



# VOLUNTARY SAFETY SELF-ASSESSMENT (VSSA)

Autonomous Vehicle  
Safety Ecosystem

2026

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*Disclaimer: Because Motional is committed to maintaining the highest standards of safety and to continuous improvement, our safety practices may evolve over time and this VSSA may not fully align with current practices. Motional may update the VSSA at a later date to reflect these changes.*

# Acronyms

<b>ADAS</b>	Advanced Driver Assistance System
<b>ADS</b>	Automated Driving System
<b>AEB</b>	Autonomous Emergency Braking
<b>AV</b>	Autonomous Vehicle
<b>AVCDL</b>	Autonomous Vehicle Cybersecurity Development Lifecycle
<b>AVSC</b>	Automated Vehicle Safety Consortium
<b>AV STEP</b>	ADS-Equipped Vehicle Safety, Transparency and Evaluation Program
<b>CRM</b>	Continuous Risk Management
<b>DSSAD</b>	Data Storage System for Automated Driving
<b>EDR</b>	Event Data Recorder
<b>E-Stop</b>	Emergency Stop
<b>FMVSS</b>	Federal Motor Vehicle Safety Standards
<b>FRAV</b>	Functional Requirements for Automated and Autonomous Vehicles
<b>HMG</b>	Hyundai Motor Group
<b>IEEE</b>	Institute of Electrical and Electronics Engineers
<b>IVA</b>	In-Vehicle Application
<b>MPI</b>	Multi-Point Inspection
<b>MRM</b>	Minimal Risk Maneuver
<b>NHTSA</b>	National Highway Traffic Safety Administration
<b>ODD</b>	Operating Design Domain
<b>ORAD</b>	On-Road Automated Driving
<b>RVA</b>	Remote Vehicle Assistance
<b>SA</b>	Safety Assurance
<b>SAE</b>	Society of Automotive Engineers
<b>SRB</b>	Safety Review Board
<b>SMS</b>	Safety Management System
<b>SPI</b>	Safety Performance Indicator
<b>SRM</b>	Safety Risk Management
<b>SRR</b>	Safety Risk Register
<b>SSVN</b>	Second-Stage Vision Network
<b>UNECE</b>	United Nations Economic Commission for Europe
<b>VMAD</b>	Validation Method for Automated Driving
<b>VSSA</b>	Voluntary Safety Self Assessment

# Executive summary

Motional's Voluntary Safety Self-Assessment (VSSA) reflects the company's ongoing commitment to safety. It details the steps Motional takes to ensure safety across the full ecosystem: employees, customers, vehicles, and the public.

A VSSA is intended to provide the public and policymakers with clear insight into how an autonomous vehicle company approaches safety. This VSSA is one step in Motional's wider public outreach effort to educate regulators, officials, riders, and the public to answer their questions and enhance confidence about safety in this field.

## Developments

This VSSA reflects progress Motional has made to its technology – including our vehicle platform (Hyundai IONIQ 5), partnerships, and industry collaboration surrounding safety. For example, Motional is now offering a supervised autonomous passenger service on the Las Vegas Strip via a major national ride-hail company using robotaxis built on the all-electric Hyundai IONIQ 5 platform.

In these pages, we describe how Motional's technology operates and the safety principles that define safe driving behavior within our current Operating Design Domain (ODD).

## Motional's Mission

Motional's mission is to change the way the world moves by delivering safe, reliable, and accessible autonomous passenger service. Safety is the foundation of that mission.

When deployed at scale, all-electric, driverless vehicles can improve roadway safety, reduce emissions, and expand mobility, including for people with disabilities. Realizing these benefits requires autonomous systems that are demonstrably safe and built for scalable operation.

Our approach to safety is organized around organizational, vehicle and operational pillars.



## Organizational Safety

A strong safety culture is foundational to Motional's operations and decision-making. Safety is embedded at every level of the organization through a top-down governance structure.

Our Safety Review Board (SRB), composed of enterprise-wide leaders, oversees safety across operations, product design, cybersecurity, and internal processes. The SRB evaluates the effectiveness of safety measures, ensures rigorous documentation and reporting, and reinforces accountability, including through mechanisms such as our Red Button program, which allows employees to raise safety concerns directly and anonymously.

This report also outlines the structured process used to evaluate new driverless milestones. Advancement decisions are based on comprehensive evidence from public road testing, closed-course testing, simulation across diverse scenarios, and detailed verification and validation of safety-critical systems.

## Vehicle Safety

Motional's current vehicle platform, the all-electric IONIQ 5, is the hallmark for vehicle safety, having earned the Insurance Institute for Highway Safety "Top Safety Pick +" rating.

This VSSA outlines how Motional ensures vehicle features – from sensors and passenger displays to software and external assistance platforms – work together to maintain a high level of safety. Through continuous monitoring, Motional ensures its perception, prediction, and planning systems can functionally see, hear, think, and react appropriately enough to manage steering, braking, and propulsion systems. The company also evaluates critical redundancies and failsafe approaches, including emergency braking and emergency stop buttons, and cybersecurity protections.

## Operational Safety

With robotaxis already carrying passengers on public roads, Motional has created policies, processes, and playbooks to ensure driverless operations are safe for all. This VSSA details the levels of review that take place before, during, and after operational hours.

The assessment outlines how Motional defines safe operating domains, trains personnel, and maintains vehicle inspection protocols. It describes structured procedures for interactions with first responders, incident response, fleet grounding decisions, and protection of customer and vehicle data.

During operations, the fleet is supported by systems such as Remote Vehicle Assistance (RVA) and customer support services that provide supplemental guidance and passenger assistance.

## About Motional

Headquartered in Boston, Motional has operations in the United States and Asia, including offices in Pittsburgh, Las Vegas, and Singapore. Motional is backed by Hyundai Motor Group (HMG), one of the world's largest vehicle manufacturers.

# 2. Overview of AVs and Motional's Safety Work

## 2.1. Motional's Focus

Motional is developing safe and effective SAE Level 4<sup>1</sup> autonomous vehicles (AVs) for deployment in on-demand ride hail services for the public. Motional will partner with service providers that share our goals to enhance road safety, improve accessibility, and increase transportation options for society.

## 2.2. AV Track Record

Motional has driven more than 2 million autonomous miles across multiple platform generations, including in complex urban environments, without an at-fault incident. The broader industry has similarly moved from pilot programs to scaled commercial deployment. Fully driverless passenger service is now available in ten U.S. cities, where members of the public can summon an autonomous vehicle as part of daily transportation, with many more coming online in 2026. In addition, autonomous trucking companies are operating driverless freight routes on busy interstates, an activity that did not exist just a few years ago. Published safety analyses from our peers have begun to demonstrate lower crash rates and severity relative to comparable human-driven benchmarks in similar operating domains. Continued collaboration among industry, researchers, and government will be important to ensure these early gains translate into sustained and measurable safety improvements.



