared and ready to do so safely. Only designated ATOs and safety drivers are permitted to operate an ARC prototype when the autonomy is active (e.g., ready or engaged) for a truck in the convoy. Every ATO must pass a driving skills test, and is trained on safe operation of the ARC system.

Locomation has already begun working with our customers to optimize their supply chain for autonomy, prior to providing them their trucks, including the training materials for their drivers. However, the scope of this VSSA does not cover the upcoming planned activities for the full training of Locomation customers, including Wilson Logistics, PGT Trucking, and Christenson Transportation, to operate their commercially-deployed ARC vehicles.

Locomation’s driver training programs, and testing feedback, are building on the safety practices outlined below for the development of a Driver Education Plan for future commercial ATOs.

This will include:

- An end user education plan, which communicates the ODD and the proper vehicle use.
- Identification of any and all restrictions applicable to the automated driving technology in the ARC system and an explanation of the educational materials that will be provided to end users of the system.
- A copy of the ATO instruction guide that provides information explaining the autonomy’s HMI, how to use the overall system, and the ATO and carrier’s responsibilities with respect to the operation of the automated driving technology.
Locomation realizes the ability, experience, and attitude of the drivers is critical in the hiring process. Therefore, we have established qualification standards for new and existing ATOs/safety drivers. Locomation uses Motor Carrier Safety Audit (MCSA) Compliance Consultants to verify drivers’ records. Locomation requests and reviews a Motor Vehicle Record (MVR) for driver applicants being considered for employment to determine if the driver meets our hiring standards. Drivers must comply with state requirements for medical examination and license renewal. Supervisors maintain a system that monitors license and medical examination expiration dates. A formal review of the drivers’ MVR is conducted on an annual basis to ensure compliance. Locomation requires all applicants to successfully complete a road test (on an appropriate vehicle) prior to an offer of employment. If Locomation offers the applicant a position, the applicant is required to take a pre-employment DOT drug screen. Current drivers are subject to random drug screens as defined in 49 CFR 382.

Because our drivers are required to hold a Class A CDL, this implies that our ATOs/safety drivers have a very high level of competency when it comes to driving a Class 8 truck equipped with automated driving technology. Locomation, as a part of its driver hiring process, tests the candidate to ascertain these essential driving skills.

1. Communication between the ATO, safety driver, and test engineers in each truck including clear wording to reduce potential for testing mistakes.
2. Visual and audio indicators for the ARC prototype HMI system. Drivers learn where the visual indicators are located and what each color represents. They will also hear the audio indicators and learn what each different sound represents.
3. An explanation of the ODD (e.g., weather, traffic, road, time, speed conditions) the ARC prototype vehicle is designed to operate in and how potential ODD changes will be communicated.
4. Exact procedure to arm/disarm and then engage/disengage the automated driving system.
5. Ways in which the safety driver can cancel autonomy (e.g., interacting with the manual driving controls or the autonomy disengage switch).
6. Ways in which the safety driver is alerted (visual and audio) by the ARC system to take control of the vehicle.
7. The situations in which the safety driver is expected to take control.
8. Incident response and reporting procedures including crashes and other interactions with law enforcement.
9. Locomation’s safety culture, procedures for safety concern escalation, responsibility for reporting issues, and Locomation’s grounding process. All employees and contractors will be assured that there will be no retribution for initiating a grounding in good faith.
Locomation is committed to the continued training and safety of ARC drivers. We have put in place several policies consistent with SAE J3018 and AVSC recommendations regarding driver training, including driver orientation, periodic driver safety meetings, driver performance evaluation and reviews, continued education, and annual refresher training.

Ongoing driver training includes classroom instruction, closed-course track training, and on-road training. Protocols are in place for workload management for the drivers. Additionally, routes are selected in advance and reviewed for roadway type, traffic conditions, time of day, seasonal impacts, etc. Pre-trip protocols are conducted, including advanced pre-trip checklists and vehicle inspection. Post-trip feedback procedures have been structured to capture information that will improve safety in the future.

Locomation typically conducts driver safety meetings once a week. These meetings between drivers and management/supervisors are held to share news, information, and to give our drivers a forum to discuss issues, questions, or concerns. All drivers are expected to participate in these meetings, and all drivers’ input is welcome, appreciated and valued.

Some subjects that are covered in the safety meetings are:
- Any software or hardware updates to the ARC prototype
- Any new or updated policies or procedures relevant to ARC prototype or testing
- Regulatory compliance

The education and training steps outlined are a vital piece of Locomation’s Safety Culture and are designed to help assure that all roadway users can use the road safely together.
Our Safety System processes provide the mechanism to make sure the ARC system meets federal and state regulations and local laws. One of the key things that makes Locomation unique is the ability to legally deploy our Human-Guided Autonomy based ARC systems today. The ARC system is being developed to comply with federal and state regulations and local laws applicable to its intended use within the product ODD. Specifically, the ARC prototype being tested in Spring of 2022 will also comply with all current and anticipated regulations.

