



SAFETY REPORT

DECEMBER 2023

MESSAGE FROM CEO

Stack AV was founded with the core belief that advanced autonomous systems will revolutionize the transportation of goods. With the support of our key partner, SoftBank Group, we're working to realize a safer, more efficient vision of the transportation industry: one in which supply chains are smarter, business outcomes are improved, and goods are delivered to end-users faster. We're designing the right solutions to help realize this vision.

In order to do this, safety is our foundation. It is at the core of everything we do, including our values, our mission, and our culture. It is the key to public acceptance of Stack's transformative technology and its potential to improve peoples' lives.

At Stack, our values of safety, excellence, humility, grit, transparency, and passion define our culture. Our employees have decades of experience in this field and share our vision for the broad acceptance and responsible deployment of autonomous vehicles. They, too, believe our work should have safety at its core, guided by thorough processes and data-driven approaches to bring that vision to life.

Our work is carried out in collaboration with a broad range of carefully selected partners. They include responsible companies, governments, external stakeholders, and the communities in which we will operate. These partnerships will enable us to deploy our technology responsibly when the data tells us it is safe to do so.

When it comes to testing AVs, there is simply no substitute for real-world experience—this is why we're testing our technology on public roads. We do so with a deep understanding of the responsibility we have to do it safely. Before going on the road, we conduct extensive testing in simulation and on private test tracks, and we provide recurring training for our vehicle operators.

Our journey is a marathon, not a sprint; it requires collaboration and transparency in order to build trust with the public and other relevant stakeholders. We created this Voluntary Safety Self-Assessment to begin the conversation and look forward to more dialogue in the months and years ahead.

We hope the reader will take away the following from this VSSA:

- 1 Stack understands the technology we're developing and intend to deploy.
- 2 Stack knows that in order to do that successfully, the right partnerships and ecosystems need to be built.
- 3 Stack regards safety, transparency, and collaboration as essential to its mission.

Thanks for coming on this journey with us. We look forward to working with you.

Sincerely,



Bryan Salesky

CEO, Stack AV



ABOUT STACK

Stack is creating technology solutions to revolutionize the transportation industry through the deployment of advanced autonomous systems designed to help meet the safety, reliability, and efficiency demands of the trucking industry. We're working to create smarter supply chains for our partners, improve business outcomes for customers, deliver goods to end-users faster, and move the trucking industry toward the future.

Stack's autonomous technology incorporates cutting-edge advancements in artificial intelligence, robotics, machine learning, and cloud technologies—empowering us to build innovative solutions that address the needs and challenges of the dynamic trucking industry.



At Stack, we love what we do, we set high standards, and we aim to deliver compelling customer outcomes. We believe in a culture of safety, excellence, humility, grit, transparency, and passion. This combination of values creates an environment that ensures safe, reliable, and effective solutions that can revolutionize the transportation of goods.



OUR SAFETY PHILOSOPHY

SAFETY CULTURE

Safety is our foundation, with every employee responsible for maintaining safety standards. It drives our innovation, development, testing, and progress, and extends beyond our products to all aspects of our business.

OPEN COMMUNICATION

We foster a culture of open communication and empower our employees to report safety issues. Our transparent decision-making and safety processes help address such concerns, and we consult with first responders and other relevant stakeholders to augment this process.

SAFETY REPORTING CHANNELS

Supervisors, managers, and committees are available for employees to express their concerns. Employees are empowered to issue safety advisories, access and review test data analysis, and report any issues via Stack's confidential 24/7 ethics reporting hotline.

DATA ANALYSIS AND REPORTING

We carefully analyze data from our daily test drives, including disengagements, to review and address issues, and fully comply with all government reporting obligations.

EXTERNAL STAKEHOLDER ENGAGEMENT

Stack engages with external stakeholders, such as its independent Safety Advisory Council (SAC) and industry safety bodies for existing, new, and emerging standards development, and collaborates with governments and regulatory bodies.

SAFETY CONCERN ESCALATION

We have a structured escalation process for safety concerns and can enter into immediate manual control if an issue is found. Our Operations Managers and engineers have the ability to stop autonomous testing until the root cause is identified and a solution is found and validated.



OUR VISION

WE DEVELOP TRUCKING SOLUTIONS

Focused on our customers' needs, Stack is designing solutions to alleviate challenges faced by the trucking industry to create smarter supply chains for partners, improve business outcomes for customers, deliver goods to end-users faster, and move the trucking industry forward.

SAFETY IS AT OUR CORE

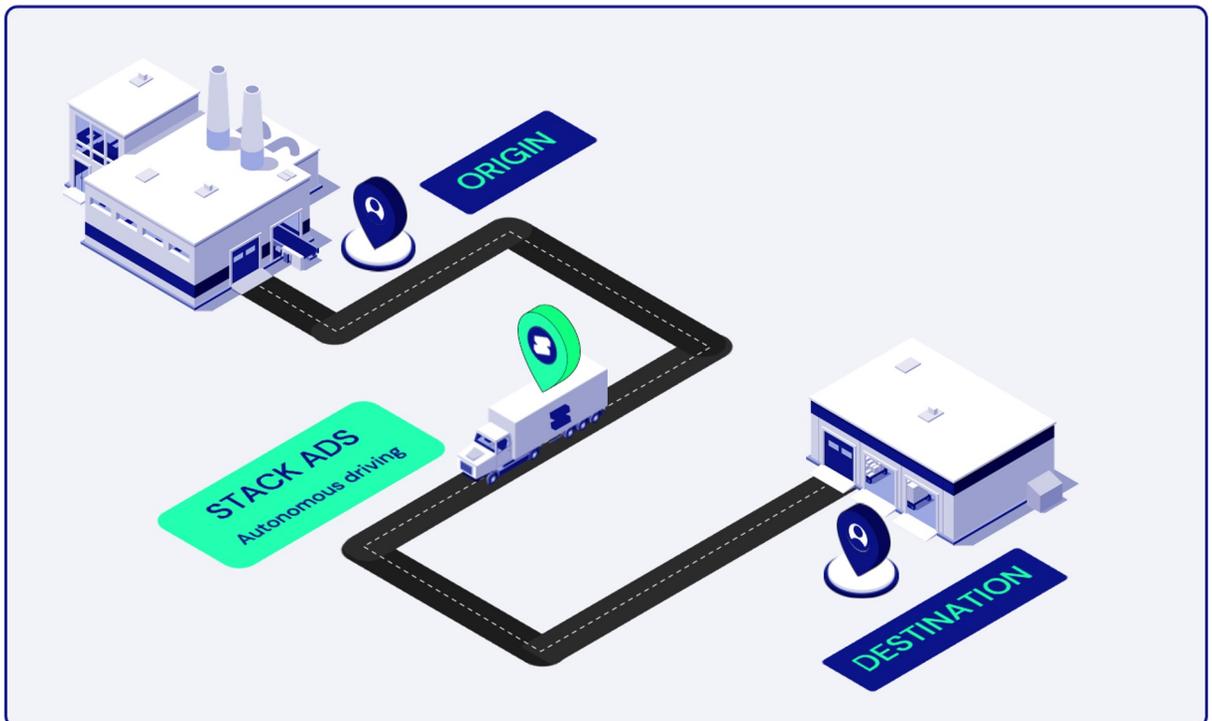
Safety is the foundation of our culture. We embrace a safety-focused approach driven by transparency and accountability.

AI POWERS OUR AUTONOMY

Stack's autonomous technology incorporates cutting-edge advancements in artificial intelligence, robotics, machine learning, and cloud technologies, empowering us to create innovative solutions that address the needs and challenges of the dynamic trucking industry.

OUR PEOPLE DETERMINE OUR SUCCESS

With decades of experience creating and deploying real world systems for demanding environments, the Stack team is dedicated to developing an autonomous solution ecosystem tailored to the trucking industry's unique demands.



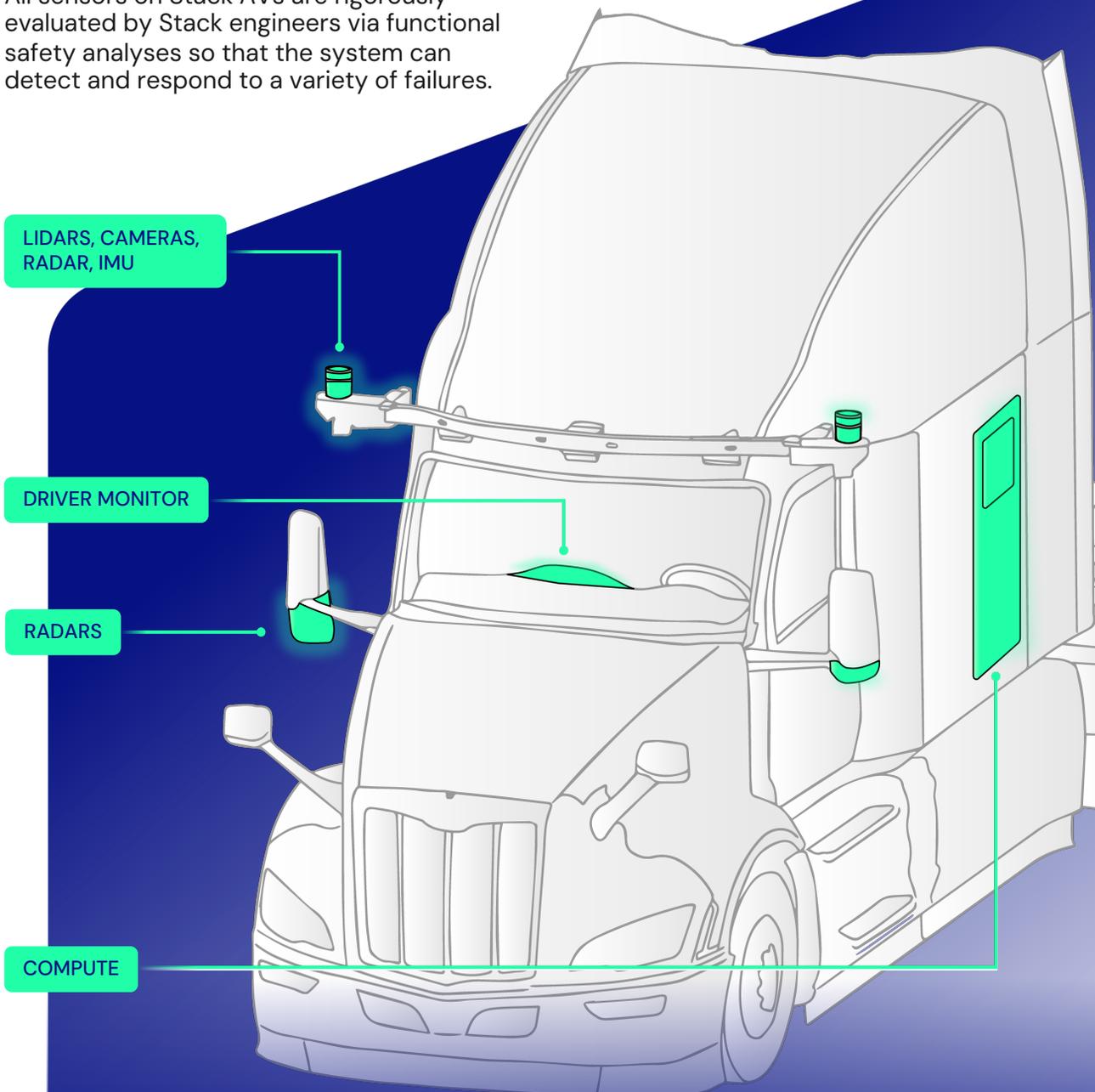


HOW OUR ADS PERCEIVES THE WORLD

Stack uses a multimodal sensing system installed on our AVs to provide situational awareness around the vehicle. The sensors provide field of view coverage from the boundaries of the AV up to long range views around the AV.