<sup>1</sup> Motional references the Society of Automotive Engineers (SAE) 5 levels of driving automation in describing a vehicle's driving capabilities. See SAE J3016 "Taxonomy and Definitions for Terms Related to Driving Automation Systems for On-Road Motor Vehicles" 2021. Available at: [https://www.sae.org/standards/content/j3016\\_202104/](https://www.sae.org/standards/content/j3016_202104/)



# Developments Since Motional's First VSSA

# 2. Overview of AVs and Motional's Safety Work

## 2.3. Technology Evolution

Autonomous vehicle technology has evolved from early research prototypes to production-integrated platforms. Motional's current IONIQ 5 robotaxi reflects that progression: it is manufactured on Hyundai's existing assembly lines, certified to applicable FMVSS and EPA standards, and integrates advanced sensing and computing systems within a commercially scalable vehicle architecture. This evolution is supported by a centralized command center and informed by extensive validation across public road testing, closed-course testing, and simulation. Additional details regarding our technical approach are provided in Section 6(c), "Technical Approach Highlights."

## 2.4. Safety Enhancements

Motional continuously strengthens its safety framework as technology and operations mature. Key enhancements include:

- Implementation of relevant Automated Vehicle Safety Consortium (AVSC) information reports, including guidance on change risk management and adaptation of Safety Management Systems (SMS) for SAE Level 4 and 5 systems.
- Developed safety principles to characterize safe driving behavior within a vehicle's ODD.
- Comprehensive Failure Modes and Effects Analyses (FMEA) to identify and mitigate subsystem-level faults that could lead to vehicle-level hazards.
- Deployment of subsystem and component-level safety monitors designed to transition the vehicle to a minimal risk maneuver (MRM)<sup>2</sup> when a fault is detected.
- Ongoing refinement of Motional's safety case framework to support intended operations and align with relevant industry standards.
- Motional participates in industry initiatives, including the AVSC, and aligns its practices with emerging standards such as IEEE P2846, UNECE FRAV and VMAD, and SAE On-Road Automated Driving (ORAD) guidance.

## 2.5. Commercial Partnerships

Motional's goal is to partner with ride hailing companies and third parties to deploy autonomous vehicles at scale. In furtherance of this goal, Motional has conducted pilot programs through partnerships with ridehail and delivery partners including Uber, Uber Eats, and Lyft. Motional has now completed over 130,000 autonomous rides and deliveries on partner networks.

## 2.6. Growth of Operations and Deployments

Motional has achieved a number of key milestones including:

- From 2018 to 2023, Motional conducted autonomous ride-hail rides for over 100,000 riders in partnership with Lyft in Las Vegas.
- In 2021, Motional and Uber signed an agreement to pilot a meal delivery service using Motional AVs. The service went live in 2022 in Santa Monica, California and expanded to over 20 merchants with thousands of autonomous deliveries completed during its operation from 2022 - 2024.
- In 2022, Motional and Uber expanded their partnership by finalizing a 10 year multi-market Master Framework Agreement to deploy Motional AVs for ride hail and delivery on the Uber network.
- Motional launched an autonomous ride hail pilot on the Uber network in Las Vegas in 2022 and completed thousands of rides through its conclusion in 2024.
- In 2023, Motional launched autonomous deliveries for Shake Shack, Motional's first strategic national merchant on the Uber network.
- In 2023, Motional launched fully driverless rides, without a vehicle operator in the left seat, for preliminary, pre-selected riders on the Uber network in Las Vegas.
- Hyundai began production of its first fully integrated IONIQ 5 robotaxis in Singapore which will be used for Motional's commercial driverless service.

Motional continues to be a leader in the autonomous vehicle and mobility space, with plans to deploy fully driverless commercial passenger service for the public in 2026 and continue expansion of the company's existing service area.

<sup>2</sup> Per ISO 23793A an MRM is an automatic maneuver to drive the vehicle in to a MRC (Minimal Risk Condition) safe state.

# 3. Motional's Approach to Safety

## 3.1. Overview

Motional's Safety Management System (SMS) focuses on three primary and interrelated areas: (1) organizational safety, (2) vehicle safety, and (3) operational safety. Together, these elements provide a comprehensive framework for managing safety across development, testing, deployment, and ongoing operations.

To support risk-informed decision making and demonstrate that safety objectives are being met, Motional employs a safety case. The safety case provides a structured, evidence-based argument that the autonomous vehicle system is absent of unreasonable risk for its intended application within defined operational boundaries. The safety case is informed by outputs from Motional's Safety Risk Management, Safety Assurance, and Safety Investigation programs and is maintained as system capabilities, operating conditions, and deployment scope evolve.



# 3. Motional's Approach to Safety

## 3.2. Motional's Safety Case

A Safety Case is a structured argument, supported by a body of evidence, that provides a clear, comprehensive, and valid demonstration that a system is absent of unreasonable risk for a given application in a defined operating environment. Motional has established a safety case framework that articulates safety claims supported by documented evidence and aligned with relevant standards and industry best practices.

Motional's Safety Case is maintained throughout development and operations. Periodic reviews of the Safety Case are triggered by changes to system design, software or hardware updates, operational configurations, deployment scope, or findings from safety performance monitoring and investigations. Outputs from Safety Risk Management, Safety Assurance activities, and Safety Investigations are used to assess the continued validity of safety claims, identify gaps in evidence, and determine whether additional mitigations or operational controls are required.

The high-level safety case claim that Motional demonstrates the absence of unreasonable risk in our autonomous driving system through organizational responsibility, system resilience, and competent driving backed by evidence-based safety claims is supported by three main pillars:

### Operate with Responsibility

Operate with Responsibility defines the organizational governance, safety culture, and lifecycle management protocols that ensure safety is prioritized throughout the company's operations. This pillar asserts that Motional maintains a robust Safety Management System (SMS) to oversee the development, testing, deployment and scaling of autonomous fleets. It encompasses the establishment of rigorous internal safety standards, transparent reporting mechanisms, and continuous employee training. By integrating safety into the organizational DNA, this pillar ensures that every operational decision—from fleet maintenance to remote assistance—is governed by a proactive risk management framework that identifies and mitigates potential hazards before they manifest in the field. In addition, when issues arise the risk management framework investigates, resolves, and contains them.

### Architect for Resilience

Architect for Resilience focuses on the redundancy, structural integrity and fault-tolerant design of the vehicle's hardware and software architecture. This pillar claims that the system is designed to maintain safe operation even in the presence of internal component failures or external environmental stressors. The architecture utilizes redundant sensing and diverse actuation paths for steering and braking. By addressing both functional safety, cybersecurity, and foreseeable misuse, this pillar ensures the system can transition to a MRC during hardware malfunctions or adversarial interference, thereby preventing a single point of failure from resulting in an unreasonable risk.

### Drive with Competency

Drive with Competency addresses the behavioral intelligence and decision-making capabilities of the system. This pillar demonstrates that the vehicle can navigate complex, dynamic ODDs with a level of skill that meets or exceeds that of a competent human driver. It focuses on the Safety of the Intended Functionality (SOTIF), ensuring the ADS can accurately perceive the environment, predict the movements of other road users, and execute maneuvers that are both safe and predictable. Evidence for this pillar is derived from a multi-modal testing regime—including high-fidelity simulation, closed-course testing, and public road data—to verify that the vehicle abides by traffic laws and effectively manages edge cases.



# 3. Motional's Approach to Safety



## 3.3. Organizational Safety

Motional implements organizational safety through an SMS that defines governance, accountability, and oversight. The SMS ensures safety risks are systematically managed and responsibilities are clearly established across development and operations.

These include tailored application of standards such as ISO-26262, ISO-21448, UL-4600, and relevant AVSC guidance. Motional also maintains an Environmental, Health, and Safety Policy which addresses occupational safety and environmental impacts associated with its operations.

