

# **Operational Safety**

PROCESSES FOR SAFE DESIGN AND OPERATION



## Letter from Aicha and Jesse

#### AICHA EVANS, CEO, AND JESSE LEVINSON, CO-FOUNDER AND CTO

It was a significant moment for the autonomous vehicle industry. On February 11, 2023, Zoox achieved a historic milestone, marking the first time ever that an autonomous, purpose-built robotaxi operated on public roads without a safety driver. We proudly announced the inaugural run of our employee shuttle service in Foster City, California, using our purpose-built vehicle — a robotaxi designed without traditional driving controls. The culmination of years of dedicated work by many individuals and teams, it also represented a significant step on the path to launching our future service to customers.

Our employee shuttle service began daily operations in June, 2023, and has since taken employees between our Foster City offices more than 29,000 times. In February, 2024, we received our permit from the CPUC to offer unpaid rides to the public; we have since taken more than 4,000 guests on autonomous rides.

On March 14, 2024, we announced another technological milestone: broadening our operational design domain. Our vehicle could now travel at speeds up to 45 mph and take unprotected turns on high-speed roadways. We also extended our operational hours to include driving at nighttime, under light rain, and on damp roads. These critical achievements put us even closer to launching our commercial service.

The Zoox vision and mission have been consistent for ten years, and our commitment to safety has remained steadfast. We have uncompromisingly maintained our strategy of meeting critical safety objectives before deploying our robotaxi on public roads. Adopting a measured long-term approach, we are deliberately and methodically expanding our geofences across multiple locations. We understand the complexities in deploying such vehicles — an AI challenge that, while demanding, holds immense potential to transform our society. As we continue to expand, we are committed to fostering close collaboration with the communities in which we operate and exist, particularly first responders from those communities.

We eagerly anticipate welcoming our first customers and hearing about their experiences riding in our vehicles. This report describes our operational approach to keeping all who ride in our vehicles safe, as well as those around them. We extend our heartfelt gratitude for everyone joining us on this journey to a safer, more efficient transportation future.



Aicha Evans Chief Executive Officer



Jesse Levinson, Ph.D. Co-Founder & Chief Technology Officer

### Letter from John Maddox

#### SENIOR DIRECTOR, SAFETY STRATEGY AND OPERATIONS

Safety is and always has been foundational to our mission. We recognize the opportunity of advancing road safety with AV technology and believe that a purpose-built, vertically-integrated holistic approach is the best way to meet that challenge. Similar to our commitment to build the best robotaxi, we're committed to building and deploying innovative and diligent safety policies, practices, and procedures to implement that mission as embodied in a holistic safety approach. We know it's critical to build awareness and trust, and we regularly connect with stakeholders, regulators, policymakers, and others to demonstrate that commitment. It's especially important that Zoox continues to share information transparently, from how we develop and operate our robotaxi to how we integrate that safety culture into all aspects of our business.

Our last safety report highlighted examples of the more than 100 safety innovations Zoox has implemented into our purpose-built vehicle. These include optimized driving controls, system redundancy, and equal occupant protection at every seat. We have also publicly shared the results of our crash tests. These innovative safety features are tangible examples of Zoox's commitment to safety in all aspects of our business and operations.

In this report, we will summarize our Operational Safety Program, which includes processes for planning and ensuring safety during our robotaxi operations, as well as maximizing the safety learnings from those operations. By sharing this information, we intend to provide clarity and transparency, emphasizing our commitment to maintaining a comprehensive safety culture at Zoox and within the broader autonomous vehicle industry. We firmly believe that dedicating considerable time and resources needed to achieve our safety goals and establish this Operational Safety Program is not only the right thing to do, but is required to earn the trust of external stakeholders, riders, and the public.



John Maddox Senior Director, Safety Strategy & Operations

ZOOX

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## Zoox Safety Reports: Recap

Ten years since our founding in 2014, our mission remains to make personal transportation safer, cleaner, and more enjoyable for everyone. To achieve this goal, we have engineered a purpose-built autonomous vehicle with over 100 safety innovations that allow you to relax and enjoy the ride. Safety is built into every facet of our work so that you can let Zoox do the driving and choose how to spend your time.

We introduced our safety philosophy in our first Safety Report, <u>Safety Innovation at Zoox, Volume 1.0</u>, released in 2018. In it, we explained how autonomous driving technology works, what makes Zoox vehicles unique, and how these vehicles will interact safely with the public.