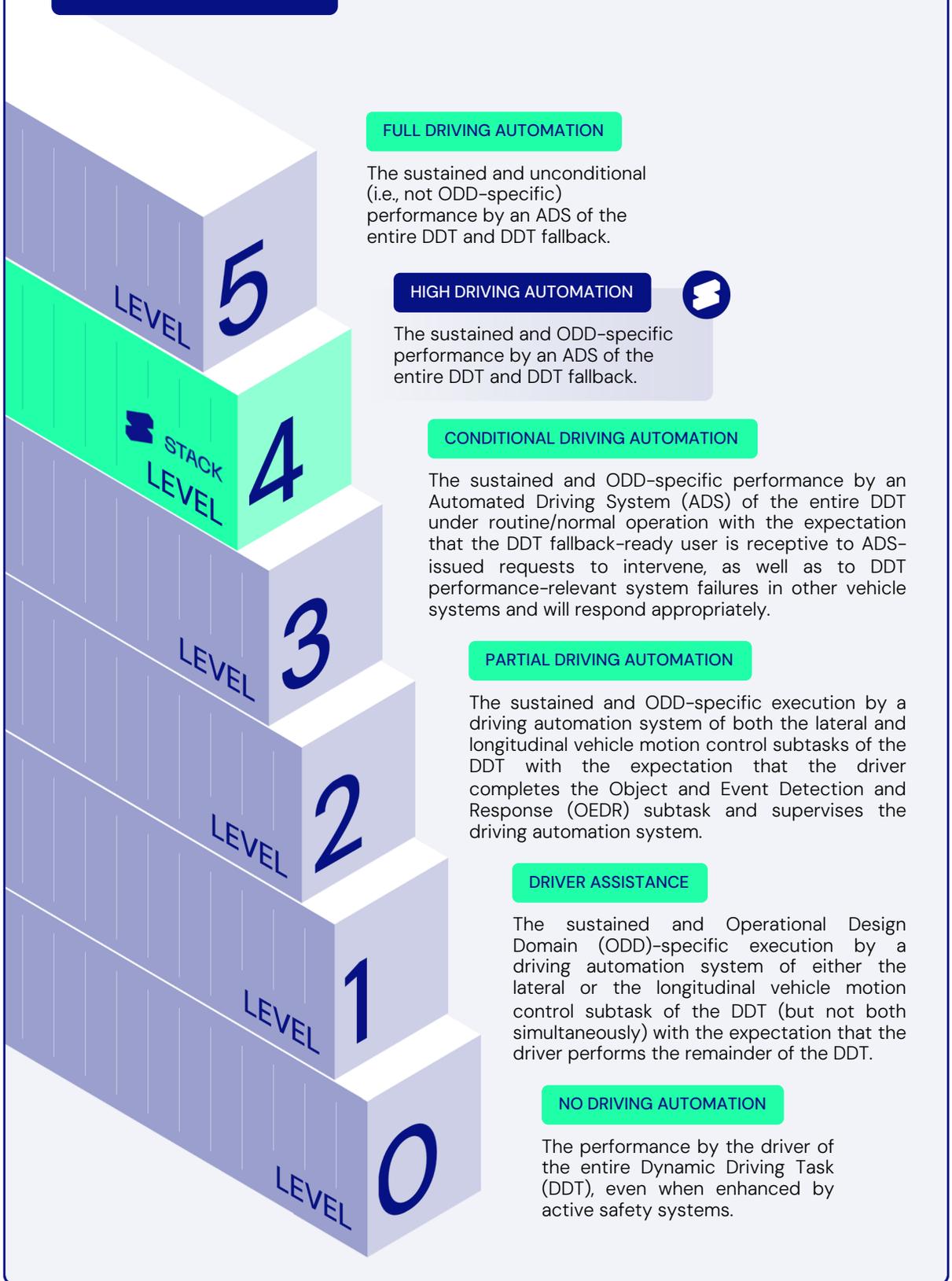
To mitigate any single sensor error or limitation, the Stack system leverages a combined, multimodal suite of radar, camera, and lidar sensors. Additionally, Stack uses dual redundancy perception in the forward direction so that if a single sensor fails the system does not go blind, and the redundant sensors will allow our AVs to maneuver to a minimal risk condition.

All sensors on Stack AVs are rigorously evaluated by Stack engineers via functional safety analyses so that the system can detect and respond to a variety of failures.





LEVELS OF AUTOMATION



Note: The definitions outlined above have been taken from SAE J3016¹
Level 4 automation is the ultimate goal for Stack's ADS.



OUR VALUES

— ABOUT STACK

SAFETY

Safety is our foundation. We embrace our obligation to be responsible and practice safety as our company's bedrock—both individually and collectively.

EXCELLENCE

As a team, we execute and deliver a world-class product that brings value to our customers by solving their critical business needs in a safe and efficient manner. Our collective accomplishments are greater than any individual effort.

HUMILITY

We operate with respect for all and are humble in our achievements and mistakes. We take ownership of our conduct, embrace one another's differences, and uphold an environment of kindness and dignity.

GRIT

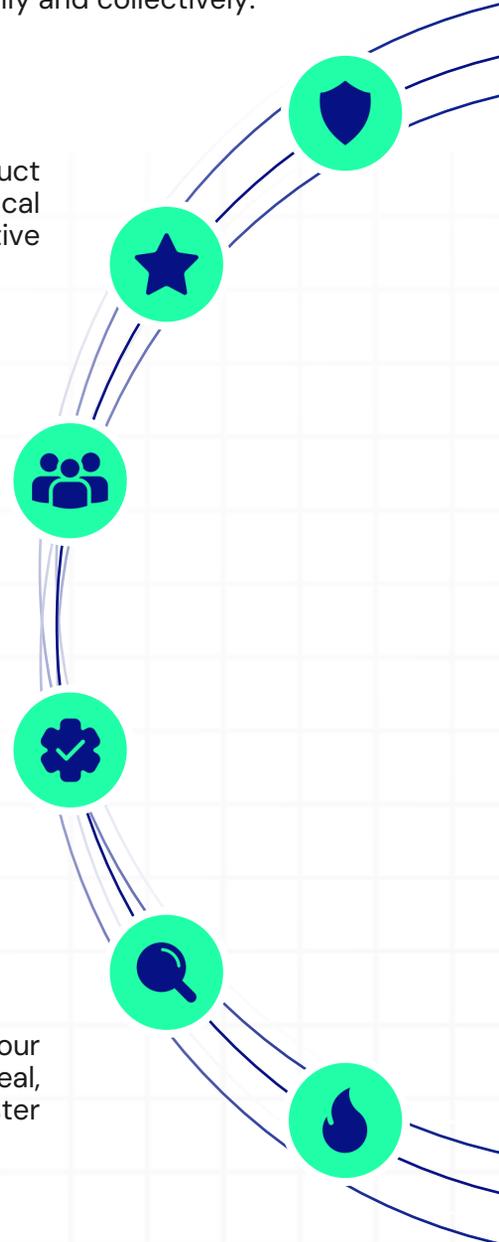
The path to success is rarely straight or smooth. We succeed as a team through disciplined execution, by working together to understand the problems at a fundamental level, and by developing thoughtful and practical solutions.

TRANSPARENCY

We are transparent and honest about the facts of our execution and hold ourselves accountable to drive real, continuous improvements through our work, and to foster public trust and support of our products and services.

PASSION

We are passionate about our mission and our culture. Our passion motivates our success and creates an environment where our teams thrive.





OUR IMPACT

— ABOUT STACK



ENHANCED SAFETY

Autonomous trucking has the potential to eliminate human error, fatigue, and distraction—leading to safer roads.

455,000

crashes per year involve large trucks³

155,000

injuries were caused by large truck collisions in 2021⁴

5,000

people each year are killed due to crashes involving large trucks⁵



increase in fatalities due to collisions with large trucks in 2021 compared to 2020²



of large truck front-to-rear crashes could be prevented with driver assistance technology solutions³

TRAFFIC FLOW IMPROVEMENT

Autonomous trucks will have the capability to coordinate, reducing congestion and disruptions to traffic.

ENVIRONMENTAL

Efficient driving practices can reduce fuel consumption and emissions, promoting sustainability.

SUPPLY CHAIN OPTIMIZATION

More reliable and predictable deliveries can enhance supply chain efficiency, leading to better inventory management.

Driver retention is a persistent problem for carriers that can exacerbate supply chain issues⁸.

By 2031, there is a projected shortage of 160,000 drivers⁷.

OPTIMIZED EFFICIENCY

As parts of connected fleets, autonomous trucks can operate 24/7. These fleets can optimize routes in real-time, improving asset utilization, delivery times, and reducing fuel consumption.



In 2021, trucks traveled over **327 BILLION MILES⁶**



In 2022, trucking accounted for **80.7% OF THE NATION'S FREIGHT BILL⁶**

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STACK



01

VSSA SUMMARY



VSSA SUMMARY

Stack's Voluntary Safety Self-Assessment will educate the public about how we safely develop and test our autonomous trucking technology. We believe that public acceptance is crucial to realizing the benefits of this technology; this begins with education and open dialogue.

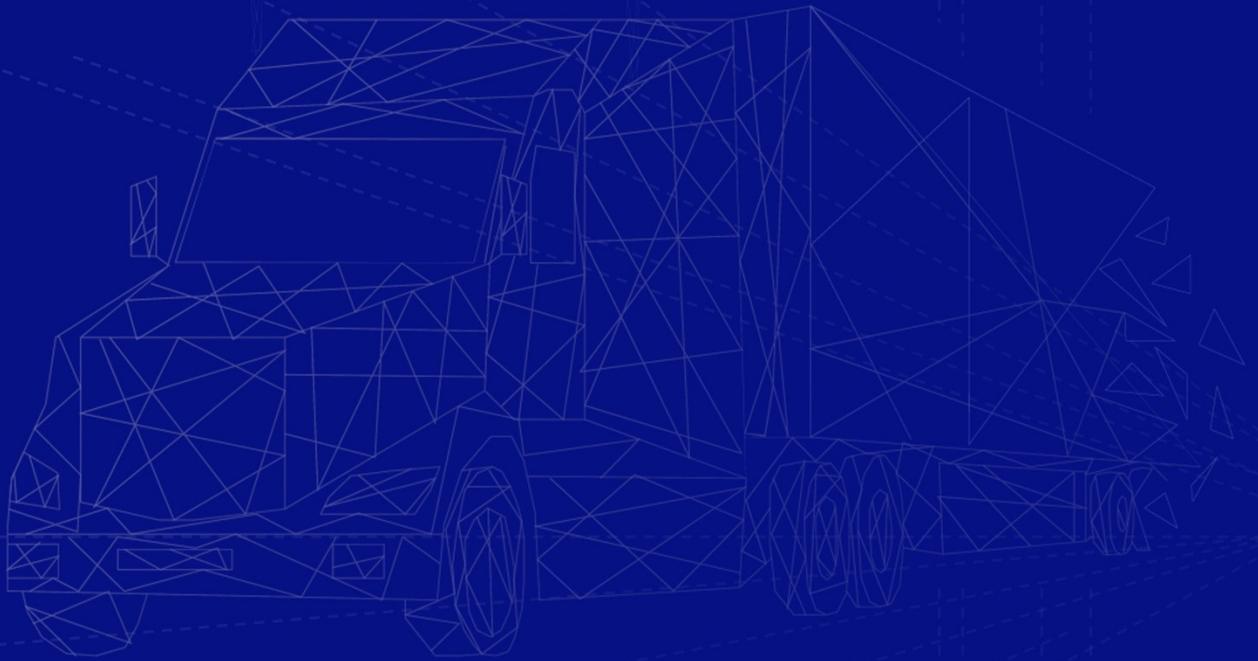
The Stack VSSA is broken down into four sections, taking the reader on a journey exploring who we are, what we do, and how we operate.