### 3.3.1 Safety Culture

Safety is central to Motional's mission and embedded across the organization. It begins with leadership expectations and extends through employee onboarding, training, operational procedures, and day-to-day decision-making. "Safety as our Bedrock" reflects the principle that safety takes precedence over competing objectives.

Employees are expected and empowered to identify, report, and escalate safety concerns without fear of retaliation through tools such as our anonymous safety concern reporting or RED BUTTON immediate safety stop process. Clear accountability, leadership oversight, and integration of safety expectations into performance objectives reinforce this standard and support effective reporting, investigation, and resolution of safety issues.

### 3.3.2 Safety Policies and Objectives

Motional's Safety and Cybersecurity Policy establishes the overarching principles and expectations governing safety-related activities across the organization. The policy defines responsibilities for identifying and managing safety risks and provides the foundation for Motional's SMS.

Motional executes its safety policies through structured processes designed to achieve defined safety objectives and maintain alignment with applicable standards and industry best practices.

### 3.3.3 Safety Review Board

The Safety Review Board (SRB) is the governing body of Motional's SMS and serves as the enterprise-level forum for oversight, escalation, and decision making on safety and cybersecurity related matters. The SRB provides executive accountability for safety risk management and ensures that safety considerations are fully integrated into Motional's product development, operational planning, and deployment decisions.

The SRB evaluates safety and cybersecurity related proposals and issues across Motional's organizational, vehicle, and operational domains. It evaluates performance against safety objectives, assesses the effectiveness of safety controls, and determines whether risks, including residual safety risk, are acceptable prior to deployment.

The SRB's responsibilities include:

- Acceptance of residual safety risk and approval of mitigation strategies for high-risk issues;
- Go/no-go decisions for software releases, hardware changes, and operational deployments;
- Approval of safety cases supporting current and future deployments;
- Oversight of corrective and preventive actions; and
- Escalation and resolution of safety-critical and cybersecurity risks.

# 3. Motional's Approach to Safety

## 3.3.4 Safety Risk Management

Motional's Safety Risk Management (SRM) program is a key element of the company's Safety Management System (SMS) and is responsible for ensuring that safety risks associated with autonomous vehicle development and operations are systematically identified, assessed, mitigated, and managed to an acceptable level. Residual risk is defined as the level of risk remaining after the implementation of credible mitigations and controls.

The SRM program applies across the full lifecycle of the autonomous driving system, including design, validation, deployment, and ongoing operations. It supports risk-informed decision-making and requires explicit evaluation of safety impacts when technical, operational, or organizational changes are introduced.

Key functions of SRM include:

- Identification and documentation of safety risks arising from design decisions, system architecture, operational changes, and safety performance trends
- Evaluation of risks associated with changes to the Operating Design Domain (ODD), deployment configurations, and operational practices:
- Maintenance of a centralized Safety Risk Register (SRR) in coordination with the Safety Assurance (SA) program; and
- Escalation of hazards and associated mitigations to support risk acceptance, additional mitigation, or operational restriction decisions.

## Design Risk Management

The Design Risk Management function addresses risks identified during product development, including those related to system and subsystem design, software and hardware architecture, functional behavior, and human-machine interfaces. Risks are identified through hazard analyses, design reviews, failure mode assessments, and validation activities, and are documented in the SRR prior to deployment.

## Continuous Risk Management

The Continuous Risk Management (CRM) function provides ongoing oversight during testing and deployment. It evaluates risks arising from operational changes, performance trends, incident data, and Safety Assurance monitoring. Identified hazards are assessed for safety impact and entered into the SRR for review and mitigation as appropriate.

## Risk-Informed Decision Making

Risk-informed decisions are made based on documented risk assessments and defined risk acceptance criteria. Escalation mechanisms ensure that deployment milestones, operational changes, and system updates are approved only with a clear understanding of associated residual safety risk.



# 3. Motional's Approach to Safety

## 3.3.5 Safety Assurance

Motional's Safety Assurance (SA) program provides independent and ongoing confidence that safety objectives are being achieved and that safety risks are being effectively managed throughout development and operations. The SA program evaluates safety performance across the organization, documents results in a traceable manner, and supports informed decision-making by providing objective safety evidence.

The SA program functions as a continuous feedback mechanism within the SMS, confirming that safety controls and mitigations remain effective over time and that emerging safety risks are identified and addressed promptly.

The SA program is implemented through three primary functions:

- Metrics Monitoring
- SMS Auditing
- Safety Risk Register (SRR) Maintenance

### Metrics Monitoring

The Metrics Monitoring function continuously tracks Motional's safety performance indicators across four domains: Operational Safety, Organizational Safety, Product Safety, and Workplace Safety. These metrics provide leading and lagging indicators of safety performance and are used to identify potential degradation, emerging trends, or anomalous behavior that may indicate elevated safety risk.

Identified trends, anomalies, or threshold exceedances are evaluated to determine whether an elevated risk condition exists. When appropriate, these findings are escalated into the Safety Risk Register and managed to ensure timely assessment, mitigation, and tracking.

### SMS Auditing

The SMS Auditing function supports continuous improvement by periodically evaluating the effectiveness, consistency, and maturity of Motional's SMS and its supporting programs. Audits include a combination of internal peer reviews and independent assessments.

Safety Culture audits are performed using tools such as employee surveys and structured interviews to assess workforce engagement, reporting confidence, and adherence to safety principles. SMS Program audits focus on identifying gaps in processes, documentation, implementation, and governance, with an emphasis on corrective actions and sustainable closure of findings.

In addition, workplace safety audits are conducted to verify compliance with applicable occupational health, safety, and environmental regulations and to ensure that Motional's facilities and field operations provide a safe working environment for employees and contractors.

### Safety Risk Register Maintenance

The SRR Maintenance function ensures that documented safety risks, associated mitigations, and residual risk assessments remain current, accurate, and reflective of actual system and operational conditions. This includes periodic review and update of risk entries based on new data, audit findings, investigation outcomes, and changes to system design or operational configurations.

Maintaining an up-to-date Safety Risk Register supports effective risk tracking, enables informed risk acceptance decisions, and fosters alignment between Safety Assurance findings and Safety Risk Management activities.



# 3. Motional's Approach to Safety

## 3.3.6 Safety Investigations

Motional's Safety Investigations program provides a structured and objective process for identifying, analyzing, and addressing safety-relevant events, conditions, and concerns. The program supports Motional's SMS by ensuring that safety issues are consistently investigated, documented, and resolved in a manner that strengthens risk management, supports continuous improvement, and reinforces a strong safety culture.

The Safety Investigations program manages the intake, assessment, and resolution of safety-related inputs, including outputs from the Safety Assurance program, voluntary safety reports, operational events, and workplace incidents. Investigations are conducted using defined procedures to ensure timely response, appropriate escalation, and traceable outcomes.

The objectives of the Safety Investigations program include:

- Proactively improving safety performance by encouraging voluntary safety reporting and investigating anomalies, trends, and precursors identified through safety performance monitoring before an undesired outcome occurs;
- Reactively addressing safety events by investigating operational, vehicle, or workplace incidents where an undesired outcome has occurred;
- Supporting a robust safety culture by promoting transparency, accountability, and a non-punitive approach to safety reporting;
- Providing clear and accessible mechanisms for employees and contractors to report safety concerns without fear of retaliation;
- Identifying and documenting hazards, contributing factors, and systemic issues revealed through investigations to support effective risk management; and
- Maintaining investigation records, analyses, and outcomes to inform corrective actions, trend analysis, and future safety improvements.