In <u>Purpose-Built for Safety: Introducing Zoox Safety Innovations, Volume 2.0</u>, released in 2021, we highlighted three categories – and nine specific examples – of unique Zoox safety innovations we build into every robotaxi: "driving control," "no single point of failure," and "rider protection." These categories represent the Zoox safety philosophy: Prevent and Protect. The safety features clustered under "driving control" and "no single point of failure" are proactive safety innovations. These innovations are designed to prevent incidents from occurring in the first place. The third category – "rider protection" – is reactive. Should an incident occur, the vehicle is designed to provide equal protection to all riders.

We encourage you to read <u>these safety reports</u> to learn more about our safety innovations and how we've incorporated them into our vehicle's design.

In this report, we describe the role and function of Operational Safety in Zoox's safe system approach, a safety system that extends to all company processes and operations.



### Operational Safety: An Overview

The Zoox Operational Safety Program comprises three major components: safety analysis and assurance, field safety processes, and continuous learning. These components work in synchrony with, among others, our safe system design, software and hardware development processes, and fleet operations programs. This approach allows Zoox to systematically and rigorously learn from events through the normal course of operations and implement improvements in process, product, and/or service that keep riders, employees, and other road users safe.

Operational Safety at Zoox is a comprehensive program for our employees, riders, and communities that goes beyond traditional automotive practices. The program supports the Zoox approach of a vertically integrated company, purpose-built robotaxi, and self-operated business model. This holistic safety methodology puts equal weight on up-front "safe-by-design" and "safe-in-operation." In setting the bar for operational safety, we have looked at the airline industry's example, given its exemplary track record and diligent attention to identifying and addressing operational issues. We have implemented a company-wide safety framework of operations, principles, processes, and practices that deeply integrates proactive and reactive safety risk assessment into our decision-making and actions.

Zoox owns its vehicle fleet and is responsible for daily operations, including fleet monitoring, management, maintenance and repair, fleet routing and optimization, remote operations, and customer support; therefore, it is fully accountable for safety from design to manufacturing to operations. Our Operational Safety processes are designed to maintain the highest level of safety, react quickly and decisively, and help us learn from every experience.



Therefore, we define processes and procedures that incorporate safety at every step along the path to providing rides in our vehicles. Because we are not selling our vehicles to third parties, they will remain in our direct control at all times, allowing us to maintain the focus on day-to-day operational safety. Likewise, we will be able to wholly and swiftly resolve any safety or operational concerns because we retain direct control of the fleet.





#### THREE PHASES OF THE ZOOX OPERATIONAL SAFETY PROGRAM

Operational Safety at Zoox consists of three major components, as illustrated in the diagram above: safety analysis and assurance, field safety processes, and continuous learning. These components work in an iterative loop to ensure that Zoox keeps riders and other road users safe while learning from the course of operations to implement improvements in process, product, or service.

Conceptually, the process flow is illustrated by the diagram above. First, Zoox assures safe design through a rigorous safety case definition to identify, quantify, and mitigate potential safety risks before deployment in any public setting. This approach includes a comprehensive safety clearance process and readiness assessments. Once deployed, Zoox has developed field safety processes to react and respond to any safety issue during operations. These processes include continuous vehicle monitoring as well as TeleGuidance, incident response, first responder protocols, and when necessary, vehicle recovery. Finally, learning opportunities that present themselves through ongoing operations can be triaged to the appropriate teams (e.g. Engineering, Operations, etc.) for analysis and implementation (such as standard operating procedures, operational playbooks, part designs, or manufacturing quality control). These learnings are incorporated through ongoing operations and the feedback loop continues.

When riders step into a Zoox vehicle, they should know that Zoox is already keeping them safe. However, our process continues during and after the ride as well. Let's see how Zoox practices its operational safety program to achieve safety throughout the ride timeline.



### Safety of our Riders: From Start to Finish

The safety of riders was extensively highlighted in our <u>second Safety Report</u>. As we continue on our journey toward commercialization, Zoox has developed and will continue to iterate on the specific procedures in place to ensure the safety of the vehicle, our riders, and other vulnerable road users (VRUs). In addition, Zoox has created several documents highlighting the safety features available on the vehicle, rider safety procedures, and the shared responsibility of the rider, all of which contribute to a safe service. Zoox will share this content with riders to keep them informed and safe during each ride.