It incorporates the United States Department of Transportation's twelve priority safety design elements for Automated Driving Systems⁹:

- | | | | |
|---|-------------------------------------|----|-----------------------------------|
| 1 | System Safety | 7 | Fallback (Minimal Risk Condition) |
| 2 | Consumer Education & Training | 8 | Post-Crash ADS Behavior |
| 3 | Crashworthiness | 9 | Human Machine Interface |
| 4 | Federal, State, & Local Laws | 10 | Data Recording |
| 5 | Operational Design Domain | 11 | Vehicle Cybersecurity |
| 6 | Object & Event Detection & Response | 12 | Validation Methods |

A glossary of terms and references is provided at the end of this document.

Stack welcomes public feedback about this VSSA to help improve future versions. **Visit stackav.com to provide your comments.**



02

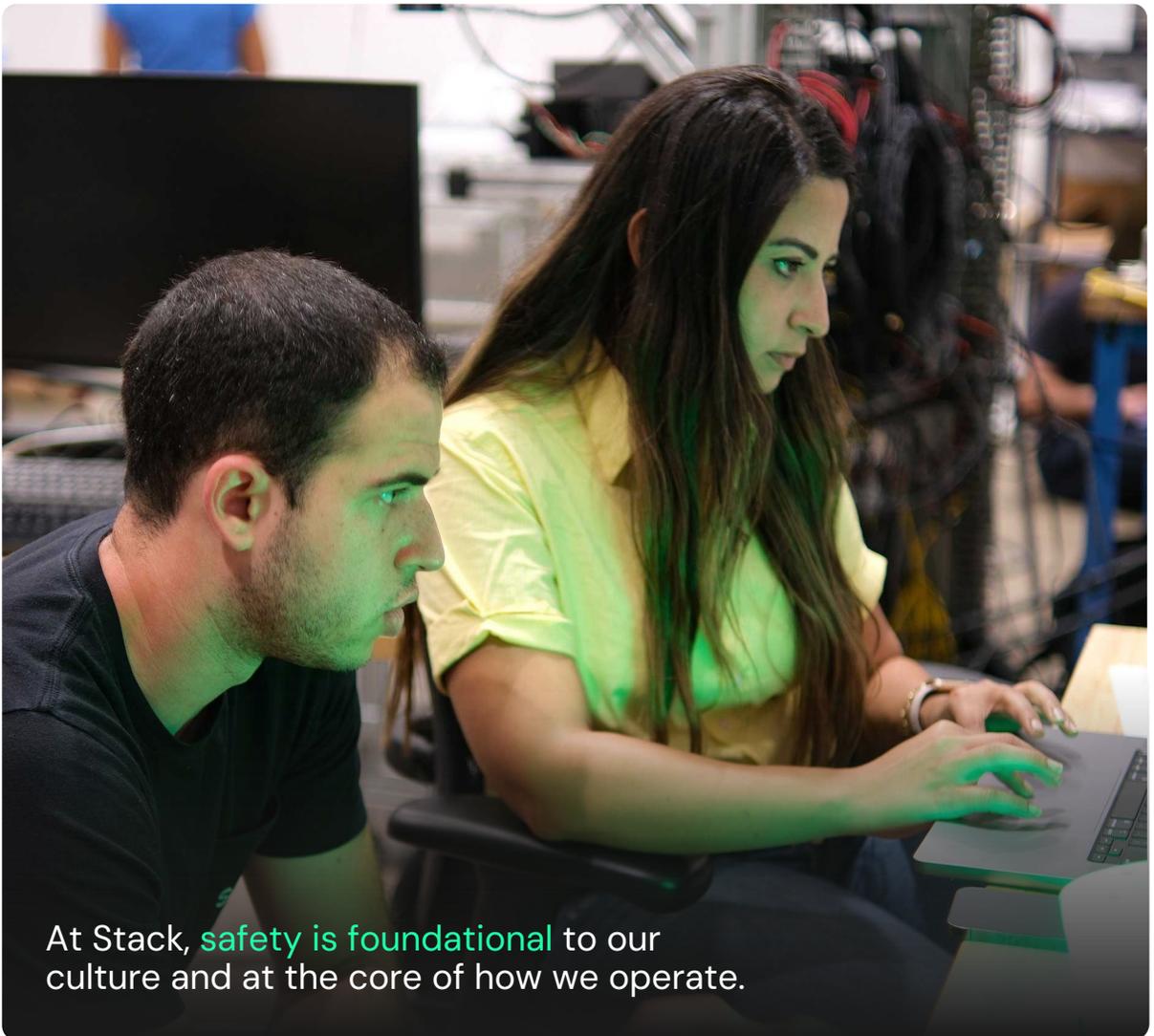
LET'S TAKE A RIDE



SYSTEM SAFETY

— LET'S TAKE A RIDE

Our objective is to build a thoroughly tested and fail-safe Level 4 ADS. To achieve this, we adhere to a principled framework that leverages widely accepted standards, such as ISO 26262 (Functional Safety)¹⁰ and ISO/PAS 21448 (Safety of the Intended Functionality)¹¹. The output of our work, alongside a safe L4 ADS, is an evidence-based safety case that draws from standards like UL4600 (Standard for Safety for the Evaluation of Autonomous Products)¹² and utilizes industry best practices to validate the safety of the Stack ADS using well-structured and quantitative arguments. Furthermore, we encourage and empower all Stack employees to escalate safety-related issues and concerns. We believe everyone in our organization has a role to play in fostering our safety-centric culture, consistent with the National Transportation Safety Board's (NTSB) safety culture recommendations¹³.



At Stack, **safety is foundational** to our culture and at the core of how we operate.

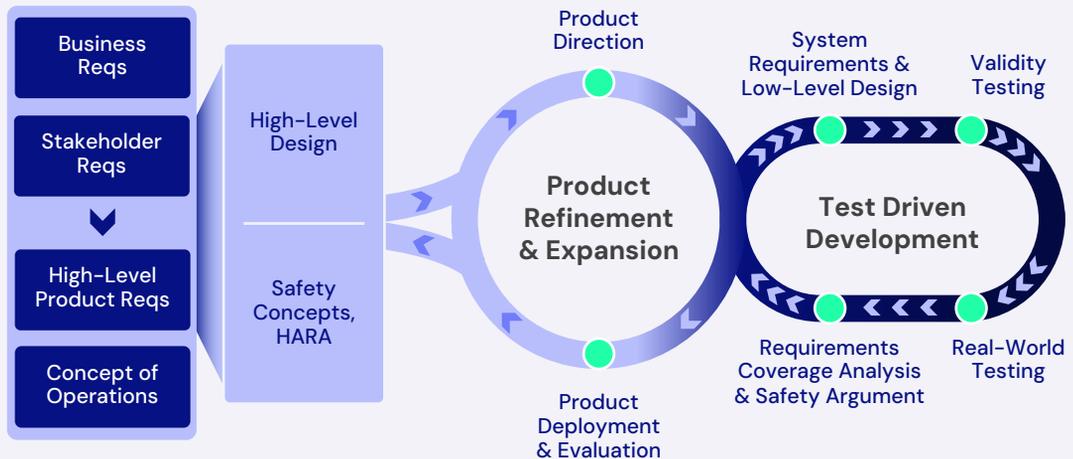


OUR PROCESS

— LET'S TAKE A RIDE

Our safety approach is based on risk assessment, mitigation, and sound engineering practices to design, implement, integrate, and rigorously test our autonomous trucks. We rely heavily on analysis, complemented with test-driven development that utilizes simulation, track-based, and public road testing to promote the safety of the whole system from development to production.

Conceptual illustration of a standard Stack product testing workflow

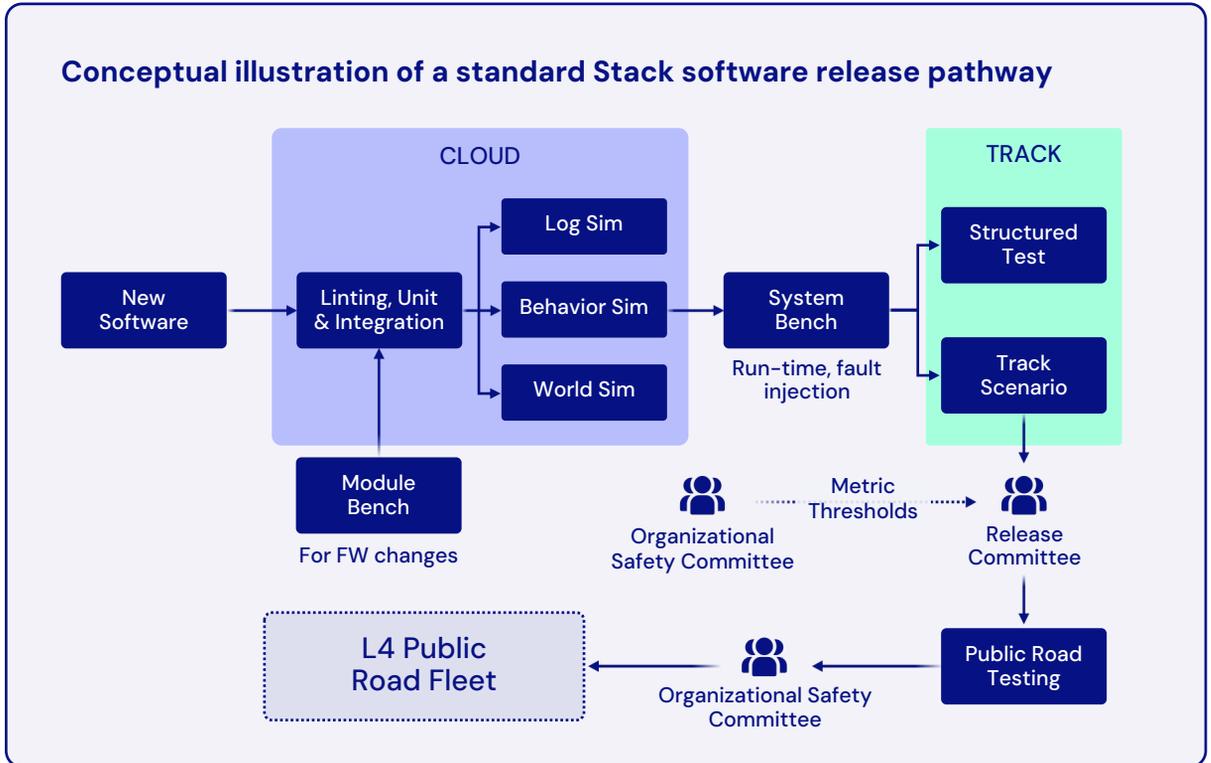


The process begins by establishing high-level requirements and operational concepts to ensure a common understanding of what the system must do and how it will function when deployed. Using this initial information, we apply principles of ISO 26262 (Road vehicles – Functional safety)¹⁰ and begin the process of identifying hazardous scenarios and their potential mitigations, which take the form of safety goals.