Investigations are conducted at a level of rigor commensurate with the potential safety impact of the event or condition.

Findings from investigations, including identified hazards, contributing factors, and recommended corrective or preventive actions, are documented and reviewed. Where appropriate, investigation outcomes are captured in the Safety Risk Register and managed through the Safety Risk Management and Continuous Risk Management processes to ensure effective mitigation, closure, and verification.

## 3.3.3. Safety Promotion Of Safety Culture

Safety Promotion activities reinforce Motional's safety culture, our "Safety as a Bedrock" company value, and ensure that employees understand their roles, responsibilities, and available safety mechanisms within the SMS. These activities support consistent application of safety policies and processes across the organization.

Safety Promotion includes employee onboarding, role-specific training, ongoing safety communications, and leadership messaging that emphasizes safety expectations and accountability. Employees are encouraged to raise safety concerns through established reporting mechanisms, including confidential and non-punitive reporting channels such as the Red Button reporting system and the Ethics Hotline.



# 3. Motional's Approach to Safety



## 3.4. Vehicle Safety

Motional's vehicle safety approach is informed by automotive industry regulations and standards as well as AVSC best practices for ADS equipped vehicles. In particular, Motional considers and utilizes relevant elements of:

**ISO 26262** - Functional Safety

**ISO 21448** - Safety of the Intended Functionality

**UL 4600** - Standard for Safety for the Evaluation of Autonomous Products

### 3.4.1. Vehicle Platform Safety and Continuous Monitoring

Motional's base vehicle, the Hyundai IONIQ 5, has earned the Insurance Institute for Highway Safety "Top Safety Pick +" rating. Hyundai and Motional incorporate the ADS into the IONIQ 5 base vehicle platform, which is FMVSS certified. Installation of AV components occurs directly on the production line.

Motional also has processes in place, once the vehicle is operating, to ensure continuous monitoring. Motional's Multi-Point Inspection (MPI) is a multipurpose checklist which includes review and measurement of items such as mileage, coolant levels, brake pads, and other vehicle features. This checklist is used in a variety of scenarios to ensure vehicle safety, such as during regular maintenance, after towing or shipping, following a safety incident, or other situations. The MPI is developed using two primary sources: (1) Hyundai's maintenance check recommendations for the base IONIQ 5 vehicle; and (2) Motional's maintenance check recommendations for the ADS specific components. Combined, these efforts serve to ensure the vehicle is in proper working order.

Motional organizes vehicle data to track anomalies and fault precursors using an internal tool called Command Center. Command Center is a visual interface used by Motional's Fleet Operations team to track the status of all AVs.

Motional organizes vehicle data to track anomalies and fault precursors using an internal tool called Command Center. Command Center is a visual interface used by Motional's Fleet Operations team to track the status of all AVs. This display shows telemetry data that includes fault notifications, health status indicators, battery level, and ride status. Command Center also tracks anomalies related to the health status of Motional's fleet as well as integrations with partner platforms.

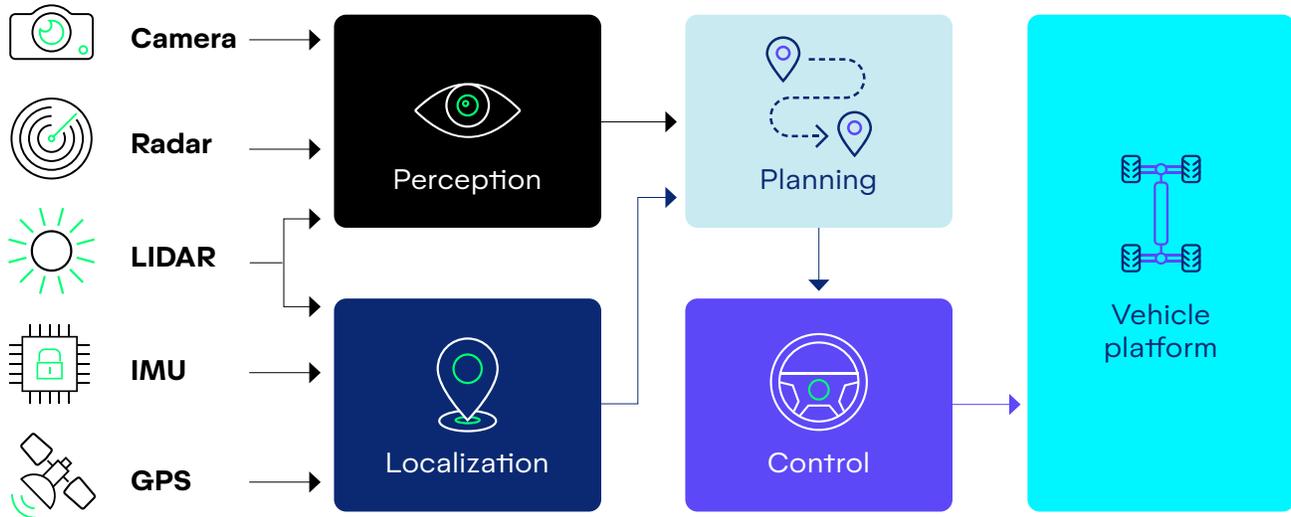
The Hyundai IONIQ 5 base vehicle platform is responsible for translating commands from Motional's drive-by-wire software into commands for the steering, braking, and propulsion systems. The platform contains redundant paths, power supplies, sensors, steering, braking systems, and communication paths to reliably perform safety-critical functions. Additionally, the platform is responsible for detecting and reporting back to the AV if there is a loss of communication with the dedicated vehicle interface control unit or other anomaly, leading to the AV executing a MRM. The design includes the ability to detect the loss of redundant communications with the vehicle control unit and triggering braking maneuvers.

The IONIQ 5 also includes manual post-crash safety measures, such as disabling the high-voltage battery. More information on post-crash actions is included in Section (ii)(6).



# 3. Motional's Approach to Safety

FIGURE 8: HIGH-LEVEL DIAGRAM OF OUR CORE AV SYSTEM ARCHITECTURE (FALLBACK SYSTEMS NOT SHOWN)



## 3.4.2. Vehicle System Safety

Motional's ADS design includes the hardware, software and operational elements that work together to perform the task of operating the vehicle.

### 3.4.2.1 Vehicle Level Autonomy

Motional's autonomous system integrates multi-modal sensing, including cameras, lidar, and radar, across short and long ranges. Sensor data is fused to generate a three-dimensional representation of the environment and to classify roadway elements such as vehicles, pedestrians, cyclists, and traffic signals. Overlapping sensor modalities provide redundancy to enhance system reliability.