We are ensuring we stay in compliance with every aspect of all applicable regulations: from operating, vehicle or subsystem performance (safety, fuel economy, and emissions), to labeling and communication requirements. We closely monitor rulemaking activities, such as updates to the FMVSS, the Federal Motor Carrier Safety Regulations, and the Federal Communications Commission rules for the use of the spectrum. Our human-centric model dramatically simplifies federal compliance, including compliance with items identified in the FMCSA’s Advance Notice of Proposed Rulemaking for the Safe Integration of Automated Driving Systems-Equipped Commercial Motor Vehicles that are the responsibility of the human CDL holder.

In both current prototype testing and future commercial deployment of the ARC model, the human driver(s) will be responsible for compliance in the following areas, the same way they are in conventional operations today:

- **49 CFR § 392.22 - Emergency signals; stopped commercial motor vehicles:** “Whenever a commercial motor vehicle is stopped upon the traveled portion of a highway or the shoulder of a highway for any cause other than necessary traffic stops, the driver of the stopped commercial motor vehicle shall immediately activate the vehicular hazard warning signal flashers and continue the flashing until the driver places…warning devices [flares or bidirectional reflective triangles], within 10 minutes…at 4 paces in the direction of approaching traffic, at 40 paces…in the direction of approaching traffic…at 40 paces…in the direction away from approaching traffic…before the stopped commercial motor vehicle is moved, the driver shall extinguish and remove each fusee or liquid-burning flare.” If a commercial motor vehicle is stopped within 500 feet of a curve, crest of a hill or other obstruction to view, the distances are changed to 100 feet and 500 feet from the stopped vehicle.

- **49 CFR § 392.9 - Inspection of cargo, cargo securement devices and systems:** “Examination of the commercial motor vehicle’s cargo and its load securement devices during the course of transportation, and the ability to make any necessary adjustment to the cargo or load securement devices, including adding more securement devices, to ensure that cargo cannot shift on or within, or fall from, the commercial motor vehicle.”
Reexamination and any necessary adjustments shall be made whenever—

(i) The driver makes a change of his/her duty status; or
(ii) The commercial motor vehicle has been driven for 3 hours; or
(iii) The commercial motor vehicle has been driven for 150 miles, whichever occurs first.

- Conduct routine vehicle inspections as specified in 49 CFR § 392.7 — Equipment, inspection and use.
- Interactions with law enforcement and roadside inspectors: Officials will be able to interact with the ATOs just as they do today to ensure the ARC system is functioning properly, as well as to perform a “walk-around” inspection of both the tractor and trailer.
- Providing proof of insurance, driver information: Locomation ATOs will be able to transfer vehicle owner or operator information in the event that either vehicle is involved in an incident such as a crash or if there is a need to provide to a law enforcement officer for any other reason.

In addition, the ATO on duty will be able to:

- Manage unplanned maintenance and repair issues.
- Detect emergency vehicles such as police, fire, and rescue, and move out of the path of first responders.
- Navigate the convoy through planned and unplanned work zones (where permitted by state and local law) and accident sites.
- Respond to adverse weather conditions and unforeseen circumstances or events.

Alternate means of compliance will have to be established, and the FMCSA Safe Integration of Automated Driving Systems-Equipped Commercial Motor Vehicle rulemaking will have to be completed before drivers can be totally removed from the safe operation of the commercial motor vehicles.

Locomation engages with state authorities to proactively communicate about our unique approach to autonomy. In the majority of the states, Locomation can deploy with our preferred model. In some other states, there are limitations on how closely vehicles can travel together, or requirements that a human be in control of the vehicles at all times. In these cases, Locomation will engage with regulators and legislators to ensure compliance, either through interpretation or modification of existing statutes or regulations. We are also reviewing and ensuring compliance with state requirements with respect to other issues, such as insurance; truck-specific requirements for lane usage, speed limits or weight limits; restrictions on operations on bridges, or in tunnels, work zones or toll plazas; requirements for vehicle identification or external markings; and data recording.

Locomation’s ATOs/safety drivers will be trained and informed on the capabilities and limitations of the technology to ensure compliance with applicable regulations, while driving vehicles that are compliant with the FMVSS.

As part of our commitment to transparency, Locomation is eager to continue routine discussions with federal, state and local officials. These discussions, particularly about our safety pillars and appendix in Safety, are an invaluable tool for feedback and collaboration. We look forward to continuing these discussions and using this VSSA and future VSSAs as one tool to help us communicate to stakeholders.
CONCLUSION

Locomation is planning to be the first autonomous trucking company to deploy safety, legally and routinely in commercial operations at scale across the United States. As such, we have a moral obligation to do this right. This means not only ensuring that we are prioritizing safety and ensuring that we are not posing any unreasonable safety risk in the advancement of our testing and demonstrations towards on-road operations, but also acting transparently as we take these steps towards a safer future.

While we have high aspirations for the future we can create with our technology, Locomation has not made any safety claims in this document that are merely aspirational. We will not claim any standard conformity, accomplishment, or safety achievement until we have fully proven such claims.

This initial VSSA serves as a marker of our progress and as a commitment to transparency. We plan to prepare and submit updated VSSAs as we progress toward our operational goals, and upon the completion of our Safety Case prior to delivery of Locomation-equipped trucks to our customers for commercial deployment.

We are creating a safer, better, cleaner future for trucking, and we are excited to take the next steps in making it happen.