A key aspect of our functional safety approach revolves around fault management (the monitors and diagnostics used to detect suboptimal conditions in the system), then selecting and executing an appropriate minimum risk maneuver (MRM) to achieve a safe state given the suboptimal condition. These monitors and diagnostics gather information from the various components and data streams onboard the AV. The mechanics of our fault management approach are discussed further in the “Fallback Methods” section.



Principles and methodologies of ISO 26262¹⁰ and ISO 21448 (Road vehicles – Safety of the intended functionality)¹¹ are continuously applied throughout the product development process. At a high level, we consider how the system can fail and work to prevent, or detect and mitigate, such failures. This work is backed by tests, empirical data, and design analysis that ensure the product achieves those goals. We use well understood safety engineering tools to conduct analyses, including HARA¹⁰, FMEA¹⁴, FTA¹⁵ and others, with the goal of identifying, documenting, and mitigating hazards, threats, design flaws, functional insufficiencies, and unexpected behaviors. Using these tools, we work iteratively to update requirements and designs while establishing traceability from top-level hazards to low-level requirements and test plans.



The safety case provides the overall structure confirming the set of tests are both necessary and sufficient. Each test modality seeks to ensure the test is able to measure the right information that can be validated against the whole system. For example, where real run-time performance on target silicon is required, we leverage Hardware-in-the-Loop (HiL) or bench testing configurations. Each test has clear pass/fail criteria and serves as a gate to the next stage of testing, and as evidence that contributes to the safety case. Once the release pipeline testing is complete and all track-based testing is complete and passing, the new software release is carefully reviewed by an internal committee and evaluated for readiness to be tested on public roads. See the Verification and Validation section for details on testing.

Every new Stack ADS software release must go through a rigorous cycle of Design, Build, Test, and Refine, based on rigorous testing and analysis, before it may be engaged in autonomous operation within the defined operational design domain. Each software release reflects an iteration of our test-driven systems development process.



We envision that Stack’s top-level safety claims and associated sub-claims for its production Level 4 ADS may look like the following. The full safety case will ultimately evolve to include hundreds of sub-claims backed by supporting evidence.

— LET’S TAKE A RIDE

CLAIM 01

The Stack ADS can safely and reliably operate within its defined operating domain

Avoids incidents with other road users

Adheres to traffic laws and norms

Operates strictly within its defined ODD

Completes operations in fully autonomous mode at an acceptable rate

Is developed and tested in accordance with industry best practices

CLAIM 02

The Stack ADS can safely and reliably handle reasonably foreseeable faults, failures, and off-nominal conditions

Foreseeable hazards and failure modes are identified and mitigated

Off-nominal conditions are reliably detected

Failure mode responses are effective at minimizing risks to other road users, the surrounding environment, and the Stack ADS

Fail safe systems are developed and tested in accordance with industry best practices

CLAIM 03

Stack fosters a culture and environment suitable for building and deploying safety critical systems

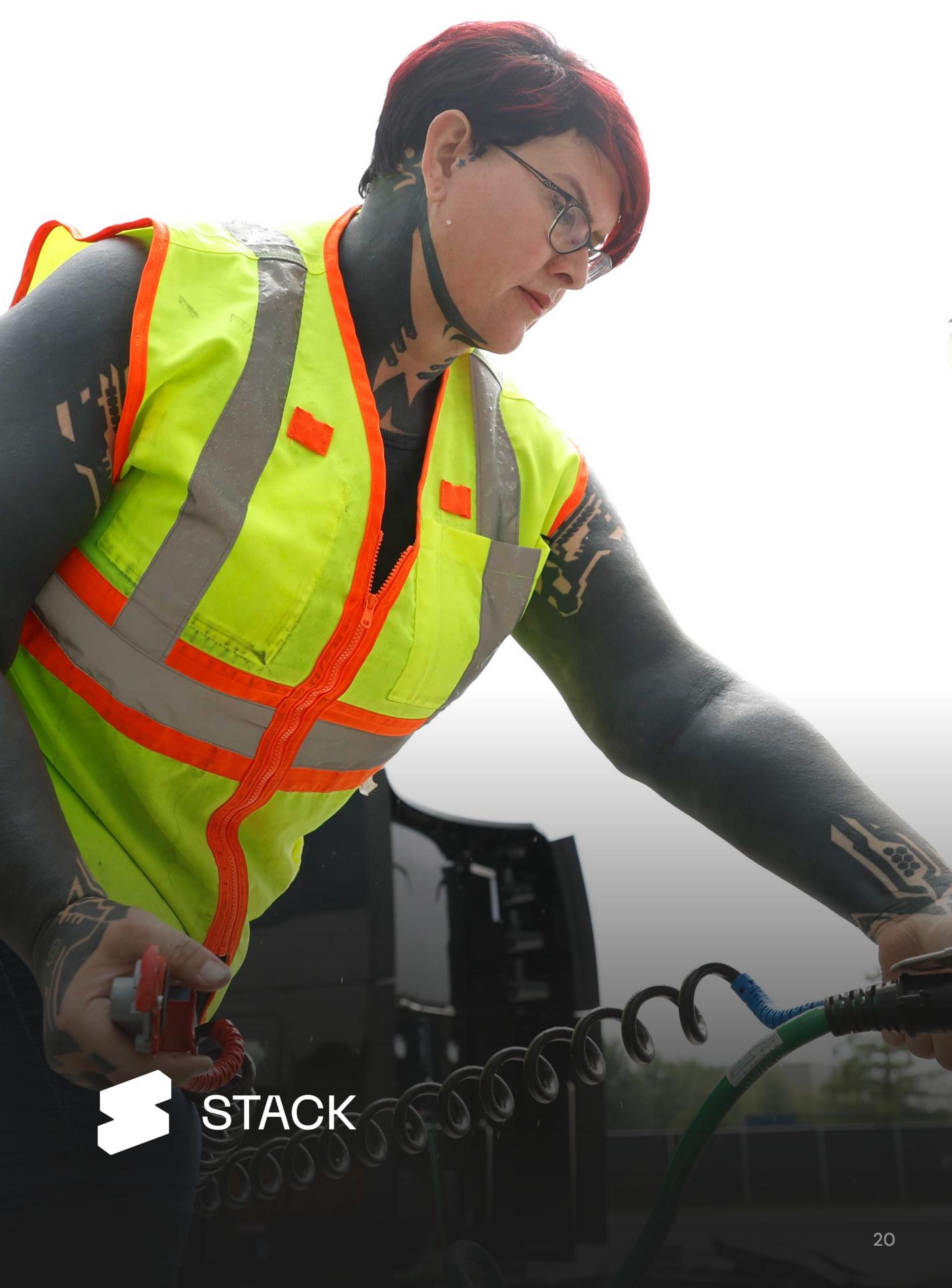
Adheres to industry-accepted safety case processes

Conducts regular safety training

Conducts independent safety reviews

Adheres to applicable laws and regulatory guidance

Promotes transparency and accountability on safety-related matters



STACK



03

PLANNING THE TRIP



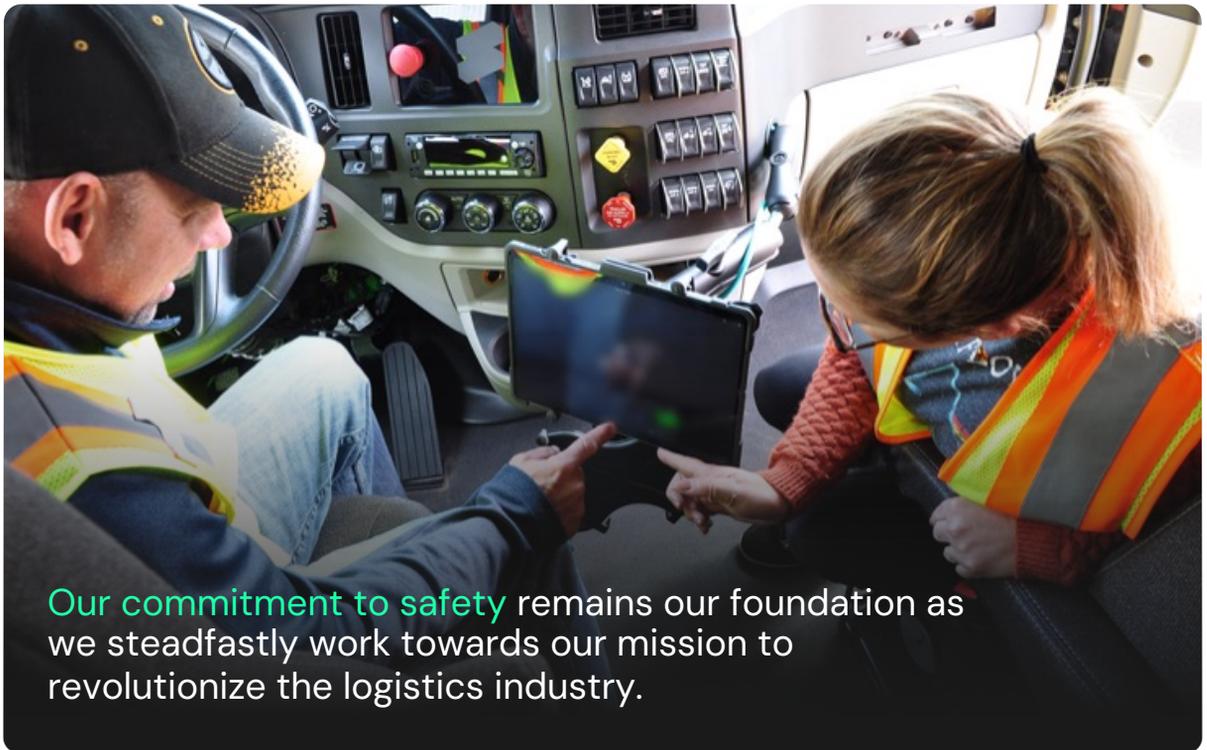
EDUCATION AND TRAINING FOR STAKEHOLDERS

COMPREHENSIVE TRAINING PROGRAM

At Stack, our commitment to the development and testing of safe autonomous technology starts with a meticulous approach to the selection of vehicle operators and the ongoing support they receive for their training and advancement. Our distinctive training program actively involves vehicle operators, empowering them to offer feedback and enhance operational practices.

Applicants undergo a comprehensive pre-employment screening process, which includes a high-skills driving test, background checks, and drug screening. Once selected, all vehicle operators undergo Stack's thorough training program based primarily on SAE J3018_202012 (Safety-Relevant Guidance for On-Road Testing of Prototype Automated Driving System (ADS)-Operated Vehicles)¹⁶, as well as the vast experience of our personnel. This program covers autonomous technology, manual driving proficiency, and the responsibilities associated with being a Stack AV vehicle operator.