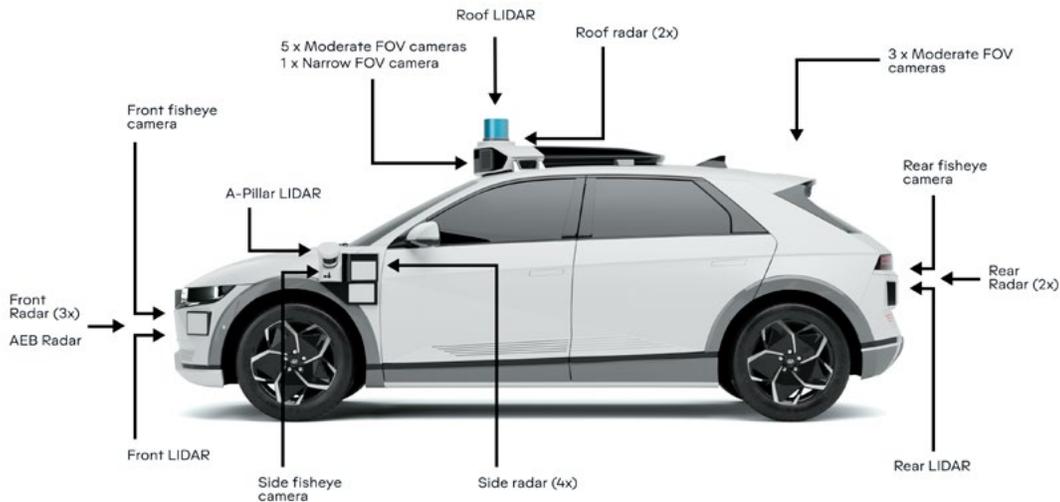
The system continuously tracks detected objects and predicts their likely intent and trajectories. These predictions inform motion planning, which generates safe and lawful vehicle paths based on current conditions and anticipated movements of surrounding actors. Prediction and planning models are developed and validated using extensive real-world driving data and large-scale simulation, putting every new major software release through 15 years worth of simulated driving.

Vehicle control is executed through a dedicated drive-by-wire interface that connects the autonomy stack to the vehicle platform and performs system monitoring. Redundant controller units with independent power and communication pathways further strengthen system resilience.

Autonomous Emergency Braking (AEB) operates concurrently with the primary autonomy system as an independent forward collision mitigation layer, supported by dedicated sensing and control hardware.

Motional's autonomous system uses an onboard map that incorporates lane geometry, traffic controls, and pedestrian infrastructure to support localization and contextual awareness.

# 3. Motional's Approach to Safety



## 3.4.2.1.1. Sensor Positioning and Aiming

Motional's sensor suite provides a full 360 degree view around the AV. These are positioned to provide near view detection of objects close to the AV as well as optimized to provide detection at a distance to support early anticipation of traffic and ensure safe maneuvers at higher speeds. The system utilizes multiple forms of sensors (i.e. Lidar, Radar, Camera) to provide robustness against performance limitations of a single sensor type. The system also provides overlap of sensor field of view to ensure the vehicle still has full environment awareness even if there is a momentary sensor blockage/failure.

## 3.4.2.2 Fallback Systems and Post Crash ADS Behavior

Motional's autonomous system is designed to be robust to faults. In addition to designed in redundancy across the architecture, Motional's autonomous system has the capability to detect and appropriately respond to faults in real time. A fault may include degradation or failure of software, sensing, communications, or vehicle subsystems.<sup>3</sup>

The vehicle architecture incorporates redundancy across safety-critical functions, including braking, steering, steering angle sensing, and power supply. These systems are designed to support fail-safe and, where appropriate, fail-operational performance.

Safety-critical components are continuously monitored. If deviations exceed defined thresholds, fault codes are generated and evaluated by the autonomy system. When required, the vehicle transitions to an appropriate Minimum Risk Maneuver, which may include controlled deceleration and movement to a safe stop based on roadway conditions.

Following an incident or significant fault, the vehicle is designed to maintain a safe state, preserve relevant system data, and prevent further autonomous operation until appropriate review and clearance occur.

## 3.4.3.2. Event Data Recording and Data Storage

Motional employs multiple sources for data capture for on-road events. The Motional AV is equipped with an airbag control module with an Event Data Recorder (EDR) function supplied by HMG that is compliant with 49 CFR Part 563 and that captures data for collisions. The data captured by the EDR does not include data specific to autonomous vehicle operations. For the expanded autonomous data suite, the Motional AV has a Data Storage System for Automated Driving (DSSAD). The DSSAD (and the data captured by it) aligns with industry standards and best practices and collects autonomous data surrounding on-road events such as collisions, minimum risk maneuvers, and disengagements.

After the completion of each mission, Motional offloads all trip data and uploads it to the cloud so that the data can be stored and analyzed if needed. Data storage and retention is governed by Motional's Data Retention Policies.

<sup>3</sup> International Organization for Standardization, "ISO 26262: 2018: Road vehicles - Functional safety," 2018.

# 3. Motional's Approach to Safety

## 3.4.3. Getting to Deployment

### 3.4.3.1. Overview

The ISO 15288 standard for system lifecycle processes for systems and software engineering defines validation as the “confirmation, through the provision of objective evidence, that the requirements for a specific intended use or application have been fulfilled.” Motional conducts ongoing validation of the AV system with the objective of demonstrating that the AV is absent of unreasonable risk for autonomous operation on public roads. This is done through safety validation activities which confirm the AV fulfills the high-level safety requirements, as documented in our safety case.

Motional's safety validation activities use a combination of proactive scenario identification and in-ODD monitoring. Motional uses simulation, closed course proving grounds, and public road test modalities to leverage the strengths of each and collectively address their respective limitations.

### 3.4.3.2. Simulation

Motional employs two types of simulation:

1. Synthetic simulation testing uses a virtual environment to evaluate AV software across many scenarios. Doing so involves optimizing the coverage of the scenario space and setting appropriate pass/fail criteria for relevant tests.
2. Resimulation testing replays an event logged from the road. A new software configuration is evaluated by replaying the event. The new response of the system is then evaluated by extracting performance metrics and applying pass/fail criteria for relevant tests.

These two types of simulation approaches are complementary. Synthetic simulation allows efficient and repeated evaluation of a large scale of scenarios that are too dangerous to test in the real world or that may only rarely occur on public roads.

Resimulation is able to recreate tests that involve complex scenarios with a potential for hundreds of dynamic agents interacting with one another. These tests are extracted from experience on public roads, which ensures realistic scenarios and allows us to test the entire autonomous system as a whole.

Both simulation types allow for simulation to be used for scenario-based testing and as a complement to monitoring and testing on public roads within the ODD and closed course testing.

### 3.4.3.3. Closed Course Testing

Closed course environments allow Motional to conduct controlled tests in specific, well-formulated scenarios and address scenario-based testing needs in real life. This testing serves the following purposes:

- Evaluating an AV's performance in a physical environment and comparing it to simulation;
- Testing challenging, dangerous or rare scenarios without risk to the general public;
- Testing key AV capabilities in repeatable scenarios; and
- Training safety drivers to safely operate the AV and remote vehicle assistance agents to efficiently provide the AV with additional context in ambiguous or unusual situations

Closed course testing is used to ensure that the autonomous system meets specific requirements and outlier scenarios by exercising the complete end-to-end system. It also supports vetting of software upgrades and evaluation against industry standard tests, such as the European New Car Assessment Program standard. In conducting this work, the Motional team can confirm the capabilities of the AV and human-machine interaction scenarios to ensure safety.