#### BEFORE THE RIDE (SAFE DESIGN AND ASSURANCE)

Before a rider gets into one of our vehicles, Zoox ensures safety through a robust safe design and safety assurance process. Zoox has constructed a rigorous and quantitative Safety Case to validate that our vehicles are safe enough to be deployed for autonomous driving. One of our Proactive Risk Management Processes at Zoox is a high-level Risk Management Process (RMP). This formal process documents, evaluates, and acknowledges potential safety risks in the technical system (driving software and robot platform) and operational processes before Zoox vehicles enter public roads. It also includes a risk resolution component with the goal of reducing the overall safety risk over time. Within the RMP, there are other processes involved in verifying, validating, and quantifying risks that we may see or encounter in the life of the vehicles. We have also developed a Zoox Safety Analysis Framework and an Autonomy Behavior Safety Assurance Methodology that feed into our Simulation, Verification, and Validation efforts, and ultimately, the Safety Clearance — a process that delineates Zoox vehicles' readiness for launch in a given operational envelope, scope, and/or Operational Design Domain (ODD). Ultimately, many thousands of component-and system-level requirements must be met, and total residual risk must be acceptably low, for clearance to be granted.

Zoox wants to ensure that all riders know what to expect, what their responsibilities are, and all other relevant information to enjoy their ride safely. Riders will have access to onboarding information via our website, app, and other channels that they must review and acknowledge before taking their first ride. These include the Rider Manual that provides basic information about requesting a ride, properly identifying a robotaxi, locations for pick-up and drop-off, and how to locate and use the "Emergency Call" button to speak with Zoox Rider Support, the "Emergency Release" lever to manually open the doors, and other built-in features and reminders to ensure safety and comfort of the rider. If there is more than one rider, the host is responsible for understanding and informing any "guests" or accompanying riders of these instructions. All riders must be aware of their shared responsibility to ensure a safe service experience.



#### DURING THE RIDE (FIELD SAFETY)

Zoox has been developing robust strategies and opportunities to keep riders safe while on their ride. As previously stated, our second safety report highlighted a selection of over 100 safety innovations that were implemented into our vehicles. From an operational perspective, Zoox also has two primary groups that support the vehicle and its riders at various stages throughout a journey. They are:

- Remote Operations
- Vehicle Operations





#### REMOTE OPERATIONS

Remote Operations comprises three integrated teams: Mission Control, TeleGuidance, and Rider Support. These teams are co-located in the Zoox Fusion Center, along with professionals from our security team, who monitor and assist the Zoox fleet and its riders. While each team has a defined scope, their responsibilities overlap to ensure the teams work together to provide a safe and seamless rider experience.

Mission Control is similar to air traffic control; this team works behind the scenes to ensure everything runs safely and smoothly. The Mission Control team is responsible for looking at the entire operation holistically and maximizing safety, service, and real-time management of the whole fleet and crew allocation. Among their responsibilities, this team monitors particular areas within the vehicle's operational design domain and determines whether certain areas should be temporarily avoided. For example, if a large parade occurs on a particular route, Mission Control can reroute the fleet to avoid the area and any potential associated service disruptions due to traffic. The TeleGuidance team is responsible for monitoring the vehicles' behavior and planning. While in autonomy, TeleGuidance will monitor the vehicle throughout the mission and remotely provide guidance to the vehicle in situations that may require deviation from the AI-generated path. The team cannot drive the vehicle in real-time; instead, they only provide guidance for the onboard system. The onboard system then decides whether and when it is safe to act on that guidance. Multiple layers of security ensure that, regardless of the remote guidance issued, the vehicle will always maintain safe operations and avoid obstacles.

Rider Support is responsible for remotely monitoring and supporting riders before, during, and after their ride. At any point during a ride, Rider Support may be called on to observe the vehicle cabin via live audio/ video feeds. This capability allows the Rider Support team to proactively address any safety concerns that may arise, such as a passenger unbuckling their seatbelt during the journey. Communication with riders is available via in-vehicle two-way audio and personal phones, either by calling or texting. Rider Support also proactively and reactively provides ride status information, troubleshoots issues, answers and documents questions or feedback from riders, and assists riders in the event of a service disruption.