We adhere to the rules set forth by the U.S. Department of Transportation ("DOT") for work hours and break schedules, as well as the regulations set by the Federal Motor Carrier Safety Administration ("FMCSA") concerning hours of service. Our vehicles are equipped with in-cab monitoring cameras, and our vehicle operators are prohibited from using mobile devices during testing.



Our commitment to safety remains our foundation as we steadfastly work towards our mission to revolutionize the logistics industry.



STACK ORGANIZATIONAL SAFETY COMMITTEE

Stack also has an Organizational Safety Committee (OSC) that is independent from the company’s Engineering team and assesses potential risks associated with safety, security, operations, and technology.

The Committee is composed of leadership from all cross-functional areas, including:

- 1 Executive Leadership
- 2 Enterprise Information Technology
- 3 People Operations
- 4 Facilities Operations
- 5 Fleet Operations
- 6 Systems Engineering
- 7 Safety Engineering
- 8 Product Security
- 9 Product Integration & Test
- 10 Hardware Engineering
- 11 Software Engineering
- 12 Safety Policy
- 13 Risk Management
- 14 Legal

Any employee concerned about a safety-related matter may raise their concern directly with any member of this committee.

STACK SAFETY ADVISORY COUNCIL

The Stack Safety Advisory Council consists of prominent figures from diverse backgrounds, such as transportation, aviation, logistics, law enforcement, and cybersecurity. Their mission is to offer guidance and advice on various critical aspects, including upholding safety, cultivating public trust, expanding seamlessly across diverse regions, and introducing commercial driverless trucking responsibly. The Council will serve as a trusted source of external expertise, advising Stack on its safety and security practices and policies.



The OSC does the following:

- Oversees and approves policies related to safety, technology, and operations
- Considers and approves initiatives, operations, and technology that change our risk profile
- Promotes and nurtures a culture of safety within the organization
- Provides a forum for discussing safety or security-related issues
- Ensures transparency in operations
- Offers guidance on best practices, procedures, and standards
- Oversees the implementation of our Safety Management System

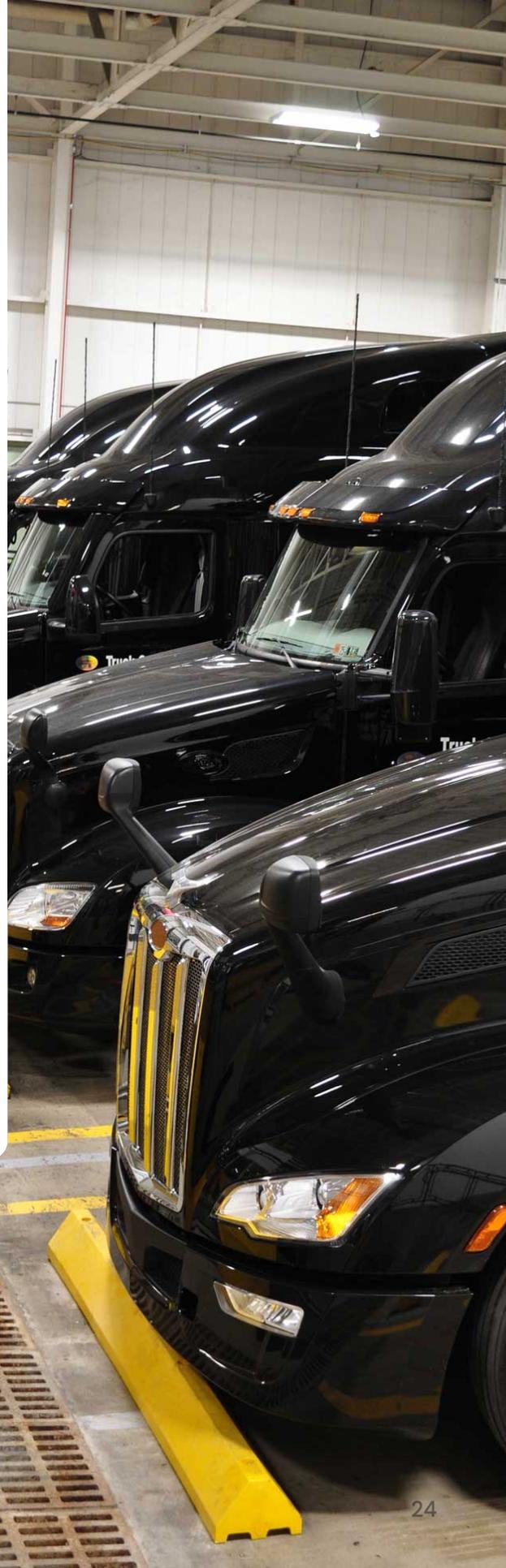


CRASHWORTHINESS & SAFETY STANDARDS

Stack currently modifies fully compliant base vehicles from established Original Equipment Manufacturers (OEM). These base vehicles are certified by the OEM to meet the safety standards and performance requirements for motor vehicles and certain motor vehicle equipment in the United States, as required by applicable Federal Motor Vehicle Safety Standards (FMVSS)¹⁷.

We collaborate with experienced OEM partners to integrate our ADS into compliant vehicle platforms and established technology, like Automatic Emergency Braking (AEB). We also seek to ensure that safety performance is maintained when modifying our test vehicles, including through the addition of redundant control systems.

Beyond crashworthiness standards, our operational policies require the use of seat belts for all persons in our test vehicle cabs.





COMPLIANCE WITH FEDERAL, STATE, & LOCAL LAWS AND REGULATIONS

Stack takes its responsibilities to federal, state, and local laws and regulations seriously—both as a matter of compliance and to earn public trust.

Our public road testing program and test vehicles meet or exceed all applicable federal, state, and local requirements. In addition, we continually engage with policymakers and law enforcement agencies to keep them informed about important developments in our work.

Stack recognizes the importance of integrating compliance with sound public policy and securing public support for our technology. This technology not only has the potential to improve safety, but also to revolutionize the trucking industry.

FEDERAL LAWS

Stack’s operations and modifications to our test vehicles comply with existing applicable federal laws and regulations, including current Federal Motor Vehicle Safety Standards (FMVSS)¹⁷ and Federal Motor Carrier Safety Requirements (FMCSR)¹⁸ for our modified test vehicles and vehicle operators. Stack’s senior leadership maintains regular contact with our primary federal regulators—the National Highway Traffic Safety Administration (NHTSA)¹⁹ and the Federal Motor Carrier Safety Administration (FMCSA)²⁰—to keep them updated on our activities and progress. We regularly engage with these agencies in their regulatory efforts to modernize requirements for ADS-equipped commercial motor vehicles.



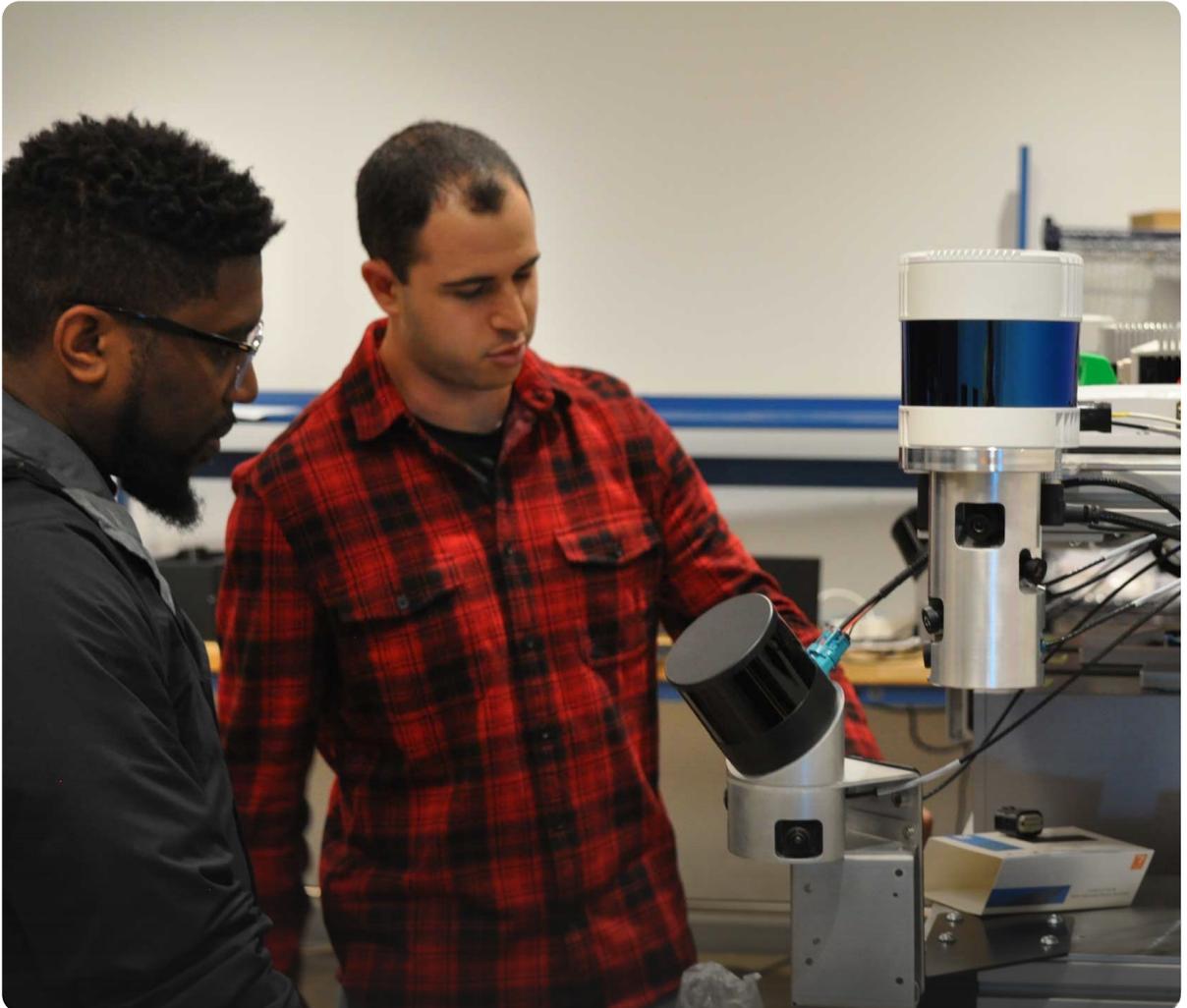


STATE AND LOCAL LAWS

Stack's testing program meets applicable state and local laws and regulations. We secure permits in the jurisdictions that require them for our operations and make our permit application materials available to the public on our website.

We engage with policymakers and communities prior to engaging in any ADS testing in their regions. Before we start testing, we analyze applicable requirements to ensure Stack's testing program and test vehicles can meet or exceed them.

Just as we do at the federal level, we maintain ongoing contact with state and local officials, including law enforcement and first responders, to exchange information about our activities. In addition, we consistently seek to engage with state and local authorities as they consider new AV policies. We value being part of that dialogue, and where possible, we help advise such deliberations as consultative members of public task forces, such as in Pennsylvania, where we are members of the Pennsylvania Automated Vehicles Task Force²¹ and the PennSTART Educational Consortium²¹.