FIGURE 5: PATH FROM SIMULATION TO DEPLOYMENT



# 3. Motional's Approach to Safety

## 3.4.3.4. Public Road Testing

Public road testing exposes the AV to scenarios that it encounters during everyday driving and is an important step in safety validation. Driving real-world miles allows the company to evaluate whether the rate of unknown hazardous scenarios is sufficiently low and serves the following goals:

- Enabling statistical inferences about safety and risk from real world testing; and
- Encountering and resolving unanticipated or complex scenarios that could not be addressed in other test settings.
- During such testing, the Motional team works to ensure safety risks are properly managed, including implementation of operational mitigations as appropriate.

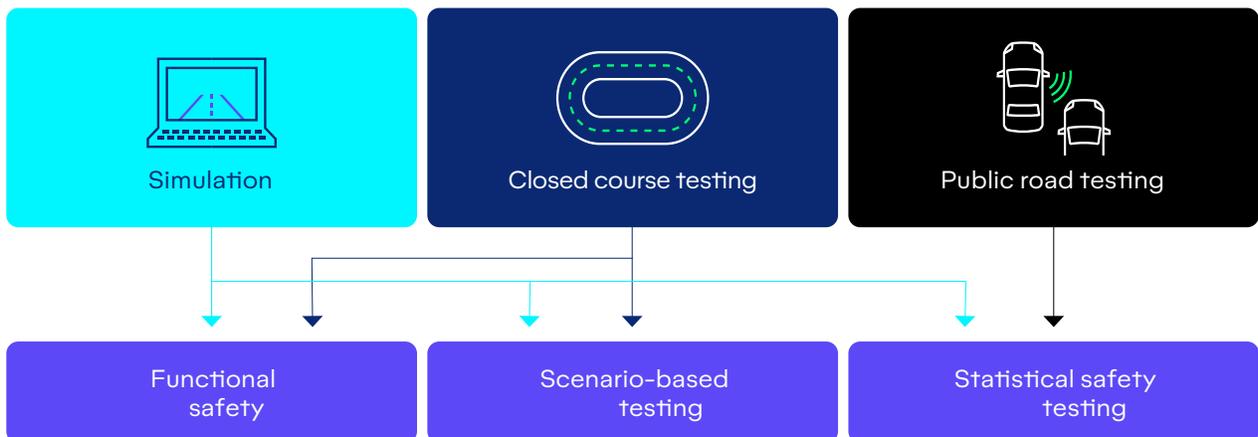
During public road testing, Motional has encountered a wide range of situations. For example, testing in Singapore has exposed Motional AVs to left-side driving, complex urban environments, and heavy rainfall. In Las Vegas, Motional AVs have encountered heavy pedestrian traffic, inclement weather such as sandstorms, and high vehicular traffic volume. In Pittsburgh, Motional has tested AVs in snow, sleet, and fog. The diversity of testing provides a unique ability to continually improve Motional's AV systems.



## 3.4.3.5. Iterative Testing and Continuous Improvement

Motional views safety validation activities as an integral element of development and conducts daily testing to monitor AV software changes for overall improvements. This testing may be focused on small changes or specific subsystems (e.g. shadow mode feature deployment) to determine how new features will respond to real-world data prior to wider deployments. Motional uses the daily cadence of testing to provide immediate development feedback to improve operating behavior. Promising daily releases are promoted to release candidates. The best-performing candidate is promoted to a best-known release, which undergoes a rigorous software validation campaign prior to a driverless public road deployment.

**FIGURE 7: RELATIONSHIP BETWEEN THE THREE PILLARS OF SAFETY SIGN-OFF AND THE VALIDATION TEST SETTINGS FROM SECTION 2.2**



# 3. Motional's Approach to Safety

## 3.4.4. Cybersecurity

Motional is attuned to concerns about cybersecurity and its teams work together to design and build AVs that will operate safely despite potential threats from outside actors who might seek to interfere with vehicle operations. Motional has established engineering processes to help discover and proactively address cybersecurity threats.

Cybersecurity goals include the following: (a) making risks harder for a threat actor to realize; (b) providing an avenue to detect an attack; and (c) enabling quicker recovery should there be a cybersecurity incident. Motional's strategy includes implementing relevant elements from international standards and best practices, including ISO 21434, R155 and NHTSA's cybersecurity best practices.

In order to effectively monitor operational cybersecurity risk, Motional has implemented a Cybersecurity Incident Response Policy and a Cybersecurity Incident Response Plan. The Policy and Plan provide Motional with a method to identify and address cybersecurity incidents. Motional identifies operational risks through several methods including external security researchers, penetration test findings, law enforcement, potential or realized vulnerabilities, and vendor disclosures. If a cybersecurity incident is determined to exist, Motional initiates its Cybersecurity Incident Response Plan in order to ensure the appropriate stakeholders are aware and involved in response activities.

Motional additionally utilizes several vulnerability management systems to routinely conduct scanning of its systems and code repositories to identify vulnerabilities. Each of these tools is used to determine vulnerabilities on Motional systems. Motional reviews these vulnerabilities for any that require elevated attention for remediation and ensures appropriate oversight and review.



# 3. Motional's Approach to Safety



## 3.5. Operational Safety

Motional's operational safety work addresses how to make vehicle on road operations compliant with key safety protocols.

### 3.5.1. Operational Design Domain of the Vehicles

Motional AVs currently operate with a Level 4 ADS within the classification system established by the SAE. This means that the AVs can only operate autonomously within a specific Operational Design Domain (ODD).

The ODD describes the specific areas where a vehicle can operate with respect to roadway types, speed, lighting (day/night), weather conditions, and other constraints. The ODD provides a constrained scope in which the AV will operate without specifically stating how to develop the AV or how to handle a situation. The constraints and maneuvering capabilities of the AV also affect the scope of the ODD. The constraints can include speed, types of intersections or lane types, traffic elements, such as temporary lanes, and weather conditions.

Motional utilizes AVSC best practices for describing an ODD<sup>4</sup> and utilizes elements, such as a map, routing, and weather tracking to determine and establish an ODD.

Driverless operations are remotely monitored to ensure compliance with the defined ODD. If an AV for some unexpected reason encounters an out-of-ODD element, the AV or RVA agent can initiate a Minimum Risk Maneuver (MRM).

Motional's AV technology continues to evolve and improve with the goal of increasing the scope and nature of situations in which it can successfully operate. Motional carefully evaluates and implements an ODD before each deployment.



### 3.5.2. On Road Testing and Operations

Through years of experience, Motional has built a robust set of processes along with a thoughtfully designed vehicle platform to ensure the safety of Motional's on-road testing and operations. This includes methods to ensure that procedures and interfaces are both functional and sufficient. First, Motional ensures that the vehicle can be safely operated in an ODD by the AV. For situations in which Motional vehicle operators remain in the vehicle, the vehicle has interfaces to allow regaining manual control if needed, including steering wheel, brake and accelerator pedal, physical disengagement button on the steering wheel, and a red emergency stop button to bring the vehicle to a halt if needed. Second, Motional has in place remote vehicle agents who can connect remotely to a vehicle and suggest a course of action to guide it out of complex on-road situations. Motional also maintains incident response channels to handle situations that require intervention in case of an incident or where further investigation is needed. Finally, Motional has in place established processes to report the performance of the AV system to ensure smooth operations and to make iterative improvements as needed for a comfortable customer experience.

<sup>4</sup> AVSC, "AVSC Best Practice for Describing an Operational Design Domain: Conceptual Framework and Lexicon" 15 April 2020. Available at: <https://www.sae.org/standards/content/avsc00002202004/> [accessed 13 February 2024].