#### VEHICLE OPERATIONS

A key group supporting vehicle operations is the Ground Support team, which is responsible for resolving issues at the vehicle's location. This team provides in-person rider assistance, interfacing with and providing information to first responders on the scene of an incident, interacting with third parties, and, if needed, recovering the vehicle and returning it to a Zoox facility. Ground Support has a branded recovery vehicle ready to dispatch during all on-road operations. This team wears high-visibility vests to be identifiable to first responders, riders, and other road users.

#### COMPLEX AND UNKNOWN SCENARIOS

Our goal is to make our purpose-built robotaxi much safer than human drivers. However, human involvement will remain relevant because maintaining humans in the loop when needed is key to safety. This human involvement is embodied by our TeleGuidance team, who monitor and provide guidance to the robotaxi when necessary. As the software in our vehicle continues to learn from challenging real-world scenarios, we anticipate the frequency of utilizing TeleGuidance support will decrease. However, given the myriad of new and unknown situations our vehicles may encounter, it will never be eliminated. By leveraging secure remote human assistance, we will be able to provide a service that is safe and smooth, no matter what surprises are in store.



If our robotaxi perceives an unfamiliar scenario — for example, a significant change in its map, such as new construction zones, flaggers, or temporary road blockages — it may seek TeleGuidance support. The TeleGuidance team monitors real-time vehicle behavior and its intended path. Should a vehicle require assistance, TeleGuidance provides suggestions and information through our proprietary software tool.

For example, if a vehicle approaches a complex construction zone and requests guidance, a TeleGuidance tactician will assist by suggesting a custom path for the vehicle to navigate. These paths, which are a series of waypoints, are a suggested route. Waypoints can be placed to develop a complete path for the vehicle, or, in more dynamic environments (e.g., with potentially hidden vulnerable road users), they can be placed incrementally in real-time to keep the vehicle moving. At the same time, the tactician continues to assess the situation. It's important to note that, even in these scenarios, the vehicle continues to operate autonomously. Tacticians offer guidance to the vehicle – much like placing breadcrumbs – but the Zoox autonomous driving system always remains in control of the vehicle's movements, including whether and when to follow the suggested path.

In addition, the TeleGuidance team helps report and respond to potential safety-related incidents. Should an incident occur, tacticians are trained to respond quickly by guiding the vehicle to a safe stop, contacting appropriate authorities, and alerting incident protocols as required.

#### AFTER THE RIDE (CONTINUOUS LEARNING)

Zoox rider safety doesn't stop after the ride is over. The mission of operational safety at Zoox is to keep people (e.g., employees, riders, and other road users) safe by reacting to events through the normal course of operations and proactively driving feedback to Zoox teams for continuous learning. To that end, Zoox has developed and implemented an Incident Response Procedure to react to significant events involving testing and/or in-service fleet vehicles to ensure safety for all members of the public and Zoox personnel. The protocol identifies, processes, and reports (internally and externally) all relevant safety incidents related to Zoox vehicle testing and deployment. Key stakeholders across the company have been designated to quickly and effectively react to any incident that may occur involving our vehicles.



Zoox has also developed a comprehensive and rigorous Pause, Restrict, and Ground (PRG) process to identify, assess, and react to operational safety events that may occur in the field (whether potential or realized). It relies on the shared expertise and judgment of cross-functional experts from our Operations, Engineering, and Safety teams, with key inputs from other stakeholders to make safety determinations. New learnings resulting from an incident, anomaly, fault, or failure mechanism are fed back into our broader operational safety framework and communicated to pertinent cross-functional teams to help improve risk management and mitigate recurrence.

Zoox has defined a number of operational safety metrics that are monitored and acted upon to 1) keep people safe and 2) provide a means to measure and provide continuous feedback to improve safety. These quantitative metrics are rate-based (for instance, normalized by mileage) and monitored by the operational design domain (geography, time of day, etc.). Live dashboards actively track these metrics to enable continuous analysis and trigger actions when necessary.

Zoox also encourages riders to provide feedback on any part of our service regarding safety concerns, quality of service, and suggestions for improvement. We will provide feedback opportunities through our app, website, and other channels. Additionally, the general public may send any safety concerns to **hello@zoox.com**.



### Safety Promotion and Education

As Zoox identifies new cities and regions to deploy our vehicles, we will proactively engage with regulators, policymakers, first responders, and community leaders. Different jurisdictions have different requirements, including state laws and regulations governing autonomous vehicle operations and services or local traffic laws and road rules. Zoox will comply with all such requirements wherever we operate.