FIRST RESPONDERS & LAW ENFORCEMENT AGENCIES

We appreciate the important roles of first responders and law enforcement agencies, and we work to make sure they are informed about our test vehicles and testing operations.

We regularly meet with law enforcement agencies and first responders to educate them on autonomous vehicle technology. Officers most often ask about the interaction between our test vehicles and active emergency vehicles, and whether our ADS is able to safely navigate in these situations. Since our test vehicles are currently overseen by vehicle operators in the cabs, those operators are trained to ensure safe vehicle behavior around law enforcement and first responders, including disengaging the ADS when necessary. This sort of engagement fosters dialogue and learning, ensuring that Stack is being a collaborative partner with those responsible for upholding roadway laws and regulations. It also emphasizes that they are a valued voice in the development of our technology.

EMERGENCY RESPONDER INTERACTION GUIDE



We maintain a publicly available Emergency Responder Interaction Guide²² on our [website](#) and update it regularly as our fleet expands and technology progresses.

We provide first responders with a point of contact and direct contact information so that they are able to reach a trained member of Stack's team if needed. Similarly, we include safety and contact information in the cabs of all of our test vehicles.



ONGOING COLLABORATION

As Stack continues to grow, we will continue our outreach and ongoing collaboration with federal, state, and local officials and important community stakeholders.

Likewise, we maintain memberships in trade associations and stakeholder groups to promote industry consensus around safe and responsible public policy.

MEMBERSHIPS



Autonomous Vehicle Industry Association (AVIA)



American Trucking Associations (ATA)



Commercial Vehicle Safety Alliance (CVSA)



Consumer Technology Association (CTA)



The Pittsburgh Robotics Network (PRN)



TechNet



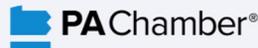
ITS America (ITSA)



The Pittsburgh Technology Council (PTC)



Pennsylvania Motor Truck Association (PMTA)



The Pennsylvania Chamber of Commerce

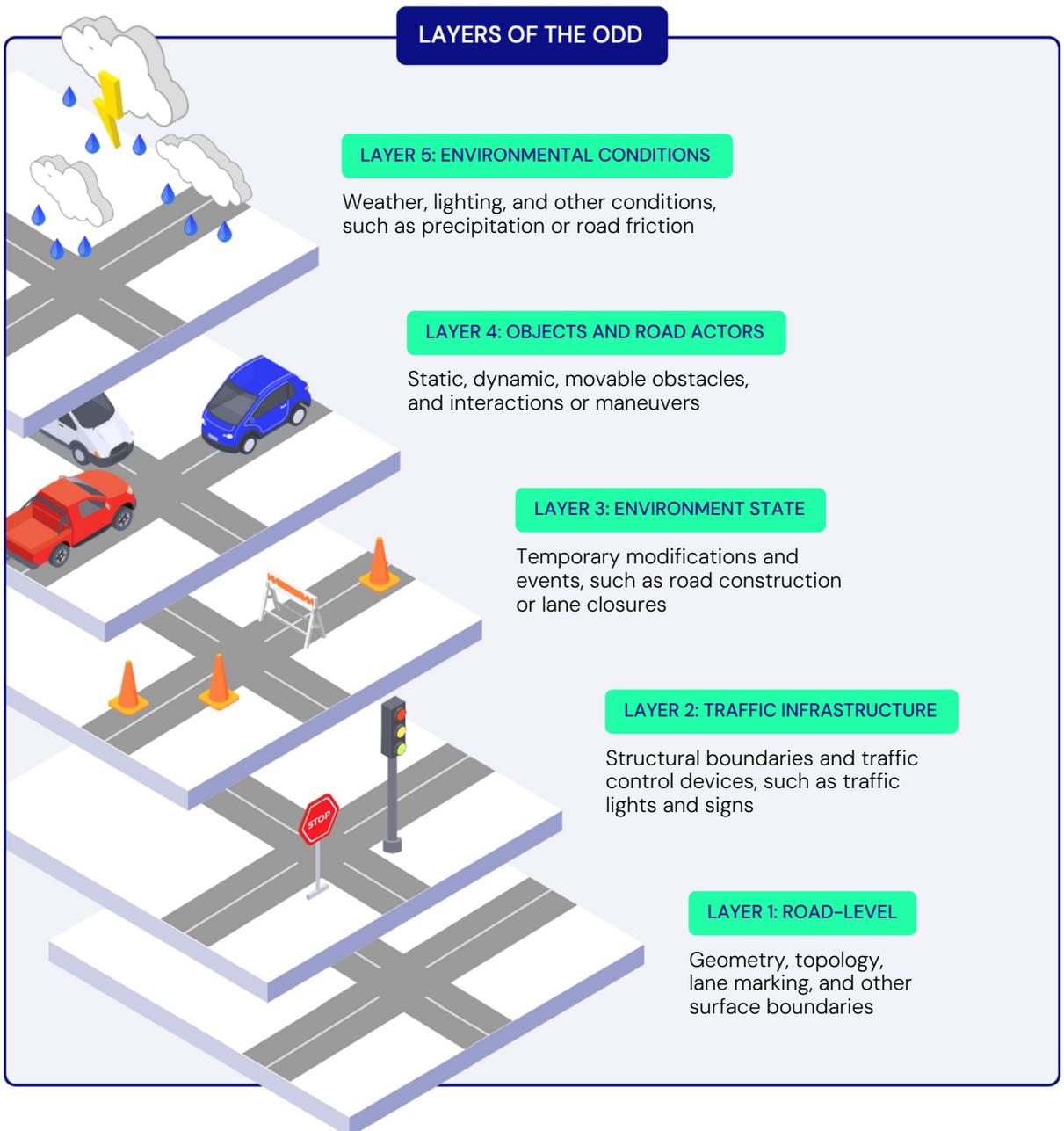
Additionally, we have chartered an independent Safety Advisory Council composed of recognized transportation safety experts to inform our development efforts and make sure we remain true to our values, **keeping safety as our foundation.**



OPERATIONAL DESIGN DOMAIN

A key step to ensuring our ADS operates safely is to define the conditions under which it is and isn't intended to operate. We then test and validate that the ADS performs as intended under those conditions. This is where **Operational Design Domain (ODD)** comes into play.

The ODD is composed of five layers, which include geography, types of roads, weather conditions, operational parameters, and other criteria. We also draw inspiration from the Automated Vehicle Safety Consortium (AVSC)²³ to help define our ODDs.

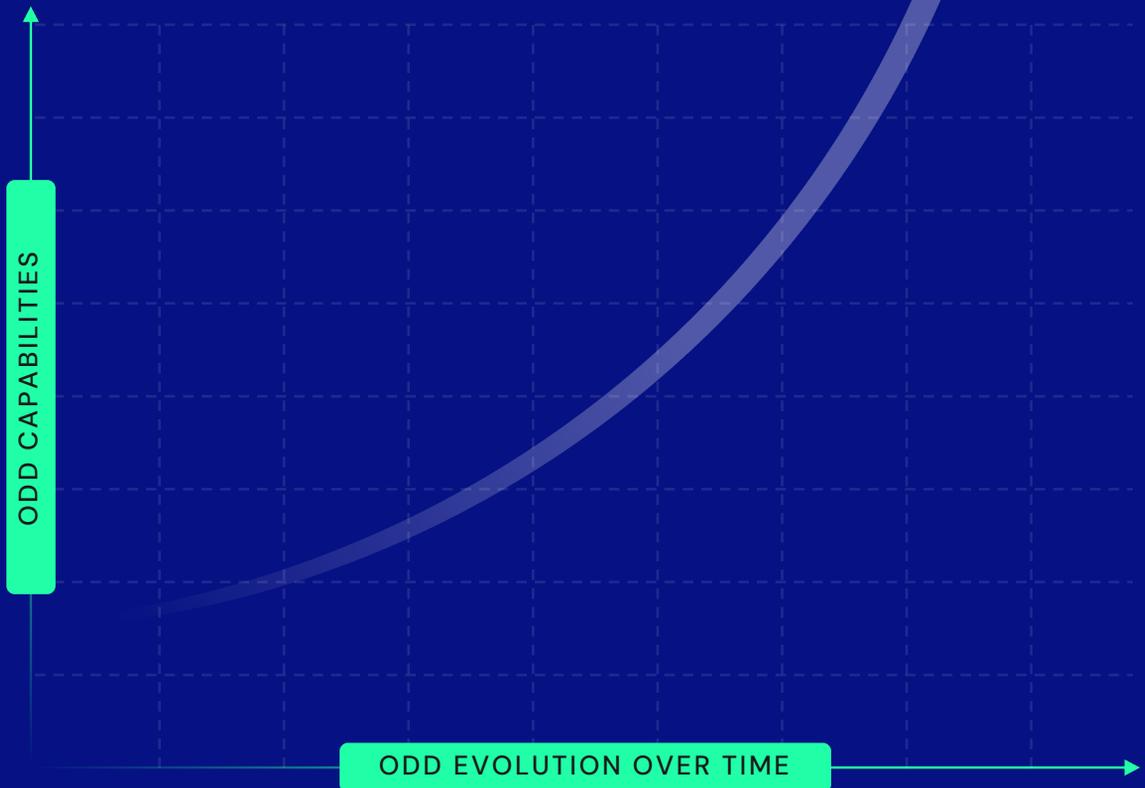




We use ODDs both to define our target product and characterize the evolution of Stack's ADS. We define our target ODD based on how our customers intend to integrate the ADS into their operations. We then measure our ADS's performance against that target ODD in simulation, track testing, structured testing, and on-road testing with a vehicle operator to identify areas for improvement and guide our development efforts.

Our system's ODD will expand over time as new features are developed.

Each significant expansion of the ODD will go through testing so that the ADS continues to operate safely and in accordance with its ODD.





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STACK



04

GETTING IN GEAR



OBJECT & EVENT DETECTION & RESPONSE

The main objective of the Stack ADS is to transport goods safely. The Stack ADS must always be aware of its environment and the vehicles, pedestrians, animals, and objects within it—both those sharing the road and those that might enter it. The Stack ADS is designed to respond to the many types of behaviors and conditions on the road—from distracted driving and drivers under the influence, to adverse weather conditions and vehicle malfunctions. This concept is referred to as **Object and Event Detection and Response (OEDR)**.