# 3. Motional's Approach to Safety

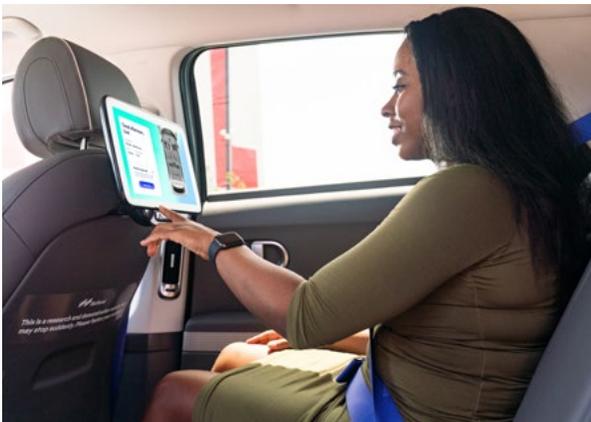
## 3.5.3. Passenger Experience and External Communications

Ensuring the passenger experience is safe is vital and, as part of that effort, Motional strives to communicate effectively with passengers and important external actors.

Motional autonomous vehicles contain an in-vehicle application (IVA) passenger display via tablets facing the rear seats where passengers can view details about the vehicle, its planned route, and perceived surroundings. Passengers can use these tablets to start the ride and get visibility into progress towards their destination. At the start of the ride, the IVA welcomes passengers and reminds them to close the doors and buckle their seat belts. When the ride reaches its destination, an end-of-ride screen reminds passengers to gather their belongings and safely exit.

For driverless operations, a passenger will be able to seek support during a ride through communication with remote customer support. Additional safeguards will be in place for bringing vehicle motion to a stop as soon as is safely possible when safety-critical events occur such as opening a door while the vehicle is in motion.

Motional also works with local law enforcement and first responders to help them understand where and how the AVs operate. For AVs with human vehicle operators, the operators can handle interactions with law enforcement and first responders. For driverless vehicles, Motional communicates law enforcement interaction plans in the areas it operates and provides channels of communication for first responders to interact with Motional personnel for emergent situations. Field support personnel are able to be dispatched on scene when necessary.



## 3.5.4. Operational Safety Measures

### 3.5.4.1. Personnel and Training

Motional maintains structured, role-specific training and qualification programs designed to ensure personnel are prepared for their assigned responsibilities in autonomous vehicle testing and operations. These programs include both knowledge-based and skills-based components and are integrated with Motional's operational safety framework to support safe and effective execution of AV operations.

Training for autonomous vehicle test operators consists of three core components: (1) classroom- or module-based instruction with associated knowledge assessments; (2) hands-on, in-vehicle mentoring combined with skills-based performance evaluations; and (3) ongoing continuing education delivered through a combination of self-paced e-learning and instructor-led training. Together, these elements are intended to ensure operators develop a comprehensive understanding of vehicle systems, autonomous driving behaviors, and operational procedures prior to participating in public-road testing or deployments.

Training content includes standardized curriculum elements applicable across Motional operational sites, supplemented by location-specific instruction addressing regional traffic laws, roadway characteristics, regulatory considerations, operational constraints, and site-specific testing requirements. This structure ensures personnel receive a consistent baseline of knowledge while developing the localized awareness necessary to safely support operations within each deployment environment.

# 3. Motional's Approach to Safety

In addition to autonomous system training, Motional provides training and evaluation of manual driving skills: including situational awareness, hazard recognition, and safe driving behaviors, to ensure operators are prepared to take manual control when required in accordance with operational procedures.

Ongoing operational readiness is supported through periodic communications and refresher activities that reinforce training objectives and keep personnel informed of vehicle behavior updates, software changes, procedural revisions, and operational best practices. These activities promote consistent application of safety procedures and alignment with evolving operational needs.

Motional also maintains defined training and qualification requirements for Remote Vehicle Agents (RVAs). RVAs are trained to provide remote assistance in support of vehicle operations and must complete a comprehensive training program prior to performing operational duties. Training may include online coursework, instructor-led sessions, simulation-based exercises, shadowing, and in-vehicle situational exposure, as appropriate. Continued readiness is supported through ongoing training and assessment to ensure RVAs can safely and effectively support autonomous vehicle operations.

## 3.5.4.2. Fleet Management and Remote Assistance

Motional utilizes a fleet management system that monitors vehicles individually and as a fleet, performs centralized dispatch, and manages software versions and updates. Motional's Fleet Operations team implements vehicle inspections and checks to ensure the safety and reliability of Motional's vehicles prior to the start of each shift.

Motional's driverless operations also utilize Remote Vehicle Assistance as an additional tool to support Motional's autonomous vehicle operations. A small subset of situations the autonomous vehicle may encounter are unusual or ambiguous. In these situations the autonomous system utilizes Remote Vehicle Assistance ("RVA"). Motional's RVA is part of its overall system architecture and provides assistance in these limited instances, but at no time is control of the vehicle transferred away from the autonomous system, which retains full responsibility for evaluating road conditions and executing any maneuver safely.

Motional has integrated RVA into deployed operations in a support capacity rather than as a substitute for autonomy capability or as a failsafe. While the autonomous system remains responsible for the entire dynamic driving task, live service assistance may provide additional context in limited circumstances where ambiguity exists and help guide the vehicle to proceed safely through those situations where human judgment is beneficial. RVA assistance enables a trained agent to connect to a specified AV and receive relevant real-time information regarding the AV's status through a user interface. This includes agents who monitor vehicle operations.

## 3.5.4.3. Grounding Policy

Motional maintains a Grounding, Ungrounding, and Pause Policy as part of its operational safety framework. This policy defines the conditions and processes for suspending, restricting, or resuming vehicle operations to ensure that safety risks are effectively managed and that operations proceed only when appropriate safety conditions are met.

Grounding actions may be initiated in response to a range of safety-relevant conditions, including but not limited to:

- Severe environmental conditions or emergency situations, such as natural disasters, civil unrest, or other Acts of God;
- Degraded or unavailable vehicle connectivity that may impact safe operation or oversight;
- Regulatory, legal, or permitting actions that affect operational authorization;
- Identified safety concerns related to vehicle behavior, system performance, or operational procedures;
- On-road incidents involving Motional autonomous vehicles or other vehicles under Motional's operational control; and
- Observed or suspected software, hardware, or system failures that may impact safe operation.

Grounding decisions are made using a risk-informed approach and may apply to individual vehicles, subsets of the fleet, or broader operational configurations, depending on the nature and scope of the identified concern. Operations are resumed only after the underlying issue has been evaluated, appropriate mitigations have been implemented, and authorization to return to service has been granted through established governance processes.

# 3. Motional’s Approach to Safety

As part of its safety practices, Motional also maintains a “Red Button” reporting protocol that enables employees to promptly suggesting to stop operations. Employees are empowered to submit “Red Button” reports when they believe an immediate or elevated safety risk may exist. These reports are reviewed through defined escalation and assessment processes and may result in actions up to and including vehicle or fleet grounding, pending further evaluation and resolution.

### 3.5.4.4. Incident Response

Motional maintains a formal incident response program designed to identify, contain, and manage operational incidents during live deployment. The program defines how events are detected, classified, escalated, and resolved to minimize risk and support safe outcomes.