Our approach is rooted in a philosophy of "no surprises and full transparency." To that end, we have developed a comprehensive training program for first responders that covers our purpose-built robotaxi and retrofitted test vehicles. As part of this training, first responders are introduced to Zoox and led through exercises and scenarios that prepare them to respond to incidents involving one of our vehicles.

For the sessions focused on the robotaxi, the goal is to help first responders identify and understand how to use important safety and emergency features. They include information on the design, capabilities, and behavior of our autonomous vehicles, both in emergency situations and normal conditions. They also cover how to contact remote operations for support, how to identify the mode or state of our vehicle, the location of high-voltage lines, how to identify if high-voltage is disabled; and the safety innovations integrated into our vehicle. Our training presentation is provided to community members, including city, county, and state law enforcement officers, fire & rescue, traffic safety, emergency dispatch, and other first-responding organizations. As our operations continue to grow, we plan to evolve and expand our educational platform to further enhance our engagement with first responders. As more of our vehicles are on the roads, we are committed to working closely with them and providing relevant safety operations materials.



Zoox has prepared and provided a Law Enforcement Interaction Plan (LEIP), Emergency Rescue Guide, and Emergency Rescue Sheet to our first responder partners in our current operational areas. These documents can be accessed online at <u>zoox.com/leip</u>. We have also established a dedicated emergency contact number whereby first responders can speak directly with Zoox remote operations teams that have situational awareness of a specific location. On each end of our vehicle, there is a decal with the Zoox emergency support contact information and QR codes that link to our first responder resource documents.

During these training sessions and afterward, we are available to support first responders — answering questions, receiving feedback, or providing in-person or remote assistance on public roads.

The feedback from various groups indicates that these first responder training sessions and the information provided have been well-received.



#### FIRST RESPONDER TRAINING SESSION FEEDBACK

"LVMPD [Las Vegas Metro Police Department] appreciates the invitation from Zoox to participate in their First Responder Training Day alongside other community partners. Our Traffic Division responds to thousands of car crashes each year but a new dynamic is presented specifically with completely autonomous vehicles. There is also the community safety concern of responding to other police-related calls that may stem from an autonomous vehicle."

Sgt. Russell Bybee, Las Vegas Metro Police Department

> "The San Francisco Fire Department works collaboratively with many public and private entities to enhance our ability to provide services during potential emergencies. We thank the team at Zoox for providing training to our SFFD members and for taking proactive measures to address the concerns of first responders."

Captain Schorr, San Francisco Fire Department

#### FIRST RESPONDER TRAINING SESSION FEEDBACK

"In the ever-changing world of emergency response, staying on top of the latest technology and trends in the world can be challenging. The San Mateo Consolidated Fire Department appreciates the proactive firefighter training provided by Zoox on their new autonomous vehicles. Before the vehicles began their on-road testing, engineers consulted with SMC Fire to determine some of the issues that could affect an emergency response involving one of their vehicles. Once the autonomous vehicles were on the road, Zoox brought one of them to the SMC Fire Training Facility for a hands-on training highlighting the vehicle's safety features with our Firefighters. SMC Fire looks forward to continuing to learn more about this emerging technology through our relationship with Zoox."

Training Battalion Chief Cook, San Mateo Consolidated Fire Department

"It was valuable for us to see the autonomous vehicle firsthand that will be on our roadways. We gained a better understanding of how our Traffic and Patrol Officers can effectively respond to any issue that may arise. We appreciate the openness of Zoox and for them fielding our questions and concerns as it relates to police response to any incident involving an autonomous vehicle. We look forward to participating in any other trainings and are grateful for local companies who seek to be partners with our community."

Sgt. Russell Bybee, Las Vegas Metro Police Department



### On the Horizon

There is an old mantra: safety is a journey, not a destination. Safety operations have no endpoint. Our commitment to safety is the basis for our "tiny, small, medium, and large" approach to deployment. This strategy allows us to build operations incrementally and to systematically incorporate learnings along the way, which is designed to assure safe, robust deployments as the fleet grows.

Zoox continues to learn from our daily activities as well as from questions, input, and feedback from our riders, communities, and stakeholders. As we continue on our journey, we will continue to incorporate these insights to develop new and/or improved processes and innovations to support Operational Safety. We are already updating processes to be more efficient, improve vehicle data ingestion and analysis procedures, and expand benchmarks. Through these activities, we will continue to demonstrate our unwavering commitment to the safety of our future riders and the communities where we operate.



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