Self-driving systems consist of three primary components used to accomplish safe operations:

PERCEPTION

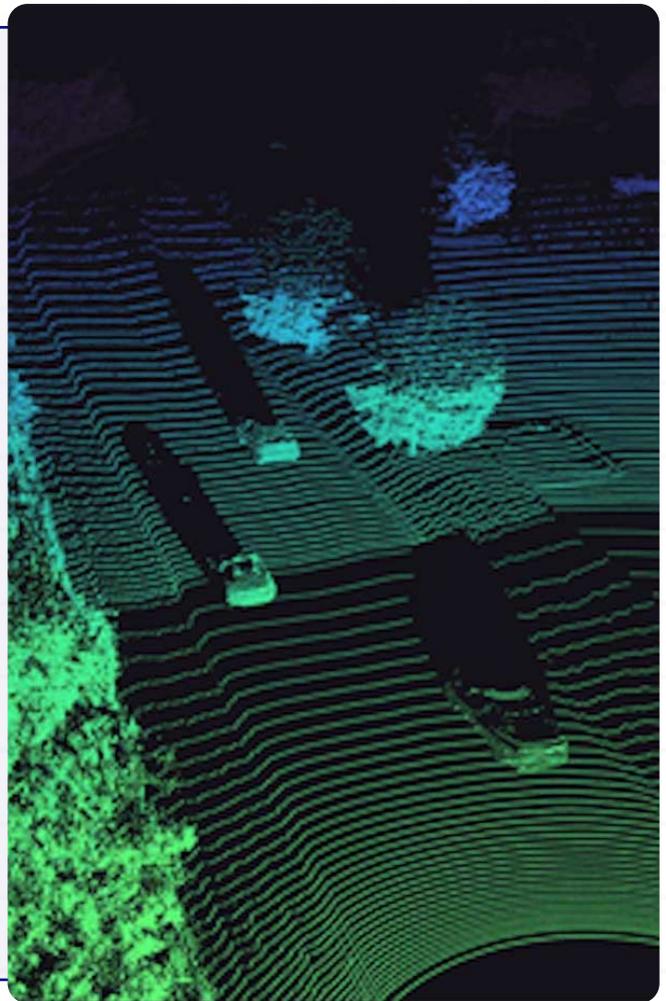
Using sensor data to understand events occurring around the autonomous vehicle and tracking that behavior over time

PREDICTION

Anticipating what might happen next and how the autonomous vehicle's own actions might change or impact the behavior of other actors in the environment

DECISION MAKING

Selecting actions for the autonomous vehicle to take next, so that safety is enhanced, and the vehicle makes progress toward its destination



The Stack ADS employs **carefully designed and rigorously tested** state-of-the-art perception, prediction, and decision making techniques to operate safely.



OEDR

Since a large part of trucking involves driving on highways, Stack’s ADS will eventually be highly capable of navigating all the specificities of safe highway driving. Therefore, our ADS’s perception will detect and track vehicular traffic, recognize specialized vehicles, such as emergency vehicles (including when they are active with signs, lights, or sirens), as well as construction equipment, and construction and road maintenance crews. Stack’s ADS will also be capable of navigating surface streets, from stop signs to traffic lights and different behaviors from other road actors.

Stack’s ADS leverages redundant design features to be robust to failures in components or the power system. It also uses prior knowledge of test areas based on previously constructed maps, multiple types of sensors, and a variety of different algorithms to optimize its ability to execute its perception–prediction–planning loop and maximize its capability for safe and effective operations.





FALLBACK METHODS

While our ADS is in the development phase, specially trained drivers and engineers act as operators in our test vehicles and are prepared to intervene before the ADS enters a situation beyond its developmental capabilities. Our ADS offers many ways for the operators to take over driving control of the vehicle. The most common take-over methods include pressing the disengagement button, pressing the brake or the accelerator, and turning the steering wheel. If faults are detected at startup, the ADS will not allow the operator to engage autonomous driving mode. As an additional failsafe, the safety operator may press a clearly marked red button to disable autonomy.

PREPAREDNESS:

Our ADS will be prepared to take appropriate action if it experiences a problem that could compromise safety. If necessary, the Stack ADS will be able to carry out a fallback maneuver, putting the vehicle into a safe state that reduces the risk of a crash, known as a minimal risk condition (MRC).

FALLBACK MANEUVER REASONING AND PROCESS

1. **Detect** conditions that are off-nominal in one or more components of the system and recognize them as faults
2. **Prioritize** the detected faults and enumerate the different consequences relating to system capability while remaining in the faulted state
3. **Understand** the local environment around the vehicle (e.g., *Is a shoulder available? Is the vehicle in a construction zone? What is other traffic doing?*) using a combination of map data and data from onboard sensors and localization systems
4. **Evaluate** the state of the ADS due to the identified fault
5. **Navigate** a complex decision making process that takes into account the local environment and the current state of the ADS to determine a minimum risk maneuver that achieves the MRC to address the fault condition
6. **Notify** the remote supervision team (Mission Control), which will then trigger any additional operational actions based on the situation
7. **Execute** the minimum risk maneuver to completion



Should faults occur while driving in the future, the ADS will attempt to slow the vehicle down at an appropriate deceleration rate until it reaches a stop or, if possible, pull over to come to a safe stop. In every case, once the vehicle is in a fault state, the ADS will not allow further operations in autonomous mode until the fault state is fully cleared with verification.

The Stack ADS is being designed to ensure multiple redundancies and fallbacks that include the following major components:

- 01** Diagnostic coverage of hardware and software elements in the system
- 02** Prioritization of faults
- 03** Enumeration of possible maneuvers
- 04** Risk assessment to guide selection of maneuvers given specific faults

When our system is ready for driverless operation, the entire ADS will have completed thorough engineering analysis, design, implementation, and extensive verification and validation testing.



POST-CRASH ADS BEHAVIOR

Stack is developing and implementing comprehensive post-crash behavior protocols that will, in the future, provide step-by-step instructions for both the system and those supporting it.

STEP 1



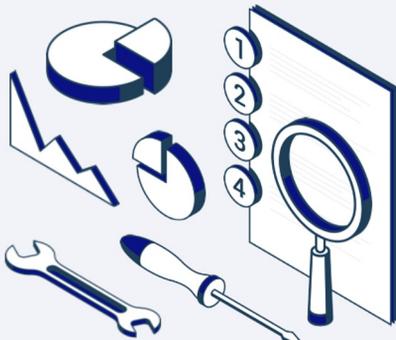
Upon detecting involvement in a collision, **the ADS will be able to immediately alert Stack mission control and seek to remove energy from the system by bringing the vehicle to a stop in the safest way possible.** Once stopped, the ADS will then be able to engage the parking brakes, release air from the trailer’s air supply, turn on hazard lights, and wait for recovery. Data logs immediately prior, during, and after the event will be saved to enable root cause analysis of the event.

STEP 2



Once Stack mission control is alerted to a potential collision, **trained mission control specialists will follow a carefully designed playbook** that involves monitoring vehicle diagnostics and providing remote guidance, alerting authorities, and dispatching a vehicle recovery team to assist at the scene, as needed.

STEP 3



Post-incident and recovery, **the base vehicle and ADS will be thoroughly inspected to identify damaged and malfunctioning equipment.** Each affected component will be appropriately repaired or replaced, followed by a comprehensive set of functional checks to validate that the repaired ADS and base vehicle are ready to be returned to service.



HUMAN MACHINE INTERFACE (HMI)

The **Human-Machine Interface (HMI)** is a critical component of the Stack ADS that is carefully designed to convey key safety information and the intent of the vehicle, while decreasing the cognitive load (attention to the HMI) for any human operators, and avoiding distractions from the monitoring and driving process. The HMI must interact closely with human drivers and engineers who will act as vehicle operators in the development stages of the Stack ADS. Therefore, Stack considers relevant and appropriate human-machine interface design standards and best practices when designing its HMI.



Stack is working toward its ADS-equipped trucks performing safely and effectively while in operation, including when the vehicle must interact with humans. Even when the vehicle is fully autonomous, remote monitoring teams, safety inspectors, loading dock operators, emergency responders, and any other humans in the vehicle's vicinity must be able to interface effectively with the ADS.

Important notifications on the Stack HMI will include visible and audible alerts and all vehicle operators will undergo extensive training to familiarize themselves with the HMI so that they can monitor or support the ADS during its tests and operations.

The HMI will also undergo a variety of validation and verification tests before it is deployed in road operations. When individuals external to Stack must interact with the Stack ADS for any reason, they will have clear directions to contact and interact with a Stack employee, who can guide their interactions with the ADS remotely or in-person.





STACK



05

SAFE JOURNEY



DATA RECORDING

The data captured and recorded by Stack-enabled trucks during operations is an essential element of our product development lifecycle and necessary for safe and continuously-improving autonomous vehicle development. Our fleet is outfitted with a robust data recording solution that ensures all datastreams—including camera feeds and all other sensors—are appropriately recorded. It also ensures that they meet the recommended practice laid out by SAE J3197_202107 (ADS Data Logging Systems)²⁴.



The purpose of our data recording solution is to help us reconstruct and analyze any scenario or triggering event encountered during operations and ultimately determine why the system behaved the way it did—whether correct or incorrect.

Data recording requires both analysis of the environment and the internal state of Stack ADS. Scene reconstruction is critical in safety-related incidents, such as near misses or collisions. In these instances, we want to quickly and accurately understand all factors that contributed to the incident, so that we can apply those learnings across the entire fleet.



VEHICLE CYBERSECURITY

Cybersecurity is an essential element of Stack operations and applies to various levels of Stack operations and infrastructure.

PRODUCT LEVEL

Vehicle cybersecurity is a key consideration at Stack and is addressed as part of our secure development lifecycle—from concept through operation and maintenance. We constantly perform Threat and Risk Assessments across all of our corporate activities, as well as on everything related to our product. We use best-practice approaches to cybersecurity to promote safety and security in all of our policies, in our hardware and software, and across our operations. Protecting our vehicles from any unauthorized deployment of code or data remains a critical priority. Moreover, everything we do is designed for privacy, so we secure all data and protect the confidentiality of sensitive data gathered during operations.

CORPORATE SECURITY AND TRAINING

Stack supports a zero-trust model leveraging multifactor and biometric security. Identity and access are centrally managed and monitored, user-based, and assigned only as required by role, while a 24-hour security operations center monitors our systems for abnormal behaviors and access.

All Stack team members, including senior executive level, undergo an ongoing program of cybersecurity training—from basic education and phishing exercises to specific courses on internal cyber risks. We also provide role-specific training for safe code-writing and reading, and for the secure use of open-source software. All of this ensures that cybersecurity remains front of mind throughout the company at all times.

INTERNATIONAL STANDARDS AND INFORMATION SHARING

Stack incorporates guidance from NHTSA’s Cybersecurity Best Practices for Modern Vehicles²⁵, NIST: SP 800-160 (Engineering Trustworthy Secure Systems)²⁶, the Auto-ISAC Automotive Cybersecurity Best Practices²⁷, 20 ISO/SAE DIS 21434.13²⁸, and ISO/IEC 27001:2013.21²⁹. In addition, we draw from standards such as Automotive SPICE17³⁰ and ISO/IEC 33020:201922³¹ to provide guidance for good software development processes that support cybersecurity. We also stay aware of evolving threats and relevant standards to maintain our high safety standards in everything we do.