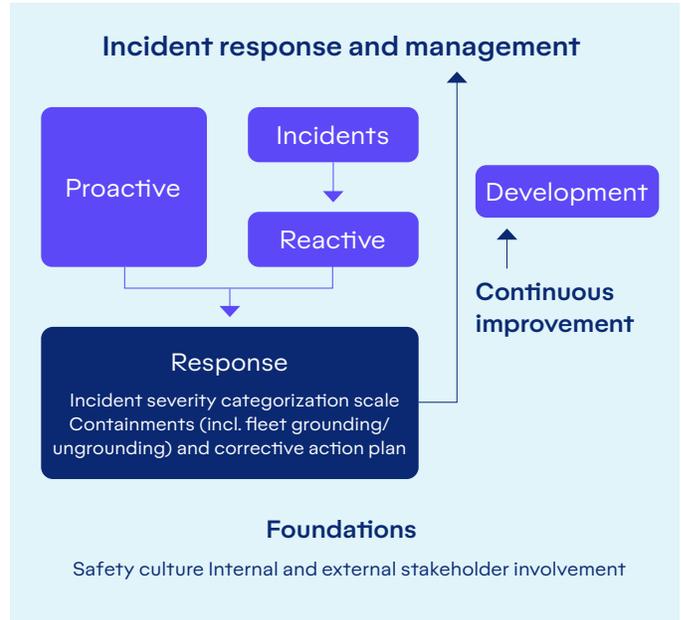
Clear roles and responsibilities are established for vehicle operations, remote support, and relevant functional teams. Procedures address initial response actions, communication protocols, coordination as appropriate, and defined criteria for escalation, including fleet grounding or operational restrictions when warranted.

Personnel in driverless and safety-critical roles are required to complete incident response training prior to certification. Quick reference guides support consistent execution during live events.

Following containment, incidents are evaluated through Motional’s Safety Investigations program using a documented process to determine severity, contributing factors, and root causes. Identified hazards, containment measures, and corrective or preventive actions are tracked to closure within the Safety Management System.

Investigation findings inform Safety Risk Management, Safety Assurance activities, and ongoing system and operational improvements.

**FIGURE 12: OVERVIEW OF OUR FLEET SAFETY RESPONSE PROCESSES**



### 3.5.5. First Responder Interactions

Motional is committed to ensuring productive dialogue and communication with first responders to ensure safety issues are handled effectively. Motional has developed a First Responder Interaction Plan in each of its primary ODDs to educate First Responders on how to effectively manage interactions with Motional’s AVs, including communications, disengagement and release of such vehicles, and maintaining accessible emergency contact information should an incident arise. Motional’s work in this area utilizes the AVSC’s Best Practice for First Responder Interactions with Fleet-Managed Automated Driving System-Dedicated Vehicles (ADS-DVs)

### 3.5.6. Regulatory Compliance and Approvals

Motional works closely with federal and state regulators to comply with applicable laws and regulations applicable to autonomous vehicles.

# 3. Motional’s Approach to Safety

## 3.5.7. Data Management and Privacy

Motional’s operations generate operational and vehicle data necessary to support autonomous system performance and oversight. The company maintains formal Records Management and Document Control policies to govern data creation, retention, and storage in accordance with applicable legal requirements.

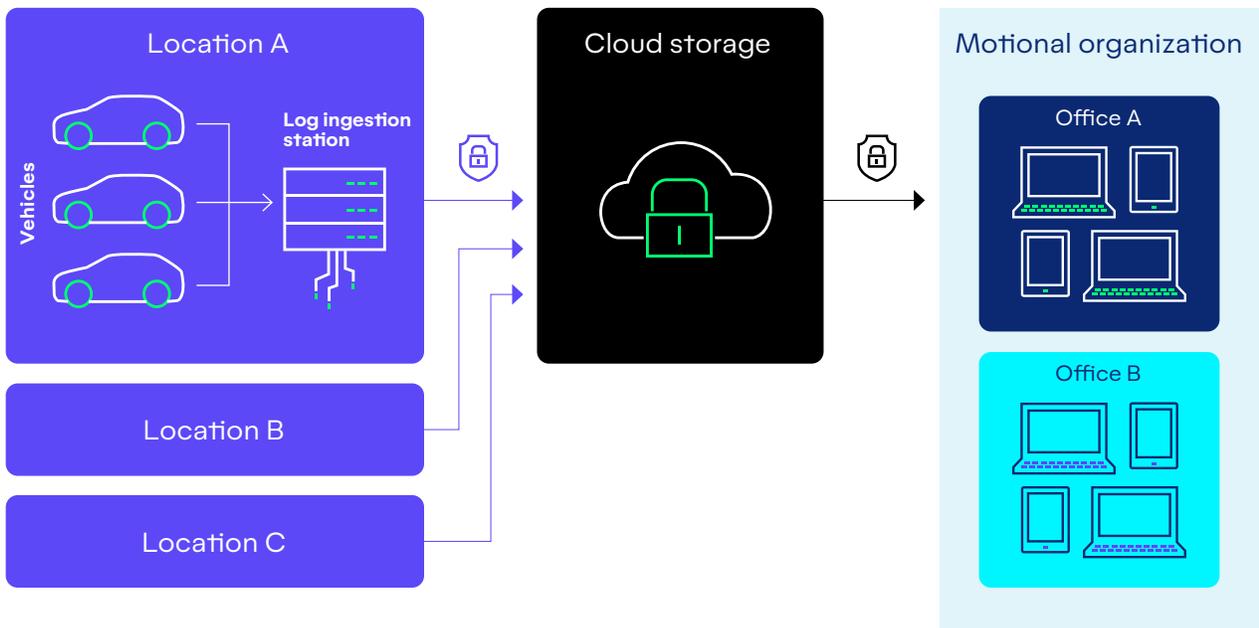
Operational data supports safety-related functions, including:

- Providing authorized access to relevant incident information in accordance with applicable law and process;
- Analyzing simulation, closed-course, and public road data to evaluate system performance and identify improvement opportunities; and
- Contributing, where appropriate, to industry safety standards development and related safety initiatives.

Motional publishes its vehicle user privacy policy<sup>5</sup> and maintains safeguards to protect personal data collected in connection with vehicle operations.

Vehicle data is secured through purpose-built hardware and software systems that preserve integrity, generate metadata, and enable encrypted transmission to protected storage environments. Access to sensitive data is restricted based on defined roles and business need.

FIGURE 13: OUR DATA PIPELINE



<sup>5</sup> Motional, “Vehicle User Privacy” Available at: <https://motional.com/vehicle-user-privacy> [accessed 13 February 2024].

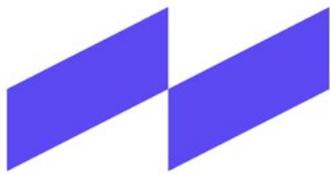
## 4. Community Engagement

Motional engages directly with the communities in which it operates to support understanding of autonomous vehicle technology and its safe integration into local environments.

Community engagement includes outreach to schools, neighborhood organizations, advocacy groups, and other local stakeholders. These efforts may include educational sessions, vehicle demonstrations, and opportunities for members of the public to experience the technology firsthand.

Feedback gathered through community engagement activities is incorporated, where appropriate, into operational planning and public-facing programs.





**Motional**