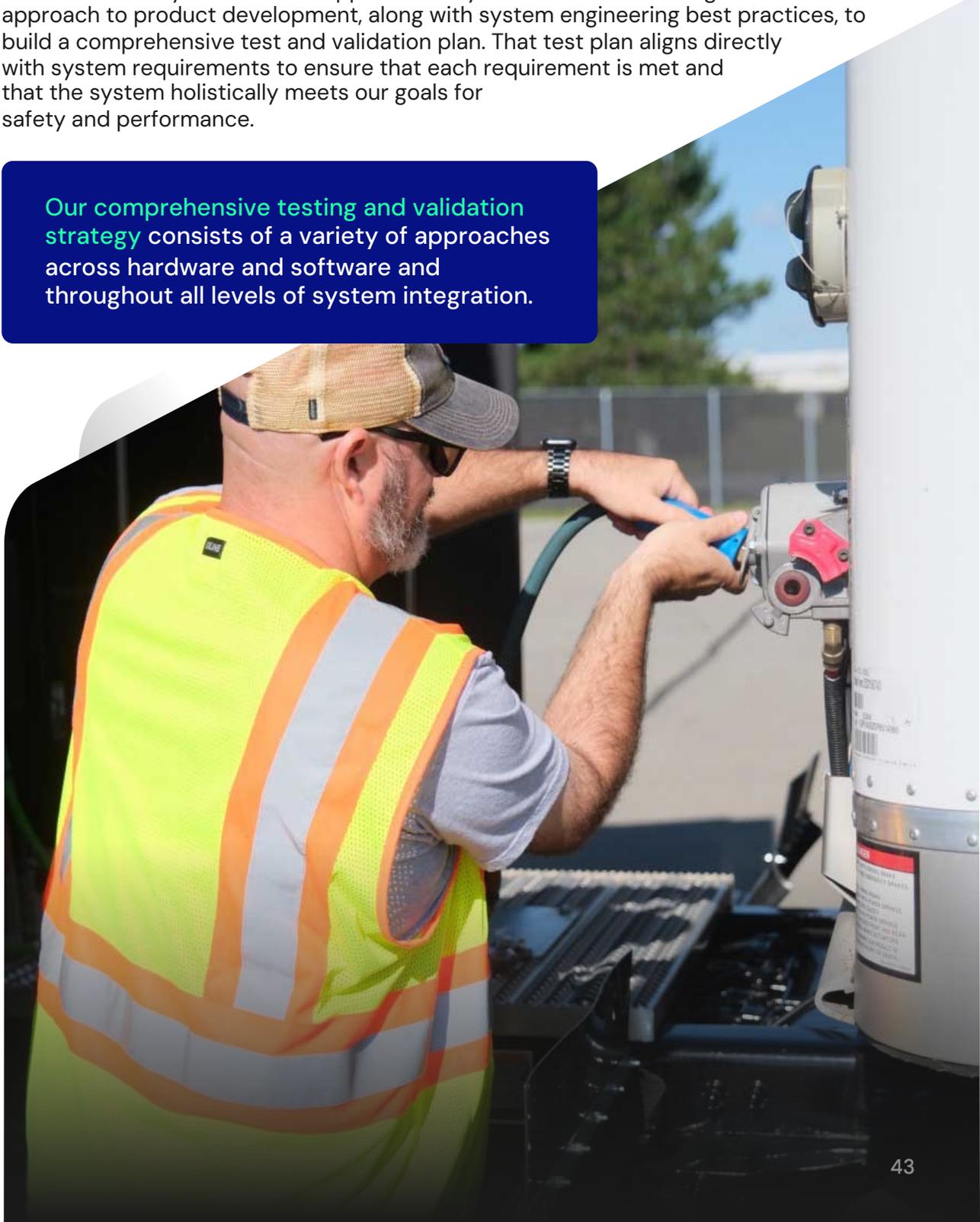




VERIFICATION & VALIDATION

Enabling an autonomous truck to operate safely on the road requires rigorous testing at all levels of the system. Stack's approach to system validation leverages our test-driven approach to product development, along with system engineering best practices, to build a comprehensive test and validation plan. That test plan aligns directly with system requirements to ensure that each requirement is met and that the system holistically meets our goals for safety and performance.

Our comprehensive testing and validation strategy consists of a variety of approaches across hardware and software and throughout all levels of system integration.



BASE VEHICLE

Stack's ADS integrates with the vehicle platforms provided by established OEMs. Today, our testing is primarily conducted on Peterbilt 579s, which are fully FMVSS certified by the manufacturer—meaning they meet the safety performance requirements for motor vehicles and certain motor vehicle equipment in the United States. Utilizing the Peterbilt 579 as the base vehicle for our ADS provides Stack autonomous vehicles with a solid foundation to build on.



HARDWARE TESTING

Critical hardware components, such as sensors, compute, and more are sourced based on their industry-standard safety and reliability ratings. Our approach is to promote system safety; we decompose the hardware system and assess components to ensure they meet our requirements, promoting the safety of the system.

We select components to meet the specifications dictated by our larger system design and work with suppliers to put in place Design Verification Testing (DVT) and Process Verification Testing (PVT) phases so that parts in production meet those standards. That testing includes rigorous accelerated life testing for shock, thermal, and vibration, along with electromagnetic compatibility (EMC) and electromagnetic interference (EMI). Moreover, we design and source ADS hardware subassemblies, which are put through extensive accelerated wear, thermal, shock and vibration, ingress, and other tests designed to assess whether Stack ADS hardware can meet the demands of a commercial duty cycle on a class 8 truck.

Finally, Stack ADS hardware is integrated onto the base vehicle and with ADS software, where final acceptance testing takes place over thousands of miles.

SOFTWARE TESTING

Software development at Stack follows strict development practices to ensure that every line of code is sufficiently reviewed and tested. We strive for comprehensive unit test coverage to regularly check that even the lowest-level functions perform as expected.

Beyond unit tests, we look to verify the integration of autonomy subsystems. Virtual testing, or simulation, is often the most efficient means to ensure autonomy subsystems are interacting in a way that produces expected outcomes on the road. The following section dives more deeply into how simulation is used at Stack.



SIMULATION

Simulation is a valuable tool that allows us to test many elements of the ADS, including sensors, specific driving scenarios that cover all of NHTSA's 37 pre-crash examples³², and low-level controls based on simulated vehicle dynamics. Our simulation tools serve as a critical gate to on-vehicle testing, where we attempt to validate as much functionality as possible virtually in order to avoid potentially risky or inefficient use of vehicles.

The following is a brief overview of the simulation tools used at Stack:

	LogSIM	WorldSIM	BehaviorSIM	HiL/Benchtop
TYPE	 <p>Re-play and perturbation of real logged sensor data and actors</p>	 <p>Simulated sensor data and actors</p>	 <p>Simulated perception output and actors</p>	 <p>Real sensors or synthetic input including injected faults, real ADS hardware subsystems and components</p>
PURPOSE	<p>Tests software system/integrated module functional and SOTIF requirements with real perception, injected faults, and FuSa behavior response</p>	<p>Tests autonomy SOTIF and functional requirements with synthetic input and injected faults</p>	<p>Tests decision making functional requirements with synthetic input and injected faults</p>	<p>Tests run-time, startup and shutdown, functional and FuSa requirements.</p>



CLOSED COURSE TESTING

After passing all simulation tests, new software is moved to the track testing phase. Stack utilizes both low-speed and high-speed testing for what we call *structured testing*. During structured testing, we design and execute against specific scenarios up to and beyond what our trucks may encounter on public roads. This allows us to test integration up to the full ADS in a physical environment that is highly representative of the routes our trucks cover.



PUBLIC ROAD TESTING

Once our system has been put through its paces across all of the testing modalities outlined in this section, we roll it out on public roads. Public road testing allows us to test the full system—including the ADS and remote and on-the-ground operational support—in the exact environments in which we intend to operate. At this stage, we can evaluate our true progress against our goals. Additionally, this type of testing is performed using trained vehicle operators onboard, whose assessment of system performance contributes to the feedback loop.

By accumulating real-world miles, we evaluate full system reliability and performance, while also uncovering edge cases that drive our product development priorities and continuous improvement.



STACK

Thank you for
taking the time to
read our VSSA.

As our journey continues, we
welcome your feedback and can
be reached at info@stackav.com.



06

GLOSSARY



Term	Acronym	Definition
Automated Driving System	ADS	The hardware and software that are collectively capable of performing the entire dynamic driving task (DDT) on a sustained basis, regardless of whether it is limited to a specific operational design domain (ODD); this term is used specifically to describe a Level 3, 4, or 5 driving automation system.
Automatic Emergency Braking	AEB	Detects potential collisions with a vehicle ahead, provides forward collision warning, and automatically brakes to avoid a collision or lessen the severity of impact. Some systems also detect pedestrians or other objects.
Autonomous Vehicle	AV	A vehicle that is capable of making decisions without human interaction by using a combination of sensors, cameras, and other technologies.
Base Vehicle		The underlying vehicle upon which an ADS is applied, the combination of which results in an AV.
Commercial Motor Vehicle	CMV	A vehicle that has a gross vehicle weight rating (GVWR) of 10,001 pounds or more; designed to transport more than 15 passengers, including the driver; or transporting hazardous materials in quantities requiring the vehicle to be placarded.
Design Verification Testing	DVT	A testing regimen to evaluate if a system meets its requirements specification.
Driver Monitor System	DMS	A vehicle safety system to assess the driver's alertness and warn the vehicle operator.
Driverless Operation		On-road operation of an ADS-equipped vehicle that is unoccupied, or in which on-board users are not drivers or in-vehicle fallback-ready users.
Dynamic Driving Task	DDT	All of the real-time operational and tactical functions required to operate a vehicle in on-road traffic, excluding the strategic functions such as trip scheduling and selection of destinations and waypoints.
Fallback		The response by the user to either perform the DDT or achieve a minimal risk condition (1) after occurrence of a DDT performance-relevant system failure(s), or (2) upon operational design domain (ODD) exit, or the response by an ADS to achieve minimal risk condition, given the same circumstances.
Fault State		The state of the system when one or more off-nominal conditions have been detected. For example, if the ADS detects that a sensor is not providing updated data that would be an off-nominal situation. The system would indicate a fault and the system would be in a faulted state.



Term	Acronym	Definition
Functional Safety		Part of the overall safety of a system or piece of equipment that depends on automatic protection operating correctly in response to its inputs or failure in a predictable manner.
Incident		Any contact made with a vehicle, person, or static object which results in or allegedly results in damage or injury.
Minimal Risk Condition	MRC	A stable, stopped condition to which a user or an ADS may bring a vehicle after performing the DDT fallback in order to reduce the risk of a crash when a given trip cannot or should not be continued.
Minimum Risk Maneuver	MRM	Actions taken by the ADS in order to achieve a MRC.
Object and Event Detection and Response	OEDR	The subtasks of the dynamic driving task (DDT) 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 (i.e., as needed to complete the DDT and/or DDT fallback).
Operate		The activities of driving, controlling, monitoring and taking control of a vehicle, as needed, to maintain safe operations.
Operational Design Domain	ODD	Definition of the conditions in which the ADS is intended to operate with respect to roadway types, geographical location, speed, range, lighting conditions, weather conditions, and other.
Original Equipment Manufacturer	OEM	The original supplier/manufacturer of a vehicle's components and parts.
Remote Monitoring Team (Mission Control)		Authorized personnel who can monitor and inspect the status of the AV remotely from an operations center via cellular data connection.
Routine/Normal [ADS] Operation		Operation of a vehicle by an ADS within its prescribed ODD, if any, while no DDT performance-relevant system failure is occurring.
Safety of the Intended Functionality	SOTIF	A safety process in the automotive industry that addresses unintended system behaviors in the absence of electronic faults.
Safety Management System		A comprehensive framework for identifying, assessing, and mitigating safety risks across all aspects of the organization.



Term	Acronym	Definition
System Failure		A malfunction in a driving automation system and/or other vehicle system that prevents the driving automation system from reliably performing its portion of the DDT on a sustained basis, including the complete DDT, that it would otherwise perform.
Test Vehicle		A vehicle that is used for testing purposes during the development process that may or may not have been modified from its original factory specifications.
User		A general term referencing the human role in driving automation.
Vehicle Operator	VO	Any Stack employee who operates a Stack Test Vehicle within the scope of their employment.



07

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